National Water, Sanitation and Climate Outlook

An evaluation of water and sanitation in

The Kingdom of Tonga

July 2011

Produced by the National Water Resources Committee

With the assistance of SOPAC

Forward

The provision of safe water and sanitation in Tonga for now and in the future is a national priority, as it impacts directly on the quality of life of the people and overall productivity of the population.

Economic growth, urban development, climate change effects are imposing growing demands and pressures on water resources, and contributing to rising water pollution, increases in salinity and the potential spread of disease. We are at a critical time in Tonga where we need to work together across institutions and look to the future with an integrated water resources management focus.

The way forward to a prosperous and sustainable future is by assessing and monitoring water use, education and capacity building in communities, and developing water resources with an environmentally and financially sound strategy. Integrated water resources management is an approach towards assimilating and effectively coordinating agencies, policies, programs and practices addressing water and sanitation-related issues, and takes into consideration socio-economic development and environmental conservation.

The National Water, Sanitation and Climate Outlook for Tonga identifies the Government's and other stakeholder's priorities to address driving forces of change in these key areas. It is one of many steps required to guide the development and security of a safe water supply and sanitation facilities for the future of Tonga, and will ensure that efforts are focused on supporting sustainable development of water resources for all Tongans.

Lord Ma'afu Tukui'aulahi
Minister for Lands, Survey and Natural Resources
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KINGDOM OF TONGA

Acknowledgements

The preparation of the Kingdom of Tonga's National Water, Sanitation and Climate Outlook was supported by the Pacific Islands Applied Geoscience Commission (SOPAC) through the European Union Integrated Water Resources Management program. The support of this organisation is gratefully acknowledged.

The support and encouragement from Mr Rennie Vaiomo'unga, the Acting Principal Geologist, and his staff at the Geology Unit, Ministry of Lands, Survey and Natural Resources (MLSNR) are fully acknowledged.

Sincere appreciation extended to the people of Tonga, including government, non-government and private stakeholders who were willing to attend meetings and workshops and share their experiences, knowledge and information, whose inputs are the foundation of this document.

Finally, thanks are extended to those who offered comments and reviewed documents or in any other way assisted with the development of this Outlook.

National Water Resources Committee, July 2011

Editor / Compiler

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List of Abbreviations and Units

°C	degrees Celsius
µg/L	micrograms per liter
µS/cm	micro Siemens per centimeter
ADB	Asian Development Bank
AusAID	Australian Agency for International Development
B Envelope	Disaster Risk Reduction in Eight Pacific ACP States project (B Envelope)
CFU/100ml	colony forming units per 100 milliliters of sample
ENSO	El Niño-Southern Oscillation
EU	European Union
GDP	gross domestic product
GEF	Global Environment Fund
GEF-IWRM	GEF Funded - IWRM Demonstration Project, Vava'u
GoT	Government of Tonga
HYCOS	Hydrological Cycle Observing System
IWP	International Waters Project
IWRM	Integrated Water Resources Management
JICA	Japan International Co-operation Agency
kg/hectare	kilograms per hectare
kL	kilolitre
km	kilometer
L	liters
L/s	liters per second
m	meters
MAFFF	Ministry of Agriculture, Food, Forestry and Fisheries
MDGs	Millennium Development Goals
MECC	Ministry of Environment and Climate Change
ML	megaliters
MLSNR	Ministry of Lands, Survey and Natural Resources
mm	millimeters
MoFNP	Ministry of Finance and National Planning
MoH	Ministry of Health
MoW	Ministry of Works
MPN/100ml	most probable number of coliform per 100 milliliters of sample
NDMO	National Disaster Management Office
NGO(s)	Non-Government Organisation(s)
NWRC	National Water Resources Committee
PACC	Pacific Adaptation to Climate Change project
PET	polyethylene terephthalate

pH	a measure of the acidity or basicity of an aqueous solution
POPs	and Persistent Organic Pollutants
SMB(s)	salinity monitoring bore(s)
SMEC	Snowy Mountains Engineering Company
SOPAC	Pacific Islands Applied Geoscience Commission
SPCZ	South Pacific Convergence Zone
TANGO	Tonga Association of Non-Governmental Organistions
TMS	Tonga Meteorological Service
TOP	Tongan Pa'anga
TSDF	Tonga Strategic Development Framework
TWB	Tonga Water Board
USA	United States of America
VWC(s)	Village Water Committee(s)
WASH	Water Supply, Sanitation and Hygiene
WHO	World Health Organisation

1 Introduction to the National Water, Sanitation and Climate Outlook

Water is a vital resource that underpins human well-being, cultural and spiritual values, and economic and development opportunities for Tonga. The country faces unique challenges in the water and sanitation sector. Areas of concern in water and sanitation Tonga include:

- Human and animal-induced pollution and associated reduction in water quality
- Water resource protection and adequate sanitation to preserve water quality standards
- Demand management and control of wastage
- Fragmented national management

Water supply, water quality monitoring and sanitation are being carried out by many different agencies. An integrated high-level approach is needed to reduce fragmented water resource management leading to counteractive approaches and duplication of effort. The National Water Resources Committee's aim is to coordinate management of water resources at an executive level to address the main gaps, key national priorities and objectives in regard to water and sanitation using an integrated water resources management (IWRM) approach.

The National Water, Sanitation and Climate Outlook is a document that captures the status, trends, current issues, emerging threats and recommendations related to water and sanitation in Tonga. It also provides a situational analysis of the sector by capturing some of the work done in the past, and present. The Outlook also highlights the added vulnerability these resources face as a result of climate change.

The National Water, Sanitation and Climate Outlook focuses on key areas of concern based on the following themes:

- Water governance
- Security of water supply
- Sanitation and human health
- Environment
- Resilience to climate variability and to climate change

1.1 Development of the Outlook

The National Water Resources Committee (NWRC) was the key player in the Outlook development. The contents of the Outlook result from information drawn from recent literature and a consultation process undertaken with water and sanitation stakeholders within Tonga, either individually or through a stakeholder workshop. The list of consulted stakeholders is available in Annex 1. This integrated approach aims to ensure snapshots of the situation from all sides are captured, and to present the situation without bias. The development of the Outlook was supported by an outlook facilitator from SOPAC being present in Tonga for a 3 month period.

1.2 How to use the Outlook

The National Water, Sanitation and Climate Outlook is a document that can be used to inform communities and report at a community and national level against strategic targets for water, sanitation

and climate. It can also be used at a higher level, displaying priority areas to the Government of Tonga, international agencies, implementing partners and international donors. By being a repository of national water knowledge, the Outlook enables a foundation for long term, efficient planning, and is the first step for improving coordination between agencies within the water and sanitation sector. Due to the short time frame for the development of the Outlook, it should be seen as the "tip of the iceberg" and the starting point of integrated water resources management within Tonga for the future.

2 Background information to Tonga

2.1 Geographical setting

The Kingdom of Tonga is located in the Central South Pacific and lies between 15° and 23°30' South and 173° and 177° West (see Figure 1).

Tonga has a combined land and sea area of 720,000km^2. It is an archipelago of 172 named islands with a land area of 747km^2, of which 36 islands are inhabited with an area of 649km^2. The total surface of Tonga equals to about 0.7 x 106 km^2 of which only 747 km^2 is land area. Tonga stretches over 1000 km from the northernmost island of Niuafo'ou to the southernmost point of Tonga, the Minerva Reef.

Tonga consists of four groups of islands: Tongatapu (260km^2) and 'Eua (87km^2) in the south, Ha'apai (109km^2) in the centre, Vava'u (121km^2) in the north, and Niuafo'ou and Niuatoputapu (72km^2) in the far north. Nuku'alofa, the capital, is situated in Tongatapu, the largest island.

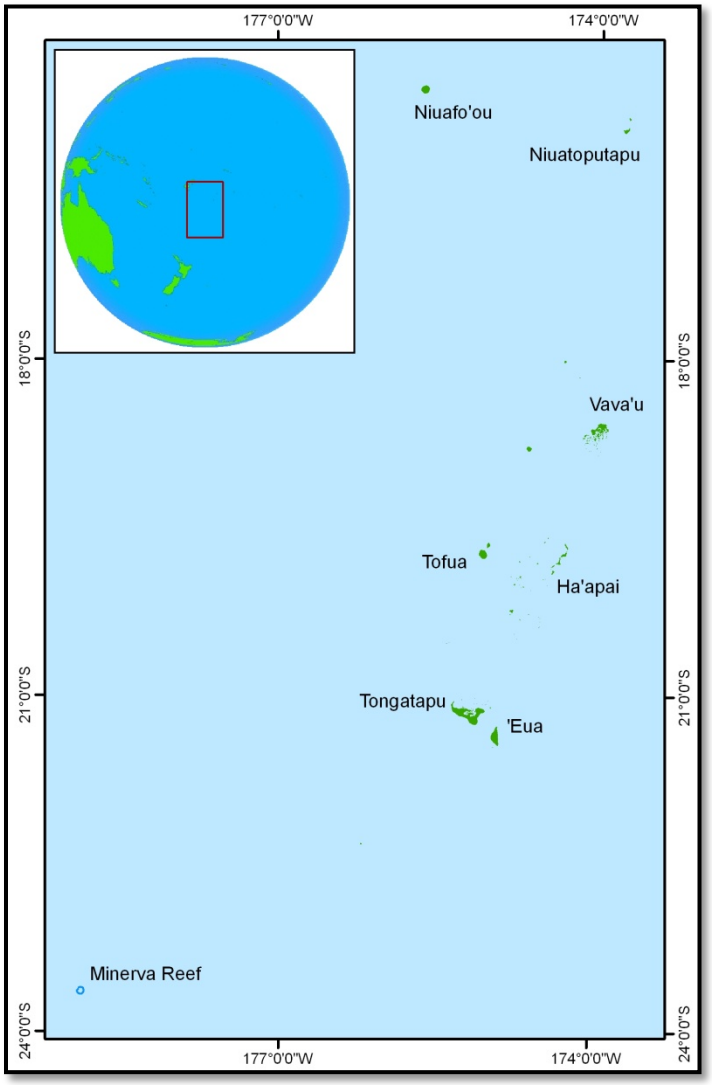

Figure 1: Location map of Tonga. (MLSNR data)

2.2 Climate

Tonga has a semi-tropical climate with moderate rainfall and high relative humidity. A seasonal trend is noticed with a relatively wet, hot season extending from November to April and a relatively dry, warm season from May to October. On average, approximately two thirds of the annual rainfall falls during the wet season. 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 Niño-Southern Oscillation) and Tropical Cyclones: ENSO causes prolonged drought whereas tropical cyclones can result in unusually wet years (Crennan and Mafi, 2007).

Daily mean temperatures vary in Tongatapu between 24.8°C in August to 29.9°C in February; in Niuatoputapu, mean temperatures vary between 22.6°C in August to 24.6°C in February (TMS data). 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 (Crennan and Mafi, 2007).

Cyclones periodically affect the islands of Tonga, the last major one being Cyclone Wilma in March early 2011. Considerable damage to property and crops was sustained during the passage of Wilma, particularly on the Ha'apai group of islands. It has been estimated that southern Tonga is hit by an average of 1.3 cyclones per year, since 1969 (van der Velde, 2006). Tropical cyclones may occur all year around, but they are principally confined to the wet season from November to April. During El Niño 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 (Crennan and Mafi, 2007).

2.3 Geological setting

Tonga's archipelago is situated on the Tonga-Kermadec Ridge, an active fore-arc, to the east of the Lau Basin and to the west of the Tonga Trench, a deep sea trench (10,882m below sea level) which separates two tectonic plates, the Indo-Australian Plate from the Pacific Plate (Figure 2). The ridge is formed by the subduction of the western edge of the Pacific Plate under the eastern edge of the Indo-Australian Plate.

Located within the island group and approximately parallel with and to the west of the Tonga trench is a smaller scale depression (1,800m below sea level) called the Tofua Trough. The islands to the west of the trough are of volcanic origin and some are still active with more than 35 recorded eruptions in the last 200 years (Falkland, 1992). The islands to the east of the trough are generally low-lying coral limestone islands built from reef deposits deposited at times when sea level was on Tertiary to recent volcanic sediments and are older than the western islands. These eastern islands include Tongatapu and the Ha'apai and Vava'u groups of islands.

2.4 Hydrogeological setting

There are almost no surface water catchments in Tonga (except for some streams in 'Eua and lakes in Vava'u, Nomuka, Niuafo'ou, and Tofua). 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,

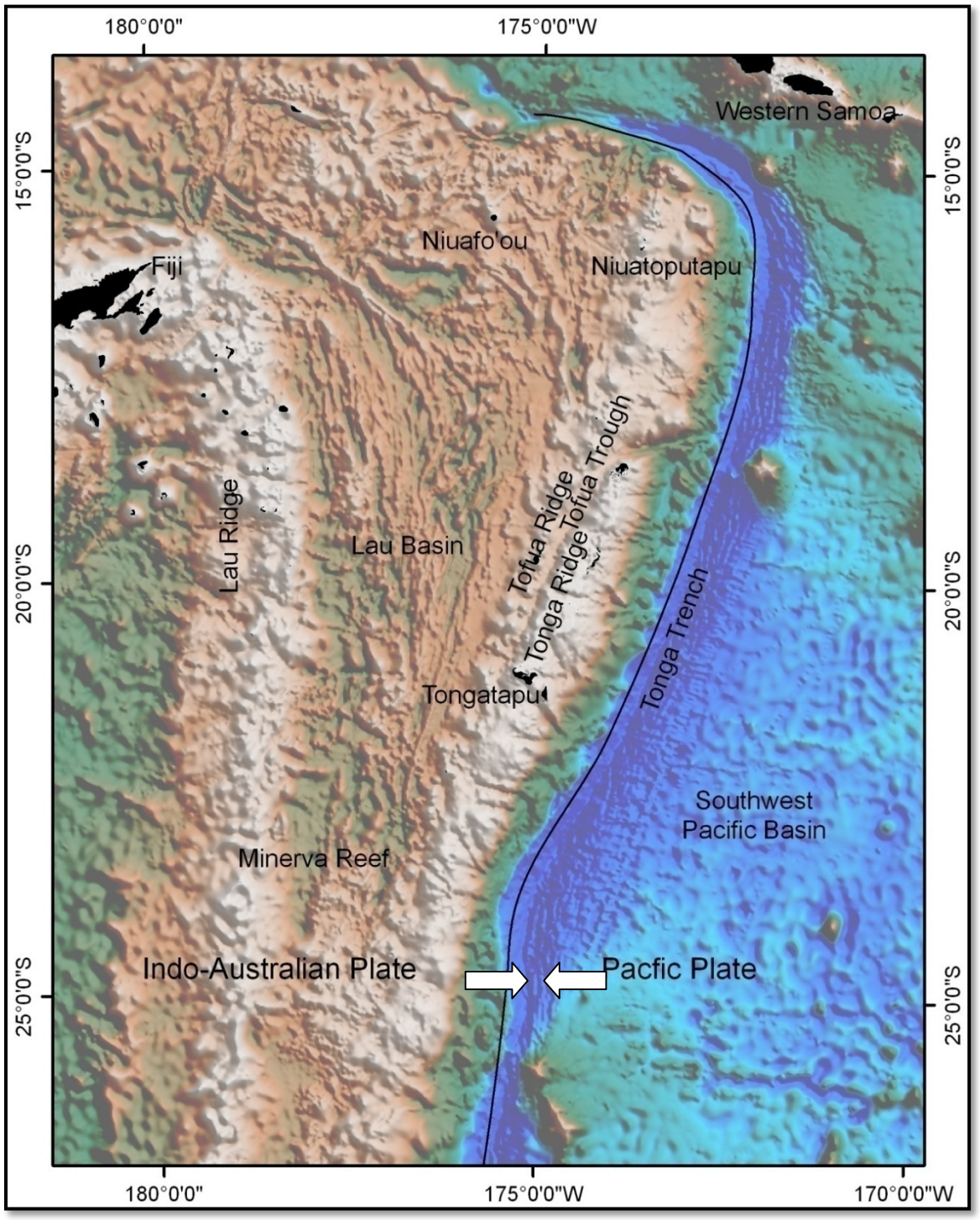

Figure 2: Seafloor map of the region showing significant tectonic features. The black line represents the approximate location of the convergence zone between the Indo-Australian Plate and the Pacific Plate. The dark blue colour represents deep sea areas, up to 10km deep, the lighter brown areas are shallow sea areas, and land areas shown by the black shapes. (Digital Elevation Map produced by FrOG Tech, 2010[1])

[1] www.frogtech.com.au

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 being fresh to being seawater over a number of meters.

The upper surface of a freshwater lens is the water table. The thickness of freshwater and transition zones are dependent on many factors but the most important are:

- Rainfall amount and distribution
- Amount and nature of surface vegetation and the nature and distribution of soils (influencing evapotranspiration)
- Size of the island, particularly the width from sea to lagoon
- Permeability and porosity of the geological formation, and the presence of cave systems and solution cavities
- Tidal range
- Methods of extraction and quantity of water extracted by pumping (Falkland, 1992).

Within Tongatapu, the freshwater is stored in the coral limestone layer, whereas many of the low lying islands of Ha'apai, for example, have shallow sandy aquifers. The thickness of the freshwater lens at Mataki'eua, Tongatapu is about 12m thick whereas in the low lying island of Kotu, Ha'apai, where the freshwater is in a shallow sandy aquifer, it is less than a meter thick (MLSNR data).

2.5 Soil

Most of the islands of Tonga have a soil layer overlying coral limestone. The soils are mainly derived from andesitic tephra (volcanic ash) (Roy, 1997; Falkland, 1992). Other soils including coral sands and lagoonal sands and clayey-muds are also found.

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 (Falkland, 1992). 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 (Falkland, 1992). 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 (Falkland, 1992).

From a water resources viewpoint, the factors which are important with soils are the rate of infiltration, the thickness and the moisture contents at both field capacity and wilting point (Falkland, 1992).

2.6 Demographics

According to the 2006 Census (Department of Statistics, 2006, from herein referred to as "2006 Census"), Tonga's population was 101,991 distributed amongst 17,529 households, with 49.24% females and 50.76% males. 23.20% of the population resided in urban areas, whereas 76.80% resided in rural areas. Tongatapu has the highest population (72045 people) and the highest population density (263 people per km^2), with 71% of the total population. The remaining island groups contain 15% (Vava'u), 7% (Ha'apai), 5% ('Eua), and 2% (Niuas) (Figure 3).

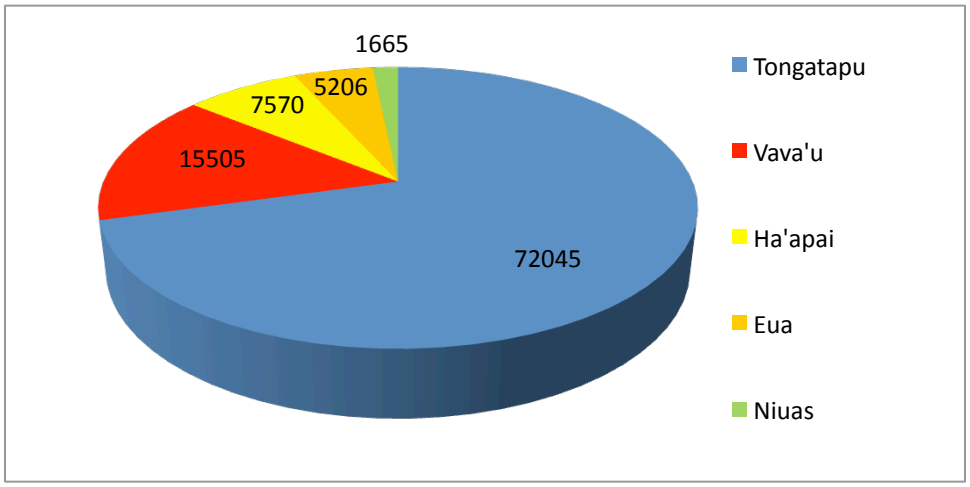

Figure 3: Total population by divisions, Tonga. (2006 Census)

The rate of net population growth in Tonga has reduced in the last few decades, most likely due to citizens emigrating overseas (Figure 4). It is estimated about 100,000 Tongans live overseas (van der Velde, 2006). Nevertheless, the increase in population has an unavoidable and substantial pressure on natural resources, in particular water. Urban population growth rates in Tonga for the period 2005-2010 were 1.1% - significantly higher than the continents of South America (0.5%) and Central America (0.6%), and above the densely populated nations of India (0.9%) and Brazil (0.5%) for the same period (UNDESA, 2007).

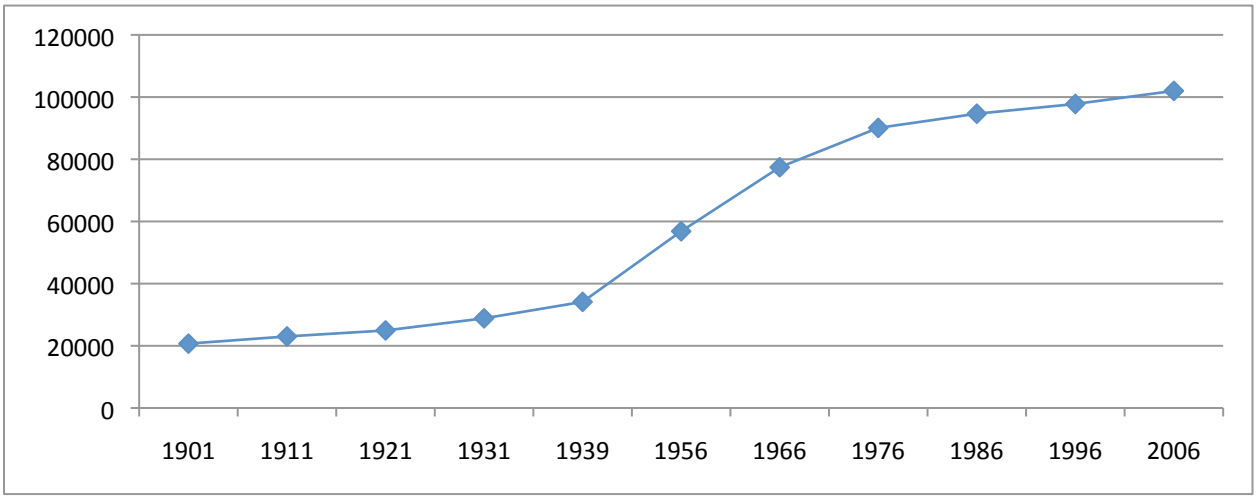

Figure 4: Net population growth, Tonga. (Statistics Department, 2006[2])

2.7 Economy and economic development

Tonga's economy, as a small island developing state, has been typically structured around a large public sector with dependence on remittances, and foreign aid. Imports are larger than exports which results in a strongly negative trade balance (van der Velde, 2006, and references therein). Exports are equivalent to about 20% of total imports and are mainly of agricultural products. Squash, coconuts, bananas, and

[2] Viewed online July 2011, http://www.spc.int/prism/Country/TO/stats/

vanilla beans are the main crops, and agricultural exports make up two-thirds of total exports. The country must import a high proportion of its food, mainly from New Zealand. The country remains dependent on external aid and remittances from Tongan communities overseas to offset its trade deficit. Remittances accounted for, and financed about 50 to 60% of total imports over the 1994-2002 period (van der Velde, 2006). Remittances are an integral part of Tonga's economy.

Tourism is the second-largest source of hard currency earnings following remittances; fisheries and industry are also growing sectors. The number of visitors arriving in Tonga is increasing each year at a rate of 9.14% (between 2001-2010) (Figure 5) and is contributing a significant portion to the GDP (Ministry of Tourism, 2011). The government is emphasizing the development of the private sector, especially the encouragement of investment, and is committing increased funds for health and education. Tonga has a reasonably sound basic infrastructure and well-developed social services. High unemployment among the young, a continuing upturn in inflation, and rising civil service expenditures are some of the issues facing the government.

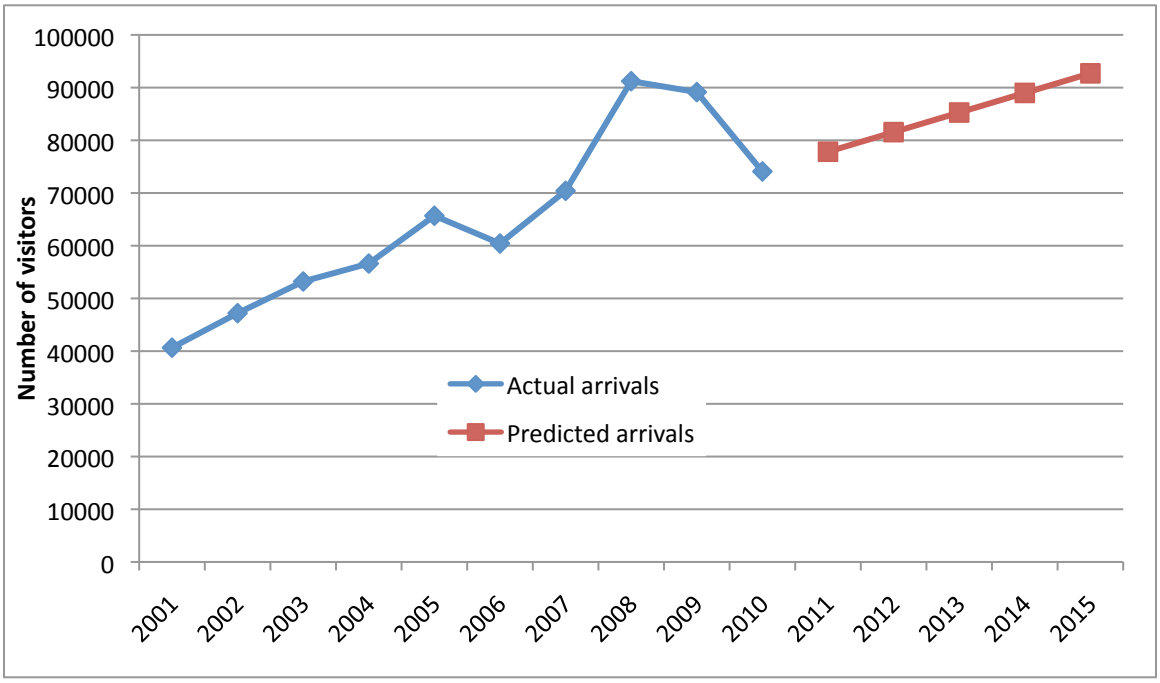

Figure 5: Tourism growth: numbers of tourists arriving in Tonga. (Tonga Visitors Bureau, 2011)

The Initial National Communication (GoT, 2005) reports Tonga's economy grew at the average annual rate of 1.8% during the period 1973-1995, with per capita growth at 1.2%. Remittances and government spending were engines for growth. 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 -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 were regularly paid in cash.

According to data available on the Statistics Department website[3], in the past decade, constant price GDP grew at about 0.5% (Figure 6). The primary sector, which makes up about 20% of the GDP, grew at 0.02% (constant prices), and consists of agriculture, forestry and fisheries. The secondary sector, which also makes up about 20% of the GDP, grew at 0.5% (constant prices), and consists of manufacturing, construction, electrical and water supply, and quarrying. The tertiary sector, which makes up about 60% of the GDP, grew at 1.0% (constant prices), and consists of services such as public administration and services, trade, finance, transport and storage, hotels, education, for example.

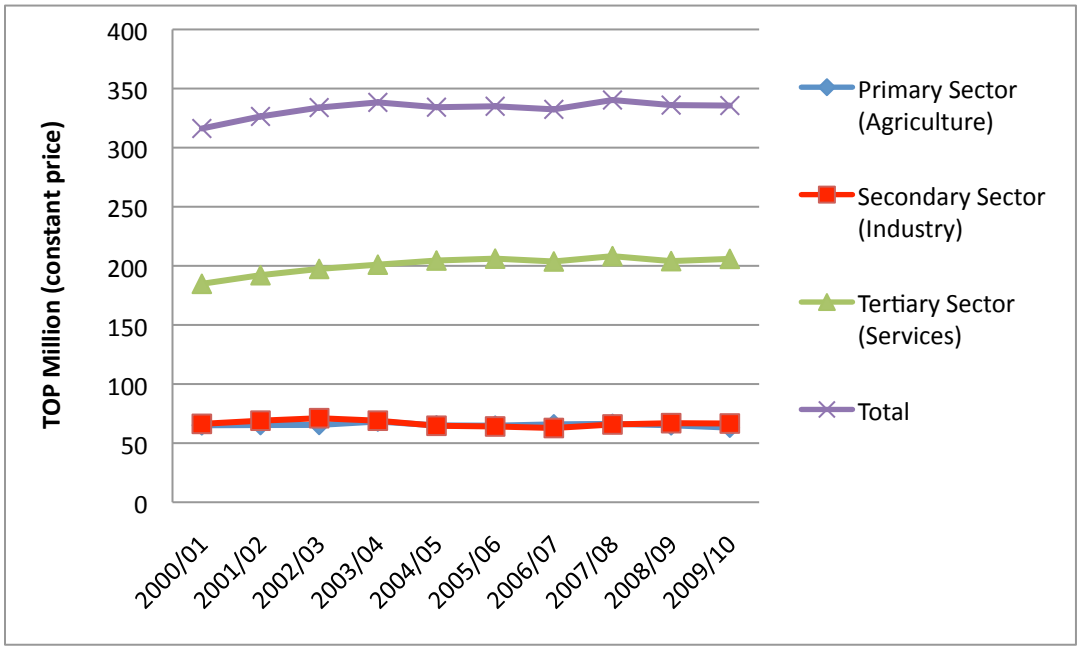

Figure 6: Economic growth. (Statistics Department Data, 2011)

2.8 Political setting

Tonga operates as a constitutional Monarchy. The Tongan constitution of 1875 remains in use and was federated by George Tupou the 1st. The head of State is the Tongan monarch, currently King George Tupou the 5th, who was crowned in 2008. The Monarch oversees the three arms of the executive: the Cabinet - as appointed by the Monarch, The Privy Council which includes all members of Cabinet and The Monarch, and the Legislative Assembly (Fale Alea).

The Legal system applies Acts of the Tongan Legislative Assembly and recognizes the application of Common Law. Magistrates Courts preside over district matters, with The Supreme Court and the Court of Appeal (Privy Council with the Chief Justice of the Supreme Court). Bills are placed in the Legislative Assembly, and are subject to approval from the Privy Council before they are gazetted.

Under the constitution, the King has the power to make treaties, veto legislation, and dissolve the Legislative Assembly. The King also has the authority to appoint the Speaker of the Legislative Assembly,

[3] http://www.spc.int/prism/country/to/stats/

Supreme Court Justices, Court of Appeal Judges, Cabinet ministers and the Governors of Ha'apai and Vava'u.

Tongan Citizens over age 21 can vote, with Federal and local elections taking place every 3 years. Voting is not compulsory, and citizens must register with their province in order to vote.

November 25, 2010 saw a significant change to structure of the Legislative Assembly – for the first time the majority of seats (17 of a total of 30 seats) in the Legislative Assembly were people's representatives. The current breakdown is nine seats for nobles (selected by the country's 33 nobles), seventeen elected by popular vote based on their constituency. The King may administer up to 4 additional seats, traditionally given to previous serving members of Cabinet, although these powers have not been invoked in the 2011 Government.

There is no Party system in Tonga, but notably 12 of the 17 people's representatives were from the Friendly Islands Democracy Party. Five popularly elected MPs joined with the nine nobles to elect a noble, Lord Tu'ivakano, as prime minister. No women were elected to the new Parliament in November. A woman may become queen, but the constitution forbids a woman to inherit hereditary noble titles or become a chief.

Tonga has a centralised governance structure and does not operate sub-national government. All financial accountabilities reside with the Ministry of Finance and national planning. Local government is administered by the Town or District Officer, who is paid a retainer from the Government based on the populations that they serve. The structure and reporting processes for Town Officers is not formal, although they are obliged to report regularly to the Prime Minister. The methods employed vary widely between districts; some have established informal counsels and advisories, which draw on community groups, including women's handicraft organizations. All Town Officers are male.

The Tonga Strategic Development Framework (TSDF), as administered by the Ministry of Finance and National Planning, is the central reporting mechanism utilized by the Legislative Assembly. It has outlined a significant change in the governance structures for the outer islands through the establishment of village districts and councils with the objective to give communities a greater say in local and regional development. At the present time, including matters of significance to communities within the TSDF is the primary way to administer national funding to the sub-national governance district.

2.9 Society and gender roles

Tongan society continues to be grounded in the core values of Fe'apa'apa'aki (mutual respect), Feveitokai'aki (sharing, cooperating and fulfillment of mutual obligations), Lototo (humility and generosity) and Tauhi vaha'a (loyalty and commitment). The traditional structure is strongly hierarchical, with different languages and obligations for those in the Monarch, the Noble class, and the Common class. Obligations to family and Church continue to be the primary motivators of many aspects of daily life for the majority of Tongans, although Western influence, changes in migration and increased financial hardship are having a significant impact on lifestyle.

The subsistence economy exacerbates the importance of land security as Tonga is becoming increasingly urbanised. Male citizens of Tonga are entitled to own land; the eldest son in a family is provided with the hereditary estate, other male members of the family may apply for allotments (both in the bush and in the town) and finally there are complicated leasehold arrangements, usually coordinated between private parties. Women do not have the same privileges as men to own land, which has implications for accessing loans and the requirement to make alternative leasing arrangements in order to establish stability of their land.

The structure of society in Tonga is predominantly patriarchal, with men across all areas of society in key decision making positions. Since 1951, when women were permitted to become Members of Parliament, only 4 women have been elected, and only 3 women have been delegated as Ministers of the Public Service. Women are well represented in private industry, although the Chamber of Commerce reports that they have faced significant adversary in establishing their practice.

Families are traditionally administered by the Fahu, who is the paternal Aunt. She has obligation to distribute the family assets and has a specific role to play in family events. Traditionally, men in the family are to fulfill their paternal duties by providing for their sisters and aunts. However modern families are changing these traditional roles. In some families men perform the role of Fahu, traditional gifts are being replaced with cash, and family life is becoming more nuclear in light of economic pressures. Within the family, women are generally expected to perform household duties and are often more active contributors to their Church.

3 Water governance

3.1 Current status/situation

3.1.1 Management, monitoring activities and responsibilities

Water resources and sanitation in Tonga are currently managed by a number of government and non-government agencies. Some have specific and some have general monitoring responsibilities as follows.

National Water Resources Committee (NWRC)

The NWRC was endorsed by Cabinet in 2009 and will be legally endorsed by the Water Resources Bill 2011 when it is passed. The functions of the Committee are to promote the effective and sustainable management of the water resources including:

- Advising the government of any issues relating to quality and quantity of water resource
- Promoting coordination between stakeholders
- Ensuring that effective water resource monitoring occurs
- Promoting dissemination of information about the water resources
- Providing guidance to the Minister on such issues as recommending water source protection zones, and any other issues
- Approving management plans for water source protection zones
- Arranging preparation, confirmation and implementation of the Tonga Water Management Plan
- Identifying and endorsing projects to protect and sustain the water resource.

The members of the Committee are currently mostly all government representatives, with no non-government or private stakeholders apart from the Director of TWB. There has been recent talk by the committee and other stakeholders for the need to rectify this situation. Prior to the NWRC, there was a national water committee established within the Central Planning Division, however, the current NWRC members are not very familiar with the work that was done by this committee.

Geology Unit, Ministry of Lands, Survey and Natural Resources (MLSNR)

The Geology Unit is the Government's designated section for monitoring and managing the Kingdom's groundwater resources, however, at present there is no legal basis for this role. It is responsible for quarterly monitoring of salinity, pH, temperature, and water table elevations across Tonga. It also has facilities to do basic nutrient testing. The Geology Unit also carries out monthly monitoring of 7 salinity monitoring bores (SMBs) in and around the Mataki'eua well field for thickness of the freshwater lens. Currently, with no operational budget, monitoring efforts have been focused on Tongatapu and other islands only when external funding is available. There is currently no formal requirement to report to the Government with results. The Geology Unit also provides advice on permission to drill bores and location of bores when requested.

Ministry of Health (MoH)

In line with the Public Health Act 1992, the Public Health Section of the Environmental Health Division, MoH, is responsible for supervising overall operation of rural water supply systems and for monitoring and surveillance of biological quality of public water supply schemes. The Public Health Section has also

the responsibility of inspecting dwellings for the quality of sanitation facilities and providing advice to homeowners. Water samples are collected by Health Inspectors monthly from each village in Tongatapu and are tested for faecal coliforms within the Ministry's laboratory located at Vaiola Hospital. If faecal coliforms are present in a village well water sample, the Public Health Section will deploy chlorine into the reservoir and then retest the result at a later date. MoH has a legal basis to order the closure of wells that are habitually contaminated. Due to budgetary constraints village water supply schemes are rarely tested outside of Tongatapu. The Public Health Act 1992 dictates that MoH is responsible for routine sampling of supplied water for physical, chemical, biological and radio-active content but, due to budgetary constraints, samples are only tested for faecal coliform indicators.

Tonga Water Board (TWB)

The privately owned Tonga Water Board regulates and controls the supply of water to the four urban areas of Tonga, those being, Nukualofa in Tongatapu, Pangai in Ha'apai, Neiafu in Vava'u and fourteen villages on 'Eua Island. The urban population represents about a third of the total population of Tonga. Supply is metered and billed at each household within the urban areas. TWB monitors pH and salinity of their production wells. Tests of faecal coliforms and chlorine residual levels in the Nuku'alofa distribution area are also performed by TWB in its laboratory in Nuku'alofa. Calibration of equipment is not performed regularly. TWB owns a portable desalination plant for the purpose of supplying a small population (1500 people) with 12L of freshwater per person per day after a disaster event; to date, the equipment has never been used and it is likely the staff may no longer know how to operate it (TWB, personal communication, 2010).

Tonga Meteorological Service (TMS), Ministry of Transport

TMS is responsible for operating and maintaining weather/climate stations in all island groups of Tonga, and collects data on daily rainfall, temperature and cyclones.

Ministry of Agriculture, Food, Forestry and Fisheries (MAFFF)

MAFFF monitor water usage for irrigation and farm usage and supervises use and import of fertilizers and pesticides (MAFFF, personal communication, 2011). However, there are no facilities for monitoring groundwater contamination (White et al., 2009).

Waste Authority

The Waste Authority is responsible for the management of solid waste in Tonga. The Tapuhia Waste Management Facility, located on Tongatapu near Vaini, is the main official rubbish dumping area. There are also facilities here for wastewater treatment, including dumping of sludge from septic tanks. There are facilities here to monitor groundwater to ensure that pollution from the waste is not entering the groundwater, however, monitoring at this site is not being currently performed.

Ministry of Works (MoW)

MoW used to operate a drilling rig for installation of water bores; however, this is now defunct. The only drill rigs in the country are privately operated. MoW is currently hosting phase 1 of the ADB funded Tonga Integrated Urban Sector Development Project (run via SMEC through MoW), which involves

monthly water testing (physical, chemical and biological) of the groundwater around Nuku'alofa and the Fanga'uta Lagoon.

Ministry of Environment and Climate Change (MECC)

The Ministry of Environment and Climate Change is a young Ministry (established in 2009). Previously, Environment was under the Ministry of Lands, Survey, Natural Resources and Environment. The Environment section provides Environmental Impact Assessments when requested and is also involved with assessing Fanga'uta Lagoon water quality and biodiversity impacts, although with minimal operational budget most of this work only happens when project funding is available. A National Monitoring Team was established in 2001 and led by the Environment section with the purpose of assessing the quality of the environment of Tonga, budgetary constraints, again, however, limit the functionality of this team. Environment has also been involved, in the past, in testing sea water, lagoon water, sediments, and bivalves for pesticides and POPs, but at approximately TOP$1000 a sample, this is not a regular activity (MECC, Personal communication, 2011). The Climate Change section receives significant funding from donors and, with respect to water, is currently involved in undertaking a vulnerability assessment focused on the Hihifo area, on the west coast of Tongatapu. MECC has also been involved with drafting a Water Policy that mainstreams climate change into water management legislation; at the time of writing the draft had not yet been submitted to Cabinet.

Aid Management Division, Ministry of Finance and National Planning (MoFNP)

The Aid Management Division is responsible for seeking and coordinating funding through the GoT from development partners on all aid projects, including water and sanitation projects.

Ministry of Tourism

The Ministry of Tourism is responsible for managing the fastest growing sector in Tonga; and the sector is also one of the largest users of water due to the many requirements washing, cooking and cleaning at resorts and hotels.

Village Water Committees (VWCs)

Each village outside of the urban areas has a Village Water Committee, which consists of 10 elected members and the Town Officer. The Committees are responsible for coordinating the village water scheme and to carry out all the necessary work to provide water for the use of the village. The Committee decides on the cost of water per month that each household must pay; usually this is a flat rate of about TOP$10 per month unless the village has installed meters at all households, whereby they are charged per amount used (Vaini Water Committee representative, personal communication, 2011). The Prime Minister is scheduled to meet with town officers and district officers from all villages in Tongatapu once a month in a meeting as a forum for where relevant issues can be reported.

Langafonua and Village Women's Groups

Langafonua is an NGO involved with coordinating village woman's groups and providing awareness and training in many subjects, including water and sanitation. Langafonua also runs village inspections working with the village women's groups whereby every house (in Tongatapu) is inspected for cleanliness, garden beauty, pig enclosures, surrounding waste, waste disposal methods, and whether

the village has done any work to improve the cleanliness and beauty of the village as a whole. Water and sanitation facilities used to be inspected but this has been removed from the inspection criteria due to lack of funding. Incidentally, Hauoli Vi (Secretary General of Langafonua) reported that over the last decade or so the cleanliness and friendliness of the communities has significantly declined and the attitude towards the inspections by home owners has also deteriorated.

NGOs

NGOs such as TANGO, Tonga Trust, and 'Aloua Ma'a Tonga Association are involved in coordinating and facilitating community groups and seeking funds and implementing water and sanitation related projects, such as sustainable rainwater harvesting projects and community awareness programs. Tonga Trust has also been involved with performing faecal coliform tests on rainwater tanks throughout the Kingdom.

Private Organisations

Waste Management Ltd, for example, is a privately owned and operated company that provides waste management services such as septic tank pumping and solid waste collection and disposal at a cost to the client.

SOPAC

SOPAC, under SREP, is the regional agency mandated to coordinate water and sanitation in the Pacific, and provides support to its member countries through three components: Water Resources Management; Water and Sanitation Services; and Water Governance. SOPAC has been involved with several water and sanitation projects within Tonga in the past and present, including the HYCOS, GEF-IWRM, and WASH projects which provide funding for activities as well as capacity building for local staff.

Donors

JICA, AusAID, GEF, ADB, for example, provide funding for projects focussing often on water resources and climate change adaptation strategies, and rainwater tanks or village well upgrades for communities.

Householders

Householders are responsible for the supply and cleanliness of their own rainwater tanks and catchments, as well as connections to the reticulated supply. They are also responsible for providing and maintaining suitable sanitation and greywater disposal facilities on their own land.

3.1.2 Legal framework

There are currently several legislative Acts that deal with water and sanitation in Tonga: Tonga Water Board Act 2000, Water Supply Regulations 1963, Health Services Act 1991, Public Health Act 1992, Aquaculture Management Act 2003, and Waste Management Act 2005. At the time of writing, the Water Resources Bill 2011 was being considered by Parliament and not yet passed as an Act. Following are summaries of each piece of legislation, where relevant to water and or sanitation. Each piece of legislation can be accessed at: http://legislation.to

Water Supply Regulations 1963

The Water Supply Regulations 1963 details the requirement and responsibilities of Village Water Committees to assist the village water scheme and to carry out all the necessary work to provide water for the use of the village. The Committee must contain 10 elected members and the Town Officer, and a Water Superintendent is elected from the Committee. The Regulations also describe penalties for persons who waste water within the village.

Public Health Act 1992

The Ministry of Health has clear responsibility in relation to water quality in accordance with the Public Health Act 1992. A range of matters are provided for in this regard, including routine sampling of supplied water for physical, chemical, biological and radio-active content. However, the Act does not specify the water quality standards that are to be applied and does not deal with the publication of test results. The Ministry of Health retains this responsibility for supply water in rural areas, not covered by TWB. MoH has the duty to determine which sources of water in Tonga are suitable for public supply. The Act also includes waste management, citing no person is allowed to dispose of waste in any road, vacant land, foreshore, waterway, well or sea. The Act also refers to sanitation, citing every owner of premises shall provide suitable sanitary facilities and no pit latrine shall be constructed within 30m of any public or domestic water supply.

Tonga Water Board Act 2000

The Tonga Water Board Act 2000 continues to recognise the TWB as the body corporate to control water supplies. Under this Act, a Board of Directors is established and shall be deemed to hold office and responsibility for provision of water supply services for domestic, stock, horticultural, industrial, commercial, recreational, environmental and other beneficial uses in any area it may be appointed to do so under the Act. In this context, water supplies in the four main urban areas of Tonga are a mandate of the TWB. The Act does not state the discretion of the Board on rural area water resources.

Marine Pollution Prevention Act 2002

This Act details legislation relating to pollution of marine waters (including discharge of ballast water, dumping of pollutants and oil spills), the response required and liabilities for pollution damage.

Aquaculture Management Act 2003

The Aquaculture Management Act 2003 details the responsibility of Ministry of Fisheries with respect to aquaculture areas within the marine zone. Notice must be given of an intention to use chemicals, pesticides, pharmaceuticals and bio-remediation products, and such substances may be restricted or prohibited (Powell, 2006). The Minister with the consent of Cabinet may make regulations, including measures to be taken to minimize the escape of water and the pollution of land and water (Powell, 2006).

Environmental Impact Assessment Act 2003

This Act provides a framework for development planning which aims to prevent the making of arbitrary decisions with regard to land, marine, coastal areas and resources use.

Waste Management Act 2005

This Act regulates the collection and disposal of solid wastes and concerns the management of all wastes in the Kingdom. According to the Act, the Waste Authority is the approved authority for waste management in Tongatapu, whereas MoH is the authority for all other areas until an approved authority exists in those locations. The Authority is to promote recycling of waste, and the Act also contains details regarding offences for illegal dumping of waste and management of toxic waste.

Environment Management Act 2010

This Act details the roles, responsibilities and powers of the Ministry of Environment and Climate Change with respect to monitoring and protecting the environment, including water resources, of Tonga.

Environmental Impact Regulations 2010

These regulations detail the procedures for Environmental Impact Assessment for major projects as required by the Environmental Impact Assessment Act 2003.

Hazardous Waste and Chemicals Act 2010

This Act details prohibitions related to Persistent Organic Pollutants (POPs) and other hazardous waste as well as the management of hazardous substances for the purpose of protecting the environment and people of Tonga.

Water Resources Bill 2011

This Bill makes comprehensive provision in relation to the ownership, management and regulation of water resources of the Kingdom of Tonga in order to ensure sustainable management of the water resources. The water resources of the Kingdom of Tonga are vested in the Crown, and individuals may claim ownership of water that has been legally taken and stored by them. Management of the water resource is a responsibility of the MLSNR (Geology Unit). The Ministry may grant rights to take and use water from aquifers, lakes, streams and springs, and persons who take water must have a license to do so. Environmental and health standards applying to the water resource may be imposed by the Ministry of Environment and Climate Change and Ministry of Health. The Bill also details the establishment of the NWRC, Chaired by MLSNR.

Section 7 of the Bill provides for the functions of the MLSNR:

- the sustainable management of the water resource through coordinated and scientifically sound planning of water resource development and regulated water utilisation for all lawful purposes;
- the avoidance of overdrafts of available water supplies through the establishment of an inventory of water resources and the effective monitoring of water levels;
- the improvement of the chemical, physical and biological integrity of the water resource by -
- regular monitoring of water quality;
- promoting coordination amongst all agencies of government having roles and functions associated with the testing and monitoring of water quality and supply;
- recording the results of monitoring and maintaining records of other matters associated with the management of the water resource; and

- the control of pollutant discharges; and
- the proper assessment of the impacts of proposed developments on the water resource, and the implementation of effective urban and rural planning regimes that take account of water supply and water quality issues.

The Water Resource Bill will also legally establish the NWRC as the advisory body to Government on water issues (quantity, quality, monitoring of water resources, dissemination of information on water resources to both government and communities etc). The Bill also requires the NWRC to facilitate the development of the Tonga Water Management Plan, which would address a wide range of management issues and practices applying to the water resource.

3.1.3 Financial Aspects

Within government, there is currently no specific allocated operational budget for monitoring, maintaining, upgrading, or investigating the status of water and sanitation within Tonga, even though many of the departments are legally required to do so (refer to section 3.1.1). Funding, at present, must come through donor funded projects.

Some of the Village Water Committees manage their water supply schemes in a way that enables them to collect a profit which is subsequently used for maintenance of the systems; however, many villages do not collect a profit or even enough money to pay for fuel that would enable continuous supply of water and so pumps that break down are often not able to be fixed and villages can be without pumped water for a substantial amount of time (Village Water Committee members (Vaini and Nomuka, for example), personal communications, 2010-2011). Villages can apply to the Aid Management Division of MoFNP to request a donor funded project for upgrades of their groundwater well, reticulated system or rainwater catchments, for example. However, according to the Acting Deputy Secretary of Aid Management Division (personal communication, 2011), for example, out of 30-40 funding requests per year only 6 are accepted due to limited funds.

Out of a total of 57 projects recorded by Aid Management Division, MOFNP, since 2008, 6 have been sanitation related projects and 22 have been water supply related projects. A total budget of $96,782,056 was allocated by donors for aid projects, and $4,199,746 (4.3% of total budget) was allocated to water and sanitation projects. The water and sanitation projects are relatively evenly distributed across the island groups (Figure 7). The projects are chosen, by MOFNP, on a needs basis, by amount of people that will benefit from the project (MoFNP, personal communication, 2011). Water and sanitation projects documented in the Aid Management database involve upgrading of village water supplies (which might include purchasing of a new water pump, upgrading pipelines etc), supply of rainwater catchment tanks to a number of houses within the villages, or upgrading toilet facilities at schools or other public areas.

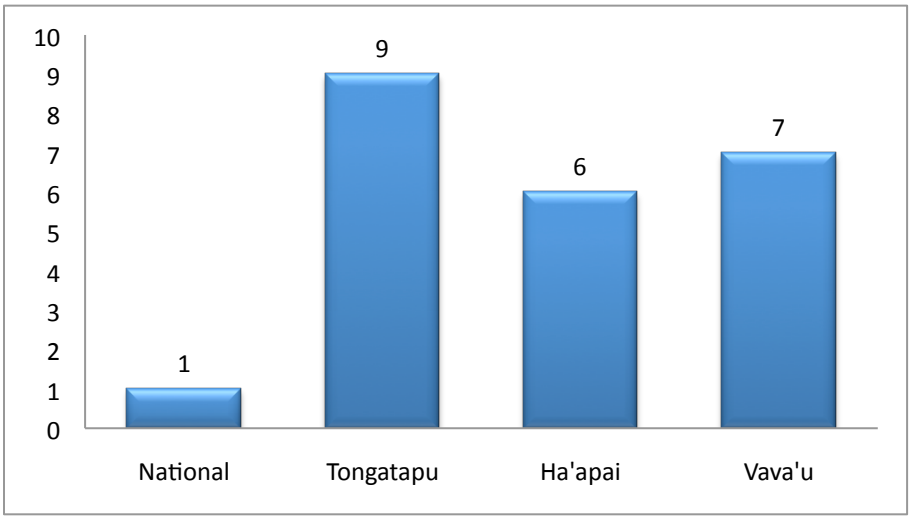

Figure 7: Number of water/sanitation aid projects managed by Aid Management Division, MOFNP, since 2008. (Aid Management Division, MOFNP Data)

In line with the Millennium Development Goals (MDGs), water is now briefly mentioned and clearly stated within the 2010 Government's Tonga Strategic Development Framework (TSDF) which is updated whenever there is a change in government or sporadically at other times) as a focus. The Government has identified as a part of one of its primary outcomes, to maintain and expand access to safe water, sanitation for all communities. The TSDF also states that the Government of Tonga takes seriously the responsibility of preserving for future generations the economic opportunities and environmental resources that we enjoy today, which includes water resources. The TSDF also states there is a need for exploring the environmental, economic and societal consequences of changes in the availability of freshwater and other resources. The TSDF identifies the following targets:

- Installation of sewage treatment plant for the Nuku'alofa region
- Increase accessibility for water and sanitation for the outer islands and improve the water quality in Tongatapu (treat)
- Proportion of total water resources used-maintain 2.2% (In line with the MDG 7)
- Proportion of population using an improved drinking water source- maintain between 98% - 100% (In line with the MDG 7)
- Proportion of population using an improved sanitation facility-maintain between 98%-100% ((In line with the MDG 7)

Work still needs to be done in order to increase the profile of IWRM activities within the Government's agenda in order to have a budget allocated.

3.2 Trends

The stakeholder opinion of trends regarding water governance is that it is getting more fragmented due to more occurrences of separate projects hosted by different ministries and organisations (for example, MECC, MLSNR, MoH, MoW, TWB) focusing on similar topics (for example, water resource supply and quality) and with minimal collaboration between organisations.

With respect to governance in rural settings, there is no indication of practices changing greatly as the Village Water Committees have been in operation for many decades now and that does not appear to be changing overall. Some village committees, however, are more progressive than others and have developed coordinated and profitable systems that manage to provide continuous water supplies to their community.

3.3 Current issues

The following are current issues with respect to water governance that have been collated from interviews with stakeholders.

3.3.1 Lack of national legislation

There is currently no legislative piece that deals solely with water. The Water Resources Bill 2011 attempts to rectify this; however, it focuses heavily on management and, at the time of writing, was not yet passed by Parliament. If this piece of legislation is passed there will need to be a significant increase in capacity in order to implement and enforce it.

3.3.2 Lack of enforcement of existing legislations

The existing legislations (as detailed in section 3.1.2) are often not enforced. For example, although it is stated in the Public Health Act 1992 that it is not permitted to dump waste along a road or vacant land this practice is widely performed and rarely punished; and it is also required to seek permission from the GoT before a private well is installed, this is not always conducted or enforced. This is the case for many laws in Tonga: the laws exist, but they are not often enforced. The main reason cited for this occurring is a lack of funding and human resources required to bring about enforcement as well as political pressures (for example, EIA's may not be done prior to the start of a project as required because there are pressures to get the project started (Stakeholder, personal communication, 2011)). It is also an issue that there is a lack of regulations that would enact the existing legislations and an alleged lack of understanding of the existing legislations within the relevant agencies.

3.3.3 Lack of water quality standards

There are no drinking water standards within Tonga or water quality standards for any other use (Kingston, 2004; Mitri and Davies, 2005). The Public Health Act 1992 states the MoH's responsibility to carry out routine water quality tests and issue potable water certificates, but no regulation exists regarding what is defined as potable water or good water quality. This leads to confusion for the decision makers as to what is good quality and safe water and what is not.

3.3.4 Lack of institutional coordination

Water and sanitation stakeholders reported prior to this project that they have never had the opportunity to meet and discuss water and sanitation issues in Tonga as a group. Coordination between Ministries, sections, and NGOs, etc, rarely happens unless they are directly involved in a project together. Information is also rarely shared between groups. This frequently leads to duplication of work and also different advice being fed to the government by different groups. The establishment of a functioning National Water Resources Committee, that includes representatives from non-government

groups, is essential to improve coordination between the agencies and increase the efficiency and drive the national focus of the water and sanitation sector.

3.3.5 Lack of reporting

There is no formal requirement of MLSNR, MoH or TWB to report to the Government or population on the status of water resources in Tonga (TWB, however, is required to report to its Board). The lack of reporting leads to an uninformed government and also to poor maintenance of databases. This also means that various agencies are not aware of the data and the overall situation of the water resource.

3.3.6 Lack of information on groundwater extraction

Due to a lack of functioning meters in both the TWB well fields and rural village wells, there is no accurate estimate on the amount of water being extracted from the underground freshwater supply. This means that the amount of water extracted could already exceed the sustainable yield of the aquifers. Without this information it is very difficult to estimate how sustainable the water resources are for the future. Meters at the domestic end of the reticulation line, currently installed in urban areas and some rural areas, are helpful for estimating leakages and losses from the wells to the houses.

3.3.7 Lack of monitoring of private wells/bores

Currently there is no agency that monitors the sustainability of private wells/bores. The Water Resources Bill 2011 states that all private wells/bores are to be licensed and regularly monitored by MLSNR, which may not be possible if an operational budget is not allocated. If an unmonitored private bore/well is extracting water at an unsustainable rate it could be damaging the underground water resources and affecting public supplies.

3.3.8 Lack of support for VWCs

Village Water Committees consist of generally untrained volunteer members who spend large amounts of their own time ensuring the security of their village water supply (Vaini VWC representative, personal communication, 2011). The village water technicians who operate the pumps and distribution systems are employed on very low wages and are mostly untrained (White et al., 2009). If the system breaks down or requires parts or complicated maintenance the VWCs are in most cases not able to fix it themselves. MoH provides some support for the systems in terms of mechanics; however, budgetary constraints restrict the effectiveness of this support (MoH, personal communication, 2011). It is often the case, especially on islands other than Tongatapu, that if the system breaks down the village will go without piped water for a long time before funding can be secured from a donor to fix the system. There is a great need for VWCs to be adequately trained and supported financially (or at least with advice on how to run the system at a profit) and educated with regards to sustainable water management.

3.3.9 Lack of controls on quarrying

Once a quarrying company is licensed there are no further controls on the quarrying (White et al., 2009). The quarrying can occur close to a water supply and will often occur below the water table, which can increase potential contamination to the groundwater and reduce the resource via evaporation (White et al., 2009).

3.3.10 Lack of institutional capacity

There is a lack of institutional capacity both in terms of number of staff dealing with water resource management (particularly in routine, non-project work) and also lack of capacity in terms of training/education of those staff. There are currently no local hydrogeologists employed in Tonga or staff with a Bachelors degree or higher employed within the Geology Unit of MLSNR, the primary water management section of the GoT. Although recent efforts have been made in up-skilling of staff in technical areas (for example, in data collection through HYCOS project, implemented by SOPAC), there is a general lack of ability to analyse and determine implications of these results, which can lead to poor decision making.

3.3.11 Lack of funding, particularly in outer islands and rural areas

Lack of funding to improve the situation of water and sanitation in Tonga was most commonly identified as one of the biggest current issue by stakeholders. Currently, approximately 60% of the entire government budget is spent on staff salaries, and within some Ministries it is over 90%, which leaves little room for operational budget (MoFNP, 2011). A lack of operational budget leads to the omission of routine, non-project related work (such as regular monitoring of water quality); this particularly affects the outer island areas where it is costly to send technical staff. The GoT has not allocated a discrete budget line for water and sanitation tasks, which further implies the current lack of recognition of the importance of these sectors. Aid projects, particularly capacity building focused projects, tend to be located in Nuku'alofa or other urban areas, due to population densities and impact within institutions (for example, the HYCOS project was focused in and around Nuku'alofa with capacity building of the Nuku'alofa MLSNR staff). That being said, MoFNP (personal communication, 2011) reports that the aid projects they manage are frequently focused in rural and also outer island areas.

3.3.12 Lack of operational resources

At present, and for some years, there has been no operational budget allocated to monitoring water resources, especially for islands other than Tongatapu. Monitoring by Geology, MLSNR, has only been possible when project funding is available to provide enough funds for transport, so data collection is sporadic. White et al. (2009) recognise that this lack of operational funding emphasises the lack of recognition by the GoT of the importance of monitoring water resources. MoH also only conducts bacteriological testing on villages within Tongatapu, not other islands, on a regular basis, and does not test for physical or chemical properties of the water, as specified in the Public Health Act 1992, due to a lack of operational resources (both financial and technical).

3.3.13 Lack of data storage standards and data archiving

Across the sector there is a severe lack of data storage standards, archiving and backups. Throughout the compilation phase of this project, many times agency representatives would quote a report or piece of data but then were not able to find a copy of it, either due to non central data storage system and people not knowing where the data is located or the data being lost (for example, from office fires, stolen hard drives, or broken computers). It is common for agencies not to have backups of data and the single piece of electronic data is often stored on personal hard drives. Hard copy reports are also commonly not archived well in agencies; staff not commonly aware where documents are located or what documents are present, and also documents often become mouldy or eaten by insects. MECC

commented that since losing a lot of their previous data they have started storing reports online in addition to external hard drives, which is a progressive step. However, there is a need for a central archive within Tonga to store all Government data (reports, monitoring results etc) or at least some training for each agency on the importance of good data management systems and archiving.

3.3.14 *Lack of long term government strategic plan for water resources/sanitation*

At present there is no long term government strategic plan with respect to water resources and sanitation which reflects the lack of recognition of the importance of these sectors. Some projects are currently in effect (for example, PACC project in MECC and the GEF-IWRM project based in MLSNR) which aim to help address this, however, again lack of coordination and support from high-up within the government and also lack of capacity within the agencies may limit the effectiveness of these tasks. Water is now mentioned in the National Strategic Planning Framework, yet water resources management is still not recognised by having a discrete budget line allocated to it.

3.3.15 *Lack of will*

It has been reported that there is a noticeable lack of will amongst the communities in comparison to previous times. In the past, development projects usually required a financial contribution from the community, but now, it is alleged communities feel that it is not the responsibility to pay for development projects, but that it falls under the responsibility of the GoT and so they are reluctant to contribute or take ownership of the projects.

3.4 Emerging threats

With increased use of water and contaminants, due to increased development, it is likely that the water may become more polluted and less potable. However, without the regular reporting and standards in place there is no way of monitoring this before it becomes a significant problem.

In addition, without coordination between the sectors there is the potential for an increase in duplication of work and inefficient use of donor money.

Without adequate training and awareness programs for the institutional staff, VWCs and the community (including at a school level) regarding integrated water resources management, with an increase in pressure on the water resources due to climate change and economic development effects, decision makers will be misinformed and may find it difficult to make comprehensive decisions.

3.5 Recommendations/ Way forward

Apart from the recommendations already discussed in section 3.3, the following recommendations are proposed.

3.5.1 *Functioning NWRC in order to achieve IWRM operational budget*

A fully functioning NWRC, with non-government members incorporated and regular meetings would be able to drive pressure on the GoT to recognise water and sanitation issues as a National priority and allocate an operational budget for IWRM activities. This funding could then be used to implement activities required (for example, upgrading village water supply systems) but also to build the institutional capacity of the GoT.

3.5.2 *Establishment of Water Authority*

Founding one body solely responsible for monitoring, managing, and supplying water in Tonga has been suggested by several stakeholders, with the purpose of centralising water related tasks to solve the problem of fragmentation and duplication. There would still need to be a watchdog organisation, potentially a government department, to ensure the consumer is being served accordingly and the water resources are being managed sustainably.

3.5.3 *Establishment of Tonga Water Resources Management Plan*

In addition to the long term strategic plan for the GoT, a Water Resources Management Plan needs to be developed. The details of this are outlined in the Water Resources Bill 2011, and mainly concern technical aspects of a national water resources assessment, including a national water budget and sustainable yield estimates and monitoring plans. This information is vital for decision making concerning any future development of the water resources, and if updated to contain priority areas, it could feed directly to donors and the Aid Management Division, MoFNP, to provide advice on where donor money would be most beneficial.

3.5.4 *Education and Awareness*

Continued efforts need to be made to raise awareness within communities, government staff, and through school education about water and sanitation, including IWRM and climate change effects, so the people of Tonga can make educated decisions and behavioural changes where needed and to ensure that donor funding is effective and systems are maintained after programmed funding ceases. This is particularly pertinent to help communities understand how groundwater flows underground and how contaminants can be transported from one area to a water supply area. Also education is needed in terms of maintaining household water and sanitation equipment, such as clean rainwater tanks and regularly pumped septic tanks, to reduce the spread of disease. Perhaps this could be done by developing a set of school educational resources, which could then become part of the curriculum and by developing (or improving existing) informative websites to hold up to date Tonga specific data and other information available for all. Education and awareness needs to occur within all generations for behavioural changes to actually occur.

3.5.5 *Installation of meters*

In terms of infrastructure, it is recommended to install meters at every household and water usage point in order to accurately monitor how much water is being used and also monitor the systems for leakages. Currently, most houses within Nuku'alofa have functioning meters and some in rural villages as well. However, many villages have no way of knowing how much water each household is using and whether or not it is at a sustainable rate. Having records of water use would also be valuable information for constructing the sustainable yield estimates for Tonga's water resources. It would also allow villages to transition into a "user pays" scenario rather than households simply paying a flat rate. "User pays" schemes are typically more profitable for the VWCs and also encourage sustainable use.

3.5.6 *Capacity build and support VWCs*

As mentioned previously, VWCs often operate with very limited technical training and it is mostly volunteer work. It is critical that they are given capacity building opportunities and support in order to

be able to provide their village with a continuous supply of safe and clean water and not run at a loss. Training in terms of: maintaining water supply infrastructure (pumps, pipes, meters etc.), financial aspects (how to make a profit and invest that back in the committee for maintenance and upgrading funds), and IWRM training to help them educate their village about sustainable water use and its implications, would all be very valuable in each village. It is recognised that there is frequently a high turnover in VWC members, due to the high demand required by each member, so perhaps training individuals would not be effective in the long term. To solve this, perhaps a VWC manual could be produced and handed down to each new committee, or training could be an annual event, or a website could be developed that contains technical details (like how to fix a broken pump) and a function to lodge a request for support from MoH and report the village monthly water use. A review of all the VWCs and village water supply schemes would need to be done in order to assess what the needs are and where priorities lie.

4 Security of water supply

4.1 Current status/situation

4.1.1 Water resources

Apart for some streams and lakes in 'Eua, Niuafo'ou, and Tofua, Tonga has no surface freshwater source, and relies on groundwater and rainwater catchments for water supply.

Rainwater

Rainwater is the main water source for drinking water within Tonga (80.5% of all households rely on rainwater as their drinking water source (2006 Census)). Rainwater is collected at individual households from roof tops and transported, via gutterings into storage tanks (usually 5000L cement tanks, and plastic tanks are also becoming common). Most households do not perform any kind of treatment prior to drinking, although some (49% in Neiafu) occasionally boil their water in a kettle before consumption (GEF-IWRM project survey, 2010). To ensure cleanliness of water, tanks should be cleaned at least once a year and gutters and gutters and roofs kept clean from debris; installing a first flush diverter can assist in reducing the amount of contamination going into the tank, but most houses do not have this installed. Of note, tests done by the TIUDSP project in 2010 on water from the rainwater tank at MOW office indicated the presence of faecal coliforms (including E.Coli bacteria) (>100 CFU/100mls), which is considered unsuitable for drinking, it is likely many other tanks have similar conditions and maybe conduits for disease. Tonga Trust has been involved with performing faecal coliform indicator tests no rainwater tanks in the past.

Groundwater

Like many Pacific islands, the groundwater is stored in underground aquifers within a freshwater lens, usually in porous limestone (for example, Tongatapu) or unconfined sandy aquifers (for example, Lifuka, Ha'apai). Below the freshwater lens lies a brackish transition zone, which gradually becomes saltier until sea water is reached. The thickness, or volume, and also salinity of the freshwater lens depends on a few factors including: the size and shape of the island, the composition of the host rock/soil/sand, the rate of recharge (rainfall), the rate of abstraction (pumping), changes in sea level and elevation of the land surface. Generally, areas that are located with a higher elevation are able to hold a thicker freshwater lens, but this is not always the case. In Tongatapu, the water table is situated less than a meter above sea level.

Freshwater is defined as water with an electrical conductivity (similar to salinity) of <2500µS/cm and is considered suitable for drinking. For reference, rainwater has low conductivity, about 100µS/cm; water with salinity > 4000 µS/cm can cause shell cracking in laying hens; water with salinity of < 6000 µS/cm is suitable for drinking water by poultry and pigs and irrigation; and sea water has an electrical conductivity around 55000µS/cm.

The salinity of the "freshwater" lens varies significantly spatially. Some villages are able to continuously pump very fresh water (for example, Tefisi and Holonga, Vava'u, pump up very fresh water at 530 and 500 µS/cm, respectively (MLSNR data, 2011)). Whereas some villages do not have a supply of fresh

water, and their wells pump up brackish or very salty water (for example, Pangaimotu, Vava'u, pumps up brackish water, at 7040µS/cm, and Holeva, Vava'u pumps very salty water, 25400µS/cm (MLSNR data). Villages on Tongatapu mostly pump within the freshwater range and tend to average around 1100µS/cm, and range from about 430µS/cm, in Pelehake, to >5000µS/cm on the Hihifo peninsula on the west coast, although the data varies depending on time of year (MLSNR data, 2011)(Figure 8). A similar map for Vava'u (Figure 9) demonstrates the wide range of salinity values across the main islands; some villages have very fresh water (dark green colours in map, for example, Tefisi) and some have very salty water (orange and red colours, for example, Pangaimotu and Holeva). Due to lack of monitoring data, salinity maps have not been produced for any other island groups.

pH measurements are collected by Geology, MLSNR, for village wells, but calibration of the equipment is questionable. pH is a measure of the acid / alkaline nature of the water; values can range between 0, very acidic, and 14, very alkaline; values between 6.5 and 8.5 are ideal for drinking. pH can be affected by the presence of organic material (decaying vegetation, for example) and chemical pollutants added to the water. Groundwater areas with lots of limestone or coralline sands typically have higher pH values. Water from village wells in Tongatapu ranged between 6.7 (Kala'au) to 10.3 (Ha'alalo), and averaged around 7.9 when tested by Geology, MLSNR in early 2011. The pH value in limestone or coralline sand islands tends to be higher during times of drought.

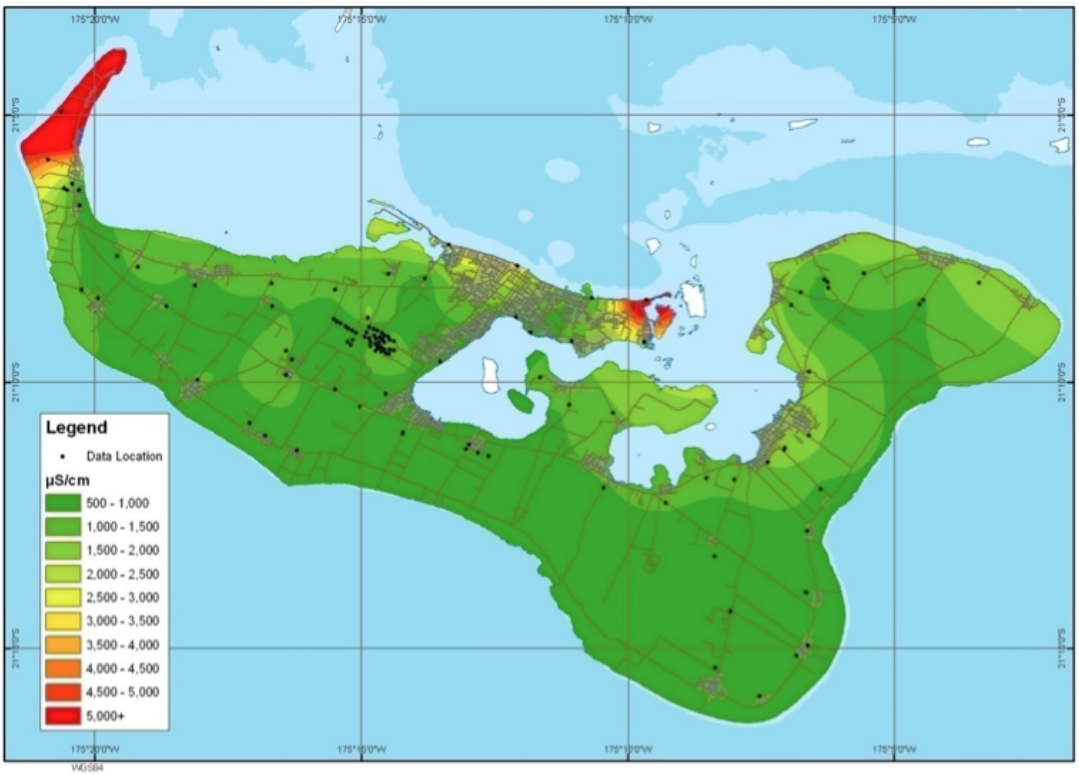

Figure 8: Salinity (Electrical Conductivity) map of Tongatapu, representing data collected in August – September 2010. Data was collected from village wells, which usually pump from within the first meter beneath the water table. Mataki'eua TWB well field is also visible by the dense collection of black dots. (MLSNR data, 2010)

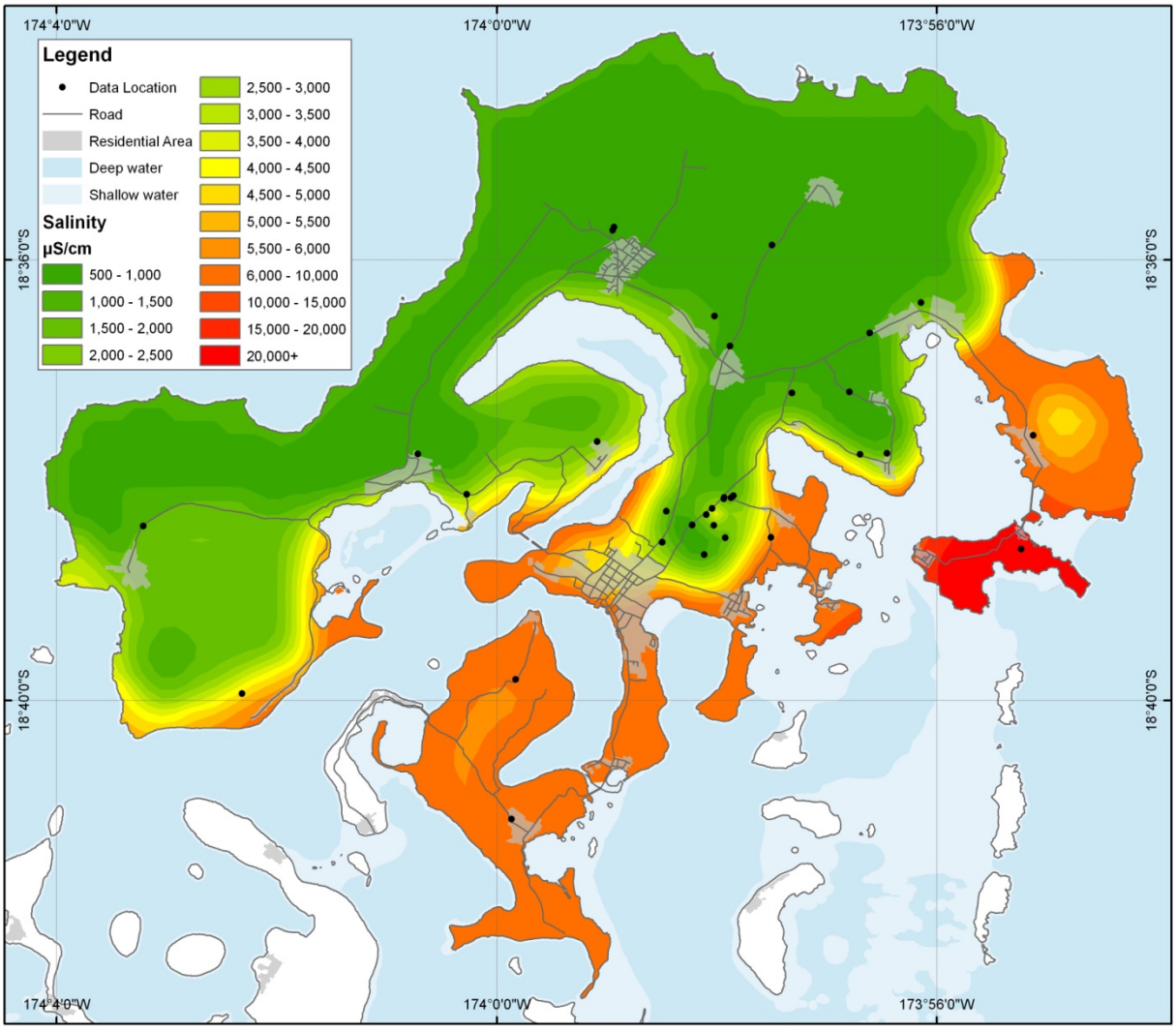

Figure 9: Salinity (Electrical Conductivity) map of Vava'u (main islands), representing data collected in November 2010. Data was collected from village wells, which usually pump from within the first meter beneath the water table. The TWB well field is the area just northeast of Neiafu where there is a more dense distribution of black dots. (MLSNR data, 2010)

4.1.2 *Water supply*

The various water supplies of Tonga are discussed following, excluding rainwater (which is the responsibility of each household).

Urban water – TWB – Nuku'alofa

The urban water supply for Nuku'alofa is abstracted from the highland area of Mataki'eua, behind the King's residence (Figure 8 and **Error! Reference source not found.**) where 36 wells are located and operate approximately 24 hours per day (TWB data, 2010). 23 wells have been upgraded to electric pumps, mostly with functional meters, whereas the remaining wells operate diesel pumps, mostly with non-functional meters (TWB data, 2011). The water from all wells is directed to 6 reservoir tanks located at the site office, where daily chlorine treatment occurs (in the form of calcium hypochlortite being directly added to the reservoir tanks using a chlorination dosing system (Nath et al., 2006)). When the

chlorination dosing system malfunctions (which can occurs regularly), the chlorine is applied manually (Crennan and Mafi, 2007). On average, the electric submersible pumps extract at a rate of 4.24 L/s and the diesel pumps extract at approximately 2.11 L/s (MLSNR analysis of TWB production records, 2010). This leads to an extrapolated estimation of 320 ML abstracted per month (MLSNR data analysis of TWB production records, 2010).

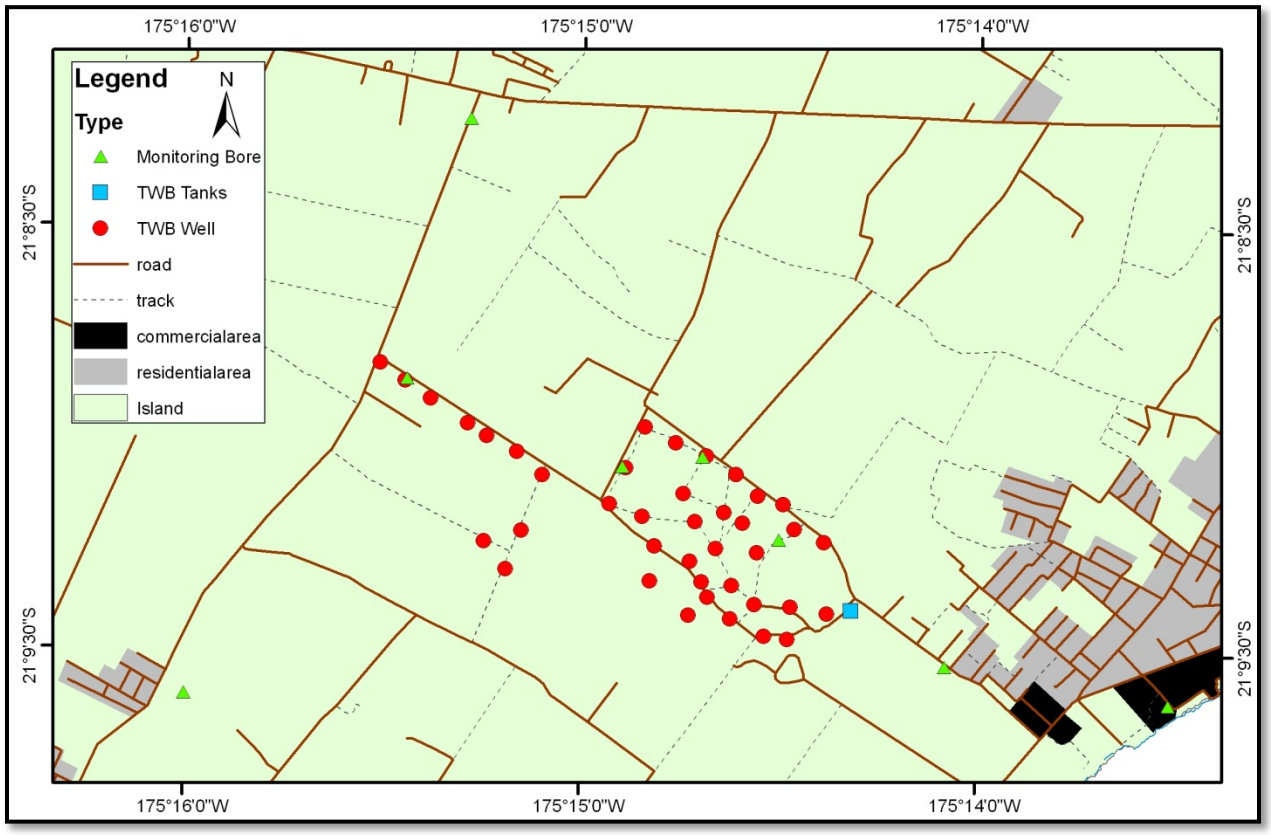

Figure 10: Map of Mataki'eua – Tongamai well field, showing location of wells, monitoring bores and reservoir tanks. (MLSNR data)

The bulk meter located at the distribution end of the reservoirs does not function (due to a design error), so, combined with incomplete pumping data from the wells due to broken meters, it is not possible to get an accurate measurement of the volume of water extracted from the ground. The average salinity of the water extracted from Mataki'eua wells is about 1020 µS/cm (MLSNR data, 2010), which is relatively fresh. The grounds of the Mataki'eua-Tongamai well field are partly fenced, and so in the main, electric pump area roaming animals (like pigs) are never found, however the outer area, to the northwest, has pumps amongst farm land and no fences are present to restrict access and/or contamination. 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 field, leading to changes in the groundwater gradient, there is the potential for contaminants approaching the wells (Crennan and Mafi, 2007). The reservoir area is not secure and easily accessible, should any want to purposely contaminate it. It should also be mentioned that the

area surrounding the Mataki'eua well field and the TWB office is the official location for evacuation during tsunami warnings. There are insufficient sanitation facilities to serve the evacuated people for the many hours that they are required to be there for; this could potentially lead to significant contamination of the groundwater resource. There are 7 salinity monitoring bores installed in and around the well field and the Geology Unit, MLSNR, collects data on the salinity profile of the lens monthly; this data is not formally reported. TWB diligently collect monthly data of the salinity of each production well, however the accuracy of this data is questionable due to poorly calibrated equipment.

The thickness of the freshwater lens around the Mataki'eua well field varies on location and ranges between about 7m (on the eastern edge, closer to the lagoon) and 15m (on the western edge), close to the centre of the well field the lens is about 10m thick (Figure 11) (MLSNR data).

Although around the diesel pumps there appears to be some hydrocarbon spillage and contamination, it appears the dense, clayey topsoil is impermeable enough and hydrocarbon contamination has not reached the water resource (White et al., 2009). Monthly testing at wells 101 and 128 by the TIUSDP project indicates that the production wells are free from faecal coliform contamination, and nutrient tests generally show low levels for ammonium, nitrate and phosphate (MOW, TIUSDP Water monitoring data, 2010-11).

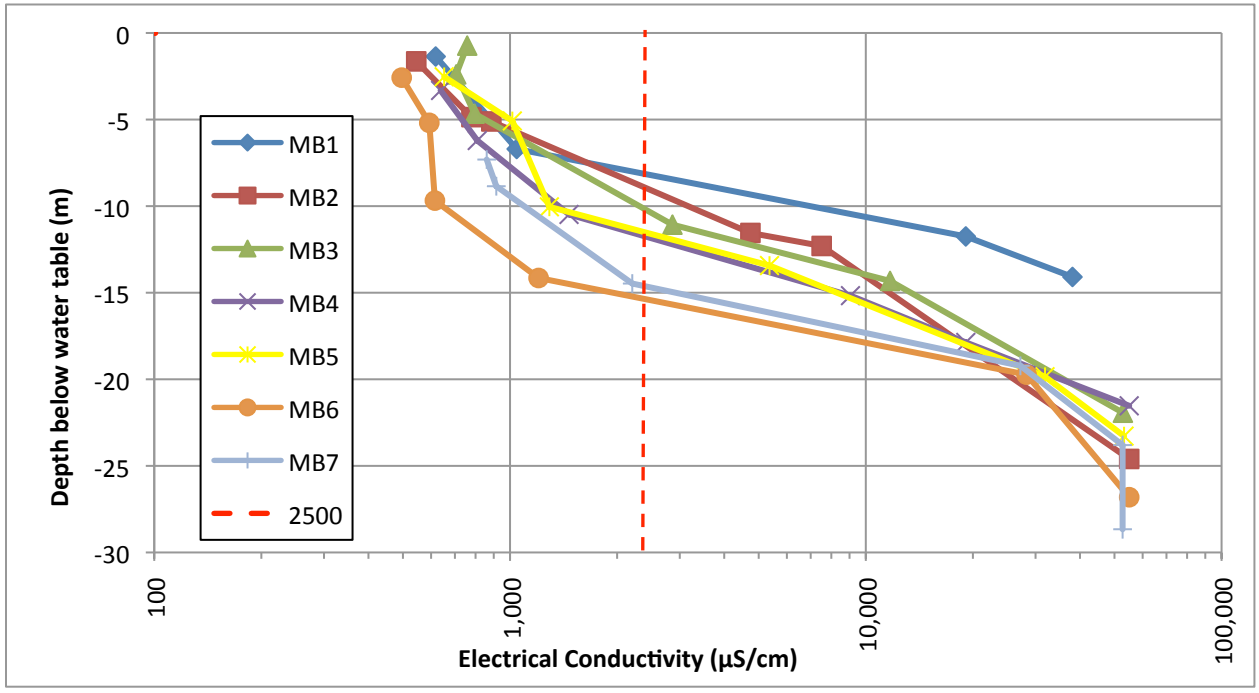

Figure 11: Profile of EC (salinity) measured through the freshwater lens at SMBs around Mataki'eua/Tongamai well field in July 2010. Also shown is the freshwater limit (red dashed line). (MLSNR data, 2010)

Loss of water within the distribution line may be significant and could be the reason for the estimated 40% of unaccounted for water, according to TWB (personal communication, 2011). TWB is progressing well with approximately a 2% target reduction of this volume per year since 2009, and they are currently reviewing and strengthening their billing and metering system in order to better account for the

majority of the water produced. They plan to subsequently focus on eliminating visible leaks and then fully engaging their leak detection program (TWB, personal communication, 2011).

Urban water – TWB – Neiafu

The urban water supply of Neiafu is abstracted from grounds northeast of Neiafu (Figure 9 and Figure 12). There are 16 bores; however, at the time of writing, only 6 were operational as production wells and these operate about 24 hours a day. Most of the wells pump at a rate around 2.5L/s, except for well 18 which pumps at a much higher rate of 7.1L/s (MLSNR data, 2010). The water table in the area of the well field is about 22-30m below ground, which makes maintenance of the pumps difficult and many bores have "collapsed" as a result of pump parts falling to the bottom of the bore rendering the well unusable (TWB, personal communication, 2010). The benefit of such a deep water table, however, seems to be that no contamination has been picked up in basic nutrient tests (nitrate, phosphate, and ammonium) (MLSNR data, 2010). The thickness of the freshwater lens around the Neiafu well field appears to be less than 5m thick (MLSNR data, 2011). Three reservoir tanks are located on high ground, near Mt Talau (to the west of the well field). The reservoir is treated every few days with chlorine. The TWB Vava'u office keeps paper records for a month and sends data to Nuku'alofa for archiving (TWB, personal communication, 2010).

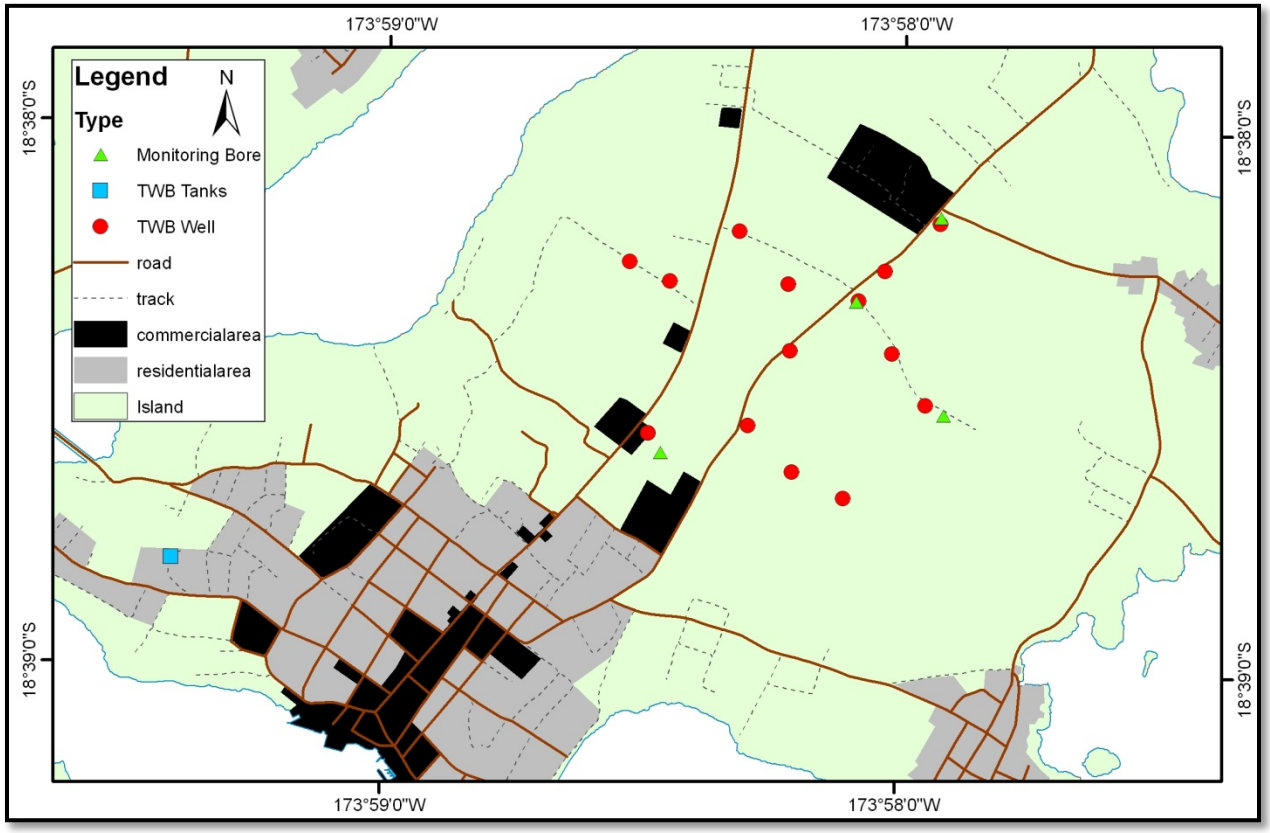

Figure 12: Map of Neiafu well field, showing locations of wells, monitoring bores and reservoir tanks. (MLSNR data)

Urban water – TWB – Lifuka and 'Eua

The urban water supply on Lifuka, Ha'apai comes from 11 vertical wells and several horizontal well galleries located within the Pangai town settlement area. The groundwater sits in a shallow sandy aquifer which causes concern for contamination from leaking septic tanks and other human activities especially as the wells are integrated within the town area (Falkland, 2000). The freshwater lens is less than 5 meters thick, and in some areas only a meter or so (MLSNR data, 1999). Falkland (2000) reports on improvements to the Pangai water supply salinity via the installation of shallow galleries that pump water out of the aquifer in a horizontal line, rather than a vertical line. Monitoring efforts in Lifuka have been very limited; the last time MLSNR was able to do a monitoring trip was in 2005, when wells gave an average salinity of around 1200µS/cm.

The urban supply of 'Eua comes from 4 underground stream sources that run through caves within the karst system, called the Kolomaile intake system (Fielea, 2002). It produces very fresh water around <400µS/cm. There is also a groundwater bore at Ha'atu'a that supplements the cave supply during times of low rainfall; it produces water of around 980µS/cm (Fielea, 2002). MLSNR does not have any official data on water 'Eua water monitoring.

Bottled water supply

There are an increasing number of private bottled water suppliers within Tonga. Companies such as Tonga Pure Water, Tasilo, Vai (Waves Café) and also international companies such as Fiji Water, and Waiwera Water (NZ) have bottled water available to purchase, and many people who can afford to do so rely on bottled water as their drinking water source (3.63% of households in Tongatapu rely on bottled water for drinking (2006 Census)). The Tongan based bottled water is sourced from the TWB supply (Tonga Pure Water) or rainwater (Vai) and treated by boiling prior to bottling (Tonga Pure Water and Waves Café, personal communication, 2011). The plastic bottles used for selling the water are becoming an increasing problem in terms of waste; to mitigate this issue some companies supply water in 20L reusable bottles, which require a deposit.

Village water supplies

Village water supply schemes vary between each village (see Figure 13 for one example). There is no standard design or requirements for the system. Generally, the wells are located towards the outskirts of the village, possibly on higher ground. The bores are either hand dug or newer, drilled bores and they usually penetrate a meter or so into the water table. Most have diesel helical pumps operating, but systems that have been upgraded in recent years tend to have electric pumps and there are also some solar submersible pumps being used. The water is pumped from the ground for a few hours each day (maybe 6 hours or more), depending on demand and fuel supplies, and is pumped to a reservoir, which is usually a plastic or cement tank on a stand about 10m high and maybe 15m from the well. The water is then distributed to houses along the reticulation system, and may or may not be metered for consumption. In some villages households pay a fixed rate of TOP$10 per month, for example, regardless of amount used, and in other villages, that have meters installed, users pay per consumed volume. The latter seems to be more effective in generating sustainable funding for the VWC (Vaini VWC representative, personal communication, 2011).

Figure 13: 'Utulau village well supply (Tongatapu), showing pump house and reservoir. (Nicola Fry, 2010)

The quality of the water supply system seems to depend on the VWC's ability to procure donor funding for upgrades and also generate their own income for maintenance reasons. Some villages have water supply systems that are very well kept, clean, and efficient, and others are in disrepair (Figure 14). Many villages do not have the surrounding area of the pump house fenced off so animals, such as pigs, can roam freely leading to potential contamination from their waste. Some villages, particularly in outer islands, have latrines or septic tanks located closely to the wells, which also is a source of potential contamination (for example, Nomuka, Figure 25).

MoH (personal communication, 2011) reported that most villages in Tongatapu now have meters installed within their reticulated system, however, some of these are old and not maintained. Some VWCs monitor their village water use (for example, Fatumu), but many villages do not monitor how much water is being used or extracted from the ground.

As mentioned previously, MoH is responsible for monitoring the quality of the rural water supplies but they only have the resources to monitor for faecal coliform indicators monthly on Tongatapu. Geology, MLSNR, monitors the salinity (and where possible pH and temperature) of the Tongatapu village wells quarterly, but up until recently the data collection was only sporadic. Currently, the VWCs do not receive information on the quality of water unless they request the data officially. The water supplies of the villages on the remaining islands are rarely monitored, although the GEF-IWRM project in Vava'u has allowed for some recent monitoring efforts by the project team.

Figure 14: One of Vaini's village wells (Tongatapu), showing diesel runoff contaminating exposed groundwater (blue circle). Note the presence of the pig roaming in the area (red circle). (Nicola Fry, 2010).

Private wells

Some households have private wells that tap into the groundwater resources. In some cases, these wells have been in existence for several generations and are often wide, hand dug, open bores accessible using a bucket on a rope, whereas some are drilled and have pumps attached. There are currently no regulations regarding the licensing or monitoring of water quality of private wells (including proximity to latrines, for example), although the Water Resources Bill 2011 aims to change this.

4.1.3 Water use

The majority of water use in the Kingdom is domestic, although there has been an increase in industrial use in recent years, particularly in the construction industry. There is little improved irrigation within the nation, except within the MAFFF operated farm in Tongatapu and 2 commercial operations also in Tongatapu: Afeaki Farm (20 acres of farmland using drip irrigation for production of Japanese Taro (Satoimo) for export to Japan), Nishi Trading Co. Ltd (uses overhead sprinkler for 7 hectares of land) (MAFFF, personal communication, 2011) . Historically, irrigation was used widely when squash pumpkins were a prime export, in the late 1990s-early 2000s. The tourism industry is a large user of water (particularly in resorts, for showers and washing) and as the industry is growing, it will likely put more pressure on the water supplies (TVB, personal communication, 2011).

Domestically, according to the GEF-IWRM project survey in Neiafu, approximately two thirds of the households rely on rainwater for drinking, cooking, washing and bathing, and one third also use it for gardening; the remaining households rely on groundwater for those uses, and water used for toilet flushing is solely groundwater in all houses surveyed.

4.2 Trends

4.2.1 *Physical water quality*

The salinity trend of water tested in wells across Tonga is related to rainfall, showing increasing salinity during and just after drought periods, particularly in El Niño years (Figure 15). The same can be said for pH levels, with higher pH during drought periods, particularly for water in limestone aquifers (Figure 16). Pumping rates also have an effect on salinity, although, with the overlay of rainfall effects, it is not always easy to interpret. White et al. (2009) show that an increase in pumping rate at the Mataki'eua/Tongamai well field produces an increase in the salinity of the water produced from the wells, over time since the inception of the well field. Utungake village in Vava'u is another example of salinity increasing due to pumping. The electric submersible well was installed there about 3 years ago and produced relatively freshwater for a few years (according to one resident), but the water got saltier and saltier and eventually the VWC shut the well down (a year ago), and is remains shut today. At this stage, with limited data, it is difficult to make an assertion regarding an increase in sea level and saline intrusion within wells.

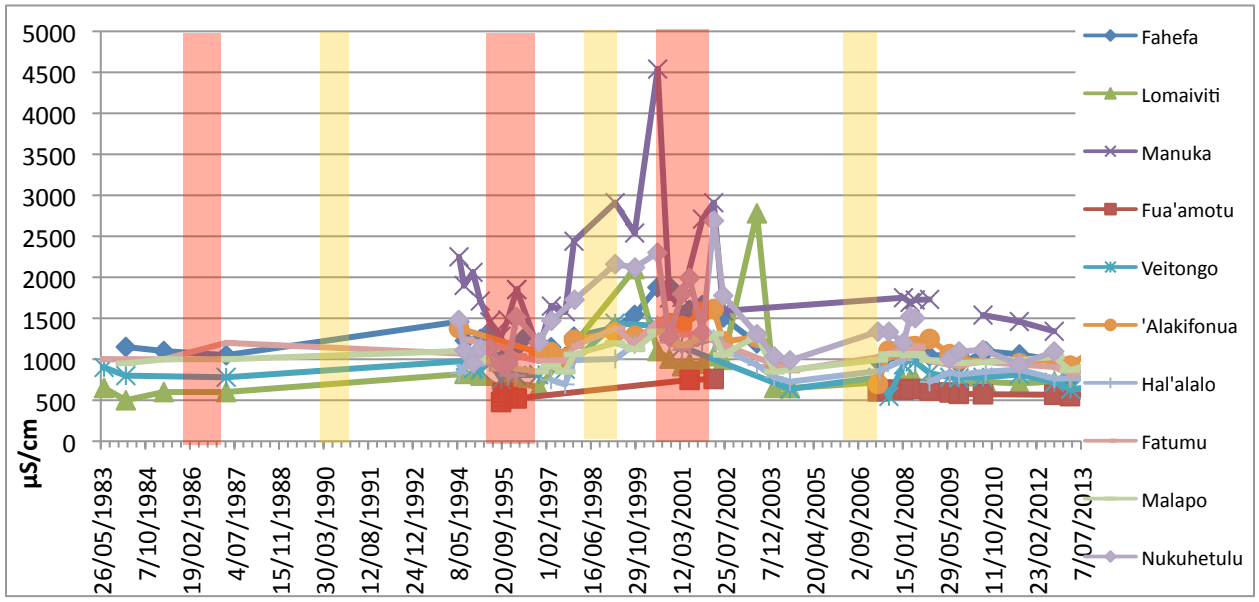

Figure 15: Historical salinity data for selected village wells from Tongatapu shown against El Niño years (strong = red shading, medium strength = orange shading)

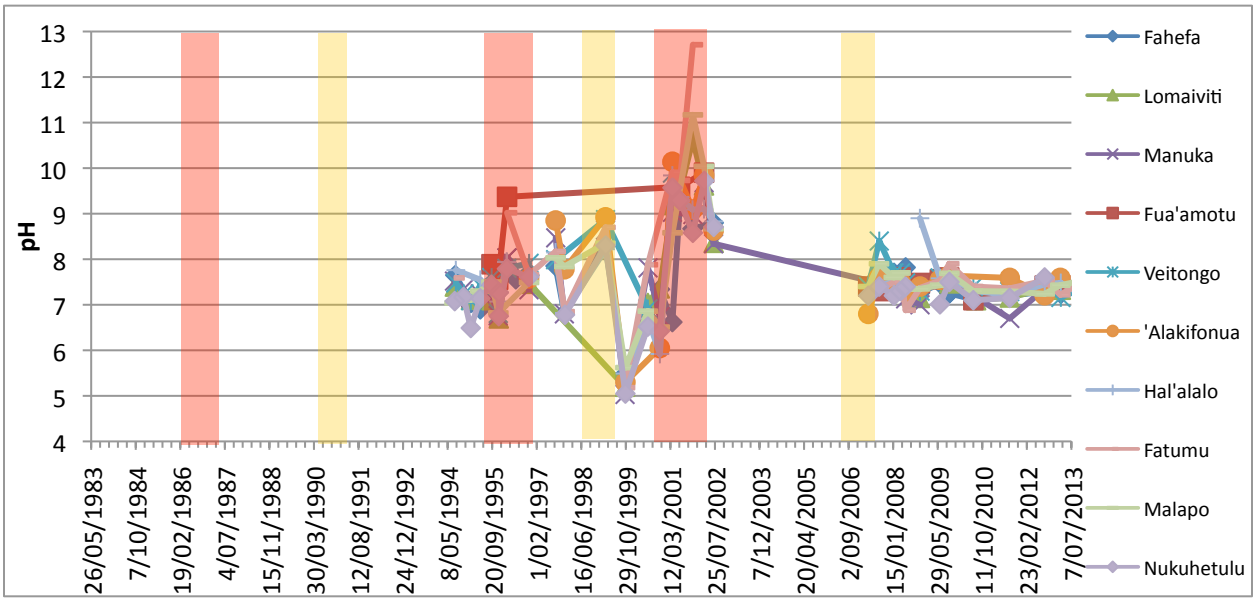

Figure 16: Historical pH data for selected village wells from Tongatapu shown against El Niño years (strong = red shading, medium strength = orange shading)

4.2.2 *Water use*

Water use has increased over the years, and is likely to continue along this trend with population growth and economic development influences. For the Nuku'alofa water supply area, water produced by TWB at the Mataki'eua well field has significantly increased over the last 25 years (Figure 17).

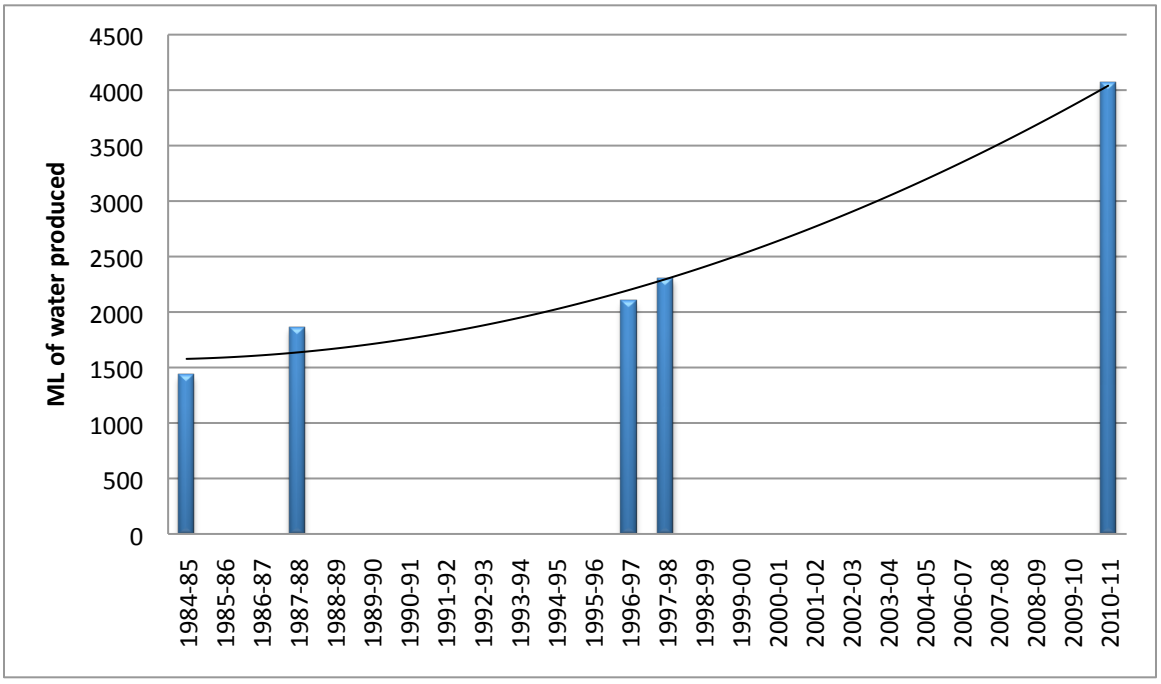

Figure 17: ML of water produced at Mataki'eua for July-June financial years. (Kafri, 1989; TWB data, 2011)

4.3 Current issues

The following are current issues with respect to the security of water supply that have been collated from interviews with stakeholders.

4.3.1 Inadequate supply of rainwater catchment

As mentioned previously, rainwater is relied on for the primary water source for drinking and in some areas is also the only water source (for example, low lying islands in Ha'apai with virtually no sustainable freshwater lens), yet when it rains in many places there are not enough rainwater catchments to store adequate supplies. According to the GEF-IWRM project household survey, 30% of Neiafu houses do not have their own rainwater tanks, and only 5% of all houses have more than 1 tank; 70% of houses catch rain from only half the surface of their roof, and 30% catch rain from only one third of their roof. This means there is a lot of catchment space not being used. The village of Koloa, in Vava'u, has a groundwater pump but the water there is very salty (>25000µS/cm) and so they do not use the groundwater; each house has 1 rainwater tank, but in times of low rainfall the tanks do not provide adequate supply. For an average Tongan household of 6 people, a 5000L rainwater tank would last for only 8-16 days if the WHO recommended amount of water required per person per day is used (50-100L per person per day). Historically, there used to be village rainwater tanks installed in every village, large in size and connected to a community building (church or hall) which was available for all village people to use should they require. These have not been maintained and most are in disrepair (some are reported as being used as rubbish dumps) (residents of Tongatapu, personal communication, 2011).

4.3.2 Pollution of water supply

The security of the water resources is dependent on being protected from contamination. The heavy reliance on septic tanks and pit-latrines in Tonga provides a risk of contamination from health-affecting faecal coliforms and water borne diseases. Continued pressures from economic development and population growth increases the amount of waste (garbage and also human waste) into the environment, and without sound waste disposal practices, it puts a large pressure on the security of the freshwater resources, particularly in low lying areas where the water table is shallow. Although, according to White et al. (2009), the wells in Tongatapu do not appear to show contamination from hydrocarbons or pesticides.

4.3.3 Leakages in distribution lines and unaccounted for water

Leakages within the distribution lines within the urban (TWB) and rural (VWC) areas are common and cause a significant loss of income. Without installation of functional meters in most village supply systems it is impossible to gauge an estimation of unaccounted for water, but TWB believes is it likely to be high in many villages. It is expensive to purchase diesel to power the pumps, so financially, the loss of pumped water has a big impact on householders. It also means that more water is being pumped out of the ground than needs to be, which puts unnecessary pressure on the freshwater lens and can result in increases in salinity of the water.

4.3.4 Pressure changes and unreliable supply

Householders, in some areas of Nuku'alofa, for example (Vaololoa, among others), report changes in the pressure of their piped water throughout the day, with commonly very low pressure in the morning

during peak usage times (around 7:00am each morning (Vakasiuola and Schölzel, 1999)). They report that this has only recently become a big issue in the last year or so, and is most likely due to an increase demand across the distribution line. Rural villages face similar problems, and often only have piped water available into their houses at certain hours of the day. Often the pump at the village well will be turned on for a few hours each day to fill up the reservoir tank and then switched off to conserve fuel, but the reservoir tank is not a substantial volume to adequately supply the village with enough water for 24 hours. Some residents of Ha'ateiho, Tongatapu, for example, report that they only have piped water in the morning, until it runs out, and they have to rely on bucket water from their rainwater tanks for the remainder of each day.

4.3.5 *High salinity areas and increases in salinity*

Some areas do not have easy access to fresh groundwater sources, for example Hihifo peninsula on Tongatapu and many of the low lying islands in Ha'apai and Vava'u (for example, Figure 8 and Figure 9). This causes a heavy reliance on rainwater sources in these areas. The Hihifo area is where several tourist resorts are located, which have a high demand for water, so a reliance on rainwater is not sufficient. At present the Hihifo area pumps groundwater from sources to the southeast, along Loto Road, to mitigate this high demand. Some areas are also noticing an increase in salinity in their water (for example Utungake village in Vava'u) and a once freshwater supply is now salty and unusable, this may be due to unsustainable pumping rates or less rainfall. Theoretically, after enough time has passed with no pumping, the well should rehabilitate itself if over pumping was the cause for the increase in salinity, but this is not always possible in areas where there is a large demand for water.

4.3.6 *Inadequate distribution of salinity monitoring bores (SMBs)*

Currently there are 7 SMBs in Tongatapu, 4 in Vava'u, and 9 in Pangai, Lifuka, located in and around each TWB well field. The Tongatapu SMBs are now regularly monitored (monthly) by Geology, MLSNR, staff, but the remainder are very rarely monitored or maintained (until 2010, the last time the Neiafu SMBs were monitored was in 1999, and the Lifuka SMBs have not been monitored since 2001). SMBs provide information on the thickness of the freshwater lens. It is important for an overall picture of the situation of the lens to have a good distribution of data points, and not just located around the TWB well fields. White et al. (2009) recommended 10 more SMBs should be installed in Tongatapu and monitored quarterly. There are currently 2 projects that are planning on installing additional SMBs on Tongatapu. The PACC project (run by MECC) has proposed installation of 2 SMBs along Loto road to monitor the Hihifo water supply. The EU-B Envelope project (implemented by SOPAC) is planning on installing 3 additional SMBs at Mataki'eua and possibly 3 to monitor the freshwater lens around Fua'amotu as a potential alternate urban water source.

4.3.7 *Lack of calibrated equipment*

Un-calibrated and poorly calibrated equipment leads to poor data. Prior to each field trip, all water testing equipment must be calibrated against a known standard solution to ensure accurate and reliable data. Budgetary limitations and priorities of focus have meant that agencies are not able to or do not purchase enough standard calibration solutions and so solutions are recycled after each use. This is the case with TWB and also was the case, until recently, for Geology, MLSNR. On a field trip in Vava'u (2010) a correctly calibrated salinity meter was used to test the same water as the TWB meter. The TWB meter

gave results in the order of 1000µS/cm lower than the calibrated meter, which is a significant difference. The staff at TWB Vava'u said that the meter is only calibrated once a year when staff from Nuku'alofa come and visit and after calibration the standard solution is put back into the bottle for reuse next year. Standard solutions only have a shelf life of maximum 2 years (Envco Global[4], personal communication, 2011).

4.3.8 *Inadequate maintenance of rainwater tanks and not enough first flush diverters*

According to the GEF-IWRM project survey of Neiafu householders (2010), 17% of houses clean their rainwater tanks on a regular basis and only 27% of houses have a first flush diverter. Rainwater tanks can get a build-up of contamination over time and without proper maintenance, this can become a health problem. Without the aid of a first flush diverter, the tanks have a much higher risk of contamination (refer to the faecal coliform count of the MOW tank mentioned in section 4.1.1).

4.4 Emerging threats

4.4.1 *Climate change effects on rainfall and sea level rise*

This topic will be covered in more detail in chapter 7. The predicted changes in rainfall (increase frequency of droughts and heavy rainfall, and less rainfall overall) and sea level rise over the coming years will likely have a large effect on the security of the water supply in Tonga. Due to sea level rise and less overall rainfall, an increase in salinity of water pumped from wells and a thinner freshwater lens is likely to be noticed, particularly in the prolonged drier seasons.

4.4.2 *Increase in demand and over pumping*

Due to population growth and economic development (including a growing tourism industry), it is likely the demand for freshwater will increase over the coming years. Without a sufficient increase in rainwater catchments, this will place a significant pressure on the groundwater resources and may result in unsustainable abstraction rates if not managed/monitored adequately, leading to a decrease in water quality (higher salinity).

4.5 Recommendations/ Way forward

Apart from the recommendations already discussed in section 4.3, the following recommendations are proposed.

4.5.1 *Installation of more rainwater catchments*

Additional rainwater catchments would help to take advantage of heavy rainfall periods and relieve pressure on groundwater during dry periods. Catchment from entire rooftop surfaces is also recommended. Rooftops need to be in good condition, not too rusty and maintained from debris. It is also recommended that rainwater tanks are fitted with first flush diverters to ensure that the first wash of the roof does not go into the tank and potentially contaminate the water. Also recommended is rehabilitation of large village water tanks for community use within villages during times of lower rainfall to supplement household supply.

[4] http://www.envcoglobal.com/

4.5.2 *Proper calibration procedures*

Correct and frequent calibration of monitoring equipment is very important. Calibration should be performed prior to every monitoring session with new (not recycled) calibration solutions to ensure that data is reliable.

4.5.3 *Increase monitoring efforts, including SMBs, particularly in islands other than Tongatapu*

In order to get a good representation of the capacity and sustainable yield of the water resources in Tonga there needs to be frequent monitoring of village wells and SMBs, and there needs to be a substantial distribution of SMBs across the freshwater lens. Installation of more SMBs on Tongatapu was recommended in White et al. (2009), and it would also be good to have more on other islands as well, provided frequent monitoring occurs.

4.5.4 *Test water for contaminants*

There is no routine water testing apart from salinity and faecal coliforms (and pH and temperature to some extent), and this is only done frequently in Tongatapu. Other contaminants, such as heavy and trace metals, fertilisers, pesticides, other industrial chemicals, hydrocarbons etc may be present within the water and go by undetected. There are currently no facilities within Tonga to test for other contaminants and samples must be sent overseas for testing, which is costly. It may be worth considering implementing a functioning laboratory equipped with a variety of equipment that can test for all potential contaminants to comprehensively monitor the water quality, although only worthwhile if a Government allocated annual operating budget was also allocated. It has been reported (TWB, personal communication, 2011) that a central laboratory within Tongatapu may be installed in the near future under funding from a development project to serve the purpose of comprehensive water testing, including hydrocarbons. However, this has not been confirmed yet and it is also not known if an operating budget will be also assigned.

5 Sanitation and human health

5.1 Current status/situation

5.1.1 *Sanitation facilities*

The major objective of a sanitation system is the sanitary disposal of human wastes in a hygienic way to protect human and environmental health (Belz, 1985). Currently, there are no central/public sewerage systems in Tonga. Most of the population is served by on-site facilities. According to the 2006 Census, 70% households have flush toilets, 11% have manual flush toilets, 18% have pit latrines, and 0.3% of households reported having no sanitation facilities (Figure 18). It is the mandate of MoH to investigate sanitation facilities of dwellings. One stakeholder commented that "access to sanitation facilities is generally adequate within Tonga, but it is the disposal of the subsequent waste that is questionable".

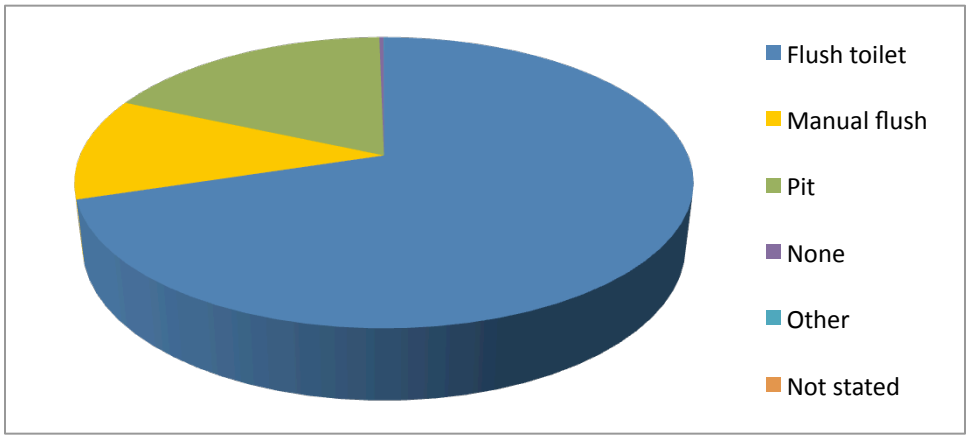

Figure 18: Sanitation facilities at households (2006 Census)

The commonly used disposal methods are briefly discussed following.

Septic tanks

Septic tanks are a common means of disposal in residential and commercial areas with piped water. Newton (2008) indicated that septic tanks are rarely properly designed, usually consisting of single compartment tanks, the sizes of which are not adjusted for the number of persons using the facility. Septic tanks in Tonga usually consist of concrete or fibreglass tanks with vertical soakaways to 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) (Crennan and Mafi, 2007). According to the GEF-IWRM project survey (2010), 92% of Neiafu households have at least 1 septic tanks, the average age of the tanks in households is 17 years and most (85%) households report that they do not recall the tank being emptied during this time. A similar survey conducted in 2006 in by the IWP in Nukuhetulu, Tongatapu, found that more than 63% of households have not emptied their septic tanks in the last 5 years, and 41% have never had it emptied (Prescott et al., 2007). Due to poor maintenance and design, septic tank leaks are common and local contamination of groundwater in addition to contamination of lagoonal and marine environments (Newton, 2008).

Septic tanks can be used for an indefinite time; however the solids that accumulate in the septic tank will need to be pumped out after a certain number of years (Belz, 1985). Belz (1985) estimated for a Tongan household, pumping should occur at least every 7-10 years. Sludge can be extracted from septic tanks by using the Waste Authority or Waste Management pump truck in Tongatapu or the newly purchased MoH pump truck in Vava'u (funded through the GEF-IWRM project), and is disposed of in a stabilization pond at the Tapuhia Landfill, in Tongatapu, and at the newly established Kalaka site in Vava'u,. There are no official sites for disposal of sludge on any other islands. It has been observed that the size of the pond at Tapuhia Landfill underestimates the volume of sewage taken in daily (Newton, 2008). Holding tanks for downtown restaurants and other businesses are reportedly pumped weekly or bi-weekly; residential septic tanks are rarely pumped every 5 years (Crennan and Mafi, 2007). Poor maintenance of septic tanks (and in a few cases, poor design) results in significant groundwater contamination (Lau and Takau, 2006).

Improved Ventilation Pit Latrines and Water Seal Latrines (Pour flush latrine)

These are promoted by the health inspectors in areas where water supplies do not allow septic tanks to be constructed (Newton, 2008).

Flush Pits and Traditional Pit Latrines

These are still in use especially in the rural areas and outer islands (Newton, 2008).

Composting Toilets

Dry sanitation options (which are good for areas with limited water and also have the benefit of no water-borne diseases associated) such as composting toilets have been introduced in Tonga over the last 15 years or so (Crennan and Mafi, 2007). Composting toilets are arguably the most environmentally sound method of human waste disposal and groundwater contamination is largely prevented if there is no waste water discharge (Depledge, 1997). Fifteen units were trialed in Pangai–Hihifo in the late 1990s in a project funded by AusAID, and four of these systems are still operating successfully (Crennan and Mafi, 2007), although many have been converted to tool sheds and other storage units by the households (AusAID, personal communication, 2011). The community of Ata'ata, in the Tongatapu group observed the trial and subsequently installed composting toilets for each house and school in the village in 2001 (Crennan and Mafi, 2007). These toilets are still being used and the community is generally satisfied with the technology (Crennan and Mafi, 2007). The GEF-IWRM project in Vava'u is currently in the process of installing several demonstration composting toilets with the hope that communities will be able to see that the benefit outweighs any assumed stigma.

Open Soaked Pits

Households all over Tonga still direct domestic wastewater (particularly greywater) into open soaked pits (or alternatively into septic tanks) (Newton, 2008).

5.1.2 Solid waste disposal

Lau and Takau (2006) report that each Tongan household produces about a tonne of solid waste per year and extrapolated this to apply to the country as a whole: 16,194 rural and urban households produce about 16,400 tonnes of waste per year, of which Tongatapu residents would account for 67%, or 11,000 tonnes of solid waste. Of these wastes, garden and organic kitchen waste comprise about

65%, followed by diapers and recyclable materials such as beer bottles, aluminium cans, metals and polyethylene terephthalate (PET) bottles. Urban households produce about the same average volume of waste (19 kilograms per week) as those in rural areas, although their waste differs in composition (Lau and Takau, 2006). Individual households primarily undertake their own solid waste management with limited government and private sector-organised collection and disposal services. Government-organised solid waste collection is limited to Nuku'alofa and Neiafu. During the 2006 Census, most households reported that their main solid waste disposal method is burning (85%) (Figure 19).

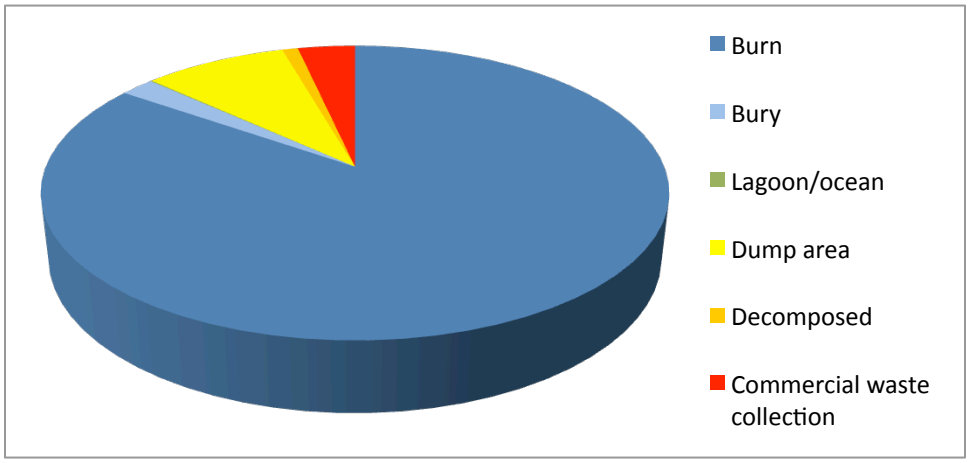

Figure 19: Waste disposal methods by household (2006 Census)

Animal waste is also a major source of pollution in Tonga. An average Tongatapu household owns between 3 and 14 pigs and an average of 7 chickens and 2 dogs (Lau and Takau, 2006). With an average of 5 pigs per household, Tonga is estimated to have about 90,000 pigs (Lau and Takau, 2006). Most of these pigs are allowed to roam free despite a legislative regulation requiring that pigs be kept in pens and households manage animal waste to a limited extent (Lau and Takau, 2006). Animal waste is either swept into a rubbish heap or dumped in nearby bush, but is still at risk of entering the groundwater during rain periods (Lau and Takau, 2006).

In recent years, there have been some projects which have looked at converting pig waste products into biofuel; some have had sustainable success. Commissioned last year, at the Ministry of Agriculture, Vaini Division, is a Chinese Government funded biogas demonstration plant (Energy, MLSNR, personal communication, 2011). Energy, MLSNR reports there have been various pilot biogas project in the past and have reached some level of success, but most are not running anymore due to various social, financial, and technical constraints. The Project Manager from 'Aloua ma'a Tonga Association reported that her household is now self sufficient in terms of gas, which they generate as biogas from their pig's waste; they have not needed to buy gas for many months (personal communication, 2011).

5.1.3 *Human health in Tonga, related to sanitation*

Solid and liquid waste has a significant impact on human health as well as on the environment. It is the aesthetic effects of solid and liquid waste that cause the most concern to locals, although almost 50% of surveyed households reported suffering from waste-related illnesses such as diarrhea and other gastrointestinal illnesses, dengue fever and skin infections during a survey in 2006 (Prescott et al., 2007).

According to the 2005 Ministry of Health annual report, the four most common notifiable diseases in Tonga were respiratory infections, influenza, bronchopneumonia, and diarrhea in both adults and children (Chamberlain et al., 2010). However, there are issues with the rigidity of the data as many illnesses are commonly classified under the term 'influenza' (Chamberlain et al., 2010). The leading causes of morbidity in Tonga in 2009, leading to admission into the main Vaiola hospital, include pregnancy and related issues, diseases of the respiratory system (with a high proportion of children aged 0-13), injuries and poisoning, infectious and parasitic diseases, diseases of the genitourinary system, diseases of the digestive system, and diseases of the circulatory system (MoH, 2010). Women and children constitute a large proportion of patients suffering from these leading causes of admission; in most cases these illnesses are treatable and do not lead to mortality.

Chamberlain et al. (2010) report that the Department of Environment's 2005 National Communication (GoT, 2005) included the country's first attempt to assess the vulnerability of the human health sector to climate change and, although this section of the report is brief and lacking definitive research, it provides an outline of some of the preliminary climate- and water-based health issues facing Tonga. There have been high percentages of diarrheal disease reported in both children and adults, mainly caused by the drinking of contaminated water. During the wet season the incidences of dengue fever have been found to increase, as the wet conditions and accumulation of water provide favourable conditions for mosquitoes to breed.

Newton (2008) reports that three broad categories of water-related conditions have been identified to be caused by poor sanitation practices: dengue fever, gastrointestinal diseases, and skin infections; and of these, only dengue and gastrointestinal cases are officially reported by the Ministry of Health. Leaking septic tanks, animal waste and chemical runoff can leach into and contaminate groundwater supplies, resulting in detrimental health effects, including the presence of faecal coliforms and *E.coli* (*Escherichia coli)* bacteria (Newton 2008).

Data from MoH indicates that there has been an increase in water related diseases since 1996 (Kingston, 2004); cases of diarrhea and gastroenteritis incurred a 30% increase in reported cases over a 4 year period, for example (It is noted that the cause of diarrhea and gastroenteritis is not necessarily the water supply). The last case of a typhoid outbreak was at least 10 years ago, and MoH report that it appears to be restricted to confined areas (for example, low lying areas). The isolated cases that have been presented more recently, MoH report, are related to food contamination and hygiene practices rather than water supply and sanitation conditions (MoH, personal communication, 2011). MoH reported that in the last 2 years there has only been 1 reported case of typhoid, and the last dengue outbreak was in 2003 and since then only isolated cases have been presented (307 cases of dengue fever were reported in 2009 (MoH, 2010)).

MoH performs monthly biological water quality tests (total coliforms and *E.Coli*) on village water supplies within Tongatapu and recently has started storing this data digitally (although the database suggests the testing occurs less frequently than monthly). If the faecal coliform colony count is >1 MPN/100ml then the sample is considered unsuitable for consumption. In which case, MoH will treat the reservoir with chlorine and inspect the site to see if there is any visible reason for contamination. In

the database, out of 1073 samples (note, some samples are from non village well locations), only 48 have a total coliform count of 1 or less. The average total coliform count out of the 1073 samples is 199 MPN/100ml and the average count of *E. Coli* bacteria is 23 MPN/100ml. There are many villages that repeatedly report high coliform counts; it is clear there is a need for more thorough investigations into the cause of contamination in order to mitigate the potential health effects.

Chamberlain et al. (2010) report that the number of reported skin infection cases (and other presenting diseases) in two low lying, flooding prone villages in Tongatapu (Popua and Patangata) has a high correlation with rainfall and associated flooding. These results indicate the spread of water related diseases is greater during times of flooding, which also mobilizes contaminants located on the ground surface, underground and within the water table.

Several stakeholders reported that water-related diseases are common and happen, but they are far less of a concern for the Tongan people compared to non-communicable diseases, such as lifestyle related illnesses (diabetes, for example). Non-communicable diseases are also the primary focus of efforts for the Tongan WHO office, as they recognize non-communicable diseases as the biggest health issue in Tonga at present (WHO Tonga Office, personal communication, 2011).

5.2 Trends

The life expectancy at birth of Tongans is currently estimated at 72 years, which is significantly less than Australia and New Zealand (at 82 and 80 years, respectively), on par with Samoa, and higher than Fiji and the global average (69 years) (Figure 20) (World Bank, 2011). Tonga as a nation appears to be getting healthier at a slower rate than in the past, indicated by the rate change of life expectancy at birth slowing to a plateau within the last few decades (Figure 20). According to MoH, this is due to the increase of non-communicable diseases, such as diabetes and other lifestyle diseases (MoH, personal communication, 2011).

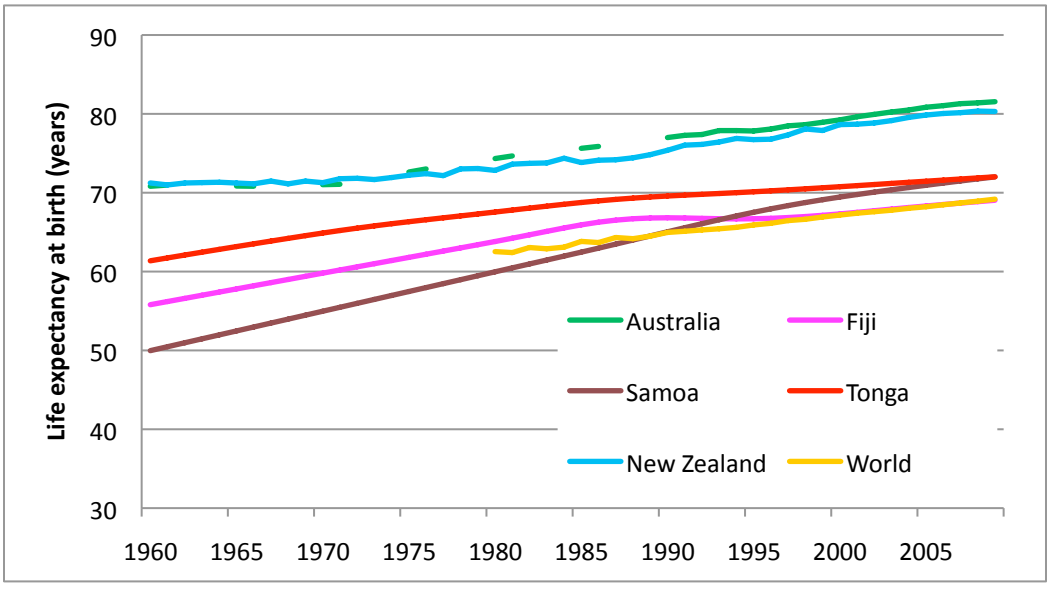

Figure 20: 50 year trend of life expectancy at birth for Tonga, selected neighbouring countries, and global life expectancy. (World Bank, 2011).

Kingston (2004) reports that there has been an increase in water related diseases since 1994, with an almost 30% increase in reported cases of diarrhoea and gastroenteritis in a 4 year period. Water and sanitation related diseases that MoH collect data on are typhoid, dengue and gastroenteritis. Trends within these diseases are discussed following.

According to data contained within MoH annual reports, the incidence of typhoid fever (which is transmitted by the ingestion of food or water contaminated with the feces of an infected person, which contain the bacterium *Salmonella typhi* or *Salmonella paratyphi)* has significantly declined over the last 10 years (Figure 21). MoH attributes this to improved and cleaner water supplies as well as better hygiene and sanitation practices of the people of Tonga (MoH, 2010), although perhaps longer term data is needed to see if this is actually the case.

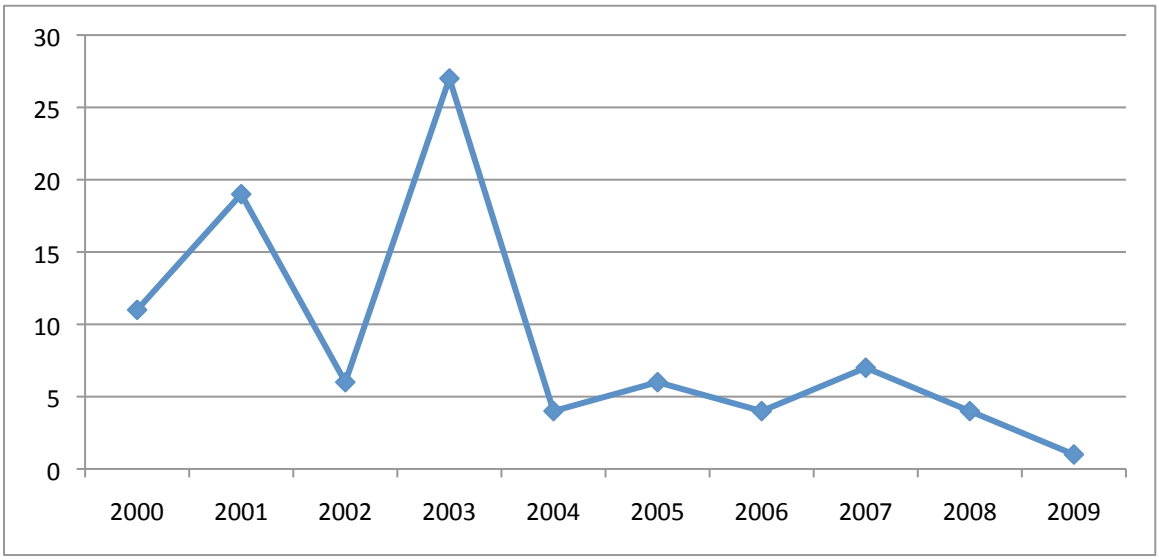

Figure 21: Annual diagnosed cases of typhoid (*Salmonella typhi* and *Salmonella paratyphi)* within Tonga. (MoH Annual reports, 2001-2009; Kingston, 2004).

There have been a significant number of cases of confirmed/suspected dengue fever over the last few years (Figure 22). The data in Figure 22 only represents people who sought medical help, so it is likely there were more cases. Dengue fever occurs in most of the South Pacific and is caused by a mosquito which predominates in urban environments, and although it prefers to breed in man-made containers (such as poorly maintained water tanks), there is also a possibility that receding floodwaters provide an ideal breeding habitat (Few et al., 2004). Dengue fever often occurs in outbreaks within certain areas, particularly areas that are prone to flooding where mosquitoes are likely to breed and reside. During the wet season the incidences of dengue fever have also been found to increase, as the wet conditions and accumulation of water provide favourable conditions for mosquitoes to breed (Chamberlain et al., 2010). During 2008, the age group that was mostly affected by dengue was the 11-20 year old group; this is because this particular age group is very mobile and is less likely to use personal protection against the *aedes aegypti* mosquitoes that carry the dengue virus (MoH, 2009).

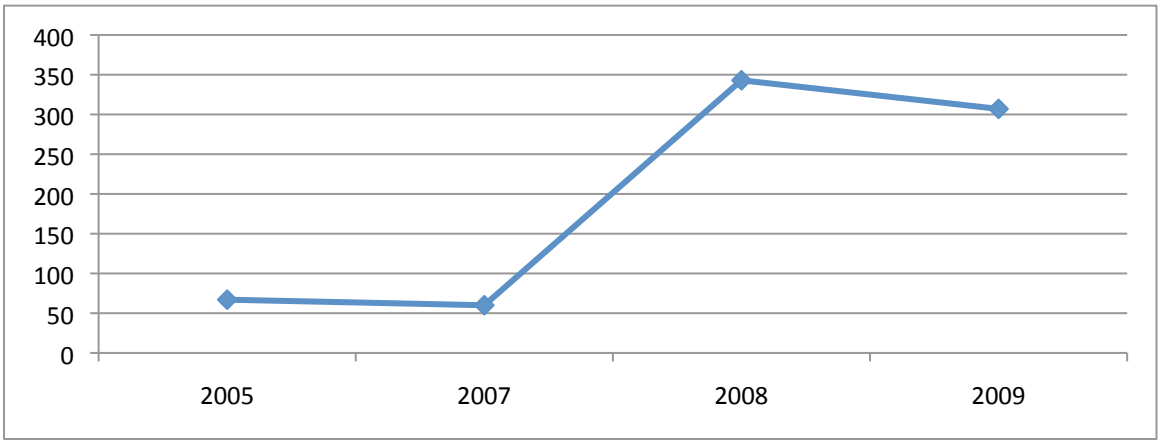

Figure 22: Dengue fever cases confirmed/reported for years 2005-2009 (note, 2006 data is not included). (MoH, 2006-2010).

In 2007, and most years, more than 50% of the patients admitted with diseases related to digestive system are aged 1-12. The majority of these patients suffered from gastroenteritis (MoH, 2008). Figure 23 shows admissions of infants presenting with diarrhea with a significant increase in admissions since 1989. Acute gastroenteritis accounts for about 10% of all paediatric admissions (MoH, 2010). Diarrheal disease has been linked to seasonal rainfall and flooding, and can be caused by both viral and bacterial pathogens (Chamberlain et al., 2010). This is observed in the paediatric admissions data for gastroenteritis, where admissions appear to be higher during the wetter months (summer: December, January, February) (Figure 24), and is likely to be linked with increased flooding and mobilization of contaminants within the groundwater. Gastroenteritis admissions amongst paediatrics remained high for the 3 years of 2006-2008 (Figure 24).

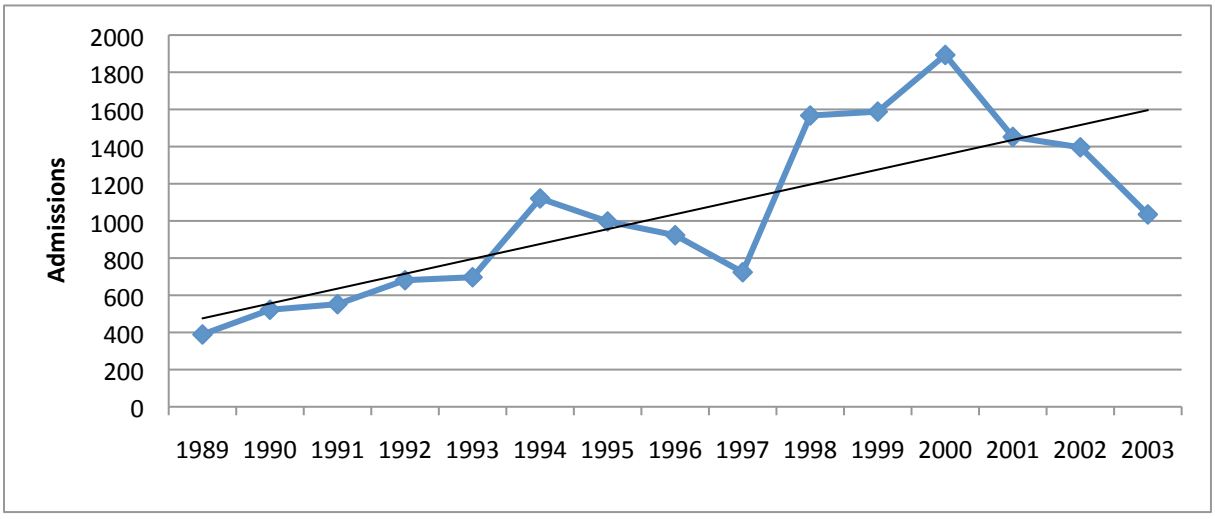

Figure 23: Admissions of infants presenting diarrhea in Tonga, 1989-2003 (MoH in GoT, 2005)

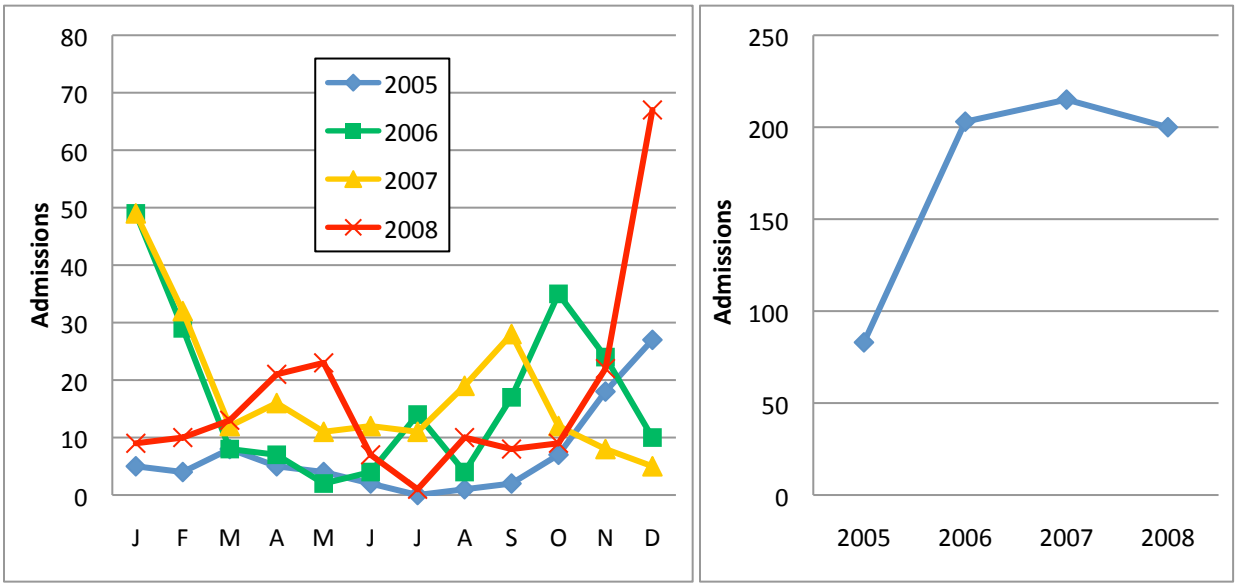

Figure 24: Gastroenteritis admissions per month (paediactric ward) (left). Gastroenteritis admissions per year (paediatric ward) (right). (MoH Annual Reports, 2005-2009)

5.3 Current issues

The following are current issues with respect to sanitation and human health that have been collated from interviews with stakeholders.

5.3.1 Contamination of water resources from sanitation facilities

Effluent from septic tanks and seepage from pit latrines can cause pollution in shallow aquifers (Crennan, 2001). A study in Pangai, Ha'apai, showed how contaminants migrate underground and the importance of sanitation facilities not being too close to a water supply (Crennan, 2001). The study showed that, in the type of soil and geology around Pangai, contaminants can flow at a rate of about 5m per fortnight in all directions. Crennan (2001) reports that some micro-organisms responsible for waterborne disease (for example viruses) can reside for indefinite periods in cool wet conditions, such as groundwater, and other pathogens could at least survive the time taken from diffusion from a toilet to a well within 100m in any direction. The Public Health Act 1992 states "no pit latrine shall be constructed within 30m of any public or domestic water supply" (section 108.1) and does not stipulate on distance required between septic tanks and wells. Waste from animals, such as pigs, can also penetrate the groundwater and contaminate the water supply. In light of the results of Crennan's report, it appears this regulation is not sufficient to mitigate the effect of contamination of water supplies from sanitation facilities, and in accordance with the MoH faecal coliform database, water supply contamination from sanitation facilities is a significant problem. It is also important to restrict roaming animals from around the well site. Figure 25 shows an example of a well that has close proximity of pit latrine and roaming animals; photograph was taken standing at the pump house.

Figure 25: Nomuka, Ha'apai, solar panel that powers pump, with pit latrine and roaming pig in the background (red circle), not more than 30m away. Photo was taking standing next to pump house. (Nicola Fry, 2010)

5.3.2 *Lack of maintenance of private sanitation facilities*

In addition to the normal outflow of functioning septic tanks contaminating the groundwater resources over time, unmaintained septic tanks are a large contributor to pollution. As mentioned previously, according to the GEF-IWRM project survey (2010), 85% of septic tanks in Neiafu have never been emptied by pumping and the IWP survey revealed 41% of septic tanks in Nukuhetulu have never been emptied (Prescott et al., 2007); this should occur approximately every 5 years (depending on size of tank and size of household) (Crennan and Mafi, 2007). In addition, it is reported that some tanks are never pumped because they have no base to the tank, or it has disintegrated over time, which raises significant concerns about the amount of contaminants released into the groundwater, lagoon and marine environment (Crennan and Mafi, 2007; Fakatave et al., 2000).

5.3.3 *Lack of community awareness and stigma*

The topic of toilets and sanitation is traditionally a taboo topic in Tongan culture, and as such, historically, has not received much discussion or education around the subject (Newton, 2008). For example, during the GEF-IWRM project survey, it was found that 98% of people surveyed do not know how a septic tank works. Community understanding of hygiene and sanitation practices is vital for the health of Tongans and the Tongan environment. Stakeholders commented that frequently public toilet facilities (at the Talamahau Market or Vaiola Hospital, for example) are nonfunctioning due to people's abuse of the facilities via incorrect use, such as using cloth instead of toilet paper and blocking the pipes; although, the question remains whether this behavior is due to naivety or carelessness. It is also apparent, when conducting village water supply site visits, that community knowledge on the way contaminants can move through the ground or soil is limited, in that it is possible for a pit latrine to contaminate a water source that is 50m away. Several awareness and community education campaigns on IWRM topics have occurred within in Tonga in the past (refer to Crennan and Mafi (2007) for discussion), and were conducted through public meetings, school presentations, TV programs, theatre,

and radio broadcasts. Crennan (2001) reports a major shift in perception and behaviour that would contribute to a sustainable use of groundwater and reduction of water-borne disease could only be achieved by a comprehensive long term consultation, information and education program, and extensive demonstration of strategies that provide practical solutions such as pollution source control. There is a need for ongoing education and available awareness information, perhaps being embedded in school curriculums or Government informative websites.

5.3.4 *Solid waste disposal*

Not only resulting in aesthetic pollution, which has been proven to deter tourists (Lau and Takau, 2006), the practice of dumping rubbish in areas other than designated rubbish dumps is also a health concern, particularly in times of high rainfall and flooding, when contaminants are likely to become more mobile (Chamberlain et al., 2010). SKM (2000) claimed that the dumping of waste in open pits without adequate control and management can result in serious public health and safety problems, in addition to the clearly negative environmental impact. Contaminants such as heavy and trace metals (from electronic waste, for example) and pathogens (from used diapers, for example) can easily become mobile and contaminate water leading to skin infections, diarrhoea and other serious conditions; this is particularly risky to children who often spend more time playing outside in flooded areas.

5.4 Emerging threats

5.4.1 *Climate change*

The impacts of climate change (sea level rise and increased heavy rainfall/flooding events) will likely make the current issues, such as contamination of groundwater resources and solid waste disposal impacting on health, more threatening. With the predicted increase in heavy rainfall and flooding events in the future, the contaminants (from leaking septic tanks and improperly managed solid waste) will be more mobile within the ground and within flood waters, and will be available to impact on human health. Sea level rise and an increase in flood frequency will also have a significant impact mobilising contaminants in areas where shallow septic tanks are constructed, as they are not designed to be below the water table.

5.4.2 *Population growth and economic development*

If septic tanks remain the main method of managing human waste, pressures of population growth and economic development will lead to an increase in number of tanks and the overall density of tanks, particularly in urban areas, such as Nuku'alofa. 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 km^2 as having potential contamination problems (Dillon, 1996 in Crennan, 2001). A study in Pangai in 2001 reported a density of at least 300 toilets per square kilometer, which would indicate widespread contamination of the aquifer (Crennan, 2001). Further, assuming 1 septic tank per household, Tongatapu has approximately 45 septic tanks per km^2, Kolomotu'a, Nuku'alofa has approximately 103 tanks per km^2 and there are approximately 242 tanks per km^2 for Kolofo'ou (derived from the 2006 Census). These numbers are likely to increase with increasing pressures of population growth and economic development, leading to even further groundwater contamination and threat to human health.

5.5 Recommendations/ Way forward

Apart from the recommendations already discussed in section 5.3, the following recommendations are proposed.

5.5.1 Thorough investigations into contamination source of village water supplies

As a result of the a high prevalence of faecal coliforms and *E. Coli* detected within village water supply water samples and also the repeated detection of these disease causing pathogens within many villages, efforts need to be focused to undertake through investigations as to the cause of the contaminants and to mitigate these threats, rather than just simply treating the water within the reservoir. The reservoir is only treated once by MoH after being detected and the treatment will only last as long as the water is present within the tank, which is usually 1 or 2 days. If the source of the contaminant prevails, such as a leaking septic tank, then the remaining days of the month prior to the next visit by MoH staff will continue to supply contaminated water to the village. At least, with most people relying on rainwater as their drinking water source, there is less of a chance of ingesting the pathogens and becoming ill; however the risk of illness (including skin disorders and other water related diseases) is still there, and the risk of illness increases during times of flooding.

5.5.2 Reticulated sewage system

The PUMA department of MLSNR is currently investigating the feasibility of constructing a reticulated sewage system and treatment plant for Nuku'alofa. This would reduce the reliance on septic tanks for the Nuku'alofa urban area and reduce the amount of contamination of groundwater, lagoonal and marine water from septic leakages. It should be noted, however, that Crennan and Mafi (2007) reports the implementation of a reticulated sewage system may actually 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.

5.5.3 Community awareness

As mentioned previously, most people rely on rainwater as their drinking water source yet many householders do not regularly clean or maintain their rainwater tanks or have first flush diverters installed to prevent risk of disease (GEF-IWRM Project Survey, 2010). In addition, as mentioned previously 98% of surveyed people in Neiafu do not know how a septic tank works. Community awareness and education is needed in order to help the population reduce their own risk to disease as well as their potential impact of polluting the environment.

6 Environment

6.1 Current status/situation

Tonga is considered extremely vulnerable on the Environmental Vulnerability Index (EVI) and has a high score of 392[5]. Some of the identified issues of greatest environmental vulnerability are natural disasters (eg volcanoes), loss of biodiversity, and impacts on low lying land areas.

6.1.1 Pollution sources

Pollution is a problem largely arising from increasing utilisation of fossil fuel, improper solid waste disposal, pesticide and fertilizer runoff into the groundwater lens and sea, and random waste disposal by seagoing vessels (GoT, 2009). Littering and indiscriminate dumping of solid waste are major concerns in urban areas; beaches, vacant land and roadsides are seen as dumping grounds for old vehicles and other metal parts that cannot be burned, diapers, wholesale/retail waste and domestic waste (Strategic Development Plan, 2009).

Pesticides and fertilizers are abundantly used in agriculture, and Persistent Organic Pollutants (POPs) and other chemicals are used in other industries such as power supply and construction. The waste from these pollutants is not properly disposed of, leading to runoff into the ocean, which has detrimental effects on marine organisms, and seepage into groundwater, which becomes a health hazard (GoT, 2009). There is a general lack of information about the types and volumes of chemicals stored and a poor understanding within the wider community of the potential dangers of certain chemicals and how to use and store chemicals (GoT, 2009).

Ship traffic is high in Tonga, with containerships arriving weekly and several inter-island ferries running weekly or daily. Also, about 500 yachts arrive in the Port of Refuge harbour in Vava'u every year (GoT, 2009). There has been no effective regulation of the waste dumped from all these vessels.

Other causes of pollution are the burning of trash and garden waste, combustion of fossil fuel, leaking of septic tanks/latrines, and deforestation. As mentioned previously, according to the 2006 Census, the most common form of waste disposal by households is burning (85%).

Agrichemicals

The use of pesticides and fertilisers is the major concern in relation to the impact of agriculture on the underground water resources (Crennan and Mafi, 2007). Application of fertilisers has grown from 5kg/hectare at the end of the 1980s to 80kg/hectare at the end of the 1990s, and there is anecdotal evidence that eutrophication of the lagoon at points where groundwater is seeping through may be caused by artificial fertilisers (Crennan and Mafi, 2007). 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; White et al., 2009). It is also assumed that coral die-off can be attributed to a combination of nutrient run-off from urban and agricultural sources (Crennan and Mafi, 2007). MAFFF records annual imports of fertilizers and pesticides, and in 2009 26,213kg of pesticides (herbicides, insecticides and fungicides)

[5] http://www.vulnerabilityindex.net/index.htm viewed 11th July, 2011.

were imported (MAFFF, 2010). 55% of all imports were of the herbicide paraquot. The high import amount of the herbicide, *paraquat*, directly relates to the high cost of labour and the vigorous growth of weeds related to higher rainfall years in the last 5 years (MAFFF, 2010). MAFFF conducts training for farmers to choose the right pesticides for each pest, the right rate, the right methods of application, the proper safety gear and precautions, the safe withholding period after the last application before harvest and the proper storage of pesticides and also public awareness programs on the radio regarding use of pesticides (MAFFF, 2010).

Nutrients

High amounts of substances like ammonium, nitrate and phosphate typically represent waters polluted with human waste (household rubbish and/or sewage), agricultural waste (fertilizer), and animal waste (sewage). Nutrients, particularly nitrate and nitrite, are of concern in groundwater in Tonga due to the use of fertilisers, leakage from septic tanks and contamination from animal waste. High levels of nutrients can lead to algal blooms in lagoons (from the discharge of high nitrate-rich groundwater into the lagoon or from surface runoff) (Fakatava et al., 2000; White et al., 2009), which may lead to potential health issues from consuming seafood harvested in contaminated areas. High levels of nitrate and nitrite can also lead to methaemoglobinaemia ("blue-baby syndrome") in bottle fed infants, and can potentially be fatal (White et al., 2009).

6.1.2 Groundwater health

Testing for pesticides, hydrocarbons and some trace elements was conducted on selected water supplies in Tongatapu (White et al., 2009), and also reported in van der Velde (2006, and references therein). Results suggest that some movement of agrichemicals has occurred towards the groundwater, although in the samples of White et al. (2009) results were all below the limit of detection. Detection of other metals, such as nickel, lead, copper, zinc was found in some well water samples during testing (White et al., 2009), however, results were all under the recommended WHO guidelines.

Basic nutrient testing can be performed by Geology, MLSNR, although it is not part of the routine monitoring. Basic nutrient testing in TWB wells from Neiafu (GEF-IWRM project, 2011) indicated that agriculture and other pollution sources are not being influencing the groundwater quality, this may be due to the deep water table in this area (~22-30m), and that pollution has not infiltrated that deep. Other nutrient testing was performed during White et al.'s study (2009) and found that in the selected samples all results were below the WHO guidelines for drinking water. Nutrient testing is currently being performed monthly as part of the Tonga Integrated Urban Sector Development project by SMEC/MoW on groundwater samples around Nuku'alofa and from the lagoon.

6.1.3 Lagoon health

A good indicator for the environmental health of Tongatapu may be provided by the state of Tongatapu's internal lagoon (Fanga'uta Lagoon), this is especially so since the lagoon is relatively sheltered from oceanic influences (van der Velde, 2006). Over time, there has been a decrease in water clarity of the lagoon and nutrient concentrations have generally increased (van der Velde, 2006). The western side of the lagoon appears to be affected from pollution influences from Nuku'alofa and is the least healthy part of the lagoon (Fakatave et al., 2000).

The Fanga'uta Lagoon had for many centuries supported an important mullet fishery, although commercial fishing in the lagoon is now banned. Declines in catches from 1960 onwards led to the lagoon being temporarily closed for commercial fishing in 1975, it was subsequently reopened in 1981, the ban on fishing was reintroduced in 1991 but fishing still occurred in limited numbers (Prescott et al., 2001; van der Velde, 2006; Fakatave et al., 2000). Currently, the Tongan mullet industry has disappeared and mullet is imported from Australia (Stakeholder, personal correspondence, 2011).

Since 1980, there have been increases in salinity, nutrients, faecal coliforms detected in all parts of Fanga'uta Lagoon, indicating impacts from urban development. The faecal coliform counts (up to 240 colonies per 100ml), nitrate levels (up to 520µg/L) and phosphate levels (4305µg/L) detected during Fakatave et al.'s (2000) study exceed the Australian standards for recreational use, seafood and algal blooms. A lack of adequate soakage areas for houses close to the lagoon is believed to lead to septic tank overflow and runoff during heavy rain events (Chamberlain et al., 2010).

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 (Crennan and Mafi, 2007). In addition, there are concerns that fish harvested in these areas, particularly shell fish, may be contaminated (Crennan and Mafi, 2007; Prescott et al., 2001).

Prescott et al. (2001) report 71% of people responding to a household surveys were of the opinion that the major cause of pollution in Tonga was laziness and carelessness of the people; secondary causes were seen as the importation of too many products into the country (38%) and the effects of development. Low-grade, reconditioned vehicles and disposable nappies were identified as the worst imports.

There are also reports of nutrient overloads in the Vava'u habour (lagoon) as a result of yachts unloading sludge into the water (MECC, personal communication, 2011).

6.1.4 Marine health

In addition to coral bleaching as a result of annual mean temperature increases (JNAP, 2010) the health of the marine life is being noticed to have an effect on the livelihoods of fishermen. Stakeholders report that the price of fish has increased in recent times as a result of less fish in the sea (due to overfishing and pollution), and there has been an increase in imported fish from overseas (mullet from Australia, for example) (Stakeholders, personal communication, 2011). There are also speculations that cemeteries located by the sea, in addition to septic tanks, are leaching nutrients into the groundwater and marine zones, causing nutrient imbalances and impacting on marine life (MECC, personal communication, 2011).

6.1.5 Data collection

Environmental indicator data is rarely routinely collected by the Government of Tonga due to budgetary limitations. Most data that exists is a result of project work and is only collected during the lifespan of the project. A National Monitoring Team was established in 2000, lead by MECC, to monitor the state of the environment in Tonga, however, funding constraints have limited the amount of work that has been carried out (MECC, personal communication, 2011). Unfortunately, many of the previous environmental

indicator reports have been lost due to unfortunate data storage facilities at MECC (which is not an uncommon situation in other agencies).

6.2 Trends

Without a comprehensive environmental indicator database, it is difficult to assess the trends of the health of the environment with respect to water and sanitation. The few studies performed on the Fanga'uta Lagoon (Fakatave et al., 2000, and references therein) indicate that overall the water quality is declining due to impacts from urban development, although there are some areas in the eastern sections that are improving in health (increased clarity and dissolved oxygen levels). White et al. (2009) present a thorough summary of the trends in groundwater pollutants within Tongatapu, of which the major points are mentioned following.

- There was no discernible temporal trend in pesticide contamination, and very few pesticides were detected above the limit of detection, but well below the WHO guidelines.
- Heavy metal concentrations sampled in groundwater around the Tapuhia waste disposal site in Tongatapu do not show an increase from 2007-2009, and are well below WHO guidelines.
- There was no significant increasing trend of nitrate or phosphorus between 1978 and 2007, despite the significant increase in imports of fertilisers since 1988. This indicates that fertilisers are not the sole source of nitrate into groundwater and further study indicated that human and animal waste constitutes a significant source of nutrients in groundwater.

6.3 Current issues

The following are current issues with respect to the environment that have been collated from interviews with stakeholders.

6.3.1 Environmental Impact Assessment Act 2003 not being enforced

Stakeholders have reported that the requirement to have an EIA conducted prior to implementation of a project that may impact on the health of the environment is mostly not being performed or enforced. The reasons given for why this is not happening is due to low resources in MECC to undertake the assessments as well as some political pressures that may require particular projects to start by a certain timeframe, which makes an EIA not possible.

6.3.2 Harbour water from sludge

It has been reported (MECC, personal communication, 2011) that there are significant amounts of sewage being dumped from visiting yachts into the Port of Refuge Harbour in Neiafu, which is having a large impact on the marine environment. A study would need to be performed to assess the impact that is occurring and to provide mitigation advice.

6.3.3 Lagoon water quality

As mentioned previously, the water quality of the lagoon is declining and affecting the biodiversity of the lagoon environment, including fish stocks and land plants.

6.3.4 *Lack and loss of data, and no ongoing data collection*

There is a severe lack of environmental indicator data and, in particular, there are currently no ongoing routine monitoring tasks, due to a lack of resources within MECC. All monitoring efforts that currently occur are project driven. The data that has been collected in the past also may no longer exist due to substantial loss of files for various reasons. It is essential to start collecting this data on a frequent basis in order to establish the current and predicted situations of Tonga's environment.

6.3.5 *Lack of information on use of agricultural nutrients and fertilisers*

According to White et al. (2009), there are partial statistics available for the importation into Tonga of agricultural chemicals and fertilisers, however, knowledge of where these chemicals are being used and the rates and amounts of application would greatly assist in the ability to identify potential contamination sources.

6.3.6 *Minimal "care" from local citizens*

Many Tongans believe the reason the environment needs to be clean is to attract tourists rather than for the sake of Tonga (Vi, 2002). Prescott et al. (2001) report 71% of people responding to a household surveys were of the opinion that the major cause of pollution in Tonga was laziness and carelessness of the people. Despite multiple public awareness campaigns littering and burning of unsafe products (plastics, for example) are still common practices within Tonga. Awareness is the first step; changing behaviour, practices and the care of the people is the second step, and this is yet to be achieved (Stakeholders, personal communication, 2011).

6.4 Emerging threats

With increasing pressures from population growth and economic development, pollution, deforestation, and loss of biodiversity are only likely to increase without changes in behaviour of the Tongan people.

6.4.1 *Increased waste – e-waste*

Population growth and economic development will lead to the introduction of even more imported un-natural products, which produce a lot of non-biodegradable waste. In addition, e-waste is a fast growing problem within Tonga and the Pacific with high numbers of electronics, phones and second hand computers being imported without plans for safe and effective disposal. Tonga and other Pacific Island nations face the issue of dealing with mountains of hazardous e-waste with serious consequences for the environment and public health (Matangi Tonga Online, 2010). The toxic components found in electronics, if not disposed of correctly are attributed to a range of potentially lethal conditions including cardiovascular disease, cancer, diabetes, respiratory problems, nervous system damage and blood, brain, liver and kidney disorders. The organisation E-waste Tonga is currently working towards improving this situation.

6.5 Recommendations/ Way forward

Apart from the recommendations already discussed in section 6.3, the following recommendations are proposed.

6.5.1 *Discrete budget line for routine monitoring of environmental indicators and EIAs*

A discrete budget line is required by the Government to ensure regular, routine monitoring of environmental indictors is being performed as well as capacity provided to undertake EIAs, which would enable the Environmental Impact Assessment Act 2003 to be enforced.

6.5.2 *Development of a central database/archive*

The construction of a central database and archive backup for environmental data and reports is essential to ensure the work that has been done is not lost and remains valuable. This is also relevant for all sectors within the Ministries.

6.5.3 *Continued community awareness campaigns*

Community education and awareness campaigns are vital to install a sense of "care for the environment" within the population. Campaigns either need to be long term or frequent short term in order to be able to develop a change in perception and behaviour with respect to protection of the environment.

7 Resilience to climate variability and to climate change

7.1 Current status/situation

Tonga's susceptibility to the impacts of climate change is principally due to its geographical, geological and socio-economic characteristics (JNAP, 2010).

7.1.1 Agency focus

The Tongan Government, particularly MECC and NDMO, are doing a lot of good work in preparation for the emerging threat of climate change and natural disasters. There are currently several large projects with climate change as a focus currently operating, and some of these have parts that relate to water. One project in particular, PACC, is attempting to construct a Water policy that has climate change mainstreamed into water regulations.

TWB is starting to build climate change into their business plan, including allocating some budget to climate change awareness programs (TWB, personal communication, 2011). Climate change as a topic is now being taught in high schools in Forms 4 and 5, although the teachers report that it is difficult to access information that is relevant to Tonga (Stakeholders, personal communication, 2011).

7.1.2 Climate variability - ENSO

The El Niño-Southern Oscillation (ENSO) is a quasiperiodic, interannual climatic phenomenon. It influences the location of the South Pacific Convergence Zone (SPCZ) that moves northeast during El Niño and southwest during La Niña events. ENSO impacts the hydrological cycle, and it has been related to floods and droughts, river discharge, soil moisture, coastal water quality, and sea surface salinity (Glantz, 2001, in van de Velde et al., 2006). The El Niño event usually happens once in every 3-7 years when the warm sea surface temperatures move eastwards, resulting in reduced rainfall or drought conditions within Tonga (JNAP, 2010). The last 3 major droughts that occurred in Tonga are in 1983, 1998 and 2006 and all directly link to El Niño events (JNAP, 2010). El Niño also impacts on the marine life and fisheries sector due to increased sea temperatures, usually reducing overall catches and significantly impacting on revenue in Tonga (JNAP, 2010).

7.1.3 Observed long term climate change effects and trends

Increased heavy rainfall events and decreased rainfall overall

Shown in Figure 26 is the annual mean rainfall for the 5 islands groups from data collected at each island group's meteorological station from 1971-2000 (TMS data).

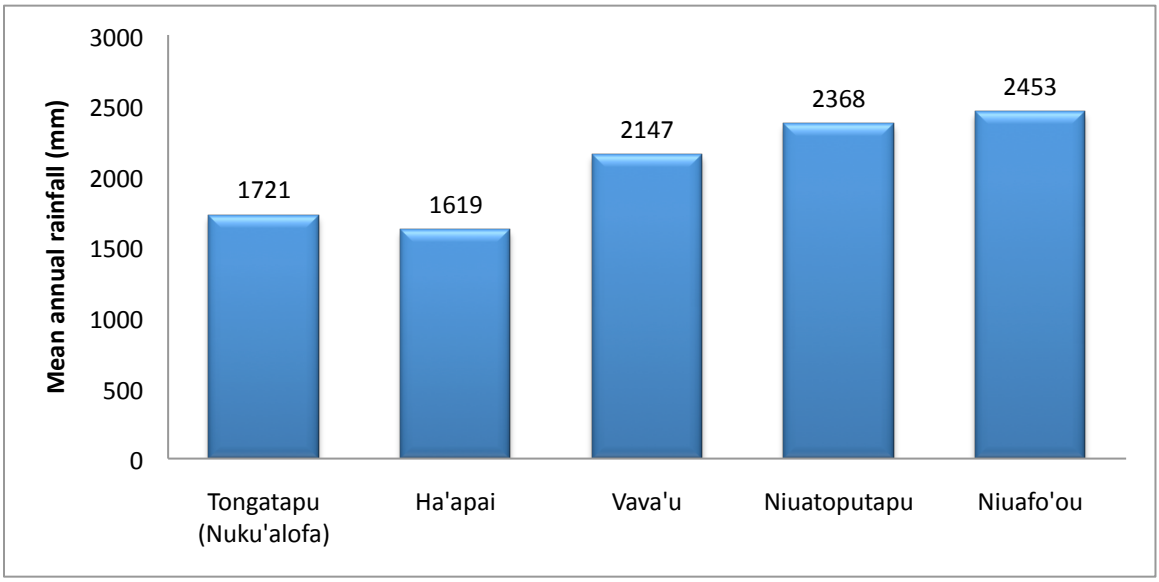

Figure 26: Mean annual rainfall collected at meteorological stations within each island group between 1971 -2000 (TMS data)

Tonga has occasionally received heavy rainfall, which causes flooding and prolonged collection of water posing damage to infrastructure and health risks with the outbreak of water borne and vector diseases, such as dengue fever (JNAP, 2010). Heavy rainfall also has affected the agriculture sector; causing difficult conditions for some crops (JNAP, 2010). Heavy rainfall also has increased surface runoff and the mobilisation of pollution into coastal areas and lagoons (JNAP, 2010).

As mentioned previously droughts in Tonga are generally linked with El Niño events. The last 4 strong El Niño events were recorded in 2009-2010, 1997-98, 1991-1992 and 1982-83[6] and all of these link with reduced rainfall in Tonga (Figure 27). Severe droughts can significantly affect the economy and livelihood of the people and food supply. The severe droughts recorded in the past caused stunted growth in sweet potatoes and coconuts and of root crops (JNAP, 2010). Livestock, particularly on the smaller islands, were also severely affected. The cost of droughts on the Government of Tonga is a large burden; in the 1997-98 El Niño period, the Government spent TOP$200,000 on shipping water to Ha'apai, for example (JNAP, 2010). Droughts can potentially cause health and sanitation problem due to increased dust and contamination in the air and water shortages, causing diarrhea, respiratory diseases and skin diseases (JNAP, 2010). El Niño drought periods are also associated with an observable increase in salinity in groundwater wells, due to lack of recharge of freshwater (van de Velde et al., 2006).

[6] http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

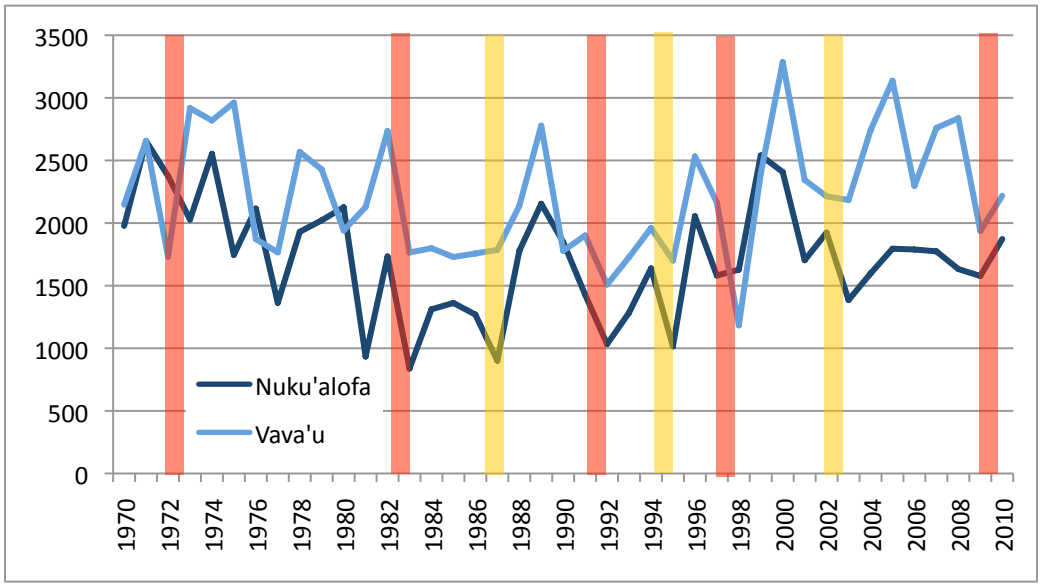

Figure 27: Annual rainfall for Nuku'alofa (dark blue) and Vava'u (light blue), lined up with El Niño periods (red=strong, orange = moderate El Niño events) (TMS data and NOAA, 2011).

Increased temperature

Based on historical climate data from 1971-2007 for Nuku'alofa, Ha'apai, Vava'u and Niuatoputapu, it appears there is an overall increase in annual mean air temperature of about 0.4-0.9°C (JNAP, 2010). There also appears to be a slight increase in sea temperature of 0.057°C per decade, according to data from the Nuku'alofa tide gauge (JNAP, 2010). The effects of this increase in temperature include health effects (increased asthma and heat stress), agricultural effects (reduced soil moisture and fertility leading to less crop yield), increased evapotranspiration (leads to less available water for recharge into the freshwater lens), coral bleaching and coral mortality (leads to effects on fisheries sector due to a reduction in reef species habitats and reduction of reef species) (JNAP, 2010).

Sea level rise

According to data from the two Nuku'alofa tide gauges, the sea level change trend appears to be +6.4mm per year (older gauge) and +9.5mm per year (SEAFRAME gauge, 1993-2007) (AusAID, 2009; JNAP, 2010). This change in sea level is already being observed by an increase in coastal erosion (also an effect of cyclones and storms), removal of coral life and coastal vegetation (JNAP, 2010). Low lying areas that are already subject to tidal inundation (for example, Popua and Nukunukumotu, Tongatapu) are already noticing an increase in inundation (JNAP, 2010). Sea level rise can also affect the volume of freshwater available underground and also have an impact on agriculture.

Increased frequency and intensity of tropical cyclones/storms

Figure 28 shows an increasing trend in the occurrences of tropical cyclones in Tonga on a decadal basis. In the past there have been several cyclones that severely affect the islands of Tonga, including Cyclone Renee in 2010, which cause severe damages to crops and food supplies, infrastructure, tourist resorts, vegetation, buildings and disrupt essential services and the wellbeing of the people of the affected communities for some time after the event (JNAP, 2010).

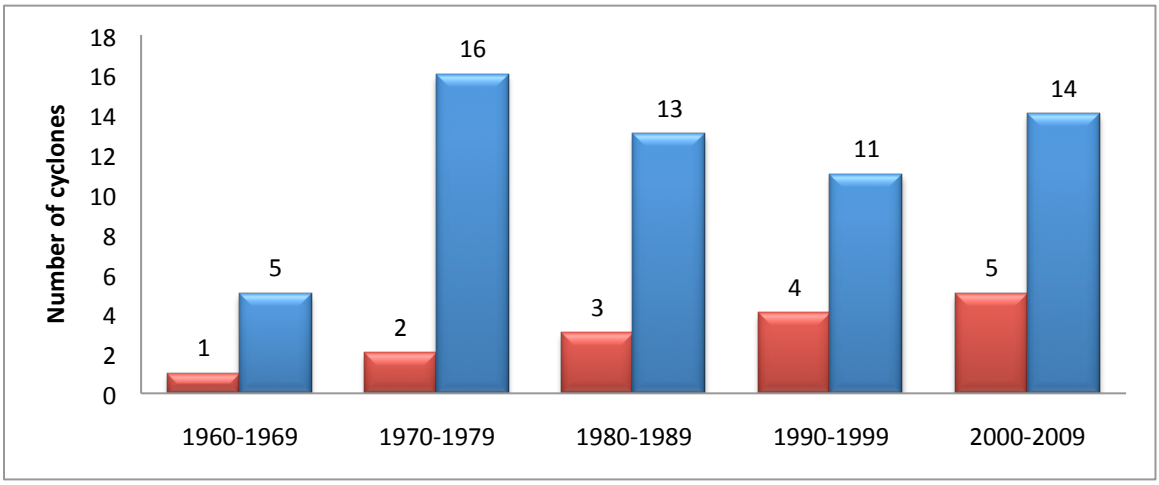

Figure 28: Decadal occurrences of tropical cyclones in Tonga, 1960-2011 (TMS data)

Apart from the destructive effects of damaging water supply infrastructure, cyclones have also impacted on the quality of the water by causing sea water intrusion into the freshwater lens by inundating wells and land surface close to the sea with salt water during large waves or winds (Crennan and Mafi, 2007). For example, the recently (2010) upgraded well on Kotu Island, Ha'apai (Figure 29) was producing water of good quality for several months until Cyclone Wilma impacted in January 2011; sea water surged over the area and apparently went down the well shaft contaminating the freshwater with salty water for months afterwards (Kotu Village spokesperson, personal communication, 2011).

Figure 29: The new well at Kotu Island, Ha'apai, installed in late 2010. The well was producing good water until Cyclone Wilma (27/1/11) washed sea water down the well and made the groundwater salty for a period of time. (MLSNR data, 2011)

7.2 Current issues

Apart from the specific impacts of climate change, the following are current issues with respect to the climate change and water and sanitation that have been collated from interviews with stakeholders.

7.2.1 Lack of data, and good data and good presentation of data

In addition to other areas lacking data, it is important to routinely collect climate change indicator data. TMS are very active in climatic data collection and sharing, and MLSNR holds the sea gauge data. Stakeholders reported that it is also important to make sure the integrity of this data is high and be able to present it in a way that is easy to interpret and have it easily available and stored in a way for access for all people.

7.2.2 Lack of educational resources

As mentioned previously, it has been reported by stakeholders that there is a lack of educational resources available to teachers, school children and the community regarding climate change and its impacts, particularly specifically regarding to Tonga.

7.2.3 Surface drainage

Currently, the infrastructure does not exist to provide adequate surface drainage in urban and low lying populated areas during and after high rainfall events. There are frequent moderate to heavy rainfall events throughout Tonga, particularly in the period November – April, that result in significant pooling of water along roads other land surfaces, particularly in urban built up areas. This often leads to disruption of schooling (schools are often closed due to heavy rainfall), traffic and damage to infrastructure, in particular roads (Belz, 1985). A planned focus on drainage development, reclamation of land and possible ruling out of certain flooding prone areas for further development is required before the effects of climate change become more severe.

7.3 Emerging threats and impacts on water and sanitation

The predicted long term changes in climatic parameters for Tonga are as follows (JNAP, 2010):

- Reduced overall rainfall
- Higher occurrences of heavy rainfall
- Increased sea level
- Increased frequency and intensity of tropical cyclones, and
- Increased average temperature.

Many of these are already starting to be observed and their follow on effects. Almost all of these parameters will have an effect on water and sanitation in Tonga, which will then lead to further problems down the line.

The reduced overall amount of rainfall will mean there is a heavier reliance on groundwater and rainwater catchments will no longer be as reliable. Reduced rainfall will also mean that the freshwater lens will not be recharged as much and so there will be less underground freshwater available to be extracted by the wells. More reliance on groundwater will also mean that over pumping may occur in some areas, resulting in an additional increase in salinity.

Higher occurrences of heavy rainfall will lead to increased flooding episodes, especially in urban areas where there is less infiltration into the ground water due to the presence of infrastructure. Flooding will increase the potential for contamination of water supplies via septic tank leakages by making the contaminants mobile, as well as increase the spread of water related and water borne diseases. Flooding may also damage water supply infrastructure and make contaminants flow down well shafts and pollute groundwater. With increased flooding events and less overall rainfall, it is likely that the current numbers of rainwater catchment tanks are not sufficient in volume to make use of the heavy rainfall.

The changes in rainfall and amount of available freshwater will have follow on effects on food security, health of humans, and the health of the environment. With less available freshwater and changes in the rainfall pattern it will be more difficult to grow the amount of food required to feed the Tongan population. Locally grown fresh food will become scarcer and Tonga will be required to rely more heavily on imported foods, which may further impact on the health of the population. Changes in rainfall will affect human health by increases water borne and water related diseases during increased rainfall time, and increase in asthma and other respiratory related diseases during times of drought.

An increase in sea level will mean that the volume of freshwater within the underground freshwater lens will be reduced. The use of groundwater resources presents a common problem throughout the islands due to saline intrusion with sea level rise; in the main island of Tongatapu the groundwater is as little as 0.6m above sea level (Kingston, 2004). Sea level rise will push the lens higher, and it may not be possible to contain the same volume, wells will be tapping into saltier water. Increased proximity of the freshwater lens to land surface may result in greater concentrations of contaminants (Crennan and Mafi, 2007). Sea level rise will also impact on coastal morphology, leading to erosion of the coast and damage to coastal infrastructure. Sea level rise will also impact on root crop agriculture and hence food security (Mimura, 1999). Sea level rise could inundate land, resulting in land loss, which 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 (Crennan and Mafi, 2007).

7.4 Recommendations/ Way forward

Apart from the recommendations already discussed in section 7.2, the following recommendations are proposed.

7.4.1 Awareness raising in community, government, schools

Continued efforts need to be made to raise awareness within communities, government staff, and through school education about climate change and impacts so the people of Tonga can make educated decisions and behavioural changes where needed. Perhaps this could be done by developing a set of school educational resources, which could then become part of the curriculum and by developing (or improving existing) climate change websites to hold up to date Tonga specific data and other information available to all.

7.4.2 *Mainstreaming climate change into legislation*

Already a goal of the Government, but yet to be effected is mainstreaming climate change into all policy and legislative documents. The PACC project is starting by drafting a Water Policy with respect to climate change. Emphasis needs to be put on the importance of this task and so that it becomes a government priority to change the legislation as well as enforce it.

7.4.3 *Reporting to government and population*

Agencies involved with collecting data for climate change need to develop a set of routine reporting methods in order to provide the government decision makers and the communities with up to date and relevant climate change information.

8 Priority areas and conclusions

The most common answers to the question "what is the biggest issue in Tonga with relation to water and sanitation" when posed to all stakeholders consulted during the development of this Outlook were, in order of frequency,

- "lack of funding",
- "fragmented management and lack of integration",
- "awareness and education (for community and agencies working with water)",
- "solid and liquid waste disposal practices and management", and
- "pollution and salinity of the water supply".

The first three points are directly included in the priority areas listed in section 8.1. "Solid waste disposal practices and management" is out of the scope of this report. "Pollution and salinity of the water supply" can be mitigated, to some extent, through better management practices and changes in community behaviour and practices, which are both identified in section 8.1.

In no particular order, the following are the standout priority areas that require immediate focus from Government and other water and sanitation agencies in order to improve the situation of water and sanitation within Tonga that were identified during the development of this National Water, Sanitation and Climate Outlook report. Once these areas are addressed, the recommendations posed throughout this document could then be focused on.

8.1 Priority areas

8.1.1 Develop a national strategic plan in relation to water and sanitation, and allocate a discrete budget line for operation of IWRM activities

At present there is no long term government strategic plan with respect to water resources and sanitation, which reflects the lack of recognition of the importance of these sectors. It is of vital importance to develop a national strategic plan in relation to water and sanitation and incorporate vulnerability to climate change in order to ensure good IWRM practices to provide in the future a safe and secure supply of water and sanitation facilities within Tonga. This should be driven by the cross-institutional NWRC. Once the strategic plan exists it would then be easier to request and apply a discrete budget line for IWRM activities from the Government's budget. These activities are routine and ongoing and must be funded by the Government of Tonga, rather than a donor aid project, to ensure their longevity and sustainability.

8.1.2 Foster cross-institutional cooperation to reduce fragmented governance

Cross institutional cooperation could be achieved through frequent NWRC meetings and comprehensive stakeholder meetings where reporting from monitoring agencies occurs in order to update all stakeholders and coordinate focus across the sector. It has also been suggested by some stakeholders that there is a need for one authoritative body that is responsible for the coordination, integrated management and supply of water resources and also for raising awareness regarding water and sanitation issues to the community and other stakeholders. This body could also act as an umbrella to

the VWCs and provide much needed continual support. Regardless whether this body is formed or not, the current situation of the fragmented governance needs to be addressed; particularly coordination and cooperation between the Government Ministries is vital.

8.1.3 Increase capacity of government staff (number and appropriate education) and government funding

There is a severe lack of appropriately educated government staff working in water and sanitation and IWRM and also a severe lack of operational budget. In order to comprehensively serve the public and national interest, the government needs to focus on up-skilling its current staff and also recruit more staff trained in IWRM fields. The current financial situation of the water and sanitation sectors within the Government is dire; very little progress can be made with such limitations. The government needs to recognise the importance of water and sanitation in Tonga's future and needs to allocate appropriate funding in order to carry out the required tasks for managing and maintaining a safe and secure water supply and safe sanitary conditions for the Tongan people now and for the future.

8.1.4 Focus on rainwater harvesting and cleanliness of rainwater

In terms of preparation for the future reduction of available water resources (due to economic development and population growth pressures and climate change effects), Tonga needs to focus on improving the existing and increasing the number and volume of rainwater catchments. This will reduce pressure from the stressed freshwater lenses as well as aiding continued access for all the population to a freshwater supply. As mentioned previously, the historical use of village or communal rainwater catchments could be re-established. Aid projects need to focus on areas with limited rainwater catchments and especially in areas with limited potential for groundwater development, due to thin freshwater lenses. There also needs to be a focus on education and awareness regarding maintenance and cleaning of tanks, gutters and roofing and the installation of first flush diverters to prevent the transfer of disease, especially as rainwater is the primary drinking water sources for most of the population.

8.1.5 Data management

Evident across all agencies consulted during the development of this Outlook is the severe lack of data management and data archiving systems. Much of the results of the work performed in the past have been lost due to poor data management. Most commonly reported problems were: loss of reports and databases due to broken or stolen computers or office fires, lack of general knowledge of where data is stored, no backups or archives of data. In many cases data was stored on personal hard drives and not on the agency's property. There is a great need for a central data repository, particularly in terms of water and sanitation related data/reports, as well as data management training within all Ministries. There is also a need for standard database structures to ensure data is being stored in a usable and useful format available for all. Without access to past reports and data to learn from, progress within water and sanitation development becomes very slow and work is often duplicated.

8.1.6 Education and awareness

Continued efforts need to be made to raise awareness within communities, government staff, and through school education about water and sanitation, including IWRM and climate change effects, so

the people of Tonga can make educated decisions and behavioural changes where needed. It is particularly pertinent to help communities understand how groundwater flows underground and how contaminants can be transported from one area to a water supply area. Also education is needed in terms of maintaining household water and sanitation equipment, such as clean rainwater tanks and regularly pumped septic tanks, to reduce the spread of disease. Perhaps this could be done by developing a set of school educational resources which could then become part of the curriculum and by developing (or improving existing) informative websites and TV shows or advertisements that consist of up to date Tonga specific data and other information available for all. Education and awareness needs to occur across all generations for behavioural changes to actually occur.

8.2 Conclusion

With the increasing pressures of population growth, economic development and a changing climate, it is more important than ever that Tonga works together as a nation and plans for a future with continued access to safe and secure freshwater and safe sanitation facilities for all.

Many of the current responses to address water and sanitation problems focus on Tongatapu. There is a clear disparity in access to quality of water and improved sanitation within the outer islands and rural areas, which suffers from higher incidences of water-related diseases and water shortages during drought situations. The geographic dispersion of Tonga has, in the past, made it difficult to maintain a universal level of water and sanitation access across the country.

Coordination of governance and management of water resources and sanitation by involving the GoT, NGOs, community leaders and including women in decision-making is necessary for achieving long-term solutions for water supply and sanitation in Tonga, as they provide effective methods for community engagement and uptake of new technologies.

Community groups, NGOs, civil society and government ministries have collaborated or consulted throughout the Outlook's development process to identify the main issues and possible strategies to address the problems associated with water and sanitation and plan for a future with continued access to a safe and secure water supply and sanitation facilities for all Tongans.

The National Water, Sanitation and Climate Outlook serves as the first step towards integrated water resources management in Tonga.

9 References

Unless specified, references are in electronic format and a copy is stored within the Geology, MLSNR digital library. Locations of hard copy documents are also mentioned.

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APPENDIX 1 - Consulted Stakeholders

The following table lists the stakeholders who were consulted (or who were attempted to be consulted) during the Outlook development process.

Institution/Stakeholder	Role/Responsibility with respect to water and sanitation	Name	Title	Phone (+676)	Email
Government Agencies					
Ministry of Lands, Survey and Natural Resources	Key Ministry for management of Tonga's underground water resources; responsible for monitoring water resources and reporting/advising Government	Dr Sione Nailasikau Halatuituia	Secretary, SOPAC representative	23611	secretary@lands.gov.to
		Salesi Fotu	Acting Secretary		
MLSNR – Geology Unit	Key Unit within MLSNR for for management of Tonga's underground water resources; responsible for monitoring water resources and advising Government	Rennie Vaiomo'unga	Acting Principal Geologist	7714395, 25508	rjegsen@yahoo.com
		'Esetelelita Fulivai Lakai	Project Manager GEF-IWRM Demonstration Project	8747533	esefulivailakai@gmail.com
MLSNR - PUMA	Key Unit for urban development planning, and planning to deal with sanitation infrastructure project in the future	Taaniela Kula	Urban Planner	21784	tkula@puma.gov.to
		Roger Mottet	Environmental Engineer		mottet.roger@gmail.com
Ministry of Environment, Climate Change	Key Ministry for management and monitoring of Tonga's environment and assessment of climate change affects	Asipeli Palaki	Acting Director	25050	a_palaki@yahoo.com
		Luisa Tuiafitu Malalo		27262, 7714067	ltvtuiafitu@yahoo.com
		Tom Carr	Policy Officer		
		Mafi'leo Masi			Mafileo.masi@gmail.com
		'Ofa Kaisamy			Kaisamy_ofa@yahoo.com
		Lupe Matoto			lupe.matoto@gmail.com

MECC - PACC Project	Pacific Adaptation to Climate Change project - key unit to asses Tonga's resilience to Climate Change. Contain substantial indicator data; concerned with all facets of environment including water.	Mr Paula Taufa	Coordinator	25050 / 21506	taufapaula@yahoo.co.nz
		Saia Kami	Project Officer		mrkami79@hotmail.com
Ministry of Health	Key Ministry that assess the health of the Tongan population. Should have data detailing health trends with respect to water and sanitation.	Siale 'Akau'ola	Director of Health	23200	sakauola@health.gov.to
		Dr Malakai Ake	Chief Medical Officer	27985	
Ministry of Health – Public Health Division	Key Division that monitors water with respect to health. Conduct faecal coliform analysis on village water supplies and should have information showing trends.	Dr Reynold 'Ofanoa	Medical Officer in Charge in Environment		rofanoa@health.gov.to
		Niu Fakakovikaetau	Public Health Inspector	23200	niu.fakakovikaetau@gmail.com
Ministry of Finance	Key Ministry that deals with the financial situation of Tonga.	Ana Fakaola 'I Fanga Lemani	Chief accountant	23066	flemani@finance.gov.to
		'Ana Lotuma Falefehi Ika	Policy and Planning Division		aika@finance.gov.to
Ministry of Finance - Aid Management Division	Key Division that manages and prioritises aid projects, including water and sanitation projects.	Natalia Latu	principal economist	23066	nlatu@finance.gov.to
Ministry of Agriculture, Forestry and Fisheries	Key Division that monitors health of the sea in terms of fish stocks and other marine life.	Vailala Matoto (Fisheries)	Secretary for Fisheries	21399	vailala@kalianet.to
		Dr Viliami Manu	Head, Research and Extension Divison	23038	mafsoils@kalianet.to

Ministry of Works	Key Ministry dealing with government infrastructure development and also host to National Disaster Management Organisation	Leveni Aho	Acting CEO	23100	levenih5@gmail.com
		Tevita Lavemai	Works Officer		tlavemai.minworks@gmail.com
Ministry of Agriculture, Forestry and Fisheries - Agriculture	Department that deals with agricultural issues within Tonga, and deals with irrigation, pesticides and fertilizer imports	Vunivesi Minoneti	Senior Agricultural Officer	23038	
Ministry of Tourism	Ministry that deals with Tonga's largest growing industry, Tourism, quality water and sanitation is of vital importance to ensure Tourism is successful	Sakopo Lolohea	CEO	25334	sloloheatvb@gmail.com
Waste Authority	Oversees solid waste removal from urban areas, and manages rubbish dump in Vaini	Kalolaine Fifita	Acting CEO	27826	klainef@yahoo.com
Tonga Meteorology	Key Ministry dealing with climate data	Ofa Fa'anunu	CEO	7770610	ofaf@met.gov.to
		Sione Tu'ungafasi	Climate Officer	35008	sionet@met.gov.to
Prime Ministers Office		Busby Kautoke	Chief Secretary	24644	busbykautoke@gmail.com
Prime Ministers Office - Local Government & Community Engagement Division	Deal with local Governance, including villages.	Uini Aleamotu'a	Assistant Secretary	24644	ualeamotua@pmo.gov.to
Governor's Office, Vava'u	Deal with local Governance within Vava'u	Masina Talakai	Secretary		
Non (Tongan) government bodies					
Tonga Water Board	Key organisation that extracts groundwater and supplies to urban areas	Saimone Helu	CEO	23299	twbhelu@kalianet.to
		Litili 'Ofanoa	Chairman		
		Pita Moala	Project Manager	23298	ewsup@kalianet.to

		Quddos (Kutusi) Fielea	Senior Planning and Engineer	23299	qfielea@gmail.com
		Lindsay Lavemai	principal distribution officer	23299	alevemai@yahoo.com
SMEC-MoW (TIUSDP Project)	Currently undergoing a project that has a component of groundwater monitoring around Nuku'alofa	Malakai Jay Vakasiuola	Deputy Team Leader, TIUSDP Project	24668	jay@itstonga.to
Waste Management	Private company that offers waste disposal services and some recycling facilities	Lee Miller	Manager	26991	leeintonga@gmail.com
		Satelaite Tenefafu	Assistant Manager	26991	meliame.tenefufu@yahoo.com
Tonga Trust	Coordinates community development projects, including some in water and sanitation sector	Sione Fakaosi	executive director	21494	s.fakaosiwp@yahoo.com
Aloua Ma'a Tonga (Women in Development Group)	Represents women's interests in terms of development	Mona Lisa Tukuafu	Project Manager	25-161, 7718597	monalisa.tukuafu@gmail.com
Langafonua 'a Fafine Tonga	Represents women's interests in terms of development	Hauoli Vi	General Secretary	25988/ 8866724	langakali11@gmail.com
TANGO	Umbrella organisation for NGOs, some of which are interested in water and sanitation sector	Simi Silapelu	President?	7717582	tango_nukualofa@yahoo.com
WHO	Deals with health issues, some with respect to water and sanitation	Wayne Antkowiak	WHO Country Liaison Officer	23200	antkowiakw@wpro.who.int
Tonga Red Cross Society	Humanitarian society dealing with human rights and has an interest in climate change activities.	Sione Taumoefolau	Secretary for Tonga Red Cross	21360	redcross@kalianet.to
Village water committee representatives	Provide and maintain water supply for village community use	Seini Moala	Vaini Water Committee	7719402	
		Nivaleti Melekiola	Lapaha Town Officer	32025, 7716983	

SOPAC	Regional agency mandated to coordinate water and sanitation in the Pacific	Rhonda Robinson	Project Adviser IWRM	.(+679) 3381377	rhondar@sopac.org
		Tasleem Hasan	Water Services Coordinator	.(+679) 3381377	tasleem@sopac.org
JICA	Frequently provides aid for water and sanitation projects	Alfred Vaka	Project Officer	23 072	freddyvaka@yahoo.com
AusAID	Frequently provides aid for water and sanitation projects	Lilieta Takau	Senior Program Manager	23451	lilieta.takau@ausaid.gov.au
ADB	Donor, currently involved with Nuku'alofa Urban Development Sector Project	Sonia Chirgwin	Consultant		soniac@unops.org

APPENDIX 2 – List of Datasets

MLSNR - GEF-IWRM Project Data

- *Household survey results, 2010*
- *Nutrient testing results, 2010*

Contact: 'Esetelelita Lakai, Project Manager GEF-IWRM Demonstration Project, esefulivailakai@gmail.com

MLSNR Data – Geology Unit

- *Village well monitoring database, 1959 – 2011*
- *SMB Monitoring database, 1997 – 2011*
- *Location of hydrogeological data (GIS), 2010-2011*

Contact: Amelia Sili, Assistant Hydrogeologist, siliamelia@yahoo.com

MLSNR Data – GIS

- *Tonga mapping datasets*

Contact: Richard Kautoke, Senior GIS Specialist, rakautoke@lands.gov.to

MoW TIUSDP-SMEC Data

- *Water testing results, 2010 – 2011*

Contact: Malakai Jay Vakasiuola, Deputy Team Leader, NIUDSP Project, jay@itstonga.to

MoFNP Data

- *Aid projects database, 2008-2011, Aid Management Division*

Contact: Natalia Palu Latu, A/Deputy Secretary, nlatu@finance.gov.to

MoH Data

- *Village Faecal coliform testing database, 2000-2010, Public Health Division*

Contact: Reynold 'Ofanoa, Medical Officer-Public Health, rofanoa@health.gov.to

Statistics Department Data

- *2006 Census*
- *Population growth*
- *Economic growth*

Available online: http://www.spc.int/prism/country/to/stats/

TMS Data

- *Tonga cyclone data, 1960-2011*
- *Tonga rainfall data, 1944-2011*
- *Tonga mean temperature data, 1980-2011*

Contact: 'Ofa Fa'anunu, Director of Meteorology & Permanent Representative of Tonga with WMO, ofaf@met.gov.to

TWB Data

- *Mataki'eua Production Records, 2010-2011*

Contact: Quddos Fielea, Senior Planning Engineering, qfielea@gmail.com