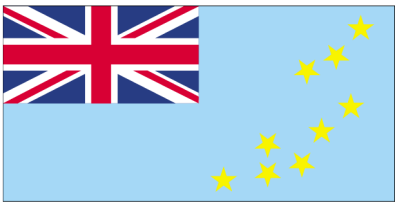
Sustainable Integrated Water Resources and Wastewater Management in Pacific Island Countries

National Integrated Water Resource Management Diagnostic Report

Tuvalu



Published Date: November 2007
Draft SOPAC Miscellaneous Report 647

GLOBAL ENVIRONMENT FACILITY

UNDP

SOPAC

UNEP

ACRONYMS

AusAID	Australian Agency for International Development
EU	European Union
FAO	Food and Agriculture Organization
FFA	Foreign Fisheries Agency
GEF	Global Environment Facility
HYCOS	Hydrological Cycle Observing System
GPA	Global Programme of Action for the Protection of Marine Environment form Land Based Activities
IWRM	Integrated Water Resources Management
IWP	International Waters Programme
JICA	Japanese International Cooperation Agency
MPWE	Ministry of Public Works and Energy
MNRLE	Ministry of Natural Resources, Lands and Environment
FCA	Funafuti Conservation Area
FD	Fisheries Department
MDG	Millennium Development Goals
MPA	Marine Protected Areas
NAFICOT	National Fishing Corporation of Tuvalu
NTF	National Task Force
NEMS	National Environment Management Strategy
NZAID	New Zealand Overseas Development Assistance
PIC	Pacific Island Countries
PWD	Public Works Division
SAP	Strategic Action Programme
SOPAC	Pacific Islands Applied Geoscience Commission
SPREP	South Pacific Regional Environment Programme
TANGO	Tuvalu Association for Non-Government Organisation
UNDP	United Nations Development Programme
UNESCO	United Nations Economic Social and Cultural Organisation
USAID	United States Agency for International Development
WHO	World Health Organization
WSSD	World Summit for Sustainable Development

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Tuvalu is a Pacific Island country of 9 low-lying coral atolls, humid tropical climate and high rainfall, with limited land area, high mean population densities, and an Environmental Vulnerability Index of 3.6. Tuvalu has a GDP per capita of US$1,681. 30% of GDP is attributable to government wages, with 40% from public enterprises. The private sector contributes approximately 30% of GDP of which half is from external remittances.

The islands of Tuvalu are generally composed of very coarse coral gravels and sands. The coarse sediments cannot sustain substantial fresh groundwater lenses to the extent that exists in other atoll countries in the region. In Tuvalu the primary freshwater source is from stored household and communal rainwater. The overall available water resources are only partly known, and in most of the outer islands the available groundwater and its quality is largely unknown. The estimated demand for freshwater in the main population centre of Funafuti is close to the estimated sustainable freshwater yields indicating vulnerability to variations in climate.

Groundwater salinity levels vary, but it is historically a non-potable secondary source in areas where salinity levels are not prohibitive. In times of prolonged drought it has also been a source of drinking water on some islands. Its use as a secondary source has been severely compromised by pollution from inadequate sanitation systems on Funafuti, and there is an increasing threat that this could also occur on the outer islands. Waterborne diseases are common and exact a significant toll on the health, wellbeing and productivity of the population. The coastal areas of Funafuti are a major source of livelihood and also contain marine biodiversity of conservation value. These areas are also under threat from poor solid and liquid waste management.

As many reports and reviews have recommended in the past there is an urgent need to revise, update and implement the draft Water Resources and Sanitation Management Bill, the draft Integrated Water Resources Management Plan, and the Tuvalu National Building Code which provides regulations and guidelines for design of roof catchments, rain storages, and sanitation systems. Among other benefits, this institutional support will strengthen the authority of the Water and Sanitation Committee and will assist in clarifying roles and responsibilities within and between organisations and provide a framework for long term planning for staff requirements and funding. The reasons that this institutional support has not happened until now need to be analysed, understood and addressed.

There is a need to refurbish or supplement fresh water resources by repairing rainwater harvesting systems, increasing household and community rainwater storage and investigating and expanding the use of groundwater resources.

It is important to ensure that there are enough personnel to attend to water and sanitation requirements within organisations that are responsible for managing the water sector. There is a also a need to strengthen the capacity of these organisations including the Public Works Department, Meteorology Department, the Waste Management Unit, the Kaupule[1] and Public Health Division of the Ministry of Health. Support and training is required in the following areas:

- water resources assessment (groundwater and rainwater), monitoring and analysis;
- integrated planning including reference to climate variability and drought proofing;
- cost recovery and demand management strategies;

[1] Previously, Island Council

- training for plumbers and other relevant personnel on design and maintenance of rainwater harvesting systems, and design and construction of septic tank toilets and waterless zero-discharge toilets; and
- community liaison

There is no centralised sewerage system and 100% of households depend upon on-site wastewater systems and/or practices, so wastewater/sanitation management is entirely in the hands of the community. Most households also rely on individual or communal rainwater tanks so water management is largely in the hands of the community. Householders require training as follows:

- demand management including use of water saving devices, leakage control and adaptation to climate variability;
- design, construction and maintenance of rainwater harvesting systems;
- design, construction and maintenance of effective and appropriate waterborne sanitation systems;
- design construction and maintenance of waterless sanitation zero discharge systems (including method of treatment, advantages and disadvantages, cost);
- water quality monitoring and protection including use of filters and first flush mechanisms; and
- training in hygienic construction and maintenance of wells should also be provided to households in relevant locations. Training should draw on traditional understanding of groundwater management.

Awareness raising activities are conducted by government, NGOs and community based organisations in relation to water resources and sanitation management, usually in association with donor funded programmes. However there appears to be limited understanding of the linkages between poor sanitation, disease, degradation of the marine and aquifer environment and the indirect and direct impacts on livelihood and food security. The need to reduce demand and conserve water is also not widely appreciated, and complex cultural and land tenure conditions limit the opportunity for intervention by government. Practical training will not only raise awareness but will also provide households with the necessary skills to take action and responsibility.

ACKNOWLEDGEMENTS

Tragically, the Director for Public Works, and National Focal Point for IWRM, Mr Filipo Taulima died in June 2007. Mr Taulima was a passionate advocate for Pacific Island culture and wellbeing. He also energetically supported sustainable water and wastewater management for Tuvalu. His death is a great loss to his country and his friends and colleagues throughout the region.

Arrangements were made to continue the IWRM consultation process on Mr Taulima's behalf and it is hoped that the outcome reflects his aspirations for water resource management in Tuvalu. Thanks are due to all the members of the Water and Sanitation Committee who provided their views and information, and to Ms Loia Tausia who facilitated discussions and continued to support the research process.

This report has drawn extensively on reports and reviews conducted over the last 15 years and this is reflected in the References. The Diagnostic process also drew upon previous national consultations including those undertaken during the recent International Waters Programme, and refers to the challenges and goals highlighted in the draft Integrated Water Resources Management Plan which was prepared by Mr Kelesoma Saloa with the assistance of Mr Taulima and the Water and Sanitation Committee.

Thanks also to the staff of SOPAC for guidance, and assistance with logistics.

INTRODUCTION

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

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

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

A. Integrated Coastal and Watershed Management and

B. Oceanic Fisheries Management (addressed in a separate GEF project)

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

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

All countries could benefit from an integrated approach to water resources management but the Pacific SIDS have an urgent need to adopt this strategy due to small land mass, fragile ecology, limited financial technical and human resources, and a vulnerability to natural disasters and extreme weather events. In the past water supply and sanitation services and programmes have not been devised in an integrated way that takes into account all the inputs and output of a system. For example the positive benefit of providing a reticulated water supply may be outweighed by the health hazards and poor living conditions which could result from not considering the appropriate disposal of used water which may create standing water or pollution of receiving waters.

Source control and more efficient use and re-use of water is the most effective way to reduce demand for treatment and disposal. While an integrated approach to the management of natural resources existed in traditional societies, population growth and rapid development and introduction of ‘modern’ technologies and practices over the last 50 years has not allowed enough time and perspective to adjust and plan holistically. Now that the damage is clearly apparent there is an attempt to reverse the environmental degradation and threat to public health and security, by addressing all inter-connected elements of the system.

For Tuvalu the objectives of Sustainable Integrated Water Resources and Wastewater Management as stated by the Water and Sanitation Committee are:

- to ensure that the Integrated Water Resources Management Plan is endorsed and legalised by Government and implemented;
- for the people of Tuvalu to have secure access to potable water; and
- for the safe disposal of wastewater.

1. GENERAL OVERVIEW

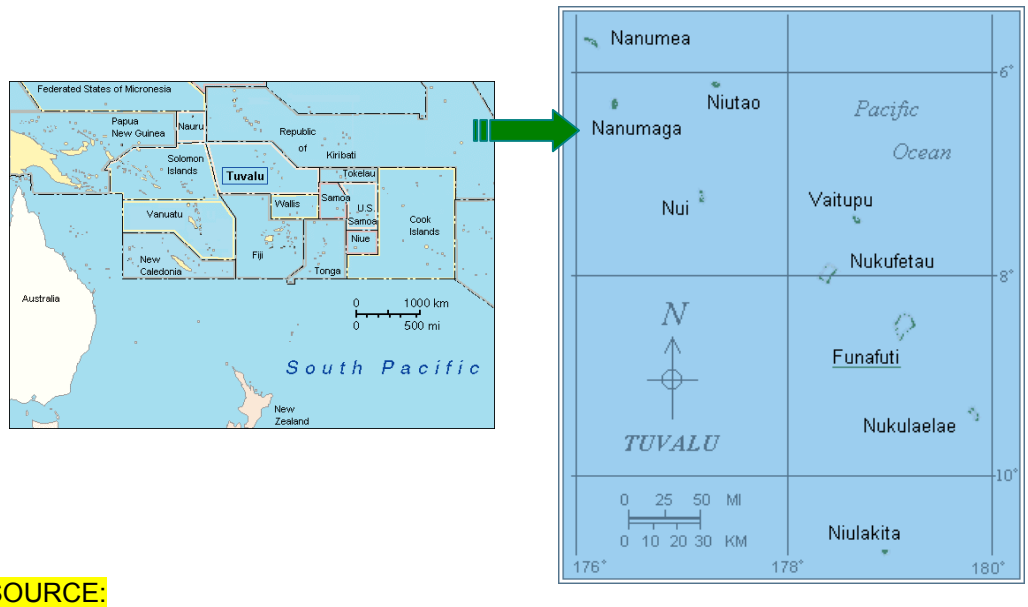
Country Background Information

Tuvalu is an atoll country consisting of nine atolls, with a total land area of 26 km^2 dispersed over 1.2 million km^2 of the Pacific Ocean. It has a total population of 11,000 (2007 estimate), with 4,500 located on the capital atoll of Funafuti. Population pressures on Funafuti are high with a population density of 1600 persons per km^2.

Tuvalu has a GDP per capita of US$1,681. 30% of GDP is attributable to government wages, with 40% from public enterprises. The private sector contributes approximately 30% of GDP of which half is from external remittances.

1.1 Geography and topography

Figure 1: Tuvalu location and spread of islands



SOURCE:

The nine islands are located within latitude 5.5 to 11 degrees south and longitude 176 to 180 degrees east. The distance between neighbouring islands varies from 67 km to 158 km. Nanumea, Nui, Nukufetau, Funafuti and Nukulaelae are coral atolls with a continuous eroded platform surrounding a lagoon. Their shapes and orientation vary. Nanumaga, Niutao and Niulakita are single islands composed of sand and coral material created by wind and wave action. Vaitupu is a composite atoll/reef island.

Islets refer to land which is above the high water mark and this land is a relatively small proportion of the reef platform and overall area of the islands. At Vaitupu the reef flat includes an area of lagoon of 108.88 hectares. The total area of islets is 2608.62 hectares or 26.08 sq. km and the maritime Economic Zone is approximately 518,670 sq. km.

The following table from White (2005) provides a summary of key data relating to Tuvalu.

Table 1: Summary of key information for Tuvalu

Location[1]	8º S 178º E (Savave)
Composition [1]	9 coral atolls
Land area (km^2) [1]	26
Length of coast (km) [1]	24
Length of coast/land area (km) [1]	0.92
Highest elevation (m above mean sea level)[1]	5
Fraction of land elevation< 10 m above msl (%) [2,3]	100
Climate [1]	Tropical
Cyclones	Yes, infrequent
Annual rainfall (P mm) [4, 5, 6]	2737 (Nanumaga) 3569 (Funafuti)
Coefficient of variation annual rainfall (CV, %) [4,5,6]	22 (Funafuti)
Annual potential evaporation (E mm) [4,5,6]	1730 (Funafuti est.)
Aridity ratio = E/P	0.48 (Funafuti)
Principal water sources [5, 6,7]	Private rainwater tanks Communal rainwater tanks (drought) Private groundwater wells (minor) Desalination*
Estimated per capita demand freshwater (L/cap/day) [5, 7]	100 (Funafuti)
Estimated sustainable yield freshwater (L/cap/day) [5, 8]	97 (Funafuti domestic rain tanks)
Agency responsible for water supply	Households PWD (dry periods)
Population [1]	11,636 (est. Jul 2005)
Population growth rate (%) [1]	1.47 (est. 2005)
Median age (years) [1]	24.45
Fraction 0-14 years (%)[1]	30.8
Mean population density (cap/km^2)	448
Gross Domestic Product (GDP) (US$) [1]	12.2 million (est. 2000)
Real growth rate GDP (%) [1]	3
GDP per capita (US$/cap) [1]	1,100 (est. 2000)
Agriculture products[1]	Coconuts, fish, pulaka
Exports[1]	Copra, fish
Value exports (US$) [1]	1 million f.o.b. (2002)
Environmental Vulnerability Index (EVI)[8]	3.76

Source: White 2005

[1]CIA The World Factbook (2005), [2]Pratt and Mitchell (2003a), [3]Pratt and Mitchell (2003b), [4]Falkland and Woodroffe (1997), [5]SOPAC (2001), [6]Falkland (1999a), [7]Fakland (2005), [8]Alam *et al.*(2002), [9]Kali et al. (2003). *Desalination plants currently inoperative † Excludes use of private wells or raintanks.

1.2 Soils

The soils are derived from skeletal reef material, corals, calcareous algae, foraminifera and mollusk, and composition is mainly carbonate. Such soils are characterised by their alkalinity, immaturity and lack of natural fertility. Actual fertility depends on the proportion of organic matter, incorporated into the soil either naturally or artificially, and upon the size of the constituent “coralline” materials.

Using FAO-UNESCO criteria the soils can be classified as calcaric aerosols, i.e. weakly developed soils on coral sand and rubble with a high calcareous component from the parent materials. The soils may be phased according to the presence of undulate layers or hard rock at shallow depths, stoniness, salinity and alkalinity. All these phases are present.

In addition, three other soils are common: mangrove muck, phosphate soils, and human made soils of the pulaka pit complex. Presence of the various soils varies from island to island and within islands.

A description of the differing types of soils is given below

(i) Light soils

Sands and gravels distinguished from those on the beach by the presence of organic matter (leaves, roots, branches) in varying stages of decomposition and organic staining. Soil colour is typically grey brown or brownish grey. Horizon differentiation is poor in these immature soils and as depth increase organic matter and staining decrease.

Organic content by weight ranges from 4-8% with pH from 7.1 – 7 .8 (slightly to moderately alkaline). However on Nanumea, the ranges are wider, being 5 -15% and 7.8 - 8.5 respectively.

(ii) Dark soils

So called due to their colour. Generally the soils are deeper and two horizons can be seen - a brown or grey black surface horizon 5-20 cm thick, with a lighter stained zone below which grades to unaltered sands and gravels, Topsoil colours are typically brown or dark brown. The surface horizon is rich in decomposed organic matter (15 – 20%) which gives a silty feel and loamy texture and is the most fertile. The soil is often associated with coconut woodland where it is usually reddish brown.

(iii) Phosphatic soils

Multi-coloured due to the interaction of organic matter, guano and water in a parent material of sand or gravel. It comprises consolidated blocks of dark brown to oranges, white speckled material separated by, or underlain by loose mottled sands or gravel. The parent materials are being changed from calcium carbonate to phosphate.

(iv) Soils of the Pulaka pit

Spoil bank complex as the pit has been artificially constructed. It has been excavated to the level of the watertable and the resulting spoil dumped around the edge to give an elevated rim above the level of the surrounding land.

In the pit, organic material from shrubs, creepers and ferns are mixed with sand from the pit floor. The resulting soil is a dark organic muck (sandy loam) that does not usually have much profile differentiation. The break between growing medium substrate is usually sharp with the substrate compacted rather than loose. Soil bulk density is low and organic content high.

Spoil banks have varying proportions of sand and gravel that has been dumped during excavation. The profile consists of a thin organic litter layer, a few centimetres thick over-lying the stained sand and gravel that usually extends down to the original ground level. Coconut palms and large broadleaf trees grow on the bank providing shade for the crops and cultivators.

(v) Mangrove muck

Fine grained muddy brown organic sediments with bleached coral gravel mixed throughout. Mangrove roots penetrate the sediment. More peaty mucks are associated with the red flowering mangrove. Low bulk density, low carbonate content and very high organic content (80 – 90%)

(vi) Saline Soils

Could be included with unaltered sands and gravels or light soils. Saline soils are typified by a high salt watertable and are associated with saline flats, sandy inlets that are or were affected by salt water intrusion or inundation.

(vii) Airfield soils

Artificially constructed or compacted during the Second World War. The surface was not broken up subsequently and so poor vegetation growth results as fertility is low.

1.3 Hydrogeology

The soils are highly permeable above the hardpan of the reef flat, due to the porosity of the sands and gravels. There are no permanent surface streams as excess rainfall drains to the watertable where a lens of fresh to brackish water is formed and floats on the saline marine water, a phenomenon known as the Ghyben-Hertzberg effect.

Because of the limited height of the islands above sea level (a maximum of 4-5 metres and usually much less) and their limited area, the lenses are assumed to be small in area, limited in volume and of uncertain quality. But comprehensive groundwater assessments have not been undertaken, despite many recommendations to do so.

1.4 Climate

The climate is tropical with high humidity. In 1987 the New Zealand Meteorology Office published "The Climate and Weather of Tuvalu" which was based on meteorological data for the period 1951-1980. This data serves as the baseline against which subsequent data is compared. This is particularly useful in view of the uncertainties related to climate variability and change.

Rainfall

Rainfall in Tuvalu tends to be considerably higher than for island groups further north, e.g. Kiribati or south e.g. Fiji and Tonga, and generally decreases when moving north from Niulakita to Nanumea. Approximately 60% of the total annual rainfall occurs during the period November to April. The more northerly islands have the larger variations. Abnormal monthly rainfall is defined as a departure of at least 50% from the average monthly amount. Most years usually have some months of abnormal rainfall but periods lasting more than two months are not common.

Rainfall persistence over several consecutive varies with the characteristic of the disturbance causing the rain. For up to one or two hours, thunderstorms produce the heaviest falls. For longer durations, rainfall is usually produced from weather systems such as those associated with tropical cyclones and as such, intensities decrease as the duration increases.

Dry spells are defined as 15 consecutive days with less than 0.1mm rain per day. A short record (1971-85) indicates that on average between one and ten dry spells can be expected every decade. About two-thirds of such spells occur during the drier season, i.e. May to October, and are more likely in the northern islands.

Table 2: Mean Annual Rainfalls in Tuvalu to 1984

Island	Rainfall Record	Mean Annual Rainfall (mm)
Nanumea	1947-84	2891
Nanumaga	1947-84	2799
Niutao	1955-84	2737
Nui	1941-84	3245
Vaitupu	1948-84	3117
Nukufetau	1955-84	2831

Funafuti	1941-84	3498
Nukulaelae	1953-84	3291
Niulakita	1945-84	3478

Source: Taulima 2002

Sunshine and solar radiation

This has only been measured on Funafuti from 1932 until 1941 and resumed again in 1977. Based on these records sunshine averages 2,237 hours each year.

Air Temperatures

Air Temperatures are uniformly high all the year round. There is a lack of pronounced seasonal variation and a limited daily variation of 5-6ºC. The mean maximum and minimum temperatures are 31ºC and 25ºC respectively and departure from these means in any month is less than 0.5ºC. This is applicable to all islands.

Wind

The islands lie within the trade wind zone of the South West Pacific and on the edge of the austral summer equatorial doldrums. Predominant surface winds are from between the Northeast and Southeast for 55-65% of the time. East to Southeast winds are most frequent from May to October (drier) than at other times of the year. At this time the doldrums zone lies predominantly in the Northern hemisphere and the trade winds blow largely undisturbed over the tropical Southwest Pacific.

Whilst winds over 22 knots (40.7 km/hr) occur 2-4% of the time, gale force winds, with a mean speed over 33 knots (61.0 km/hr) are relatively rare. At Funafuti, over the period 1978 – 1983, 13 gales were recorded, averaging two a year. 80% of the gales were with West northwest winds during November to April. Data for Funafuti show gusts over 33 knots occur on 50-60 days each year.

There is a diurnal variation in wind speed; with the maximum occurring in the middle of the day resulting from the augmentation of the trade winds by a local sea breeze regime, and the minimum occurring at night. The range of variation is 5-15% of the mean. In contrast over the ocean, night time winds are the stronger. This is typical of the trade wind regimes of the Pacific Ocean.

Wind as an energy resource is often discussed in Tuvalu as a preferable alternative to 100% oil dependence. The potential of a location in Tuvalu is dependent on the prevailing mean wind speed and distribution since wind power is proportional to the cube of the wind speed. The total potential between 6 and 30 knots over the ocean is 1305 KWH/square metre/ year which are nearly 50% larger than the estimate for the sheltered Nanumea site but only 12% greater than at Nui and Funafuti.

1.5 Agriculture

As previously discussed Tuvalu's soils are generally limited in depth and area. They lack a full range of nutrients and trace elements. They are highly permeable.

Rainfall is generally sufficient so that soil moisture deficits do not occur very often. Deficits are more likely on the northern islands, and result in a reduction in the fresh/brackish water lens with consequent effects for pulaka pits. High tides and/or seas can produce similar effects with a reduction in groundwater quality from the increase in salinity.

Even so, all the islands have an extensive cover of trees and other vegetation which has been mapped in the Land Resources Surveys. Agricultural practice is mainly of a subsistence nature and highly dependent on the existing vegetation. The Land Resources Survey provides a good guide to such uses.

Coconut woodland

The nuts are used for domestic purposes and animal food, for the production of copra and provided to relatives on Funafuti. The making and export of copra is becoming less important as the market price is low.

Leaves are woven into blinds, rough mats and roofing thatch. Green leaves are made into baskets and trays for immediate use. Husks provide fibre for string and cord, and when left to decompose they also provide organic matter for soil. They provide a source of firewood and charcoal and a basis for some traditional medicine. Palm trunks and stems are used in house and pig pen construction. The spathe of young palms is cut to provide toddy for drinking and cooking.

The Agriculture Division estimated that a hectare of coconut palms produce approximately 1.2 tons of copra at the standard density of 215 palms giving 30 nuts per year which yield 187 grams of copra per nut. Overall the number of palms is estimated as being equivalent to 2100 hectares at the standard density and thus a theoretical production of 2520 tons of copra is possible. However, in contrast, the Land Resources Survey made a more detailed estimate of palm density and used a lower nut production figure of 20 per palm. As a result the Survey gives a considerably reduced figure for copra production.

From the Agriculture Division census it is apparent that a considerable proportion of the trees are not available for copra production. Based on the censuses for 1988 and 1990, and using the Division's standard figures it can be seen that at present 60-75% of the palms are used for immediate local needs. Daily toddy production is of the order of 6200 litres of which about 54% is converted to syrup and 40% used fresh. The remainder is changed to sour toddy which is alcoholic.

As the population of people and livestock (particularly pigs) increases the local demand will also increase and thus what is available for copra production will be reduced. It can be seen that copra production is a relatively small proportion of what is theoretically possible in Tuvalu.

In the Fourth National Development Plan it was stated that the optimum level of replanting was estimated at 35 hectares per year to maintain and/or improve the existing situation. In view of the importance of the coconut tree to the economy it appears that greater attention to replanting is needed. The replanting would be expected to give rise to increased timber production and have some effect on groundwater through the use of fertilisers and the change in tree density. Transpiration from trees was recorded as 70 -130 litres/day suggesting a total transpiration rate of 400-740 mm/year per tree planted at 8 m centres with 100% tree cover (Falkland and Brunel 1989).

Pandanus (fala)

Second to the coconut, pandanus has the greatest range of uses such as poles and posts for house construction, leaves for roofing thatch and quality mats, and fruits for eating.

Pulaka Pits

The main crops are pulaka (Cyrtosperma) and taro (Colocasia). In addition banana (Musa), sugar cane (Saccharum), sweet potato (Ipomoea), pawpaw (Carica), and cassava (Manihot) are grown on many islands.

Production within the pits is dependent on the creation of a humus rich soil, availability of good groundwater and suitable cultivation. Problems have arisen from changes in groundwater and increased salinity giving rise to damaged crops and abandonment in the worst cases. Coconut, pandanus and other trees grow on the raised banks of the pits.

Root crops

Taro and pulaka are both grown in pits at about groundwater level. Thus, it is important that there are no substantial changes in the average water level or quality. The yield of taro is dependent substantially on the age at harvest and at 8-10 months can yield approximately 26 tons per hectare.

In contrast, Pulaka plants require a much longer time to mature. A survey of Vaitupu farmers' crops had plants up to 12 years old although 80% were less than 6 years old. The plants were normally harvested for eating after 2-3 years when the yield would be about 65 tons per hectare. For feasts and other special occasions harvesting would be much later, after 6 years or more.

Sweet potatoes are grown on all islands except Niulakita. The area allocated for the crop has varied in recent years and is of the order of 6 hectares with the greatest area on Vaitupu (4.2-5.0 hectares). A crop can be harvested after 4-5 months but can also be deferred for the same period. Yield per hectare is about 18 tons with 63% of the crop being available for sale. In practice considerably less is sold; at present about 2.2 tons per hectare, that is12.5% of the total crop.

Fruit crops

Although breadfruit, bananas and pawpaw are grown extensively and are a significant contribution to the local diet, information on crop yields is not available. It is reported that the Agriculture Division intends to monitor the yields in future and may include yields for pandanus fruit, sugar cane and water melon.

Fertilisers and pesticides

To improve yields it has been considered necessary in some cases to add fertilisers and possibly use pesticides. However cost of imports and transport is a deterrent. In view of the high rainfall and high soil permeability it is essential to take care with applications to ensure that surplus material does not contaminate the groundwater. There is no data available on the use of synthetic fertilisers or pesticides but Atrazine and Simazine are common pesticides.

The issue of soil fertility and pest control is relevant to potential use of composted human and animal manure and promotion of organic gardening.

Livestock

The keeping of livestock is an important aspect of community life. Pigs, chicken, and more recently ducks are common. Goat rearing was tried and abandoned in 1986.

Raising livestock is part of the subsistence economy. Animals and birds are reared and used by individual families. Livestock is generally left to scavenge for food, however pigs in particular are fed with coconuts and house scraps. It is estimated that 30-40% of available coconuts are being fed to pigs.

Attempts being made to improve the quality of the livestock by cross breeding with imported stock. Success requires better husbandry and stock facilities which are addressed through programmes by the Agriculture Division.

In terms of water demand and pollution from domestic livestock production, the government does not consider that there is any problem due to "the relatively small numbers and large area allowed for scavenging". Well water is often used for pigs, and they are kept outside the residential areas as far as possible. However pens are constructed on the edges of villages usually adjacent to the ocean or lagoon. This is an accepted practice despite obvious signs of nutrient overload and degradation on lagoon and ocean shoreline especially in Funafuti. On Funafuti, the edges of old burrow pits, which fill and empty with the tide, are common sites for pig pens.

In the case of commercial production it has been advised that concentration of livestock creates the need for a suitable and sustained water supply and method of dung disposal, together with a well managed slaughterhouse with proper facilities.

This has not yet occurred. Domestic production generally satisfies household demand. There are approximately 450 pigs on Funafuti and approximately 4,500 people (Census 2002).

On Vaitupu, the Agriculture Division has a pig breeding programme using imported pigs to improve the quality of the local pigs. Elsewhere on Nukulaelae, Nukufetau and Nanumea, communities have established herds which provide pigs for cross-breeding. The dung is used to fertilise home gardens.

Ideas for alternative uses for pig dung have been researched in order to reduce pollution and increase financial returns such as generating bio-gas and using the slurry as fertiliser, composting and in combination with fish farming.

Chickens are reared to provide protein from eggs and/or meat. Feathers are used for handicrafts. Commercial production occurs mainly on Funafuti. However there is an interest on other islands which may increase if suitable feed becomes more readily available. Birds raised as layers are kept for approximately 12 months before being sold for slaughter. The dung is used on gardens. On some islands sea birds are trapped and eaten, especially Noddies. This practice is particularly prevalent on Niulakita.

1.6 Fisheries

The Exclusive Economic Zone, of 518,670 sq. km. is reported to hold rich stocks of Skipjack, Yellow fin and Big-eye Tuna as well as deep water fish such a snapper. These resources are primarily available to foreign countries that fish under license and take their catches elsewhere for processing. Given Tuvalu's limited financial resources it is effectively impossible to control the licensees through surveillance and enforcement.

For the people of Tuvalu, fishing is a subsistence activity. Fish forms a major part of the diet and the small (motorised) fishing canoe/boat together with the relevant gear, is an important family asset. When ocean fishing conditions are good, surplus fish may be passed on or sold to others or dried for use later when conditions are poorer. Atoll islands have an advantage in that fish in the lagoon can be caught at any time. For the reef islands bad ocean conditions can result in sometimes lengthy periods, when fish is not available and hence the greater need for other sources of protein, such as sea birds.

At Funafuti where the population is concentrated and there are limited land resources, there is some small scale commercial fishing in addition to the subsistence fishing.

The headquarters of the Government's Fisheries Division and of the National Fishing Corporation of Tuvalu (NAFICOT) is on Funafuti. From 1985 onwards the facilities have been considerably improved by the provision of new offices, a fish market, an ice making plant, a training centre, fishing boats, jetty improvement and a slipway.

The fish market was transferred to NAFICOT in 1987 and has a capacity of 50 tons of fish per year but is currently producing 15-20 tons. It is expected that at some stage disposal of fish waste will be a problem which might be solved by plans to process the fish waste into pig and poultry feed.

There are plans for facilities at Vaitupu, Nukufetau and Nanumea. There have been consultations on the provision of water and sanitation to these facilities.

The Fisheries Division is involved in conducting projects for the production of Trochus, sea weed, Beche-de-mer and pearl oysters. As yet it is not known if they will become commercial propositions and no detailed consideration of water and sanitation arrangements has been made.

NAFICOT is proposing to charter/purchase two 20 m fishing vessels with the

intention of starting to export fish.

1.7 Socio-economic conditions

Government revenue comes from the income generated by the Tuvalu Tonga Trust (capital), the 'dotTV' internet domain (asset) and from fishing licences granted to foreign fishing companies (natural resources).

Based on the 2004-05 Household Income and Expenditure Survey, taking into account all forms of income, including non-cash items such as subsistence food consumed by a household, cash and in-kind transfers between families, there are noticeable income inequalities across the country. While just over half of the population lives on the outer islands, this includes three-quarters (76%) of households in the bottom fifth of the income scale. The other quarter of the poorest households live on Funafuti. While there is little if any absolute poverty, or complete destitution in Tuvalu, some people nevertheless are considerably worse off than others and live in very poor conditions (Conway 2007).

For low-income households, those on Funafuti are often worse off. In contrast to low income households in the outer islands, those on Funafuti often have no access to land on which to produce food, have less access to water, electricity, sanitation or waste management services, have insecure tenure, and are more likely to live in substandard housing.

Although cash incomes are considerably higher on Funafuti, once the contribution of subsistence activities is factored into household incomes it appears that around one third of the wealthiest households live in the outer islands. Overall, the distribution of income is more even there than in Funafuti.

Generally, the distribution of the population across nine widely spaced reef islands and atolls and the concentration of people, economic opportunities and high level services on Funafuti contribute to a poverty of opportunity. The most common experience of this lack of opportunity is an insufficient access to education, health and other basic services, or economic opportunities.

The poverty of opportunity generally experienced by outer island communities is indicated in their depopulation and the inward movement of people to Funafuti and beyond. A small but emerging subculture of disaffected youth; and the exasperation outer island people express about the poor quality of services; the lack of opportunities for almost anything; and weak markets for local agriculture and fishing is increasingly visible.

Table 3 highlights select macro indicators on income, health, education and water. While some of the data is sketchy, most indicators suggest that levels of income and health are generally improving, and access to education remains universal and more or less gender neutral, with 100% primary completion rates.

Tuvalu's population is currently growing at 0.5% annually. The most populated islands are Funafuti (47%) and Vaitupu (16.6%), where most economic activity occurs. Most outer islands have a negative growth rate due to outward migration of residents seeking employment opportunities elsewhere.

The main source of household income is paid work (59.1%) either as public servants or employment in the private sector, followed by remittances (18.1%), mostly from seafarers working on foreign merchant ships, followed by income from fishing or copra sales.

Table 3: Select macro indicators: income, health, mortality, education

Indicator	2000	2001	2002	2003	2004	2005
1. GDP (market prices, AU$'000)	24.04	26.41	27.79	na	na	na
2. GDP per capita (market prices, AU$)	2,116	2,529	2,875	na	na	na

3. Prevalence of underweight children (under five years of age)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
4. Life expectancy (M/F)	62/6[1]	62/65	62/66	62/66	62/66	na
5. Infant mortality rate (per 1,000 live births)	34.6	25.4	25.3[2]	32.2	42.3	17.4
6. Primary school enrolment[3]	1,965	1,798	1,693	1,955	2,032	2,010
7. Primary completion rate	100%	100%	100%	100%	100%	100%
Ratio of females to males in:						
Primary education	.88:1	.92:1	.92:1	.93:1	.94:1	.92:1
Secondary education[4]	.89:1	.93:1	.96:1	1.06:1	.91:1	na
Tertiary education[5]	1.1:1	.86:1	na	.46:1	.92:1	.69:1
11. Birth rate attended by skilled health personnel	85%	100%	100%	100%	100%	100%
Immunization coverage rate against tuberculosis and hepatitis B	100%	100%	100%	100%	100%	100%
12. New HIV/AIDS cases reported	0	2	7	0	0	0
13. Population access rate to safe drinking water.	85%	85%	85%	85%	na	na

Source: Statistics Division, Ministry of Finance; Department of Education, Ministry of Education and Sports; Department of Personnel and Training, Office of the Prime Minister; Department of Health, Ministry of Health; Asian Development Bank (ADB)

1 Up from 57/60 for males and females, respectively, in 1990.

2 Down from 43.5 per 1,000 live births in 1990.

3 2003-2005 figures include approx. 160 students enrolled at the SDA primary school.

4 2003-2004 figures include, respectively, 99 and 183 students enrolled at Fetuvalu Hugh School.

5 Based on Tuvalu Government 'In-Service Scholarships'. Does not include donor-funded scholarships. 2003-2004 estimates are incomplete. (Conway 2007)

The most common communicable diseases are respiratory infections (flu/common colds). The most common injuries/wounds are septic sores, with males being the most susceptible. The most common non-communicable diseases are diabetes, hypertension and obesity, with females being the most susceptible. Waterborne illness such as diarrhoea and gastroenteritis are also common especially in young children but they are often not reported unless it becomes severe or dehydration sets in. Life expectancy for males is 60.7 years and 65.1 for females. The number of sexually transmitted diseases is rising, in particular Hepatitis B (23%) and Syphilis (46%) compared to the previous five years. There are nine known cases of HIV/AIDS, up from zero ten years ago, though factoring in thus far undetected HIV/AIDS cases the number is probably higher.

The largest employment sector is in the professional and technical occupations. A small number of people are engaged full-time in agriculture and fishing. More than half the employed population resides in Funafuti and about two-thirds of those are males. According to a recent study by UNDP, with an increasing proportion of the population becoming economically active, limited new jobs opportunities and the drift away from subsistence agriculture means Tuvalu is facing rising rates of future unemployment. Conversely, a recent study by the ADB suggested otherwise. It concluded that although unemployment is likely to have increased since 2002 (the 2002 Census estimated a national unemployment rate of 6.5%, and a slightly higher rate on Funafuti of 8.9% given the completion of major public projects), nonetheless, the large public sector, an ability to switch to subsistence activities and continuing offshore employment opportunities are likely to prevent very high unemployment rates from emerging in the future (Conway 2007).

2. Integrated Water Resource Management for Tuvalu

2.1 Water Resources management

a) Types of freshwater, uses, major issues and concerns

Rainwater

Rainfall and rainwater harvesting is the primary source of water supply in Tuvalu but this was not always the case as is the following extract from a paper by Mr Filipo Taulima reveals.

> "In the olden days, where there were very limited or few water storage catchments, people depended mostly on groundwater wells for drinking and cooking. Rainwater from thatched roof catchments and coconut tree trunks was used mainly for washing, bathing and other use. Drawing and transporting water from unprotected groundwater wells to houses can be unhygienic using traditional methods thus having high risks of consuming contaminated water. During a dry spell on an island, where green coconuts become unavailable for consumption, groundwater wells begin to dry up, the people depend mainly on the water drawn from holes dug in a Pulaka pit (traditional plant similar to a dalo). These practices were later changed by the arrival of western missionaries when churches were constructed together with their water storage catchments. The storage catchments slightly improved the standard of living in terms of health and sanitation. Moreover, the skill of western construction and western culture slowly influenced the local people who later adopted and relayed them from generation to generation" (Taulima 1994).

In the early 1980s most families took advantage of an aid project for provision of ferro-cement storage tanks attached to small areas of roofing sheets providing the catchment and shelter for an external kitchen area. The tanks had an approximate capacity of 3.6 m³ and were intended only to meet drinking water demands. However once supplied, usage increased and the available water quickly depleted. A contributory factor was the limited catchments supplying the tank at 9 -12 sq. m. The adjacent house at that time normally had a traditional roof of pandanus thatch and the run off was (and still is) not acceptable for personal use.

Average family size in Tuvalu is 6 people but there is a considerable range. It is not unusual to find families of 8 or 9 people. With a standard size tank it is the larger families that have a reduced supply. This is exacerbated on the more northerly islands by the reduced and more intermittent rainfall.

There are tanks of materials other than ferro-cement, such as hollow concrete blocks filled and rendered with cement mortar, or fibre glass. These are usually bigger than the ferro-cement tanks ranging from 9 to 18 m³. They are connected to houses with metal sheet roofs.

Public cisterns or communal water tanks are usually attached to public buildings such as offices, Falekaupule or Ahiga, churches, schools and hospitals. Usage is subject to control particularly during periods of low rainfall and consequent water shortage.

Groundwater and wells

Groundwater is available on all islands, but the extent and quality are mainly dependent on factors such as size of the island, type of soil and its permeability, amount of infiltrated rainwater, and density of seawater.

Tuvalu has some of the smallest islands in the world, so therefore these lenses are assumed to be quite small compared to other countries in the Pacific. Preliminary assessments have suggested that useable groundwater may exist on the western side of the airport in the wider section of Fongafale (Funafuti) and in the small islands of Tepuka and Fualifeke in the north-western part of the Funafuti atoll (Falkland 1999a). Earlier rapid, hydrogeological and geophysical surveys (van Putten 1988, Salzmann-Wade and Hallett 1992) found fresh groundwater on many outer islands of Tuvalu.

Apparently significant groundwater occurs on the atolls of Nanumea, Nanumaga, Niutao, Vaitupu and Nukufetau. It was estimated that the thicknesses of freshwater

lenses ranged from 3.2 to 7.9 m. Taking a conservative freshwater thickness of 2 m and assuming that 10% of this can be sustainably abstracted; there is potentially about 1.0 million m^3 of groundwater of variable quality available for extraction (White 2005).

Table 4. Location and estimated area of groundwater in Tuvalu

Island	Islet	Location	Estimated Groundwater Area (km^2)
Nanumea	Main Village		0.10
		Matagi	0.63
	Lakena	Majority	0.53
Nanumaga		Majority	0.90
Niutao		Eastern half	0.81
Nui	Fenua Tapu	Limited	0.08
	Meang	Central	0.15
Vaitupu		Northern	0.94
		Motufua	0.34
Nukufetau		Fale	0.21
Nukulaelae		Fagaua	0.03
	Fenualago	Central	0.02
	Tefakai	Northern	0.02
Niulakita		Western half	0.15
TOTAL			4.9

Source: Taulima 2002

However it has to be stressed that comprehensive groundwater assessments is required. An immediate indicator is the presence of existing wells and pulaka pits which have been tested in the past. The groundwater that is available feeds the natural vegetation and crops grown in the pulaka pits and elsewhere. Abstraction for human and other uses varies form island to island and no accurate figures are available. The water is used for livestock, washing clothes and bathing, and has been used for drinking during drought.

The majority of islands have wells. Some wells are just holes dug down to the groundwater lens and are not protected from contamination and pollution. However within the villages most wells are protected by coral stone walls, capped and provided with hand pumps (diaphragm type) with latrines often adjacent. Water quality is often poor.

Well water is now seldom used for drinking and it is has been observed that during periods of low rainfall the quality can deteriorate, and becomes more saline. Groundwater is used for domestic needs in the outer islands as an emergency supply in times of drought. Over-extraction in 1999 and 2000 resulted in groundwater becoming brackish/salty, the water level dropped with serious consequences for the vegetation as witnessed in Vaitupu.

On many of the islands groundwater is available under the villages, which is probably why the villages were originally settled in that location. However because of the extensive use of pit latrines and septic tanks the water is contaminated and its use can lead to disease. On Funafuti groundwater is only used for feeding pigs, washing pig pens and flushing toilets. During droughts its use extends to washing clothes, bathing and flushing toilets.

For human consumption, groundwater has to be treated which effectively means boiling the water for more than a minute after boiling point (WHO recommended period). It has been recommended that the safest solution is not to use the groundwater for food preparation and just to restrict use to toilet flushing which can

be a major demand on water supply. Some landowners resist use of groundwater for flushing because they are concerned that salt levels will be raised on their land.

Groundwater can be polluted from livestock waste and indiscriminate dumping of refuse and particularly chemical wastes such as medical, batteries, oils and fertilisers. Since areas of groundwater have been identified, it has been recommended that refuse disposal has to be restricted to those areas which will not affect groundwater supplies. Similarly the roaming of livestock should be controlled as should the use of agricultural chemicals.

Desalinated Water

Originally for emergency use only it is now used as a main water supply especially on Funafuti. It is a very expensive way to acquire freshwater, so the Integrated Water Resources Management (IWRM) Plan aims to identify cheaper ways to meet public demand with minimal dependence on desalinated water.

The first desalination units were installed in Funafuti in the early 1980's and had the capacity to extract 27 m^3 of freshwater a day. The plant that was installed during the 1999 drought in Funafuti has the capacity to extract 65 m^3/day. There are smaller plants in other parts of the group (Vaitupu (30 m^3/d) and Nanumaga (30 m^3/d). These plants were donated by the Japanese government as measures to counter the water shortage problem during the state of emergency proclaimed in August 1999.

In 2006 another plant was also donated by the government of Japan to help supply water in Funafuti but was intended for emergency purposes only. The plant on Funafuti produces water at a unit cost of AU$3.50 per m^3. The existing tariff used in Funafuti recovers less than half of the ongoing operation and maintenance costs. The Public Works Department (PWD) considers these costs unsustainable as it is not possible to recover any capital investment costs for replacement of the plant. On Funafuti the seawater is extracted from the lagoon and it has been reported that its quality is dubious due to its closeness to the village.

Burrow Pits

'Burrow' pit is the name given to large holes excavated by the Americans during the WWII to build the airstrip, and other construction. They contain water and provide communities on Funafuti with a number of economic and social benefits, so the government and community advise that they need to be protected to sustain these activities.

Major use of these burrow pits are as follows:

- Dumping of rubbish
- Construction of pigpens
- Construction of houses
- Construction of two tennis courts
- Cleaning of pigpens
- Swimming and bathing of people especially children.

During the two assessments of water quality conducted by the government and AusAID in 2005, it was confirmed that water in all burrow pits on Funafuti is highly contaminated with faecal bacteria, and has low Dissolved Oxygen.

Natural ponds

These water bodies are known to be formed under natural conditions unlike the burrow pits. All the islands in Tuvalu have natural ponds, but they differ as some of them are more saline then others. There has been no testing of the water quality in the ponds in the outer Islands, but the public uses some of these ponds for swimming, and washing clothes as they are not very saline like the one in Funafuti.

Some of these ponds are getting shallower and smaller from mud and runoff. Ponds closest to villages have been protected from human defecation and the construction of pig pens by their respective Kaupule.

On Funafuti the natural pond (Tafua pond) is highly contaminated as pig waste from the pigpens is released into the 'pond'. The water is also as salty as seawater, with low levels of dissolved oxygen towards the pigpen areas. The only fish in the water is Tilapia. People fish Tilapia to feed to the pigs as a source of protein.

Major uses of the natural pond on Funafuti include the; construction of pigpens; cleaning of pigpens and dumping of rubbish.

Bottled water

Bottled water, usually from Fiji, is increasingly being used by those who can afford to buy it. It was reported that bottled water is becoming more popular because of the requirement to boil rainwater which can be inconvenient, or expensive due to the cost of fuel. Groundwater is no longer an option for human consumption. It is common for participants at meetings at the government hotel to be provided with bottled water, which is also generating large quantities of plastic bottles which require disposal. Over the last three years, Tuvalu imported on average about 21,700 litres of water (unsweetened water), at an estimated retail value of AU$43,000 (Lal et al. 2006).

b) Measures to manage impacts and concerns (IWRM approaches)

There is no National Hydrological Network for water resources assessment and monitoring. There is a Water and Sanitation Committee which will be referred to in Section 2.5 but this committee does not engage in assessment and monitoring.

There are concerns that rainwater harvesting systems could be polluted from dust, and animal droppings and it is recommended by the Ministry of Health that rainwater be boiled before drinking. There is also a recommendation that rainwater tanks be chlorinated especially the government reserves.

A small number of households have been introduced to the strip paper hydrogen sulphide test (H2S) during an eco-sanitation training, and they tested the quality of water in their tanks, but there is no community-based monitoring of quality. Households monitor quantity only to the extent of observing when the supply in the tank is about to run dry and then they call on the PWD water tanker to refill their tank from the government reserve.

Maintenance of rainwater harvesting systems and conservation of water needs to be improved and demand management activities and practices are an essential requirement in any future community based capacity building programme.

Quality of groundwater has been measured intermittently during various donor funded projects such as the AusAID Waste Management Project, and the International Waters Programme which focused on improving sanitation in an attempt to reduce pollution of groundwater and marine waters.

A number of planned programmes will address monitoring and assessments needs including the HYCOS, and AusAID Vulnerability and Adaptation, and Water Safety Plans. The draft Integrated Water Resources Management Plan also advocates monitoring and assessment activities, as have many previous plans and reviews.

2.2 Island vulnerability

a) Types of disasters, issues and concerns

The natural disasters that can affect Tuvalu include cyclones (not common but highly destructive when they do occur) and drought, both of which could be exacerbated by climate variability and change and sea-level rise. Climate models are not yet able to state with any certainty what changes in variability and extremes may occur. In the

absence of such certainty, historical events are used to provide indicators for considering effects of variability and extremes, in association with mean changes in climate:

- Tropical cyclones appear to have increased in frequency in Tuvalu. The most recent severe event was cyclone Bebe (in 1972), which had significant impact;
- ENSO events have been experienced with greater frequency over the last two decades. In Tuvalu, El Nino events bring warmer, drier conditions, whereas La Nina conditions are cooler and wetter.

Human activities/practices also contribute to vulnerability to disaster as follows:

- *Water supply*

Due to high rainfall water supply is usually adequate but quickly becomes an issue during dry spells. Insufficient capacity and storage and poor construction and maintenance of rainwater harvesting systems means that supply is depleted in dry spells of one or two weeks. The community then relies on the government tanker to transport water from the national reserves.

- *Pollution from solid and liquid waste*

Poorly controlled waste disposal is still commonplace throughout Tuvalu. Inadequate disposal management methods associated with landuse is common on Funafuti, including dumping of chemicals and used oil. Pollution of groundwater and marine waters from inappropriate sanitation systems and animal waste (especially pigs) is a serious threat. These practices are contributing to deteriorating public health and environmental degradation. On Funafuti groundwater is no longer a viable secondary source for human use, and groundwater is being similarly threatened in the outer islands.

- *Coastal erosion and infrastructure development*

Increase in population and the growth in demand for permanent housing and infrastructure in Funafuti has resulted in an increased demand for sand and gravel for building and construction purposes. The sourcing of aggregate from coastal environments is increasing the risk of coastal erosion and flooding.

- *Housing, land availability and population growth*

Available land and adequate housing has become a problem due to a rapid increase in population in Funafuti.

- *Food and health.*

There has been a shift in diet from traditional food to imported food. The capital, Funafuti in particular is depending more on imported food due to population pressure and limitation of land for subsistence farming. This has led to an increase in so-called lifestyle diseases, and an increase in packaging which requires safe disposal.

- *Growth of cash economy*

The development of a cash economy in Tuvalu is increasing the material expectations and individual aspirations of the people, and demands on the environment. Although, subsistence activities and sharing and reciprocity with extended family and the community are common features of Tuvaluan traditional life, people are increasingly participating in the cash economy.

- *Exploitation of marine resources*

The exploitation of marine resources is increasing due to population pressure,

and the limitation of land for subsistence agriculture particularly in Funafuti. The establishment of the Funafuti Conservation Area has been a response to growing pressure on marine resources, but this only protects a small percentage of the area under pressure.

Tuvalu has a disaster management plan which recommends actions to be taken by the government in the case of natural disaster such as drought and during a major fire. Desalination and distribution of water from reserves are listed options. Tuvalu has a water acquisition provision in the Constitution which gives the government and the Kaupule the right to acquire all available freshwater during drought and distribute equitably to all the community. The plan does not provide any guidance to secure freshwater resources during more physically destructive disasters such as hurricanes, cyclones or storm surges and tidal waves.

b) Measures to manage impacts and concerns (IWRM approaches)

Reviews and studies over the last decade have made many recommendations to reduce vulnerability to climate variability. In the Pacific Vulnerability and Adaptation Background Paper it was noted by White (2005) that the following aspects of previous studies "raise concern as follows:

- The failure to formalise the draft Water Resources and Sanitation Management Bill and the draft Tuvalu Water and Sanitation Plan to provide the necessary institutional support.
- Limited knowledge of water resources, demand and storage particularly in outer islands.
- The fact that the demand for delivered (government) water starts directly after a week of no rain.
- The findings by Dawe[2] (from a limited sample of three households) that mean demand in Funafuti appears slightly higher than the estimated mean yield of rainwater storage and that average per household storage is about 40% of that required for a one in eleven year failure rate.
- The very limited use of groundwater, which in some islands appears a substantial resource.
- Water use by freshwater-flushed toilets and leakage from septic tanks and pit latrines to groundwater and marine waters."

The report goes on to conclude that "together these mean that Tuvalu is extremely vulnerable to climate variability and that adaptation is currently difficult. The priorities for the water sector in Tuvalu follow from the above concerns.

1. Establish a sound institutional basis for the management of water and sanitation (policy, regulations, incentives, plans, organisational reform and responsibilities).
2. Increase capacity to manage water and sanitation and predict water related extreme events (household and community).
3. Improve knowledge of available water resources, demand and prediction of extreme events.
4. Improve water conservation and demand management strategies.
5. Increase household and communal rainwater storage.
6. Increase the use of groundwater.
7. Improve sanitation systems" (White 2005).

[2] SOPAC TP 2001 An integrated approach to rainwater harvesting analysis using GIS and recommendations for roof-catchment legislation in Tuvalu.

2.3 Awareness

a) Types of awareness campaigns/advocacy initiatives

As previously discussed the community largely depends on supply from household rainwater tanks supplemented by communal and national reserves. There are ongoing routine activities by the Public Health Officers and the Sanitation Aides to encourage households to properly construct and maintain their rainwater harvesting and sanitation systems, and conserve water, however staff and resources are limited especially for attention to the outer islands. Boiling of rainwater is also advocated by the Health Division to ensure drinking water is sterilised in case of contamination in the rainwater harvesting system from animal droppings and other sources.

Awareness initiatives include ongoing departmental activities and project related campaigns. Some recent donor funded campaigns have focused on wastewater management and pollution control of groundwater and marine waters.

International Waters Programme (IWP)

Community-based awareness raising and capacity building activities were undertaken during the International Waters Programme 2002-2006 which addressed wastewater management.

A Participatory Problem Analysis (PPA) workshop was held with local community stakeholders on Funafuti in December 2003. Participants identified some root causes associated with waste in the community, which included:

- limited financial resources and technical support available to households to install and maintain environmentally sound wastewater treatment systems;
- limited types of wastewater treatment systems available to the community;
- a lack of knowledge and awareness of people within the community of the environmental impacts caused by 'unmanaged' wastewater on surrounding marine and freshwater quality; and
- a lack of legislation and enforcement in relation to waste (IWP Tuvalu Baseline Assessment Report 2004).

In order to further understand and quantify the extent of these root causes and to consider the identification of solutions, the IWP conducted baseline assessment work in April–May 2004. The assessment considered among other topics:

- wastewater treatment systems existing in the community (including seepage data);
- waste stream and waste characterisation;
- community social structure and governance systems;
- government and community waste services and roles including policy and institutional arrangements for waste management;
- testing and general observation of the groundwater in the area; and
- assessment of waste issues in local school curricula.

In October 2004 a review was undertaken of work conducted by the National Coordinator and IWP Task Force to date and a Solutions Report was prepared to support the identification of possible low-cost no-cost options that could be piloted with support from the IWP in the communities of Alapi and Senala on Funafuti. These options were intended to address root causes of pollution on marine and freshwater quality. The solutions identified reflected (i) technological solutions (ii) relevant behavioural change campaigns and (iii) institutional and capacity building solutions required to ensure the sustainability of change. Institutional or individual capacity

building required to support implementation was also identified. Activities that were recommended included the following:

- A short-term communications campaign to raise awareness of the urgency of issue within the communities and with government decision makers.
- Training in design, construction, operation and maintenance of on-site sanitation. An interactive community training workshop could help participants compare a range of practices and technology such as: using the ocean beach for defecation, upgrading existing septic tanks systems, installing composting toilets and using composted animal and human excreta as a soil improver.
- A community run groundwater monitoring exercise that could demonstrate the need for improved waste management. The sanitation and water quality training could provide practical skills and comprehensive knowledge about health and environmental risks and benefits so that people can make informed decisions about water supply and pollution prevention, and take the necessary steps towards implementation (Crennan 2004).

The Solutions Report did not recommend promotion of one particular practice or technology. The original intention was rather to provide participants with a sound basis for making their own decisions about the most appropriate options for their communities.

It was recommended that a range of treatment options and their advantages and disadvantages including cost, was to be explored in the sanitation training with the objective of allowing the participants to then choose the most appropriate system based on their evaluation. However, the Tuvalu IWP team decided that a broader campaign which introduced the composting toilet as the most desirable option would be the most efficient strategy, given the prevailing conditions in Tuvalu, and the short time left for the IWP to be implemented.

It was decided that the communications campaign should included audience research, competitions in poem, songs and drama on campaign themes, and promotion of campaign objectives through radio and video.

Among other issues, it was advised that it could be useful to survey communities on the following:

- What do people understand about the causes of disease including the connection between the waterborne/septic systems contamination of the groundwater and health problems?
- What are current toilet habits, including how often do people use the beach for defecation, and what is the reason? (E.g. no toilet, water shortage, socio-cultural preferences, convenience etc)?
- What do people think are the advantages/disadvantages of the pour flush, water-seal or septic systems?
- What is the groundwater used for (e.g. washing clothes, gardening and flushing toilets?) Are there other non-secondary uses? What is seawater used for domestically?
- Do people know about organic waterless toilets (composting toilets) and if they do, what do they think about them?
- What objection would people have to using waterless-composting toilets?
- How much money are people able/prepared to pay for the various kinds of toilet, including the waterless compost toilet? What priority do toilets have in the family budget?

Over several days 70 community members (10 from seven villages) were interviewed by a team of five people (one from Public Health, three from the Environment Department and one from the Persistent Organic Pollutants (POPs) programme. The results were used to develop the marketing content and target audience for the national communications campaign and to establish a baseline against which to assess impact of campaign (Saloa 2006).

Part One of a promotional documentary was made during IWP with the professional assistance of the Department of Community Affairs and personnel from the Tuvalu Media Corporation. This video delivers the history and technical issues of inappropriate or malfunctioning sanitation systems and resulting environmental and public health problems in an engaging, accessible format. Part Two explored possible solutions but was not completed during the IWP.

A national campaign was launched in Tuvalu on the 18th May 2006 to promote and raise public awareness of groundwater contamination and its health/economic costs based on the cost benefit analysis and previous studies and reports. A second goal of the campaign was to drive demand for a safe toilet system.

The campaign was conducted by the IWP Communications Team which included personnel from government ministries, non-government organisations and volunteers.

The campaign utilised a variety of medium to disseminate information to the public, including a series of talk shows on Radio Tuvalu which reportedly provided a venue for useful discussions and debate. One of the talk shows focused on groundwater pollution caused by careless disposal and poor management of liquid waste. Another talk show discussed and shared information on the formulation of the National Integrated Water Resource Management Plan and the National Water Plan.

Information was also disseminated through speech competitions, reciting of poems, drama, songs, and poster competitions. These competitions were completed with a quiz between Nauti and Seventh Day Adventist Primary schools. The Prime Minister closed the campaign at an official function on July 8. The competitors performed their poems, songs and drama and the First Lady awarded prizes to winners of the competitions (IWP Tuvalu 2006).

A “hands-on” training in sustainable sanitation was conducted in October 2006 in Funafuti for personnel from government, NGOs, the private sector, the communities, and the team members of the International Waters Programme. Government personnel from Kiribati were also invited to attend. The training included an examination of the invisible threats (disease causing organisms) to public and environmental health from inadequate management of human excreta and compared the design and maintenance requirements of a range of common sewage treatment technologies.

Construction of a waterless composting toilet was led by the Water and Sanitation Officer from the Public Works Department and all the trainees assisted with the required masonry, plumbing, and carpentry. The trainees expressed satisfaction in acquiring new technical skills and theoretical knowledge and intended to pass the information on to their home communities. Some trainees volunteered to promote the waterless composting toilets to the wider Tuvalu community. The representatives from Kiribati submitted a proposal to SOPAC to have a similar training in Kiribati. A two week practical skills training was conducted in April 2007 in Tarawa funded by Taiwan ROC and involved trainees from government, NGOs, church groups and the community. This is a good example of country activities being taken up and replicated in other parts of the region.

Jingles and other promotional items continue to be played on the radio, and after the Sustainable Sanitation training radio interviews were recorded with the IWP team, the

landowner where the composting toilet was built, and some of the trainees.

The team for the International Waters Programme in Tuvalu recognised that a staged approach would be required to move from initial awareness of the problem, to the development of appropriate solutions, and then on to sustained behaviour change. However, the community communications campaign and sanitation training were conducted in 2006 in the last year of a five year programme so there was no opportunity for assessment of the impact of the campaign or monitoring of the technical or socio-cultural issues relating to the trial of the household composting toilet (Crennan 2006).

Tuvalu Environment Day 2007

Community based activities were funded jointly by the Tuvalu Government and SPREP with additional support provided by Tuvalu RED Cross and Alofa Tuvalu, a recently established NGO, and linked to UN World Environment Day. The activities were organised by a committee made up of representatives from Department of Environment, Tuvalu Waste Project, Funafuti Island Council (Kaupule), Department of Energy, Department of Agriculture, Department of Fisheries, Nauti Primary school. Tuvalu Media Corporation, Island Care and TANGO (Tuvalu Association of NGOs).

The theme for Environment Day included SPREP's promotion of "Strong Islands Strong Future" and the importance of conserving coral reefs and mangroves to reduce vulnerability to climate change. This was linked to Alofa Tuvalu's promotion of sustainable energy and waste management. A clean-up of the foreshore and tree planting were conducted to demonstrate how human activities can destroy or protect the natural function of the shoreline and coastal waters.

The foreshore on the lagoon side of Fongafale was divided into five sections of between 800 m and 1500 m (depending on severity of damage and amount of rubbish) and each section was adopted by a volunteer church group which conducted the clean-up. The emphasis was on engaging the whole family in an entertaining way. The 4 'Rs' were an integral part of the message: Reduce, Re-use, Re-cycle and especially Refuse. The message aimed at raising awareness that people can chose not to expose themselves to dangerous household chemicals which can have a devastating effect on health and the environment. Radio programmes were also conducted throughout the week on the themes of Tuvalu Environment Day.

Fisheries Department Monitoring Programme

Fisheries have monitoring programmes to address issues related to depletion of fish stocks and biodiversity and loss of habitat. Probable causes of degradation are:

- Pollution of shoreline and marine waters from wastewater and solid waste
- Reef channel blasting and dredging;
- Beach/rock mining and sedimentation;
- Ciguatera fish poisoning;
- Overharvesting of marine resources.

The programmes focus on human activities that can be improved at the community level such as extraction of resources and waste management. Socio-economic surveys were conducted to ascertain the level of utilisation of marine resources and attitudes towards conservation.

Monitoring concentrates on coral reefs and inshore fisheries with the goal of training locals in monitoring techniques and raising awareness on conservation, to ensure locals feel some sense of ownership and control over the monitoring protocol. It is anticipated that key local people will be able to continue monitoring without

supervision. Researchers are selected from Fisheries Department, Environment Unit, Funafuti Conservation Area project, Marine studies programme, TANGO and other relevant institutions.

b) Measures to manage impacts and concerns (IWRM approaches)

Due to the termination of the IWP at the end of 2006 the sustained behaviour change in wastewater management which was one of the goals of the programme will need to be achieved through ongoing activities supported by government with possible co-funding from programmes that support integrated water resources management, including planning and regulation. Monitoring of the use and performance of the demonstration toilet will also be required for at least two years from the time of construction.

In July 2007, 8 months after the toilet was installed the household members expressed satisfaction with the system and it appears to be functioning properly and is well maintained. The owner of the toilet reported that many other people in his neighbourhood have now requested assistance to build a composting toilet for their families. It is recommended that the experience skills and capacity which have been developed during the International Waters Programme be utilised to establish sustainable sanitation in Tuvalu. The documentary that was produced during IWP should be completed and distributed.

The goals of the Fisheries Departments monitoring process are to:

- establish national database on state of coral reefs;
- build national capacity for improved management and monitoring of coral reefs and data analysis;
- promote establishment of long terms monitoring sites including Marine Protected Areas (MPAs);
- enhance levels of awareness of the marine environment in all sectors of society thru training and awareness campaigns;
- increased involvement of stakeholders, including women in the sustainable management coral reefs and their resources;
- improved community-level understanding of the value of conserving marine resources and their habitats, and how their activities can contribute to conservation or cause degradation.

All the activities described in this Section help to demonstrate the impact of human activities on the hydrological cycle, but awareness has to be complemented with practical skills, opportunity, and motivation to take constructive action.

2.4 Technology

a) Types of water supply systems, and major issues and concerns

As discussed in previous sections of this report rainwater is provided from household tanks, communal cisterns, and national reserves (e.g. storage in the foundations of the Public Service building on Funafuti). Groundwater is provided from wells, and desalinated water is provided from a plant operated by the PWD.

Rainwater harvesting systems

In 1986 the Government's policy for water supply and storage was developed. The stated aim was to provide each person with access to a minimum of 50 litres per day on all islands. In developing the policy, droughts occurring once in five years and lasting for up to four months were considered. Storage was to be provided by a mixture of direct house storage (tanks) and community storage (cisterns).

It was recognised that funding would be required from donor agencies to continue to build rainwater harvesting (RWH) systems and implement the policy. Projects were commenced in 1990 to provide households with ferro-cement tanks. It proved impossible to obtain the household level of storage as required by the Government.

Over the years other funding was sought to provide additional catchment area of about 22 m² to 230 houses on eight of the nine islands. The exception is Niulakita. To make use of the storage being provided it is required that all houses have at least 30 m² of catchment.

Water storage consists of either above-ground tanks made of a variety of materials (primarily ferro-cement but more recently fibreglass and polyethylene, and in-ground cisterns constructed from concrete and concrete blocks). During dry periods when household supplies run low water deliveries are made by tankers from communal cisterns which are fed by rainwater from churches, halls and offices (and/or from the government operated desalination plant on Funafuti).

Table 5: Survey of Household rainwater tanks, wells and toilets/latrines in 1997

Island	Households	Water tanks	Wells	Toilets/latrines
Nanumea	178	163	5	127
Nanumaga	167	167	0	147
Niutao	183	163	7	150
Nui	167	136	5	102
Vaitupu	300	233	0	206
Nukufetau	151	122	2	107
Funafuti	540	540	4	500
Nukulaelae	64	65	0	61
Niulakita	12	16	1	12
TOTAL	1762	1605	24	1412
Total/household	1	0.911	0.014	0.801

Source: modified from Burke 1998

A study by SOPAC in 2002 found that only 80% of the mean roof area in Funafuti was available for rainwater harvesting, indicating that improving the system could result in up to a 20% increase in rainwater supply (SOPAC 2001). A limited study was conducted of rainwater yield from roof catchments and domestic demand using rainwater tanks for four households in Funafuti over a few days. From this limited study, it was found that demand varied from 52 to 153 L/capita/day and that roof runoff coefficients for three households varied from 0.42 to 0.95 with a mean of 0.76. This is lower than the expected (normally at least 0.9) and this together with the high demand could indicate significant rainwater system leakage, a problem identified by Burke (1998) and Falkland (1999a).

The condition of roof catchment collection and storage systems using data from the partial Funafuti GIS (SOPAC 2001) was also reported. Table 6 summarises this data. From the study 37% of roof catchments and 59% of guttering were in fair to poor condition. For raintanks, 33% were either not used, leaking or in fair to poor condition. This data and the mean runoff coefficient of only 76% demonstrate that there is considerable scope for improvement.

Table 6: Rain catchment statistics Funafuti

Attribute	**Value**
Total Number of Buildings (houses, govt buildings, sheds)	660
Mean Domestic Raintank Capacity (m^3)	13.1
Average Number of Tanks per House (m^2)	1.5

Mean Building Roof Area	102
Mean Private-Dwelling Roof Area fitted with Gutters (m^2)	81
Mean Total Building Storage Capacity(m^3)	18.5

Source: SOPAC 2001

The SOPAC study recommended that if the rainwater supply systems in Tuvalu are to have any kind of consistent reliability several key points should be addressed.

1 Roofs, gutters and storage tanks need to be properly maintained.

2. Water conservation practices should be encouraged.

3. Roof areas with guttering need to be maximised.

4. Rationing schedules need to be developed and followed by users during periods of drought.

5. The design standards for roof catchments need to be amended.

Table 7: Condition of roof catchment system components in Funafuti

Condition	Gutters	Roofs	Raintanks
Poor	29%	13%	4%
Fair	30%	24%	17%
Good	41%	63%	67%
Leaking	-	-	6
Not Used	-	-	6

Source: SOPAC 2001

The current situation in Funafuti is that the demand for delivered (government) water starts directly after a week of no rain. This is a reflection of the lack of proper water management skills at the grass roots level and the need to improve demand management at the government level. During the 2006 PWD water storage survey of households it was noted that most households, particularly in Funafuti are dependent on government water. Most families buy their water requirement from government despite heavy rainfall during the period in question. The survey also revealed that at that time the rainwater storage throughout the islands, with the exception of Funafuti, was largely unknown. The April 2006 survey is the most recent account of storage facilities and it is estimated that Funafuti private and community storage facilities capacity is approximately 2,830,280 gallons (Taulima 2006).

Pumps. Many of the domestic supplies (household tanks) require the use of pumps to supply an overhead tank which then feeds by gravity to taps, showers, and waterborne sanitation systems. Pumps are also used for community cisterns to pump water into personal containers used to carry water back to households.

The three main types are;

- Electrically powered centrifugal pump with air vessel and controlled by a water pressure switch. Sometimes there is no air vessel and control is by a water level switch.
- Hand powered diaphragm systems. Usually at wells and community cisterns.
- Semi-rotary systems for households.

Wells. The majority of islands have wells. Some wells are just holes dug down to the groundwater lens and are not protected from contamination and pollution. However within the villages most wells are protected by coral stone walls, capped and provided with hand pumps (diaphragm type) with latrines often adjacent. Water quality is often poor.

At Nukufetau in the early 1980s an effort was made to develop a groundwater source to serve the main village. It involved a wind powered pump feeding an overhead storage tank of approximately 10 m³ capacity which was fed by gravity to four standpipes. It worked for some years but then had maintenance problems. During the time it did work no records were kept as to consumption and so it is not known if the design supply criteria were met.

On Nukufetau, Niutao, Vaitupu and Nanumaga, community wells provide backup supply in times of low rainfall. Small solar-powered pumps lift water from a depth of about one metre into a storage/header tank from which people fill their water containers. Most of the existing wells are located outside the main villages. Nukufetau has the best prospect for increasing freshwater usage since the water table is deep and stable; and boreholes can be dug to a depth of 6 m. Additional wells into the freshwater lens are a viable option on all four islands, especially if combined with pumps powered by solar panels. This option could be further explored under disaster preparedness projects.

Desalination. The government operates a desalination plant on Funafuti which produces approximately 27 m³/day , and is sold to the general public at a unit cost of AU$3.55 per m³, a tariff which recovers less than half of the ongoing operation and maintenance costs. PWD considers these costs unsustainable with no possibility to recover any capital investment costs for replacement of the plant.

A second unit was recently contributed by JICA intended for emergency use only so the plant in Funafuti has the capacity to extract 65 m³/day. There are smaller plants (capacity of 30 m³/d) in other parts of the group (Vaitupu and Nanumaga). These plants were measures to counter the water shortage problem during the state of emergency in August 1999. The attraction of the plant is justified by calculating “that production is equivalent to storage of 450 m³/day, with a catchment of 2100 sq. m. Thus if the plant can be kept running then the available storage is increased by 450 m³ and the need for additional storage on Funafuti can be deferred based on current population predictions”(Taulima 2006).

On Funafuti seawater is extracted from the lagoon and the source quality is dubious due to its closeness to the village. Desalination was originally for emergency purposes only but now it is used as a main water supply especially on Funafuti. With the new power station (which is encouraging increased energy use) energy costs and reliability are not considered to be such a problem, but the need for skilled and consistent maintenance and replacement of parts still remains. It is recommended in the Integrated Water Resources Management Plan that cheaper ways need to be identified to meet public demand with minimal dependence on desalinated water.

b) Types of wastewater/sanitation systems, major issues and concerns

Sanitation education and latrine construction were included in the donor funded programmes of the early 1980s.

Toilets. While the intention was to improve hygiene and protect public health, common in-ground systems such as pit latrines, pour flush latrines and septic tanks were introduced and promoted without consideration of the local porous soils and shallow groundwater.

Table 5 shows, in addition to the water facilities, the number of household with toilets and the number of households without by the late 1990s. Where there are no toilets, people use the bush or more commonly the beach where tidal movements disperse the excreta.

Table 8 provides distribution by toilet type on all islands. However it does not indicate whether or not the toilets were functioning properly. Blockages and leaks are common in waterborne systems.

Table 8.Distribution of toilet type by islands				
Islands	Flush & septic toilets	Pour toilets	None	Total
Nanumea	31	75	22	128
Nanumaga	5	103	11	119
Niutao	11	81	51	143
Nui	9	84	15	108
Vaitupu	101	92	41	237
Nukufetau	22	82	14	118
Funafuti	424	163	43	639*
Nukulaelae	26	39	3	68
Niulakita	5	3	0	8
Total	634	722	212	1568
Source: (Government Census 2002, Lal et al. 2006) * Includes 4 composting toilets on trial				

The majority of the toilets are sited outside the house and are usually pour flush latrines which may be a pit, lined with coral stone, sealed with a concrete slab on which is installed a toilet seat. Flushing is manual and inefficient due to the design of the pan and its seal.

It has been observed by government personnel that toilets are not used as frequently as expected. Even with the additional rainwater storage now being provided there are times when the use of water for flushing has to be limited. In addition, particularly on outer islands, toilet paper has not always been available and/or affordable and this has led to disuse of flush toilets. There is a prejudice in Tuvalu that toilets are only for the weak, sick or old, and so usage is restricted further. Consequently even if a household has a toilet, some family members will still use the beach.

It is not surprising therefore, that many of the pits are not filling up even with solids after periods of 7-10 years. However, when latrines do fill up, they have to be sealed and a new pit dug out by hand. This has repercussions regarding available space on the house plot, and can be a further deterrent for usage especially on Funafuti.

Indoor flush toilets are mainly in Funafuti and Vaitupu where they are associated with “permanent” housing rather than “traditional” housing which usually has dry pit or pour flush latrines. The flush toilets discharge into septic tanks which are often poorly constructed and have no treatment trench. There are no satisfactory facilities for the treatment of sludge on any of the islands.

Most people repair or maintain their own septic tanks. PWD has produced a draft National Building Code that includes clear and easy-to-follow specifications for the proper construction of septic systems, the required fittings, and the minimum distance from buildings and groundwater wells. The PWD has been involved with the construction of wastewater treatment systems for government facilities and a few private households (based on requests and the availability of PWD staff). However, many of their own septic systems are leaking, because they are poorly constructed or have incorrect fittings.

The groundwater under villages on all the islands is polluted and lagoon shoreline and waters show signs of high nutrient loads and algal growth. In 1990 there was an outbreak of cholera. There were 1,809 reported cases of diarrhoea between July and November. Diarrhoea is usually not reported unless it is severe. It was considered that the outbreak was due to inadequate hygiene resulting from lack of water, and

contamination of water supplies and the lagoon water due to poor sanitation. There were 2,449 cases of acute respiration infections from June to October, and a conjunctivitis outbreak, in November. All of these problems are associated with sub-standard hygiene, and high household densities exacerbating disease transmission by flies.

Greywater disposal

Bathhouse. Indoor bathhouses are generally associated with "permanent" dwellings and usually discharge into septic tanks. Outside shared bathhouses are associated with "traditional" houses and may/may not be combined with a pit latrine. Often it is a thatched hut where people wash and the used water soaks directly into the ground. There may be a concrete slab to give a cleaner footing. It is preferable that the water should discharge through a water sealed trap into its own soakaway. Where no bathroom is available the people use the lagoon for washing and later rinse with small quantities of freshwater.

Kitchen greywater. In the "permanent" houses most greywater discharges into the septic tank. Where the drainage layout is inconvenient the greywater discharges into a separate soakaway where difficulties can arise due to poor construction and/or grease blocking the drainage surface. In "traditional" houses most greywater is just thrown over adjacent ground.

Laundry greywater. Washing of clothes follows a similar pattern to that of kitchen greywater disposal. Some "permanent" houses have specific laundry sinks where the sullage drains into a septic tank or soakaway. With the latter, grease is not usually a problem. Those without laundry sinks use the kitchen sink and/or shower. "Traditional" houses do not have sinks and the sullage is thrown away over adjacent ground. For both, disposal to a soakaway is to be preferred or into the latrine.

2.4.1 Measures to manage impacts and concerns (IWRM approaches)

There are no active measures in place to prevent pollution from poorly managed wastewater treatment and/or discharges. The National Building Code has been accepted in principle but not endorsed and implemented.

'Progress' was made in the 1980's to reduce beach defecation, however the introduction of septic tanks and pour flush latrines resulted in a considerable increase in water demand (typically 25-40%), and inadequate design and construction and maintenance of sanitation systems, porous soils and the shallow groundwater resulted in widespread groundwater contamination. It was estimated in a cost benefit analysis (IWP 2006) that the 'do nothing' costs of sanitation on the national economy are AU$ 475,000 per annum, of which 80% is attributable to health treatment costs. Whilst 87% of households reported having access to flush or pour toilets (as reported in the 2002 census) a national septic tank audit (AusAID 2001) confirmed 96% of tanks were inadequately designed to operate as required for household inputs and to prevent groundwater contamination. Furthermore there is no regular sludge management in the country (Lal et al. 2006).

When looking at the issues of water supply and sanitation together the impact of water scarcity becomes obvious. Lal (2006) reports that during periods of water shortage, the waterborne systems toilets cannot be used, and 80-90% of the households surveyed use lagoon and ocean side beaches for defecation purposes. Thus water scarcity not only affects potable water supply but also affects non-potable water usage including specifically its use in sanitation and therefore results in increased social, environmental and economic costs to the country.

Two domestic composting toilets have been trialled in Tuvalu, one installed in 2006 and one in 2001, both of which are functioning well and accepted by the host families. There is an opportunity to build on the work undertaken during the

International Waters Programme and further promote the links between ecological sanitation and adequate water supply.

For Funafuti, any solution to chronic water shortages may have to take on a larger dimension, possibly in the form of construction of one or more large cisterns for rainwater storage. When the new government building in Vaiaku on Funafuti was built (2002-2004) a water cistern was built in the basement storing up to 360,000 gallons of water. Water from this storage facility is used to meet the demand in the building and also for filling up the PWD water trucks that sell water to the public on demand.

At present, the government basement storage facility can bridge a period of 10-14 days without rainfall once private household supplies start running low, which usually takes about two weeks without significant rainfall. The objective of the government is to have enough water storage for droughts lasting up to two months, if not longer. A recent submission by the Tuvalu Government to the ACPEU-Water Facility included a proposal to transform one or more of the Funafuti's 'burrow pits', into one or more water catchment and storage facilities.

Japan has recently provided a second water desalinator, meant to be used for backup supply only. However, both desalinators are often used on a 24-hour basis to refill the government building's underground cistern and it may only be a matter of time until such expensive water production becomes unaffordable.

2.5 Institutional arrangements

a) Types of institutional arrangements, major issues and concerns

Tuvalu has a complex formal and informal governance structure which has challenging implications for the water sector, waste management and pollution control.

Prior to 1997 the community was governed by two bodies: the customary Maneapa and the introduced colonial Council. After December 12 1997, a new form of governance was established in all of the communities in Tuvalu. The Falekaupule Act of 1997 passed by the Parliament of Tuvalu, devolved authority to the Falekaupule and Kaupule (two separate bodies) to work together in addressing community affairs.

The merging of the two systems has implications for how the authority deals with its own affairs, and how it manages issues relating to waste management and pollution control.

Traditional hierarchy

Traditional Funafuti society is structured around the Pule Fenua (Head Chief) and Sina o Fenua (elders of the island) as seen in Figure 2. The executive is made up of the Pule Fenua (Head Chief), the Tokolua Pule Fenua (Assistant Chief) and the Failautusi (secretary). The Sina o Fenua which consist of toeaina (male elders of the island) assists the Pule Fenua in executing its function. Members of the community over the age of fifty elect the executive. There are only three clans on Funafuti, known as Vaitafe, Malunga'ata and Matailima.

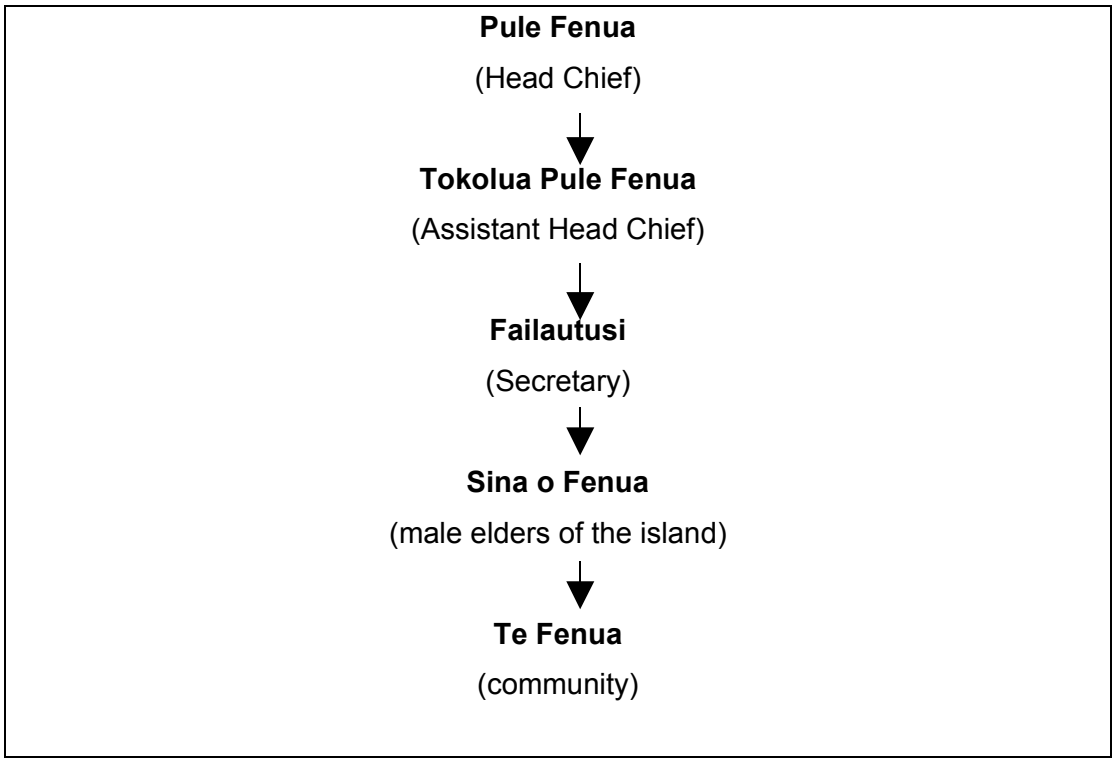
<u>Falekaupule</u>

The Falekaupule is a traditional assembly (in its formulation and practice) and was established in accordance with the aganuu (i.e. customs and tradition). The Falekaupule has control over the affairs and activities of the islands by being vested with powers and functions once held by the island councils.

The passing of the Falekaupule Act of 1997 enabled the island community of Funafuti to have greater say in designing development programme that addressed

their local needs. One of the functions of the Funafuti Falekaupule is to ensure proper management of waste on the island. The Falekaupule has the highest authority in the Funafuti Community to make decisions. The Falekaupule includes everyone from the Pule Fenua to the Sina o Fenua.

Figure 2: Traditional Tuvalu hierarchy



Kaupule

The Island Councils, renamed the Kaupule after the Falekaupule Act in December 1997, function as the executive arm of the Falekaupule. The Funafuti Kaupule has six elected local members. The Chief, *Pule o Kaupul*, and Assistant Chief *Tokolua Pule o Kaupule* are elected from these local members. The other four members represent different development sectors within the Kaupule. One of these members is responsible for health and sanitation issues on the islands and a second member is responsible for the Funafuti Conservation Area

Any external issue or development matter that requires the community's support is channelled through the Kaupule before going to the Falekaupule for deliberation and final decision.

The Kaupule's role is to contribute to the enhancement of the community's livelihood by working towards the achievement of the following development goals:

- Increase the ability to generate revenue within the community for its common good;
- Fund community projects that improve communities living conditions;
- Assist in developing skills and self-reliance in communities through local training;
- Enable the communities to acquire, maintain and improve community assets and resources to boost education and self reliance.

b.) Institutional mechanisms

There are minimal institutional mechanisms in place to manage water resources and wastewater. It has been observed by government personnel that the development of community fisheries management plans under the Fisheries Act assists in the better management of marine water resources, and this indicates that a similar plan for fresh water resources would be very beneficial (Saloa 2006).

There is no national plan endorsed for the management of water resources in Tuvalu. There was a ten-year Master Plan developed in 1992 which was shelved until recently when it was used to develop the draft Integrated Water Resources Management (IWRM) Plan. The Plan was developed by the National Coordinator for the International Waters Programme Mr Kelsoma Saloa and the Director of Public Works, Mr Filipo Taulima in consultation with the Water and Sanitation Committee in 2005-2006.

A draft Water Resources Act is ready for revision together with the completion of the IWRM Plan. Currently, the only significant legislative reference to water resources management is a provision in the Constitution for government and councils to acquire freshwater resources during drought emergency periods. In times of water shortage the government will take control of all freshwater resources in Funafuti, and on the outer islands. The Councils (now Kaupule) can requisition all community cisterns and impose rationing.

There are no regulations apart from Kaupule by-laws to ensure that the public build a water storage facility when building a new home, or that they properly construct and maintain rainwater harvesting systems and sanitation systems. The Cabinet decided to only approve in principle the draft Building Code in 2005, “as the initiatives documented in the code need improvement, and have to be implemented timely and consistent to our economic status and cultural values.”

Land disputes are a major problem in Tuvalu, and particularly in Funafuti where there is shortage due to overcrowding. Most of the land is owned by families with the government renting a small portion on other islands and a larger area of land on Funafuti. Landowners usually undertake whatever developments they wish on their land, which in many cases conflicts with both national and communal policies, regulations and interests.

Development is under the control of the Falekaupule and its executive arm the Kaupule. On Funafuti there are some exceptions where the Government is providing facilities for its own use on land that it leases. The process of controlling development is unsatisfactory and it is reported that the Kaupule regulatory supervision of construction is largely non existent (Saloa 2006).

Stakeholders in the water sector

The water sector includes government departments, NGOs local government (Kaupule) and community members that have direct and indirect responsibilities for the management, protection, analysis, storage, transportation and control over water resources. The Government contribution to water developments every year is estimated at around AU$132,468 (using 2006 prices) primarily directed to the payment of government staff undertaking their duties providing water treatment and delivery, and attending consultations and meetings. Donor agencies fund almost all water-related infrastructure programmes at the national, communal and household level. See Section 4 for responsibilities of various stakeholders

On the majority of islands the Sanitation Aide (a Medical Division staff member attached to the Kaupule) gives advice and assistance in regard to maintenance of water and sanitation facilities. A Public Health Inspector from the Medical Division visits periodically to conduct inspections. Recently simple testing equipment for bacteriological and saline contamination has been provided to the Medical Division and its staff on the outer islands. The Division’s main laboratory is associated with

the hospital on Funafuti. There are also laboratories associated with the government Secondary school of Motufoua on Vaitupu, and the Tuvalu USP Centre Augmented Foundation programme on Funafuti.

On Funafuti, the Government through PWD and the Kaupule both control public cisterns. Both manage their cisterns without reference to each other and coordination only occurs in times of drought and not always then. Water from the community cisterns is restricted usually to Funafuti born residents. Water from Government cisterns is distributed for a fee even in times of shortage when it is rationed. If a drought is declared rationing is more severe and then no charge is made.

PWD staff take care of Government buildings and are available to advise other landowners. PWD staff travel to other islands to carry out inspections and supervision of works when required.

c.) Measures to manage impacts and concerns (IWRM approaches)

In 2001 a Water and Sanitation Committee was established by the Ministry of Works and Energy to examine the management of water resources, and increase collaboration in decision making between the stakeholders. The following personnel are members of the committee:

- Director of TANGO (Tuvalu Association of NGOs)
- Director of the Ministry of Health
- Secretary for the Kaupule
- Director of Environment (Acting)
- Private Secretary to the Prime Minister
- Secretary of Ministry of Works and Energy and Chairperson of the National Water and Sanitation Committee
- Director of Public Works Department (Acting)
- Waste Management Coordinator (Acting)
- Director of Meteorology Department (Acting).

The Committee usually meets to decide what should be the priorities for water and sanitation programme which are funded by donor agencies. The Committee was consulted in preparation for the Sustainable Integrated Water Resources and Wastewater Management programme and its ongoing engagement is a major step forward in collaboration between the various agencies.

As discussed in previous sections there are a number of policy matters and legislation issues that need to be resolved in the near future. Many of these matters and issues have been raised in previous reports and are planned to be addressed in various programme. Some have been “on the table” for many years waiting to be dealt with either by legislation or other administrative arrangements. The obstacles to improved institutional arrangements need to be understood and addressed so that the following activities can take place.

- Review update and approve the draft Integrated Water Resources Plan.
- At the same time review, update as necessary and approve the draft Water (Resources) Act which was previously known as the Resources and Sanitation Management Bill (referred to in Kageega o Tuvalu, 1995-1998, p70).
- Engage community support for the draft Building Code so that it will be endorsed and implemented, including regulations to require minimum storage sizes for all new buildings and extensions to existing buildings, and to ensure that households maintain their rainwater collection and storage systems in good order, and that water saving devices are used in houses and buildings, and appropriate plumbing standards develop are implemented.

At previously discussed, there is a complex array of different factions or groups that each have roles in managing water resources, through a range of semi-regulatory mechanisms. There is no one document or legislation that deals directly with the proper management of water, and because of socio-economic and cultural factors it is reported that it is complicated to formulate such an over-arching mechanism. There is a public expectation that all levels and agencies of government and the Kaupule should coordinate their activities to ensure that water is adequately protected. The question remains how coordination can be achieved between agencies to reduce duplication and overlapping responsibilities. Can responsibilities be harmonised across jurisdictions? Which agencies are best positioned to perform which activities?

2.6 Finance

a) Types of financing arrangement, major issues and concerns

Once constructed household rainwater harvesting systems (RWH) have virtually no running costs apart from occasional repair of tanks and gutters. The cost of construction of almost all domestic rainwater harvesting systems in Tuvalu has been provided by donor agencies with family members usually assisting with labour.

However full capital cost recovery analysis indicates a unit value of AU$0.69/m³. This is considered to be readily affordable compared to the existing desalination delivery tanker tariff of AU$3.50/m³ paid by Funafuti residents. PWD advises that the tariff system for desalinated water only recovers less than 50% of the operation and maintenance costs of operating the unit (AU$7.9/m³), thus providing a revenue burden on the government and creating serious doubt as to the sustainability of desalination as a full time water supply technology (Taulima 2003).

In 2005-2006 a cost benefit analysis study was conducted by the International Waters Programme. “Tuvalu faces some real challenges in relation to the management of its human wastes, Fekau o Tino. Taking a conservative approach, this study estimates that current largely septic based system of liquid waste management is costing the nation about $500,000 a year. This estimate is based on partial analysis of the costs of poor sanitation on human health, the preventative costs incurred by individuals and government in the use of alternative water, including rainwater tanks, bottled water and desalinated water, as well as limited costs to the coastal fisheries” (Lal et al. 2006).

The study examined the options available which include:

- fix the current septic systems including provision of functioning sludge collection and treatment;
- establish a centralised reticulated system; and
- ecological sanitation systems based on compost toilets.

The study observes that options available to the government for improving the sanitation system are constrained by:

- availability of financial resources (even if capital costs were covered by donor agencies) particularly for ongoing maintenance of a centralised system and a sludge management systems.
- Tuvalu’s unique biophysical atoll environment including the ground water level being within 2 metres of the surface.
- Tuvalu experiences dry weather for up to 3-4 months of the year, as well as extended periods of drought.
- In periods of rainy season and king tides, much of the land area is subject to

regular flooding.

The study concludes that "the annual cost to Funafuti of establishing and maintaining a compost system as part of a new home is even less than the current total cost to human health, preventative costs and loss in coastal fisheries. The initial capital investment necessary to convert existing homes to compost toilets is approximately the same as it would take to replace the leaking septic tanks. Even with a well operating septic tank system, the economic outcome will be one of negative net economic benefits due largely to the high shadow value of scarce water. Desalinated water is known to be costly through the world because of high energy and operating costs (UNESCO 2001)" (Lal et al. 2006).

Table 9: Total economic cost associated with current status of human waste management

	High	Best	Low
Human Health	452,630	395,807	284,749
Desalination Water	49,961	37,470	12,490
Rain water	44,584	27,020	-
Bottled Water	4,676	9,784	4,892
Fisheries	14,190	5,676	2,838
Total economic costs (AU$)	**576,040**	**475,758**	**304,969**

Source: Lal et al. 2006

b) Measures to manage impacts and concerns

Improved wastewater management

In regard to sanitation the cost benefit analysis makes the following recommendations:

- Compost toilet systems established using 'local' material in Tuvalu has net positive economic benefits. Despite such economic benefits, social acceptability of the ecological sanitation system is, however, likely to be slow. To encourage the adoption of compost toilets, a multi pronged and sequenced programme is needed.
- An intensive education programme highlighting the merits of using compost toilets vis a vis other management options, including the do nothing option is needed. Economic values estimated in this study could help provide more focused and objective quantitative information that can demonstrate the economic costs of the current system as compared with the expected net benefits of changing over to an alternative system, including the savings in freshwater.
- Develop an integrated liquid waste management plan, involving key stakeholders, including PWD, Local Kaupule, Department of Environment and the Ministry of Health. The liquid waste management strategy must be linked to the national budgetary process through the national sustainable development strategy or the Te Kakeega II. The annual budget allocation explicitly reflects the integrated approach needed to manage sanitation, water and human health, as well as the environment.
- Institutional reforms: In the outcome focused plan, it is imperative to establish an interdepartmental waste management task force. Clearly define roles and responsibilities of each government organisation involved in waste management, while emphasising the shared responsibility for the management of liquid wastes in Tuvalu. Each agency must be adequately

resourced and their programme of work coordinated and harmonised.

- Economic Instruments: Adopt economic incentives such as subsidy to bring about conversion to compost toilets.
- Legislative instrument: Develop an appropriate liquid waste management legislation in which compost toilet system is made mandatory in the design and construction of all new homes, and new additions to existing homes. The cost of doing so could be provided as a subsidy by the Government. Together with this, an effective monitoring and enforcement system would also be needed.
- The Government could approach a development partner to assist with the conversion of the existing septic system to compost toilets for households that show commitment to the use of ecological sanitation system. The Government could also consider approaching development partners for assistance under the Clean Development Mechanism of the Kyoto Protocol.

In conclusion, Funafuti has very few choices available in regards to its management of human waste. If the country does not tackle this issue urgently, the problem is likely to become more acute as population increases and especially if predicted climate change become a reality (Lal et al. 2006)".

Improved rainwater harvesting

In regard to rainwater harvesting systems there is currently a programme planned through AusAID to ship a portable manufacturing plant to Funafuti to carry out the manufacturing of polyethylene tanks. With possible "business case" options for consideration, the proposed strategy of manufacturing water tanks in Tuvalu is intended to achieve the following benefits.

- Building water tanks in Tuvalu will save freight costs (AU$5,000 plus for each 10,000 litres tank) thus addressing affordability of water tanks for all households.
- Quality assurance guaranteed as Tuvaluans will be involved in building tanks.
- Accessibility of affordable water tanks in Tuvalu.
- Improved water catchment in Funafuti and Tuvalu will seriously address and reduce the risk of drought.
- Allows possibility to move water tanks to outer islands.
- There will be potential for foreign direct investment (Rotomould Fiji) and through partnership can lead to private sector development.
- Building tanks in Tuvalu will mean capacity building and transfer of technology and knowledge (from Rotomould to Tuvalu).
- Sustainability will be enhanced as skills in the maintenance of water tanks will be developed through local involvement in building the tanks.

Attention will also be required to ensure collection systems and foundations for the tanks are adequately funded, properly designed and constructed, and education in demand management and maintenance complements installation of infrastructure.

3. LINKAGES TO OTHER AREAS

3.1 Landuse and Agriculture

There is no existing landuse policy with special emphasis on water resources, wastewater management and water source protection.

Most land use conflicts relate to shortage of land especially in Funafuti and the tensions between landowners from Funafuti and residents who have migrated to Funafuti from other islands because of perceived increased opportunities. This affects availability of land to construct rainwater harvesting systems at household and communal levels. There is also limited land for construction of septic tanks, pour flush pit latrines pig pens and particularly public systems such as a sludge treatment facility. As one Funafuti resident commented “my neighbour’s septic tank is their back yard and our front yard”.

As previously discussed high density domestic, government and commercial occupation of limited land impacts on groundwater to the extent that it is no longer fit for human use even as a brackish secondary source on Funafuti, and is increasingly being threatened in the other islands.

Irrigation for crops is minimal as most root crops are planted into the groundwater in pits, and rainfall is high. Small domestic vegetable gardens are fed by hand with rainwater if necessary during dry periods.

As previously discussed in this report effluent and leaching from sanitation systems contaminates groundwater and leaches into the lagoon. Solid waste leachate is also a contaminant.

There is an Island Council (Kaupule) collection service only on Funafuti and Niutao Many houses practice recycling. Containers are kept to reuse for storage. Tins are used for gardening, or if aluminium, sold on Funafuti to a private firm who bales and exports them and other metal wastes. Food scraps are saved to feed the family pigs and birds. Leaves and other vegetables matter is collected and used as compost. Thus the amount of refuse to be collected depends on the life style of the family.

On Funafuti collected refuse is disposed into burrow pits. The pits are porous and subject to tidal movement. The refuse is not covered and so the tip site is a health hazard. Disposal of the following waste items pose potential threat:

- Batteries (particularly on the outer islands) from solar power installations. Battery life is about 5 years.
- Medical wastes: drugs, syringes, bandages etc.
- Oils from the growing number of vehicles and motorcycles (mainly on Funafuti).
- Household chemicals.

3.2 Habitats and ecosystems

A Marine Conservation Area (MPA) encompassing marine and terrestrial habitats has been established on the capital atoll of Funafuti in Tuvalu, and is known as the Funafuti Conservation Area (FCA). The conservation area is the first of its kind to be established in Tuvalu and covers a total area of approximately 33 km² of the western reef margin, accounting for 20% of the reef area of the atoll.

Included in the conservation area are six small islets or *motu* which total 8 ha of terrestrial habitats (including 40% of the threatened native broadleaf vegetation in Funafuti - Environment Unit 1995). The boundaries of the conservation area have been set at 50 m from the ocean side reef crest in the west, to the 30 m depth contour on the lagoon side in the east. In the north-south direction, the conservation area extends from just north of Tepuka Vilivili to just south of Tefala islets. The marine habitats incorporated in the conservation area include channels from lagoon to ocean, ocean side and lagoon side reef crests, reef slopes, back reef areas and the sandy lagoon floor.

The Funafuti Town Council (FTC) is the executing agency for the new conservation area which works in close collaboration with the traditional Falekaupule (maneapa)

system of elders or toeaina. Although the conservation area has been declared under the traditional system, the passing of a legal framework is also required.

The primary aims of establishing the conservation area are:

(i) to preserve a representative area of the atoll habitats to conserve the marine and terrestrial biodiversity of Funafuti;

(ii) the preservation of a breeding stock of exploited organisms (providing a substantial breeding stock of all species is maintained) to allow replenishment of fished areas of the atoll (and other atolls) by export of gametes and larvae;

(iii) the export of adult fishes by migration from the conservation area to surrounding fished areas thereby improving overall fishing or catch per unit of effort.

In Funafuti lagoon there are at least 400 recorded species of fish alone so surveys and monitoring have concentrated on indicator species which relate to the three main marine groups: food fishes; corals and algae; other invertebrates.

The indicator families of fish includes the Acanthurids (surgeon fishes or pone), Chaetodontids (butterfly fishes or moepepe), and Labrids (wrasses or kiole) which provide good indication of the "health" of reef fish communities. This group includes fish of most trophic types present on the reef (such as herbivores, carnivores, piscivores, plankton-feeders) and fish that use many different habitat types (live coral, rubble, sand). Many of the species are site-attached (have home areas or territories for their life time) so will be forced to respond if changes to their habitat occur. The relative abundance of each species can also give an indication of changes in overall reef structure.

The "food fish" category includes the larger, more mobile fish such as Siganids (rabbit fish or maiava), Lutjanids (snappers or fakamea, taia) and Serranids (groupers or gatala, loi) which tend to be targeted by local fisheries.

Corals and algae were surveyed to provide direct information on the health and condition of the coral communities because they are the organisms that form the habitat that fishes and other invertebrates respond to. The "other invertebrates" category was included because several of the species (sea cucumbers, giant clams) are exploited and because the species are likely to respond to changes in ecosystem health (Kaly et al. 1999).

Within the MPA surveys have confirmed that there is rich biodiversity:

- 36 species of coral
- 23 species of seabirds
- 2 species of land birds
- 40% of the total area of threatened native broadleaf forest
- indigenous coconut crabs
- nesting turtles
- 400 species of fish

Community support of the FCA has been strong and there has been observed increase in some fish species throughout the lagoon since the MPA was established but ongoing funding, capacity building and monitoring is required.

As a result of the successes experienced in the FCA, other islands such as Nui, Vaitupu, and Nukufetau are interested in setting up MPAs in support of their traditional marine management systems.

As discussed in previous sections of this report the primary threats to these habitats/ecosystems within the Funafuti lagoon and elsewhere in Tuvalu are from:

- Pollution of shoreline and marine waters from wastewater and solid waste

- Reef channel blasting and dredging
- Beach/rock mining and sedimentation
- Ciguatera fish poisoning
- Overharvesting of marine resources

It has been estimated that the net economic value of the MPA is AU$162,120 per annum (ADB 2003) and relates to:

- increased fisheries productivity
- coastal protection from healthy coral reefs
- improved opportunities for eco-tourism, dive tourism, ocean recreation and similar income generating activities.

3.3 Health and hygiene

3.3.1. Major health concerns

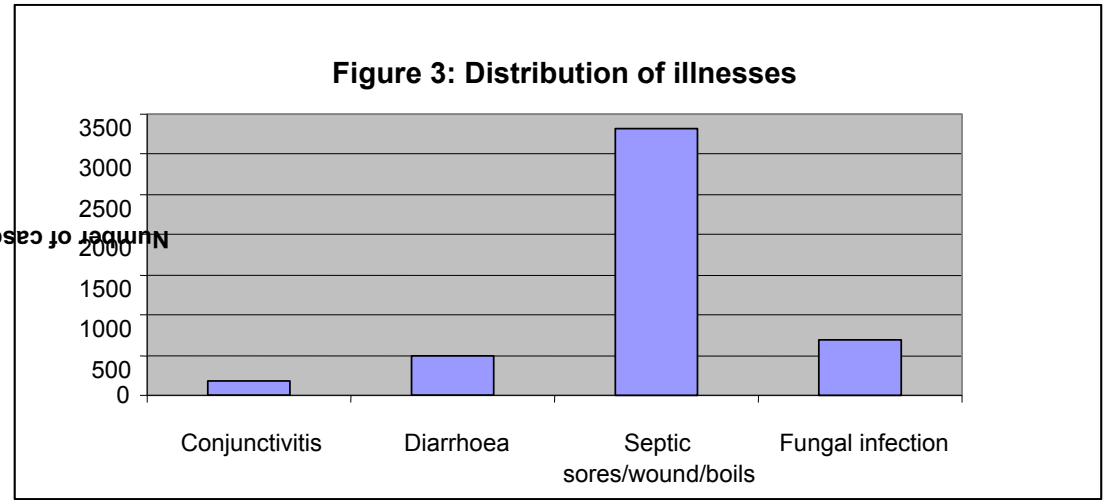
As discusses in previous sections of the report the major health concerns related to water resources and wastewater management are:

- pollution of groundwater and coastal waters from solid waste and human and animal excreta, and invisible threats from exposure to disease causing organisms especially for children;
- household rainwater harvesting systems polluted from animal droppings and dust;
- water supply delivered to household tanks may be contaminated during delivery from communal cisterns or the desalination plant;
- insufficient storage may mean there is not enough water for basic hygiene and flushing of waterborne toilet systems.

The groundwater under villages on all the islands is polluted and lagoon shoreline and waters show signs of high nutrient loads and algal growth. In 1990 there was an outbreak of cholera. There were 1,809 reported cases of diarrhoea between July and November that year. Diarrhoea is usually not reported unless it is severe. It was considered that the outbreak was due to inadequate hygiene resulting from lack of water, and contamination of water supplies and the lagoon water due to poor sanitation. There were 2,449 cases of acute respiratory infections from June to October, and a conjunctivitis outbreak in November. All of these problems are associated with sub-standard hygiene, and high household densities exacerbating disease transmission by flies.

Many children under five have diarrhoea and intestinal parasites. Boils, septic sores, fungal skin infections, tinea and conjunctivitis are also common and are considered to be waterborne, water-washed and water-related diseases.

Figure 3: Distribution of waterborne illnesses and diseases



Source: Kilisimasi Setoga Statistics Officer, Princess Margaret Hospital, Ministry of Health, Tuvalu. Figures from Lal et al. 2006

In Tuvalu, information about the effects of poor human waste management on human health, groundwater and coastal ecosystem is limited, and in some cases almost non-existent. In the IWP cost benefit analysis in 2005-06, impact models were derived using expert knowledge from specialists working in the respective fields to determine the impact of poor waste management on human health; on likely changes in the use of desalination water, and rainwater. In the case of coastal fisheries, a 'benefits transfer' method was used in the absence of local empirical data to determine the likely quantitative impact on fish output. Since there is a level of uncertainty associated with each of the data sets, sensitivity analysis was also carried out giving, low, best and high estimates for proportionate changes in each of the key parameters due to the improvements in sanitation. These assumptions are summarised in Table 9.

Table 10: Range in attribution factor of the effects of poor sanitation on human health, groundwater, use of bottled and desalinated water, and coastal fisheries

	High	Best	Low
Human Health (Dr Stephen, Acting Director, Department of Health oral comm. Nov 2005)			
Conjunctivitis	30%	20%	10%
Diarrhoea	80%	60%	50%
Septic wounds/ sores	90%	70%	60%
Boils	90%	70%	60%
Fungal infection	90%	70%	60%
Skin rash	90%	70%	60%
Ringworm	80%	60%	50%
Dhani/tinea	90%	60%	50%
Helminth and other worms	na	na	na
Alternative Water Sources			
Desalinated Water (Source: Filipo Taulima, oral comm. November 2005	40%	30%	10%
Bottled Water*	30%	20%	15%
Rainwater tanks*	33%	20%	0%
Fisheries**	10%	4%	2%
* based on personal opinion of Kelesoma Saloa, IWP Coordinator, SPREP, Funafuti ** Based on Tonga experience (see Lal and Takau 2006)			

Source: Lal et. al. 2006

Tourism

Tourism is a minimal industry in Tuvalu partly due to lack of accommodation and the high cost of airfares (e.g. AU$300 from Fiji to Tuvalu, a distance of 1000 km), although there are plans to engage a second airline which promises lower fares. There are a couple of private guest houses and one hotel on Funafuti. The hotel is owned by the government, and is usually occupied by visiting consultants. When there has been no rain for a couple of weeks, water supply at the hotel is reduced and the guests are unable to have showers or flush toilets until the delivery truck refills the hotel cistern which may take several days given the long queues of households waiting for water delivery.

The environmental degradation on Fongafale would be a deterrent to many tourists as would the evidence of poor sanitation but since the establishment of the MPA there is opportunity for eco-tourism, dive tourism and other marine recreation within the Funafuti Conservation Area. Promotion of the MPA and the conservation work that is being undertaken there would be a useful focus for marketing Tuvalu tourism, and increased visitor numbers would help to generate funds to support the MPA. However facilities for visitors need to clearly demonstrate sustainable water resources and wastewater management. These facilities could also serve as a model to the local community, thus raising the status of ecological alternatives.

3.4 Watershed and coastal management

There is a need to integrate watershed management and coastal management in the context of IWRM.

If the groundwater is to supplement rainwater and provide an emergency supply for the population in times of drought, great care will have to be taken to ensure that the water is not polluted or over-extracted. If it is over-extracted as happened on the outer islands during drought in the 1990s, the water will become brackish/salty, and the water level may drop with serious consequences for vegetation.

To prevent such possibilities, control can be exerted by licensing abstraction in the same way that the Constitution provides for rainwater supply to be controlled and rationed during times of drought.

There is a need to monitor near shore waters, especially the lagoons, and the impact from land based activities. Funafuti and Nukufetau have open lagoons, which large vessels can access through navigated passages. As previously discussed, in Funafuti the lagoon shoreline adjacent to settlements is degraded and showing signs of contamination.

In Nanumea, Nui, Vaitupu and Nukulaelae, there are ‘ponding’ lagoons. There has not been any monitoring of the quality of the water in these lagoons, but it is reported that the condition of the coral indicates that these lagoons “are much better off than the lagoon in Funafuti.”

Vaitupu lagoon is becoming shallower from erosion and runoff. The community have requested for the lagoon to be dredged so that the sediment can be used use as aggregate for construction. This will have to be undertaken with great care and is also important that measures are taken to reduce further run-off and sedimentation.

Part of the lagoon on Nanumea was used as a dumping ground after the Second World War and the area is covered with dead coral.

Efforts have been made to integrate water resources management through an institution which would also facilitate and coordinate watershed and coastal management. The Water and Sanitation Committee was established to undertake the integration of water resources management through its members who are stakeholders in the various sectors/disciplines. It would possibly be beneficial to include the Fisheries Department and the Finance Department in more active roles on that committee. See Section 4 for stakeholders.

4. Stakeholder engagement

The following individuals and institutions were consulted to gather information for the diagnostic report.

- Ms Annie Homasi, OBE Director of TANGO
- Dr Nese Ituaso Conway. Director of the Ministry of Health
- Ms Hellani Tumua, Secretary for the Kaupule
- Mr Enate E Taua, Director of Environment (Acting)
- Mr Kelesoma Saloa, Private Secretary to the Prime Minister
- Ms Misalaima P Nelesone, Secretary of Ministry of Works and Energy and Chairperson of the National Water and Sanitation Committee
- Mr Ampelosa Tehulu, Director of Public Works Department (Acting)
- Ms Susan Tuplaga, Waste Management Coordinator (Acting)
- Mr Uale Taleni, Secretary to the Ministry of Natural Resources and Environment.
- Mr Tauala Ketea, Director of Meteorology Department (Acting)
- Mr Panapasi Nelesone, Secretary to Government
- Mr Semu Malona, Secretary of Finance Economic Planning and Industries
- Members of Funafuti community
- Construction contractors
- Mr James Conway, EU Country Representative for Tuvalu

Table 11: Roles and responsibilities in water and sanitation sector

Institution/ Role in Consultation	**Stakeholder Interest /Responsibility Relevance to IWRM and reason for inclusion**
Kaupule **Member of Water and Sanitation Committee**	• Solid waste collection, transportation and disposal • Provision of rubbish bins to households • Cut grass and clearing of tree branches around streets • Public awareness programmes • Sanitation and health committee monthly inspection of households on Funafuti • Inspection of domesticated animals facilities, and ensure animals don't roam freely in settlement areas. All pets should have license or owner can face penalty or pet will be removed from the family • Manages Funafuti Conservation Area
Waste Management Unit **Member of Water and Sanitation Committee**	• Collects, separates, transports and disposal of solid waste • Provision of rubbish bins • Septic tank pump-out, transport and disposal at the piggery site (when de-sludge truck was working) • Waste management awareness programmes • Collection and storage of hazardous waste • Incinerating of hospital waste • Organising solid waste Community Clean-up campaigns • Conducting waste management related workshops with

	communities
Public Health Unit, Ministry of Health **Member of Water and Sanitation Committee**	• Quality sampling and testing of freshwater from tanks and water reservoir • Mosquito larvae treatments in water cistern, tanks and pulaka pits • Spraying of town area, inspection of houses, roof-tops and town area
Local Contractors	• Construction of septic systems • Empty sludge from septic tank and bury in ground.
Individuals	• Septic tank construction • Septic tanks sludge removal, and bury in ground • Collection of household solid waste and transport to dumping sites when other services not in operation
Public Works Department **Member of Water and Sanitation Committee**	• Provide technical advice to the public and formulation of building code that include sanitation, RWH and some waste management issues • Inspection of government facilities wastewater systems • Maintain and repair government facilities water supply and septic systems • Construction of government building water supply and septic systems • Operate and maintain desalination plant • Water distribution • Water quality and plumbing supervision
Ministry of Natural Resources and Environment **Member of Water and Sanitation Committee**	• Department of Fisheries monitors and manages marine resources • Department of Environment conducts awareness and monitoring programmes in relation to pollution control and conservation of freshwater and terrestrial resources, and land use

5. Other Activities Related to IWRM

The following table provides information regarding other programmes and activities that will potentially contribute to the implementation of IWRM in Tuvalu.

Table 12: Activities in support of the Water Sector

Project Acronym	Partners	Donor	Funds	Timeframe	Activities	Outputs
V&A = Vulnerability and Adaptation	ANU Australian National University	AusAID	1.2 M AUD	2007-2008	RWH Tank Construction WQ and GW Monitoring Water Management	250 -300 10Kl tanks GW Assess Monitoring Plan Galleries?
RWH = Rainwater Harvesting	UNDESA	Italy	US$100,000	2006-2007	RWH Tank Construction	50 10 Kl tanks
PACC = Pacific	SPREP	GEF	US$500,000	2006-2007	RWH Tank	

Adaptation to Climate Change		SCCF		and 2008-2012	Construction WQ and GW Monitoring Water Management Climate Information	
EDF / B-Envelope = Reducing Island Vulnerability	SOPAC	EU	US$0.7 million	2003-2007 and 2008-2010	National Reserve Tank Maximise RWH Grey water In-filling borrow pit	1500 m³ Emergency Storage Drought risk reduction
HYCOS = Hydrological Cycle Observing System	SOPAC WMO & UNESCO	EU Water Facility	US$50,000?	2007-2010	Drought forecasting Groundwater monitoring including baseline Data storage and analysis Water quality data Climate information	
WDM = Water Demand Management	SOPAC & Pacific Water Association	NZAID	?	2006-2009	Demand Analysis Use Analysis Leak Detection Water Use Efficiency Conservation Awareness	
WSP = Water Safety Planning	SOPAC & WHO	AusAID	?	2006-2007	Introduction of Risk Management Approach Improvement Schedule Draft Water Safety Plan Catchment to Consumer Awareness	
WQM = Water Quality Monitoring	SOPAC WHO & IAS	NZAID	?	2006-2009	Training in Water Quality Monitoring Laboratory Support Community-Based Monitoring	
Amatuku Center for Sustainable Development	Tuvalu Maritime Training Institute ADEME	Alofa Tuvalu NGO	US$800,000	2006-2009	Sustainable energy Biogas from pig and human waste Training esp. for women	
IWRM	SOPAC	EU Water Facility	?	2007-2010	• Policy • ?	
ICU = Island Climate Update	SOPAC, SPREP & NIWA	NZAID	?	2007-2010	• ?	
EDF10/A Envelope		EU	€2.25 million	2008-2013	Collection and disposal of solid waste.	
Fisheries Protection	Fisheries Dept	Foreign Fisheries Agency	AU$200,00 per annum		Onshore fisheries management programmememe Coral shelf	

					monitoring Clam hatchery in Funafuti Lagoon Prevention of discharge from boats and ships. Review Fisheries Act to include run-off	

In addition to the projects in the above table there is the annual government contribution to water sector developments which is estimated to be AU$132,468 using 2006 prices. This includes wages for government personnel involved in water treatment, supply, consultations, and meetings including the Water and Sanitation Committee meetings.

6. Capacity development needs for removing barriers to IWRM

All stakeholders in the water and sanitation sector require support and capacity building to achieve integrated water resources and wastewater management.

1. As many reports and reviews have recommended in the past there is an urgent need to revise, update and implement the draft Water Resources and Sanitation Management Bill, the draft Integrated Water Resources Management Plan, and the Tuvalu National Building Code which provides regulations and guidelines for design of roof catchments, rain storages, and sanitation systems. Among other benefits this institutional support will strengthen the authority of the Water and Sanitation Committee and will assist in clarifying roles and responsibilities within and between organisations and provide a framework for long term planning for staff requirements and funding. The reasons that this has not happened until now need to be analysed, understood and addressed.

2. There is a need to strengthen the capacity of the Public Works Department in the following areas:

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

In-country training would probably best address Tuvalu's specific needs and should include field work to investigate expansion of the use of groundwater resources. It would also allow personnel from the Kaupule, Public Health, TANGO and other stakeholder organisations to attend activities relevant to their field of work.

Given the broad range of responsibilities that the Public Works Department carries it is important to ensure that there are sufficient skilled personnel to attend to water and sanitation requirements. The recent tragic loss of the Director, Mr Filipo Taulima puts extra responsibility on existing staff and assistance will be needed to rebuild corporate knowledge and experience.

3. The Meteorological Service requires support to more effectively record, archive and analyse data and predict extreme events and the condition of climate stations should be reviewed and where necessary, refurbished.

4. There is no centralised sewerage system and 100% of households depend upon on-site wastewater systems and/or practices, so wastewater/sanitation management is entirely in the hands of the community. Most households also rely on individual or communal rainwater tanks so water management is also largely in the hands of the community. Householders require training as follows:

- demand management including use of water saving devices and leakage control;
- design, construction and maintenance of rainwater harvesting systems;
- design, construction and maintenance of effective and appropriate waterborne sanitation systems;
- design construction and maintenance of waterless sanitation zero discharge systems (including method of treatment, advantages and disadvantages, cost);
- water quality monitoring and protection including use of filters and first flush mechanisms;
- training in hygienic construction and maintenance of wells be provided to households in relevant locations. Training should draw on traditional understanding of groundwater management.

There is limited understanding of the linkages between poor sanitation, disease, degradation of the marine and aquifer environment and the indirect and direct impacts on livelihood and food security. The need to reduce demand and conserve water is also not widely appreciated, and complex cultural and land tenure conditions limit the opportunity for intervention by government. Providing training will not only raise awareness but will also provide the necessary skills to take action and responsibility.

5. The Fisheries Department requires support to amend the Fisheries Act to include control of land-based pollution of marine waters within their supervision, and as part of their community fisheries management plans.

6. The Water and Sanitation Committee could benefit from capacity building in resource assessment and demand management, and sustainable integrated planning and policy making.

7. Introducing an integrated approach to barrier removal

The people of the islands of Tuvalu are primarily dependent on rainwater. This freshwater supply is limited by natural and human parameters: rainfall; sufficient storage and proper construction and maintenance of rainwater harvesting systems at the national, communal and household level; and demand management.

Groundwater salinity levels vary, but it is historically a non-potable secondary source in areas where salinity levels are not prohibitive. In times of prolonged drought it has also been a source of drinking water on some islands. Its use as a secondary source has been severely compromised by pollution from inadequate sanitation systems on Funafuti, and there is an increasing threat that this could also occur on the outer islands.

The coastal areas of Funafuti are a major source of livelihood and also contain marine biodiversity of conservation value. These areas are also under threat from poor solid and liquid waste management.

It is necessary to approach these inter-related challenges with an integrated strategy. There is a need to refurbish or supplement freshwater resources by repairing rainwater harvesting systems, increasing household and community rainwater storage and investigating and expanding the use of groundwater resources. However there is also a need for demand management. Improvements and innovations in the management of wastewater could contribute to the protection of water supply and reduce pollution and degradation of land, groundwater and marine environments. To achieve this, collaboration of all stakeholders will be required: government institutions, non-government and community-based organisations and in particular householders themselves.

The technical improvements which are required include the repair and/or re-design of existing waterborne systems and the trial of waterless zero discharge sanitation systems in the homes of a broad cross-section of the community.

These improvements and innovations in the management of wastewater would contribute to protecting water supply as follows:

- Reduction of demand on primary water supply (rainwater harvesting) for flushing of waterborne sanitation systems.
- Reduction of dependence on national reserves to supplement household supply by reducing the need to flush waterborne systems (could reduce demand by 25 - 40%).
- Protection of secondary source of water (groundwater) from pollution by inappropriate sanitation technology.
- Protection of groundwater for use as a viable secondary source of water during drought, thus reducing vulnerability to climate variability.
- Development and implementation of improved and coordinated water resources and wastewater management through cooperation of civil society and government.

Source control of pollutants which impact on land, groundwater and marine environments will also be achieved through improvements in wastewater management as follows:

- Reduction of ingress of sewage to groundwater, lagoon and fringing reefs, and protection of marine habitat, and fish stocks and food security.
- Reduction of diffuse pollution of soil around malfunctioning and surcharging septic tanks and pour flush latrines, and protection of public health.
- Provision of organic fertiliser, and renewable energy, from alternative treatment of human and animal manure.
- Practical demonstration of the links between water conservation, effective waste management, public and environmental health, and food security.

These community-based activities in wastewater management will provide tangible economic and social benefits to households, and this is the most effective form of education. There will also be flow-on benefits such as enhanced potential for income generation through eco-tourism, dive tourism and marine recreation which in turn will raise the value of conservation and pollution control in the eyes of the community.

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ANNEXES

ANNEX 1: Funafuti Conservation Area

Funafuti lagoon and Marine Conservation Area. See Section 3.2

(southern end of Funafuti Atoll, looking west)

ANNEX 2: Topographical View of Urban Funafuti

Topographical view of main urban settlement of Funafuti, airstrip, and indicating location of burrow pits where it is recommended to build water cisterns as strategic reserves. See Sections 2.5 and 5.