FACULDADE DE LETRAS

UNIVERSIDADE DO PORTO

Maluseu Tapaeko

2nd Cycle Studies

MASTERS IN HAZARDS, CITIES AND SPACIAL PLANNING

WATER SCARCITY AND ITS NEGATIVE IMPACT ON HEALTH: CASE STUDY OF FUNAFUTI, TUVALU.

2015

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Classificação:

Ciclo de estudos: 2nd Cycle Studies

Versão Definitiva

To my lovely aunty, Mrs Aloiti Vakadranu and my late parents, Mr Tapaeko Fepuali and Mrs Naomi Tapaeko. With all my Love.

Acknowledgements

I would like to take this opportunity to firstly thank the Lord who is the source of my strength and life. Even though I falter many times and my faith seldom seem to dwindle, I knew that He has never forsaken me and always guided me.

My heartfelt gratefulness and utmost appreciation goes to my supervisor, Professor Ana Maria Rodrigues Monteiro Sousa for her tireless assistance and guidance throughout this research process and also for being an inspiration and an exceptional mentor. Also Luis Fonseca, your friendly and technical assistance is really appreciated.

I thank the European Union for the scholarship opportunity enabling me to further my studies. I am also very thankful and forever be appreciative to the contribution, assistance and friendliness of the following professors who educated me at the University of Porto: Prof. Carmen do Céu Gonçalves Ferreira, Prof. Carlos Valdir de Meneses Bateira, Prof. Helder Trigo Gomes Marques, Prof. Maria Helena Mesquita Pina, Prof. Mario Fernandes, Prof. Theresa Maria Vieira de Sà Marques, Prof. José Alberto Vieira Rio Fernandes, Prof. Helena Cristina Fernandes Ferreira Madureira, Prof. António Alberto Teixeira Gomes

I also acknowledge the advice and support of Dr. Tamarisi Yabaki. Sincere thanks to Dr Nese Ituaso and Ms Kaeva Lototele of Princess Margaret Hospital, Tuvalu; Elifaleti Ene and Niko Iona of Tuvalu Weather Office and Sakaio Malo at Tuvalu PWD for your contributions. To the administrative staff at FLUP who are always joyful, friendly and willing to help (Carla, Alexandra, Sandra, and Christina), thank you very much.

I acknowledge and appreciate my colleagues and friends who made life in Porto an interesting experience (Nemaia, Tara, Poonam, Ilaisa, William, Baraniko, Kesaia, Mere, Epeli, Beshoy, Mohamed, Taylor). Also to the Leuelu family, Ravono family, Natunivalu family at Brussels, the McNaughton family in Scotland and Jane Soani, a big thank you.

My special thanks to my family for their prayers and support that they provided, giving comfort to know that you all were always there. To my aunty, Mrs Aloiti Vakadranu, my appreciation and gratitude for your endless support. Lastly to the people of Kioa Island, Fiji, and Labasa congregation, thank you very much for the prayers.

Muito Obrigado/ Thank You very much/ Fakafetai Lasi

Abstract
Freshwater is a basic need that is necessary for human survival. Lacking water or facing water scarcity, in most cases often results in many problems of which health is one of them. Governments, organisations and all those concerned have been trying to find ways to solve this problem of water scarcity which in turn would prevent the increase of communicable diseases around the world.

Studies have revealed that a lot of people in the world face water scarcity at least one month every year, and this number is to increase in the future due to soaring world populations. This shortage of water has seen an increase in communicable and respiratory diseases mostly in developing. Most of these diseases are 'washable diseases' (Curtis, 2006) , meaning that the diseases are preventable, provided that there is sufficient availability of fresh clean water for bathing and more so for minor hygienic practises such as washing of hands after visiting the bathroom, before and after food preparation and before eating as well as other very basic hygienic habits.

Key words: Water scarcity, Health, Funafuti, Tuvalu

Acronyms

AUD – Australian Dollar

CIA – Central Intelligence Agency

EEA – European Environment Agency

ENSO – El Niño Southern Oscillation

FWLs – Fresh Water Lenses

GEF – Global Environment Facility

HDI – Human Development Index

HIV/AIDS – Human Immune Virus/ Acquired Immune Deficiency Syndrome

IWMI – International Water Management Institute

Km – Kilometres

NBT – National Bank of Tuvalu

NCDs – Non- Communicable Diseases

NGOs – Non- Government Organization

PASW – Predictive Analytics Software

PCCSP - Pacific Climate Change Science Program

PMH – Princess Margaret Hospital

TB - Tuberculosis

TMTS – Tuvalu Medical Treatment Scheme

UN – United Nations

US – United States

USD – United States Dollar

UNDP – United Nations Development Program

UNICEF – United Nations International Children Emergency Fund

WEI – Water Exploitation Index

WHO – World Health Organization

WSSCC – Water Supply & Sanitation Collaboration Council

WWF – World Wide Fund for nature

SPC – Secretariat of the Pacific Community

SOPAC – South Pacific Applied Geoscience Commission

Glossary for Tuvaluan word/terms used

Atua – God

Falekaupule – Local governing body at island level

Falesa – Church building/ Chapel

Fatele – Traditional Tuvalu dance

Fenua – land/ people

Kāiga – family *Kaupule* – Island council

Kaleve – sweet sap extracted from young soot of coconut trees

Maneapa – Community hall

Pālagi – white person/ people, mostly referred to Europeans

Te malosiga te fenua – literally mean ´the strength/ strong of the community´ meaning the youths and strong able bodies of the community

Te malae – Island ground

Te ulu sina – literally means ´white hair´ but it refers to the elders

Tino Funafuti – Person/ people from the island of Funafuti

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When the well is dry, we know the worth of water

BENJAMIN FRANKLIN, (1706-1790)

Chapter 1

Water has become a highly precious resource. There are some places where a barrel of water costs more than a barrel of oil

Lloyd Axworthy, Foreign Minister of Canada (1999 - News Conference)

1 Objective and Place

1.1 Objective

- To study the negative health outcomes due to water scarcity in Tuvalu. The perception is that with water being scarce and Tuvalu solely dependent on rain for fresh clean drinking water, the health of the people is likely to be affected in more ways than is already being acknowledged.

- To determine whether communicable diseases in Tuvalu increases when there is dry season which causes water to be scarce resulting in it being kept for food and drinking, that the very basic health hygiene are unknowingly neglected.

- To explore and mitigate approaches the government and people of Tuvalu can use to solve the problem of water scarcity and decrease related diseases.

1.2 Place

This research is based on Tuvalu, a small Pacific island country that is mostly unknown to many. Therefore this section of the dissertation draws the attention of the reader to Tuvalu, in order to get to know Tuvalu. The idea is that in order to fully understand the importance of this research work, it is only fitting to have a vivid understanding of Tuvalu.

1.2.1 Geography and Background of Tuvalu

Tuvalu is located in the Western Pacific Ocean, relatively about 4,000 kilometres (2,500 mi) Northeast of Australia, and West of the International Dateline. It is approximately midway between Hawaii and Australia. The island group is absolutely located at 8 00S, 178 00E (Resture, n.a). The islands consisting of Tuvalu are spread out between 5º 41'S 176º 12'E to 10º 45'S 178º 51'E. Tuvalu's Exclusive Economic Zone is 200 nm (686.858 sq km) (Agency, 2014).

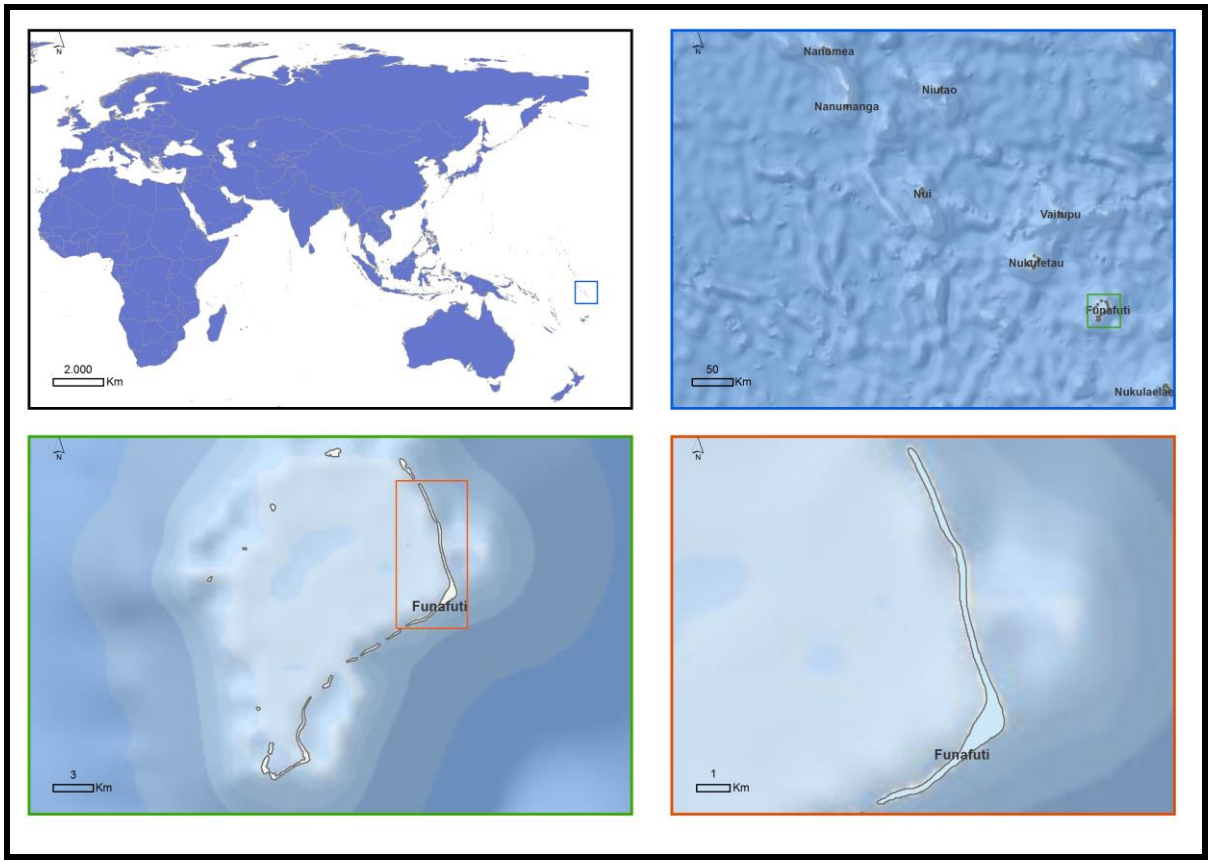

Figure 1 Clockwise starting from top left: World map showing location of Tuvalu; the map of Tuvalu; map of the capital Funafuti and finally the study area.

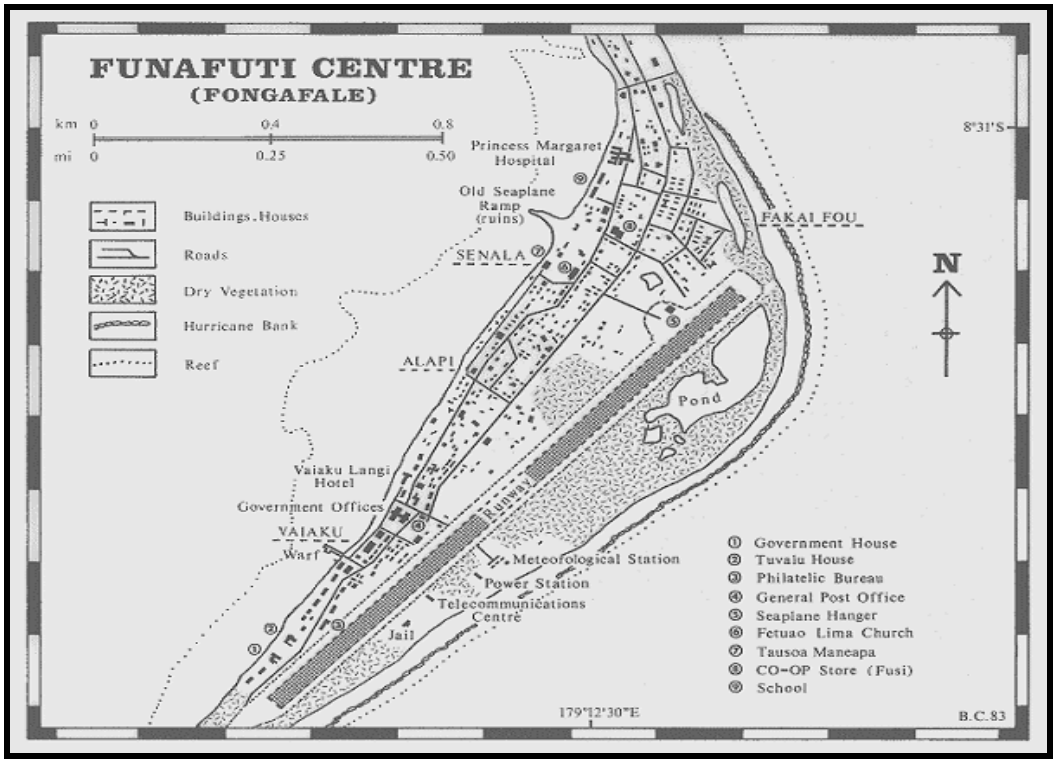

Figure 2 Funafuti centre, with village sites, main buildings and surface planning of Funafuti, capital of Tuvalu. **(**Source**: SOPAC, 2007)**

The islands of Tuvalu are low-lying, narrow coral atolls of which 9 are inhabited. Of the inhabited islands, 6 have lagoons open to the ocean with uninhabited smaller islands surrounding the lagoons, while 3 have landlocked lagoons. Tuvalu has a total land area of 26 km square. The capital is Funafuti with land area of 2.4 km square (254 ha) and also where the country's only airport is located. The biggest island is Vaitupu which has land area of 5.6 km square (Duncan, 2010) and also where the country's biggest secondary school, financed by the government is situated. A smaller secondary school financed by the church is in the capital Funafuti. Since land is scarce in Tuvalu, all land are family owned and no land is for sale, except for the government leasing land from the people.

Tuvalu island group is divided into 3 – the Northen islands consisting of Nanumea, Nanumaga, Niutao, the central islands – Nui, Vaitupu, Nukufetau and finally the Southern islands – Funafuti (Yamano et al.) Nukulaelae and Niulakita. Tuvaluan and English are the two official languages spoken in the country and are also taught in schools.

1.2.2 Climate

Tuvalu lies within the trade wind zone but on the edge of the South-west Pacific equatorial doldrum zone – the zone that is affected by the Inter-tropical Convergence Zone, a low pressure area around the equator where the prevailing winds are calm. Thus it has two distinct seasons – the wet season, also known as the hurricane season, from November to April and the dry season from May to October. Prevailing winds are from the easterly quarter and they occur most frequently between June and August. In most years from December to March, winds between the west and north usually equal or exceed the easterlies in frequency. Wind speed over surrounding ocean is about 10 knots (5.14 m/s) on average. Temperatures are uniformly high all year round with the mean annual temperature approximately of 28 degrees Celsius as shown in figure 3 below. Rainfall is also high from October to April which is the wet season.

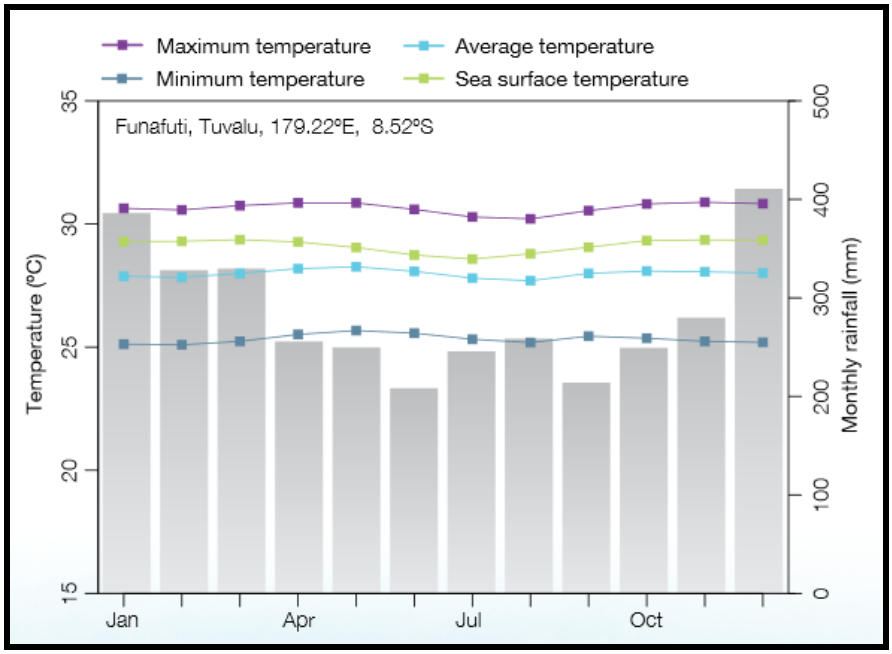

Figure 3 Seasonal rainfall and temperatures of Tuvalu as recorded at Funafuti **(**Source**: PCCSP)**

Rainfall in the southern Tuvalu atolls is high and reliable throughout the year but less so in the northern atolls. Average annual rainfall across the country is 3,000 mm per year (Stanley, 2014) but it can vary considerably from year to year. Sixty percent of the rain falls in the November to April period and it is in this wetter season that the heaviest rates are recorded. There is a significant inverse relationship between rainfall and the El Nino/Southern Oscillation Index leading the rainfall response by several months. Most years usually have some months of abnormal rainfall, but high or low rainfalls in the southern atolls are not very common. However abnormally low rainfalls do persist longer than high rainfalls especially in the northern atolls where they can last up to eight months, thus creating a shortage of fresh water supply for these islands. The average duration of rainfall on the capital, Funafuti is 525 hours per year. It rains fifty percent more often (317 hours) during the wetter season than during the drier one (208 hour) (Office)

With the high levels of sunshine, evapotranspiration rates are also high, but in most years in the south, rainfall is sufficient to meet these requirements. Dry Soil moisture deficits are most likely in the northern atolls which are drier.

Wet and hot weather occasionally bring cyclones to the vicinity of Tuvalu but rarely hit the country directly. Tropical cyclones occasionally develop near to Tuvalu and they rarely become hurricane force in Tuvalu waters but the strong winds from this cyclonic development cause a lot of destructions on land. This destruction is brought about by high

waves caused by cyclonic winds that wash onto the land damaging infrastructure and killing crops. Over a period of 41 years (see figure 4 below), 33 tropical cyclones passed within 400km of Funafuti.

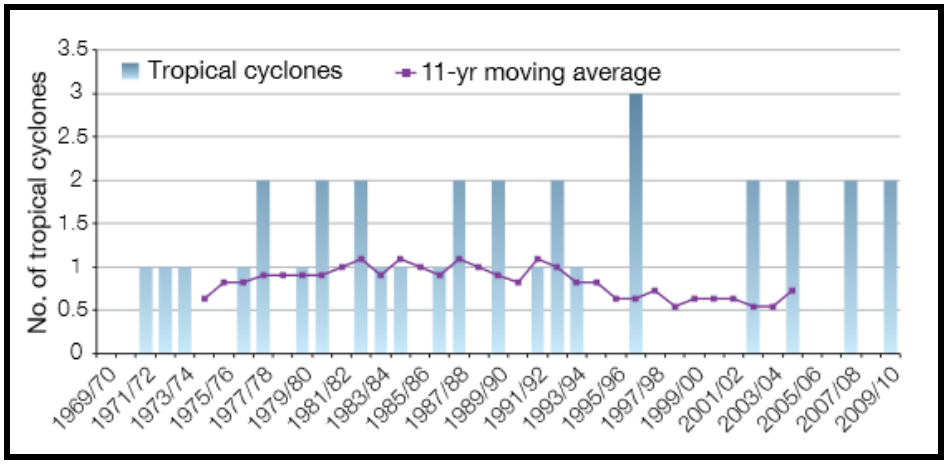

Figure 4 Number of tropical cyclones passing within 400km of Funafuti. Eleven year moving average in purple**. (**Source**: PCCSP)**

However, Tuvalu has experienced strong cyclones which caused massive destruction to its infrastructure, the worst being cyclone Bebe in 1972.

Dry weather in Tuvalu is quite hard to define because due to its sole dependent on rain for fresh clean water, a period of one month without rain with forecasts predicting no rain in the days that follow, is considered dry and in most cases publicly declared by the Tuvalu government as a drought period.

1.2.3 Geomorphology

Throughout the surface of the islands of Tuvalu (see figure 5 below), one could observe that the islands are covered with sand, unconsolidated sand and gravel deposits. During extreme king tides, mostly occurring between January to April, sea water is observed to be bubbling from underground, through holes of porous rocks, flooding the islands. This gives a general insight into the geomorphological formation of the atoll islands.

Figure 5 Clockwise starting from top left: water bubbling through porous holes in the ground; children bathing in their flooded front yard of the house; children playing volleyball in their neighbourhood with sea water ankle deep; picture of the same house during extreme king tides **(**Source**: Niko Iona)**

Studies have shown that the atoll islands of Tuvalu are predominantly composed of foraminifera[1], coralline algae and coral sands derived from the surrounding reef flats (Paul S. Kench, 2014). Based on these studies and of record dating, it was scientifically concluded that the islands of Tuvalu are geologically young at the age of a little more than 3000 years old (< 3000 year) (McLean & Hosking, 1991). The islands of Tuvalu, especially Funafuti atoll had a very rapid growth rate. Carbon dating the storm blocks, coral rubble and island sands indicated that islands 'growth took place very rapidly and recently during the period from approximately 2000 to 1000 radiocarbon years ago' (McLean & Hosking, 1991). Study on crustal thickness of Funafuti revealed that the cross section of the atoll has mostly three layers. The first and topmost layer is the reef and the lagoon calcareous deposits. Carbonate rocks make up the second layer, while the third layer is mainly oceanic crust and composed

[1] Single-celled protists with shells. Dead foraminifera pile up the ocean floors, and at present found deep within atoll island structures. Record dating these fossils give a high-precision age of the islands.

with basaltic rocks (Srivardhan, 2013). The presence of the basaltic rocks proves that the islands initially formed from a volcano which erupted under the ocean. However, the volcano has been inactive for thousands of years, and the islands formation has been on sedimentary deposits by waves, weather and of course fossil remains. Figure 6 below shows the rock properties found on Funafuti as per the study done by Srivardhan (2013).

Rock Properties of Funafuti:

Rock Specimen	Properties
Coarse Sand	Found in the western sea beach of the atoll and is entirely calcareous.
Calcareous Conglomerate	Found at a depth of 10 feet from a bore in the southern sea coast. It is loosely cemented and its composition is similar to beach sand.
Conglomerate	There exists abundant wornout pieces of coral which is very much consolidated with limestone and is heavier than the calcareous conglomerates.
Coral Rock	Found abundantly in conglomerates and breccias.
Pumice Pebbles	Found in the outer circumferences of the atoll and are well rounded and water worn with a fibrous texture.

Figure 6 Rock properties found on Funafuti **(**source**: Srivardhan, 2013)**

1.2.4 Hydrology

The online Oxford dictionary defines hydrology as the branch of science concerned with the properties of the earth's water, and especially its movement in relation to land. It is therefore a scientific study of the movement, distribution and quality of water on earth, including the hydrologic cycle, water resources and environmental watershed sustainability.

Many small islands in the Pacific, Indian and Atlantic Oceans have maximum widths less than 3 km. In these very small islands, surface water resources are almost non-existent because the soils are coarse coral sands. There are no rivers and the islands are only a few metres above sea level. Fresh groundwater resources often exist as shallow, thin veneers of freshwater floating over seawater (IAN WHITE, 2008). Urban and semi-urban low coral atoll communities face water problems that are among the most critical in the world (Carpenter, 2002).

The availability of clean, potable water is already a challenge for public health, especially as overcrowding on some atoll islands has long since reached critical levels (Spennemann, 2006; I. White, Falkland, Rebgetz, & Metutera, 2010). For instance, 15,755 people live on

Betio (1.7 km^2) in south west Tarawa Atoll in Kiribati (Finance, 2012), while tiny Ebeye (0.36 km^2) in Kwajalein Atoll in the Marshall Islands has a population density exceeding 40,000 people per km^2. Such overcrowding poses huge management issues, with food security and water supply already under strain (Virani, 2011) and Tuvalu is no exception.

Since there are no rivers or streams on atoll islands, the only natural source of fresh water, besides collecting rainwater, exists in the form of thin aquifers of fresh groundwater. These are known as freshwater lenses (FWLs), which accumulate within the island substrate of coral sands and gravels and their underlying platforms of reef-limestone geology. Rainwater infiltration into these porous sediments is entirely responsible for groundwater recharge, with FWLs essentially 'floating' on top of the denser seawater beneath. Brackish water occupies a wide transition zone at the base of the FWL, with fresh–saltwater mixing occurring mostly in a vertical direction (Underwood, Peterson, & Voss, 1992). The significance of predominantly vertical mixing is that the FWL is vulnerable to threats not just along island coastlines, but throughout the areal extent of the lens.

Expanding human settlements and increasing demand, agricultural activities and waste disposal, frequent droughts, climate variability and seawater inundation during storms as well as conflicts between traditional subsistence resource rights and the demands of urbanized societies are some of the challenges that the people face in obtaining and maintaining freshwater (IAN WHITE, 2008). Urban atoll communities have the potential to rapidly pollute groundwater with human and animal wastes so that water-borne diseases are often endemic. Due to this fact, there is no or little groundwater on the atoll islands. Where there is groundwater available, it is not suitable for consumption, which makes rain water, collected from house roof tops and stored in family owned tanks, the major source of clean fresh water available for people to use.

1.2.5 Demography

The last published census for Tuvalu is the 2002 census report. According to this census report, Tuvalu has a population of 9, 561 people, with 47% living on the capital Funafuti and 53% living on the other 8 atoll islands. This census report have separate count of males and females in its total population as well as other indicators on the report as shown in figure 8. However, the census does not report different cases or counts respective to each island but rather give a total figure for the whole country, like that shown in figure 7 below. For instance, 'crude birth rate' that is reported in figure 9 is for the whole Tuvalu. There is no

separate figures for the capital Funafuti, as well as all the other islands to indicate each individual Island's 'crude birth rate' compared to the whole country when put together. It is therefore only fair to mention that the 2002 census report give separate figures for only some cases even stating the different number of males and females, while in some indicators, the figure given represents the total male and female put together and is also for the whole country.

The 2012 census report is yet to be published which will definitely have the population of Tuvalu on an increase. However, the 2014 estimate of the country's population is 10,782 people (Agency, 2014). As per the census report, the country has a population density of 373 persons per square kilometre. The people of Tuvalu are Polynesians which make up 96% of the populations while the other 4% are other minority races: Micronesians, Melanesians, Europeans and Asians.

Tuvalu has 5.3% of its population over 65 years of age, 8.2% between the ages of 55 to 64 (see figure 7 below). The working age, known in Tuvaluan as '*te malosiga ote fenua'*[2] constitutes more than half of the populations at 56.8%. The children from 0-14 years is 29.6% of the population (Division, 2010). Figure 7 below shows the population pyramid for Tuvalu, illustrating the age and sex structure of the country.

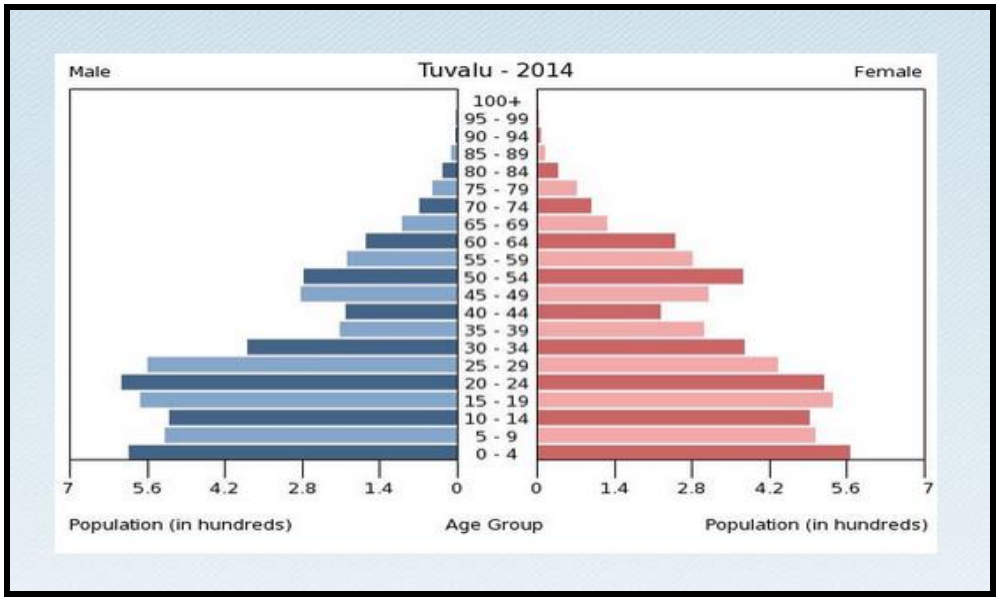

Figure 7 Tuvalu population pyramid **(**Source**: Central Intelligence Agency, US)**

[2] Directly translated into English as the 'strength of the community/country, but in a Tuvaluan context it means the youths of the Island communities who do all the work for the betterment of the communities

Life expectancy at birth is 63.6 years for the whole country. Females tend to live longer than males with a life expectancy of 65.1 and males at 61.6 (Division, 2010). However, the Central Intelligence Agency (CIA) ((SERI)) estimates for the population of Tuvalu for the year 2014 has the life expectancy at birth at a high of 65.81 years, with females still expected to live longer than males at 68.05 and 63.69 years respectively.

The 2002 census report states that the average annual rate of growth of the population from 1991 – 2002 is 0.6% and the Central Intelligence Agency ((SERI)), (Agency, 2014) rated this growth as 139 compared to other countries of the world. It is with utmost importance to take heed that in Tuvalu, there is interdependence between the people in all island communities. It is a mutual and communal understanding that everyone gives a helping hand whenever there is a need. Family and community are regarded as very important to all and thus is taken seriously. Due to this and also to the fact that the people are very resourceful with what little they have, that they live a more subsistence life. Therefore, the United Nations Development Program (UNDP) ranking of Human Development Index (HDI) (UNDP, 2013), do not have data for Tuvalu among other countries because the many products used are subsistence, given and taken freely, as well as the services provided are without charges, resulting in Tuvalu not having a ranking. However the country's Gross Domestic Product per Capita is $3,500 USD as of 2012 (Agency, 2014).

According to the census report, it was found that the capital Funafuti was the most crowded of all the islands. Considering that it is the most modernized of the islands compared to the others, services of all kinds and employment opportunities are abundant, and the internal migration of the population of Tuvalu from outer islands to Funafuti is evident in it being overcrowded.

Vaitupu Island is the largest island in Tuvalu with 5.6 square kilometres of land. It is also on Vaitupu Island that the only Government owned secondary school, known as Motufoua Secondary School is situated. Apart from Funafuti, there can also be found on the island the country's largest agricultural piggery site and fresh food gardens which provides employment to the island people as well as people from other islands. Due to these facts and employment opportunities (agriculture, teaching, nursing), that the population of Vaitupu is noticeably the second largest after Funafuti. There is extensive internal migration of the population especially towards the capital and second to it is to Vaitupu Island. Although separated by

vast distance of ocean, the people of Tuvalu are constantly moving from one island to another that the individual island populations are always almost constant.

Tuvalu was also affected by the slave trade of the 1800's. In 1863, 75% of the population of Nukulaelae were tricked into boarding a ship which carried them away for slavery trade and work plantations in Peru (Resture, 2014). This event had a massive impact on the island and now, 150 years later, the population on the island of Nukulaelae is still the lowest in Tuvalu with only 393 people residing on it during the census period in 2002, not counting Niulakita, because people residing in Niulakita are actually from the island of Niutao. Table 1 below shows the population distribution on each island in Tuvalu.

Table 1: Island of Enumeration by Nationality and Sex, 2002

Island of Enumeration	Total			Tuvaluans			Non/Tuvaluans		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Total	9,561	4,729	4,832	9,358	4,617	4,741	203	112	91
Nanumea	664	305	359	661	303	358	3	2	1
Nanumaga	589	276	313	582	272	310	7	4	3
Niutao	663	314	349	652	312	340	11	2	9
Nui	548	263	285	540	262	278	8	1	7
Vaitupu	1,591	799	792	1,579	791	788	12	8	4
Nukufetau	586	286	300	582	285	297	4	1	3
Funafuti	4,492	2,281	2,211	4,343	2,190	2,153	149	91	58
Nukulaelae	393	186	207	384	183	201	9	3	6
Niulakita	35	19	16	35	19	16	0	0	0

(Source**: Tuvalu Central Statistics Division)**

Map of Tuvalu

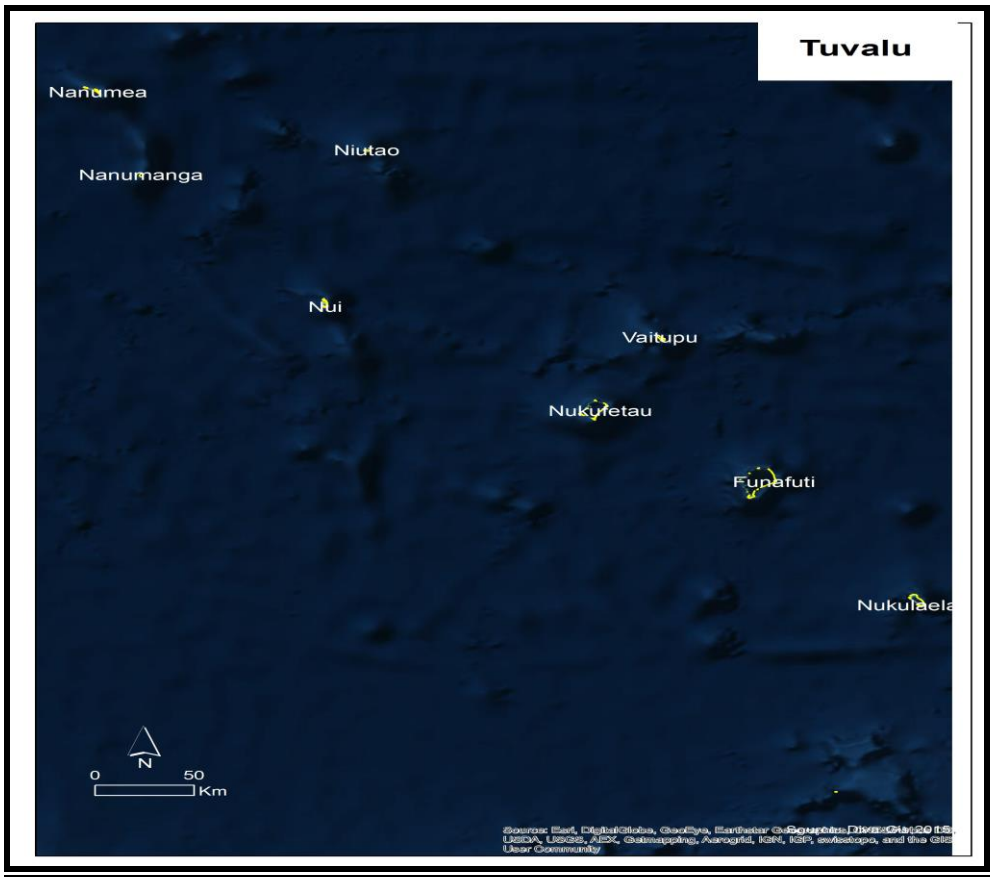

Figure 8 Map of Tuvalu

1.2.6 Health

Tuvalu has free medical and health services, providing most of the key health services to its citizens. Serious cases are sent under a medical referral scheme, the Tuvalu Medical Treatment Scheme (TMTS), mostly to Fiji or New Zealand. Non-communicable diseases (NCDs) are a major cause of morbidity and mortality, and the government has put up a road map for the Department of Health to combat NCD's in the future. Communicable diseases are also a common cause of morbidity and mortality, with alarming numbers of acute respiratory infections, eye infections and skin infections. An increase in tuberculosis prevalence has resulted in strengthening of the TB programme with improved testing facilities and diagnostics (WHO, 2014).

For diagnosis of many diseases, specimens need to be shipped to overseas laboratories, limiting the sensitivity and timeliness of surveillance. There is a limited supply of safe water and whatever little water that is available is strictly and properly utilized. The Princess

Margaret Hospital is the only hospital in Tuvalu. However, since 2008 a number of new medical centres have been built on outer islands.

According to the report by WHO (2011), there are 132 staffs employed by the Tuvalu Ministry of Health. There are 7 Tuvaluan doctors, 4 Cuban doctors, 35 registered nurses and 18 paramedics. All the doctors and paramedics are stationed at Princess Margaret hospital along with 18 nurses. The other 17 nurses are assigned to 9 medical centres on the outer islands including Motufoua Secondary School. Since there are no doctors available to the outer islands, the nurses are equipped with multi-tasking in order to be able to serve the people. They take up duties as dentists, mid-wives and pharmacists when the need arises. However this is done with close monitoring from the doctors in the capital through telephone. Contrary to the lack of human resource, the hard work done by these medical and health services personnel improve the overall health of the country. The Ministry of Health in 2009 revealed that the under-five mortality rate fell from 68.7 per 1000 live births in 1991 to 24.6 in 2009, a 72.6% reduction (more than the targeted 66.7%). In 2009, there were 5 under-five deaths and 203 live births. The infant mortality rate has also declined remarkably, from 57.3 per 1000 live births in 1992, to 34.6 in 2000, 38.3 in 2005 and 14.8 in 2009, a 74.1% reduction (more than the targeted 66.7% (WHO, 2011)

Additionally, according to the 2002 census report, from 1997 to 2002, the total for Crude Birth Rate stood at 26, whereas the crude death rate was at 10.2. Infant mortality rate between the same time periods in Tuvalu was quite high at 35. Alarmingly is the mortality rate of children 5 years and under, which at this time stood at 41 for a period of 6 years. Figure 9 below shows the demographic health indicators as recorded in the 2002 Tuvalu census report. Some of the indicators show numbers for males and females differently while others show only a total figure which is the sum of the two genders.

	Total	Males	Females
Total enumerated population (November 2002)	9,561	4,729	4,832
Resident population size (November 2002)	9,359	4,614	4,745
Rate of annual growtd (%), 1991–2002	0.6		
Rate of annual increase, 1991–2002	1.7		
Crude net migration rate, 1991–2002	–1.1		
Fertility			
Average annual number of birtds, 1997–2002	241	132	109
Crude birtd rate (CBR), 1997–2002	26		
Total fertility rate (TFR), 2000–2003	3.7		
Teenage fertility rate, 2000–2003	40/1000		
Mean age at child bearing (MAC), 1997–2002	29.3		
General fertility rate (GFR), 1997–2002	104		
Mortality			
Average annual number of total deatds, 1997–2002	94	48	46
Average annual number of infant deatds, 1997–2002	8	5	3
Crude deatd rate (CDR), 1997–2002	10.2		
Life expectancy at birtd, 1997–2002	63.6	61.7	65.1
Infant mortality rate (IMR), 1997–2002	35	41	28
Child mortality rate (4q1), 1997–2002	9	6.5	11.7
Under 5 mortality rate (5q0), 1997–2002	41	44	36

Figure 9 (Source**: Tuvalu Central Statistics Division)**

Table 2 below shows the leading causes of mortality in Tuvalu. The figure for all indicators is the total number of deaths in Tuvalu per sickness per year. The census report does not give individual deaths per island per year.

Looking at table 2 below, it is evident that the leading cause of deaths in Tuvalu is non-communicable diseases such as cardiac arrest, senility hypertension and heart problems. The year 2000, is the only one showing death by 3rd degree burns. It was a tragedy in Tuvalu on that year that 18 female students and their matron died in a dormintory fire (Taylor, 2000) in one day, which in proportion to Tuvalu's populations, the 19 deaths is equivalent to 8,000

New Zealanders or 25,000 Australians in one 'calamity in their respective countries' (Taylor, 2000).

Table 1 Leading causes of mortality in Tuvalu

Year	1997	1998	1999	2000	2001	2002
Cardiac arrest		13	18		16	8
Senility	12	8	11	12	16	5
Unknown	10	6	5		14	
Hypertension	10	6	3	2	4	1
Myocardinal infarction				2	2	1
Peptic ulcer	2		3	2	1	1
Stillborn	2		3		2	1
Pneumonia		4		1	1	4
Heart problems	16			23		1
3rd degree burns				19		
Diabetes	5	3	4	4	1	
Asthma			2	1	1	3
Abdominal pain		2		1		2
Dysentry		2		3		1
Congestive heart failure	4			7	3	3
Meningitis	3		1		2	
Suicide	5				1	2
TB & others	3			29	14	2

(Source: **Tuvalu Central Statistics Division**)

1.2.7 Socio-cultural and economic

Tuvalu is a very culture centred country. Life in Tuvalu is always defined in a tripod like system – *kaiga* (family), *fenua* (land/people) and *Atua* (God). These 3 are the main build-up in a Tuvaluan culture and way of life and as such, held with very high regard.

Family ties in Tuvalu are very important and strong that in an island it is just as that almost everybody is related to one another. Many households in Tuvalu are extended families, where everybody has a role to play. For instance, the men mostly fish, attend to

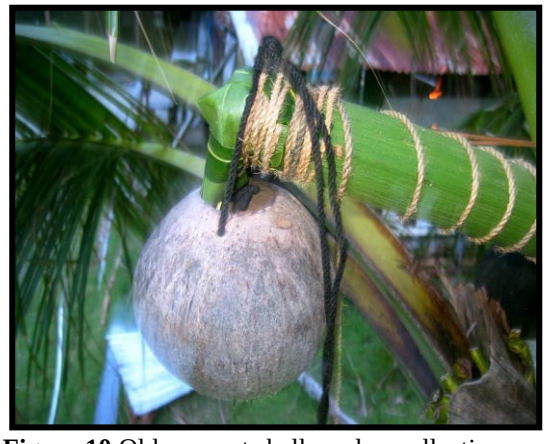

Figure 10 Old coconut shell used as collective container for *kaleve*, hanging from young coconut soot (Source: **Niko Iona**)

the domesticated animal such as pigs and poultry, plant and cut *kaleve*[3] (figure 10), the women care for the children and do the cooking while the children mostly do the simple chores of the house such as sweeping the compound. However, there are also nuclear families that can be found mostly on the capital, Funafuti, and this can only be ascribed to the influence of modernization on the Tuvalu way of life. Although these nuclear families live on their own, but their daily activities involve characteristics of extended families, since giving and receiving is an everyday norm and these families are not limited to themselves only. Caring for children is the responsibility of everybody in the family as well as the whole community in some instances and gifts of food from one family to another is a normal daily practise.

The people of Tuvalu are very communal and always look out for each other. The act of helping each other is a norm in Tuvaluan culture and life. The phrase 'no person is an island' is very true in Tuvalu, because in Tuvaluan culture, there is always inter-dependence. Social norms and practise are such that an individual belong to his or her island community and has a role and responsibility to that community. The Tuvalu people love doing things together and it can also be reflected in the *fatele*[4] (see figure 11) where everybody is involved in the singing and clapping while the dancers stand around dancing and singing as well.

Figure 11 Fatele - the traditional Tuvalu dance **(**Source:**Niko Iona)**

Te ulu sina[5] in all islands of Tuvalu are highly respected and well looked after by members of their respective extended families as well as the community as a whole. Most decision making at family level and also at community level is done with the approval of the elders. The elders are seen to have wisdom in them that the youngsters sought their opinions in any matters, whether it is at family level or community. Their opinions with that of the island

[3] Sweet sap extracted from young soot of coconut trees

[4] Traditional Tuvaluan dance

[5] Literally means ´white hair', in Tuvaluan culture it signifies old age, wisdom and knowledge and refers to the elders

councils and the island chiefs are highly regarded and heeded in all Tuvalu island communities when it comes to matters that concerns the whole island community.

The island council or local government or *kaupule* is the body that connects the islands to the national Tuvalu government. They are the national governments contact to the island communities and vice-versa. It is actually the executive arm of the *falekaupule*[6]. Each island council's jurisdiction is however limited to their own island community and also to community members who live on the capital Funafuti. For instance, seldom the *falekaupule* through the *kaupule* demands a certain amount of monetary contribution from the island people age 18 to 55. All the people belonging to that island community regardless of their present place of residence in the country, is obliged to pay the given amount of money to the *falekaupule*. This huge amount of money is usually demanded from the community members only when there is a need for betterment of infrastructure on the island, or when the island is hosting a huge feast which could last for a week.

On the capital Funafuti, besides the central government, the people of Funafuti have their own island council which oversee the activities and development of native Funafuti people. These island councils work together with the chiefs to ensure the smooth running of the island communities.

The national government of Tuvalu, which is situated on the capital Funafuti is the central and head governing body to all these island councils (figure 12). The Ministry of Home Affairs is the branch in the national government that oversee to all the island councils.

[6] Local governing body at island level which in hierarchical order include the chiefs, elders and then community members

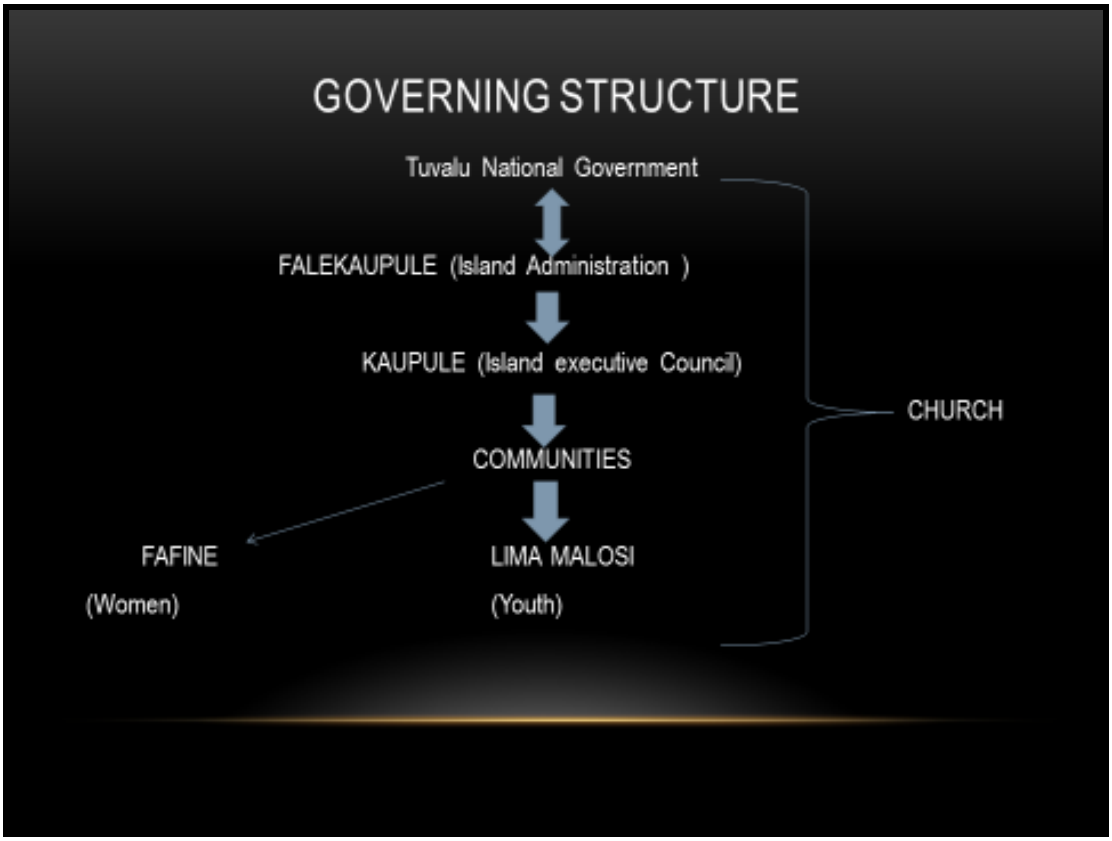

Figure 12 Governing structure in Tuvalu

The church is the third important element in Tuvaluan life. Majority of the population of Tuvalu are Christians and 91% of the population are protestant members of the Church of Tuvalu (Rank, 2015). The other 9% consists of other Christian denominations such as Seventh Day Adventists (SDA), Catholics, Mormons, Baptists and Jehovah's Witnesses. There are also a small number of people who are Muslims and Bahai (Rank, 2015). The church is also regarded with high regards in Tuvaluan life and church ministers regardless of their age, are accorded the same respect and reverence as the island chiefs. Seldom are the church ministers of island communities in their late 20's, but because of their occupation as church ministers, they are accorded high respected. The church ministers are seen as mediators between God and people and also the chosen servants of God.

The Church of Tuvalu, which is the largest in the country is the most influential. As is shown in figure 10, the church influences all levels of governing in Tuvalu and binds all levels together. Apart from the government structure as shown in figure 12, the church also have its own structure and is an independent body on its own as shown in figure 13.

All the islands have one church minister working there except for Vaitupu Island and the capital Funafuti. Since the biggest secondary school is on Vaitupu Island, the church allocated a separate chaplain for the school while one takes care of the church at the main village site. Like the national government of Tuvalu, Church of Tuvalu Headquarters is located on the capital Funafuti. However, since there are many people on Funafuti, the church divided the island into 4 parishes – Vaiaku, Funafuti, Fakaifou and Lofeagai. Although there are 7 village site as shown in table 4, but there are only 4 parishes. The other village sites are close to the one or other parish sites and people go there for church services and religiously participate in that parish. The 4 parishes have their own church minister who overlook the affairs of the church with the help of selected committee, and these Parishes are treated the same as those on the other islands. But the headquarters which is also on Funafuti Island oversee the overall functions of the church throughout the country.

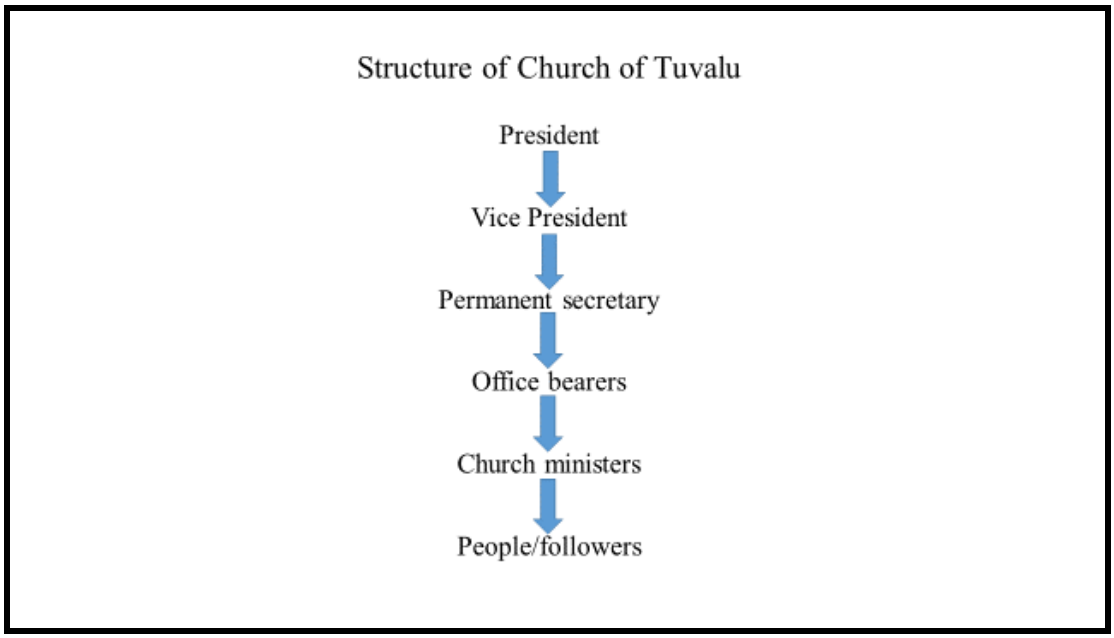

Figure 13 Structure of Church of Tuvalu

Tuvalu has very limited natural resources because of its tiny land size. Its main income is derived from foreign aid, subsistence farming and fishing. The government revenues largely come from the sale of stamps and coins, fishing licenses and from worker remittances from overseas. Substantial income is also received annually from an international trust fund which was established in 1987 by Australia, New Zealand and the United Kingdom and also supported by Japan and the Republic of Korea. The fund grew from an initial US$ 17 million

to over US$ 35 million in 1999. The United States Government is also a major revenue source for Tuvalu, with 1999 payments from a 1988 treaty on fisheries valued at about US$ 9 million, and is expected to rise annually. In an effort to reduce the country's dependence on foreign aid, the Government is pursuing public sector reforms, including privatization of some government functions and personnel cuts of up to 7% (WHO, 2014).

In 1998, Tuvalu began deriving revenue from use of sale of its '.tv' Internet domain name. In 2000, Tuvalu negotiated a contract leasing its Internet domain name '.tv' for US$ 50 million in royalties. From these revenues that the government has, as is usual, there is an allocated sum for the management of water. This allocated money on the government budget is for maintenance of desalination machines, fuel to run the machines and labour costs. For this year 2015, the Tuvalu government has allocated AUD 11,400.00 for the management and maintenance of its desalinations machines (Malo, S. personal communication, 22 April 2015), that when there is a state of water crisis, people on the capital Funafuti would be able to buy water from the government.

Overseas remittances is a constant earning for families in Tuvalu and also the government benefit from them. These remittances are from family members who have migrated to live in other countries, or seasonal workers especially in New Zealand where many go to work in farms during the harvest seasons. But the majority of the remittance sum received in the country is from Tuvaluan men who work as seamen on ships around the world. Foreign currency flowing into the country from these remittances is an enormous sum. The following figure 14 shows the contribution of only seamen remittances to the Tuvalu economy.

Year	Seamen	Ships employing	Estimated total
		Tuvaluans	remittances
2001	455	54	US$ 3.2m
2002	471	58	US$ 3.4m
2003	370		
2004	363		
2005	349		
2006	318	37	US$1.5
2007	342	39	US$1.5

Figure 14 (Source: Tuvalu Central Statistics Division**)**

Chapter 2

Water and sanitation problems have reached boiling point: children are dying unnecessarily at the rate of 20 jumbo jets crashing every single day

Ravi Narayanan

2 Literature Review

Lack of safe water to meet daily needs is a reality for many people around the world and has serious health consequences. The situation is getting worse due to population growth, urbanization and increased domestic and industrial water use.

Collectively around the world, an estimated 4000-6000 children die each day from diseases related to scarcity of fresh clean water and, or lack of access to safe clean drinking water ((WSSCC), 2014). It is a common problem that is faced by people all over the world however, their understanding and definitions of freshwater scarcity may be slightly different to each other. People of different countries would define water scarcity differently depending on the physical topography, weather and in some instances political issues. Some may have a threshold measurement that when reached, the country is considered scarce of freshwater while others may define freshwater scarcity as 1 to 2 months without rain which is their only source of fresh water.

Due to the lack of freshwater for proper basic cleanliness and for drinking, people in extreme areas of water scarcity suffer from water related diseases. These diseases are not caused by excessive of water, but by the lack of it. A few of these health consequences of water scarcity include diarrhoeal diseases such as cholera, typhoid fever, salmonellosis, other gastrointestinal viruses, and dysentery.

Following are discussions of related literatures of research works that have been done on water scarcity and health and associated pertinent issues. It purposefully draw the reader's attention to the subject of this research study before continuing into the next chapter.

2.1 Defining water Scarcity

The online Oxford dictionary defines 'scarcity' as 'not having enough of something, and it is difficult to obtain it' (Dictionary, 2014). Therefore, pertaining this definition, 'freshwater scarcity' is simply not having enough of fresh water and at the same time, having difficulty in accessing to obtain it.

Water scarcity, which is commonly understood as the lack of access to adequate quantities of water for human and environmental uses, is increasingly being acknowledged in many countries as a serious and growing concern. As a result, the term 'water scarcity' is frequently used by the media, government reports, non-government organizations (NGO's),

international organizations such as the United Nations (UN), as well as in educational literature to highlight the areas where freshwater resources are under pressure (C. White)

However, despite its frequent use, there is no agreement on how water scarcity ought to be defined or how it should be measured. Hence, a reference to water scarcity in one report may measure something totally different to other reports which use the same term. This can lead to a confusion as to what exactly does water scarcity means. Definitions to the term 'water scarcity' differ in regions under extreme water stress state.

Therefore, following are the most commonly used methods of defining and measuring water scarcity, which would be helpful in understanding the different definitions of water scarcity.

a) 'Falkenmark Indicator' or 'Water Stress Index': It is one of the most commonly used measurement of water scarcity. This method defines water scarcity in terms of total water resources that are available to the population of a region, measuring scarcity as the amount of renewable freshwater that is available for each person each year. If through this measurement, the amount of renewable water in the country is below 1,700 cubic meters per person per year, it is reported that the country is experiencing water stress. Below 1,000 cubic metres, it is said that the country is experiencing water scarcity, and when the measurement is below 500 cubic metres, it is reported to be in absolute water scarcity (Frank J Rijsberman, 2006)

b) Water Exploitation Index (Virani): (The ratio of water withdrawals for human consumption to total renewable water resources) (Frank J Rijsberman, 2006) . This measurement approach relaxes the assumption that all countries use the same amount of water. Instead it defines water scarcity in terms of each country's water demand compared to the amount of water available, measuring scarcity as the proportion of total annual water withdrawals relative to total available water resources. Using this measurement approach, a country is reported to be water scarce if the annual withdrawals are between 20-40% of annual supply. If this withdrawals exceed 40%, the country is said to be severely water scarce.

c) Another measurement approach of water scarcity was developed by the International Water Management Institute (IWMI) (C. White). This approach considers and includes all of a country's water infrastructure such as water in desalination plants, into the measure of water availability; including recycled water by limiting measurements of water demand to consumptive use rather than total withdrawals; and measuring the

adaptive capacity of a country by assessing its potential for infrastructure development and efficiency improvements. By means of this approach, countries that are predicted to be unable to meet their future water demand without investment in water infrastructure and efficiency are classified by the IWMI as economically water scarce. The countries which are predicted to be unable to meet their future demand with investment in water infrastructure are said to be physically water scarce.

d) 'Water Poverty Index': This measurement approach considers the role of income and wealth in determining water scarcity by measuring the following (C. White):

    1. The level of access to water
    2. Water quantity, quality and variability
    3. Water use for domestic, food, and productive purposes
    4. Capacity for water management, and
    5. Environmental aspects

Therefore, it is vivid that there is no single definition of 'water scarcity'. The different approaches used to measure water scarcity captures different aspects of the pressure on water resources and there is not one of the approaches that captures all the aspects.

Even though this being the case of having more than one definition for water scarcity, but one thing is for certain and that is, when an individual does not have access to safe affordable water to satisfy his or her needs for drinking, washing or to support livelihood, that person is water insecure. When a large number of people are water insecure for a significant period of time, then we call that area water scarce (Frank J Rijsberman, 2006), and they are at high risk of having water related health problems.

2.2 Global water scarcity

According to Rijsberman (Frank J Rijsberman, 2006), 'the overall conclusion of all water scarcity analysis is that a large share of the world population – up to two-thirds – will be affected by water scarcity over the next several decades'. Regardless of the approach used to measure water scarcity in each country, it seems that all point towards the same conclusion, and that is, countries are either heading towards water stress mark, or at present facing water stress or most unfortunately, extremely water scarce. Whether it is economically water scarce or physically water scarce, it is all the one and same problem – that many people have

inadequate fresh water to satisfy their daily water needs and that basic sanitation and hygiene are unintentionally ignored.

It is quite a clear and an inescapable fact that as populations grow, demand for water will also grow which will decrease the availability of water resources in the world. It is therefore of great importance that each country have a threshold which will indicate when the danger zone is approached or when there has been excessive abstraction of its water resources ((SERI)), 2011).

The Water Exploitation Index (WEI), (Virani) approach is defined by the mean abstraction of fresh water divided by the long-term average freshwater resources. It considers a warning threshold could be 20% which distinguishes a non-stressed region from a stressed one. When the WEI is greater than 40%, there is an indication that the region is water scarce and there may exist competition for water (Joseph Alcamo, 2000).

Using the 'Water Exploitation Index' (Virani) approach, the European Environment Agency ((EEA)) found that in Europe, a total of 20 countries (50 % of Europe's population) can be considered as non-stressed. These countries lying mainly in central and northern Europe. Nine countries could be considered as having low water stress (32 % of Europe's population). These countries include Romania, Belgium and Denmark and southern countries (Greece, Turkey and Portugal). Finally, there are four countries (Cyprus, Malta, Italy and Spain) which are considered to be water stressed (18 % of Europe's population). These water stressed countries could face the problem of groundwater over-abstractions and the consequent water table depletion and salt-water intrusion in coastal aquifers ((EEA)), 2015).
The following figure 15 shows the WEI of European countries.

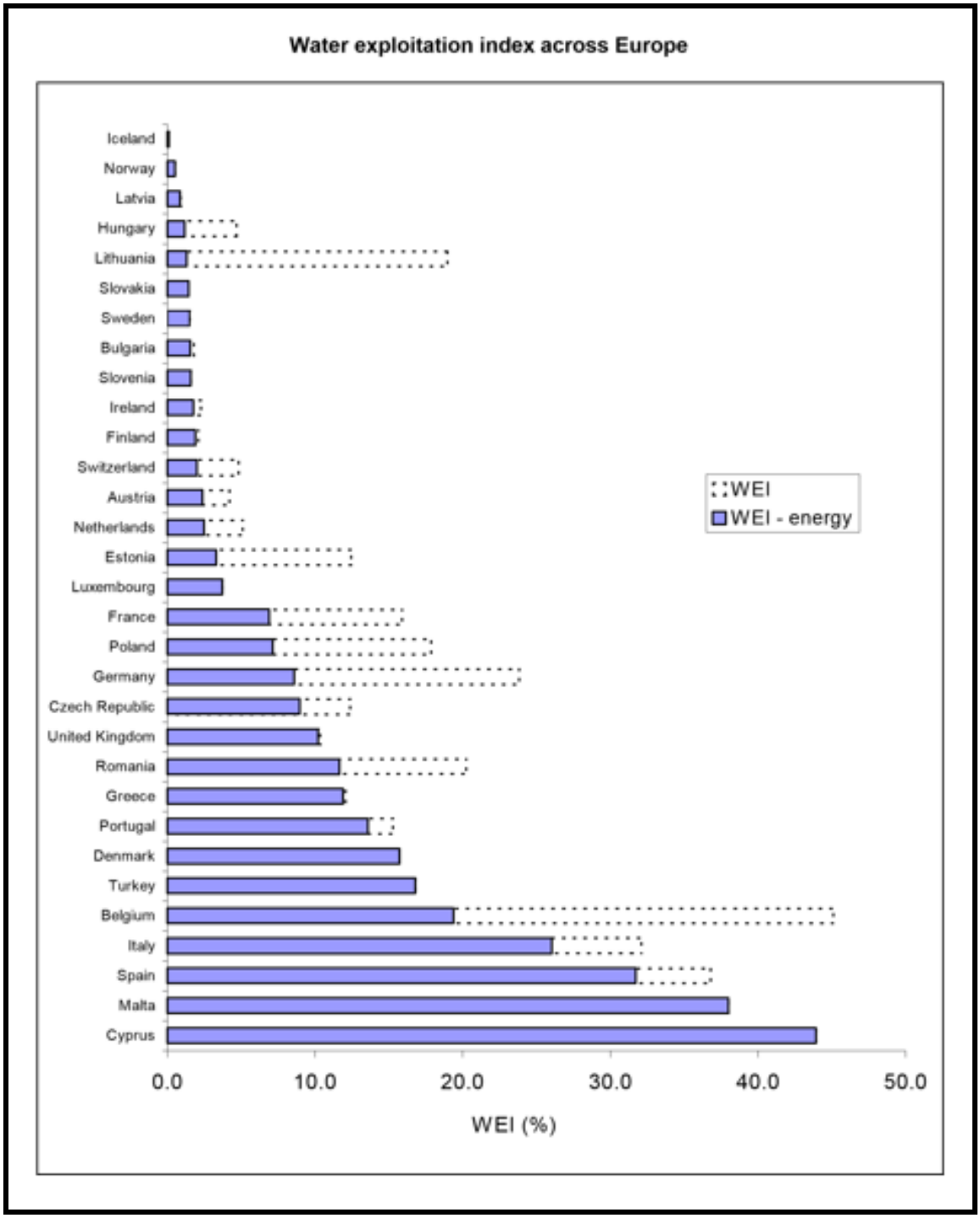

Figure 15 (Source: Eurostat, New Cronos database**)**

Countries in the arid part of the world, mainly in Central and West Asia and North Africa are already close to, or below the 1000 cubic metres per capita per year in their threshold (Frank J Rijsberman, 2006). Africa being the second driest continent in the world after Australia, have majority of its population facing water scarcity on a constant basis. Due to its massive populations and uneven distribution of water, many people are forced to live on very little water ((WWF)), 2015). For instance, the Congo water basin hold approximately 30% of the

continents total water, but only 10% of Africa's population benefit from it. Research by the World Wide Fund for Nature ((WWF)), showed that fourteen countries in Africa are already experiencing water stress; prediction of 11 more countries to experience water stress by 2025 at which time nearly 50 per cent of Africa's predicted population of 1.45 billion people will face water stress or scarcity. Nearly 51 per cent (300 million people) in sub-Saharan countries lack access to a supply of safe water and 41 per cent lack adequate sanitation ((WWF)), 2015).

People in the North-Africa belt from Morocco to Egypt including Sudan live on less than a 1000 cubic metres per year and those in the Middle East and Southern Africa live on one to two thousand cubic metres per year (Wallace, 2000). The most populous country in this region is Egypt. Using the Falkenmark indicator, Egypt is likely to drop below 500 cubic metres per capita per year in the next 25 years (Frank J Rijsberman, 2006)

In small island states, like those of the Pacific, it is quite unclear as what method is used to measure water scarcity. However, water scarcity is a threat that is continuing to affect the small island states. Some islands are so small in size with no surface water and very limited groundwater resources, that their only source of fresh water is rain (Sharon Hophmayer-Tokich, 2007).
Although different in many features (size, isolation, geology and topography, climate and hydrology, economic development, etc.), the island countries share common water related problem and challenges (Sharon Hophmayer-Tokich, 2007). This leads to there being no common approach as to define water scarcity in the whole Pacific Island countries. Pacific island states with lots of fresh water reserves, their governments try their best to have piped water to all residences, but in most cases this is almost impossible due to many reasons, mostly common are economic and traditional conflicts. The difficulty in controlling and having good water governance in the Pacific Islands contribute to the inaccessibility of fresh water to every household/individual. This is due to the unambiguous socio-political and cultural structures relating to traditional community, tribal and interisland practices, rights and interests, which are all interwoven with colonial and 'modern' practices and instruments (Sharon Hophmayer-Tokich, 2007).

For people living on low lying coral islands, water scarcity is when families have to live on less than 20 litres of water per day. There is no need for an approach to define water scarcity

for them as 1-2 months without rain is generally considered water stress, and that 3 or more, the country is at risk of scarcity and a state of emergency is declared to cause people to use water wisely (Pickup, 2011). No other water sources such as underground water basins, rivers, stream and fresh water lakes are available for human extraction and consumption that the only source of freshwater is rain water.

Figure 16 Water ration in Funafuti **(Source:** Niko Iona**) Figure 17** A man with his family's 2 bucket ration (**Source**: Niko Iona)

2.3 General socio-economic impacts caused by water scarcity

Water is essential for all socio-economic development and for maintaining healthy ecosystems. As populations and development increase, the demand for increase allocations of groundwater and surface water for domestic, agriculture and industrial sectors use also increases.

The global population is expected to reach 8 to 9 billion by 2050, and this will be accompanied by the increase of global problems of which scarcity of fresh water is a major one of them (GrowingBlue, 2014). Increase pressure on water resources, withdrawals and pollution will be among the leading problems. The already competition for water landscape will become even more intensive, stretching to the limits and tensions will arise between people, communities and countries that share common water sources. Increasing stress on freshwater resources brought about by the ever rising demand and reckless use, as well as by growing pollution worldwide, is of serious concern.

A recent event of conflict over fresh water was between South Sudan and Egypt over the river Nile. South Sudan, located above the river Nile decided to build a dam which was highly opposed by Egypt from the lower end of the river, because this would reduce their fresh water availability and would have great negative impact on its economy and people (Rwakaringi, 2013).

2.4 Food Security and water scarcity

To maintain healthy diets and sufficient supply of food, a lot of water is necessary for food production. This is not only for one stage of food production, but all stages, from primary to secondary production, even just before consumption in households. By far, the greatest global demand on freshwater resources is for agriculture. The International Water Management Institute estimates that over 70% of the world's developed water supplies are used for irrigation (Seckler, 2000). Recent estimations show that 300 to 3000 litres of water are required to produce one kilogram of grain and that food production for a balanced diet requires 1300 cubic meters of water per person per year ((SIWI)), 2004). However, water requirements for food production vary regionally by type of diet and need for irrigation. Gleick estimated the average daily water input to produce a typical diet in California, with high meat consumption and heavy water irrigation needs, to be 5908 litres; in Egypt, with lower meat consumption but considerable water irrigation, to be 3242 litres and in Tunisia, with lower meat consumption and less irrigation, to be 2964 litres (Gleick, 1996). This example illustrates the large range in water consumption used for the production of food in order to have a proper balanced diet, which in turn would reduce the risk of sicknesses or diseases. Therefore lacking water to produce food, would result in low production and in turn not enough food to cater for the increasing population, creating higher risks of sicknesses and diseases.

When water resources are unhealthy, unreliable and scarce, businesses whether big or small cannot thrive or sustain (GrowingBlue, 2014). All businesses and any other economic activity needs abundant supply of healthy water to keep it alive, and the industries concerned with food production is no exception. Healthy water is needed for reliable and efficient services and goods to be produced in every country, and without it, all social and economic activities of the world would cease to exist.

The available quantity of freshwater is linked to human health in several ways: water for ingestion, water for hygiene and water for food production (Moe & Rheingans, 2006). Sufficient water for ingestion and food preparation is absolutely essential for maintaining good human health. It is estimated that the minimum daily water intake range from 1.8 to 5 litres per capita per day (Gleick, 1996).

2.5 Water scarcity related health problems

Water is life and also death. Excessive water and the lack of it, is life threatening and many deaths are related directly to these two reasons. Due to the global unequal distribution of clean freshwater, with differences also in landscape and constant increase in populations, many are unfortunate to live in areas prone to water scarcity. This has resulted in health problems leading to increasing worldwide morbidity and mortality.

According to a report by WHO/UNICEF, of the estimated 7 billion people in the world, 1.1 billion lack access to proper clean freshwater supply and 2.6 billion lack adequate sanitation due to water scarcity (U. WHO, 2004). The WSSCC (2004) study (as cited in (WHO, 2004), showed that an estimation of a stunning 4000 – 6000 children die each day from diseases related to lack of clean safe water for drinking and use leading to poor sanitation and unhygienic living conditions.

A recent WHO review commended a minimum of 7.5 litres per capita per day to meet the requirements of most people under most conditions (G. H. J. Bartram, 2003). This amount of water is believed to be efficient and adequate enough to keep oneself in hygienic, healthy and low risk of contracting diseases. Health consequences of water scarcity for human use and consumption include diarrhoea diseases such as cholera, typhoid fever, salmonellosis, dysentery, dehydration and malnutrition especially children, scabies and trachoma (A. P.-O. R. B. F. G. J. Bartram, 2008)

However, the need for water consumption increases in countries with warm climates, increasing physical activity and during pregnancy and lactation for women (Gleick, 1996). The amount of water use also varies with distance from the water source. Where people must walk farther than 1 kilometre or spend more than 30 minutes for total water collection time, per capita water use drops to between 5 and 10 litres per day. At this level of service, sufficient hygiene is not possible contributing to increasing diseases and even death in extreme water shortage areas (G. H. J. Bartram, 2003). Furthermore, the vast distances travelled daily by people, mostly women and children to collect water added with the weight of the water on their return is a health hazard. In many African countries it takes up to six hours per day to collect sufficient quantities of water to serve a single family, and much of that time is spent walking; the typical round-trip distance is approximately three miles, although in some instances it can be considerably longer (Freling, 2013). Freling (2013), also observed that majority of the water collected is untreated and unsafe for consumption.

Women cooking with dirty water unintentionally expose their families to diseases such as chronic diarrhoea, typhoid, cholera, worms, parasites, dysentery and hepatitis (Freling, 2013).

In 2012 during a conference on 'Water Scarcity in Africa: Issues and Challenges', it was stated that as of 2006 Sub-Sahara Africa had the largest number of people suffering from water scarcity than any other region in the world which is directly reflected in their health statistics with soaring deaths related to preventable diseases if only there was enough water for human use and consumption (Challenges, 2012). Humans can only live 3 to 5 days on average without water (Limited, 2012), that people in this region who are deprived of clean fresh water are forced to turn to using unclean water, contributing to the increasing health problems and eventuating in death, especially children who are the most vulnerable and affected.

An African country with soaring health problems as a result of inadequate freshwater for human consumption is Nigeria. According to Krebs (2010), (as cited in (Muta'aHellandendu, 2012) that among the 152 million people residing in Nigeria, less than 30% have access to adequate drinking water. The scarcity faced by the country is both physical as well as economical where people are too poor to pay for proper clean safe water. This leads to the country having a very high mortality rate of 130,000 deaths per year which are diarrhoeal diseases, more than 10% of the total population (WHO, 2015). Uwejamomere (2011) observed that based on UNICEF records 11% of deaths of all children under the age of 5 in Nigeria is related to diarrhoeal diseases. Children in the country continue to suffer from diarrhoeal diseases and more than 2 million under 5 die every year (as cited in (Muta'aHellandendu, 2012).

On the '2nd seminar on water management in islands coastal and isolated areas' in Noumea, New Caledonia, 2008, it was found that communicable diseases in many Pacific countries was quite high (SPC, 2008). The 3 major diseases of discussion were: cholera, typhoid fever and leptospirosis. Water play a major role in spreading these diseases. All 3 diseases are transmitted either by consumption of contaminated water and food or coming in contact with polluted water and also having poor sanitation and hygiene (SPC, 2008). High probability of poor sanitation and hygiene is because of the lack of water for the purpose of it, causing a high risk of the spread of the diseases. Table 3 below shows the reported cases of cholera and typhoid in 2 Pacific island states during the seminar. These cases are the highest to be ever recorded in the Pacific region countries in these two small island states but there are minor

cases also in other Pacific countries, but not as high as these. Both countries are flat atolls, like Tuvalu, with similar landscape, morphology and also have scarcity of safe clean drinking water.

Table 3 Pacific Island countries affected by cholera since the last 10 years

Country	Year of Outbreak	Comments
Pohnpei, Federated State of Micronesia	2000	Serotype: Ogawa. Cases: 3500. Deaths: 20
Marshall Islands	2000	Serotype: Ogawa Cases: > 300. Deaths: 6

(Source**: SPC, 2008)**

Typhoid fever (Salmonella *typhi*) is also very common in the small Pacific Island states and since it is contagious and transmitted through water and poor hygiene, many of the Pacific islands are easily exposed to it. If it is not from consumption of contaminated water, then it is from poor sanitation and hygiene practices which in most cases is triggered by the lack of water (SPC, 2008).

Table 4 below shows typhoid fever outbreak in the Pacific from 1999 to 2008. Papua New Guinea had typhoid as the 10th top cause of death and is spreading fast and increasing number of people are being infected. Fiji, like Papua New Guinea have typhoid increasing in spread and infections and have 100-200 reported cases per year. The other Pacific countries as shown in table 4, have these cases reported only on those particular months and years, otherwise they are free of typhoid. For instance, in March of 1999, Nauru had 50 reported cases, Samoa had 122 reported cases with 1 death in July of 2000. Tuvalu had 22 reported cases with 6 patients being hospitalised on May, 2001. So SPC identified Fiji and Papua New Guinea as countries where typhoid is a constant health problem while the other countries have only certain times when there is reported cases otherwise they are typhoid free.

Country	Year of Outbreak	Comments
Papua New Guinea (PNG)	1999-2008	Endemoepidemic[7] 10/1000 cases per year includes many small outbreaks. It is among the 10 top causes of death in PNG. Outbreaks in schools and prisons
Nauru	1999 (March)	50 reported cases
Tonga	1999 (April)	14 reported cases
Samoa	2000 (July)	122 reported cases, 1 death
Vanuatu	2000 (December)	Small outbreak: 26 cases
Tuvalu	2001 (May)	~22 cases, 6 hospitalised
Fiji	2005 – ongoing	~100-200 cases per year since 2005. Now endemoepidemic, especially in Vanua Levu

Table 2 Typhoid fever outbreak in the Pacific 1999-2008 **(**Source**: SPC, 2008)**

2.6 Water-washed diseases

In 1977, Bradley observed that many "waterborne" diseases are actually "water-washed" diseases but due to inadequate quantities of water available for washing hands, food, laundry, and cooking utensils resulting in poor hygiene and sanitation that the diseases are easily spread and contracted (Bradley, 1977). He concluded that the many diseases labelled as waterborne were preventable has there been adequate water for proper hygiene. The appropriate intervention to prevent these diseases, such as shigellosis[8], trachoma and scabies, is to provide more water quantity rather than improve microbiological water quality. The very

[7] Term used for disease that used to be found in one location but now has spread to other location and affected numbers are rapidly increasing.

[8] Shigellosis, also known as bacillary dysentery. It is contracted through oral methods: direct contact person to person, hand to mouth in an environment of poor hygiene.

simple act of washing hands with soap at critical moments, such as after using toilet and before handling food, remains a key ‘cost- effective and life-saving intervention in preventing these diseases and deaths’ (Akintola, 2011; SPC, 2008). This is definitely to increase and improve hygiene through basic washing with soap and clean freshwater and preventing oneself from contracting the diseases.

An earlier review on the impact of clean freshwater, proper sanitation and good hygiene interventions observed that having enough clean water and good hygiene interventions were associated with a 20 to 33% median reduction in diarrhoeal disease morbidity (Esrey, Potash, Roberts, & Shiff, 1991). A more recent review and analysis of the impact of water supply and hygiene interventions concluded that water supply interventions in developing countries were associated with a 24% reduction in diarrheal disease and hygiene interventions were associated with 42% reduction in diarrhoea morbidity (Fewtrell et al., 2005). The common hygiene interventions were identified as conjunctivitis, acute respiratory infection, skin diseases of all kinds, sores, scabies and boils, (Curtis, 2006), which could be avoided if hygiene was paramount with the simple act of washing hands, beddings, clothing and infected areas once the symptoms started to show.

Deliberating on a report by the WHO (A. P.-O. R. B. F. G. J. Bartram, 2008), a total of 10% of diseases worldwide could be prevented from having improved and adequate fresh clean water for drinking and basic hygiene needs. These communicable diseases are therefore preventable if adequate clean water is available for everyone for drinking, basic hygiene practises like washing of hands and for sanitary use to avoid using anywhere as a lavatory.

2.7 Influence of Climate change on water scarcity and health

Water scarcity which is already a major global issue and having great negative health impact is to increase with climate change furthering to threaten access to fresh water. It is expected to intensify water scarcity in several ways. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), climate change will ‘shrink the resources of fresh water’, increase evaporation rates, cause rainfall variability, salt water intrusion and increase the occurrences of extreme weather patterns (Ulisses Confalonieri, 2007).

Scientists predict that the hydrologic cycle will be altered with wet areas becoming wetter while dry areas become dryer (Bernstein, 2011). For Instance, the Atacama Desert in Chile,

which is the driest place on earth, receives very little to no rainfall annually. On the other hand, Mawsynram, Assam in India receives over 450 inches of rainfall annually (Vorosmarty, 2000). This comes to show that people living in water scarce areas are vulnerable to water related diseases because of the lack of it for consumption, proper sanitation and hygiene, while those living in areas with extreme rainfall and availability of water are at high risk of contracting water-borne diseases and drowning.

With higher temperatures, the capacity of the atmosphere to hold water and also the rate of evaporation increases. This favours increased climate variability causing more intense precipitation and more droughts over the surface of the earth. Higher water temperature and differences in precipitation levels are likely to produce adverse changes in water quality affecting human health, ecosystems, and water use (Patz, 2001).

According to New Zealand climate change centre, warmer temperatures and increased rainfall variability are likely to increase diseases (Philipa Howden-Chapman, 2010). Diseases which are climate sensitive such as malaria, dengue, diarrhoeal diseases, heat stress, skin diseases, acute respiratory and asthma are likely to soar with frightening figures relative to climate change.

The impacts of climate change will be felt by all countries in various ways and no doubt risks of its negative impacts on human health will certainly increase. Many fatal diseases will increase in drought and flooded areas and will correspondingly increase morbidity and mortality rate. Other diseases, however, are not related to excessive or inadequate of freshwater but nevertheless are triggered by changing climates. For instance, the 2003 European heat wave. Temperatures were 10 degrees higher than the normal average and killed between 21,000 to 35,000 people in five countries with France on the lead with more than 14,800 deaths (Institute, 2015). While Europe, America and some Indian cities are impacted by heat waves and bush fires, the coastal tropical islands are battling intense tropical cyclones, changes in wave and storm surge, salt intrusion and damages to coral reefs (Ulisses Confalonieri, 2007), which are only a few of the many problems that have recently been frequent.

It is therefore an inescapable truth – that with changing climates, diseases are predicted to continue to increase throughout the world. The WHO in its best interest to saving human lives is battling climate change through awareness, advocacy, advance scientific research to enable accurate prediction, adaptation projects, partnerships with interested scientific organisations and many other ways necessary to overcome climate change (WHO, 2014).

2.8 Methodology

The procedures undertaken to compile and complete a very good research cannot be based on a single set out plan. There are many different approaches which are used in order to come to a satisfactory conclusion of the research. However during the process, there are a lot of decision making, choices to be made, changes and rearrangement of approaches and writing which are necessary to have the best outcomes. Every alteration during the process leading up to the completion of the research have disadvantages but more advantages (Schutt, 2006) which positively contributed to the completion and success of the research.

This research involves different trusted approaches which have been used and still being used by researchers in different academic and scientific fields. They broaden the knowledge and understanding of the research topic as well as the objectives that needs to be answered. Therefore this section of the write-up will discuss the methods and tools which were used in this research.

2.8.1 Literature Review

Similar to all research works, literature review is mandatory as it broadens the researcher's understanding and also introduces new ideas and findings related to the topic. This include academic journals, presented papers, government documents, policy reports, books, relevant websites, newspapers, conference papers and unpublished works. It was necessary and also used throughout the research in understanding water scarcity and the negative impacts it has on human health.

This method provides an overview and understanding of the research topic based on published works from other researchers. This enables the researcher to compare and contrast the findings and writings of others in relations to the topic matter. Literature review connects this research to former published works of different researchers and is also the foundation which keep the research intact.

However there are some weaknesses of this method which were encountered in the process of this research. Seldom, the information obtained was vastly generalized by the author(s), texts and data are no up to-date and the sometimes the information from online sources and reports are not peer reviewed (Schutt, 2006).

2.8.2 Case Study

"The case study is a research approach, situated between concrete data taking techniques and methodologic paradigms." (Lamnek., 2005). This approach is relevant for small scale researches like this one. Given that Tuvalu is a very small country with a small population, case study was appropriate as the approach to undertake in this research. The selection of Funafuti, the capital of Tuvalu was suitable since almost half of the population of Tuvalu reside here (see table 1). It is also the only island in Tuvalu which has seen a lot of changes and a constant movement towards modernization. Also on Funafuti water shortage is a consistent problem, making it all the more appropriate as the selected case study area.

This method would enable the study to contextualize and have intense focus on the impacts of water scarcity on human health at Funafuti and capture the reality of health problems faced by the people. The concluding results could also be assumed to represent the whole of the country since almost half the population live in the selected study area.

But there were also challenges which were obstacles to the research with this method. Negotiation and obtaining data from the country's only hospital on Funafuti proved to be very challenging. Data may not always be up to-date or may not be readily available.

2.8.3 Data Collection

Regardless of the field of study, accurate data collection is essential in order to maintain the reliability of the research. Selection of appropriate data collection and clearly outlining instructions for correct use, reduce the likelihood of any errors from happening.
Due to the distance between the researcher and the case study area, data collection was done by means of internet interaction. Requests and correspondence with the correct stakeholders concerned were made available through internet connection.

2.9 Tools and Software

Tools and software are mandatory and essential in any research to ensure accurateness and completion. These tool and software enable the researcher to visualize, analyse, interpret and most importantly understand the data.

Therefore the following tools and software were used in this research: Geographic Information System (ArcGIS 10.2), Microsoft Office, Internet and Search Engine, Predictive Analysis Software (PASW)

Chapter 3

No water, no life. No blue, no green.

Sylvia Earle

Chapter 3: Study Area: Funafuti, Tuvalu

This chapter looks closely at the chosen study site and also discuss the methodologies that were taken to obtain data so that reliable conclusion could be drawn in correspondence to the research objectives.

This research is based on the capital of Tuvalu, Funafuti where almost half of the country's population reside. Therefore, following will discuss and give a more detailed glimpse of the study area in order for the readers to fully understand the purpose and importance of this research.

3.1: Geography and background of Funafuti

Funafuti, the capital of Tuvalu, lies just east of the International dateline. Its geographic coordinates are 8°31′27″ S and 179°11′39″ E (time.info, 2015). The island has a land area of 2.4 km sq (0.9 sq mi) (Land, 2015). The small strip like island is home to 4,492 people as of 2002 (Division, 2010), almost half of the total population of the country. This makes the island one of the most overcrowded places in the world with an estimated population density of 475.88/km^2 (Agency, 2014).

Figure 18 Pictures taken from an airplane showing the widest part of Funafuti Island where the airfield is located (Source: **DS World's Kand**)

Majority of the people living on Funafuti are Tuvaluan with minorities consisting of other Pacific Islanders and *palagi* (white people/ European), who during the 2002 census were 149 altogether. The official languages used for communication are Tuvaluan and English.

Map of Funafuti Island

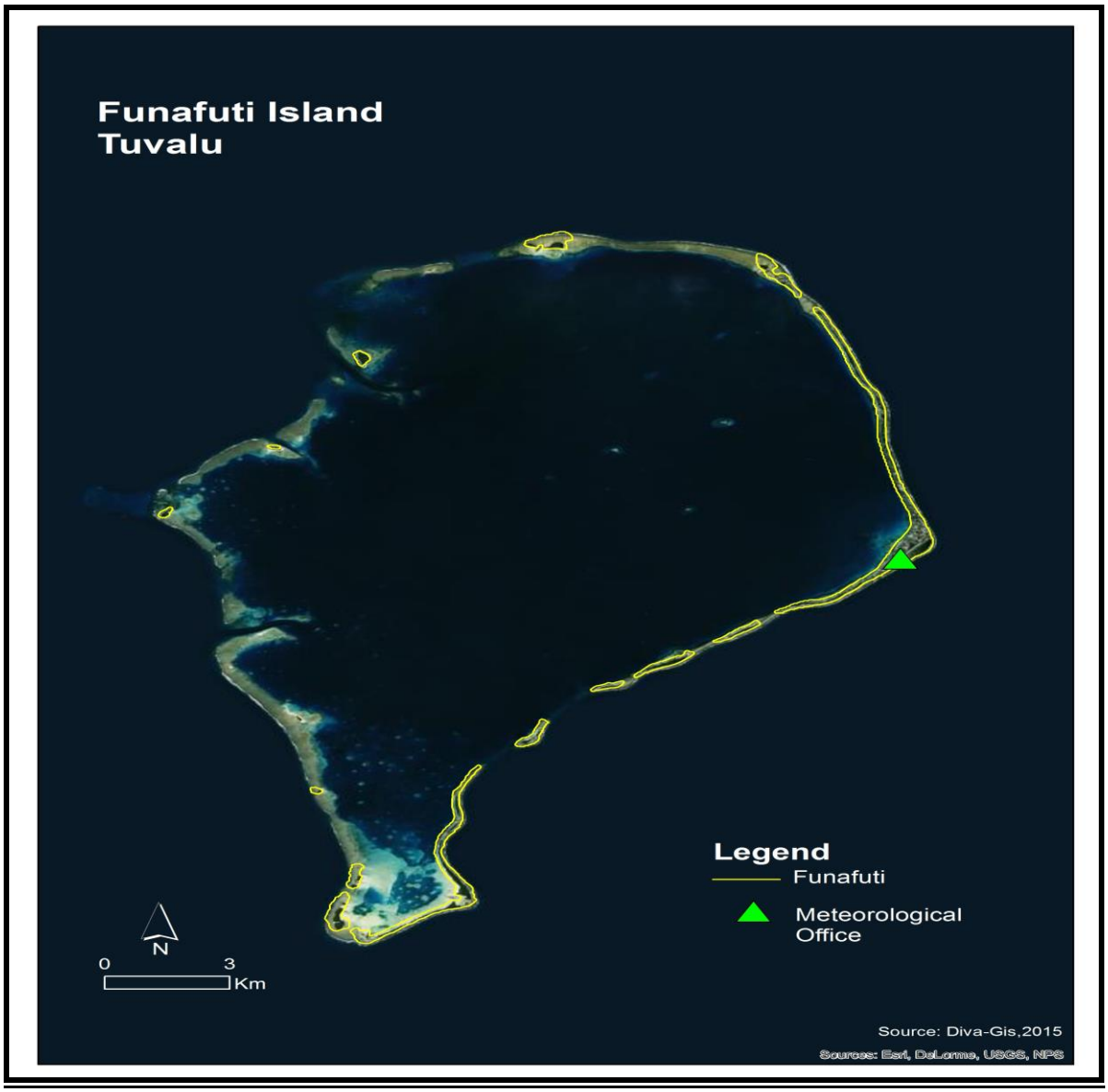

Figure 19 Map of Funafuti

There is only one main road on the island ´Tuvalu Road´ which runs through from the North end of the island to the South end. However on the widest part of the island, there are other two roads: one on the lagoon side 'Alofa road' and the other beside the airstrip 'Vaiaku road'.

The highest point on the island is between 4.6 – 5 metres high, which is a limestone wall as a result of cyclone Bebe in 1972 (Yamano, 2007). Most of the island is between 2.6 -3 metres above sea level (see figure 21), and very little space on the island is suitable for agriculture.

Figure 20 Map of Fongafale islet, Funafuti

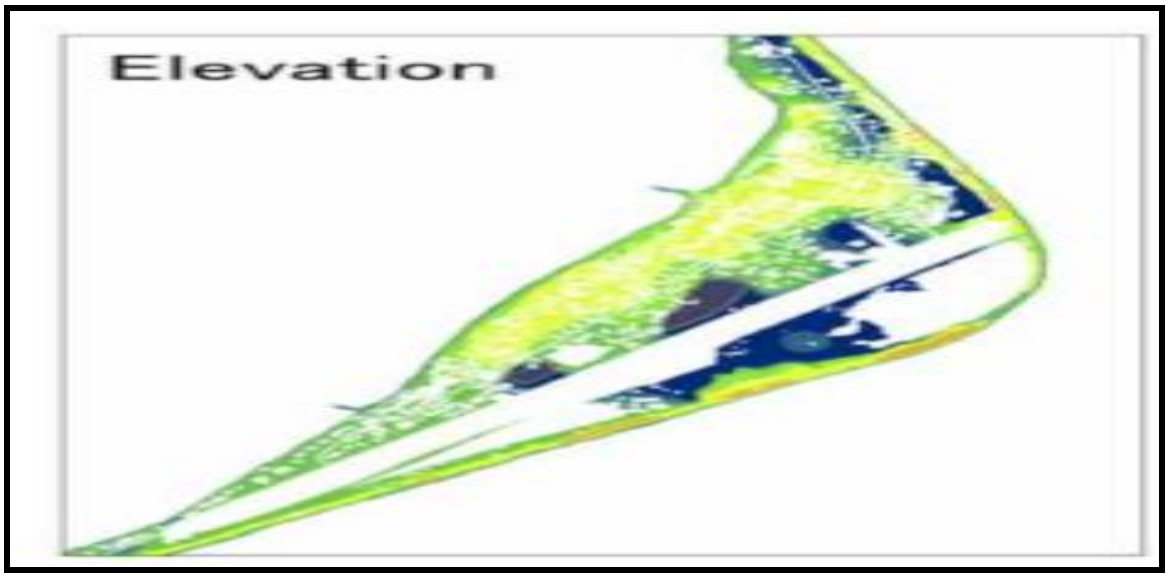

Figure 21 Map showing elevation (height) of Funafuti relevative to sea level **(**Source: **Hajime Kayane et al, 2003)**

The island of Funafuti is divided into smaller divisions or villages. These villages are Vaiaku, Alapi, Senala, Fakaifou, Tekavatoetoe, Teone and Lofeagai (see figure 2). Vaiaku is located on the Southern coast of the island. All administrative buildings are located here, including the country's only bank, The National Bank of Tuvalu (NBT) as well as the only hotel, the Vaiaku Lagi Hotel. The Parliament is also found in Vaiaku including residences of Members of Parliament as well as the Governor General's residence. Tuvalu International Airport is also located at Vaiaku, however the airstrip northern half is on Fakaifou. Police headquarters is situated opposite the Government building and next to it is the Tuvalu Telecommunications Company. Opposite the airport is the Tuvalu Public Works Department, Tuvalu Meteorological Office, Tuvalu Electricity Cooperation and Tuvalu Prisons. The magistrate and high court are also situated at Vaiaku.

Figure 22 The Vaiaku Lagi Hotel: Front view and lagoon view **(**Source: **Niko Iona)**

Figure 23 Funafuti International airport with the Tuvalu Government building showing at the back (Source: **Niko Iona**)

Alapi and Senala are the two villages where the native owners of Funafuti Island reside. As is the common case in all islands of Tuvalu, there are two sides or villages on all islands and are separated by the *falesa* (church building), the *maneapa* (community Hall) and *Te Malae* (Island ground). Therefore the original Funafuti villages are Alapi and Senala, separated by the *falesa, maneapa* and *te malae*. *Tino Funafuti* (native people of Funafuti) who owns the islands are the ones who live in these two villages.

The other villages are new, settled by people who are not natives of Funafuti, but from other islands of Tuvalu. Since they now work on the capital, they are given land by their Funafuti relatives or friends to build their houses. Others rent houses from the people of Funafuti while

some live in Government owned houses, which are built on land that is leased from the people of Funafuti. These settlements have a common church building, but on their respective island matters and celebrations, each island community have their own community hall on the capital and that is where they meet.

3.2 Climate

Funafuti has a tropical warm weather all throughout the year, as is also other island at Tuvalu. The hot and wet season is from November to April and the drier season is from May to October. Temperatures on the island are uniformly high all year round with mean annual temperatures approximately 28.1ºC (Services, 2014). The hottest months November to April have temperatures soaring above 30ºC in most days while in the cooler months, the temperatures decrease just a little below 30 between 26-29ºC. Figure 23 below show the average maximum and minimum over the year temperatures of Funafuti.

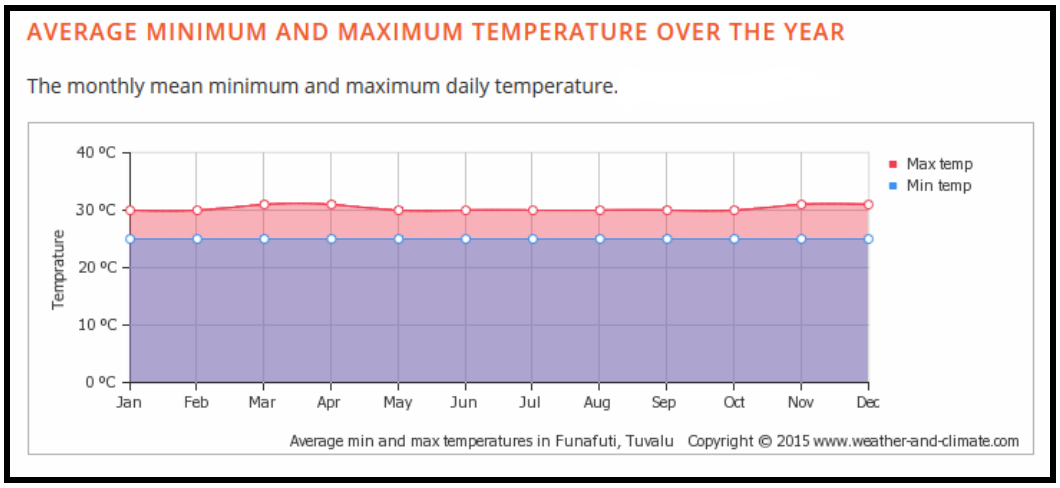

Figure 24 (Source: **Weather-and-climate.com)**

Prevailing winds at Funafuti are from the easterly quarter and they frequently occur between the months of June and August at an average of 10 knots[9] (Office, 2014). In most years, winds between west and north are usually stronger than the frequent easterlies. Figure 24 shows the average wind speed of a year at Funafuti. Strong winds at Funafuti are not common and occur mostly during the wet hot period. During this period, the island always experience inundation and destruction to infrastructure from massive wave impact. Cyclones are not frequent in Funafuti or for the whole of Tuvalu for that matter, but they occasionally develop near to Tuvalu and the strong cyclonic winds cause destruction on land as well as accelerate destructive waves onto the land causing massive damage.

[9] Unit of speed equivalent to 1.852km/h

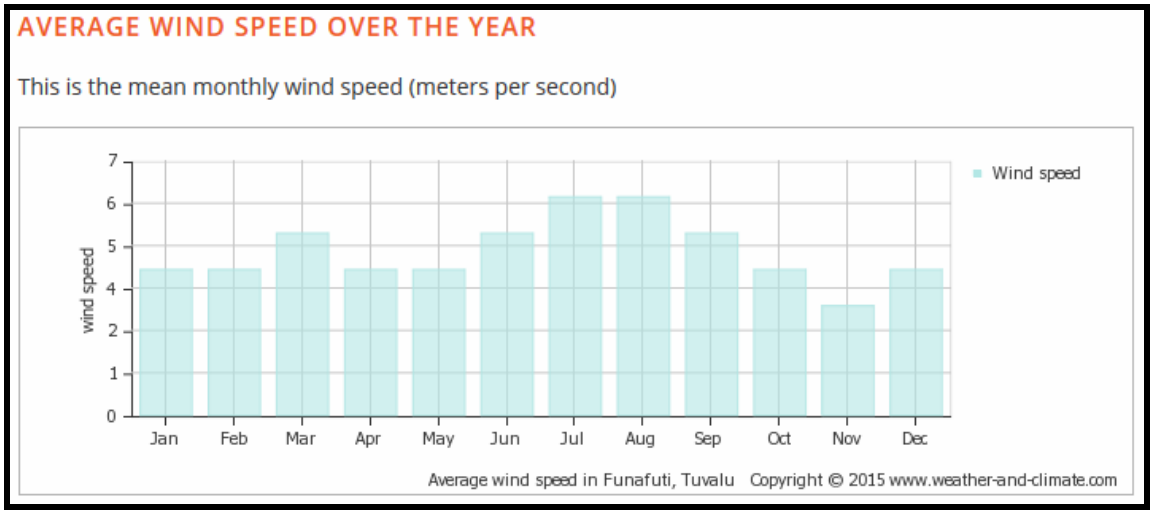

Figure 25 (Source: **Weather-and-climate.com)**

Figure 26 A usual sight at Funafuti every year during strong winds combined with high tides **(**Source**: Tataua Pese)**

Rainfall in Funafuti is high and reliable throughout the year. According to the Tuvalu Meteorological Services, rain falls approximately more than 60% of the time on Funafuti during the wet period from November to April (Office, 2014). Average rainfall for the island is >3660mm per year (SPC, 2010). The El Niño/ Southern Oscillation Index has an important impact on the rainfall variability on the island. It has an inverse relationship with rainfall on Funafuti where by the more intense it is the lesser to no rain falls on Funafuti. Inter-annual variability is modulated by the El Niño Southern Oscillation, which tends to produce wetter conditions during El Niño events. Droughts occasionally occur during La Niña events (Ene, 2007). Latest La Niña effect on the island of Funafuti and the whole of Tuvalu was in 2011, when the impact was so great that the country declared a state of emergency because of the shortage of water that some people were reported to have only two days of clean consumable water left (Pickup, 2011).

Figure 27 below shows mean rainfall for Funafuti. It also shows that during La Niña rainfall decreases and increases with El Niño. Additionally, figure 28 shows annual rainfall for Funafuti and the respective years of ENSO that affected the island.

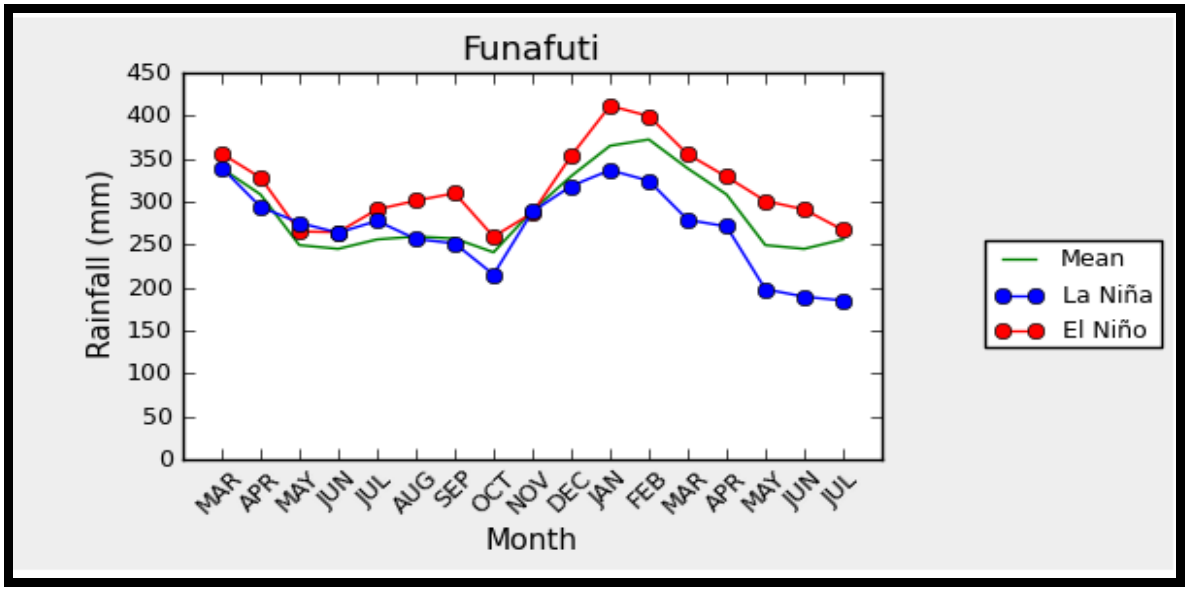

Figure 27 (Source: Andrew Charles, Yuriy Kuleshov and David Jones, 2012**)**

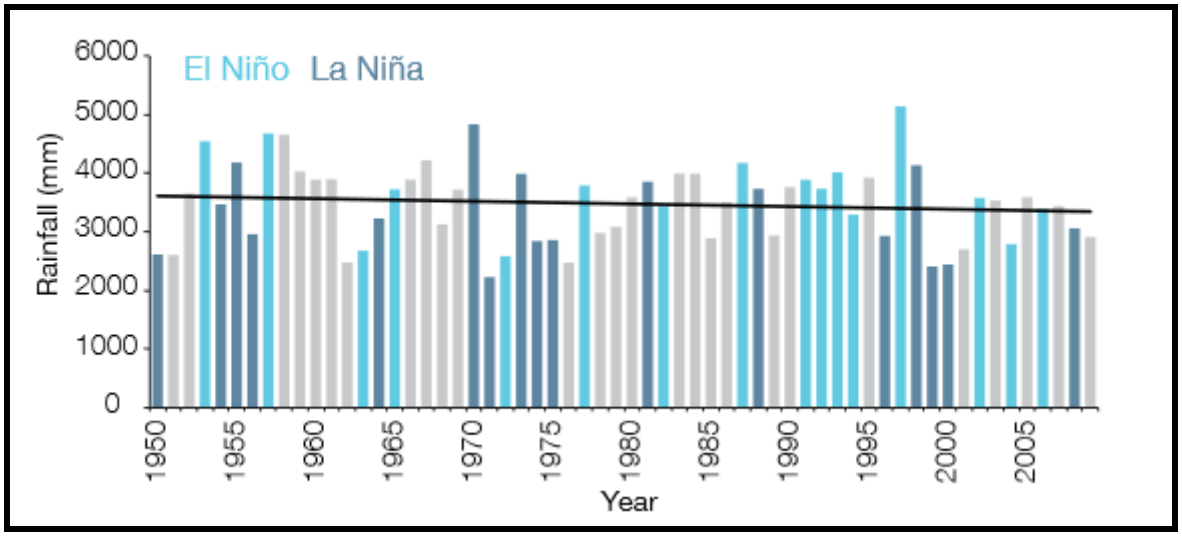

Figure 28 Annual rainfall for Funafuti. Light blue bars indicate El Niño years, dark blue bars indicate La Niña and grey bars indicate neutral years. **(**Source: **PCCSP, 2013)**

3.3 Demography

The Tuvalu census of 2002 showed that 4,492 people out of the total population of 9,561 live on Funafuti (Division, 2010). This is 47% of the total population living on land area of 2.4 sq km, causing Funafuti to be one of the most crowded place in the world with population

density of 1,610 (Division, 2010). Since Funafuti is the administrative centre for the whole country, that it explains the reason as to why the population is extremely high compared to the other islands. People flock to live on the capital to work, for higher education through the University of the South Pacific Centre situated on Funafuti, and some are self-employed having small businesses or employed by construction companies. The majority however are employed by the Tuvalu government.

The over crowdedness of Funafuti, with approximately an average of 6 people in one household (Division, 2010) contributes to the probability of high health risks and fast spread of viruses and diseases. Six persons per household is an average of the total population residing on Funafuti at the time of the census survey, but in reality, many households have more than 10 people living under one roof, while a few consist only of the nuclear family which may account to 3-5 people.

Table 5 below shows the population distribution of Funafuti in the different villages (also see figure 2). Alapi, is the most populated because it is the closest village to the administration centre – Vaiaku.

Table 5: Population distribution on Funafuti as of census 2002

Village Name	Population
Vaiaku	516
Senala	599
Alapi	1024
Fakaifou	1011
Teone	560
Tekavatoetoe	363
Lofeagai	410

(Source: **Tuvalu Government Statistics Division)**

3.4 Hydrology

The soils at Funafuti are highly permeable due to the porosity of the sands and gravels. There are no permanent surface streams and rainfall mostly runs freely to the ocean and also drains through the porous sandy surface. Below the sandy surface exits a tiny lens of fresh to brackish water which floats on the saline marine water. Because of the limited height of the islands height 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, very limited in volume and of unsafe quality for human consumption ((SOPAC), 2007). There are no rivers or streams on the

island and the common way that people get fresh water for consumption is by harvesting rain from house rooftops and storing it in water tanks. One house have many water tanks as the family could afford in order to store sufficient water to cater for the family needs.

In addition, each of the villages also have huge cisterns built to cater for the members of the respective communities when there is shortage of water. These community owned cisterns are carefully administered by selected people in the communities to ensure that the water is well stored, properly managed and allowed to be used only when there is extreme shortage of water. The latest water cistern which could hold 700,000 litres of water was built on the most northern village of Lofeagai, funded by Global Environment Facility (GEF) and Australian government and UNDP (SPREP, 2013). Since groundwater at Funafuti is totally polluted and unsafe for human and animal consumption (Padma Lala, 2006) the people rely almost exclusively on harvested rainfall for drinking water, supplemented by desalinated water.

Figure 29 Houses surrounded by water storage tanks at Funafuti, Tuvalu **(**Source: **Niko Iona)**

Figure 30 Huge Funafuti community water cistern in front of its *falekaupule* **(**Source**: Niko Iona)**

3.5 Health

The whole of Tuvalu have only one hospital, the Princess Margaret Hospital (PMH) which is situated on Funafuti. Located towards the north coast of the island, the hospital serves the whole of the country. Serious cases from outer islands health clinics are referred here to the PMH for admission and treatment. Generally the people living on the capital are at an advantage of receiving better medical attention compared to the rest of the population on other islands because with the only hospital in the country on Funafuti, the expert specialised medical staffs such as public health doctors, surgeons, dentists, dieticians and pharmacists are readily available (Prime, 2015).

Figure 31 Princess Margaret Hospital, Tuvalu's only hospital **(**Source**: Niko Iona)**

For the reason of being close to medication and professional medics alone, all reported cases of HIV/AIDs at Tuvalu, reside on Funafuti. Since the population is very small, Tuvalu is regarded as high risk country because of high mobility of its population especially with large number of seafarers serving overseas and students studying abroad. According to the Tuvalu Ministry of health as reported by UNICEF that as of December 2008 there were 9 diagnosed cases of HIV/AIDs on Funafuti, Tuvalu. There were 8 men and 1 woman (UNICEF, 2010). Since Tuvalu's population is very small, these 9 cases of HIV/AIDs is one of the highest in the Pacific. Fortunately, there has never been any new cases, but the health department and medical personnels are worried because of the high reported cases of sexually transmitted infections (STIs) ((UN), 2014).

Non-communicable diseases (NCDs) have been lately identified as the leading cause of mortality in Tuvalu and that most reported cases are in Funafuti ((UN), 2014) The reasons for most reported cases being from Funafuti is because the patients from other islands seek medical attention at the country's only hospital (see figure 29) on Funafuti, and is here that

they die and the death reported as from Funafuti. The leading cause of mortality is heart disease. In 1992 there were 9 deaths, 14 in 1995 and increased to 16 in 1998. There was a slight decrease in 2000 with 13 deaths but in 2008 the deaths increased again to 16 ((UN), 2014). Diabetes is the second highest cause of mortality in Funafuti and Tuvalu as a whole, and like cardiac arrest, the expert medical opinion on these two diseases is the 'limited range of food to choose from' ((UN), 2014). This limited choice of food and the changing in diets of Tuvaluans is because preference is now more on imported food and fizzy drinks and this has seen soaring health problems in the country.

Communicable health risks on Funafuti is very high compared to other islands because of crowdedness, poor sanitation, water pollution and constant scarcity (Padma Lala, 2006). Many of the houses on Funafuti are merely half a metre apart that chances of passing communicable diseases around is very high. To add to the high risk, one household itself consists more than 7 people. The most crowded families could have members of more than 10 people living in one house, with small shelters build close to the main house (UNICEF, 2010). These are the major contributing factors to high health risks at Funafuti.

The most common reported communicable diseases on Funafuti which are water scarce related are: 'diarrhoea, dysentery[10] and other gastroenteritis illnesses, various types of skin infections including rash, tinea versiolor[11], boils and septic wounds and sore' (Padma Lala, 2006). Waterborne illnesses such as diarrhoea and gastroenteritis are also common especially in young children.

Negative lifestyle behaviour is contributing to the increasing health problems in Tuvalu. The lack of physical exercise on the country especially on Funafuti has seen a lot of the adult population being overweight and obese. The 2000 SPC report (as cited in (UNICEF, 2010) on health in Tuvalu confirmed that 75% of women 29 years and above were overweight or obese and 50% were obese. Men had a slightly lower percentage at 70% being overweight or obese with 47% obese. Majority of the overweight and obese population of Tuvalu reside on Funafuti. This is more common to people living on Funafuti because of their changing diets and little physical activities, since there is no farming activities or any other constant recreational activities to allow people to have physical movement. Using motorbikes to travel

[10] Diarrhoea which the watery stools contain visible blood

[11] A fungal infection of the skin. Fungus interfere with skin pigmentation resulting in small discoloured patches on the skin.

locally on the island instead of walking means that ‘many people do little to offset their high calorie intake’ (UNICEF, 2010).

Widespread cigarette smoking and increasing alcohol consumption is another lifestyle behaviour that is contributing to increasing health problems in Tuvalu, mostly the capital Funafuti. The SPC 2000 report (as cited in (UNICEF, 2010) states that as of 1976, 50% of women and 65% of males in Tuvalu were smokers, which was the third highest in the Pacific region after Kiribati and Nauru. The 2002 census (figure 30 below), showed that smoking was very high in men than women. Both men and women started smoking at a very young age and then the trend increases and slowly decreases at the very old age. The graph show that majority of the working age groups, from 25 to 59 in Tuvalu are smokers especially men.

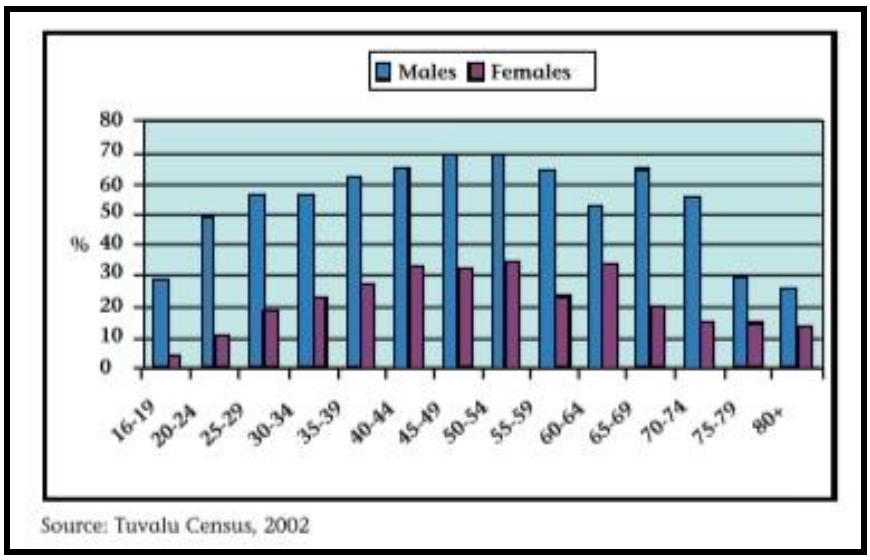

Figure 32 Tuvalu population who smoke (%)

Alcohol consumption is very high too in men and mostly concentrated on the capital Funafuti. It is only on Funafuti that one could find pubs and nightclubs where the alcohol is freely sold to consumers. None of the other Tuvalu islands have pubs or nightclubs and alcohol consumption is very low as compared to Funafuti. Although the Tuvalu census 2002 did not distinguish the number of alcohol consumption by individual islands, it is quite clear and justly valid to assume that a large part of the given data are people residing on Funafuti. Not many women in Tuvalu consume alcohol whereas the percentage of men consumption of alcohol is really high (figure 31). Tuvalu culture and traditions concerning women consumption of alcohol may be the main reason why there is very little women who consume alcohol.

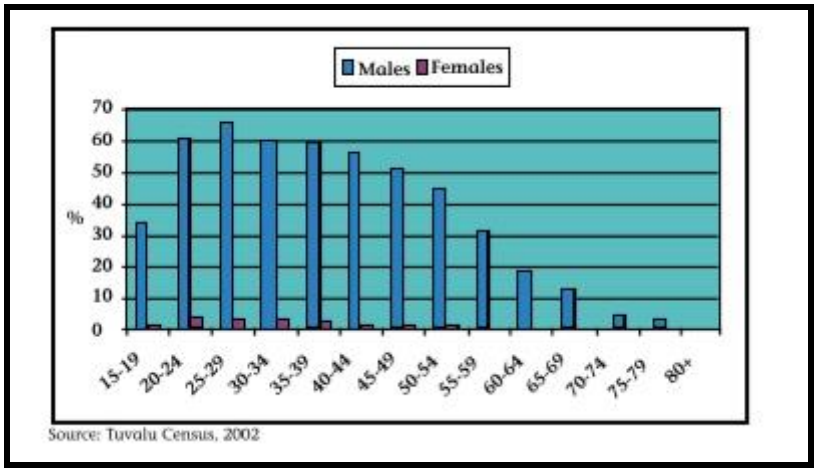

Figure 33 Tuvalu population that drink alcohol (%)

Men and women consume alcohol at very young age but the most alarming fact is the high percentage of men that consume alcohol. These lifestyle behaviours combined with unfavourable environment conditions with over crowdedness increase the tendency of infectious diseases in Tuvalu and mostly on Funafuti.

Chapter 4

Water is fundamental for life and health. The human right to water is indispensable for leading a healthy life in human dignity. It is a pre-requisite to the realization of all other human rights

The United Nations Committee on Economic, Cultural and Social Rights

Chapter 4: Analysis and discussion

This chapter presents the findings from available statistics on the case study area. Using excel spreadsheet and predictive analytics software (PASW), data were recorded and analysed. Primary data received from the Tuvalu Meteorological Services and Princess Margaret Hospital (PMH), at Funafuti are analysed individually, to show the annual trends of each disease. Rainfall is also analysed and tabulated in graph form. Since the PMH have only 17 years of data available which are from 1997 till 2013 of some of the reported diseases, the weather data, rainfall, is also shown for 17 years to correspond with the period of the health data. This however, does not limit the analysis of the whole weather data for Funafuti which is from 1945 until 2013, and is the first graph presented in this chapter (see figure 34 below).

The results of the data analysed separately are later compared to see whether the results correspond with the objectives to the research. Ultimately the strengths and weaknesses of this study are considered and accounted for.

4.1 Analysis of total annual rainfall for Funafuti

The graph below shows the total annual rainfall for the study area, Funafuti, from 1945 to 2013. Average total annual rainfall for Funafuti is >3660 millimetres (see page 49). Analysing the rainfall data received from the Tuvalu meteorological services has resulted in the graph below (figure 34). For the 69 years of recorded rainfall data for Funafuti, 41 years recorded rainfall below average. This leaves only 28 years of above average rainfall recorded.

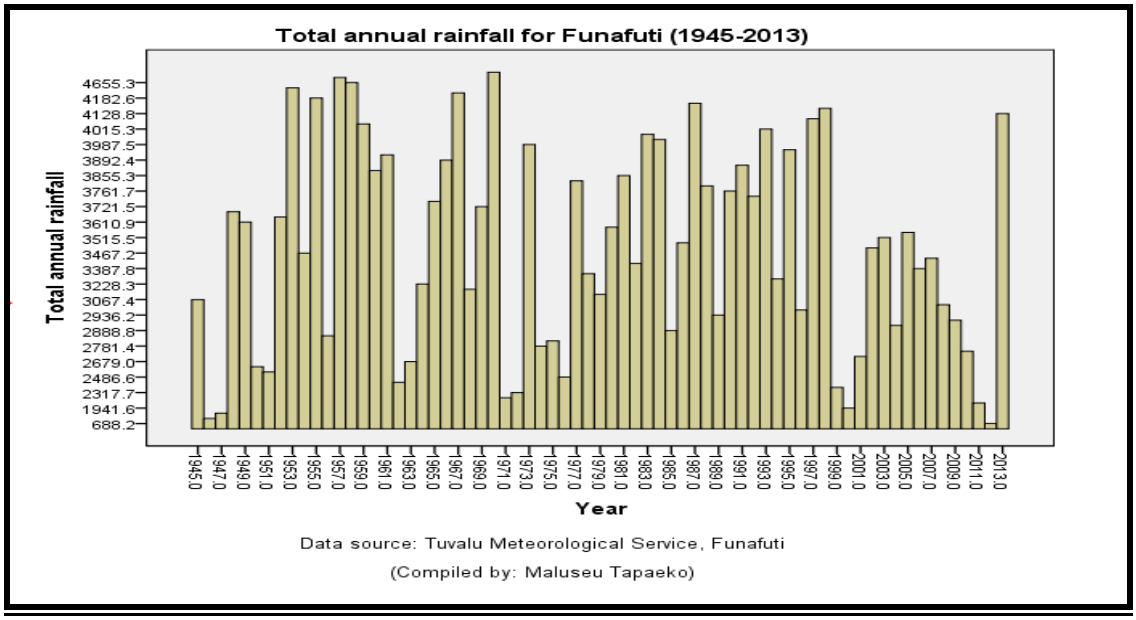

Figure 34 Total annual rainfall for Funafuti 1945-2013

Judging from the above bar graph of total annual rainfall for Funafuti, it is very clear that the island have great fluctuations in its rainfall. In other words, it has substantial changing rainfall pattern, which in some years is way high above the measured average and for some years, the rainfall does not even reach half mark of the known annual rainfall average.

4.2 17-years total annual rainfall for Funafuti, 1997-2013

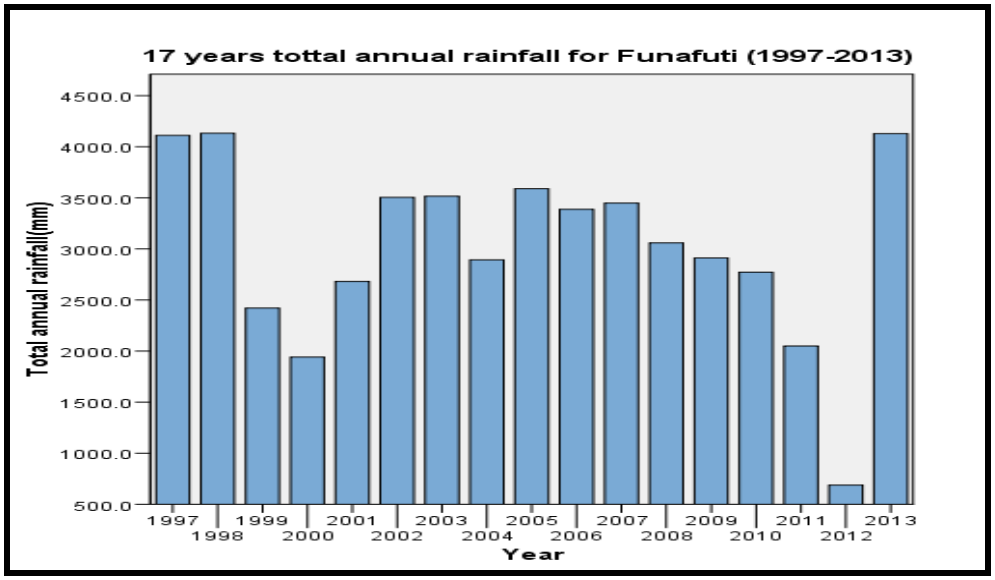

Figure 35 17-years total annual rainfall for Funafuti

The figure above is the 17-years total rainfall for Funafuti. This many years of rainfall is particularly selected because it is the period that corresponds with the number of years of data that was received from the PMH at Funafuti. According to the above selected years, the average rainfall is 3013mm per year. With this average of total rainfall, it is found that 8 years recorded below average rainfall. These years are 1999, 2000, 2001, 2004, 2009, 2010, 2011 and 2012 respectively. 2012 showed extreme low rainfall of 688.2mm of rainfall and this is a direct result of a La Niña occurrence that was affecting the country since 2011 (see pg 49).

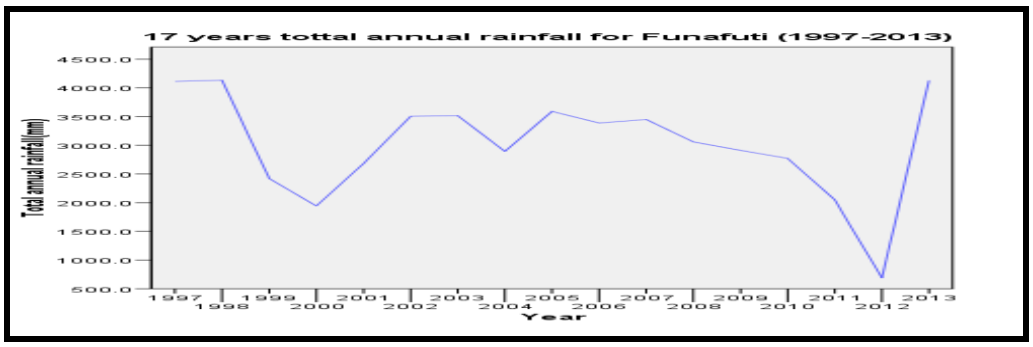

Figure 36 Line graph of the 17-years total annual rainfall at Funafuti

Following are the individual graphs of the reported diseases at the PMH. These diseases are selected because although they are caused by many different factors, the lack of water is one of them (see page 33 paragraph 4).

4.3 Reported cases of conjunctivitis at Funafuti – 1997 to 2013

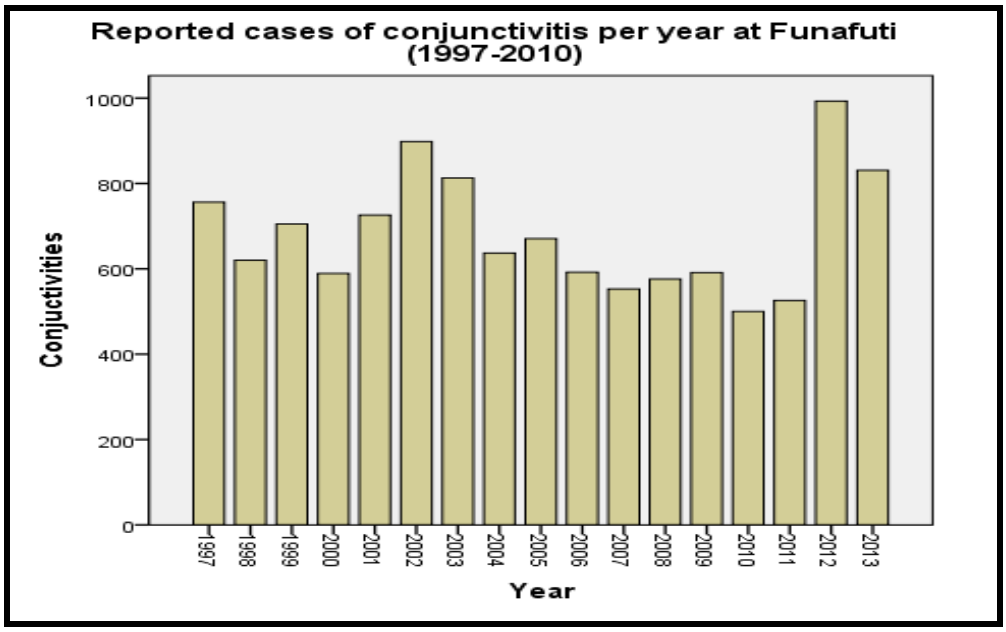

Figure 37 Reported cases of conjunctivitis per year at Funafuti

Conjunctivitis, a disease where the eyes become red when infected is preventable with the simple act of washing hands before handling food and after a visit to the wash room, also clothing and beddings with water. Even when the eyes are infected, this very simple act is mandatory to avoid the infection from getting severe which could cause blindness when untreated. The graph above shows that within the available 17 years data at the PMH, conjunctivitis cases was the highest in 2012 at 993 reported cases to be exact. This corresponds well with the rainfall data above, where the year 2012 recorded the extreme lowest annual rainfall of 688.2mm (see figure 35). The other years also have high reported cases of the disease with most high figures corresponding to the 8 years of below average rainfall.

4.4 Reported cases of diarrhoea at Funafuti – 1997 to 2013

Diarrhoea, a very common disease that is contracted with the consumption of untreated water, poor sanitation and unhygienic lifestyle. Funafuti, being crowded with no natural source of water except their dependence on rain, makes it vulnerable to the disease which is one of the highest global killer especially in children under the age of five. The following

figure 38, is the total reported diarrhoeal cases at Funafuti. It does not specify the age of the reported cases, but just gives the total sum of reported cases per year.

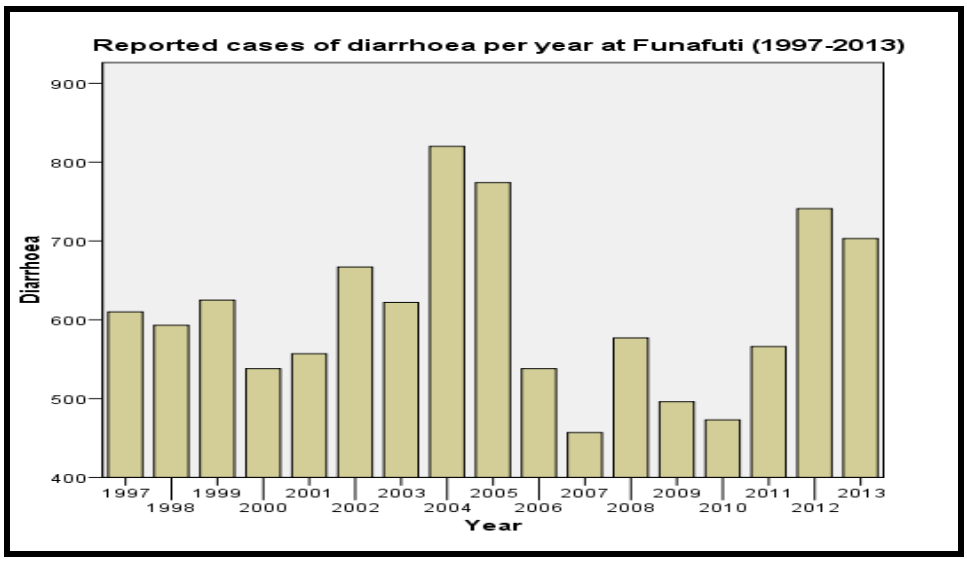

Figure 38 Reported cases of diarrhoea per year at Funafuti

The year with the highest recorded cases of diarrhoea is 2004. It is not surprising though because this is one year which have a below average of recorded rainfall. However it is quite interesting that by looking at the graph, it is very clear that after 2005, the reported cases of diarrhoea started to decrease, only to have a sharp increase in 2012, which is the year of the lowest annual rainfall ever recorded for Funafuti.

4.5 Acute respiratory infection cases per year for Funafuti – 1997 to 2013

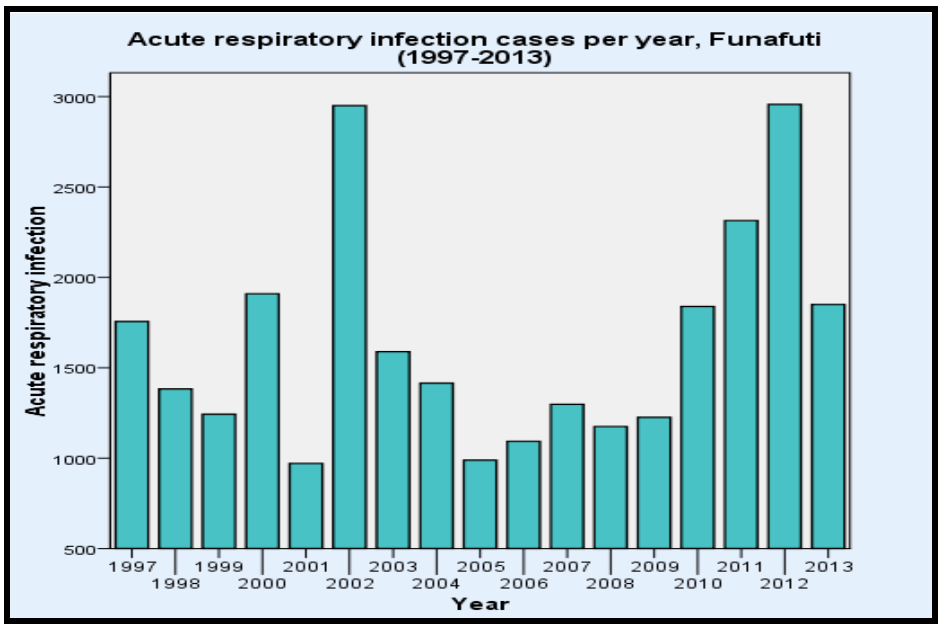

Figure 39 Reported cases of acute respiratory infection for Funafuti - 1997 to 2013

Acute respiratory infection, like all the other diseases have many ways that can cause it. However, in order to initially prevent the disease one has to frequently wash hands especially after visiting the lavatory. Germs are quickly introduced into the respiratory system when dirty hands touch the mouth and eyes. With scarcity of water, this initial act of hand washing is unintentionally neglected, giving a high probability of infection and contraction of diarrhoea. Figure 39 show the reported cases of acute respiratory infection at Funafuti for 17 years. The year 2001 have the least recorded cases of 971 while 2012 have an alarming 2,957 cases. Again this high report of cases directly correspond with less rainfall record for that year. During 2002 there is also a very high case report of the disease, which dramatically decrease in the years that follow only to peak at 2012, then again decrease the following year as rainfall started to increase.

4.6 Reported cases of septic sore per year, Funafuti – 1997 to 2013

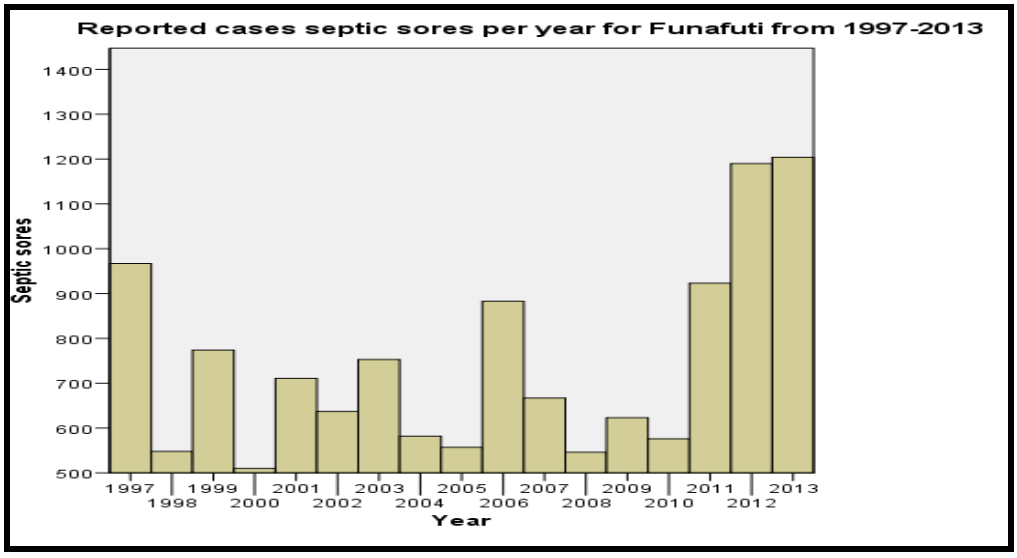

Figure 40 Reported cases of septic sores per year for Funafuti - 1997 to 2013

Septic sores is one of the most common diseases reported at Funafuti. It is an infected wound or sore that takes longer to heal. The high number of septic sore cases at Funafuti can be attributed to infrequent cleaning of the sores as a result of lack of water, which makes the cleaning of the sore less of a priority and also of exposure. Additionally another contributing factor to this high cases of septic sores is the increasing people with diabetes also see pg 54, paragraph 1). Figure 40 above show mostly a variation from year to year with the year 2000 as the lowest recorded cases of 510. Beginning from 2011 the reported cases have increased constantly with the latest records in 2013 as the highest reported of 1,204 cases of septic sores at Funafuti.

4.7 Reported cases of ringworm at Funafuti – 1997 to 2013

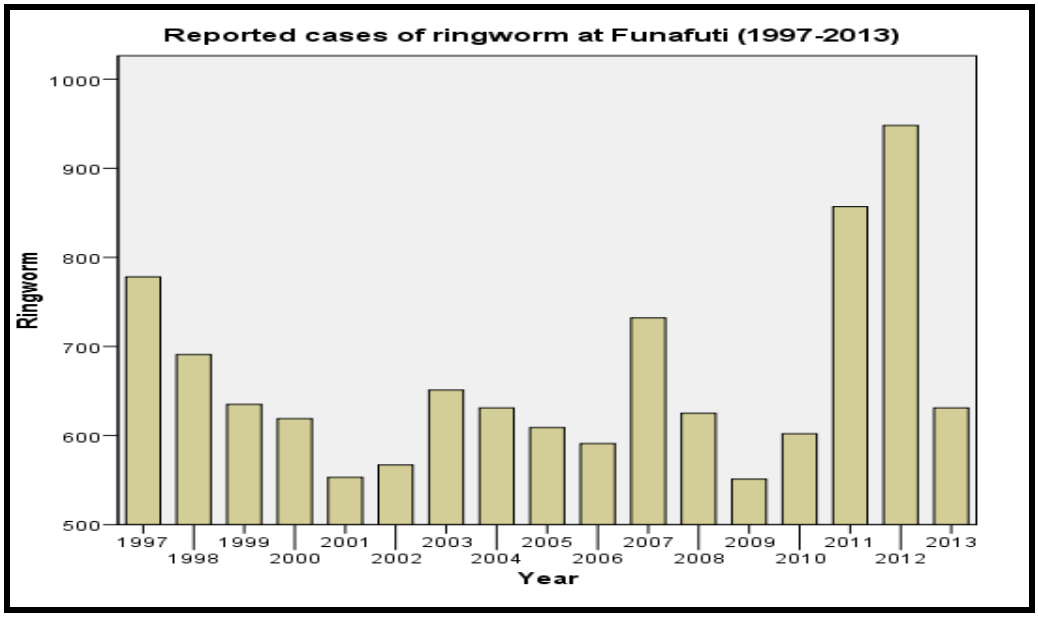

Figure 41 Reported cases of ringworm at Funafuti

Figure 41 above shows the reported cases of ringworm, a skin disease, which is very common at Funafuti. The disease is basically caused by fungus that grows on the skin. Personal hygiene is very important in avoiding contracting ringworm. Taking a shower or bath twice a day is essential and important to avoid getting infected with ringworm. But lacking fresh water for this purpose would eventuate in having less than 2 showers per day as well as having inadequate water for a clean one shower per day. For Funafuti, the year with the highest reported cases of ringworm is 2012 with 948 cases. This is already been seen also on other diseases above, which directly corresponds with the very low rainfall recorded on the island that same year. The disease after 1997 was quite contained with very little fluctuations until 2011 where there is a sharp increase and to peak the following year with 948 cases. As expected on 2013, the disease dropped dramatically to 631 cases with an increase in rainfall.

4.8 Reported cases of dhani and other skin rashes at Funafuti – 1997 to 2013

Dhani is a disease that appear like whitish patches on the skin or a discolouring of the skin. Just like ringworm, personal hygiene is very important in order to prevent contracting the disease. This important hygiene is possible with cleanliness which is possible with washing and bathing. Where there is a lack of water, this cleanliness is unknowingly ignored as water is kept for the more basic needs such as food preparation and drinking. The other skin rashes

which are mentioned here, are not actually specified by the PMH as to which particular skin rashes they are.

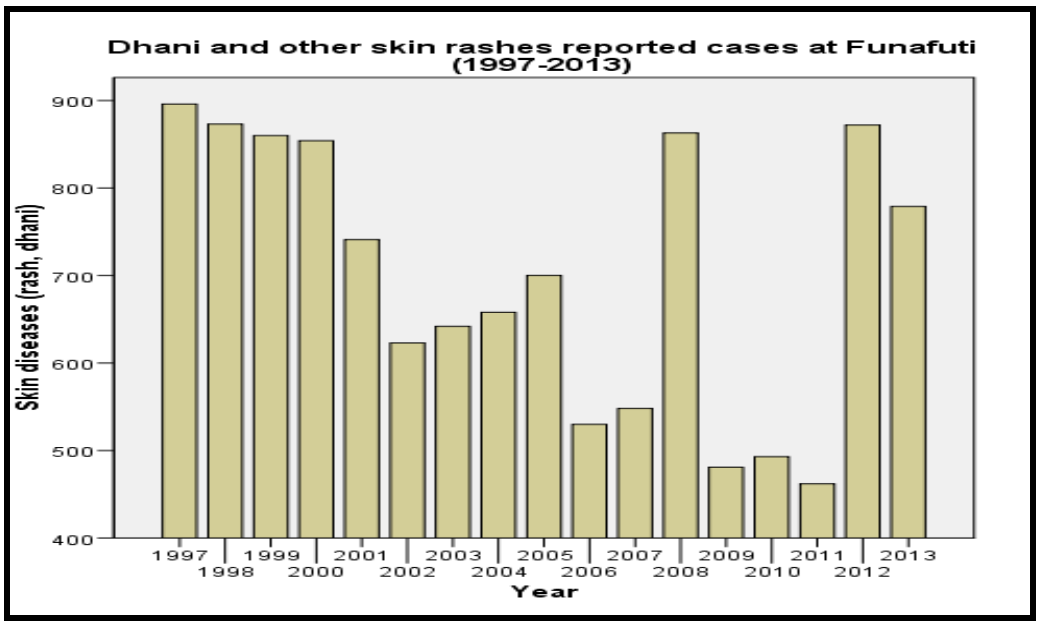

Figure 42 Reported cases of dhani and other skin rashes at Funafuti

Dhani and other skin rashes recorded the highest in 1997 at Funafuti with 872 cases. Then they decrease slowly in the later years until 2008 when there is a sharp increase. The following year 2009 the diseases decreased dramatically until 2012 when they increase again to second highest reported cases so far in the 17 years. Though there was a decrease in 2013, but it was only a slight decrease of the disease as rainfall increased.

4.9 Comparative discussion

The distance between the researcher and the case study area is a colossal challenge in obtaining sufficient data for the research. Moreover, all the data that managed to be collected and used in the research are the primary data that are available and supplied by Tuvalu's Princess Margaret Hospital and the Tuvalu Meteorological Services. The climate data though are more adequate for the research but the health data from PMH were only for 17 years and that of a few diseases only. However, by looking at all the available data and after analysing them as shown above, it appears that reported cases of diseases increase when there is a decrease in recorded annual rainfall.

With that in mind, it is quite a challenge though to depict an on flowing trend, taking into considerations the below average rainfall years with that of the reported cases of different

diseases. The substantial changes in recorded annual rainfall per year as well as the immense fluctuations in the reported cases of disease has made it a challenge to find a smooth proportionate comparison of the two; rainfall patterns and reported cases of diseases. The expected trend as is mentioned in the objectives (see objectives pg 2) is that there is an inverse relationship between annual average rainfall and the number of reported cases of diseases - increase in reported cases of diseases with a decrease in recorded annual rainfall. By looking at the data presented above, it seems to me that there is increasing in reported cases of diseases with decreasing in recorded annual rainfall. This is especially when recorded rainfall is below average.

It looks like that with 2012 having the lowest ever recorded annual rainfall in Funafuti, there is sharp increase in all diseases from the previous year. Although 2012 do not have the highest record of all diseases, but it is vividly clear, that the diseases increased immensely on this year as compared to the previous years and then slightly decrease in 2013 when rainfall started to increase. This is true for all the diseases except for septic sore cases (see fig 40), which continued to increase in 2013. This increase could be explained as an ongoing impact from the previous years that even though rainfall has increased in 2013 and therefore more water for the people, but the infection is far spread from the previous years with lack of water, resulting in poor hygiene and eventually increase in the disease.

Chapter 5

Water is life's matter and matrix, mother and medium. There is no life without water

Albert Szent

Chapter 5: Recommendations and conclusion

Results from the previous chapter proves that with a decrease in rainfall, there is an increase in diseases at Funafuti. Since the island and the whole country do not have permanent fresh water sources such as rivers, lakes and underground water, all water collected from rainfall is precious and ought to be properly managed in order to ensure that sufficient fresh water is available for basic needs and also for maintaining proper hygiene. This would certainly assist in controlling the diseases, resulting in their decreasing. This chapter therefore will provide recommendations that can be adopted by the people and also behaviours of wise management of water which would assist in maintaining good health and controlling diseases.

5.1 Solutions and recommendations

Obviously, the unfortunate morphology of Funafuti and also of Tuvalu, its isolated location in the middle of the vast Pacific ocean and absence of permanent fresh water sources have caused the people to solely dependent on rain for fresh water. Fresh, clean and adequate consumable water as a basic human need, is as we know very scarce on Funafuti.

Surprisingly, the people are mostly ignorant of this realistic situation and in most cases water is not prioritized until the problem present itself in extreme. Individual families collect, store and manage their own water supply and government assistance is only sought when families water supply have run out. Failure to have sufficient water for daily basic needs and maintaining good hygiene and health is initially the sole responsibility of individual families. Therefore proper water management skills at the grass roots which in this case is at family level is of utmost importance. Using water wisely and in a sustainable manner in their daily lives to satisfy their basic needs and maintain proper hygiene to prevent diseases has to be every family and individuals chief priority. These proper water management skills are somehow lacking in the people causing demand for water assistance from the government only after one week period of no rain ((SOPAC), 2007). Therefore, the government ought to increase awareness of proper water management and educate the people on its importance in order to equip them with better skills of sustainable water use and management.

Water managed by the *kaupule* or island council is seldom the next option that families turn to once their own stored water runs out. In some cases, the selected members who were to overlook the management of these community cistern, allow people to use the water, even when there is no serious case of water shortage or less rainfall. This act jeopardises the health

and lives of the whole community when real water shortage strikes. Therefore this practise of allowing anybody to use the water from community cistern has to be stopped completely and community rules concerning the use of the water from community cistern should be followed strictly. These rules are such that water from the community cisterns are only to be used in extreme periods of low rainfall and when all families are having low water rates to no water at all in their individual storages. This practice of traditional water management of community cistern is to be encouraged and strictly followed in order to be able to have sufficient fresh water for all people.

Moreover, house gutters and water catchment pipes are seldom not in proper condition, so that when there is rain, the water runs freely onto the ground instead of being collected into the family's storage tanks. This also was observed by SOPAC ((SOPAC)), and recommended that it is obligatory to have the following in order to collect maximum water when there is rain:

1. Roofs, gutters and storage tanks need to be properly maintained
2. Water conservations practises should be encouraged
3. Roof area with guttering should be maximised
4. Rationing skills should be developed and strictly followed by users at all times

The people then have to try to always make sure that the above mentioned recommendations are adhered to in order to be able to collect maximum amount of water during rainy days. This would ensure that sufficient water is available for individual use and promote a healthy hygienic lifestyle.

Population increase and individual household crowdedness is a big challenge in trying to manage water use and maintain good health. It is recommended that during the census when population data is gathered, that the government in collaboration with the Funafuti *kaupule* and other island *kaupule* should find way to discourage urban drift. This could be achieved by creation of job opportunities at outer islands through development projects as well as skills and knowledge of self-employment opportunities so that there is a decrease in the rate of people moving towards Funafuti in search of jobs. The government ought to emphasise that the number of people living in one household should be just enough in relation to that household's water capacity. This would ensure that each and every household would have

sufficient water to cater for each and every member of the house, maintaining suitable hygiene and healthy living, lessening disease contractions and outbreaks.

Like in Nigeria in Africa, health consequences of water scarcity resulted in diseases such as 'diarrhoea, typhoid fever, salmonellosis, other gastrointestinal viruses, and dysentery' (Muta'aHellandendu, 2012), which are also similar to those that have been seen above (see chapter 4) which are present at Funafuti, Tuvalu. Water scarcity presents itself as a major challenge for the people, concerned organisations and the government and its direct impacts can be seen in the countries weak health, improper sanitation and poor hygiene. Thus, in order to be able to control and prevent these infectious diseases, citizens of the country and government should ensure that the availability of abundant clean fresh water is a top most priority.

5.2 Conclusion

Clean fresh water is crucial to support hygienic healthy living. Irrespective of all odds in life, adequate availability of fresh water for human basic needs is essential in order to ensure healthy living and human survival. Maintaining the highest level of good hygiene, proper sanitation and best of health is only possible with the adequate availability of clean fresh water for human consumption.

Communicable diseases are mostly preventable and 'washable' as mentioned by Curtis (Curtis, 2006) but only with clean fresh water being available in abundance. Having inadequate clean fresh water to cater for human basic needs, sanitation and hygiene results in the contraction of infectious communicable diseases. Therefore is it with utmost importance that an individual have access to clean fresh water in order to live a healthy life. When it comes to this, it is the sole responsibility of an individual and also of families to guarantee that everyone receive fresh clean water for consumption, sanitation purposes and hygiene. Water management skills on how to use water in a sustainable manner is critical to be practised in places that have water scarcity.

Availability of clean fresh water alone would not assure proper healthy lives. The people should always try to maintain healthy living by practising proper and simple hygiene methods such as washing of hands after visiting the bathroom, before and after handling food and whenever necessary.

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