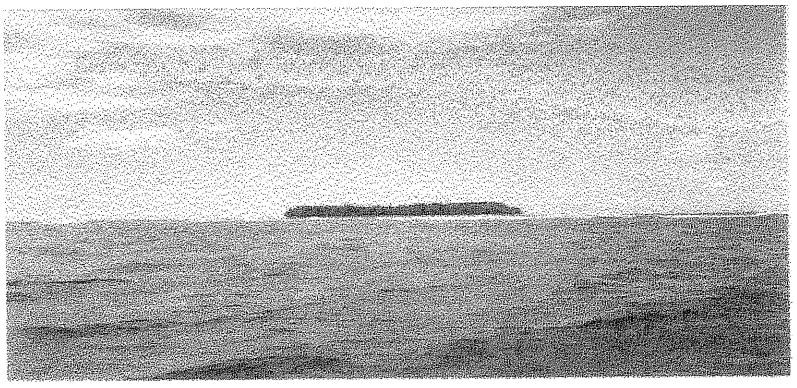
TUVALU INITIAL NATIONAL COMMUNICATION

UNDER THE UNITED NATIONS FRAMEWORK

CONVENTION ON CLIMATE CHANGE



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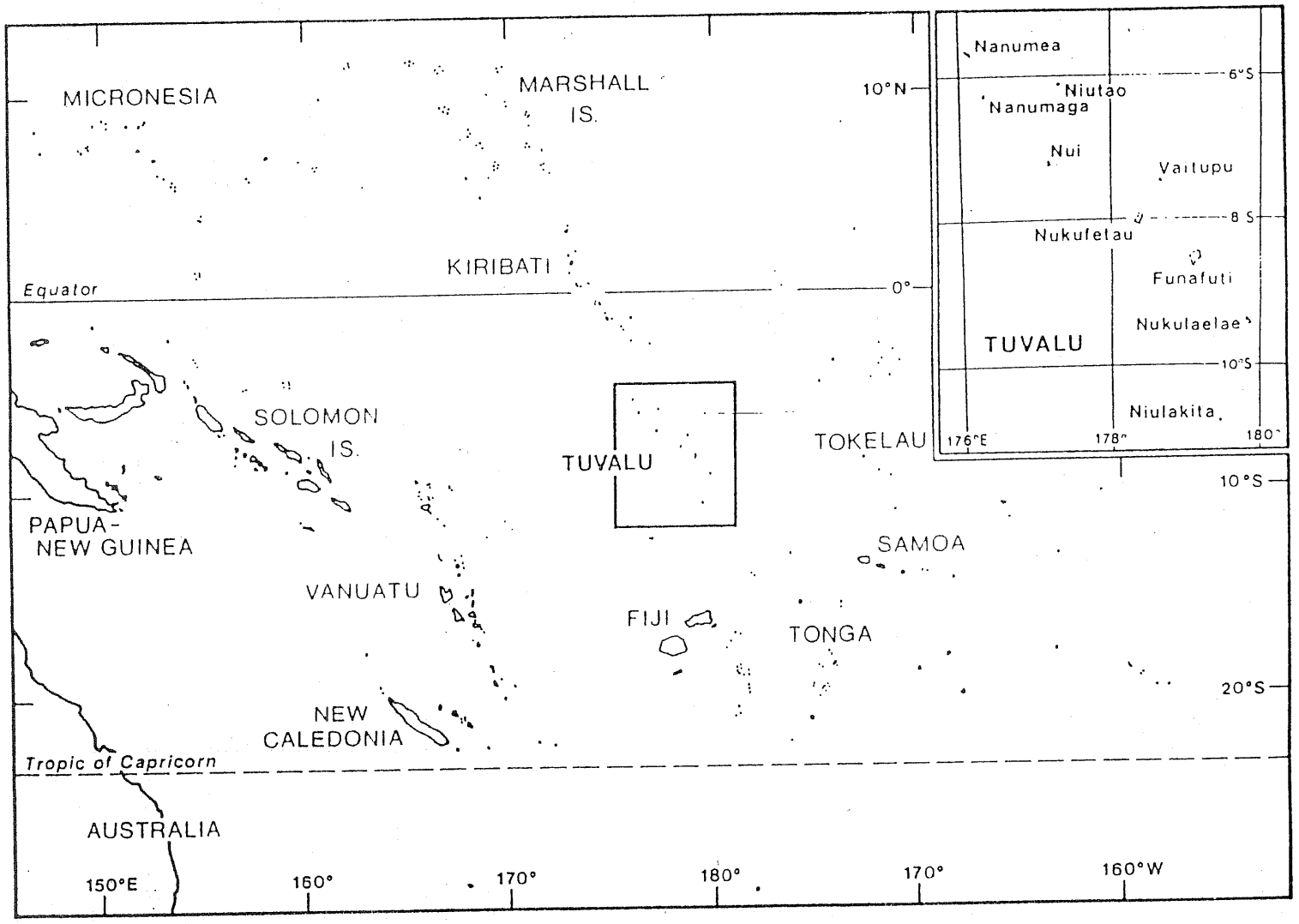

Figure 1 Location of Tuvalu within the Pacific and islands within Tuvalu

EXECUTIVE SUMMARY

Tuvalu, a non-annex I party, signed and ratified the United Nations Framework Convention on Climate Change in March 1994. This Initial Communication describes the context for considerations of the impacts of climate change, provided by the natural and human systems in the country. This background information is followed a sectoral analysis of GHG emissions for the country. Tuvalu's vulnerability to climate change and sea level rise is then analysed in relation to the environmental changes expected for the country under two climate change models for "best guess" and "high" scenarios. The complex interactions of other environmental and socio-economic factors with the expected effects of climate change are examined to provide an overall assessment of the expected effects of climate change in Tuvalu. The final section of this document deals with the steps being taken in the country towards limiting emissions and adaptation to the expected changes due to climate change.

Tuvalu is a highly fragmented tropical state comprised of nine atolls and low islands located 5-11°S and 176-179°E. The total land area of the country is 26 km^2 spread within a sea area of over 900,000 km^2. The islands low in relief and subject to cyclones, variable rainfall and tidal inundation. The islands were settled by Polynesians from Tonga and Samoa in the 16th Century and later Kiribati. Tuvalu was a British colony for 150 years, during which it was called the Ellice Islands, and became independent in 1978. The existing environmental and socio-economic challenges facing Tuvalu are limited land for housing and development, shortage of groundwater resources, erosion, and problems of disposal of solid and liquid wastes.

The emissions of carbon dioxide, methane and nitrous oxide are low. These are largely derived from modest imports of fuels for aviation, sea transport and the generation of electricity, limited subsistence agriculture and wastes produced by approximately 10,000 people.

The climate scenarios predict that by 2050 temperatures in Tuvalu will rise between 0.5 and 2.2 degrees Celsius. The predictions for rainfall are contradictory, with a decrease of between 0.4% and 46% by one scenario (BMR & UKHI) and an increase of between 1.6% and 18% for the other (CSIRO9M2 & HADCM2). These contradictory predictions make an assessment of likely impacts difficult. The expected changes in sea level are those predicted for the globe at between 20 and 40cm by 2050. Over the same time period, it is expected that the human population will increase to between 17,800 and 26,200 and that the present economy based on subsistence, aid and managed trust funds, will move more towards a cash-based economy through the development of the private sector.

By 2050, the expected impacts of climate change and sea level rise will include saltwater intrusion of the settlements, agricultural areas and already limited groundwater resources, with a greater risk of erosion and wave damage from cyclones and storms. It is expected that coral reef areas will be adversely affected by increased rates of bleaching and disease relating to elevated sea temperatures and CO_2 concentrations. The islands in Tuvalu are largely built of slow-growing

corals which may not be able to keep up with the predicted yearly rates of sea level rise of 2-9mm/yr. If rainfall decreases, there are likely to be declines in the yield of important crops such as coconut and swamp taro. There are also concerns that the risk of epidemic diseases such as dengue fever and cholera might increase with changes in rainfall and temperature. For dengue fever, this would be mediated through an increase in numbers and a decrease in generation times in the mosquito vector.

All of the predicted effects of climate change are likely to be exacerbated by changes in socio-economic and environmental factors which are expected to occur independently of climate change. Population increases will result in more wastes, increase the demand for water and land and worsen the effects of inundation and erosion. Increased pressure on natural resources is expected to compound effects of climate change on terrestrial and marine ecosystems. These effects are unlikely to be simply additive and there are fears that they may lead to the collapse of parts of the natural resource base of the country.

The Government of Tuvalu is now looking at measures that can be taken to minimise the combined effects of climate change and socio-economic changes expected over the next 50 years. There is an understanding that resilience of the country is best supported by measures that ensure the integrity and health of natural ecosystems and resources, which in turn are the natural capital of the nation. The steps being taken include the adoption of policies to guide smart development and strengthening of the economy, identification of areas requiring research, improving education and public awareness of the issues, a move towards renewable energy, reduction of GHG emissions, the introduction of better agricultural practices and the reduction of wastes.

Foreword

Tuvalu is one of the most vulnerable countries in the world if the climate begins to change or the level of the sea rises. With so much at stake, Tuvalu is taking the risk of climate change very seriously.

This initial communication describes the steps being taken within the country and in relation to the international community to address the problems expected to come our way. We see climate change as a global responsibility which requires global action and cooperation at an unprecedented scale.

Our existing environmental and socio-economic challenges are a young and increasing. As a Developing Small Island State, funds and expertise for dealing with global problems are limited. However, with regional assistance we have been able to make our first context-sensitive assessment of the problems we might encounter and our part in contributing to the global budget of greenhouse gases.

We are taking steps towards policies to guide smart development, strengthening of the economy, identification of areas requiring research, improving education and public awareness of the issues, expanding of renewable energy, reducing our emissions, introduction of better agricultural practices and reducing wastes.

The results of the assessment embodies in our Initial Communication show that our problems are just beginning and that our responses will need to be timely and able to adapt as more information comes to light. It is also clear that for us, there is no separation between the problems of climate change and our own patterns of development. There is an understanding that the resilience of the country is best supported by measures that ensure the integrity and health of natural ecosystems and resources, which in turn are the natural capital of the nation. We are taking steps towards policies to guide smart education and public awareness of the issues, expanding the use of renewable energy, reducing our emissions, introducing better agricultural practices and reducing wastes.

As Minister responsible for the environment, it gives me great pleasure to present this initial communication of Tuvalu to the UNFCCC secretariat for submission to the Conference of the Parties (COP).

Hon. Faimalaga Luka
Minister for Natural Resources and Environment

Acknowledgement

Tuvalu gratefully acknowledged the financial support given by the Global Environment Facilities through its implementing agencies UNDP and SPREP which has made the writing up of this initial national communication possible.

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Thanks also go to the secretary himself Mr Elisala Pita and Dr. Uschi Kaly for the guidance given in producing this initial national communication.

We acknowledged also the inputs made from the various government departments and non-government agencies towards the production of this document.

A special thank go to the Assistant PICCAP Coordinator herself, Mrs Tagifoe Fakavae, for her assistance in typing this important report.

Acronyms

PICCAP – Pacific Islands Climate Change Assistant Programme

SPREP – South Pacific Regional Environmental Programme

SOPAC – South Pacific Applied Geoscience Commission

UNDP – United Nations Development Programme

UNFCCC-United Nations Framework Convention on Climate Change

TTF – Tuvalu Trust Fund

FTF – Falekaupule Trust Fund

TPF-Tuvalu Provident Fund

UNEP – United Nations Environment Programme

GEF – Global Environment Facility

UNFCCC – United Nations Framework Convention on Climate Change

IPCC – Inter-governmental Panel on Climate Change

GEIC – Gilbert and Ellice Islands Colony

ADP-Asian Development Bank

AusAID- Australian International Development Agency

GCM- General Circulation Model

CO_2 - Carbon dioxide

N_2O-Nitrous oxide

CH_4- Methane

TSECS– Tuvalu Solar Electricity Cooperative Society

ENSO – El Nino Southern Oscillation

USP – University of the South Pacific

EIA – Environment Impact Assessment

GDP-Gross Domestic Product

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CHAPTER ONE

1. 1 INTRODUCTION

The Rio Summit in 1992 culminated in the signing of the United Nations Framework Convention on Climate Change (UNFCCC) by some 165 countries that agreed to the terms of the convention. Tuvalu, a non-Annex I party, signed and ratified the convention in March 1994. Among many other commitments under the convention, the initial national communication is one obligation that Tuvalu must produce and submit to the UNFCCC secretariat.

This initial communication is a requirement under the financial assistance provided by the Global Environment Facility (GEF) through the United Nations Development Programme (UNDP), and is to be prepared in accordance with the UNFCCC guidelines already established. The content of the communication focus on the national circumstances, the greenhouse gas inventory.

This is the first time that Tuvalu has produce such a communication. It is a difficult task to try and collect data as most of the climate change data are not readily available. However, I am very grateful for the effort of the PICCAP Country Team, which was responsible for coordinating national climate change activities. This included the editing of this communication.

Photo: 1 – A typical sandbank - a common feature of an atoll.

1.2 NATIONAL CIRCUMSTANCES

1.2.1 Background - General

Tuvalu is comprised of nine small islands, six of them being atoll islands (with lagoons) namely Nanumea, Nui, Vaitupu, Nukufetau, Funafuti, and Nukulaelae. The remaining three, Nanumanga, Niutao and Niulakita are raised limestone reef islands. All the islands are not more than three metres above sea level, with the biggest island, Vaitupu, having a land area of just over 524 hectares. The total land area is approximately twenty–six square kilometres with a sea area of 900,000 square kilometres. The summary of the National Circumstances is given as Appendix 1.

1.2.2 Geography

The islands are located between latitudes 5 degrees and 11 degrees south of the equator and between longitudes 176 degrees and 179 degrees east of Greenwich (figure 1).

To the north, about 1400 km is the Republic of Kiribati and to the south, 1100 km is the Republic of Fiji. Distances to the two nearest metropolitan countries of Australia and New Zealand, with which Tuvalu has very close economic and social ties, are about 4000 km to Sydney and 3200 km to Auckland. Tuvalu is near the cyclone belt and is always at risk from the tropical storms and cyclones developing in our area.

The furthest distance between any two islands is 172 km (Nui/Vaitupu) and the nearest distance between any two islands being 67 km (Nukufetau/Vaitupu).

1.2.3 History

The first settlers in Tuvalu were believed to be Polynesians coming from Tonga and Samoa in the early 16th century. Around the same period, Micronesians from Kiribati invaded one island called Nui.The people of Tuvalu are mainly Polynesians with a minority group of Micronesians.

The main language is Tuvaluan, similar to the Samoan language, with English and I-Kiribati also spoken in the every day communications.

Tuvalu, which means "group of eight islands" is a new name given during independence in October 1978. Formerly, the group was called the Ellice Islands. During the pro-independence period, 1938 – 1978, Tuvalu was a British Colony called the "Gilbert and Ellice Islands Colony (GEIC).

Tuvalu during independence adopted a Westminister type of government with the Prime Minister as Head of Government and the Governor General as Head of State.

1.2.4 Climate

The climate in Tuvalu is tropical with a wet and dry season. The wet months are from November – April while the dry months are from May – October. The average annual rainfall for Tuvalu is 3000 mm although rainfall can exceed 4000 mm per annum at times.

Dry periods are more severe in the northern islands than the southern islands, notably in the months of August-October. Dry years in Tuvalu are associated with a positive Southern Oscillation Index (SOI). Drier than average years have occurred in 1950, 1964, 1975, 1976, 1988 and now in 1999.

1.2.5 Sea level rise

Since 1993, Tuvalu has established a tide gauge to monitor sea level rise, sea pressure, sea temperature, wind speed and wind direction.
The average sea level trend for Tuvalu (1993- 1999) is 22mm per year with a maximum sea level trend record of approximately +40mm per year observed in 1995, which exceed the global average of 1-2mm.

Negative sea level depression was first observed in December 1997 with a reading of –36.6mm per year recorded in August 1998. The negative trend in sea level is still continuing in Tuvalu as reflected in reports from the tide gauge station – Funafuti.

1.2.6 Strong winds

In the past, Tuvalu has been struck many times by strong winds of variable strengths ranging from tropical storms to tropical cyclones. Severe tropical cyclones occur 1-2 times every 50 years, with the most recent one, Hurricane Bebe, hitting Tuvalu in 1972 with associated wind speeds of over 240 km an hour.

Tropical storms also do occur but on a more regular basis (1-5 years) some of which can be damaging to food crops, shoreline vegetation and houses. The direction most of these past strong winds follow is on a south-ward bound increasing speed as the move away from the islands.

1.2.7 Population

During the post–independence period (1975-1978), population (de facto) was just over 7,000 people. A population census carried out in 1991, estimated a total population of 9,043 comprised of 47% males and 53% females. Funafuti the capital has 40% of the total population with a national average population density of 347 people per square

kilometre. The remaining 60% of the population is scattered over the remaining eight islands. For the last decade, population increase has been constant with an average annual increase of 1.7% and is slowly increasing the following years.

Infant mortality rate (per 1000) is about 41 and is continuing to improve due to health service improvements. Life expectancy is averaged at 67 years for both males and females.

1.2.8 Education

Education in Tuvalu is comprised of the pre-primary, primary, secondary and tertiary level. Literacy level is about 98% with about only 3-5% of population reaching tertiary level. The government in its efforts to strengthen the education system, has placed strong emphasis on increasing the number of teachers at both the primary and secondary levels, and promoting science subjects at all levels. Distance education is one option encouraged at tertiary level to engage dropouts in specific courses leading to career specific training.

There is a lack of technical expertise in the area of climate change in the country. This is probably because the study of climate change is quite new in the pacific region. It is also because there is a general shortage of trained scientists in Tuvalu.

1.2.9 Economy

The dispersed nature of the islands, its isolation from markets, its tiny land mass, a small population and a narrow resource base are the major constraints that have restricted Tuvalu's economy. Despite all these economic disadvantages, government is funded through aid money, revenue collected from direct taxes, custom duties, philatelic sales, licensing fees for foreign fishing vessels plus revenue generated from the Tuvalu Provident Fund (TPF). During 1994, the Gross Domestic Product (GDP) stood at AUD $15.6 millions and is slowly increasing at 1.3% per annum.

The establishment of the Tuvalu Trust Fund (TTF) in the early 1980's serves as the most important capital resource to finance recurrent government expenditure. This TTF capital resource grew from $42 million in 1987 to over $70 million in 1994: an annual increase of about 9.5 %.

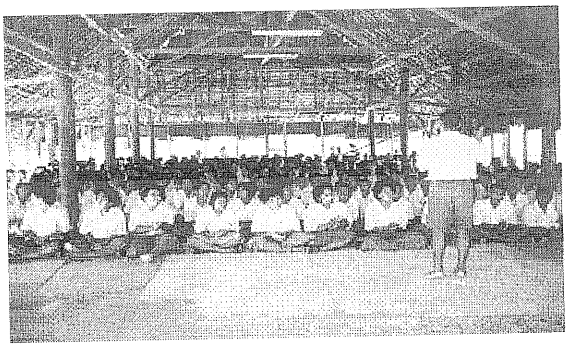

Photo 2: Motufoua Secondary School students – Vaitupu.

A similar strategy was adopted by government in 1999 to promote outer islands development. A second trust fund called the Falekaupule Trust Fund (FTF), established for outer islands Kaupule to take an initiative in development The long term outlook of government in adopting such strategies is to try and reduce full dependency on foreign aid money and try to establish a strong resource base for Tuvalu that will sustain the country's future financial needs.

Subsistent agriculture and fishing are the two main activities in rural areas, while paid jobs either in government or the private sector is the main form of living on urban Funafuti and sub-station Vaitupu. Commercial fishing, a newly established venture on Funafuti involving the sales of reef and pelagic fish to overseas markets is currently operation on Funafuti and is slowly expanding to include all islands.

1.2.10 Energy

The number one indigenous energy source used by most Tuvaluans is wood, used mainly for the purpose of cooking of food. For Tuvalu, all other fuels are imported from Fiji for the purpose of electricity production and transportation (air, land and sea), the three main sectors of CO_2 and N_2O emissions.

The main forms of fuels imported into the country are 636 kilolitres of petroleum, 302 kilolitres of dual purpose kerosene, 1192 kilolitres of diesel, and 659 kilolitres of Jet A-1 fuel. A range of oils is also imported into the country but no data are currently avaliable on quantities.

Recent research on renewable energy done by a regional organization called the South Pacific Applied Geoscience Commission (SOPAC), reported that there is potential for renewable energy in Tuvalu, especially in the area of solar energy. This energy source has not been fully commercialized in the country. Other sources of energy like wind energy, wave energy etc, have been studied, but findings show that such sources of energy would have negative results in Tuvalu.

1.2.11 Biodiversity conservation

The importance of the marine environment remains top priority in the lives of the people of Tuvalu. Conservation of biodiversity in Tuvalu is not a new concept for it has been part of the traditional lifestyle for the last 300 years or so. With population slowly increasing and the economy changing from subsistence to semi-commercial, traditional biodiversity conservation practices has been somewhat ignored by the majority of the people due to the high demand for cash. In the long term, such attitudes of resource utilization are damaging to our land and marine natural resources.

In the past few years, the government has noticed this fast change of traditional conservation practices dying out. As a result, it has taken on board a national conservation programme (called the Funafuti Conservation Programme) where both traditional and modern conservation practices have been integrated to remedy the problem. To date, the results have been encouraging and there is a long-term plan to extend the programme to the rest of the islands.

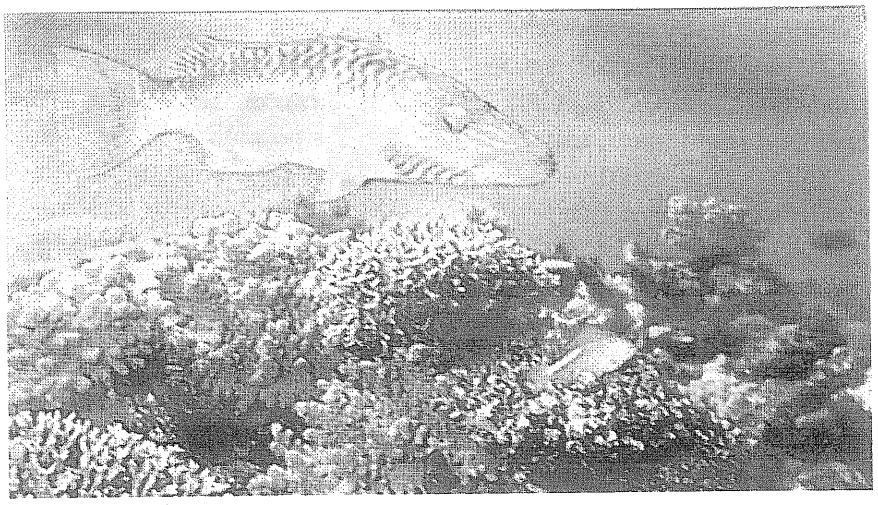

Photo 3: A marine biodiversity – Funafuti Conservation Area.

Flora on the islands is very limited with just over 300 species existing. Out of the lot, only about 65 are native species and the rest are introduced. The majority of the species are ornamentals and shrubs. Sea birds, of just over 20 species, with a few migratory ones, have been on the islands for quite some time and have adapted themselves to the hash conditions. Fish species in Tuvalu is quite abundant and up to date, 350 species of fish have been recorded.

1.2.12 Local Employment

Subsistent agriculture, fishing and other home duties are the major activities for the majority of Tuvaluans. About 80 % of the total population aged 15 years and over are involved in the above activities. The remaining 20% of the population are government and private businesses employees.

1.2.13 Land Tenure

One of the main obstacles hindering the development of land in Tuvalu is the system of land ownership. The land tenure system is based on the principle of land inheritance (from father or mother) to sons/daughters and sub-division of land between the landowners themselves. This system has advantages and disadvantages, like fragmentation of land plots through continual division, land disputes over the boundaries and multiple ownership of land plots. In the past, the above problems have acted as barriers to agricultural commercialization, infrastructure and building developments, leasing of land to others and, in particular, the exchange of land between indigenous Tuvaluans. About 95% of the total land area in Tuvalu is owned by individual ndowners. There are communal lands available on a few of the islands including crown land.

CHAPTER TWO

NATIONAL INVENTORY OF GREENHOUSE GASES

2.1 Introduction

For Tuvalu, the first greenhouse gases inventory was carried out in late 1998 focusing on the three major gases namely carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) as required by the UNFCCC. The result of the greenhouse gases inventory is given in Appendix 2.

2.2 Methodology and Source of Data

The methodology employed to estimate the gas emissions is that of the 1996 IPCC Revised Guidelines for National Greenhouse Gas Inventory. Data has been collected from the following sources:

- Energy Department
- Agricultural Department
- Environment Unit
- Burns Philip Agency
- Statistics Department

Not all data required for the GHG was acquired during the study, due to unavailability. Work on the GHG was confined to available data only.

2.3 Organization

As given in the 1996 IPCC Guidelines, the inventory confined its reporting to the six major sources of greenhouse gases namely:

- Energy activities
- Agriculture Land
- Land Use Change and Forestry
- Waste
- Industrial processes
- Solvent and other products

2.4 Emissions

2.4.1 Energy

The main emissions come from fossil fuels which are all imported from Fiji namely gasoline, jet kerosene, diesel, oil and kerosene. All fuels imported are for the purpose of production of electricity, transportation purposes (air, land and sea) and for fuel for lighting and cooking mostly at rural areas. Some greenhouse gas emissions are emitted from agriculture e.g. livestock waste and land use involving fertilizers. Emissions from other sources are not estimated for lack of data, but will be taken on board in the second greenhouse inventory.

2.4.2 Transport

Road transport is heavily reliant on imported fuel, e.g. gasoline and diesel, and the same is true for sea transportation between the islands. There

is also importation of jet-fuel for between Tuvalu and Fiji. Data on bunkering fuels is not available for the year 1994.

2.4.3 Electricity.

Most diesel imported into the country is used for the running of generators on Funafuti and the outer islands, for the production of electricity. A few households also use small gasoline and diesel generators to generate their own electricity. All of these generators are high speed generators, which consume a lot of fuel at the same time emitting large volumes of greenhouse gases. An estimated annual figure of 709,304 litres is consumed for electricity generation. The future direction in electricity production for Tuvalu is to look for alternative sources that can generate electricity at low costs with minimal greenhouse gas emissions. Integration of both systems, the generators and solar voltaic might be the best option for Tuvalu in the long term.

2.4.4 Agriculture

Heavy cultivation of *Cyrtosperma chamissonis* and *Talo esculenta* in the man-made talo pits emit methane gas. The CH_4 emissions resulting from the above root crop cultivation have been omitted from the calculations for lack of available data. Livestock, poultry and swine are the only domesticated animals on the islands giving a total CH_4 emission of 4.32E-02 Gg. This emission is from waste, which is quite insignificant.

2.4.5 Land use change

refueling of international aircraft flying The major land use change occurred between the years 1970 – 1995 under the coconut replanting scheme when large plots of lands were cleared of bush and mono-cropped with coconuts. That programme has now ceased and was replaced by an integrated type of farming called - mix farming. Another form of land use change, is the use of chemical fertilizers in the commercial production of sweet potato and vegetables for local sale. Exact quantities of fertilizers used in the operations is not known and therefore estimation of greenhouse gas emissions has not been attempted.

2.4.6 Solid wastes

As the country has developed economically and moved towards a cash based, consumer goods society, so the volumes of waste products have increased in proportion. This is very true on Funafuti, the capital, which has a solid waste management problem. On urban Funafuti, solid and other wastes include modern refuse which may take many years before it breaks down and some of which may be harmful.

The current practice of uncontrolled waste disposal now practised on Funafuti is posing high risks to the health of the people and the environment at large, and may have an impact on the economic development of the islands. An integrated approach to the generation, recycling, collection and disposal of waste is urgently needed. The government has recognized this problem and is currently working closely with the Funafuti Kaupule to address this problem.

Several studies have been carried out by regional organizations like SOPAC and SPREP and other

organizations like ADB (1996) and AUSAID (1998) all aiming to address the problem of waste.

2.4.7 Liquid Waste

Domestic waste from hotel, motels, restaurants and residential houses have been drained through to septic tanks and soaking pits. There is no proper effluent disposal system existing for urban Funafuti, so it is not possible to estimate methane emissions for domestic wastewater as such. This is one area that is worth noting for future research work.

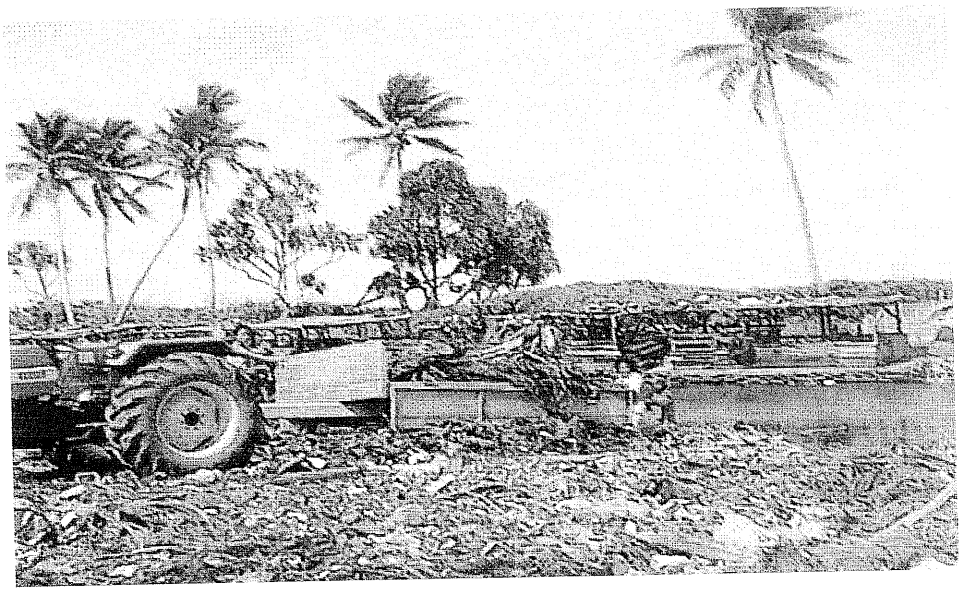

Photo 4: Waste disposal on Funafuti.

CHAPTER THREE

VULNERABILITY AND ADAPTATION

3.1 Vulnerability

3.1.1 Introduction

The problem of climate change caused by the anthropogenic emissions of greenhouse gases has posed the following impact on small island states like Tuvalu:

- Sea level rise
- Rising temperature
- Increased frequency of droughts, strong winds, floods and other extreme climatic events
- Increased coastal erosion
- Threats to food supply
- Threats to fresh water sources
- Threats to human health

3.1.2 Sea level rise

The islands of Tuvalu are only a few metres above sea level. Any rise in sea level will have very serious impact on human health, houses, infrastructure, food crops, ground water sources, land and marine biodiversity, vegetation, and the shoreline. Sea level rise could also cause serious coastal erosion and land loss on all the islands, lower crop yields and in some cases might lead to the loss of entire islets.

3.1.3 Rising temperature

As predicted by scientists, the temperature of planet earth is expected to rise slowly in the next thousand years. The impact of that rising temperature on the atoll nations will be expensive. An increase in the sea temperature by just one-degree is expected to cause coral bleaching to our corals. The loss of corals is expected to affect the population of other marine biodiversity including fishes, the shellfish species and others. Agricultural production may decline in terms of crop yields because of salination and increased transpiration, and will make local food production more expensive. There is an expected emergence of new agricultural pests, which may make local food production more difficult. Health risks through mosquito vectors are predicted to rise and may affect health and quality of life of humans.

3.1.4 Coastal erosion and infrastructure development

Coastal erosion is a common feature of the islands under natural conditions and it is a continuing problem for all Tuvalu islands. The rate of erosion during the predicted rise in sea level is at the rate of one metre of shoreline loss per year.

An increase in population and growth in demand for permanent houses and infrastructure has resulted in increased demand for gravel for building and constructional purpose. This has led to a more serious coastal erosion problem especially on the capital Funafuti.

With an expected increased in frequency of strong winds, and increased internal migration to Funafuti, the predicted problem with coastal erosion are likely to be worst on Funafuti.

3.1.5 Housing, land availability and population growth

Housing ownership is common among Tuvaluans and the majority own the lands as well as the house. Land is a scarce resource and is becoming a major problem due the fast increase in population especially on Funafuti.

3.1.6 Food and health

The overall population has shifted its food diet from traditional food to imported food, particularly on Funafuti. This us due to limited land for subsistence agriculture and the increased purchasing power of the employed population. As a result, an increase in lifestyle diseases has occurred and is expected to increase.

3.1.7 Growth of cash economy

Despite the strong features of a Tuvaluan traditional life where sharing and living as an extended family still predominate, the emergence of a cash economy lifestyle has slowly changed the overall lifestyle of the urban population. As the economy slowly grows employing more people, the private sector is expanding and sooner or later, the private sector will dominate the economy in terms of employment opportunities and contribution to the economy itself.

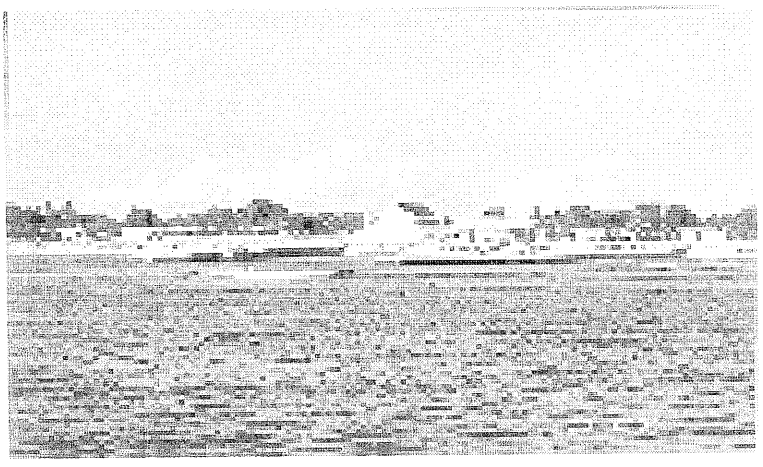

Photo 5: Fisheries harbour – Vaitupu very vulnerable to storm surges

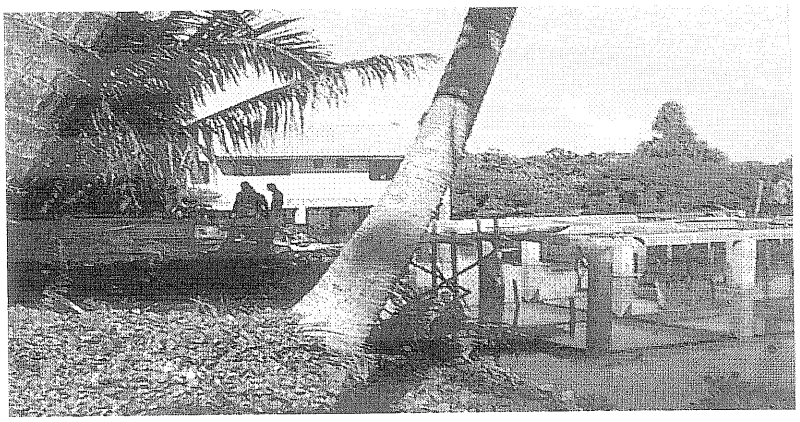

Photo 6: House build on fish pond - Funafuti

3.1.8 Biodiversity

The entire population of Tuvalu depends largely on marine resources as their main source of protein. With increasing pressure on the marine resources, some of these resources are becoming scarce that their continued existence is highly endangered.

Given the low lying feature of the islands, only a few metres above sea level, the predicted sea level rise, rising temperature etc, both our land and sea biodiversities are very vulnerable to these adverse effects of climate change.

Endemic species are the most susceptible to the extreme events of climate change and may reach a point of complete extinction.

3.1.9 Underground water sources

The main water supply on the islands is from rainwater collected in water tanks or cisterns. A secondary source of water, available from the underground water lens through dug out wells is also available on most of the islands.

Under normal conditions, water supply is adequate to all households. However, during drought periods, underground water sources are important as a secondary source of water for domestic purposes.

Sea level rise is expected to have serious impacts on the following underground sources and the services they provide to humans by :-

- Salt water intrusion to the wells making the water in the wells unfit for consumption;
- Increasing the water shortage problem on the islands as many wells will be closed;
- Leading to water related diseases which will pose health problems to the population;
- A reduction in the production of local food supply;
- Emerging problems with pests which are expected to worsen crop yields;

3.1.10 Solid and liquid waste

From observation, there is a marked increase in solid and liquid waste especially on Funafuti.
The overall impact of increased waste and poor management on the islands is the degradation of our clean environment.
Oil and other hazardous wastes are posing the following risks :-

- Contamination of the underground water resource and

- Sea water pollution around the main settlement area (with associated increase in algal cover, losses of corals and the emergence of algal blooms).

3.2 ADPTATION MEASURES

CLIMATE AND SEA LEVEL SCENARIOS FOR TUVALU

There is lack of available data both regionally and internationally to develop more accurate national and regional scenarios on climate change and sea level rise.
What is evident right now is that for the last two decades, there is a marked change in the weather patterns eg there is an increase in frequency of strong winds hitting Tuvalu when compared to the two decades before that.

3.2.1 Climate scenarios

In the absence of national /regional data, the best information available has been used to develop scenarios of climate change for Tuvalu.
Scenarios have been drawn from output from a number of general circulation models (GCM's) in combination with the most recent IPCC projections and from historical events such as cyclones and ENSO events.
Based on the IPCC IS92a (best guess) and 1S92e (high), two scenarios have been developed for the years 2025, 2050 and 2100 in combination with results from other sources. Refer to the two scenarios given below for full details:

IS92a (best guess) **Scenario 1**

Year	2025		2050		2100	
	Temp (deg.)	Rainfall (%)	Temp (deg. C)	Rainfall (%)	Temp (deg.C)	Rainfall (%)
BMR	0.4	-0.2	0.7	-0.4	1.2	-0.7
UKHI	0.3	-16	0.5	-27.9	0.9	-51.0

(high)

BMRC	0.6	-0.3	1.1	-0.6	2.3	-1.4
UKHI	0.4	-24.4	0.8	-45.8	1.7	-95.4

IS92a (best guess) **Scenario 2**

Year	**2025**		**2050**		**2100**	
	Temp. (deg. C)	**Rainfall (%)**	**Temp. (deg.C)**	**Rainfall (%)**	**Temp. (deg.C)**	**Rainfall (%)**
CSIRO9M2	0.5	0.9	0.9	1.6	1.5	3.0
HADCM2	0.8	3.6	1.4	6.3	2.4	11.6
(High)						
CSIRO9M2	0.8	1.4	1.5	2.6	3.0	5.5
HADCM2	1.2	9.2	2.2	18.1	4.5	37.7

From the results given in the above scenarios, we could say that Tuvalu will be experiencing an increase in atmospheric temperature ranging from 0.5 to 2.2 degrees C in 2050 to 0.9 to 4.5 degrees C in 2100 (scenario 1). It can be said here also that under scenario 1, there will be a great increase of about 95% in rainfall by the year 2100 while scenario 2 shows a moderate to high increase in rainfall. Thus scenario 1 gives warmer and drier conditions and scenario 2 gives warmer and wetter conditions. From the above two scenarios, we are able to predict changes in mean climate conditions but not climate variability or extreme conditions.

Based on historical events, following analogues for considering effects of variability and extremes in combination with mean changes in climate are used. Tropical cyclones have continued to hit Tuvalu 1-2 every 50 years. The most recent severe one was Cyclone BEBE in 1972.

In the last two decades, the ENSO events have continued to take impacts as normal. There is a high uncertainty in the above scenarios, and here it is used here for the purpose of 'what if' such events do take effects in Tuvalu.

3.2.2 Sea level scenarios

Similar to climate scenarios, global climate models are not yet in a position to develop/project changes in sea level at a regional scale of direct relevance to Tuvalu. Instead, IPCC have developed a scenario of global seal level change based on greenhouse emission scenarios, IS92a and IS92e for years 2025, 2050 and.2100.

Year	2025	2050	2100
IS92a (best guess)	9.0 cm	20.0 cm	49.0 cm
IS92e (high)	20.0 cm	40.0 cm	94.0 cm

Scenario data obtained from SCENGEN 2.3 (Climate Research Unit).

3.2.3 Environmental and Socio-Economic Scenarios

Base on experience for the last twenty years, a number of environmental and socio- economic changes have taken place in Tuvalu. These changes are expected to continue into the future. The most important ones for Tuvalu are described below.

3.2.4 Population Growth

Three population scenarios have been developed based on the population census 1991 figures and taking into account the 700 Tuvaluans in Nauru who have not been accounted for in the census. The three scenarios are high, medium and low.

Population scenarios

	1991 Census	2026	2050	2100
High	10,110	18,400	26,200	45,500
Medium	10,110	16,000	19,000	21,000
Low	10.110	15,300	17,800	18,300

The current population trend for Tuvalu is following the medium scenario although it is important to know the extremes of population growth in the country.

3.2.5 Population distribution

Internal migration from the outer islands to the capital Funafuti, is increasing. The result of this is that Funafuti has over 40% of the total population giving it a very high population density of 347 people per square kilometre. Government has developed a de-centralisation programme by way of re-distributing the population to Vaitupu. This is occurring through shifting Agriculture and the Education Department headquarters to that island.

3.2.6 Economy

At present, there is a strong traditional subsistence economy, a high dependence on foreign aid and a fast growing cash economy. The future outlook of the economy of Tuvalu is expected to move more towards a strong cash economy through the fast development of the private sector. With the establishment of the Tuvalu Trust Fund and the Falekaupule Trust Fund, it is likely that the high dependence on foreign aid will be relaxed.

3.2.7 Waste and pollution

With the fast population growth, limited land available for development, change in food preferences and economic changes, there is a growing waste and pollution problem in Tuvalu particularly on Funafuti. The Environment Unit and the Funafuti Kaupule, are closely working with the South Pacific Regional Environment Programme (SPREP) and other organizations like AUSAID to try and address the problem of waste and pollution.

3.2.8 Inundation and Flooding

Scenario IS92a gives a range of 0.2 – 0.4 m sea level rise by the year 2050. This level of sea water will not cause inundation to most islands in Tuvalu but is expected to raise the water table by 0.5 m equal to the height of Funafuti International Airport.

A sea level rise of 1 m as predicted in scenario IS92e by the year 2100 will not only put parts of Tuvalu under water but gives the country multiple risks like salt water intrusion to the man-made talo pits and the underground water system, there will be high loses of crop yields (*Cyrtosperma* and *Talo*).

There will be a high risk of waves overtopping the islands ruining the settlements as they pass through resulting to damage to the land ecosystems.

The risk of damage from cyclones is expected to increase as well as the frequency and intensity of the cyclones.

3.2.9 Erosion

Base on all the above scenarios, the risk of coastal erosion will increase given that there will be a relative increase in the frequency, and severity of cyclones in Tuvalu. Above all, there is still a need for a better understanding on the coastal erosion processes and areas of high risk from erosion around Tuvalu as well as information on the possible significance of sea level rise.

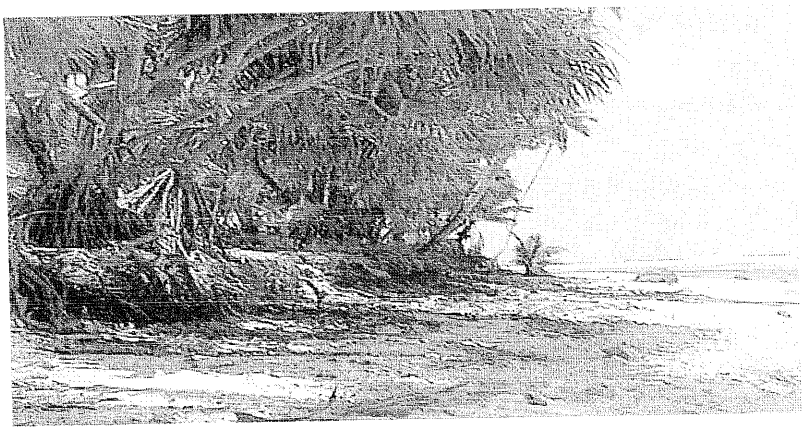

Photo 7: Impact of coastal erosion - Niutao

3.2.10 Coral Reefs

Coral reefs survive well in sea surface temperatures ranging from 25-29 degrees Celcius. The current situation in Tuvalu is that we have reached our upper limit of tolerance and it seems that at any time we will face coral reef bleaching, a problem that is already spreading in the Pacific region. Given also the estimated average reef growth rates in Tuvalu of approximately 2mm/year which is rather slow , this growth rate will not stand the sea level rise problem given the range of uncertainty in global sea level rise of (2-9 mm/year).

The question is whether the current potential of our coral reefs can tolerate the combined effect of sea level rise, sea surface temperature and increase in CO_2 concentrations in sea water or not. This is an area for future research work in Tuvalu especially in the area of coral reefs

3.2.11 Subsistent Agriculture

There will be significant yield reductions for pulaka and coconuts if scenario 1 of warmer and drier climatic conditions become true.

On the one hand if conditions become warmer and wetter as already predicted in scenario 2, then subsistent agriculture will increase in total yields. However, pulaka pits will face a problem of salt - water intrusion as they are dug down to the water lens which will result in yield reduction for the pulaka.

Drought will be more frequent causing low yields. Similarly, a rise in mean sea level rise will shorten the return period of damaging cyclones events eg increased frequency.

3.2.12 Human Health and Well – Being.

The present climate conditions in Tuvalu favour conditions for dengue fever and cholera and the breeding of the mosquito vector.If scenario 1 prevails, then the mosquito is expected to increase in numbers and the extrinsic incubation period (EIP) will decrease and there will be a rise in epidemic potential. This means that epidemic outbreaks could spread faster at higher rates of infection and be sustained through availability of the vector.

The risk of dengue fever is also expected to increase through an increase in breeding sites of the vector mosquitoes which is associated with higher rainfalls. The frequency of virus introductions is expected to increase.

3.3 EFFECT OF ENVIRONMENTAL AND SOCIO-ECONOMIC CHANGES

In the absence of climate change, effects of environmental and socio-economic changes have taken adverse effects in Tuvalu and will continue into the future. In this section we will be considering the effects of environmental and socio-economic changes with respect to scenarios identified in the earlier sections.

3.3.1 Coastal and Marine Systems

Population increases and central migration to Funafuti is expected to increase the demand for land. This would worsen the effects of inundation, flooding and erosion. Besides, non-climatic stresses like increase population pressure, over-exploitation of both land and sea resources, and increased solid waste pollution will add to the future climatic stresses in the coral ecosystems which in turn will add on to the problem of inundation, flooding and erosion.

3.3.2 Subsistent Agriculture

Increased population especially on Funafuti and Vaitupu has reduced available land for subsistence agriculture and this effect is expected to worsen.

Although production loss is at present compensated at great expense by increased intake of imported food, this situation will worsen given the likely adverse impacts of climate change and sea level rise.

3.3.3 Water Supply

As population increases the demand for water will also increase. This calls for additional water storage systems to be constructed and local wells to be carefully protected.

Under drought conditions, the water situation will be worsen and that there will be a shortage of drinking water. The quality of that water will be greatly declined.

Another problem associated with the water is the pollution of underground water sources from waste (liquid and solid) which will have adverse impact on the quality of limited underground water.

CHAPTER FOUR

POLICIES AND MEASURES

4.1 Policies

The overriding goal for Government is to :-

" *provide an environment, based on existing culture(s), within which the people of Tuvalu can strive to attain the highest possible standard of living*".

The standing government policy is that for all new or ongoing programmes, government or private owned, an environment impact assessment (EIA) has to be conducted.
This standing policy is now encouraged by the Environment Unit on all projects with a long term view as to sustaining the clean environment of Tuvalu.
In developing climate change programmes, a need for a comprehensive and consistent set of policies to support such programmes is a priority.
The focus of the government in the next few months is to look into the above and to have a set of policies established before any new programmes can be developed.
The following are possible measures under climate change that are being considered by the government for implementation beyond the year 2000.

4.1.1 Adaptation

Government will be looking at developing a list of proposed projects based on the vulnerability and adaptation study for Tuvalu conducted in 1999.
Other areas that will be looked at and perhaps considered for a project follow up are the gabs identified in phase one of the climate change programme implemented under the SPREP Pacific Islands Climate Change Assistant Programme (PICCAP).

4.1.2 Education and awareness

This a priority area in Tuvalu. Within the framework of education, there has been work done both in primary and secondary schools under the " Education for Life" programme where climate change issues have been incorporated into the schools curricula.
At tertiary level, the University of the South Pacific (USP) has taken up core courses on environment studies including a postgraduate course on vulnerability and adaptation.
In term of public awareness, a strong position has been taken by the government and communities through participatory radio programmes (interviews), leaflet production, essay competitions, poster competitions, national workshops and visits to outer islands to promote education and awareness on climate change and sea level rise.

4.1.3 Renewable Energy

The Tuvalu Solar Electric Cooperative Society (TSECS) is currently boosting the use of photo-voltaic renewable energy on all the islands.
From a total of 1,615 households on the outer-islands, 402 households are using photo-voltaic as a source of lighting. The remaining 567 households still using kerosene as a source of fuel for lighting will be slowly electrified with solar lighting systems beginning in the year 2000. The plan is to have the first 30% households provided with solar lighting by the year 2003. A further 35 % of households will access solar lighting by 2006 with the remaining 35 % to be completed by the year 2010.
This is a long term plan and requires some financial support from the government to achieve.

4.2 SECTORAL MEASURES

4.2.1 Agriculture

The main greenhouse gas emitted from this sector are CO_2, N_2O, and CH_4.
Some of the measures the agricultural department is encouraging on the islands to reduce GHG emissions are :-

- To ban burning of twigs, branches etc when clearing land
- To reduce to the minimum the importation and use of chemical fertilizers
- To encourage the use of organic fertilizer
- To promote a mix farming system (agroforestry)
- To look for alternative uses of pig's waste
- To promote management of culturally important native trees
- To encourage the planting of fast growing local trees for provision of fuel-wood
- To promote proper production of charcoal for use as fuel-wood in cooking

4.2.2 Transport

Sea transport between the islands and air transportation internationally are the two major constraints.
At an inter-island level, a faster ferry boat with low costs is envisaged. This will ease off the time taken for sea travel between the islands.
For international air transportation, the government has made negotiations with recognized air transport services from Fiji for a better air service link between Tuvalu and that country.

For the last two decades, the Tuvalu economy has relied very much on foreign aid money.A strong commitment was made by government in the 1980's through the establishment of the Tuvalu Trust Fund (TTF) to relax the above problem. The proposed measures to strengthen the economy beyond the year 2000 are as follow :-

- Strengthen the TTF capital base
- Strengthen the FTF for outer islands
- Impose high fees on foreign fishing vessel fishing in Tuvalu EEZ waters
- Invest more into the development of the private sector
- Corporatisation of certain government sectors to operate on their own
- Invest in potential dealings like sales of Tuvalu "TV" line
- Partnership with reliable commercial fishing firms from overseas

4.2.4 Land use and forestry

The importation and use of chemical fertilizers is no longer encouraged by the Agricultural Department. Instead, the use of organic fertilizer is promoted for the cultivation of food crops. Mix farming (agroforestry) where planting of potential compost trees, fuel-wood trees, winds breaks, shoreline protective trees and food crops is now encouraged on all the islands instead of mono-cropping coconuts as was the practice in the past.

4.2.5 Waste

To relax the problem of waste on Funafuti, government is encouraging the recycling of aluminium cans, waste oil and organic waste. Other forms of waste will be properly be disposed at the recommended waste sites. High importation duties are imposed on reconditioned vehicles to reduce the high rates of importation of second hand vehicles.
Reduction of waste volume through the establishment of legislation and identifying waste sites is also encouraged.

Photo 8: Mix farming practised on the islet – Funafuti

CHAPTER FIVE

5. FUTURE DIRECTIONS

This means that to ensure good quality of life for its people, Tuvalu needs to keep planning and focusing on To meet the challenges presented by climate change and development, Tuvalu needs to focus on the gaps in information and constraints identified in this document.

5.1 Information lacking for appropriate adaptation and management

Most of the predicted changes relating to climate change and sea level rise are derived from global models which have low resolution, large ranges of possible effects and sometimes providing conflicting possible outcomes. In short, it is not really clear what the changes for Tuvalu might be. For management and adaptation measures to be effective, they need to be based on models which are relevant and as accurate as possible. There is an urgent need for modelling which is focused on the Pacific Regional and which can give climate change predictions at the scale of individual countries.

At the national level, it is important that the arrangements for updating the GHG inventory are maintained and that vulnerability and assessment studies are regularly up-dated. In addition, existing programmes for monitoring changes in climate and sea level need to be supported and the data they collect compared with predictions. These mechanisms are required to ensure that the steps being taken are adjusted and remain effective in the contex of improvements in modelling, a global reduction in emissions and actual changes in climate and sea level.

5.2 Improving interactions between humans and their environments

Living with climate change is also about dealing with day-to-day environmental integrity. As discussed above, nearly all of the expected impacts of climate change are exacerbated by poor environment practices. This implies that healthy ecosystems are resilient ones, and that good policies and management practices introduced now, will lead to the best outcomes in the face of climate change. The issues are inseparabledevelopments that improve the country not only economically, socially and culturally, but also environmentally. Further, to ensure that the outcomes of climate change come as no surprise and that appropriate adaptations are made, it will be necessary to integrate climate change into national planning.

5.3 Initiatives needed to address issues of climate change and resilience

New initiatives are required to refine predictions, assess the present and future resilience of the country to climate change and other impacts, improve planning and management, and to minimise impacts. The projects needed fall into three categories. These are research, education and capacity-building and improvements in practices and technology.

5.3.1 Research

- Climate and sea level modelling specific to Tuvalu
- Study on the human carrying capacity of each of the islands to determine the size of human population that can live sustainably on each island given different development scenarios
- Determination of sustainable yields of living resources (e.g. reef, pelagic and deepwater fisheries, trees)
- Study to determine the present and predicted future requirements for non-living resources (sand, gravel, water) so that appropriate sources can be located that do not conflict with the need to maintain ecosystems in the face of climate change.
- Feasibility study (and subsequent implementation) on an appropriate system for the disposal(recycling) of sewage on all the islands, but particularly on the most populated islands of Funafuti and Vaitupu
- Rate of coral growth and sand production and the ability of coral reefs and islands to keep up wit sea level rise

5.3.2 Education and capacity building

- Appointment and training of a dedicated public educator who would work with the Department of Education, in schools, the media and with the public to improve cultural attitudes to the environment and clarify misconceptions
- Education in schools and public awareness of the issues relating to climate change and the strategies which will improve Tuvalu's prognosis
- Capacity building for environmental management in the country (e.g. Environment Unit and other sectors0

5.3.3 Improved practices

- ***Water.*** Protection of useable (fresh) groundwater resources and an increase in the catchment of rainwater
- ***Conservation.*** Development of the existing Funafuti Conservation Area into a representative network of conservation area with at least one on each of the nine islands, and with improved public awareness and enforcement
- ***Population.*** Development of a national population strategy in relation to the supportive capacity of the environment and the expected impacts of climate change
- ***Agriculture.*** Improvements in subsistence agriculture, methods of food production and handling which result in fewer environmental impacts
- ***Coastal protection***. Improvements in the management of coastal subject to

erosion with a shift towards restoration of the original ecosystems rather than seawalls and other structures

- ***Energy***. Real options for renewable energy area

Photo 9: Alofa – Tradition way of presenting gifts.

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Appendix 1: NATIONAL CIRCUMSTANCES (1994)

INDICATOR	QUANTITIES
Population (estimate value)	9391
Area size (sq km)	26
Gross Domestic Product (US $m)	15.6
GDP per capita (AUS$)	1676.2
Estimated share of informal sector in GDP	
Employment in informal sector (million)	NA
Employment in formal sector (million)	NA
Share of industry in GDP	1109.1
Share of services in GDP	1119.2
Share of Agriculture in GDP	3512.3
Land area used for agricultural purposes (ha)	NA
Land area under forest (ha)	NA
Urban population as % of total population	40
Livestock population	
Pig ('000)	54
Poultry ('000)	114
Population in absolute poverty (%)	0
Life expectancy (yrs)	67
Literacy (%)	98

Appendix 2: - Tuvalu Summary of Emmision

	Year	Gg								
		CO_2	CH_4	N_2O	Nox	CO	NMVO	HFCs	PFCs	SF6
Energy										
Energy sources	1994	4.650	0	0	0	0	0	0	0	0
Traditonal biomass burned for fuel	1994	0.000	2.34E-07	1.93E-09	6.97E-08	2.45E-05	0	0	0	0
Coal Mining and handling	1994	0.000	0	0	0	0	0	0	0	0
Oill and Gas Activities	1994	0.000	0	0	0	0	0	0	0	
Total for Energy		4.650	2.34E-07	1.93E-09	6.97E-08	2.45E-05	0.000	0.000	0.000	0.000
Industrial Process										
Cement Production	1994	0.000	0	0	0	0	0	0	0	0
Total for Industrial Process		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Solvent and Other Product Use	1994	na								
Agriculture										
Domestic livestock enteric fermentation and manure management	1994	0.000	4.32E-02	1.56923E-05	0	0	0	0	0	0
Flooded Rice Fields	1994	0	0	0	0	0	0	0	0	0
Burning of Savannas	1994	0	0	0	0	0	0	0	0	0
Field burning of Agriculture residues	1994	0	0	0	0	0	0	0	0	0
Total for Agriculture		0.000	0.043E-02	1.56923E-05	0	0	0	0.000	0.000	0.000
Lan d Use Change & Forestry										
Chang e in forest and other woody biomass stock	1994	0	0	0	0	0	0	0	0	0
Forest and Grassland conversion	1994	0	0	0	0	0	0	0	0	0
Onsite burning of forest	1994	0	0	0	0	0	0	0	0	0
Abandonment of managed land	1994	0	0	0	0	0	0	0	0	0
Total for Land Use Change & Forest		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000