Tuvalu's National Adaptation Programme of Action

Under the auspices of the United Nations Framework Convention on Climate Change

Ministry of Natural Resources, Environment, Agriculture and Lands.
Department of Environment

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The photos in the front-cover shows:

1 The western coast of Funafuti battered by overtopping waves from the lagoon driven by strong winds from a depression over Tuvalu. It highlights the direct impacts of the wave and wind disturbances on the coast, plant and lands. *Courtesy of Peter McQuarrie.*

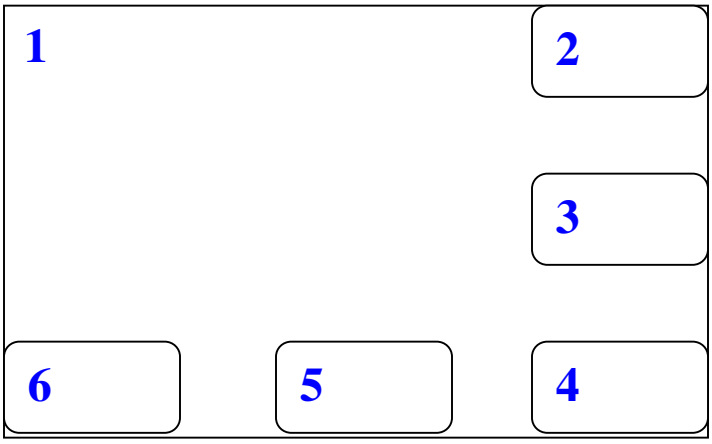
2 The collapse of a coastal seawall leading to the surface intrusion of saltwater on TAFEGA, Nanumea.

3 The ground-surface channel created by the saltwater intrusion and flow starting from the collapsed seawall.

4 The total direct impact of saltwater intrusion on terrestrial ecosystems of low-lying islands of Tuvalu. A total loss of coconut trees and the land degraded to a level where only salt-tolerant trees could grow. Therefore, transforming productive lands into non-productive land.

5 The changed land conditions resulting from the saltwater intrusion enhanced growth of salt-tolerant trees, making the land less productive.

6 Kids swimming in the Funafuti lagoon. These are the generation that will face the worst direct impacts of climate change and sea level rise. They need to decide, *'adapt or swim'*.



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Foreword

The Government of Tuvalu (GOT) signed the United Nations Framework Convention on Climate Change (UNFCCC) on the 8th of June 1992. Recognizing Tuvalu's environmental concerns due to threats caused by climate change, especially the adverse impacts of droughts, saltwater intrusion and Coastal Erosion on the livelihood of the people. Tuvalu developed the National Environmental Management Strategies (NEMS) in 1997 to assist on Tuvalu's efforts to achieve sustainable Development, and later in 2005, TE KAKEEGA II 2005-2015 National Strategy for Sustainable Development.

Currently, Tuvalu has developed policies and strategies in its Kakeega II to stimulate economic growth and stability. This is being done through structural reforms in the public sector, including efficiency improvements, further cost cutting, and focusing on activities that are core-functions and which have high rates of returns that are key strategies in the short and medium-term.

With Tuvalu's limited natural resource base, widely scattered and sparsely populated islands which rarely exceeds 3 metres above mean sea level, a small domestic market with little potential for economies of scale, isolation from international markets and smallness in size shows that Tuvalu is highly vulnerable to the adverse impacts of climate change and extreme weather events. This situation is exacerbated by increasing poverty of opportunities among rural communities, increasing population pressure on a limited land and marine resource base, land degradation arising from coastal erosion and saltwater intrusion, increasing deforestation to meet the increasing demands for construction purposes, and increasing incidences of drought.

The increasing frequency of natural disasters due to climate change, has led to the loss of human, natural, financial, social and physical capital. These are major concerns to the Government of Tuvalu in its strive to ensure sustainable living standards for its people. The sectoral threat posed by extreme climatic events is the driving force for the development of Tuvalu's National Adaptation Programme of Action (NAPA).

The Tuvalu NAPA has been prepared with the primary objective of identifying and promoting activities that address urgent and immediate needs of Tuvaluan stakeholders' for adapting to the adverse impacts of climate change among communities on vulnerable islands of the country. The primary aim will focus initially on the adaptation needs in the agriculture, water, fisheries, land, disaster, and human health sectors.

Tuvalu, in its status as a Least Developed Country, has the pleasure to submit this Tuvalu NAPA to the United Nations Framework Convention on Climate Change (UNFCCC) for funding, realizing the urgency therein of communitys' identified priority adaptation needs, and the importance of addressing adverse impacts of climate change on vulnerable islands of Tuvalu. It is my sincere hope that bi-lateral and other donor countries will assist Tuvalu to implement its identified priority adaptation needs with the urgency that each priority deserves.

Honourable Tavau Teii
DEPUTY PRIME MINISTER AND MINISTER OF NATURAL RESOURCES AND ENVIRONMENT.

Executive Summary

Tuvalu is one of the most vocal country in the world at the international arena for a solution to the global issue of climate change and how it will affect low-lying countries like Tuvalu. Dependence on natural resources, inadequate infrastructure and human resources, low economic base and social development, and lack of institutional capacity make Tuvalu more vulnerable to adverse impacts of climate change, variability and extreme events.

The National Adaptation Programme of Action (NAPA) for Tuvalu, prepared initially under the Office of the Prime Minister (OPM), and completed under the Ministry of Natural Resources and Environment, is the Government of Tuvalu's response to COP 7 decisions. It is also an opportunity for Tuvalu to communicate its priority activities to address urgent and immediate needs of Falekaupule and stakeholders' in Tuvalu for adaptation to adverse effects of climate change. The basic approach for the Tuvalu NAPA preparation is to be in line with the development aspirations of the government of Tuvalu as stipulated in "*Te Kakeega II National Strategy for Sustainable Development 2005 - 2015*". This is framed around the Millennium Development Goals (MDGs), the national sustainable development goals embodied in the *Malefatuga Declaration*, sector plans, other multilateral environmental agreements, the challenges Tuvalu is facing at present, and those that the nation will face in the coming future. Since climate change will directly impacts Tuvaluan communities, families and individuals, it is important that different stakeholders' at every level of society is engaged as part of the NAPA preparation process in the selection of adaptation measures and ranking of project activities.

The enumerated population of Tuvalu is 9,359 (Census 2002). The average population growth for the resident population is 0.6% from 1991-2002. About 42% of the enumerated population resides on Funafuti - the capital and only urban center of Tuvalu. It also has the highest population density of 1,610 as compared to the outer islands population density of 222 people per km^2. Internal migration is high due to increasing changes in lifestyle and dependence on imported foods.

Stakeholders' pointed out during the NAPA stakeholders' consultation that coastal erosion is a major problem; and for some families; lands have been lost as a consequence. Flooding, inundation and salinity intrusion especially into pulaka pits, shortage of potable water, destruction to primary sources of food and increasing frequency of natural disasters are other problems attributed to climate change, variability and extreme events. However, the problems are not limited to this list. Flooding and inundation provide suitable medium for vector breeding, and salinity intrusion enhanced by the porosity of soil in Tuvalu destroy pulaka crops and decrease fruit trees' yields of coconut, banana and breadfruit – a major concern to food security. Increasing number of low rainfall days, prolonged droughts, high extreme temperature and evaporation are major problems for the agriculture and water sector, especially for the densely populated areas (Funafuti) and islands closer to the equator (northern islands). The frequency of extreme events like cyclones, storms and surges are increasing and exacerbating climate risks.

It is envisaged that the above adverse effects of climate change, variability and extreme events noted by stakeholders' will be disparaging to the development of Tuvalu, unless they are effectively addressed. The most damaging effects of climate change are tropical cyclones, coastal erosion, salinity intrusion and drought. These have been noted to affect crops, fruit trees and human livelihood. The current challenges (as listed below) that stakeholders are facing at present are exacerbated by climate change:

i) Coastal erosion, saltwater intrusion and increasing vector and water borne diseases due to sea level rise;
ii) Inadequate potable water due to less rainfall and prolonged droughts;
iii) Pulaka pit salinisation due to saltwater intrusion; and
iv) Decreasing fisheries population.

The severity of the impacts of climate change on communities is identical on all islands since sources of staple food and village locations are similar. Furthermore, sources of subsistence food production (agriculture and fisheries) are both severely impacted by climate change, variability and extreme events. Therefore, food security will be at risk in the future.

Adaptation measures are required to enhance community livelihood and promote sustainable development by reducing adverse effects of climate change, variability and extreme events. These adaptation measures are selected from stakeholders' and sector expert suggestions, and must be based on the ability of stakeholders' and sectors concerned to easily implement adaptation measures to limit adverse circumstances of climate change. Some adaptation measures have already been undertaken in Tuvalu at community level on some islands such as coastal protection and increasing household water storage facilities. These have shown some successes on some islands and failures on others. Future climate change challenges are complex. Therefore, suggested approaches and technologies acceptable to Falekaupule and communities concerned are mostly required.

The NAPA understands that adaptation measures will relatively reduce severity of adverse impacts of climate change, but it will not absolutely solve existing problems. To this end the NAPA has selected the following adaptation projects listed in table below:

Project No.	**Project Title**
1	**Coastal**: *Increasing resilience of Coastal Areas and Settlement to climate change.*
2	**Agricultural**: *Increasing subsistence pit grown pulaka productivity through introduction of a salt-tolerant pulaka species.*
3	**Water**: *Adaptation to frequent water shortages through increasing household water capacity, water collection accessories, and water conservation techniques.*
4	Health: *Strengthening of Community health through control of vector borne/climate sensitive diseases and promotion access to quality potable water.*
5	**Fisheries**: *Strengthening of Community Based Conservation Programmes on Highly Vulnerable near-shore Marine Ecosystems.*
6	**Fisheries**: *Adaptation to Near-Shore Coastal Shellfish Fisheries Resources and Coral Reef Ecosystem Productivity.*
7	**Disaster**: *Strengthening Community Disaster Preparedness and Response Potential.*

Acronyms and Abbreviations

ADB	Asian Development Bank
DCC	Development Coordinating Committee
DoA	Department of Agriculture
DoE	Department of Environment
DoLS	Department of Lands and Survey
ENSO	El Niño Southern Oscillation
FTF	Falekaupule Trust Fund
GDP	Gross Domestic Product
NAPA	National Adaptation Programme of Action
NGO	Non-Governmental Organisation
LDC	Least Develop Countries
LEG	Least Developed Countries Expert Group
MDG	Millennium Development Goal
MNR	Ministry of Natural Resources
NIWA	National Institute of Water and Atmospheric Research
NSSD	National Strategy on Sustainable Development
OPM	Office of the Prime Minister
PWD	Public Works Department
SOPAC	South Pacific Geo-Science Applied Commission
SPREP	Secretariat of the Pacific Regional Environment Programme
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change

Glossary of Terms

Pulaka	A giant tuber plant like a taro. It corm is used as starchy food – rich in calcium.
El Niño	A climatic phenomenon resulting in erratic rainfall in the Pacific Ocean.
Extirpation	A local extinction.
Falekaupule	The Falekaupule is the traditional assembly (local government) on each island.
Motufoua	The only Government funded secondary school in Tuvalu.
Tuvalu	Tuvalu means "Eight" referring to islands standing together.
La Niña	The opposite of El Niño.
Nanumea	An atoll and northern-most island in the Tuvalu group.
Nanumaga	A table-reef island closest to Nanumea from the south.
Niutao	A table-reef island to the south of Nanumaga.
Nui	An atoll island to the south of Niutao.
Vaitupu	The only composite island closest to Nukufetau.
Nukufetau	An atoll island to the south of Vaitupu.
Funafuti	An atoll island and capital of Tuvalu.
Nukulaelae	An atoll island to the south of Funafuti.
Niulakita	A table-reef island most south island of Tuvalu.
Fogafale	The main settlement of Funafuti.
Kakeega II	The second National Sustainable Development Strategy for Tuvalu 2005 - 2015.
Vaiaku Lagi Hotel	The only and main government hotel on Funafuti.
Nauti Primary	The only government owned primary school on Funafuti.
Kaupule	The executives arm of the Falekaupule.
Pulefenua	The Island Headman
Pule o Kaupule	Te chairman of the Kaupule
Tokolua o pule o Kaupule	Deputy chairman of the Kaupule.
Aganuu	Customs and traditions of Tuvalu.
Matai	The head of a family clan
Sina o Fenua	A grouping of men aged 50 years and over.
Tepukasavilivili	An islet (motu) of Funafuti.
Tafega	A saline intruded area on the Northeastern side of the island of Nanumea.
Tau-o-lalo	The period (usually October to March annually) where the wind predominantly blows from the west (westerly season).
Amatuku	An islet of Funafuti where the first mission school was build. The Tuvalu Maritime School was established on this islet in 1979.

1.0 Introduction and Setting

The Tuvalu National Adaptation Programme of Action (NAPA) is based upon existing environmental information, reports and expert judgments, understanding gathered from community consultations and climate change awareness raising with each Island Falekaupule, and the national NAPA prioritization workshop on Funafuti. In the course of the Tuvalu NAPA development process, it has become clear that climate change will intensify existing environmental problems in Tuvalu – and natural hazards. For some existing environmental problems in Tuvalu; coping mechanisms have been developed. All new coping mechanisms under the NAPA are linked to the urgency and immediacy of the problem, and should be complimentary to the Kakeega II development process. Thus, the NAPA coping mechanisms are not totally foreign adaptation activities.

The NAPA follows the 10 guiding elements as stipulated under Section D paragraph 7 a) to j) of the LDC Expert Group (LEG) annotated NAPA guidelines. Generally, these guiding elements guide the Tuvalu's NAPA development process as stated below:

a) **Community participatory approach:** The community participatory approach is where the participation of the Falekaupule and local communities including men, women, youth and individuals at the grassroots levels, who are equitably vulnerable to the impacts of climate change. The NAPA Island and Falekaupule consultation on each of the islands ensured that all the views from the grassroots, individual communities and groupings and the general Falekaupule were included in the NAPA process, and most importantly, on how to best address the problem based on stakeholders' observation and traditional expertise. The main social groups targeted on each of the islands were the Falekaupule (the islands' decision making council men aged 50 yrs and above), the Kaupule (the executive arm of the Falekaupule), the island women (women aged 18 yrs and above) and the youths (all men and women aged between 18 to 49 yrs). The consultation was also open to interested parties and Non-governmental Organizations (NGOs).

b) **Consensus Approach**: The Falekaupule is the decision making body on the Islands and is the key factor in achieving peace, stability, development and sustainable livelihood of individuals, families and communities on the Islands. It is a valuable social security system that provides cohesion in the community. The consensus approach guided the identification, selection, prioritization and the ranking of the key adaptation activities for NAPA.

c) **Multidisciplinary Approach:** The Tuvalu NAPA composed of a multidisciplinary Team consisting of members from major government departments, various NGOs, church organizations and civil society. The team that consulted the island communities was selected from this multidisciplinary team. The National NAPA workshop was convened on Funafuti to enable stakeholders and the NAPA multidisciplinary team to prioritize and rank the final list of potential adaptation options.

d) **Complementary Approach at all levels of Community:** The Tuvalu NAPA is the product of the NAPA bottom-up participatory process where comprehensive knowledge and stakeholders' involvement were important, including the current national development plan "Te Kakeega II" National Strategies for Sustainable Development (NSSD), Sectoral Reports and Social Policies. The Tuvalu NAPA is not an independent document on its own. It complements existing national plans, programmes and policies of Tuvalu.

e) **Sustainable development:** Discussions with stakeholders during the NSSD (key sectors for national development), and later, during the NAPA island consultation (key sectors impacted by climate change) helped identify and prioritize (according to nationally agreed criteria) suitable adaptation activities. The NSSD resulted in the formulation of "Te Kakeega II" National Strategies for Sustainable Development 2005-2015, and the NAPA is building links with key sectors (suggested by stakeholders to be impacted by climate change) policy objectives of the Kakeega II. This will enhance key sectors to integrate climate change impacts into respective sectoral plans; thus, mainstreaming climate change into national plans and

policies that support sustainable development. For instance, one of the key policy objectives of the Agricultural sector in the Kakeega II is to "*Reverse the decline in subsistence agricultural production*". This declining trend is generally due to the increasing salinity of groundwater and the increasing stakeholders' preference for the cash economy. The NAPA would enhance planting of salt-tolerant and highly marketable crops to increase family income.

f) **Gender equality:** The selection of participation to the NAPA consultation on each of the island and for the national stakeholders' workshop on Funafuti, was carefully monitored, to give a generational and gender balance representation. This was also reflected in the earlier NSSD consultation on Funafuti.

g) **Country-drivenness:** The NAPA consultation is not the first of its kind to go out to get information from communities and civil societies of Tuvalu with respect to their urgent needs on any issue (for NAPA – adaptation to climate change). The bottom-up and participatory approach used for the NAPA consultation, and the inclusion of stakeholders' views in the selection and ranking of project activities, including consensus agreement between stakeholders', are examples of the country-drivenness of the NAPA development process.

h) **Sound Environmental Management:** Sound environmental management in Tuvalu is becoming more important. Without it, environmental degradation will directly affects people's livelihood. Tuvaluans depend largely on natural resources for food. Furthermore, they have observed adverse impacts of climate change on coral reef fisheries resources and terrestrial food crops and trees. Sound Environmental Management of fisheries through conservation areas established on all islands will allow ample time for fisheries population to adapt to changes in climate and variability. This will also enhance the resilience of island communities to adverse impacts of climate change.

i) **Cost-effectiveness:** The NAPA development process is mindful that project activities falls within the context of sustainable development, thus, taking into consideration the feasibility, costs, ownership, lessons learnt from past and ongoing national projects and individual Kaupule programmes. For instance, stakeholders' ownership of the project should be promoted because without stakeholders' ownership of the adaptation project activity, project maintenance will never be part of respective Kaupule budgets, and therefore, the adaptation project will be short-lived and unsustainable.

j) **Simplicity:** The NAPA development process was build upon simplicity in implementing adaptation activities, where adaptation activities are those suggested by stakeholders, and falls within the capacity of local experts to successfully implement and complete project activities.

The basic approach for the Tuvalu NAPA preparation is to be in line with the development aspirations of the government of Tuvalu in "Te Kakeega II"; which was framed around the Millennium Development Goals (MDGs); the challenges Tuvalu is facing at present, and those that the nation will face in the coming future (Te Kakeega II 2005). The national commitment to achieve the MDGs is embodied in the *Malefatuga* Declaration. From the eight strategic areas of the declaration, there are four policy objectives which link directly to NAPA interventions as listed below:

- Improving the quality of life for every Tuvaluan;
- Providing enabling environment for employment and private sector development;
- Strengthening human capacity; and
- Ensuring sustainable management and conservation of Tuvalu's natural resources and protection of the environment.

The Tuvalu National Adaptation Programme of Action was prepared and coordinated initially under the Office of the Prime Minister (OPM) and completed under the Ministry of Natural Resources (MNR). It is executed by

the Department of Environment through the NAPA multi-disciplinary Team that overlooks its development. The NAPA Multi-disciplinary Team is composed of senior officials from major government departments, Non-Governmental Organizations, religious bodies and civil societies; and is currently headed by the Secretary of the MNR.

The NAPA conducted a countrywide public consultation with stakeholders on all the nine Island Communities of Tuvalu to identify stakeholders' urgent and immediate adaptation needs through:

- Identification of existing problems observed by stakeholders due to climate change, variability, sea level rise and extreme events;
- Identification of local coping strategies to existing problems; and
- Articulation of key adaptation needs based on ideas from stakeholders and sectoral experts.

Information from the synthesis of the Tuvalu vulnerability and adaptation report, initial national communication, including other relevant national reports was pooled to identify critical sectors in Tuvalu impacted by climate change. These critical sectors are also the sectors that the communities and stakeholders suggested are already impacted by climate change. The impacts on these sectors are likely to increase in the future. NAPA observation and stakeholders' suggested damages on these critical sectors, on respective islands, further strengthen the need for adaptation intervention. Some of the most common vulnerabilities stated by stakeholders are listed below:

i. Coastal Erosion and loss of family land is evident on all islands of Tuvalu. Since the majority (more than 90%) of the communities live close to the coast, including important religious infrastructures, coastal erosion is therefore a priority stakeholders' urgent need. Sea level rise, overland flooding, storm surges, tropical cyclones and major hurricanes are the main causes of coastal erosion, including also that destruction on coastal coconut tree plantations. However, anthropogenic causes such as building aggregates excavation and coastal development activities are not exempted. Overland erosion due to heavy rainfall also resulted in sedimentation in central and coastal areas, affecting coastal and lagoon fisheries;

ii. Flooding and inundation in February 2006 becomes the worst ever on Funafuti. It resulted in the evacuation of some families including the call from the Funafuti community for compensation for damages to family pulaka pits due to saltwater intrusion. Other islands are also experiencing flooding and inundation in new areas of their lands. Furthermore, this problem will be exacerbated by climate hazards such as tropical cyclones and storm surges.

iii. Growth in population increases public demands for potable water. Since the main source of potable water for Tuvalu comes from rainwater, the quantity, quality and accessibility to water resources are very important. Vulnerability for the water sector is caused by the lack of household water storage facilities and changes to rainfall patterns due to climate change and variability. Water shortage enhances skin diseases and other health problems.

iv. Destruction to primary sources for Tuvalu subsistence such as terrestrial crops and coastal fisheries is of major concern to the islanders. With respect to crops, the current increasing occurrence of new diseases and pest, including fruit-fly infestation, is attributed to climate change and variability. Furthermore, tropical cyclones, storm surges and coastal flooding destroys coastal coconut plantations. On the other hand, coastal fisheries are affected by the sea surface temperature changes, human intrusion and increasing frequency of extreme events.

v. Climate Hazards such as tropical cyclones, storm surges, droughts, and fires results in damages to individual and community assets. Coastal infrastructures such as Harbours, church buildings, cooperative shopping centers, clinics and dispensaries, tar sealed road (Funafuti only), household properties are all exposed to the destructive forces of extreme events. Past experiences of a storm surge in the early 1990s totally dismantled the Vaitupu multi-million dollar harbour. A fire in 2000 completely obliterated a girl's dormitory and the loss of sixteen lives at Motufoua secondary school. El Niño driven drought of 1997 and declaration of the state of emergencies for two of the Northern Islands (Nanumaga and Niutao), and later declared for Funafuti resulted in the importation of Desalination plants.

The participation of stakeholders and communities is an integral part of the Tuvalu NAPA development process in identifying adverse impacts of climate change on vulnerable sectors; the selection of potential adaptation

measures and ranking of the projects to be included in the NAPA. Gender balance was also encouraged throughout the NAPA development process.

2.0 Background information on Tuvalu:

Tuvalu is an extremely small, isolated atoll island nation, aligned in a northwest-southeast orientation; dispersed within the central Pacific Ocean; and categorized as a Least Develop Country (LDC) due to its relatively low national income; weak human resources; and extreme economic vulnerability to external stresses. Furthermore, it is anticipated that Tuvalu will suffer the greatest from adverse impacts of Climate Change. Catastrophic natural phenomenon in records, and which had devastated Tuvalu occurred in 1891, 1958, 1972 (Taomia, F 1993). These environmental phenomenon are Tropical Hurricanes: the most well documented tropical hurricane in Tuvalu being the 1972 "*Hurricane Bebe*" – where a total collapse of the livelihood of Funafuti residents is recorded; and the livelihood necessities being restored through foreign assistance. Tuvalu is located between 5^0.00'S - 11^0.00'S latitudes and 176^0.00'E to 180^0.00'E longitude. The total land area is specifically 25.9 sq. km. The islands consist of 5 coralline atolls (Nanumea, Nui, Nukufetau, Funafuti, Nukulaelae), and 3 table reef islands (Nanumaga, Niutao, Niulakita) with 1 composite island (Vaitupu).

	Description of destruction
1. Residential Houses	All residential houses were destroyed, except a few concrete community and private buildings without rooftops.
2. Pulaka crop	All pulaka pits covered by seawater from the tidal wave that overtopped the island from the East side thus creating a rubble bank.
3. Trees	More than 90% of the trees were fallen by the strong winds, the remaining few standing trees are leafless.
4. Lives lost	Two, a sign of good community cooperation during disaster.
5. Rock rampant	Formed by tidal wave on eastern side of Funafuti.
6. Ships	Two ships were grounded.

Table 1. Some of the destruction that occurred on Funafuti as a result of the Hurricane BEBE episode.

Tuvalu has a consistently uniform temperature ranging from 26.0 – 32.0^0C, with high humidity and rainfall averaging 2875.9 millimeters per annum from 1942–2005. However, droughts of up to three months and longer had occurred in Tuvalu and had adversely impacted the northern islands due to their low annual rainfalls and closeness to the Equator. On the other hand, the southern island of Niulakita lies within the cyclone belt of the Southwest Pacific. The most recent cyclone that affected the islands of Tuvalu is cyclone Percy in 2005.

2.1. Current characteristics:

2.1.1. Physiographic conditions:

The islands of Tuvalu are alike in physiographic development processes with low-lying land rarely exceeding three meters above mean sea level. The islands are generally coastal in nature, that is, easily affected by coastal processes such as coastal erosion, sea sprays, etc. The coastal area especially, is the area mostly influenced by the sea. On the five atolls, there are two regions of coastal areas: coastal areas adjacent to the open ocean and coastal areas adjacent to the internal and central lagoon.

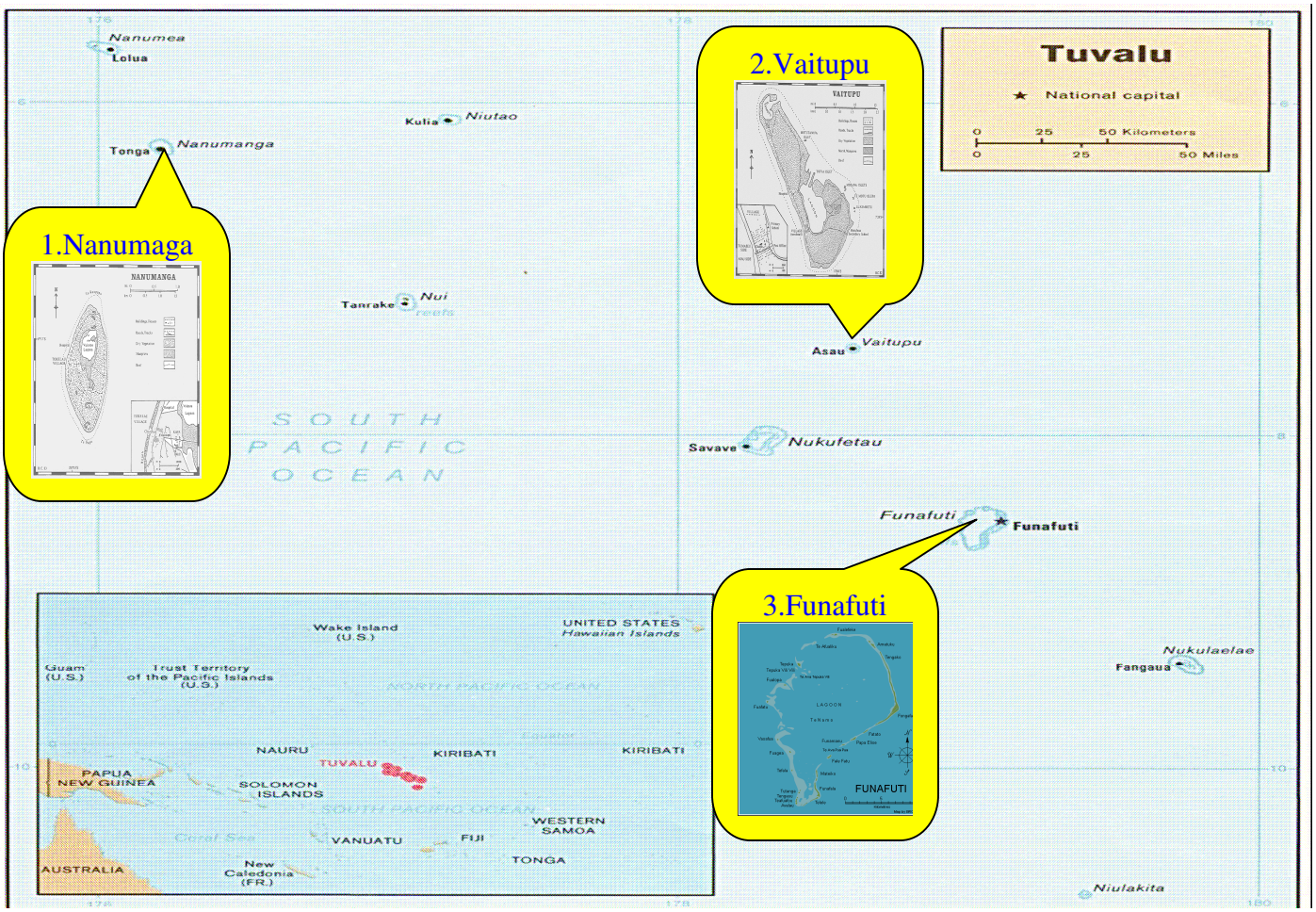


Fig. 1. The map of the nine islands of Tuvalu. *Inset map*: Shows the position of Tuvalu among Regional Countries in the Pacific Ocean. The three highlighted island maps show the three different island types in Tuvalu – 1. *Nanumaga* a Table reef Island, 2. *Vaitupu* a Composite Island and 3. *Funafuti* an Atoll island and capital of Tuvalu. Extracted from http://www.tuvaluislands.com/maps/maps.html

There is no major variation in the land or soil types of the islands of Tuvalu. The soils of the islands of Tuvalu are generally none structured, coarse texture and porous. These are characteristics of an immature and infertile soil, unsuitable for subsistent agriculture.

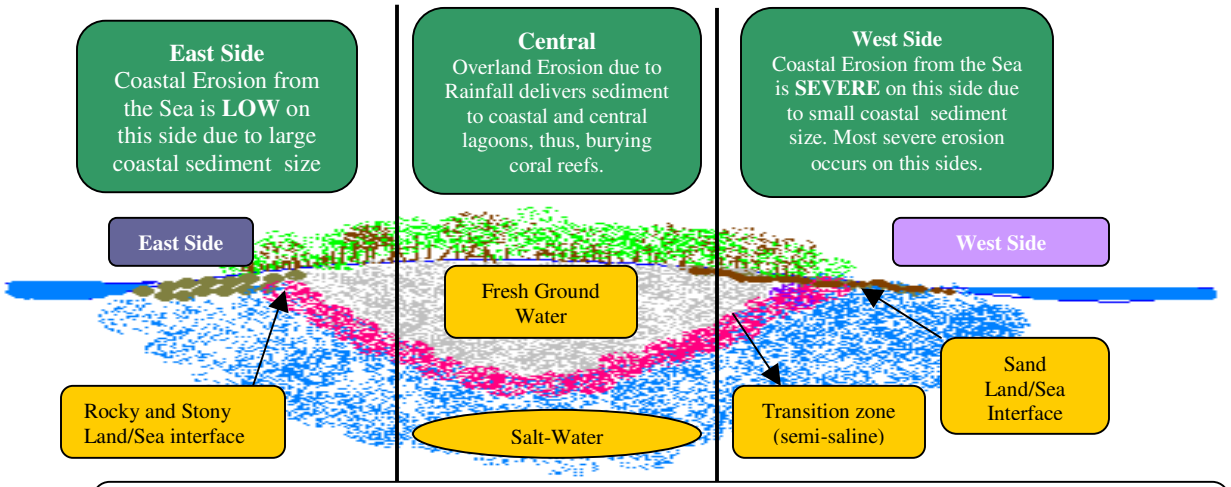


Fig 2. The general Cross-section of Islands in Tuvalu showing sites of Erosion (see above green boxes) from the Sea and Rain, including the Groundwater and Sediment sizes on the Eastern and Western Sides of the Islands. Coastal Erosion is usually severe on sandy shores.

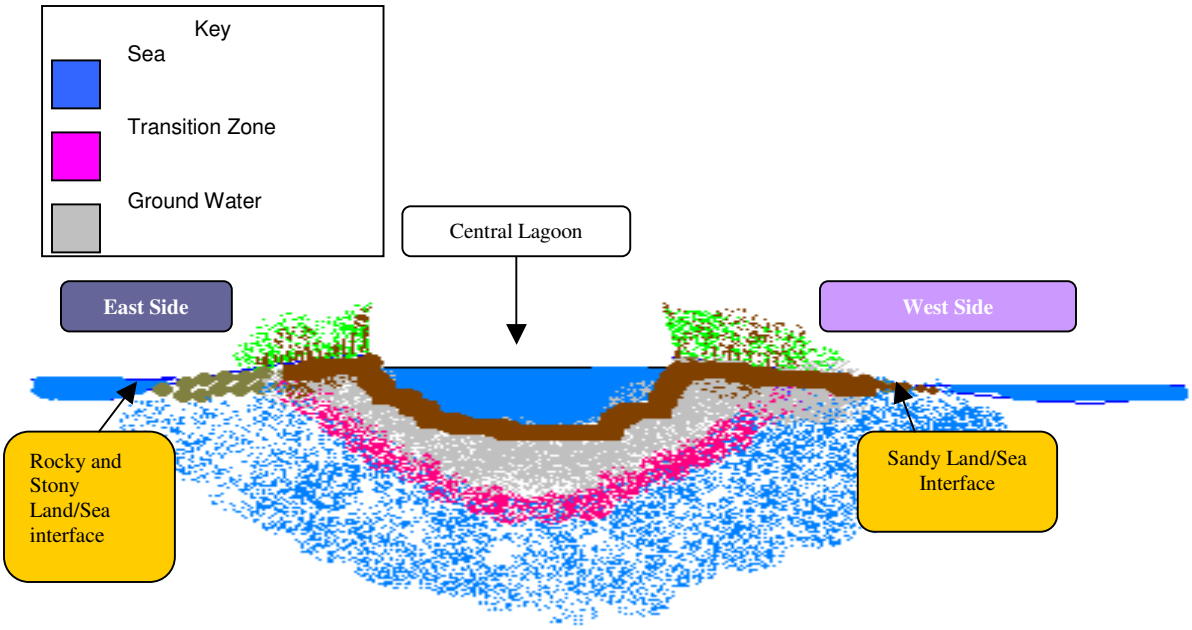


Figure 3. Shows the cross-section of an Atoll Island. Erosion is similar to those occurring on Table reef islands, and in addition, erosion from the lagoon side is an added stress.

Since much of the soil is sandy and acidic; high annual rainfall in combination to soil porosity inhibits efforts to improve soil through the use of fertilizers, and therefore, agricultural production is limited. The main tree crops are coconuts, pandanus, breadfruit and bananas. Pulaka pits were also constructed to allow the cultivation of traditional root crops such as Pulaka (*Cytosperma chamissonis*). However, traditional subsistence agricultural activities and outputs are declining, as the economy becomes more monetarised.

Coastal erosion is mostly severe on coastal areas exposed to the open ocean, most on but not limited to the western sides of the islands. The western coastal areas are also exposed to cyclones, storm surges, saltwater intrusion and coastal inundation. The severity of the coastal erosion depends on the frequency of cyclone force winds that attacks the islands, and coastal currents easily disturb and erode coastal sand sediments.

2.1.2 Demographic situation

The Tuvalu census 2002 recorded a total enumerated population of 9,359 and an annual population growth of 0.6%. The annual real growth in Gross Domestic Product (GDP) averaged 6% per annum, with a high variability from year to year low per capita. This low national population growth was largely the result of a relatively high level of emigration during the inter-census period of 1991-2002, with more than 1,000 residents having left the country rather than entering the country. About 42% of the enumerated population resides on Funafuti - the capital and only urban center of Tuvalu. Funafuti has the highest population density of 1,610 as compared to the outer islands population density of 222 people per km^2. The inter-census birth rate declined slightly from about 251 births per year during the period 1992–1997, to 241 during the period 1997-2002. However, the total fertility rate increased from 3.6 for the period 1992-1997 to about 3.8 for the period 1997-2002. Internal migration is high due to increasing changes in lifestyle and dependence on imported foods. This has led to the high population density on Funafuti. The future assumptions of the population of Tuvalu by 2100 are disclosed in Table 2 below.

	1991	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

Table2. Future population projections for Tuvalu for 2026, 2050 and 2100. Adapted from the V&A report

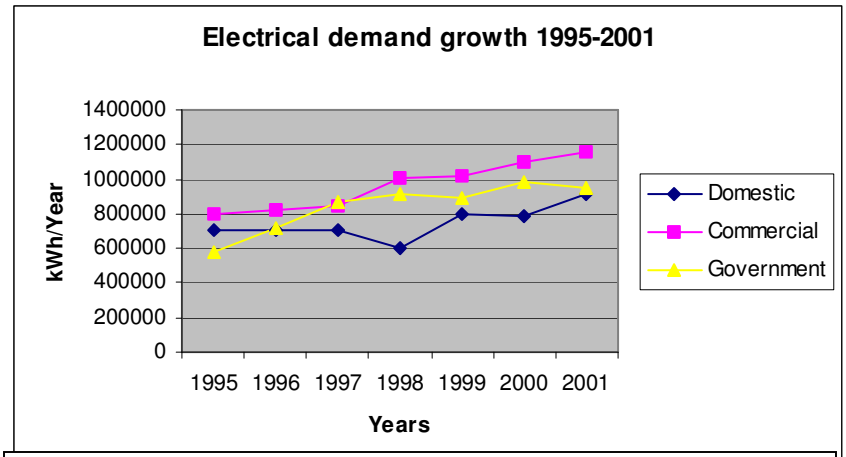
The consensus in Tuvalu is that poverty exist in relative rather than absolute terms, that is, it includes 'poverty of opportunity' due to Tuvalu's remoteness overall and the outer islands' remoteness from Funafuti which limit the opportunities available on Funafuti, and even more so, opportunities on the outer islands. For instance, the elderly on outer islands abandoned by relatives migrating to urban centers and overseas, and those who have little or no access to land tenure on Funafuti. The distribution of population per island is important with respect to the climate change issue. The islands of Tuvalu are small with the entire population living within the coastal areas creating an additional stress to already vulnerable marine ecosystems. The spatial distribution of the Tuvalu population on each of the nine islands is given below:

Island	Total Population		Total Population change
	1991	2002	
1. Nanumea	824	664	-160
2. Nanumaga	644	589	-55
3. Niutao	749	663	-86
4. Nui	606	548	-58
5. Vaitupu *	1,202	1,591	389
6. Nukufetau	751	586	-165
7. Nukulaelae	353	393	40
8. Niulakita	75	35	-40
9. Funafuti **	**3,839**	**4,492**	**653**

Table 3. Shows the distribution of the Tuvalu population and population change for each of the Islands of Tuvalu. (extracted from the Tuvalu Census Report 2002). * The positive change for Vaitupu is due to the increasing number of new intake into the only Government funded Secondary School located on Vaitupu. ** The positive population trend for Funafuti is due to the high internal migration in search for employment.

2.1.3 Energy.

Energy activities, regulation or administration are not centralized. The Ministry of Works and Energy (MWE) is obligated to develop an energy policy and the administration of renewable energy projects. The government owned Tuvalu Electric Corporation (TEC) manages all grid-based electrification on all islands. Petroleum is handled under non-competitive agreements with the only supplier Beyond Petroleum (BP), and the Tuvalu Solar Electric Cooperative Society (TSECS) is bankrupt.



Graph 1. Energy demand for the three major sectors in Tuvalu.

Custom duties and value added taxes are applied to all fuel imports except fuel for electrification on Funafuti and the outer islands. No tenders or price specific contracts has been invoked in the past. Fuel prices are not regulated and set by BP based on CIF cost. Prices of fuel in Tuvalu are one of the highest in the Pacific region (PIFS 2004).

With respect to renewable energy, no laws or regulations directly relating to renewable energy implementation are in place. Each organization or agency using renewable energy typically seeks its own funding and makes its own arrangements for purchase, installation and maintenance of renewable energy systems. Where an external donor is providing systems, the energy office may act as the interface between the donor and the recipient organization.

Solar photovoltaic has been used successfully in Tuvalu for electricity generation by renewable energy. Although there have been installed a few Australian/American style multi-bladed water pumping windmills, they were not replaced when they failed or got damaged by cyclones. None is currently functioning. No trials of wind power for electricity generation has been made nor planned. The Telecom installed 30kWp of photovoltaic system for operation of telecommunication network on the outer islands is the only currently functioning photovoltaic in Tuvalu.

Energy demand assessment for the Domestic, Commercial and Government sectors in Tuvalu from 1995-2001 showed that the domestic and commercial sectors increased rapidly, while the government sector initially increased and became more constant after 1997. The increase in energy demand at the domestic and commercial sector was initiated by the electrification of the outer islands and the increasing household ownership of cooling equipments such as refrigerators and freezers as a result. The shift of government from old offices to the new centralized government office building may have caused the recent constant government annual energy demand.

2.1.4 Socio-economic conditions.

The Gross Domestic Product (GDP) in 2001 is USD 2,286 and GDP/capita growth (%/yr,) 1995 to 2001 is 3.6% and in 1999-2003 is 1.2% (ADB estimate). The current rate of economic growth is characterized as too slow, unstable with little operational employment generating activities, lower remittances and lower public capital expenditures puts a drag on economic growth (Kakeega II 2005). One of the Macroeconomic policy objectives of the Kakeega II is to increase private sector share of GDP.

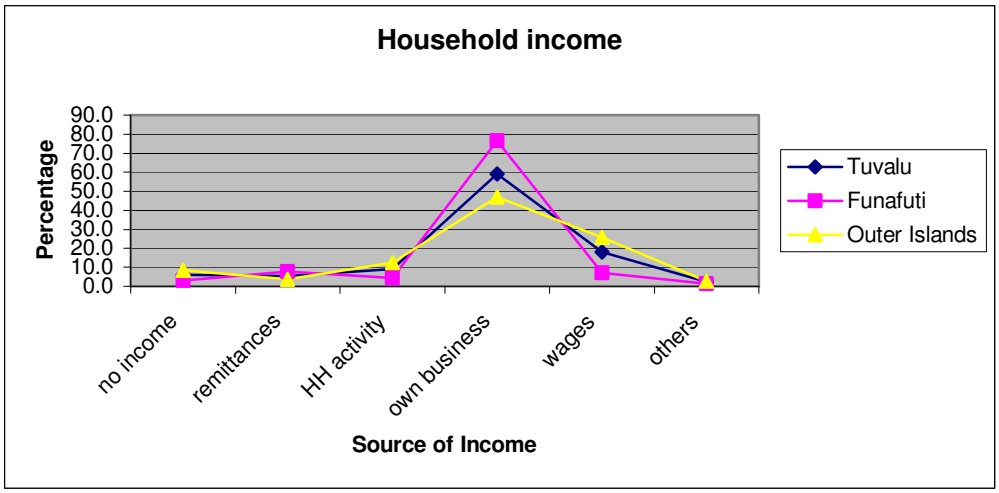


Figure 4. The source of family income comes from own business. Currently, there is a nationwide lack of price control mechanism, and this benefitted only the bussiness community.

The census 2002 identified 6 options on household incomes. Although own business is the highest contributor to household income; replanting of saline abandoned pulaka pits with a local marketable salt tolerant cash crop such as the *Morinda citrifolia* in combination with effective and innovative changes to agricultural practices will exceed income received from own business.

2.1.5 Infrastructure

In the last decades significant development occur on infrastructure, particularly building facilities on Funafuti such as the Central Princess Margaret Hospital, the Vaiaku Lagi Hotel, the Central Government Office and Nauti Primary School Classrooms. Replicas of the later have also been duplicated on some of the outer islands. In addition, the multi-million dollar tar-sealed roads infrastructural project for Funafuti only which increases connectivity of rural communities with the main settlement and urban center were some of the new infrastructural development in Tuvalu. The cost for construction and maintenance of these infrastructures are very high; the lack of adequate construction expertise and vulnerability of these infrastructures to climate change impacts will amplify maintenance cost. Indiscriminate building in the private sector and lack of a

national building code (currently approved in principle), highlights the fact that most of the private residential and private sector buildings are vulnerable to extreme events.

2.1.6 Institutions, Policy and Governance

The National Government is the focal point of all national issues including climate change adaptations. These adaptation activities are to be undertaken at the Falekaupule level taking into account the *1997 Community Governance Arrangements* is important:

2.1.6.1 Community Governance Arrangements: After December 12 1997, a new form of governance was established for all Island communities in Tuvalu. The new form of governance (Falekaupule Act of 1997), passed by the Parliament of Tuvalu, devolved the authority to the Falekaupule and Kaupule (two separate bodies) to work together in addressing community affairs in order to promote decentralization to decrease domestic urban drift. The new Falekaupule administration system merged together the traditional and the new governance systems. It also deals with island and community affairs.

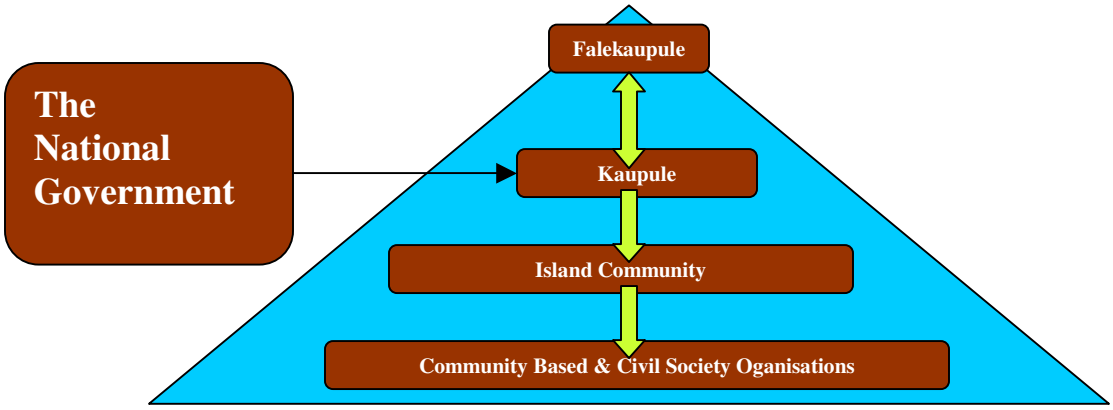


Fig 5. Structure of Community Governance in blue triangle. The Falekaupule is the product of the fusion of the traditional leadership and the introduced governing system. It functions as the decision making body on the island. The Kaupule is the executive arm of the Falekaupule. The central Government links directly to the Kaupule.

The Falekaupule economic emancipation through the Falekaupule Trust Fund (FTF) will assist in minimizing impacts of climate change on the people, and increasing people's livelihood is one of the objectives of government policy in the Kakeega II. Climate change and related disasters are major obstacles to national growth and development at all levels. Therefore, environmental management must confront two key challenges:

- *The increasing environmental issues arising from the growing urbanization of Funafuti and decreasing labour force on the outer islands; and*
- *The national impacts assorciated with climate change and sea level rise, specifically salt-water intrusion into pulaka-pits, coastal erosion and inundation.*

The Department of Environment has implemented several environmental programmes and projects; and each programme has established task committees or teams with representation from relevant and major Governmental departments, Non-Governmental Organizations (NGOs), Religious bodies and Stakeholders. These teams are multidisciplinary as the NAPA multidisciplinary team. The Development Coordinating Committee (DCC) that was setup under the Office of the Prime Minister, and chaired by the Secretary to Government assesses draft policies, projects and programmes prior to submission for approval by Cabinet. The NAPA will also pass through the same approval process before endorsement by Cabinet. However, these institutions including human resources in most of these organizations and committees are weak. Therefore, there is a need for substantial improvements, if the challenges of climate change are to be effectively addressed.

The department of environment has requested united nation agencies, to provide technical experts on selected fields, to assist in building institutional capacity and human resources in Tuvalu. Recently, a technical expert

from the UNESCAP delivered a workshop on GEF project proposal writing. This should increase the amount of GEF projects implemented in Tuvalu in the future.

2.2 Key environmental stresses

Table 6 below summarizes the climate change and vulnerabilities in several sectors in Tuvalu. Stresses currently encountered by these sectors are already national challenges and will be exacerbated by climate change. Therefore, climate change needs to be addressed at the sector level.

Climate Change and Vulnerabilities in several sectors.		
Sectors	**General or current conditions and stresses**	**Climate change stresses or risks**
Coastal Zones	Vulnerable to overexploitation	Vulnerable to Sea Level Rise and sea temperature change.
Soils	Vulnerable to increasing waste dumping.	Vulnerable to saltwater intrusion and salinization.
Water resources	Sewage and waste leachate contamination	Sea level rise and salinization
Land and Marine	Over-harvesting	Sea Level rise altering habitats.
Agriculture	Water shortage	Sea level rise and intrusion
Health	Overpopulation	Sea level rise and changing temperature.

Table 4. Climate change and Vulnerabilities in several sectors in Tuvalu.

2.2.1 Soils and Coastal Areas

Coastal erosion is severe and predominantly active on western coastlines of islands of Tuvalu. On some island, several important infrastructures on the edge of severely eroded areas, urgently need attention. Erosion on one side results in accretion (see figure 5) on other parts of the island coastline. However, in some areas such as Tepukasavilivili on Funafuti, a total loss without accretion of eroded sediments: loss of land resources and agricultural lands has been witnessed (INC 1999). Limited land resources make many terrestrial and near shore-resources vulnerable to overexploitation, and discrete dumping of wastes on land. Saltwater intrusion and water logging due to climate change cause the deterioration of chemical and biological properties of soils, and that has rapidly decreased productivity of agricultural lands and pulaka pits. Incidences of saltwater intrusion and water logging have increased overtime, and in combination with aridity of the soil, make soil parameters attractive to non-food, salt-tolerant shrubs and trees.

2.2.2 Water Resources

Tuvalu is poorly gifted with no surface water. Therefore, it is currently dependent on rainwater as its main source collected from iron roof of houses, and stored in concrete cisterns or tanks. In the past, the people also tapped the groundwater resources for household use. But, groundwater resources have been polluted by saltwater intrusion and waste leachate. Therefore, no longer suitable for human consumption. Water resources availability is a challenge that is exacerbated by climate change, resulting in frequent water shortages. Consequently, desalination plants were introduced into the country in 1999, to relieve public water demands during the water crisis, caused by the 1999/2000 El Niño.

In general, water resources are not centralized because rainwater is collected and controlled by private households, thus restricting its use. Funafuti, with the highest population density, water scarcity is a common problem: not only during the dry season (Jun – Sept), but also occasionally during the wet season (Oct – Mar). A water resource survey conducted on Funafuti in 2006 concludes that household water storage facilities are insufficient in meeting household water demand and needs. The government of Tuvalu has ensured that major water reserves are constructed on the basement of major buildings such as the New Princess Margaret Hospital and the Government Central Office. Although these are designed as water reserves including desalinated water - the water collected is being daily trucked to meet public water demand.

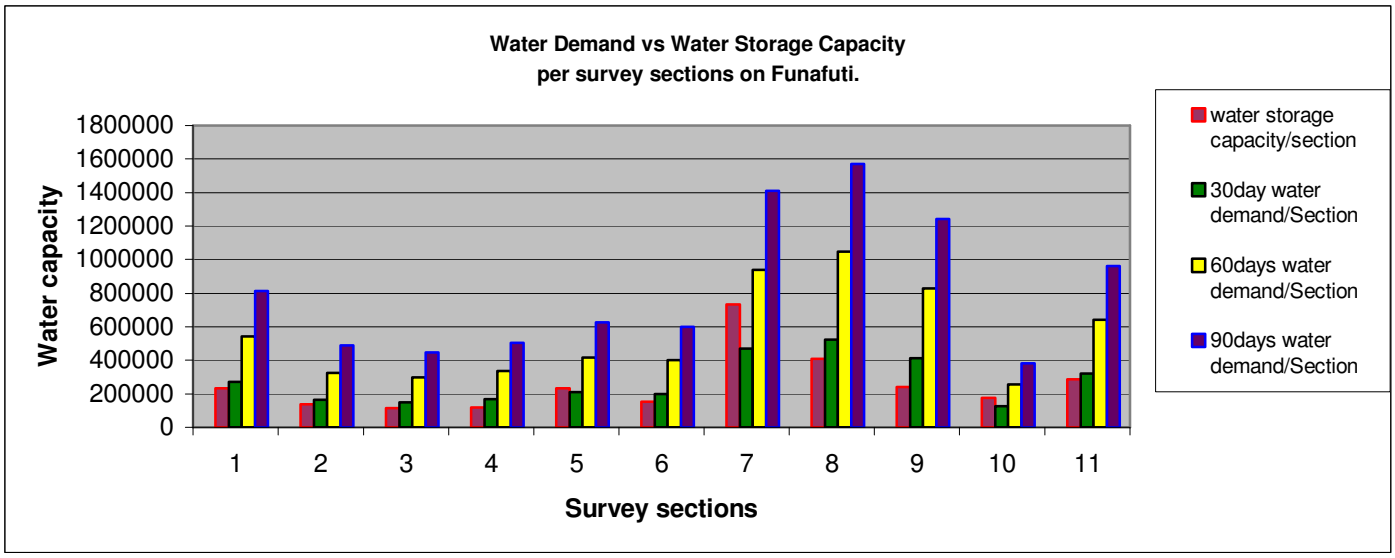


Figure 6. The Funafuti Water resources Survey 2006 showing that only three sections (5, 7 and 10) where water storage capacity is higher than the 30 day public water demand for that particular section, and no section could meet the 60 day water demand. This means that most section could not cope with a low monthly rainfall period. The water demand was calculated for the number of people residing at each section. Public Works Department & Disaster Water Resources Survey, May 2006.

2.2.3 Biodiversity

The tropical location of Tuvalu has enhanced the establishment of unique species and communities of plants and animals in the terrestrial and marine environment – some are endemic such as the recently identified *Lepidodactilus Tepukapili*. Despite the lack of marine biological resources baseline information, it has been observed and reported by stakeholders from some of the atoll islands that natural regeneration of population of *Tridacnidae* species is low, resulting in a low *Tridacnidae* species population abundance. On the other hand, over-harvesting of some marine species has also reduced population sizes to vulnerable levels. The alteration of marine habitats due to sea level rise and sea surface temperature change exacerbates stress on marine biological diversity. Therefore, Funafuti Conservation Area was established with the aim to increase population sizes of the many vulnerable coral reef species. These vulnerable reef species have already suffered natural and human stresses; climate change impacts are additional and more detrimental stresses.

2.2.4 Agriculture.

The porous soils of Tuvalu have limited fertility, and support a narrow range of food plants, unless the soils are artificially modified. It is a national challenge to increase the fertility of the soil, to enhance subsistence agriculture, in order to increase household income through selling of gardening produce. However, saltwater intrusion due to sea level rise exacerbates stress to agriculture.

2.2.5 Human health.

Increasing population pressured the government to increase procurement of health medicine; furthermore, overpopulation increases pressure on resources and risks of diseases outbreaks. Sea level rise and temperature change due to climate change exacerbates population exposure to water borne diseases.

2.2.6 Natural Disasters.

Tuvalu's southern most island of Niulakita is located within the tropical cyclone boundaries of the South-West Pacific. However, this does not exempt the northern eight islands from adverse effects of tropical cyclone and extreme events. The wet season of Tuvalu is plagued by tropical depressions that could become tropical cyclones or destructive hurricanes. Natural hazards in Tuvalu include tropical cyclones, storm surge, drought, inundation, coastal erosion, pest infestation and fire. Each year, one or a combination of natural hazards, adversely affects the livelihood of the people on all of the islands. Tropical depression at times develop around the Northern Islands and become devastative for central and Southern Islands, such as the 1992 Tropical cyclone Nina, that destructively destroyed the Japanese funded multi-million dollar harbour on Vaitupu.

Date	Name	Type	Wind force	Devastation
21/11/1972	Bebe	Hurricane	70 kts & Gusting to 100 kts	Devastation on Funafuti was caused by the strong winds and the Hurricane assisted Tidal Wave. (approx. 98% Houses & more than 100% of food crops destroyed)
26/12/1984	Un-named	Gale	48 kts & Gusting to 56 kts.	Minor destruction on outer Islands and Funafuti.
30/01/1990	Ofa	Hurricane	64 kts	Moderate destruction to fruit crop trees, few houses collapsed.
4/12/1991	Val	Hurricane	Data unavailable est. >55kts	No report
6/12/1992	Joni	Hurricane	Data unavailable est. >55kts	No report
26/12/1992	Kina	Hurricane	Data unavailable est. >55kts	No report
1/01/1993	Nina	Storm	55 kts	Multi-million dollar habour on Vaiutpu destroyed.
20/03/1994	Tomas	Hurricane	41 kts	No report
5/03/1997	Gavin	Hurricane	62 kts & Gusting to 85 kts	Devastated most of the subsistence food trees on Niulakita
12/3/1997	Hina	Storm	55 kts	No report
10/06/1997	Keli	Hurricane	70 kts & gusting at 90 kts	Devastated Niulakita & loss of Tepukasavilivili Islet
12/1/2003	Ami	Storm	35 kts & gusting to 55 kts	Devastated crops on Niulakita. Compensation for Nukulaelae and Niulakita
3/01/2004	Heta	Storm	30 kts & gusting to 35-45 kts	Damages to crops
6/2/2005	Nancy	Cyclone	15-25 kts & gusting to 30-45kts	Damages to crops
2/2/2005	Olaf	Cyclone	20-25 kts & gusting to 30-40 kts	Damages to crops
1/3/2005	Percy	Cyclone	20-25 kts & gusting 40-55kts	Damages to crops.

Table 5. Past natural disasters occurring and affecting Tuvalu and the estimated degree of destruction on communities. (Extracted from McKenzie 2005)

Agriculture (especially the limited root and tree crops) usually suffer-most when natural disasters struck as compared to the non-agricultural sectors. Consecutive cyclone Gavin, Hina and Keli in 1997 caused an estimated loss of AU$1Million (McKenzie 2005). Increasing frequency and intensity of tropical cyclones in Tuvalu will directly impact on the economy and the livelihood of the people.

2.3 How would climate change and variability adversely affect biophysical processes and key sectors in Tuvalu?

Limited studies have been carried out on the impacts, vulnerability and adaptation assessments to climate change and sea level rise in Tuvalu. These studies assessed the impacts of climate change and sea level rise by sectors such as coastal and marine systems, subsistence agriculture, water supply accessibility and quality, human health and well-being and housing (V&A 2000). The sensitivities of these sectors to adverse impacts of climate change, sea level rise and extreme events will exacerbate as a result of increasing intensity and frequency of natural disasters, increasing current and existing stresses.

The vulnerability of communities to impacts climate change, sea level rise and extreme event will increase due to the lack of national economic resources and limited investment capacity, the high dependency of communities on natural resources, and the lack of institutional capacity to address climate change. The vulnerability of communities is unvarying across the islands due to the similar location of community villages, including important infrastructure on the coastal zone. Increasing intensity of climate change impacts will significantly decrease fruit tree yields, especially the breadfruit and coconut trees. Thus, availability of nutritious domestic foods will be at risk in the future, affecting the livelihood of the people who depend solely on the natural resource base, most especially the people on the outer islands, where employment is limited. This will result in an increase consumption of imported foods, which will lead to an increase in lifestyle diseases such as diabetes and hypertension.

Some climate change and sea level rise challenges observed in Tuvalu are listed below:

a) High groundwater level during high rainfall intensities and rising sea level;
b) High incidences of water scarcity due to high frequency of low rainfall days and prolonged drought, especially on highly populated areas such as Funafuti;
c) Decrease in agricultural productivity due to pest and fruit flies infestation;

d) Decrease in coral and lagoon fisheries productivity due to the high soil erosion burying adjacent corals;
e) Increasing severity of coastal erosion;
f) Increasing and wider saltwater intrusion into coastal areas and pulaka pits; and
g) Coastal flooding and inundation.

3.0 Framework for Adaptation Programme in Tuvalu:

3.1 Goal and Objectives of the Tuvalu NAPA:

The Tuvalu NAPA was developed to support the Kakeega II, National Strategy for sustainable development 2005-2015; in synergy with other action plans and other development aspirations of the government of Tuvalu. The goal of the Tuvalu NAPA is to provide a framework that will guide the coordination and implementation of adaptation activities in the country.

The main objectives of the NAPA are:

- To develop a country-wide programme that encompass urgent and immediate needs of communities;
- To implement immediate and urgent adaptation activities to climate change and variability;
- To enhance communities awareness and livelihood; and
- To mainstream adaptation measures into national and sectoral planning.

3.2 Climate Change and Variability in Tuvalu – an overview

The Climate and Weather plays a significant role in the availability of freshwater, productivity of agriculture and livelihood of the people of Tuvalu. The national consultation 2005 reported that increasing frequency of inconsistent rainfall are impacting the people, becoming more severe if it coincides with the low rainfall periods and El Niño.

3.2.1 Observed Climate Change:

Observed past changes and projected change for the Pacific Region is summarized in Table 6.

Global	**Regional (Pacific)**
1900 –2100 Temp change 1.4 – 5.8 estimated from the IPCC Special Report Emission Scenarios (SRES) Mean Sea Level changes 9 – 88cm from SRES.	Projections: ▪ Likely to warm at a slower rate than the global average: ○ 1.98 ^{0}C by 2050 ○ 2.99 ^{0}C by 2100

Confidence in observed changes (later half of 20th century)	**Changes in Phenomenon**	**Confidence in projected changes (during the 21st century)**
Likely	Higher maximum temperatures and more hot days over nearly all lands	Very likely
Likely	Increased heat index over land areas	Very likely, over most areas
Not observed	Increased in tropical cyclone peak wind intensity	Likely, Over some areas
Insufficient data for assessment	Increased TC mean and peak precipitation intensities.	Likely, Over some areas.

Table 6. Observed past changes and projected changes for the Pacific Region.

3.2.2 Future Scenarios:

In the absence of regional and national detail, the best information available has been used to develop scenarios of climate change for Tuvalu. The following are the scenarios developed for temperature, rainfall and sea level changes for Tuvalu:

Scenario 1

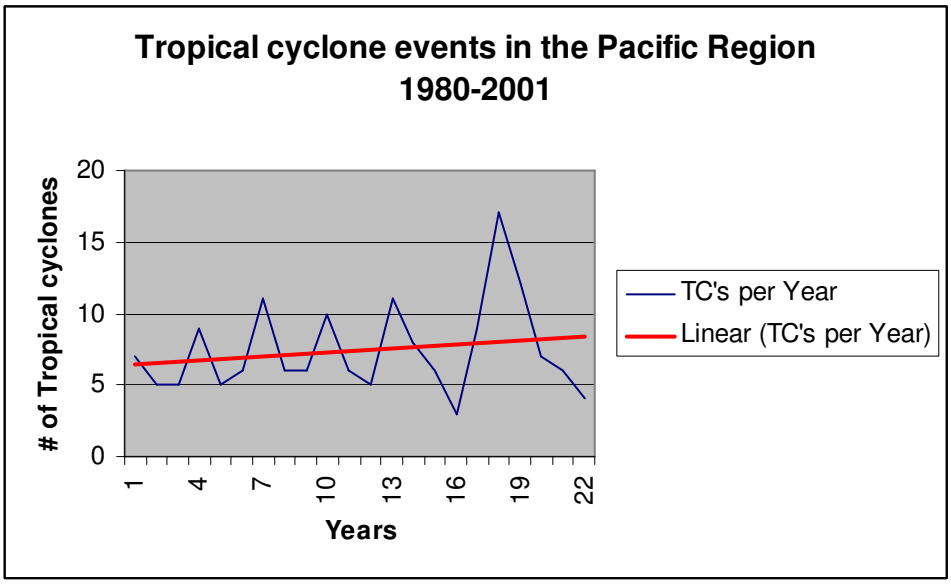
IS92a (Best Guess)									
Year	**2025**			**2050**			**2100**		
	Temp (^{0}C)	**Rainfall (%)**	**SLR (cm)**	**Temp (^{0}C)**	**Rainfall (%)**	**SLR (cm)**	**Temp (^{0}C)**	**Rainfall (%)**	**SLR (cm)**
BMRC	0.4	-0.2	14	0.7	-0.4	32	1.2	-0.7	88
UKHI	0.3	-1.6		0.5	-27.9		0.9	51.0	
IS92a (High)									
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	

Scenario 2

IS92a (Best Guess)						
Year	**2025**		**2050**		**2100**	
	Temp (^{0}C)	**Rainfall (%)**	**Temp (^{0}C)**	**Rainfall (%)**	**Temp (^{0}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
IS92a (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

Table 7. The results given in the two scenarios above conclude that Tuvalu will experience an increase in atmospheric air temperature ranging from 0.5-2.2^{0}C in 2050 to 0.9-4.5^{0}C in 2100, and Sea Level Rise is 14-88cm. Comparison of the two scenarios: *Scenario 1* gives a warmer drier condition while *Scenario 2* gives a warmer wet condition. Despite the above predictions, the two scenarios only predict changes to mean climate conditions but do not include climate variability or extreme events.

Scenario 1 gives a warmer and drier condition for Tuvalu. Beside the consideration of changes in mean climate conditions, it is important also to consider climate variability and extremes. Current climate models are still not able to state with accuracy what changes in variability and extremes will occur.



Graph 2 The number of Tropical cyclones affecting the South Pacific Region from 1980-2001 has been increasing within the last two decades. The red line shows the future linear trend-line.

Therefore, in the absence of certainty, historical events in Tuvalu are used to provide analogues for considering effects of variability and extremes, in association with mean changes in the climate:

- Tropical cyclones appear to have increased in frequency in Tuvalu. The most recent severe events was cyclone Percy (March, 2005) which had significant effects in Tuvalu –see Graph 1 above;
- ENSO events have been experienced with greater frequency over the last two decades. In Tuvalu, El Niño events bring warmer, wet conditions, whereas La Niña conditions are cooler and drier drought conditions;
- Sea level is rising - a building foundation for the church mission school in 1904 is currently submerged by inundated seawater; and
- Some families have been evacuated due to flooding from king-tide inundation of low-lying areas (first evacuation on Funafuti in 2006).

3.3 Associated Actual and Potential Adverse Effects of Climate Change

3.3.1 Current Adverse Impacts of Climate Change, Variability and Extreme Events:

In the current decade, unpredictable behavior of current climate variability and extreme events are tropical cyclones, frequent inundation of low lying and coastal areas, and frequent and significant drought has adversely affected domestic agricultural productivity, freshwater availability, and community livelihood.

NIWA reported (in SPREP 1999) that a change has already occurred in the South Pacific's Climate from the mid-1970, and Tuvalu becoming drier and sunnier. More severe weather such as frequent storms will stress infrastructures such as roads and housing, including sectors such as electricity, water, agriculture, fisheries, health, etc., which are vulnerable, and are also more expensive to repair and maintain.

Stakeholders' from the outer islands have reported saltwater intrusion into pulaka pits and overtopping waves; and the Government of Tuvalu has compensated the people affected. Furthermore, more than 30cm of intruded saltwater on Amatuku submerges a chapel foundation that was constructed in 1904 for the mission school. It is currently used as the duty officers' hut. This, apparently, is the result of sea level rise in Tuvalu. Intrusion of saltwater in Tuvalu, will also affect ground water availability for plant growth, and food crop productivity and security.

Coastal erosion is evident on all the islands of Tuvalu, and assumed to have been caused by sea level rise. However, coastal erosion is exacerbated also by human excavation of coastal aggregates for construction purposes. In addition, coastal development infrastructures such as ramps that disturbs the balance of coastal processes, and resulted in coastal erosion on other unprotected areas.

Air temperature has increased with high humidity, increasing also the heat stress on the people, plants, animals and other living organisms. Evaporation reduced soil moisture content to levels that will affect plant growth. Coral bleaching has also been noticed, and the 2005 coral fisheries survey concluded that, coral fisheries population has declined to a very low level. Shellfish population has also been reported by stakeholders to be decreasing rapidly. According to anecdotal evidence, adjacent reefs are the worst affected, as they are easily access by the people, and pollution from land, including the impacts of climate change. Biological surveys of major food fishes and selected invertebrates in 2002 and in 2003 confirmed a declining trend for almost all the different groups covered in the survey.

3.3.2 Potential Future Vulnerability of Tuvalu:

It is important to foresee potential future vulnerabilities of Tuvalu. With such understanding in hand, better adaptation planning can emerge. The future vulnerabilities of Tuvalu to climate change will depend on the frequency and intensity of climate hazards such as tropical cyclones, inundation, sea level rise, drought, etc. This means that the severity of drought, including short and extended period of low rainfall on the different islands of Tuvalu will increase in future. The growing population of Tuvalu is already placing pressure on sensitive environments and major sources of food security and livelihood, these effects, can be exacerbated by adverse effects of climate and sea level changes and extremes events. A lack of detailed information for scenarios on climate change, sea level rise, including changes in variability and extreme events for Tuvalu; the assessment of possible environmental and sectoral sensitivities will be based on current knowledge. Given the low elevation and limited land area of Tuvalu, the most direct and severe effect of climate and sea level change will be an increasing risks of coastal erosion, flooding and inundation. The magnitude of such effects will be determined by the nature and magnitude of effects of climate and sea-level changes on coral reef ecosystems, which is the islands' first natural defense against waves. Other direct effects of climate and sea-level changes will include:

- an increase in dengue fever risks and water borne diseases, where king tides and the rainy season creating water pools that enables vectors breeding grounds;
- an increase in human stress in modern houses;

- decreasing agricultural yields due to increasing salinity of groundwater, atmospheric heat and heat stress, and increasing incidences of tropical cyclones; and
- environmental and socio-economic changes in association with climate and sea-level change, only serve to increase the magnitude of adverse effects.

The overall impacts of climate and sea-level change will likely increase, and determined by the interaction and synergy between adverse effects and on-going climate and sea-level changes. Implementation of adaptation measures and strategies in Tuvalu, therefore, should take a "no-regrets" approach. The least cost adaptation options are consistent with this approach, however the highest cost options are those that would not be identified as no-regrets strategies and relate to the most severe effects, and greatest vulnerabilities and urgency. A last resort to adaptation would be migration and resettlement should the worse case scenario occur.

The weight of local evidence and reports from stakeholders' gained through the NAPA consultation and present knowledge, reinforces the view that regionally and internationally, Tuvalu is one of the most vulnerable countries to possible adverse effects of future climate and sea-level change and extreme events. These future vulnerabilities in combination with community's perception of climate change conclude that adverse changes are occurring and needs urgent intervention. Sectoral vulnerability are further described below:

3.3.2.1 Water Resources

One of the most critical national challenges with respect to impacts of climate change and sea level rise is the quality and availability of potable water for the people due to unpredictability of changes and variability in climate and weather patterns. Low monthly rainfall frequently resulted in water shortages on Funafuti and it usually occurs during the dry season (June-Sept) of Tuvalu. However, if it coincides with El Niño in the adjacent wet season (Oct-Apr), the water shortage crisis will be prolonged. During the 1999 El Niño related prolonged periods of water shortage, and in August a state of emergency was declared for Nanumaga and Niutao (two of the Northern Islands). In November a state of emergency was also declared for Funafuti (high population density). The Government imported desalination plants as a mean to urgently meet public water demand. As a result of the 1999 drought the government requested SOPAC to undertake a study of the water problem in the country.

Increasing frequency of drought and longer period of low rainfall increases salinity of groundwater. This adversely affects subsistence agriculture and increases skin diseases and eye infections. It is important to note that, what is lacking is for the Government to recognize the insufficiency and inefficiency of the water supply in Tuvalu (Taulima. F 2006).

*Table 8: Decadal monthly rainfall comparisons for **Nanumea** rainfall station. The horizontal axis is the long-term Historical Rainfall Average Normal (HRAN). Given the fact that rainfall amounts during the historical record were already limiting in terms of their ability to supply adequate water supplies to the Northern islands, therefore drought conditions easily surface in a short period of low rainfall.*

*Table 9: Decadal monthly rainfall comparisons for **Funafuti** synoptic station. The horizontal axis is the long-term Historical Rainfall Average Normal (HRAN). Given the fact that rainfall amounts during the historical record, the month of May is the driest annually. Despite the already limiting ability of rainfall to supply adequate water supplies to communities on Funafuti, high population density exacerbates the water shortage problem on **Funafuti**.*

3.3.2.1.1. Groundwater: Groundwater used to be an alternative source of water in the past, which supplement public water demands, especially during drought and prolonged periods of water shortages. Groundwater is also the main source of water for agriculture, plants and crops. Saltwater intrusion has increased the salinity of groundwater, thus, destroying traditionally important pulaka (less salt tolerant) pit gardens. Since the pulaka (*Cytosperma chamissonis*) grows best close to the water table, the direct impact of saltwater intrusion due to sea level rise on groundwater will result in total loss of pulaka productivity. Thus, the need for salt tolerant crop species. More than 60% of pulaka pit plantations have been devastated by saltwater intrusion, but the adverse effect of this saltwater intrusion is not limited to pulaka only. It will also have impact other agricultural fruit trees (coconut, breadfruit, pandanus etc.) in future. The Government has compensated Nanumaga and Nukulaelae for Pulaka plantations devastated by saltwater intrusion.

3.3.2.1.2. Desalination: The desalination technology was introduced into the country during the first declaration of the state of emergency in the month of August 1999 for Niutao and Nanumaga. These two islands are in the northern division, and they usually experience lower annual rainfall as compared to the Southern islands. The second declaration of a state of emergency was declared on November the same year,

for Funafuti – where almost half of the populations of Tuvalu congregate. Despite the fact that the month of November falls within the wet season of Tuvalu, Funafuti experienced drought conditions due to El Niño and the resulting erratic rainfall. Since then, the desalinators have been operation on a daily basis to satisfy public water demands all year round. This presents the state that household water storage facilities are insufficient. The increasing urbanization of Funafuti and the high internal urban drift will result in the public water demand exceeding the water storage capacity on Funafuti. Since the only operational desalination plant is located within the main settlement on Funafuti, land-derived pollution and from near shores, will degrade the quality of water produced, and may lead to disease and health problems on consumers.

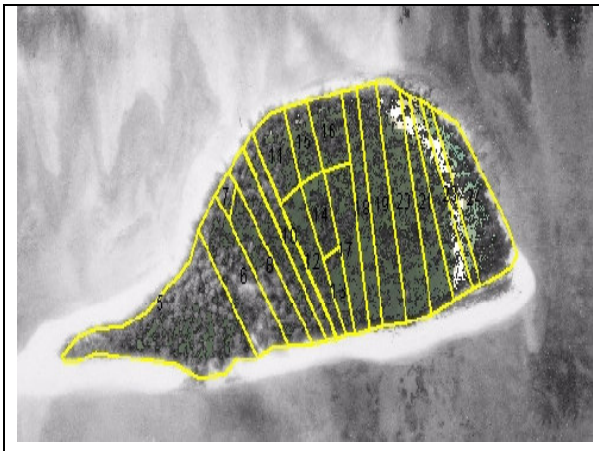
3.3.3 Health and Well-being: Good basic health services enjoyed by the people at present is downplayed by pressures from non-communicable and lifestyle diseases. Therefore, Tuvalu is currently emphasizing on curative care and services to reduce the need for overseas treatment (Kakeega II, 2006; 20), but ADB 2002, warns that it is more cost-effective to invest in public and preventive health measures. As Sea level rise elevates groundwater levels, leading to water pooling in low lying areas, and exposing polluted groundwater from chemicals and domestic septic sewage systems. These water pooling provides an ideal medium for vectors to breed, thus, increasing possibilities of water-borne diseases to occur. The impact of a high and increasing temperature in Tuvalu has not been assessed quantitatively yet. However, a combination of higher temperature and low rainfall could enhance human discomfort and stress.

3.3.4 Subsistence, Agriculture and Food-security Despite the increasing level of food importation, Tuvaluan's still relies on fruit trees such as banana, breadfruits, pandanus, coconut trees, pulaka and taro grown in pit for subsistence. Domestically grown food remains to be the main source of nutrition for the people. However, increasing saltwater intrusion has destroyed more than 60% of pulaka pit plantations in Tuvalu. The remaining 40% of pulaka pits remain highly sensitive to saltwater intrusion. Domestic subsistence agricultural production has been declining recently (Kakeega II 2006; 37). This has resulted in increasing dependence on imported foods, and increasing internal urban drift and a changing lifestyle; resulting in increasing lifestyle and non-communicable diseases.

It was noticed that the rise in temperature correlated to the increasing incidences of fruit flies destruction on fruits, and the coconut scale pest (*Aspidiotuf destructor*) infestation on Nanumaga and Vaitupu. Radiation has also been reported to directly burn sun-facing side of green coconuts and breadfruits - reducing the quality of the fruit burned. Some of the current adverse impacts of climate change and variability on subsistence agriculture are listed below:

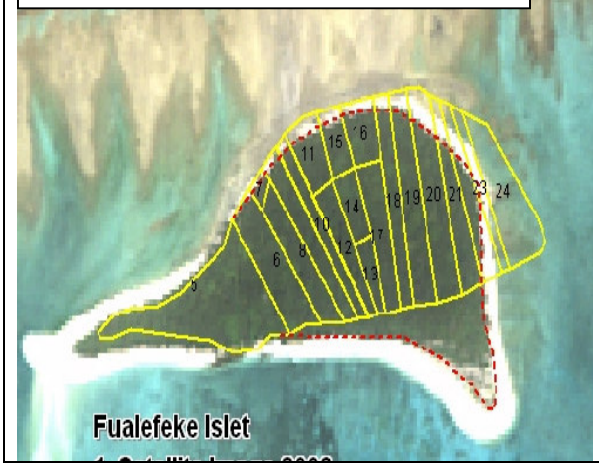
- The effect of saltwater intrusion on agriculture will be exacerbated by future increasing frequency of tropical cyclones and extreme events. This will pressure the feasibility of sustaining pulaka pit plantations due to the continuous destruction of pulaka corm.
- The combined effect of saltwater intrusion and increasing temperature will increase stress on fruit trees, thus, rendering them prone to pest infestation.
- The combined effect of saltwater intrusion and increasing frequency of extreme events and drought will result in crop yield losses of 60% pulaka and coconut, 50% banana and 50% root crops and breadfruit.
- Uncertainty exists on the impact of climate change on pigs and poultry that provide the bulk of protein in the peoples diet.

3.3.5 Coastal Areas and Erosion: Erosion and accretion are common features on all the islands of Tuvalu, especially during tropical cyclones associated with high seas and storm surges. Sea level rise will increase coastal erosion and accretion processes, and this will lead to loss from one and accretion on another family's land. Such change in coastal morphology has resulted in increasing family land boundary disputes.



Aerial Photo of Fualefeke Islet 1984.

Fualefeke in 2003 Ikonos photo.



Top Photo: Fualefeke's aerial photograph taken in 1984.
Bottom Photo: Fualefeke's Ikonos Satellite Photograph 2003.
Yellow lines: Cadastral Map Parcel surveyed 1988 overlain 1984 aerial photograph. The lines represent land's boundaries for different landowners on Fualefeke.

The cadastral map parcel was constructed from the 1988 national cadastral survey conducted in 1988, and its boundaries were made to match the 1984 aerial photograph. The lands were numbered beginning from the bottom (SW) to the top (NE) and the total number of family lands on Fualefeke is 24.

Coastal changes on Fualefeke after 19 years (1984-2003) can be seen on the bottom photo resulting from coastal erosion (approximately 3.5% land loss) and accretion:

1. **EROSION**:
   a. Loss of land parcels numbered 23 and 24 to the NE of Fualefeke;
   b. Moderate loss of northern ends of land parcels 18-21; and
   c. Slight loss of northern ends of land parcels 10,11,15 and 16.

2. **ACCRETION**
   a. Accretion is evident on the southern ends of land parcels 6,8,9,10,12,13,17 to 22.

The assumption in light of the apparent natural movement measured at Fualefeke Islet over the last 20 years, it seems most likely that an exposed islet with an area of 100m2 in size in 2003 would be extremely vulnerable if similar coastline shifts occurred. Now, the result is a total loss of lands for two landowning families on Funafuti. Therefore, the stability of the marine and terrestrial ecosystems will also be adversely affected.

Fualefeke is one of the non-inhabited islets of Funafuti and therefore, coastal changes here could not be attributed to human actions.

Fig 7: Coastal erosion and its cost on Tuvalu landowners and families.

Human activities through aggregate excavation and de-vegetation of shorelines will enhance coastal erosion. Coastal flooding and inundation are also common features on low-lying coastal areas as noticed on Tafega, Nanumea (NAPA 2005). Repeated flooding of this nature, particularly during high springtides, has resulted in degradation of the terrestrial land and permanent damages to coconut plantation and terrestrial ecosystems. Furthermore, inundation has also enhanced water logging and exposure of sewage from septic systems due to high ground-water level on the islands. Consequently, this has increased potential for water borne diseases and other health problems. It has been noticed that coastal and land surface erosion both contributes to the shallowing of central lagoon as a result of sediment deposition, which suffocates coral reefs. Coral reefs are also highly sensitive to increases in sea-surface temperature and atmospheric carbon dioxide concentrations.

3.3.6 Fisheries

Some studies indicated that the present sea surface temperature of Tuvalu is 29^0C, with a seasonal variation of +/-0.5^0C. This temperature is at the upper limit of the tolerance range for most coral species (25^0C to 29^0C) and for most marine life. Thus, future increases in the sea surface temperature due to climate change and variability will result in coral bleaching and extirpation of some marine species. That apparently, would have significant adverse effects on marine ecosystem's viability; marine species diversity and distribution. Destruction of the coral reefs has a major impact on the first line of islands' natural defense and fisheries ecology. The rate of sea level rise is expected to be higher than the rate of coral growth. It is probable that coral reefs will *give up*. It has also been reported that species diversity is higher in shallower water than at depth; higher on the north and west sides of the atolls as compared to the south and east sides (Buckley, 1983). Increasing frequency of climate hazards directly impact marine species diversity on atolls due to the direction

of tropical cyclone force winds that predominantly blows from the west. The predominance of species diversity on shallow water will also be vulnerable to sea temperature changes. However, it is unpredictable how present reef and marine ecosystems in Tuvalu would cope with the combined effects of sea level rise, sea surface temperature change and carbon dioxide concentration.

3.3.6.1 Sea Temperatures: Coral reefs are critical to Tuvalu's protection and nation building. The algae which co-habit coral organisms and generate the rainbow of colours associated with coral reefs are sensitive to increasing sea temperatures and live within a fairly narrow band of temperatures. Increasing sea temperatures cause the coral polyps to eject the colourful algae, causing coral bleaching. Destruction of the coral reefs has a major impact on the first line of defense from breaking waves as well as on fisheries ecology. Funafuti lagoon and the outer island lagoons are critical sources of both subsistence and commercial fishing. About 50 tonnes of fish per year are officially recorded from Funafuti lagoon alone. It is estimated that the population consumes about 500 grams of fish per capita per day or 700 tonnes per year.

Tuna fishing provides considerable revenue to Tuvalu. Distant water fishing nations' vessels operating in Tuvalu's exclusive economic zone pay a resource rent based on the value of the catch. In 2001, Tuvalu received A$11.8 million in license fees from distant water fishing nations' fleets, but in recent years this has dropped as low as A$1.5 million. The continued operation of these fishing activities depends on careful management of fish stocks as well as the vagaries of climate variability. As tuna are migratory fishes and the total allowable catch of around 45,000-50,000 tonnes per year has already been reached, any change in sea temperature that moves tuna out of Tuvalu's territorial waters could be disastrous for the Tuvalu economy.

3.3.7 Disasters The islands of Tuvalu rarely exceed 3m in height. There is no high ground on the islands to escape to during a tsunami or tidal wave. The combination of minimal land, high population density, and no high ground to escape to in an event of a disaster makes Tuvalu one of the most vulnerable nation in the world to natural hazards, especially in regards to rising sea levels and extreme events due to climate change. Tuvalu is highly vulnerable to Cyclones, Coastal Flooding and inundation, Drought and Sea level rise, moderately vulnerable to Storm surge and least vulnerable to Earthquake and Landslides (McKenzie, E. 2005). The natural hazards in Tuvalu are discussed below:

Table 10. Examples of climate hazard in Tuvalu.

Climate Hazards	Description
1. Sea Level Rise	Rising Sea Level in coastal areas means the sea is increasingly encroaching higher ground on already eroded and vulnerable coastline. This dynamic increases the coastal area subjected to coastal erosion and flooding.
2. Saltwater Intrusion	Rising sea level and the porous soils of Atoll Islands create the ideal conditions for inland intrusion of saltwater, and the increasing salinity of groundwater lenses.
3. Inundation	Rising Sea Level pushes water closer to the land surface resulting in upwelling at low lying areas across the Island – high frequency of inundation at pulaka pits.
4. Drought	Increasing frequency of ENSO associated erratic rainfall and periods of low rainfall leads to household water shortage with increasing stress on groundwater lenses, affecting all biomes depending on groundwater resources.
5. Cyclones	Severe destruction of vegetation, crops and humans from strong tropical cyclone wind force, and leads to flooding that increases breeding areas for vectors borne diseases.
6. Rising sea surface temperatures	Rising sea surface temperatures has and will continue to affect coral bleaching, decreasing productivity of near shore coral reef ecosystems and affecting the communities whose principal protein source is derived from these resources.

Table 11. *Likelihood of Climate Hazards in Tuvalu.*

	Sea Level Rise and Coastal Erosion	Saltwater Intrusion	Inundation	Drought	Cyclone	Increasing Sea Surface Temperature
Location	*Coastline and Settlements.*	*Pulaka pits and Groundwater pools.*	*Internal Lagoon coastlines and low lying areas.*	*All Islands and especially Northern Islands.*	*West coastline and settlements.*	*Near-shore coastline coral reef ecosystems of Islands and Islets*
Current Likelihood	Continuous	Continuous	Historically not annually	1 in 4years common in El Nino years	Continuous	Continuous
Trend in Likelihood	More pronounced since 1980s Loss of Tepukasavilivili islet on Funafuti and some other islet loss on other atoll islands.	Increasing occurrences of Saltwater intrusion into: 1. Tepela pulaka pit Niutao; 2. Motufoua pulaka pit, Vaitupu; and 3. Pulaka pit Nukulaelae. 4. Talo I tokelau, Nanumaga	Every 6 months OR annually	3 in 4 years	More pronounced since 1990	Becoming pronounced
Trend in Magnitude	Becoming more severe	Becoming more severe	More intense flooding. Higher water levels.	More intense and longer periods of drought.	Becoming more severe	Becoming more severe.
Trend in location	More areas impacted.	Localized to low lying areas and all pulaka pits	Localized to internal low lying areas (including pulaka pits) and lagoon peripheral areas	-Increasing Severity on Northern Islands with low annual rainfall. -More low income families affected.	-More islands affected. -Increasing severity on Southern Islands	-Currently localized to near-shore coastal ecosystems. -Will expand to deeper waters.
Other trend descriptions	-Severe during cyclones. -New ground level reached. -Internal Atoll lagoons becoming increasingly more shallow due to coastal erosion. -1997 Tepukasavilivili islet submerged. -erosion rate is 300cm per yr.	-Severe during drought. -increasing number of pulaka pits affected.	-Severe during high rainfall periods. -2006 results in evacuation of affected families. -Disaster plan activated.	Severe on prolonged ENSO episodes	Severe during peak king-tide levels (annually every February)	-Coral Fish population reducing to vulnerable levels. -more time needed to catch coral fish.

3.3.7.1 Cyclones: There is increasing evidence that the level of cyclone risk in Tuvalu is increasing. Tuvalu's vulnerability to cyclone threat will be increasing in the future (see table 7 and 8 above). Tuvalu was hit by an average of only 3 cyclones per decade between the 1940s and 1970s, but eight occurred in the 1980s (Nunn, P. D., 1990) and at least ten were experienced in the 1990s, suggesting that the frequency and intensity of cyclones may be increasing.

3.3.7.2 Coastal Floods: In February 2004-2006, king tides flooded homes and 40% of the tar-sealed airstrip. This has raised the question on every person's mind, "If this is the situation, what can we do?" The Prime Minister stated that even if Tuvalu was submerged below the water, "*our sovereignty will not be threatened ... Our claim would be maintained on this spot*"(AFP 2004)[1] While king tides did occur in the past, now they are occurring every year and causing major damage to pit grown root crops and bananas, the major stables in Tuvalu.

[1] AFP Interview 19 February 2004, "Tuvalu PM blames climate change as nation sinks."

3.3.7.3 Storm Surges: Tuvalu is frequently hit by storm surges associated with cyclonic disturbances. Coincidence of high tides and storm surge event can result in waves washing over low sections of the atolls and disrupting road access, increasing soil salinity, contaminating groundwater, and enhancing coastal erosion processes. There is evidence that maximum wave heights are increasing and projections of future conditions under climate change suggest that maximum wave heights will continue to increase. This suggests that storm surges may become more serious and possibly more frequent, thus causing increased damages.

SOPAC studies of Cyclone Bebe in 1972 shows that the most destructive scenario is where a cyclone derived storm surge occurred simultaneously with high tides. Under such conditions the wave run up may completely overtop the island. Fortunately, the maximum wave heights (7-8 m high, when the eye passed closest to Funafuti) during Cyclone Bebe occurred at low tide, so the overtopping occurred at a more subdued phase of the disaster—otherwise damages would have been far worse – see table 1 above.

3.3.7.4 Drought: Dry periods are more common in the northern islands than the southern and stretch from April to October, especially in El Niño periods, such as 1997-1998.[2] The atolls have poor soils that support only coconuts, breadfruit, pandanus, taro, *pulaka* and a few vegetables and fruits. Pigs, poultry and fish provide the bulk of protein in the people's diet. Drinking water and other household water supply is mainly from external tanks, which catch rain from corrugated iron roofs.[3] The traditional thatched roof houses on the outer islands are not suitable for this form of water catchment. Assured sources of water supplies are consistently ranked as one of the major risks in Tuvalu due to currently increased incidence of drought due to climate change and El Niño conditions.

3.3.7.5 Sea Level Rise: Tuvalu's land area is becoming smaller. In recent years, the country has lost a lot of land around the circumference of the largest atoll due to erosion. At its widest point, Tuvalu only spans about 200 meters, so any rise in sea level is of concern to the people. Tuvalu installed a tidal gauge in 1993 to monitor sea level, pressure, temperature, wind speed and direction.[4] From 1993-1999, the average sea level rise was 22 mm per year, rather confounded by a drop of 36.6 mm in 1997-1998 due to El Niño and La Niña effects.

3.3.7.6 Coastal Erosion: The islands of Tuvalu are geologically young, having poorly developed, infertile, sandy and coralline soils. The atolls are dynamic and are subject to continued erosion and deposition, some of this occurring over long periods, and some occurring rapidly as a result of major storms. For example, Cyclone Bebe, which struck Funafuti in 1972, produced a rubble and rock rampart nearly 18 km long on the eastern ocean side of the island of Funafuti. Typically, the lagoon side is eroded while the ocean side builds up, meaning that care needs to be taken in locating buildings and infrastructure on the more popular and attractive lagoon side.

Increased extreme storm events, rising sea levels, and more intensive land use along the coastal zone combine to make Tuvalu more vulnerable to coastal erosion. Previously constructed sea walls have not been adequately maintained and may also contribute to coastal erosion in areas not protected by sea walls. Sea walls cut off the landward supply of sand during storm events, resulting in waves attacking unprotected areas to a greater extent than they would have done prior to the sea wall construction. Soft structures, which absorb wave energy and tree planting are more suitable for erosion control. For example, the Tuvalu Council of Women implemented a

[2] Associated with the 1997-98 El Niño event, Tuvalu experienced a severe drought lasting 10 to 12 months, causing serious potable water shortages on all the islands and resulting in heavy crop yield losses e.g., over 60% for coconuts, 50% for bananas, and 50% for root crops and breadfruit trees.
[3] In Funafuti, a large underground storage tank was built under the new government office, which is used as an emergency supply for households that have run out of water. High occupancy rates in the single hotel also result in water shortage at the hotel. A reverse osmosis desalination plant provided by Japanese aid in Funafuti is supposed to be kept on standby because of its high running costs, but according to PWD, it is running every day, with subsidized supplies trucked to consumers.
[4] Tuvalu Initial National Communication under UNFCC, October 1999.

NZAID-funded tree planting project and the NGO's plant-a-tree project on Niutao with local species like *Calophyllum inophyllum* and *Pandanus* species, which could be used as a green-belt model.

In 1984, a beach profile and bathymetric survey was carried out by SOPAC to assist in the identification of problem areas along the shoreline and provide estimates of seasonal sediment transport. In addition, other studies were also carried out on Vaitupu and Nukulaelae (1993), Fongafale (1995), Amatuku (1996) and Nukufetau (1996) to address coastal erosion, sand transport and sedimentation problems in order to advance coastal management on the islands.

3.3.8 Overview of Stakeholders' Observations of Climate Change Impacts:

The national stakeholder consultative consultation was undertaken in three phases especially to raise public awareness on climate change and to record stakeholders' perception of the adverse impacts of climate change, and most importantly, to record the community's and stakeholders' urgent and immediate needs on their respective islands. The consultation convened members from different organizations on the island and people from different forms of livelihoods. The consultation also requested island Falekaupule's where women's voice is not heard in decision making to allow women's views during discussions for gender balance purposes. Stakeholders pointed out a lot of sectoral changes that they had observed and these changes could be attributed to climate change, variability and sea level rise. Despite the fact that stakeholders' understanding of the climate change issue is limited, stakeholders could identify direct impacts of climate change on their livelihood which need urgent action: such changes as in rainfall patterns resulting in frequent water shortages, saltwater intrusion resulting in salinization of groundwater and pulaka pits, decrease in easy access to coral reef fisheries resources due to lower coral fisheries population, and low agricultural yields due to increasing fruit destruction by fruit flies. The stakeholders also did not forget traditional knowledge of resource conservation that has been practiced in the past but rarely practiced at present. Prevalence and frequency of tropical cyclones, storms and drought was reported by stakeholders to be increasing on all the islands. However, they could not measure the enormity of the adverse effects of future climate change on their livelihood. The notion from stakeholders on all the islands is that climate change is already occurring in Tuvalu. Climate change adverse effects are increasing for the worse, and our collective ability to give our children a livable Tuvalu, is decreasing over the coming years.

3.3.8.1 Historical Information:

Historical information is generally passed down from father to son. However, some strategic information related to traditional knowledge is strictly passed down in the family line. The NAPA questioned the elders on some of the impacts of climate change and most importantly inundation and flooding of low-lying lands by up-welled saline waters. The Falekaupule reported that now there is an increasing percentage of land flooded due to inundation, something that has never occurred in the past.

Furthermore, the local church foundation of the first Mission school in Tuvalu that was build on Amatuku, Funafuti in 1904, and currently the Duty officers hut for the Tuvalu Maritime Training Institute is more than 30 cm below saline water level. It is unbelievable to think that the ancient builder's of Tuvalu will build a house foundation that is submerged under the water level. Similarly, more and more pulaka pits are being permanently destroyed by saltwater intrusion. Despite the fact that overtopping waves has in the past destroyed pulaka pits; such usually recover after a few months. Currently, saltwater intrusion has destroyed some pulaka pits permanently on the islands.

Fisherman also reported that coral reef fish are usually caught with ease due to the high abundance of reef-fish population. But now, more time and effort is needed to catch a fish. Some islands have already reported that bivalves were not replicating and may lead to extirpation. In addition, ocean fish like tuna rarely come closer to shore recently, and therefore; fishermen go farther out to catch tuna, thus, causing fish price inflation.

3.3.8.2 Impacts of Climate change on Livelihood

The disparity on the degree of climate change impacts that the people will experience on the islands will depend on the island's location, economic condition and population size. It is also important to know the degree of climate change impacts on different sectors as these affects the lives and livelihood of the people. Stakeholders pointed out during the consultations the observed adverse impacts of climate change on sectors such as Agriculture, Fisheries, Health and Water, which are the basic necessities of their livelihood.

3.4 Relationships of the NAPA Framework and the Kakeega II

In 2005, Tuvalu finalized it national strategy for sustainable development 2005-2015 known as "Te Kakeega II". It reflects the views of all stakeholders from all walks of life expressed during a National Summit. The vision for the Kakeega II recognizes the importance of sustainable development, and not compromising the ability of future generations of Tuvalu to meet their needs. Each of the sectoral strategic development priorities of the Kakeega II will contribute to the achievement of its vision, which is: "*To achieve a healthier, more educated, peaceful and prosperous Tuvalu*". The NAPA activities will ensure compatibility with the Kakeega II development priorities and other plans such as the National Action Plan on Desertification and Land Degradation for the United Nation Convention to Combat Desertification (UNCCD), and should also be mainstreamed into other on-going programmes to enhance synergy and cost effectiveness of programmes at sectoral level. It is also important as a way forward, to improve the way climate change is considered in national decision making processes.

The NAPA consultation pulled together a lot of valuable information for communities to develop informed decisions on adverse impacts of climate change. However, communities should also consider how they could better adapt to climate change impacts. Adopting of a "risk management" policy development approach could be an ideal solution.

Kakeega II (national plan)	NAPA (Climate change)
Hardship and poverty as obstacles to achieving the Kakeega II vision;	Address some of the causes of hardship and poverty through the provision of safe drinking water and income earning opportunities for communities;
Declining traditional subsistence economy;	Enhances traditional subsistence economy through increasing yields through introduction of salt-tolerant species as well as other agricultural initiatives;
Decreasing natural resources	Promotion and enhancement of sustainable use of natural resources through breeding programs, awareness and conservation;
Increasing growth of the cash economy	Enhance cash cropping for communities
Need for reliable climate change proof infrastructure	Support development of the national building code and better town planning.

Table 12 The table above shows some of the obstacles that the Kakeega II identifies as threats to the achievement of the national vision, but need to be addressed. The NAPA is addressing some of these constraints directly or indirectly from the climate change perspective.

3.5 Adaptation Measures, Urgency and Immediacy for Tuvalu:

Stakeholders' adaptation needs were identified and assessed based on the degree of adverse effects of climate change on Tuvalu including stakeholders' expertise in determining urgency and immediacy of adaptation needs. Adverse effects of climate change on ecological and human systems including the frequency and intensity of natural disasters were also considered. It is envisioned that without adaptation, most terrible adverse impacts are expected. Furthermore, there is solid evidence that prevention pays.

3.6 Complementarity's of NAPA with the Kakeega II and other MEAs:

The NAPA has developed adaptation measures as activities to address the immediate and urgent needs of stakeholders, complimentary to the national vision of the Kakeega II as well as other multilateral environmental agreements. The Kakeega II has identified some of the major environmental risk issues such as sea level rise, rising population on Funafuti, decline in traditional resources management and unsustainable use of natural resources to name a few. All these risks will be enhanced by a warmer climate. Minimizing climate change impacts through implementation of adaptation measures identified under the NAPA will effectively address these risks. Furthermore, the integration of climate change adaptation into sectoral policies,

programmes and development projects is vital. Enhancing this process is through increasing the awareness of stakeholders at all levels of society.

3.6.1 Potential Barriers and Constraints to Implementation:

The barriers to implementation of adaptation measures to climate change will be discussed in three levels, national awareness, integration of climate change impacts into national development plans and sectoral policy objectives, and implementation of adaptation measures. One of Tuvalu's great strength is the ability of individuals, families, communities, islands and the nation to work together cooperatively.

3.6.1.1 Lack of National Awareness: The climate change issue is new to Tuvalu. The awareness is also low, at all levels, from national level policy makers down to the Falekaupule and civil society. It is important that all key groups and stakeholders' understand the climate change issue, and how it will adversely affect their livelihood. The NAPA national consultation also included a brief stakeholders' awareness on the agenda. An awareness booklet in the local vernacular, to raise awareness of the people of Tuvalu at all levels of the civil society including primary schools, has also been completed. However, awareness on new issues of climate change should also be strengthened.

3.6.1.2 Lack of climate change impacts integration into policies: Tuvalu has no environmental law in place that will guide the appropriate treatment and protection of the environment, or to control the degradation of the environment. It is important that climate change impacts are incorporated into national development plans, especially plans and programmes for the most climate sensitive sector such as: water, coastal zone, agriculture, disaster, etc. Although, the current Kakeega II has included some environmental priorities and strategies on climate change and impacts, yet, the actual implementation of these policies and strategies is still in the distance, therefore, this process needs to be enhanced.

3.6.1.3 Implementation of Adaptation measures: Implementation of adaptation measures requires appropriate tools, knowledge and methodologies to guide the stakeholders to make informed decisions. Therefore, due to the lack of appropriate tools, knowledge and methodologies both at the technical and grassroots levels little adaptation actions will be initiated at the local level. In addition, religious misconception of the sea level rise issue is a major issue that the churches need to look into and clarify. Building the capacity and knowledge to assess climate change impacts, including appropriate tools and methodologies to identify adaptation activities needed, may lead to important adaptation activities in the near future.

4.0 Identification of Key Adaptation Needs

4.1 Past and Current Practices for adaptation to climate change and variability:

The cooperative assistance of individuals and families helped to lower the number of deaths during the 1972 destructive Hurricane Bebe on Funafuti. Over the past years the Government and Non-Governmental Organizations have implemented activities and projects to minimize adverse effects of climate change such as: development of communities disaster plan, plant-a-tree programme, transplanting local fruit trees between the islands, and community water tanks to name a few.

The Government assisted the construction of the Seawall on Nanumaga, with community participation through the provision of labour, to minimized intrusion of saline water from the sea into the pulaka pit. However, the seawall has deteriorated and the problem has returned. The government recently, assisted victims whose homes were severely inundated with saline water during the king tides of February 2006. This is also the first time that the new Disaster plan was put into action for the evacuation of king tide victims. A community disaster response plan will be useful in local communities.

Intrusion of saline water has also increased groundwater salinity thus exacerbating water problem on highly populated areas such as Funafuti. Additionally, insufficient family water storage facilities almost resulted in a water crisis and third declaration of the state of emergency on Funafuti in May 2006. Even though the

government and NGOs are active on providing tanks for household and community, water conservation technologies and awareness raising are limited, though vitally important for conserving water.

Shellfish is a delicacy and a high economic earner for families. The NAPA consultation found that *Tridacnidae* species populations are not reproducing but decreasing at an alarming rate. The government recently undertook a coral survey and NGOs replants the corals and disseminate the technology to the islands. It was also found that the people understand the motive that the destructive impacts on climate sensitive sectors were linked to climate change.

4.2 Future Potential Adaptation Strategies

Potential Adaptation Strategies (PAS) have been identified from existing practices highlighted by stakeholders during the NAPA consultation and expertise of personnel from sectors concern. The primary goal and objectives of potential adaptation strategies are to reduce adverse impacts of climate change, variability and extreme events, thus, enabling ecological and human systems to adapt accordingly.

Some initial activities on adaptation strategies for coastal erosion such as seawalls have been successful on some islands and on others fail. Stakeholders suggested that for coastal erosion, it is best to establish coastal current breakers (constructed from concrete) to decrease coastal current speed and to be installed between islets of atoll islands. On the agricultural sector, transplanting local crops between islands to increase biodiversity and food security on all islands, the NAPA is mindful not to introduce the coconut pest (currently present on two islands) into the remaining seven pest-free islands. Therefore, it is vital to assess limitation of particular adaptation strategy to achieve good results rather than re-creating a new problem.

The rate and frequency of climate change, variability and extreme event is likely to intensify in the coming future, hence, severity of adverse impacts will also intensify as well. Therefore, new and improved PAS will be needed including capacity building in the future. Although, NAPA noted that no single PAS could absolutely remove adverse impacts of climate change, variability, sea level rise and extreme events in Tuvalu, the adverse impacts of climate change, variability, sea level rise and extreme events could be minimized to a manageable level. Therefore, adverse impacts of climate change not covered by PAS will be the cost borne by the community and stakeholders concerned.

The selected potential adaptation strategies and measures were selected from stakeholders' suggestions during the NAPA consultation and selected NAPA sector task team ideas.

Several adaptation strategies and measures have been undertaken on several islands of Tuvalu, either independently, or with assistance from the government of Tuvalu and donor countries. Since coastal erosion is a major problem, several measures have been initiated as adaptation measures such as seawalls and coastal tree planting programmes. With respect to seawalls, in some cases, they have been very successful but failed in others. As observed, current designs of seawalls are more effective on coastal areas where the wave force and coastal currents are weak, as with central lagoons on atoll islands. On the other hand, planting of local trees on the coastline is still being monitored for successes.

The Tuvalu NAPA is mindful that in addressing future adverse effects of sea level rise is a complex issue for Tuvalu. A system approach acceptable to the community concerned must be suggested. In addition, NAPA is also aware that no PAS could absolutely eliminate adverse impacts of climate change, variability, sea level rise and extreme events. Therefore, stakeholders' still have to bare some of the cost of climate change. Listed below are the PAS selected for the Tuvalu NAPA in descending order of priority.

Project No.	Project Title
1	Coastal: *Increasing resilience of Coastal Areas and Settlement to climate change.*
2	Agricultural: *Increasing subsistence pit grown pulaka productivity through introduction of a salt-tolerant pulaka species.*
3	Water: *Adaptation to frequent water shortages through increasing household water capacity, water collection accessories, and water conservation techniques.*
4	Health: *Strengthening of Community health through control of vector borne/climate sensitive diseases and promotion access to quality potable water.*
5	Fisheries: *Strengthening of Community Based Conservation Programmes on Highly Vulnerable near-shore Marine Ecosystems.*
6	Fisheries: *Adaptation to Near-Shore Coastal Shellfish Fisheries Resources and Coral Reef Ecosystem Productivity.*
7	Disaster: *Strengthening Community Disaster Preparedness and Response Potential.*

Table 13. Priority Urgent and immediate needs of stakeholders in Tuvalu.

5.0 Criteria for Selecting Priority Activities

5.1 Criteria's used for prioritizing activities

The Tuvalu NAPA used some of the criteria listed under the NAPA guidelines for the prioritization of potential adaptation measures selected. During the stakeholders consultation the NAPA tried to discuss sectors impacted by climate change and those suggested by stakeholders. The NAPA selected the following three criteria for prioritization:

- The degree of severity of climate change adverse effects on sector concerned;
- Feasibility and technical suitability to local conditions;
- The perception that the adaptation activity will:
  - enhance stakeholders' livelihood;
  - to be in line with other multilateral environmental agreements and plans; and
  - to be is sustainable in the long-term.

The ranking of the priority activities used the guiding elements of country-drivenness, simplicity and flexibility in procedures of the NAPA guidelines; the following five criteria's of equal importance are selected:

- Poverty reduction and enhancement of income generation of individuals and community;
- Accessibility to good quality Water;
- Enhancement of capacity building on adaptive capacity for communities;
- Complementary to other national plans and multi-lateral environmental agreements; and
- Cost-effectiveness.

Since there is a lack of quantifiable data in most places and areas; stakeholders' preferences, sectoral expert and technical judgment have also been used for this ranking.

6 List of Priority Activities

This section will list priority climate-change adaptation activities that have been selected based on the criteria listed above.

For each of the selected urgent and immediate need priority activities, a set of profiles will be developed for inclusion in the NAPA document as annexes. This will be based on the country-driven criteria for selecting priority activities to address needs arising from the adverse effects of climate change, drawing on the criteria referred to above.

Table 14. The list of Priority Adaptation Measures (PAS) in order of priority indicated by project number, project title, primary implementing agencies (Bold) and secondary implementing agencies, and the total cost for the project.

Project No.	Project Title	Executing Agencies	Project total cost
1	Coastal: *Increasing resilience of Coastal Areas and Settlement to climate change.*	▪ Primary Executing Agencies: DOLS, PWD and Kaupule. ▪ Secondary Executing Agencies: DOE, DOA, NGOs and CBOs.	USD 1,906,500
2	Agricultural: *Increasing subsistence pit grown pulaka productivity through introduction of a salt-tolerant pulaka species.*	▪ Primary Executing Agencies: DOA and Kaupule. ▪ Secondary Executing Agencies: DOE, DLS, DRD, NGOs and CBOs.	USD 2,220,000
3	Water: *Adaptation to frequent water shortages through increasing household water capacity, water collection accessories, and water conservation techniques.*	▪ Primary Executing Agencies: PWD and Kaupule. ▪ Secondary Executing Agencies: DOE, NGOs and CBOs.	USD 2,675,300
4	Health: *Protecting Community health through control of vector borne/climate sensitive diseases and promotion community access to quality potable water.*	▪ Primary Executing Agencies: DOH, PWD, CBOs and Kaupule. ▪ Secondary Executing Agencies: DOE and NGOs.	USD 381,500
5	Fisheries: *Strengthening of Community Based Conservation Programmes on Highly Vulnerable near-shore Marine Ecosystems.*	▪ Primary Executing Agencies: DOF, DOE and Kaupule. ▪ Secondary Executing Agencies: NGOs and CBOs.	USD 636,500
6	Disaster: *Strengthening Community Disaster Preparedness and Response Potential.*	▪ Primary Executing Agencies: DMO, MET,DOE and Kaupule. ▪ Secondary Executing Agencies: NGOs and CBOs.	USD 462,000
7	Fisheries: *Adaptation to Near-Shore Coastal Shellfish Fisheries Resources and Coral Reef Ecosystem Productivity.*	▪ Primary Executing Agencies: DOF, DOE and Kaupule. ▪ Secondary Executing Agencies: NGOs and CBOs.	USD 388,000
		TOTAL	**USD 8, 669,800**

7.0 Institutional arrangement:

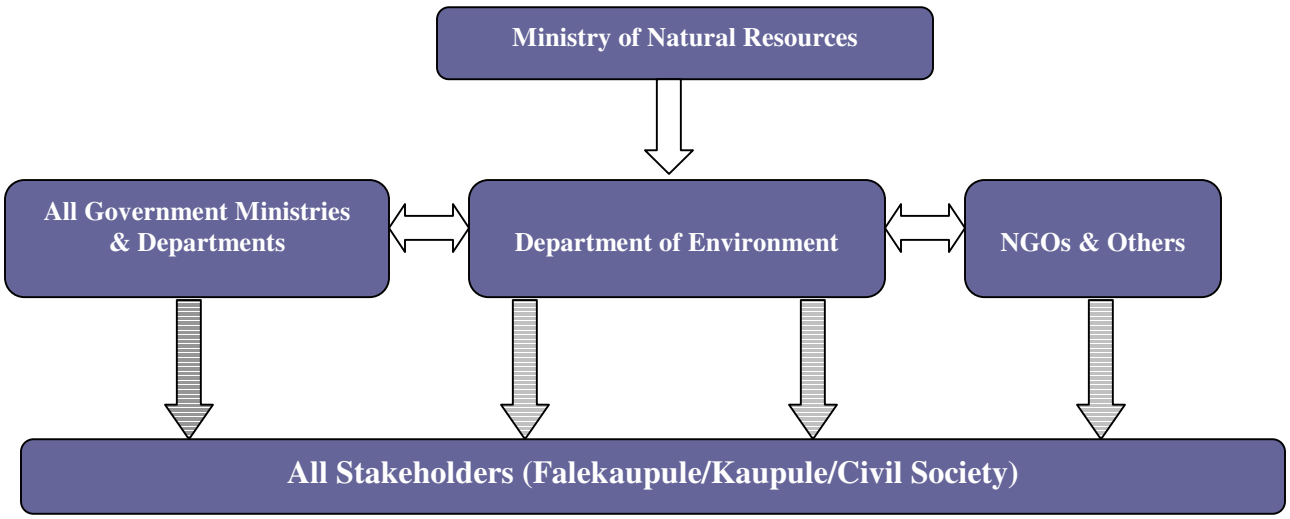


Fig 8. The institutional arrangement for the development and implementation of the Tuvalu NAPA.

8.0 The Mechanism of Endorsement by the National Government:

The preparation of the Tuvalu NAPA document was initially initiated by the Office of the Prime Minister under the Department of Environment through the NAPA Multi-disciplinary Team. The outcome of the NAPA document seeks to address the urgent and immediate needs of stakeholders and vulnerable groups of people in Tuvalu. The NAPA Multi-Disciplinary Team/Sectoral Teams will be responsible for the development of full adaptation project proposal and implementation. The projects will be subjected to accountability and transparency, including project monitoring and evaluation; quarterly reporting requirements, and financial resources auditing. Stakeholders' review the Tuvalu NAPA document, with various government departments, non-governmental organizations, international consultant and Least Developing Countries Expert Group. After the review, a draft of the Tuvalu NAPA will be developed to include comments, and will be submitted to the Development Coordinating Committee (DCC). Once it is accepted by the DCC, it is submitted into the cabinet for final approval and endorsement. Once endorse by cabinet, the NAPA will be a legal document for the government of Tuvalu.

The cabinet approved the Tuvalu NAPA document on **..th** day of **May, 2007.**

References:

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2. **McKenzie, E; Prasad, B; Kaloumaira, A 2005:** *Economic Impacts of Natural disasters on Development in the Pacific. Vol 1: Research Report.* South Pacific Applied Geoscience Commission. 2005.
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4. **SPREP**: Pacific Islands Environment outlook. Apia, 1999.
5. **Taomia, F 1993**: *Impacts of climate change in Tuvalu.* NIWA, New Zealand, 1993.
6. **Taulima, F 2006**: Public Works Department Strategic Plan. Government of Tuvalu. Funafuti. 2006.
7. **Tekinene, M; & Paelate, A 2000:** Tuvalu's Vulnerability and Adaptation assessment. Government of Tuvalu, Funafuti. 2000.
8. **Tuvalu Government 1999:** *Tuvalu's Initial National Communication.* Pacific Islands Climate change Assistance Programme, Funafuti Tuvalu.
9. **Tuvalu Government 2005:** *Te Kakeega II National Strategy for Sustainable Development 2005-2015.* Quality Print, Suva, Fiji.

Annex 1: Project Profiles.

NAPA Project Profile: 1

Title: *Increasing resilience of Coastal Areas and Community Settlement to climate change.*

Rationale/Justification:
The vulnerable physiographic condition of the Islands of Tuvalu is seen in Figures 2 and 3 of the NAPA document clearly show the vulnerability of the island's western coastal areas to erosion due to climate change and sea level rise. Severity of Coastal Erosion depends on the strength of coastal current and sediments at the sea/land interface at an area; the coastal currents are normally strong between islets. The narrowing of channels between islets due to erosion on atoll Islets further increases the channel's coastal current force flow, thus, leading to more erosion on adjacent islets and islets and lands. Figure 7 concludes that even without human interference in the coastal areas, erosion persists. Therefore, sea level rise due to climate change plays a role in coastal erosion in Tuvalu. Coastal Erosion is severe as stated in section 2.2.1 where some infrastructural buildings were at the point of collapsing as a result. Coastal areas and human settlements are exposed to coastal current force and prone to natural tragedies like strong force winds from storms, cyclones and tidal surges due to climate change. Frequency of tropical storms and associated surges are projected to increase as a consequence of climate change as highlighted in Graph 2 and Table 11. Placement of channel current breakers structures within the channels between islets and other locations of strong coastal current flow will dissipate coastal current force and this will decrease erosion on coastal areas of islets. In addition, the construction of coastal defenses and the planting of a green belt along the coastline, plays a vital role in stabilizing shorelines and protection to coastal communities against cyclones and tidal surges. Recent experiences with coastal erosion have strengthened the theoretical basis that local deep-rooted, salt- tolerant tree species reduce coastal erosion on stony coastline; therefore, a community based afforestation program with deep-rooted, salt- tolerant species was suggested.

Description:
GOAL: *Increasing resilience of Coastal Areas and Community Settlement to climate change.*

OBJECTIVES: There are two objectives for this project as follows:
- Increased protection of Coastal Areas from Erosion; and
- Increased protection of Coastal Communities from natural phenomenon.

Outcomes:	**Activities:**
1. Coastal Areas Protected.	**Activities will include:** ▪ Training of local Kaupule/Government personnel on construction of: o Coastal defenses; and Channel Breakers structures. ▪ Construction of coastal defenses; and ▪ Construction of channel current breakers.
2. Coastal communities protection enhanced.	**Activities will include:** ▪ Development of nursery ▪ Planting of a green-belt; and ▪ Public awareness

Short-term outputs
- Severely eroded areas rehabilitated; and
- Community Awareness enhanced.

Potential long-term outcomes

- Coastal erosion controlled;
- Community settlement protection enhanced;
- Decreased coral reef buried by coastal sediments;
- Coastal resources enhanced; and
- Communities easily access coastal resources.

Implementation:

Institutional arrangement

The Primary implementing agencies: Department of Lands (DOLS), Public Works Department (PWD) and Island Kaupule.

Secondary implementing agencies: Department of Agriculture (DOA) and the Department of Environment (DOE) and NGOs and CBOs.

Risks and barriers

- No practical experience with current breakers;
- Distance between the Coastal Area and Settlement is so small for a successful greenbelt to be planted; and
- Fund availability

Evaluation and monitoring

- Infrastructures risks from coastal erosion reduced;
- Coastal erosion inclusive in annual Kaupule development plans; and
- Community participation on coastal erosion control practices increased.

Financial Resources: The total cost for this project is **USD 1,906,500.00**

An indicative and tentative financial resource estimate for the activities is provided below:

Budget Breakdown

Activities	**Year 1**	**Year 2**	**Year 3**
Training of local Kaupule and Government On coastal defense and channel current breakers construction:	$50,000	$0	$0
Island Construction of Coastal defenses.	$600,000	$600,000	$400,000
Island Construction of Channel Current Breakers.	$40,000	$40,000	$30,000
Development of Greenbelt Nursery	$15,000	$15,000	$15,000
Planting of Greenbelt	$30,000	$30,000	$25,000
Public Awareness	$5,000	$5,000	$5,000
Contingencies	$500	$500	$500
Sub-Total	**$740,500**	**$690,500**	**$475,500**
		Gross Total	**$1,906,500**

Project Profile 2.

Title: *Increasing subsistence of pit grown pulaka productivity through introduction of a salt-tolerant pulaka species.*

Rationale/Justification:
The vulnerability of subsistence agriculture in Tuvalu as highlighted in section 3.3.4 of the NAPA clearly defines the cause of the shift to a more cash based way of livelihood. A rapid assessment by the agricultural department shows that the level of destruction caused by saltwater intrusion due to sea level rise on pulaka plantations is approximately 60%, and the remaining 40% of pulaka plantations remains highly sensitive to future saltwater intrusion, see Tables 10 and 11. It was assumed that an absolute destruction to pulaka crops is imminent in the near future for all islands of Tuvalu – possibly in the next decade unless urgent and immediate mitigation measures are implemented. The worst-case scenario is that an absolute destruction to pulaka crop will divert the dependence of the people of Tuvalu on imported foods, thus, an exposure of low-income families to absolute poverty. Therefore, to reduce risks of an absolute destruction to pulaka crop and preventing abrupt shift of Tuvalu's dependence on imported food is to introduce a salt-tolerant pulaka species in the region (preferably the Palau pulaka species).

Description:
GOAL: Increasing Pulaka Productivity in Tuvalu.

OBJECTIVES: There are three objectives for this project:
- Increase number of abandoned pulaka pit re-planted; and
- People's preference for fresh nutritious pulaka increased.

Outcomes:	**Activities:**	**Inputs:**
1. Enhance pulaka productivity.	**Activities will include:** Planning field work and logistics; Transfer and Establishment of salt-tolerant pulaka nursery; Dissemination of salt-tolerant pulaka to all islands	Human labour Financial resources Agricultural expert Tool and equipment
2. Local Farmers trained	**Activities will include:** Training of local farmers on: Maintaining salt-tolerant pulaka nursery Planting salt-tolerant species Preparation and printing of training manual Training local officials on monitoring	Tools and equipment Agricultural expert Financial resources
3. Improved health	**Activities will include:** Training of locals on cooking the salt-tolerant pulaka Promote eating locally grown nutritious food	Financial Resources

Short-term outputs:
- Abandoned pulaka pits planted
- Reduced unproductive lands
- Biodiversity enhanced

Prospective Long-term outputs:

- Increase of fresh and nutritious local food;
- Enhanced food security;
- Local farmers trained;
- Decreasing trend of lifestyle disease; and
- Decrease in percentage of abandoned pit gardens.

Implementation
Institutional arrangements:
Primary Executing Agencies: Department of Agriculture and Kaupule.
Secondary executing Agencies: DOE, DOLS, Department of Rural Development (DRD), NGOs and CBOs.

Risks and Barriers:
The risks for this project are:

- actual capability of the selected salt-tolerant pulaka to grow on environmental conditions and parameters of pulaka pits in Tuvalu is not known - only assumptions made;
- low possibility that the salt-tolerant pulaka will be the preferred family staple compared to rice; and
- introduction of new pest is a possibility.

Monitoring and Evaluation:
Monitoring will be done by the Department of Agriculture and the Department of Environment. The Project Steering Committee will evaluate performances on a quarterly basis through convened meetings on the progress of the project activity implementation and expenditure of project funds.

Financial Resources: The total cost for this project is **USD 2,220,000.00**
Budget Breakdown

Activities	**Year 1**	**Year 2**	**Year 3**
Planning field work and logistics	$30,000	$30,000	$30,000
Training of local farmers on planting salt-tolerant pulaka/local cash crop and maintaining the salt-tolerant pulaka/local cash crop nursery	$35,000	$35,000	
Introduction and establishment of salt-tolerant pulaka/local cash crop nurseries	$50,000	$35,000	$25,000
Local Dissemination and planting of salt-tolerant pulaka/local cash crop to other islands	$800,000	$600,000	$500,000
Monitoring	$5,000	$5,000	$5,000
Printing training manual		$10,000	$5,000
Local Promotion and advocacy	$5,000	$5,000	$5,000
Contingencies	$2,000	$2,000	$1,000
Sub-total	**$927,000**	**$722,000**	**$571,000**
		Gross Total	**$2,220,000**

NAPA Project Profile: 3

Title: *Adaptation to frequent water shortages through increasing household water capacity, water collection accessories, and water conservation techniques.*

Rationale/Justification:
In the past, Tuvalu relies heavily on two reliable major sources of potable water; rain and groundwater sources. The later has been polluted by the intrusion of saltwater due to sea level rise caused by climate change and household wastewater leacheates. Dependence on the natural storage capacity of groundwater has been adversely affected by saltwater intrusion and will increase in future as reported in Tables 10 and 11 of the NAPA. However, increasing population and internal migration to urban areas and the increasing changes in climate and variability resulting in erratic rainfall pattern changes caused the water problem in Tuvalu – see Fig 6.

Currently, Tuvalu depends entirely on rainwater collected and stored in tanks or cisterns as the main source of potable water for human consumption, and therefore, the need to increase household water storage capacity with water collecting accessories, including the enforcement of water conservation techniques are urgently needed for all stakeholders' and especially on low rainfall areas Northern islands and highly populated (Funafuti) areas.

The status of the water resources in Tuvalu is briefly outlined in section 2.2.2 of the NAPA document. Furthermore, Figure 6 clearly defines that household storage facilities on Funafuti were insufficient. Therefore, increasing household water storage capacity with water collecting accessories and enforcement of water conservation techniques is the way forward to solving this water problem and for the people to easily access quality potable water.

Description:
GOAL: Adaptation to frequent water shortages through increasing household water capacity, water collection accessories, and water conservation technologies.

OBJECTIVES: There are two objectives for this project as follows:
- Increased household water storage capacity and water collecting accessories; and
- Increased use of water conservation technologies.

Outcomes:	**Activities:**
1. Household water storage capacity increased.	**Activities will include:** ▪ Training of Kaupule plumbers in fixing water collecting accessories and water storage structures; ▪ Procurement of materials/water storage structures; ▪ Distribution of water storage structures and water collecting devices.
2. Water conservation techniques demonstrated.	**Activities will include:** ▪ Conduct a Household water use survey; ▪ Implement water conservation technologies to minimize volume of water entering waste streams; ▪ Training of kaupule expert on water conservation technologies; and ▪ Public awareness.

Short-term outputs
- Insufficiency of household potable water reduced in project areas; and

- Community access to quality water enhanced.

Potential long-term outcomes
- Household adaptation to drought and low rainfall periods improved;
- Improved family and community awareness in low rainfall periods and drought;
- Increased sustainable use of water resources at all levels of society; and
- Decreased pollution of groundwater from human wastes.

Implementation:
Institutional arrangement
Primary implementing agency: PWD and Kaupule.
Secondary implementing agencies: DOE and NGOs/CBOs.

Risks and barriers
- Insufficient space for water storage structure installation;
- Land tenure problems for non-permanent households; and
- Social acceptability of water conservation techniques;

Evaluation and monitoring
- Household water storage capacity increased;
- Wastewater reaching groundwater minimized;
- Improved Household Sanitary standard and health;
- Public Water Demand on government water resources decreased; and
- Household resilience to drought and period of low rainfall increased.

Financial Resources: The total cost for this project is **USD 2,675,300.00**
An indicative and tentative financial resource estimate for the activities is provided below:

Budget Breakdown

Activities	**Year 1**	**Year 2**
Training of Kaupule/community plumbers in fixing water collecting accessories and water storage structures.	$20,000	$0
Procurement of materials/water storage structures	$2,000,000	$500,000
Distribution of water storage structures and water collecting devices.	$15,000	$10,000
Conduct a Household water use survey.	$500	$15,000
Pilot water conservation technologies to reduce volume of water reaching the waste stream.	$10,000	$10,000
Training of Kaupule expert on water conservation technology.	$45,000	$45,000
Public awareness.	$3,000	$1,000
Contingencies	$400	$400
Sub-Total	**$2,093,900**	**$581,400**
	Total Cost	**$2,675,300**

NAPA Project Profile: 4

Title: *Protecting Community health through control of vector borne/climate sensitive diseases and promoting access to quality potable water.*

Type of project: Intervention

Rationale/Justification:
The Tuvalu initial national communication, pointed out that current climate condition enhances conditions for an outbreak of vector borne / climate sensitive diseases. The epidemic potential of climate sensitive diseases increases with increasing availability of vector breeding grounds. There are several ways that vector breeding grounds could be formed as in section 3.3.2 due to king tides and heavy rain, section 3.3.3 due to inundation and sea level rise, and Table 10 due to hazards such as tropical cyclones. Section 2.2.5 shows that Sea level rise and temperature change due to climate change exacerbates Tuvaluan communities' exposure to water borne diseases. Due to the weak adaptive capacity of the Tuvaluan communities and personnel's involved in community health sectors, building communities' and health personnel's capacities to efficiently fight climate sensitive diseases is urgent.

Description:
GOAL: *To protect Community health through control of vector borne / climate sensitive diseases and promotion community access to quality potable water.*

OBJECTIVES: There are two objectives for this project as follows:
- Increasing community access to clean water; and
- Controlling Climate sensitive and water-borne diseases.

Outcomes:	**Activities:**
1. Community resilience to climate sensitive and water borne diseases enhanced.	**Activities will include:** ▪ Community-based clean up campaign; ▪ Develop a vector outbreak control plan; and ▪ Spraying of priority vector breeding areas.
2. Community and Household access to clean water increased.	**Activities will include:** ▪ Survey on contamination of household and community water storage systems; ▪ Capacity building of community sanitary aides; ▪ Community water treatment; and ▪ Develop a cost effective water treatment plan for communities.
3. Improved Community understanding on climate sensitive/water borne diseases.	**Activities will include:** ▪ Develop Radio Programme, leaflet, etc; ▪ Awareness raising to community and Primary schools.

Short-term outputs
- Vectors controlled;
- Environment cleanliness increased; and
- Access to clean water increased.

Potential long-term outcomes

- Water related disease outbreaks controlled;
- Community understanding increased; and
- Community health increased;

Implementation:

Institutional arrangement

Primary executing agencies: DOH, PWD, CBOs and Kaupule.
Secondary implementing agencies: DOE and NGOs.

Risks and barriers

- Community commitment to clean up campaign;
- Lack of legal framework on vector control at community;
- Fund availability

Evaluation and monitoring

- Annual clean-up campaign – just before rain season;
- Existence of community water treatment plan;
- Sanitary aides trained;
- Existence of vector outbreak control plan; and
- Communities better informed.

Financial Resources: The total cost for this project is **USD 381,500.00**
An indicative and tentative financial resource estimate for the activities is provided below:

Budget Breakdown

Activities	**Year 1**	**Year 2**	**Year 3**
Community-based clean up campaign.	$30,000	$30,000	$30,000
Develop a vector outbreak control plan.	$20,000		
Quarterly Spraying of priority vector breeding areas.	$20,000	$20,000	$20,000
Survey of household and community storage system's water quality.	$15,000	$5,000	$5,000
Capacity building of community sanitary aides.	$0	$30,000	$0
Community potable water treatment.	$30,000	$30,000	$30,000
Develop a cost effective community water treatment plan.	$20,000	$0	$0
Develop Radio Programme, leaflet, etc.	$5,000	$5,000	$5,000
Awareness raising to community and Primary schools.	$10,000	$10,000	$10,000
Contingencies	$500	$500	$500
Sub-Total	**$150,500**	**$130,500**	**$100,500**
		Total Cost	**$381,500**

NAPA Project Profile: 5

Title: *Strengthening of Community Based Conservation Programmes on Highly Vulnerable near-shore Marine Ecosystems.*

Type of project: Intervention (with community focus)

Rationale/Justification:
Some islands have already instituted conservation areas. Section 2.2.3 on the biodiversity of Tuvalu illustrates the vulnerability of marine resources to alteration of marine habitats due to sea level rise and sea surface temperature change. The sea surface temperature in Tuvalu is at the upper limit of the tolerance range for most tropical marine species, therefore, future increases in sea surface temperature due to climate change including other stresses highlighted in sections 2.2 and 3.3.6 and Table 6 on marine resources will exacerbate coral bleaching and species extirpation. Coastal Marine Resources are more vulnerable to sea surface temperature change as compared to Oceanic Marine Resources. Coastal communities easily access coastal marine resources, therefore, these resources are also exposed to over-harvesting as highlighted in Table 10. Coastal Erosion exacerbates the degradation of coastal ecosystems due to the deposition of sand on coral reefs. These stresses need to be minimized through instituting community based conservation programmes on highly vulnerable marine ecosystems to ensure increasing productivity of coastal marine resources. Therefore, identification of community conservation areas in highly vulnerable marine ecosystems is urgent and must be addressed immediately.

Description:
GOAL: *To Develop and Strengthen Community Based Conservation Programmes on Highly Vulnerable Marine Ecosystems.*

OBJECTIVES: There are four objectives for this project as follows:
- Increased protection of Coastal Marine Biological Diversity;
- Develop and Strengthen Community Sustainable biodiversity conservation programme;
- Increased productivity of Coastal Marine Biological Communities; and
- Develop a Stakeholders awareness programme that will enhance traditional and modern conservation practices.

Outcomes:	**Activities:**
1. Community sustainable marine management plan completed.	**Activities will include:** ▪ Develop a Sustainable community-based coastal marine biodiversity management plan. ▪ Increase local capacity in execution of the management plan
2. Priority Conservation Area identified per Island.	**Activities will include:** ▪ Identification and implementation of priority Conservation areas per Islands; ▪ Develop a Marine resources inventory for community.
3. Improved Community knowledge, skills, and commitment to marine resource conservation.	**Activities will include:** ▪ Integration of traditional and modern conservation practices; ▪ Awareness and Capacity building for communities on conservation areas.

Short-term outputs

- Marine Resources Productivity increased;
- Community Awareness enhanced.

Potential long-term outcomes

- Coastal Marine Biological Diversity protected;
- Community understanding and commitment to conservation areas increased;
- Community based income increased; and
- Community access to Coastal resources enhanced.

Implementation:
Institutional arrangement
Primary executing agencies: Department of Fisheries (DOF), DOE and Kaupule.
Secondary executing agencies: NGOs and CBOs.

Risks and barriers

- Lack of coastal resources information;
- Lack of legal framework on resources conservation at community;
- Lack of coastal Management Systems on islands; and
- Fund availability

Evaluation and monitoring

- Bi-annual update of community marine resources inventory;
- Existence of Sustainable marine resources management plan; and
- Boundaries of conservation areas marked and public informed.

Financial Resources: The total cost for this project is **USD 636,500.00**
An indicative and tentative financial resource estimate for the activities is provided below:

Budget Breakdown

Activities	**Year 1**	**Year 2**	**Year 3**
Develop a Sustainable community-based coastal marine biodiversity management plan.	$20,000	$15,000	$15,000
Identification and implementation of priority Conservation areas per Islands.	$130,000	$130,000	$125,000
Develop a Marine resources inventory for community.	$60,000	$30,000	$20,000
Integration of traditional and modern conservation practices.			$20,000
Awareness and Capacity building for communities on conservation areas.	$15,000	$40,000	$15,000
Contingencies	$500	$500	$500
Sub-Total	**$225,500**	**$215,500**	**$195,500**
		Total Cost	**$636,500**

NAPA Project Profile: 6

Title: *Strengthening Community Disaster Preparedness and Response Potential.*

Type of project: Intervention (with community focus)

Rationale/Justification:
The vulnerability of Tuvalu to natural disasters is high. Climate change increases the frequency of natural hazards. Table 11 indicates the likelihood trend of climate hazards in Tuvalu as increasing in frequency. Losses from major disasters can be high as defined in Table 1 and also low as described in Section 4.1 on the evacuation of king-tide victims in 2006 under the Disaster plan. It is important here, to reduce risk from disaster and to increase community preparedness and response. The communities should also be aware of the disaster plan and its execution during and after disaster due to the increasing trend of climate hazard frequency as highlighted in tables 5, 10 and 11. Public awareness and traditional knowledge are also useful in enhancing community preparedness to disasters. Increased flow of public friendly climate information will increase community understanding on, preparedness and response to disasters. Increasing climate monitoring in Tuvalu will enhance community preparedness for disasters.

Description:
GOAL: *Strengthening of Community Disaster preparedness and response capability.*

OBJECTIVES: There are two objectives for this project as follows:
- To ensure community preparedness and effective response to disasters; and
- To ensure that climate hazard risks on island communities reduced.

Outcomes:	**Activities:**
1. Community disaster preparedness and response enhanced.	**Activities will include:** ▪ Develop a post-disaster resettlement and rescue plan; ▪ Awareness raising on existing disaster plan; ▪ Develop a Disaster preparedness and response strategy; and ▪ Enhancing and Documenting traditional knowledge
2. Climate Hazard Risks reduced.	**Activities will include:** ▪ Integration of risk reduction into national development; and ▪ Disaster Risk Reduction training.
3. Increased climate monitoring and information.	**Activities will include:** ▪ Establishment of new Automatic Weather Stations (AWS); ▪ Develop stakeholder-friendly climate information; and ▪ Develop early warning systems.

Short-term outputs
- Risk reduction integrated into national development;
- Community Disaster Awareness enhanced.

Potential long-term outcomes

- Preparedness and Response to disasters strengthened;
- Community's perceptions of the level of risk they face increased;
- Decreased economic losses associated with disasters; and
- Community climate understanding enhanced.

Implementation:
Institutional arrangement
Primary executing agencies: National Disaster Management Office (NDMO), DOE and Tuvalu Meteorological Services.
Secondary implementing agencies: NGOs, CBOs and Kaupule.

Risks and barriers

- Lack of financial resources;
- Lack of human resources capacity; and
- Limited lands.

Evaluation and monitoring

- Quarterly Reporting; and
- Annual Project Report.

Financial Resources: The total cost for this project is **USD 462,000.00**
An indicative and tentative financial resource estimate for the activities is provided below:
Budget Breakdown

Activities	**Year 1**	**Year 2**	**Year 3**
Develop a post-disaster resettlement and rescue plan.	$15,000		
Awareness raising on existing disaster plan.	$15,000	$45,000	$10,000
Develop a Disaster preparedness and response strategy.	$15,000		
Documenting Traditional Knowledge	$10,000	$6,000	$6,000
Integration of risk reduction into national development.	$5,000	$10,000	$10,000
Disaster Risk Reduction training.	$45,000	$10,000	$5,000
Establishment of new AWS.	$60,000	$60,000	$60,000
Develop stakeholder-friendly climate information.	$10,000	$10,000	$10,000
Develop early warning systems.	$15,000	$10,000	$5,000
Contingencies	$5,000	$5,000	$5,000
Sub-Total	**$195,000**	**$156,000**	**$111,000**
		Total Cost	**$462,000**

NAPA Project Profile: 7

Title: *Adaptation to Coastal Shellfish Fisheries Resources Productivity.*

Rationale/Justification:
The increase in surface air temperature as a result of climate change will lead to an increase in the sea surface temperature as well. The sea surface temperature in Tuvalu is approximately 29^0C; and most coral reef shellfish species in Tuvalu are living at the upper end of their respective tolerance range, and therefore, are vulnerable to a slight increase in sea surface temperature. The detrimental effect of a slight increase in the sea surface temperature is highlighted in section 3.3.6 and 3.3.6.1 where all marine organisms whether active or sedentary (more vulnerable) were affected. Human harvesting of shellfish resources is also a contributing factor to the decreasing trend in shellfisheries population as seen in table 10. However, in the past, human harvesting of shellfish resources has not been reported to adversely affect shellfisheries population as reported in the recent NAPA stakeholders' consultation.

The Atoll Islands comprising large areas of shallow reefs are vulnerable; furthermore, the Fisheries department recently reported a decrease in abundance of major coastal coral fish population on Funafuti. The urgency to address this problem is immediate since coral reef resources are the most easily accessible and main protein source of food for low-income and the majority of subsistence families on all islands of Tuvalu.

Coastal Fisheries Resources is a delicacy. However, a recent experience shows that sedentary marine resources such as shellfishes, Clams and others are becoming endangered due to low population regeneration and destruction to their habitats resulting in low breeding rates also attributed to increasing sea temperature due to climate change.

Shifting these vulnerable populations of shellfishes to suitable sites and the implementation of breeding programmes onshore or within the marine environment will result in the natural breeding of shellfish and regeneration of shellfish population. Furthermore, protection of these delicate breeding cultures is vital and will be ensured through the institution of conservation breeding sites. The success of this project will enhance community livelihood in Tuvalu. Community awareness is a vital component for the sustainability of this project. Furthermore, current level of scientific knowledge should be integrated with the traditional knowledge.

Description:
GOAL: Adaptation to Near-Shore Coastal Shellfish Resources and Coral Reef Ecosystem Productivity.

OBJECTIVES: There are three objectives for this project as follows:
- Increased protection of Shellfish population;
- Increased protection of Coral Reef Ecosystems Productivity; and
- Increased Public Awareness and Livelihood.

Outcomes:	Activities:	Inputs:
1. Shellfish Breeding Programme (Marine and On-shore) Established.	**Activities will include:** Training and Establishment of shellfish breeding programme Team for Islands; Training of Island experts; Dissemination of shellfish cultures; and Training of locals.	Human labour Financial resources Shellfisheries expert Tool and equipment
2. National Shellfish and Coral Reef Ecosystems Conservation Plan Drafted and Enforced.	**Activities will include:** Drafting of By-Laws and penalties for poachers at each participating Island; Drafting of the National Shellfish and Coral Reef Ecosystems Conservation Plan. Development of a conservation shellfish breeding area; and Training of locals.	Conservation expert Financial resources
3. Marine Resources Public Understanding Enhanced.	**Activities will include:** Public Awareness Radio Leaflets Others	Financial Resources

Short-term outputs

- Protection to vulnerable coral reef shellfish enforced; and
- Coral Shellfisheries over-harvesting reduced.

Potential long-term outcomes

- Socio-economic condition of low-income families will be improved with increased private sector contribution to GDP;
- Increased shellfish and coral reef ecosystems productivity of internal lagoons (atolls) and internal semi-saline surface water bodies (Nanumaga, Niutao and Niulakita);
- Enhanced coral reef fisheries biodiversity;
- Communities understanding on marine resources enhanced;
- Communities will easily access protein food from coral reef fisheries resources; and
- Adaptation to coral reef shellfisheries population achieved.

Implementation:

Institutional arrangement

Primary implementing agency: DOF, DOE and Kaupule.
Secondary implementing agencies: NGOs/CBOs.

Risks and barriers

- Cost-effectiveness may determine the adoption of the practice to use;
- Replication of the practice would depend on the outcomes of the project and Government/ Falekaupule commitment; and
- Fund availability

Evaluation and monitoring

- Sustainable exploitation of coral reef fisheries resources especially those species that are most vulnerable to climate change;
- Conservation Areas established and community compliance;
- Near-shore Marine Habitats and Resources protected;
- Increase in coral reef shellfish productivity; and
- Climate change impacts inclusive in fisheries policy.

Financial Resources: The total cost for this project is **USD 388,500**
An indicative and tentative financial resource estimate for the activities is provided below:

Budget Breakdown

Activities	**Year 1**	**Year 2**	**Year 3**
Establishment of shellfish breeding programme	$125,000	0	0
Training of shellfish expert	$20,000	$20,000	$20,000
Dissemination of shellfish cultures to Falekaupule/stakeholders	$15,000	$15,000	$15,000
Training of Kaupule/Falekaupule expert	$30,000	$15,000	$15,000
Drafting of the National Shellfish and coral Reef ecosystems conservation plan	$15,000	$3,000	0
Drafting of byelaws and penalties for Islands	$5,000	$2,000	0
Development of *in situ* shellfish breeding areas	$15,000	$15,000	$15,000
Development of public awareness media	$7,000	$7,000	$7,000
Training of Kaupule/Falekaupule experts.	$9,000	$4,000	$3,000
Contingencies	$500	$500	$500
Sub-Total	**$241,500**	**$81,500**	**$75,500**
		Total Cost	**$398,500**