An Assessment of the Impact of Climate Change on Agriculture and Food Security in the Pacific

Case Studies in the Republic of the Marshall Islands and Vanuatu

SUB-REGIONAL OFFICE FOR THE PACIFIC ISLANDS

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A Case Study in the Republic of the Marshall Islands

Prepared by:

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

AN ASSESSMENT OF THE IMPACT OF CLIMATE CHANGE ON AGRICULTURE AND FOOD SECURITY IN THE PACIFIC

A CASE STUDY IN THE REPUBLIC OF THE MARSHALL ISLANDS

Prepared for FAO SAPA

By

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Acronyms and Abbreviations

EEZ	Exclusive Economic Zone
NEMS	National Environment Management Strategy
RMI	Republic of the Marshall Islands
SPREP	Secretariat of the Pacific Regional Environment Programme
RMIEPA	Republic of the Marshall Island Environment Protection Agency
ENSO	El Nino Southern Oscillation
CFA	Compact of Free Association
TTPI	Trust Territory of the Pacific Islands
FAO	Food and Agriculture Organisation of the United Nations
UNDP	United Nations Development Programme
GDP	Gross Domestic Product
GNP	Gross National Product
OPS	Office of Planning and Statistics
MIMRA	Marshall Islands Marine Resources Authority
NOAA	National Oceanic and Atmospheric Administration
NEPA	National Environment Protection Act
SPCZ	South Pacific Convergence Zone
IADP	Integrated Atoll Development Project
ADB	Asian Development Bank
NIWA	National Institute of Water and Atmospheric Research
EPPSO	Economic Planning, Policy and Statistics Office
OEPPC	Office of Environment Planning, Protection and Coordination
SOPAC	Pacific Islands Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
MRD	Ministry of Resource and Development
NEMC	National Emergency and Management Coordination
MWSC	Majuro Water and Sewer Company
ADMIRE	Actions the Development of the Marshall Islands Renewable Energy
PIREP	Pacific Islands Renewable Energy Project
PIGGAREP	Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project
RET	Renewable Energy Technology
RE	Renewable Energy
CMI	College of the Marshall Islands
ODM	Office of Disaster Management
NESS	National Economic Social Summit
PICs	Pacific Island Countries
ROC	Republic of China
SDP	Sustainable Development Plan

Executive Summary

The Republic of the Marshall Islands (RMI) has identified the development of subsistence agriculture as a key strategy for the support of its rapidly growing population. The most important food crops are copra, breadfruit and pandanus. These crops used to be abundant during their seasons but harvests are reported to have been disrupted by climatic extremes such as typhoons and droughts in recent years. Prolonged periods of drought over the past twenty years caused changes to the water tables which in turn affected taro and breadfruit production during the period. This situation is expected to worsen with future climate change and has the potential to seriously affect the government's strategy for the development of the subsistence agriculture sector.

The steady shift away from the use of traditional subsistence crops especially in the urban and more populated centers is also making efforts to revive the agriculture sector difficult. Increased preference and reliance on imported foods on the other hand is putting pressure on the national economy and have implications for nutrition and health. Given these situations, the local processing of traditional crops would appear to be a reasonable and viable goal for efforts to revive the agriculture sector.

Coconut is by far the only traditional crop that has potential for commercialization although breadfruit chips have recently been developed. However, decreasing world market prices has had an adverse impact on the copra industry to the extent that very little copra has been produced in recent years.

It is not clear whether increased temperatures will directly affect subsistence and commercial crops in the RMI. The scenarios of future temperature change for the middle of the next century indicate a rise of 1.6 – 2.9°C, implying a climate that is considerably different from that of the present. While changes in crop production and behavior are expected to occur as a result of temperature changes, what and how much of such change will occur remains unclear.

Unlike temperatures, there is strong evidence in the RMI that rainfall variations directly affect crop yield and production. For example, during the El Nino season of 1997-1998, significant reductions in most crop yields was reported. It is not known if El Nino events will increase in frequency and intensity in future or whether average rainfall will decrease. However, if they do, it is highly likely that agriculture production will be adversely affected and hence traditional food crops will be in short supply.

The scenario of higher rates of sea level rise and increased incidence of extreme events such as droughts and tropical cyclones could result in increased salinity of the soils and freshwater lens, thus impairing food production. This impact could have severe effects on pit taro which is an important subsistence crop for much of the RMI.

Importantly, the increasing population particularly in the urban centers is putting a lot of pressure on land available for agriculture and human activities are having devastating effects on the coastal and marine environments of the islands. Immediate actions are required to

minimize the adverse effects of climate change and sea level rise on an already vulnerable atoll environment in the RMI.

The government of the RMI is to be commended for the actions it has already taken and those that are planned to adapt to climate change. It is noted however that this will be a long and difficult battle for the atoll nation and in this regard, the international community is duty-bound to assist the RMI with its efforts to adapt to climate change.

Summary of Recommendations

The following is a summary of recommendations emanating from this study. The recommendations are presented in greater details in section 15 in page 44. Specific recommendations for FAO are contained in sub-section 15.2.

1. Pay more attention to population growth as an important part of any strategy to adapt to climate change.

2. The government should strategically address a limited number of clearly identified priorities and actions based on the greatest needs and risks from climate change.

3. Government should consider improving service delivery to and communication with the outer islands as explicit priorities for donor-funded projects in future.

4. HRD initiatives need to be improved and expanded if RMI is to be able to effectively deal with the growing and complex issues associated with climate change.

5. Government should consider local processing of traditional food crops into more marketable commodities such as chips, flour or oil that have longer shelf-life and are easier and lighter to transport.

6. There is an important need to carry out comprehensive studies and surveys to determine how and to what extent corals and coral reefs are being affected by dredging and other coastal development activities around Majuro and Ebeye.

7. Climate change awareness and training should be continued and expanded to include outer island communities and other stakeholders.

8. Government and donor agencies should increase their support for beach restoration initiatives and measures to curtail the current rate of soil and beach erosion on Majuro.

9. FAO in collaboration with relevant local and regional agencies should support water conservation and irrigation practices that contribute to the sustainable use of the RMI's water resources.

10. FAO should support the RMI's efforts to revitalize the coconut industry by providing sound advice on scale of operation, appropriate breeding and replanting program, products and marketing.

11. Build capacity of MRD, MIMRA, Land Grant Program and College of Marshall Islands to jointly promote and carry out agriculture research, management and training in the Republic.

Map of the Marshall Islands

Source: EPPSO: Office of the President, November 2006

1. Introduction

At the 6th Meeting of Ministers of Agriculture from the South West Pacific region held in the Cook Islands from 1-3 June 2005, the Ministers, in reaffirming their commitment to enhancing food security in the region, noted the increasing need for prudent policies based on more in-depth analyses of the prevailing macroeconomic conditions and taking into account non-economic concerns. The meeting recommended that studies be carried out to assess the impact of climate variability on agriculture and food security in the region and the capacities of countries to implement international and regional agreements relating to agriculture. This recommendation was again reinforced during the 7th Meeting of Ministers (Majuro, Marshall Islands 29-31 May 2007) which amongst other things, urged FAO to pursue a study to assess the impact of climate change on agriculture and food security in the Pacific Islands region.

This study was undertaken in accordance with the above recommendations of the 6th and 7th Meetings of the Ministers of Agriculture from the Pacific Islands. A desk review of existing climate change related reports and publications on the Marshall Islands was undertaken from 18 – 29 February and an in-country consultation carried out from to 8 – 22 March 2008. The terms of reference for the study are described in Annex 1 and the list of people consulted in Annex 3.

2. Physical and natural environment of the RMI

2.1. Location

The Republic of the Marshall Islands (RMI) is composed of twenty-nine atolls and five low-elevation islands located in the north-central Pacific Ocean. Twenty-two of the atolls and four of the islands are inhabited. The islands are scattered in an archipelago consisting of two rough parallel groups, the eastern 'Ratak' (sunrise) chain and the western 'Ralik' (sunset) chain. The islands extend about 700 miles (1130 km) west to east, from 4°34'W to 14°43'E, and about 800 miles (1230 km) north to south, from 160°48'N to 172°10'S. The Marshall Islands have also claimed the Wake Islands (Enenkeo) to the north, currently an American possession and never occupied by Marshallese in historic times.

Isolated by ocean, the RMI is more than 2,000 miles (3230 km) from the nearest trading centers, Honolulu and Tokyo. Geographically, its nearest neighbors are Kiribati to the south and the Federated States of Micronesia to the west.

The total land area of the RMI is just under 70 square miles (110 square km), and the mean height above sea level is about seven feet (two meters). The soils are nutrient-poor and hence the agriculture base is very limited. The Republic's marine resource base is however broad with its combined lagoon area totaling 4,037 square miles (6511 square km), and its Exclusive Economic Zone (EEZ) encompassing 750,000 square miles (1.2 million square km) of the Pacific Ocean.

2.2. The Atolls

The atolls of the Marshall Islands are typical of atoll environments in other parts of the Pacific, and especially similar to those of the Kiribati to the immediate south (Sullivan and Gibson, 1991). Atolls are accumulations of the remains of calcareous reef-forming organisms usually arranged into a rim around a central lagoon, which is largely distinct from the open sea. They are found in tropical ocean waters within 20° latitude of the equator. As part of the environmental studies made in the Marshall Islands in connection with the atom-bomb testing, the US Navy drilled a series of deep test holes on Enewetak atoll. Two of the test holes went through a 3,936 foot cap of shallow-water reef limestone and bottomed in basalt. The age of fossils in the deepest limestone was Eocene, indicating that Enewetak atoll is the top of a coralline accumulation that began growing upward about 60 million years ago (Schlanger, 1963).

In the Marshall Islands, the islets composing an atoll usually form an elliptical or circular shape around a central lagoon of 150-foot (45 m) average depth. The surrounding ocean depth plunges to over 5,000 feet (1,525 m) within two miles (3 km), and to 3,050 meters within 16 kilometers of the typical atoll (Fosberg 1990; Wien 1962). Approximately 1,225 low-lying islets make up the twenty-nine atolls of the Marshall Islands. The low islets which form each atoll are composed of carbonate reef sands and rock, and are formed by the interaction of on-going organic and physical processes (Fosberg 1990). Marine animals and plants, mostly corals, foraminifera and calcareous algae, secrete calcium carbonate which through compaction becomes a limestone reef. Gradually, a surface of flat hard coral limestone forms and, by accumulating organic debris, may eventually extend above sea level. If storms and large waves continue to deposit materials on the exposed flat, which is typically no wider than 460 meters, an islet emerges.

The topography of the islets is uniformly low and flat, with maximum natural elevation rarely exceeding 3 meters. Around the edges of the typical islet there is generally a small tidal ridge, most pronounced on the ocean side. On the lagoon side, this ridge is generally composed of sand and fine gravel deposits, while on the seaward side it is more commonly made up of coral limestone reef surface, overlain by cobbles (NEMS, 1992).

2.3. Soils

With few exceptions, the soils of the Marshall Islands are nutrient-poor, frustrating large-scale agricultural development. Moreover, salt spray resulting from turbulence at the windward reef margin is continually carried by winds across the islands. This, in combination with high evaporation rates fostered by abundant solar radiation and high average wind speeds, results in high surface salinity which further impedes the growth of plant life.

The soils of the Marshall Islands as discussed by Fosberg in his "Review of the Natural History of the Marshall Islands" (1990) is summarized in the following paragraphs.

The soil most commonly found on the islets of the Marshall Islands lacks a series name. Consisting of almost pure white or pink coral sand, with no darkened A horizon nor any trace of a B deposition-horizon, it is found on beach ridges and dunes throughout the Republic. The youngest of all soil types, it lacks most nutrient elements except calcium.

The **Shioya Series** is composed of slightly modified coral sand and small gravel, with a slightly darkened thin A horizon, and a circum-neutral reaction. The most common and least differentiated soil series in the Marshall Islands, this soil is light brown to grey in color, with sandy texture, and lacking any coherence or structure.

The **Arno Atoll Series** is the best developed common soil found in the Marshall Islands; the type location is Arno atoll. It features a friable, usually fine textured, A horizon, with a circum-neutral reaction. It is light brownish grey to buff in color, and is found in the interior of large, moist to wet islets.

The **Jemo Series** is a localized soil found under *Pisonia grandis* forests, where acidic humus accumulates faster than it decomposes. Characterized by a conspicuous A-O horizon of mor-like humus with acidic reaction, the series features a notable but fragmented B horizon which is either a crumbly, phosphatic mixture of humus and coral sand or a hardpan of phosphatic rock, usually 2 – 8 inches thick. When present, the hardpan layer generally indicates that birds nest in the forest, depositing guano. Underlying the B horizon is a C horizon in transition to the parent material of sand or gravel. This relatively rich soil is found in various thicknesses of up to 12 inches.

2.4. The Climate

The moist, tropical climate of the Marshall Islands is heavily influenced by the north-east trade wind belt. While trade winds prevail from December through April, periods of weaker winds and doldrums occur from May through November. Annual rainfall varies considerably from north to south within the archipelago, the southern atolls receiving 300-340 centimeters and the northern atolls receiving 100-175 centimeters.

The average annual temperature is 27°C, with monthly means scarcely varying from 26.9°C to 27.1°C. The maximum daily variation is about 7°C. Temperatures are much the same throughout the country. Relative humidity ranges from 86 per cent at night to a low of 76 per cent at noon. Although hot and moist, the climate is also sunny, since rain storms seldom last longer than a few hours.

There is some climate seasonality, marked by changes in rainfall and windspeeds; there are also significant regional variations in rainfall. The southern atolls, including Majuro, where long-term weather data exists have high rainfalls that average between 3,000 to 4,300 mm whereas the northern atolls receive 1,000 to 1750 mm. The northernmost atolls (Wake, Taongi and Bikar) are direr, support limited flora and fauna and have not been occupied in recent times.

Annual rainfall in Majuro averages 3,500 mm and there are seasonal variations between the dry months of December to April, with February having an average rainfall of 158 mm, and the wet months of April to November, with October having an average rainfall of 390 mm. Rain usually occurs in brief storms, hence sunshine hours are long. Trade winds prevail in the dry months whereas weaker winds, and occasional doldrums conditions, prevail in the wetter months. Droughts are relatively infrequent, other than in 1982-83 period when

drought occurred in many parts of Micronesia, in association with a major shift in the El Nino-Southern Oscillation (ENSO), and in early 1970 (Fosberg 1990).

Major storms do not often impact the Marshall Islands, but typhoons and hurricanes frequently originate in the area, gathering strength as they move away from the equator. Prior to typhoons Zelda and Axel in 1992, the most recent typhoons to affect the Marshall Islands occurred in 1905 and 1918, and the nation never experienced a tsunami. However, high wave action and ocean swells following hurricanes in other parts of the Pacific do occasionally impact the Marshall Islands, with devastating results. In December 1979, high ocean swells inundated urban Majuro for several hours, washing away land, homes and commercial buildings. The cost of damage ran into millions of dollars.

2.5. The Natural Resources

There is no written record of the original vegetation of the Marshall Islands, and no endemic species are known today. Archaeological evidence suggests that humans have inhabited the atolls for over 3,000 years (Craib 1983) and that these early inhabitants probably altered the vegetation of the atolls by introducing plants used for food and craft materials. Furthermore, during the twentieth century, coconut plantations established by the German, Japanese and American administrators replaced most of the original vegetation. Today, over 60 per cent of the nation's total land area is covered by coconut palms.

Nine unique mangrove forests are located on the islands within Jaluit Atoll. The largest of the mangrove forests, estimated to be approximately 4 kilometers long and 0.5 kilometers wide at its widest point, is located on Jaluit Jaluit. Three species of mangroves (*Brugiera sp., Rhizophora sp.,* and *Sonneritia sp.)* have been identified in this area although it is possible other species are also present.

Freshwater lakes are rare in the Marshall Islands. Only one island, Mehit features a fresh to brackish water lake. Several large islets have central depressions with small brackish water swamps. For the most part however, fresh water resources are limited to sub-surface, Ghyben-Herzberg lenses, generally located on larger islets. Such lenses consist of fresh water "floating" on a denser seawater layer just below the surface. Regularly replenished by rainfall, these lenses can usually be accessed by digging down one to eight feet. The water is often "hard" or "limey", but it is not brackish. As these lenses are not uniformly present, most of the inhabited islands rely heavily on rainwater catchment systems to help meet fresh water needs (OPS 1988).

Seventy bird species (mainly seabirds and migratory birds) are reported to be found in the RMI. Of the 31 species of seabirds found, 15 are reported to breed in the islands. No terrestrial mammals are found in the Marshall Islands other than humans and the Polynesian rat (*Rattus exulans).* Lamberson (1984) recorded the presence of seven species of lizards and one species of blind snake in the Marshall Islands but noted that none of these species was endemic to the RMI.

Five species of marine turtles occur in the Marshall Islands with at least two species (hawksbill and green turtle) known to nest in the islands.

A compilation of published records of marine algae found in the Marshall Islands (McDermid 1989) lists a total of 238 species of green, brown, red, and blue-green algae and the Republic has begun to explore the potential for the commercial production of this resource.

Several preliminary studies undertaken by foreign researchers have confirmed the presence of limited phosphate deposits and extensive quantities of manganese in sea mounts located within the RMI's EEZ. A report published by the University of Hawaii at Manoa and the East-West Center in 1989 identified the Marshall Islands EEZ as one of the three most important areas for manganese crust deposits in the Pacific, and perhaps the world (Callies and Johnson 1989).

3. Social and cultural setting

Little is known of the prehistory of the RMI although the original Micronesian settlement was probably around 3,000 years ago. Spanish voyagers 'discovered' the Marshall Islands in the 17th century. Traders, whalers and missionaries came to the islands in the 18th and 19th centuries; amongst them was Captain John Marshall whose name was later given to the islands.

German traders encouraged the commercial planting of coconuts in the 19th century and in 1878, a German consul was appointed to Jaluit (the administrative center of the Marshall Islands at the time) and in 1885, the Marshall Islands became a German protectorate. During the First World War, the Marshall Islands were occupied by the Japanese and after the war were mandated to Japan. The islands were fortified but were captured by the Americans during WWII and later became part of the U.S Trust Territory of the Pacific Islands (TTPI). In July 1977, the Marshall Islands voted in favor of separation from the TTPI and in May 1979, it declared self-government under its own constitution. In March 1982, the Marshall Islands declared itself a Republic and in September 1991, the RMI became a member of the United Nations.

3.1. Population

The early population history of the Marshall Islands in not well-known. However, it is noted that until the Second World War, the population was actually declining and it was not until around 1960 that it reached its pre-contact level (Connell & Maata, 1192). Since then, population growth has been extremely rapid.

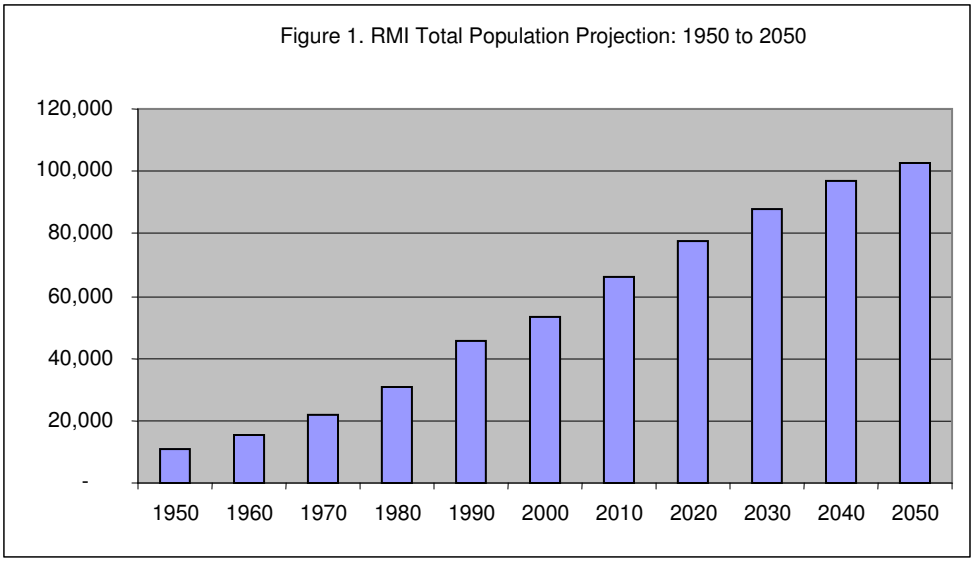
The total population of the RMI in 1999 was 50,840 people compared to 43,380 in 1988 (SPC 2007). Majuro and Kwajalein, the two largest urban centers, had the highest population counts at 23,676 and 10,902 people respectively. These two atolls represent 68% of the total population of the RMI. The population of the RMI now stands at approximately 52,700 but this does not take into account the large number of people leaving the country for the USA and other destinations (Pacific Magazine, 2008).

Between 1988 and 1999, the average growth rate for the RMI was 1.4%. This equates to an increase of 7,460 people in the 11 years. Majuro and Kwajalein experienced relatively low annual growth rates of 1.9% and 1.6% respectively compared to the previous inter-censal period when Majuro increased by 6.3% (resulting in a 67% increase in the population) and Kwajalein by 4.2%. Population projection for the RMI is shown in Figure 1 below.

The RMI population density in 1999 was 727 people per square mile but this increased substantially in urban centers. For example, Kwajalein has a population density of 1722 people per square mile which jumps to an enormous 82,000 on Ebeye. Majuro on the other hand has a population density of 6314 people per square mile which jumps to 38,000 in Djarrit (Rita) and 16,000 in Delap.

Historically, the birth rate was kept low using traditional birth control methods and the fertility was maintained at two to three children per woman. While westernization of lifestyle has facilitated higher birth rates, it has not included women as a major force in development and in the absence of widespread societal support for additional roles; women have been largely limited to motherhood (NEMS 1992).

The high rate of population growth in the Republic has resulted in an increasingly high ratio of dependency (the ratio of dependents, ages 0 – 14, to working age individuals, ages 15 – 64). According to the National Population Policy, there are 114 dependents to every 100 members of the national work force. The needs of this extremely young population can be expected to strain progressively both private and public sector resources, particularly within the healthcare and education segments. Resources available for environmental protection measures will likewise be strained by unchecked population growth, especially given that a national prioritization of needs could place health and education above environmental concerns.



Source: Benjamin Graham & Prof. Elizabeth H. Stephen. In "A Demographic Overview". Republic of the Marshall Islands. Georgetown University.

3.2. Population migration and urbanization

Approximately two-thirds of the RMI's population lives in one of the two urban centers – 45 per cent on Majuro and 21 per cent on Ebeye. The combined land area of the two urban centers is 11.4 per cent of the total national land area. Rapid population and in-migration have resulted in extremely high urban population densities and over-crowding of the centers where population densities were, in 1988, 28,724 and 58,456 persons per square mile for Majuro and Ebeye respectively. The average household size during this period was about 9.4 persons.

Until the signing of the Compact of Free Association (CFA) with the United States of America, almost all migration in the RMI was internal. International migration was confined to those moving to the USA for tertiary education and most of these graduates subsequently returned to the RMI, although this is now less true. The signing of the CFA gives all Micronesian citizens unrestricted access to the USA. The Compact provides that citizens 'may enter into, lawfully engage in occupations and establish residence as a non-immigrant in the United States and its territories and possessions'. This has encouraged movement of some of those with skills who cannot find government employment, more permanent overseas residence of students and some migration to Saipan and Guam. There is also a small but significant movement into the US military forces.

In recent times, there has been an obvious skill and brain drain as government employment opportunities within the islands decline in parallel with the decline in Compact funding. Emigration to the USA was thus viewed as a necessary future 'safety-valve' and was deliberately provided for in negotiations with the US government over the CFA. Out-migration to the USA averages 1,000 islanders annually. Far from being viewed as a menace that threatens to deplete the island's human resources, emigration is counted upon as an essential element in the government's strategy for economic and political survival (Hezel & Levin, 1989). If environmental conditions worsen, especially through greenhouse-induced sea level rises, then international migration to the USA provides one response option many Marshallese will certainly take into consideration.

It is also worth noting that international immigrants represent the greatest number of people coming into Majuro, with 556 people arriving between 1988 and 1999. Within the RMI all of the atolls lost population to Majuro, in some cases representing 15% or more of their population.

3.3. The culture

Traditional skills associated with navigation and fishing, canoe building, handicraft production, and subsistence gardening are important components of the material culture of the Marshall Islands. For millennia these skills enabled the Marshallese to endure the challenges of the atoll environment and enjoy self-sufficiency. While the importance of these skills has diminished in modern society, they remain important symbols of the uniqueness of the Marshallese culture, providing insights into a more environmentally sensitive way of life.

Archeological evidence indicates that the Marshall Islands were settled by Austronesian[1] speaking people during the first millennium BC. Evidence also suggests that although early settlers cultivated plants, they also relied heavily upon the exploitation of marine resources including fish, shellfish, turtles and marine mammals.

Marshallese society is matrilineal, based on a structure of exogamous clans (jiowi or jou); these are non-localized with members on several atolls and are similar to those of central Caroline Islands. The most important corporate descent group is the matrilineage (bwij) whose head (alab) is the custodian of lineage land and whose influence on land tenure remains of prime importance. Political and legal structure remains partly traditional, based both on matrilineal principles and on principles of 'aristocracy' with chiefs (iroij) who are largely hereditary. In pre-contact times, chiefs were occasionally able to extend their influence and authority over wide areas but only in colonial times was there joint authority over the whole of the Marshall Islands. The iroij still have considerable influence; they are respected and feared and many believe in their ability to exercise supernatural sanctions. A council of Iroij acts as an advisory to the unicameral national Parliament (the Nitijela) on matters of traditional and customary law. Complex resource shortages historically resulted in competition, conflict and warfare and also in inter-island exchanges and redistribution of both resources and population (Connell 1992).

Rapid economic development and a marked westernization of lifestyle have taken their toll on the cultural environment of the Marshall Islands in recent times. Although foreign influences have long been present in the islands, never before has the culture been so profoundly impacted. Traditional skills, oral traditions and cultural sites are all at risk in the face of newly adopted values which increasingly lead young people to under-value traditional ways, speaking the Marshallese language, and maintaining special sites.

4. The economy

4.1. Economy in general

The traditional economy of the Marshall Islands was oriented to both land and sea although land areas were much more critical than lagoon areas as an influence of atoll population size and density (Williamson 1982). In recent times, sea area has become more important; the RMI has an EEZ of more than 1.2 million sq. km and the potential economic value of the fisheries resources of the EEZ is considerable.

Growth of the nation's economy is restricted by an inadequate supply of skilled labor, an underdeveloped manufacturing sector, geographical isolation from world markets, and a relatively narrow natural resource base. Relying heavily on foreign aid, expertise and imports, the country has quickly moved away from its subsistence base, with rapid urbanization being encouraged by a profound disparity between rural and urban income levels. Faced by a rapidly expanding population and limited land resources, the Republic has proclaimed the fisheries and mariculture sectors the keys to future economic independence (OPS 1991).

[1] Malayo-Polynesian family of languages.

The Gross Domestic Product (GDP) of the RMI increased more than two-fold during the past decade from $31.9 million in 1981 to $68.7 million in 1988 (OPS 1989). This represents an annual rate of increase of nearly 12 per cent, although actual year-to-year growth rates were extremely variable. For example, the reported growth rate was 0.2 per cent in 1985, 24.5 per cent in 1986 (the year of Compact implementation), and 5.4 per cent in 1988. The GDP for 2007 was estimated to be $149.5 million and growth rate for the same year was predicted to be 1.7 per cent (Pacific Magazine 2008). Per capita GDP according to the 1988 Census was nearly $1600 and this increased to $2,836 in 2007.

The economy features a large service sector which is mainly sustained by the national government and the US Army at Kwajelein (USAKA), and a small production sector which is primarily agriculture-based. Employee compensation constituted 56-63 per cent of GDP for the period 1981-1988. Private sector wages accounted for 38 per cent of GDP in 1988, up from 25 per cent in 1981. Overall, total employee compensation for both public and private sectors increased by approximately 14 per cent per annum from 1981 to 1988.

The small production sector accounts for approximately 5 per cent of GDP, with agriculture, fisheries, and handicraft production being the major contributors. As demonstrated by the 1988 census which indicated that fewer than 3 per cent of agricultural workers receive compensation for their activities, most production is still subsistence based. In general, the development of the production sector has been hindered by an inadequate supply of skilled labor and natural resources, and by the nation's geographic isolation from world markets.

The thinly scattered population and limited infrastructure are not the only constraints to the economic development of the RMI. There are limited skills (for construction, technical activities or simply development planning), shortage of agricultural and fisheries manpower in outer islands (following migration) and the combination of a wage structure which discourages private sector employment and an import policy which effectively discourages local production.

Without substantial changes, it will be difficult to reverse the current trajectory of development in the RMI. Whilst the country has achieved almost complete political independence, it has moved further towards economic dependence, especially since the signing of the CFA. The value of imports grew from $30.6 million in 1986 to $44.4 million in 1989 while the value of exports grew from $1.2 million (a record low) to $2.3 million, resulting in a negative trade balance of $42.1 million. The increasing number of Japan Airlines charter flights to Majuro and the expected opening in early 2008 of a new tuna processing plant will certainly help improve growth in the national economy which has been flat in the past few years.

There have been widely expressed sentiments on the necessity for greater self-reliance, yet the reality of achieving this is increasingly improbable. The principal difficulty of development in the RMI is not simply one of reallocating of resources towards improved infrastructure, agriculture investment, etc., but is that of producing a fundamental change in attitudes, demanding wage restraints, raised taxation (on imports and perhaps wages) etc, that is extremely difficult to achieve in a small country where the majority of the population are now urban dwellers.

4.2. Foreign aid

The economy of the RMI is significantly inflated by foreign aid. In 1991, roughly 78 per cent of total national revenue comprised foreign aid, the Asian Development Bank estimating real GDP (i.e. reported GDP less foreign aid) at approximately $25 million, or a real per capita GDP of between $200 and $500 per annum (ADB 1991a).

The RMI relies heavily on the United States for funding provided in the form of annual grants earmarked for capital improvements and development assistance. Compact funds constituted 81 per cent of the government's recurrent expenditures in 1987, and 58 per cent in 1988 (OPS 1988). Direct grants provided under the Compact during the period 1986-1991 totaled $130.5 million. This amount decreased to $110.4 million during the period 1997-2001.

Technical assistance and grant monies from regional, national and multilateral agencies contribute an estimated $2 million per year to the economy of the RMI and as a new member of the United Nations and the Asian Development Bank, the RMI is likely to receive more aid from these agencies (including FAO) in the future.

4.3. Trade deficit

During the period 1981-1988, the value of total imports more than doubled, from $17.2 million to $44.3 million. In 1988, total imports constituted 49.9 per cent of GDP, resulting in a trade imbalance of approximately $42 million (OPS 1988, 1989). A significant percentage of imported goods are food stuff; in 1988, food items (including beverages and cooking oils) accounted for over 33 per cent of total commodity imports. In 1990, the purchase of food was estimated to constitute 58 per cent of urban and 51 per cent of rural household expenditures (OPS 1990). The Office of Planning and Statistics had estimated that urban per capita revenue generation was roughly six times that of the rural areas (OPS 1991).

Agriculture production is constrained by multiple factors including scarcity of arable land, poor soil quality, and the geographic isolation of outer atolls which makes shipments of products difficult. Nearly 40 per cent of the fish consumed in the urban centers today is imported (JICA 1991) and even though bananas are plentiful on the outer atolls, bananas from Central America are often purchased in the grocery stores. There are no laws specifically aimed at limiting imports or otherwise increasing the competitiveness of locally produced products.

4.4. Labor Force

According to the 1999 Census, the national unemployment rate for the RMI was 31 per cent, or 4536 people; the rates for Majuro and Ebeye were 31.0 per cent and 32 per cent respectively (SPC 2007). Recent estimates places the national unemployment rate at 33.9 per cent (The Pacific Magazine, 2008). In urban areas, unemployment is exceptionally high among youths, averaging 57 per cent for youth aged 15-19, and accounting for 62 per cent of unemployment overall (OPS 1989). Due to rapid population growth, each year more youth compete for already scarce entry-level positions. Despite the high unemployment rate,

however, many skilled labor and professional positions are available. The lack of skilled human resources perpetuates the high unemployment rate and forces prolonged dependence of foreign expertise (NEMS 1992).

Women are also under-represented in the work force. The 1999 Census showed that out of the RMI labor force of 14,677 persons, 10,141 were male. Women were more likely to be self-employed or members of the private sector work force than men, while men were more likely to be employed in the public sector. While the traditional matrilineal system of land inheritance accord women significant rights and powers, the transplantation of male-dominated, western values has largely undermined these traditional values and served to exclude women from "white-collar" employment (ibid). The UNDP report, *The Marshall Islands: A Statistical Profile on Men and Women,* indicated that in 1988 the average grade of educational attainment was 10.7 for males and 11.0 for females employed in the public sector. Even so, the majority of positions filled by women were clerical or janitorial in nature (Booth 1989).

5. The Agriculture Sector in the RMI

Agriculture production is relatively small but important to the livelihood of people and the economy of the RMI. It comprises food crops, small livestock and a single cash crop - copra. Land for agriculture is limited and in most atolls, there are islets that are not suitable for growing crops. Less than one half of the total land area is considered as potential agricultural area. Use of available land for housing, infrastructure and US military needs compete with that for cropping.

Typical of atoll soils, the soils of the RMI are generally thin, sandy, alkaline and lacking minerals (particularly nitrogen, phosphorus, potassium and calcium) and micronutrients essential for plant growth. Low and poorly distributed rainfall combined with poor water retaining properties of the soil limits the range and quantities of crops that could be cultivated. The domestic market is small and undeveloped resulting in volatile prices for local produce, limited opportunities to diversify production, inefficiencies and diseconomies of scale in production, processing and marketing. Introduced pests have increasingly become important and the small sizes of farming land would make any commercial agricultural development initiative extremely challenging (FAO undated).

5.1. The Traditional Agriculture System

The traditional agricultural system in the RMI is developed around a combination of three principal tree crops (coconut, breadfruit and pandanus) and the cultivation of taro in pits, but there are wide variations from north to south in crop combinations. In the northern atolls, from Enewetak east to Utirik, taro and breadfruit cultivation is unknown because of limited rainfall. More recently, a small quantity of papayas (pawpaw), sweet potatoes, limes and other vegetables have diversified the agricultural system. In the northern atolls, arrowroot and pandanus were both important. By contrast, on the five southernmost islands, rainfall is heavy and vegetation is diverse and a much wider range of food plants is available including some introduced during the German and Japanese eras.

The traditional agricultural system has declined substantially in recent times. On many atolls, such as Namu (Pollock 1974) and Lae (Alexander 1978), pit taro cultivation has declined significantly and almost ended. On Arno, Cryptosperma taro was already quite scarce by the early 1950s; the last taro pit was probably dug in the first decade of this century and only a tenth of the pits prepared for its culture were planted with significant amounts (Stone 1951). On Mili, only a few square meters of taro remain at the end of a vast abandoned taro patch and arrowroot cultivation has ended. On the densely populated atolls of Ebeye and Majuro (with the exception of a small area at Laura), traditional agriculture no longer exists. On these islands, many young people have never seen or experienced the traditional Marshallese agricultural economy. Consequently, in the last three decades, diets have incorporated a larger quantity of imported food. Crude estimates suggest that about 90 per cent of all food is imported.

Although a movement towards self-sufficiency in agriculture is favored in the RMI's development policies, it is recognized that total self-sufficiency is impossible given demand for foods like beef which cannot be produced locally. The Marshall Islands National Development Plan (1981-1995) had as its first priority the attainment of self-sufficiency in basic foods, for both economic and health reasons. Two strands of this were the rehabilitation and replanting of coconut plantations and the development of vegetable production. In 1981, a Taiwan Agricultural Technical Mission established a farm on Laura and in 1982 a second farm on Wotje, both of which were supplying vegetables to urban Majuro by mid-1982. By 1983, there was little marketing of agricultural produce and grave concern was expressed about the heavy dependence of the experimental farms on fertilizer inputs making produce both expensive and declining over time. Efforts by UNDP through its Integrated Atoll Development Project to encourage agricultural development achieved only intermittent success mainly because of transport problems (UNDP 1991).

Overall, there is a general lack of awareness about the potential of small-scale agriculture in the RMI. Very little agriculture production is marketed from the outer islands, because of transport costs, irregular services and limited production, other than occasional bananas, much of which comes from Laura or Long Island. Chickens and pigs are also occasionally sold. Land shortage, high labor costs, an educational system oriented to 'white collar' occupations rather than agricultural development, consumer tastes oriented to imported foods, limited marketing infrastructure, inadequate and expensive transport and few skilled agriculturalists all contribute to making any effective development in the agricultural economy of the RMI very frustrating and difficult.

5.2. Copra and coconuts

Copra has been the primary export of the RMI since the days of the German and Japanese occupations. Annual production of copra peaked at 7,000 tons in 1913 when the Jaluit Gesellschaft administered the Marshall Islands on behalf of the German government. Annual copra production declined by 15.1 per cent between 1979 and 1988 and production is now virtually non-existent. Dwindling production has been attributed to three main causes:

i) depressed price of copra in world markets;
ii) reduced productivity of aging coconut plantations; and

iii) inadequate storage and shipping capabilities of outer atolls.

In 1992, the government attempted to stimulate copra production by doubling the subsidy, making it possible to earn as much from making copra on an outer island as one would from working an entry-level job in the urban centers. This measure was also expected to stem migration to the urban centers and result in decreased urbanization during the next several years.

Coconut groves, many of them planted near the turn of the century, cover 22,000 acres, or 60 per cent of the nation's land. Approximately 11,000 acres of the plantations are currently still productive (OPS 1991a). A copra-processing mill was constructed on Majuro in the late 1970s, however copra prices have been generally unstable so that the mill has often been closed and prices have scarcely encouraged domestic production. In the 1980s, copra prices declined significantly due to senile trees, minimal replanting, drought (1983), poor storage facilities and migration from the outer islands. The relative dependence of the outer islands, especially in the drier north, on sources of income other than copra is considerable. Without copra production, most outer atolls would be subsistence economies almost entirely dependent on remittances and government employment for cash incomes yet copra production alone is an inadequate base for an agricultural economy. Government has plans to reinvigorate the copra production and the use of coconut wood for timber (FAO, 2007) but when these plans will be implemented is not known.

5.3. Food Crops

Breadfruit is the most widely available starch food and regularly consumed when in season from January to March and June to July. Some breadfruit is preserved using traditional methods. Pandanus produce fruits between December and March and a year's supply of leaves for roofing and handicrafts. Production of sweet bananas varies between atolls with Namdrik and Ebon atolls having the greatest relative production. Cooking banana is less common while pumpkins are widely eaten and easy to grow. Production of taro and sweet potato has fallen dramatically because of increased access to imported staples which are more convenient for preparation and storage. Arrowroot, the traditional staple of the atolls, has virtually disappeared from use.

Traditionally, food crops were not sold but shared or exchanged. Exchanging local atoll food for imported food between relatives living in the outer islands and those living in urban centers was prevalent. But many young families have been growing up in times of easy access to imported food and many youths, especially those in urban centers, are therefore unfamiliar with atoll food today. Today, local foods are used mainly on special occasions as a reserve when imported foods are not available and for variety from imported foods.

Hydroponics farming is a relatively new technology that has been tried in the Marshall Islands but whilst the technology is attractive and has potential, the lack of high quality water and occasional salt spray discourage investment in its application.

5.4. Livestock

Livestock production is non-existent except at some of the outer islands where pigs and free-ranging chicken are the main livestock kept for subsistence use. A Taiwanese-funded project on Majuro is raising a few pigs for local use and a small number of families do keep one to two pigs in sties. Demand for pork, chicken and eggs is now almost wholly met by imports and although there may be opportunities for import substitution in this area, the decisive factor determining local livestock production is the cost of animal feed since such feed has to be imported.

5.5. Fisheries

Despite a massive investment in time and money, especially since the signing of the CFA in 1986, the commercial exploitation of the RMI's marine resources is limited. Fisheries, mariculture and deep-sea mining all hold promise for economic development in the RMI. Accordingly, the Second Five Year Development Plan, 1992-1996 placed a high priority on the development of renewable marine resources as an eventual replacement for copra (OPS 1991a). Planned fisheries projects targeted both artisanal and pelagic fisheries, while mariculture projects aim to cultivate giant clams, trochus, black-lip pearl oysters and seaweed for commercial markets. Although no fisheries or mariculture projects have become economically viable so far, development of renewable marine resources is widely perceived as the "key to the future" in the Republic.

Large-scale commercial fishing is carried out by Japanese fishing boats. In recent years, lease payments have reached more than $1 million and were $1.2 million in 1988. In that same year, Japanese fishing vessels caught 19,167 metric tons of fish, mainly skipjack tuna in Marshallese waters (Connell 1992). The problems of establishing large scale fisheries, in competition with large Pacific fringe nations and with a lack of relevant skills, have hitherto limited development in the sector but transshipment and canning is possible if such problems as water supply can be overcome. The cannery that has been constructed in Jaluit could put further pressure on fresh water resources and could contribute to the degradation of water quality, if waste water is inadequately treated.

SPC (2004) reports that yellowfin tuna in the RMI is nearing full exploitation and that if the fishing effort is maintained at the current rate, yellowfin tuna stock will be overfished. The bigeye tuna stock is however reported to be fully exploited and the current level of exploitation is therefore unsustainable.

Removal of large biomass of target fish stocks may have impacts beyond these stocks, some of which may also have a high fishery value (e.g. billfishes). Due to the poor state of knowledge the impact of fishing on these species is uncertain. Other species also interact with fisheries. For example, turtles, seabirds and marine mammals are sometimes caught accidentally by longline and purse-seine operations. EPA is concerned that continuing extraction of sand and gravel aggregate from the reef, beaches and nearshore areas of Majuro Lagoon is unsustainable and may be contributing to shoreline erosion and hence, inshore fisheries.

Mariculture (aquaculture) is regarded as having considerable potential in the RMI, especially for giant clam, small clam species and trochus (Marshall Islands 1991). Giant clam cultivation began through a joint venture of the RMI government and a local private

business; a private giant clam venture also exists. No mariculture ventures in the Pacific have yet been commercially successful hence success in the Marshall Islands cannot be guaranteed. A pilot project on Callalin Island (Majuro) is investigating the economic potential of seaweed production for food and pharmaceutical industries and this may have greater viability. The RMI's EEZ is considered to be relatively rich in metallic nodules but commercial exploitation remains far into the future (Callies and Johnson 1989).

6. Significance of Climate Change in the Pacific Islands

Climate change is likely to have substantial and widespread impacts on Pacific island countries including the Marshall Islands. Among the most substantial damages would be losses of coastal infrastructure and coastal lands resulting from inundation, storm surges, or shoreline erosion. Climate change could also cause more intense cyclones and droughts, the failure of subsistence crops and coastal fisheries, and the spread of malaria and dengue fever.

Region-wide studies have shown recent significant changes in major weather patterns in the central and southern Pacific. The El Nino – Southern Oscillation (ENSO) weather pattern has changed its behavior noticeably since 1976 with more El Ninos, fewer La Ninas, the two biggest El Ninos on record (1982-83 and 1997-98) and the longest El Nino on record. These changes in El Nino patterns significantly affected Pacific tuna catch volumes, resulting in substantial reductions in seasonal tuna catches for many Pacific island countries. El Nino was also responsible in 1997-98 for severe droughts and water shortages in many PICs, and for the extremely high sea-level rise of some 25 mm, recorded across much of the Pacific since 1994 (SPREP undated).

The South Pacific has experienced the highest numbers of cyclones in a season during El Nino events. For example, in 1992/93, there were 16 cyclone events and in 1997/98, there were 17 events. The average (mean) for the South Pacific is between 9 and 10 cyclones per season (Vanuatu, undated).

During October 2007, rainfall was extremely high in areas under the active South Pacific Convergence Zone (SPCZ) with over 200% or more of normal in parts of Vanuatu, Fiji, central French Polynesia, and also well above normal in parts of New Caledonia, Niue and parts of Samoa. Heavy rainfall and flooding occurred in parts of Vanuatu at the end of the month with Aneityum recording a record high of 443.8 mm during the month. In contrast, rainfall was 50% or less of normal over much of Kiribati and parts of the Cook Islands (NIWA 2007).

Mean air temperatures for October were 1.5°C or more above normal in parts of Tonga and the Southern Cook Islands, and 1.0°C or more above normal in New Caledonia and parts of Fiji (the warmest October on record in Nadi, with records at several other sites). Temperatures were also above normal in Vanuatu and Samoa (ibid).

Changes in climatic conditions would affect most Pacific islanders, but have its greatest impact on the poorest and most vulnerable segments of the population – those most likely

to live in squatter settlements exposed to storm surges and disease and those most dependent on subsistence fisheries and crops destroyed by cyclones and droughts.

A World Bank study in 1999/2000 concluded that climate change is likely to affect coastal areas of the Pacific in three major ways: through a rise in sea level, leading to erosion and inundation; through more intense cyclones and storm surges; and through higher sea surface temperatures, leading to a decline in coal reefs.

Climate change is most likely to affect agricultural production through changes in rainfall. Agricultural crops could also be affected by rising temperatures, climate variability – such as more intense cyclones and El Nino/La Nina conditions – and sea level rise. If wetter conditions prevail in the future, water-sensitive crops such as coconut, breadfruit and cassava would likely benefit. A decline in rainfall by contrast, would hurt most crops, especially the traditional crops such as yam and taro.

Tuna fisheries in Central and Western Pacific is also likely to be affected by climate change in two major ways: by rising ocean temperatures to levels currently experienced during medium-intensity El Nino and by increasing year-to-year climate variability (Timmermann et al, 1999). The impact on tuna – the most valued deepwater fishing species in the region - is predicted to include the following:

- *Decline in primary productivity.* Primary productivity in the central and eastern Pacific could decline due to the increased stratification between warmer surface waters and colder, deeper water (and resulting reduction in upwelling). Primary production in the western Pacific could conversely increase.

- *Decline in tuna abundance.* The decline in upwelling could lead to a decline in the big eye and adult yellow fin population (the species targeted by the long line fleet). By contrast, the abundance of purse-seine-caught skipjack and juvenile yellowfin tuna is not expected to be affected.

- *Increased pressure on longline fishing.* Given the continued high demand for sashimi in Japan, it is likely that longline fishing pressure on yellowfin tuna will increase to compensate for the decline in adult bigeye tuna, leading to unsustainable exploitation.

- *Spatial redistribution of tuna resources.* The warming of surface waters and the decline in primary productivity in the central and eastern Pacific could result in spatial redistribution of tuna resources to higher latitudes (such as Japan) and towards the western equatorial Pacific.

- *Higher impact on domestic fleets.* While distant water fishing fleets can adapt to stock fluctuations, domestic fleets would be vulnerable to fluctuations of tuna fisheries in their exclusive economic zones. Countries in the Central Pacific would likely be more adversely affected than those in the western Pacific (World Bank, 2000).

Climate change could also increase the incidence of ciguatera poisoning in some areas of the Pacific like Kiribati that already has one of the highest rates of ciguatera poisoning in the Pacific. It is predicted that the rise in temperatures will increase the incidence of ciguatera poisoning in that country from 35 per thousand people to about 160-430 per thousand in 2050 (Lewis & Ruff, 1993).

More intense cyclones and droughts are likely to increase nutrition-related deficiencies as experienced in Fiji during the 1997/98 drought when US$18 million in food and water rations had to be distributed (UNCAD 1998). Loss of agriculture and fisheries could result in malnutrition and deterioration in standards of living. And the loss of infrastructure could lead to increased crowding conditions, exacerbating problems of urban management. These diffuse effects could well prove to be among the most important impacts of climate change on the livelihood of peoples in the Pacific in future years.

The disruptive changes described above are consistent with many of the anticipated impacts of global climate change. They include extensive coastal erosion, persistent alteration of regional weather patterns and decreased productivity in agriculture and fisheries. High sea levels are making some soils too saline for cultivation of crops such as taro and yams.

It is too early to say if these observed changes are the beginning of long-term climate rather than further manifestation of the natural variability of climate that characterizes the Pacific island region. However, they are the sorts of changes which can be expected as global warming sparks climate change (SPREP undated).

7. Climate Change Scenario in the RMI

A study conducted by the United States Army Civil Affairs in 2003 highlighted that exposure to the risk of future disasters is moderate in the RMI. However, while the threats (i.e. storm surges, tropical storms and typhoons, droughts, epidemics, and earthquakes) are moderately low, the country is very vulnerable to disasters. The impact of a realized threat could be very high because of high population densities on some islands (e.g. Majuro and Ebeye), low elevation, wide dispersal of the atolls over a large area of ocean, and fragile island ecosystems on which the country is highly dependent for economic survival.

The Marshall Islands is to the east of the main typhoon (cyclone) belt in the northern Pacific, hence major storms are relatively rare. However, because the islands are atolls, storm damage can be severe, and storm surges can have substantial impacts. The typhoon of 1905 formed several breaches on the southern side of Majuro atoll, which was previously continuous between Delap and Laura, demonstrating the instability of atoll environments. In 1958, a typhoon destroyed several buildings in the capital of Jabwor on Jaluit. In January 1988, Tropical Storm Roy, with winds gusting to 83 km an hour struck Ebeye, resulting in waves of 2 to 3 meters; one person died and more than a quarter of the homes on the island were destroyed. In November 1991, Tropical Storm Zelda battered the lagoon shore of Darrit, Uliga and Delap (D-U-D) washing away parts of the newly in-filled lagoon area and damaging parts of a new lagoon "sea wall". By Pacific standards, neither Roy nor Zelda were significant storms. However, in the RMI, both caused considerable damage and loss of property.

The capacity of atolls to support populations is closely related to rainfall, and to the existence of a permanent ground water system. In the Marshall Islands, only one atoll, Mejit, has a brackish freshwater lake, though several have central depressions, where taro patches are often little different from swamps. Such surface water supplies are of no use for portable water.

On small islands like those of the RMI, ground water reserves are particularly vulnerable to the vagaries of rainfall and storms. However, the most severe threat to permanent water supplies is not from climatic factors directly, but from marine processes that cause coastal erosion and increases the frequency of storm overwash. Any decline in island area has a very dramatic influence on the availability of fresh water supplies so that for any given rise in sea level, the amount of erosion will depend on the composition and height of a particular island, its exposure to wave attack and the current erosion and the frequency and intensity of storms. Greenhouse-induced shoreline erosion rates of the order of 1-2 meters per year could reduce the dimensions of some presently inhabited islands to the point where their ground water supplies would no longer support viable ecosystems or permanent human habitation.

Beach and soil erosion in the RMI, particularly on Majuro have been well documented. The problem is particularly acute in the DUD area of Majuro and in Ebeye where seawalls, coastal dredging, beach sand mining and continued environmental change has devastated what was once a natural beach barrier. Eroding coasts in the urban RMI are the norm rather than the exception (RMIEPA 2006). Erosion is evident in nearly every atoll as evident by falling vegetation, exposed beach rock and historically receding shorelines. Very little effort has so far been made to address these problems and it can be hypothesized therefore that future climate change and rising sea levels will continue to add to the problems.

In addition to the erosion problems, the lagoons of Majuro and Ebeye are also seriously polluted by land-based human activities and animal waste. Sedimentation from development projects, run-offs and eroding shorelines are also contributing to the problems as so are sand mining and oil spills. Heightened levels of algal growth, declining reefs and green waters are increasingly evident as a result from marine pollution.

Decreasing rainfall have affected crop growth and yields and salt spray from wave action is a major threat to agriculture development. This problem will worsen if current activities that are destroying the coastal areas of the islands are not properly managed.

The recently prepared RMI Standard Disaster Mitigation Plan (SDMP), as approved by both the RMI government and the US Federal Emergency Management Agency (FEMA), noted the remoteness of island communities in the RMI, and the limited resources to deal effectively with a major disaster exacerbates the vulnerability of the RMI and reinforces the need for effective risk reduction strategies such as zoning laws and building regulations to be developed and enforced. Strengthening emergency communication and early warning systems I one of the ongoing mitigation measures identified in the SDMP. The SDMP also identifies the need to provide basic information to all RMI citizens to help strengthen preparedness and community resilience through improved understanding of hazards and risks.

8. The Likely Impact of Climate Change on Agriculture in the RMI

According to Sullivan and Gibson (1990), the potential impacts of sea-level rise on the Marshall Islands are far more dramatic than the direct climatic changes alone. These impacts are summarized in the following paragraphs.

8.1. Impact on land use

Agriculture, including the subsistence production of taro, coconuts, breadfruit, pawpaw and the commercial production of copra are highly dependent on fresh ground water supplies. Similarly, a significant proportion of water used for domestic purposes is taken from ground water aquifers. Any change in ground water resources would have a significant impact on land use in the RMI. Since subsistence agriculture has a more limited role in the Marshall Islands than in most atoll states, the result would not be severe as elsewhere. Nevertheless, although atoll plant species are generally resistant to some salt intrusion, there are unlikely to be any crop or plant species that would benefit from a greater level of salinity.

Most of the settlements in the Marshall Islands are necessarily located near the coast. Increased coastal erosion would threaten some of these settlements and make relocation necessary. Unfortunately, this would be virtually impossible in Ebeye and Majuro where the urban areas are almost completely filled-up and where private land tenure prevents some kinds of relocation. Elsewhere, central depressions, and mosquitoes discourage residence at a greater distance from the coasts. Only a few areas, such as Laura, can relocation be possible, albeit to a very limited extent.

8.2. Impact on coastlines

Increased wave height and increased storminess are both likely to cause erosion of unstable coastlines in the RMI as they have in the past. In some islands coastline stability is greater than on other atoll islands because of the extensive fringe sandy or conglomeratic beachrock, and the existence of natural beachrock accumulations. These deposits will offer temporary resistance to the erosion likely to be caused by rising sea level, but in time will themselves succumb to this erosion. Few atolls, except where mangrove exist, will erosion be less significant.

Erosion of the coastline of Majuro is occurring at a considerable rate as coconut trees and coastal vegetation fall over as the soils are washed away from underneath them. This situation is not helped by the amount of dredging and sand mining that is happening especially around the airport area.

8.3. Impact on water supply

In the northernmost islands of the RMI, the ground water lens usually becomes saline following drought periods. In the southern islands including Majuro and Kwajalein, adequate rainfall prevents this from occurring except on the small atoll islets.

Warmer periods in the tropical Pacific are associated with positive Southern Oscillation Index values or anti-El-Nino movements, and drier climatic conditions. Should this association of lower rainfall with higher temperatures persist with global warming, the ground water resources of these atolls would decrease, with less rain-fed recharge, increased evaporation and increased water demand. However, should sea level rise, the fresh water lens which floats above a mixed salt water base will be elevated, and its slope and head increased. This is likely to result in increased lateral saline mixing, increased evaporation through taro pits and wells, increased loss of fresh water by coastal leakage, saline water being brought within the reach of coconut and other tree crop roots or well and pump intakes, and generally a loss of the fresh water resource. If sea level rise is accompanied by increased storm surges, which will favor island building, such wash processes will render groundwater saline until a state of stability returns. Such stability is possible only when sea level rise ceases.

Majuro's water reservoir has the capacity to supply the island's current population for between 30 and 50 days without recharge. This capacity will be severely tested in the event of prolonged droughts and it is not surprising that the MWSC is seeking assistance for the extension of the existing facility. It is estimated that about 200,000 gallons of water is being lost from the existing reservoir each year due to evaporation.

8.4. Impact on Fisheries

The tuna fishery of the EEZ of the RMI is the mainstay of the nation's economy. However, there are limiting factors to the continuing viability of the sector including the sustainable yield of the fish stock, the world markets for the products and the effects of climate phenomena such as El Nino and ENSO. It is not known how increased ocean temperatures will affect the tuna fishery industry but it is acknowledged that the tuna fishery is a risky and costly business for Mashallese. Hence, despite the fact that only about 5% of the potential fisheries revenue is retained in the RMI, the government will continue to look at foreign fishing vessels and companies for the utilization of its tuna fisheries for some years to come.

Subsistence fishery is particularly important and includes reef and lagoon, as well as oceanic fisheries. There is concern that the current rate of damage to the corals and coral reef systems from land based pollution activities is having negative effects on the life cycle of many coral and fish species. Dredging, sand mining and beach erosion are having detrimental effects on the corals and reefs and these are in turn having negative impacts on fisheries resources of the country.

Yellowfin and bigeye tuna stock are reported to be nearing full exploitation. El Nino conditions in 2002-2003 resulted in the principal tuna stock moving out of RMI waters and congregating more in the western hemisphere around Papua New Guinea and its neighboring countries. This led to decreased catch and less trans-shipments occurring in the RMI. This situation is expected to reoccur under similar conditions in future.

8.5. Impact on agricultural crops

Prolonged periods of drought over the past twenty years have been observed to have adverse effects on the agricultural productivity of the atolls. Both taro and breadfruit production have been affected by the changes to the water table under adversely dry conditions and this situation can only be expected to worsen with future climate change events such as reduced rainfall and more frequent and intensive droughts.

Although there is still not a clear understanding of whether increasing temperatures will directly affect subsistence crops in the RMI, observations seems to suggest that subsistence crops will indeed be affected. The scenarios of future temperature change for the middle of the next century indicate a rise of 1.6 – 2.9°C, implying a climate regime that is considerably different from that of the present. Crops like taro and arrowroot are already showing signs of stress under present conditions and are doubtful to survive further increases in temperature.

On the other hand, there is strong evidence that rainfall variations directly affect crop yields and production in the RMI. For example, during the El Nino season of 1997 -1998, there were significant yield reductions in most crops. During prolonged dry periods, even coconuts were affected, and many trees died.

The scenario of higher rates of sea level rise and increased incidence of extreme events such as droughts and tropical cyclones could result in increased salinity of the soils and fresh water lens, thus impairing food security.

9. Typology of likely impacts of climate change on agriculture and food security in the RMI

The likely impacts of climate change and climatic variations on agriculture and food security in the Marshall Islands are summarized in the following Table.

Table 1: Impacts of Climate Change and climatic variations on agriculture and food security in the RMI.

Threat	Impact	Potential Response
Sea level rise	• Erosion of shoreline • Expansion of flooding zone • Slow coral/reef growth affecting fisheries • Cause coral die-back • Cause salinity of ground water lenses	• Construct coastal erosion protective measures • Consider/apply appropriate fisheries management approaches • Move gardens to higher grounds • Resettle populations

	• Loss of agriculture land • Cause plant stress • Contamination of ground water lens and wells. • Inundation and flooding of settlement areas and gardens	from highly vulnerable islands • Promote water conservation practices • Plant coastal vegetation and control dredging and sand mining
Typhoons/cyclones and associated wave surges	• Damage to agriculture crops and settlement areas from salt spray and flooding • Salt water intrusion of ground water lens and wells • Erosion of coastline • Reduced water supply for human and agriculture use • Damage to corals and reefs.	• Construct appropriate coastal protection measures and control dredging operations • Relocate settlements and gardens to less vulnerable areas • Improve rain-water catchment and storage facilities • Develop / implement coastal infrastructure management plans.
Increased temperatures, droughts / decreased rainfall	• Plant stress • Low productivity of farmers due to heat stress • More droughts causing water salinity • Reduced fresh ground water supply for agriculture • Slow growth and reduced yields from food crops • May cause slow growth of corals, coral die-back and coral bleaching • Slow recharge of water lenses • Increased soil salinity • Increase in intensity and frequency of tropical cyclones or hurricanes • Changes in soil quality and crop yields • Decreased fisheries catches	• Introduce more heat / drought resistant plant varieties • Change/modify outdoor working hours • Improve rain-water catchment/storage facilities • Encourage local processing and storage of traditional food crops • Avoid monoculture strategies • Apply water conservation practices / measures. • Develop and carry out drills on early cyclone warning system. • Increase water storage facilities • Desalination
Increased rainfall	• Increased ground water	• Apply ground water

	supply thus alleviating water shortages • Contamination of wells • Create conditions favorable for spread of plant pests and diseases • Erosion of shorelines • Increased run-off causing marine pollution	management techniques • Apply pests and diseases management approaches • Improve rain water catchment and storage facilities • Apply coastal protection measures • Beach nourishment

10. Other Factors Contributing to the Vulnerability of the Agriculture Sector in the RMI

With a total land area of just under 110 square kilometers, a mean height above sea level of only 2 meters and nutrient-poor soils, efforts to develop and improve the agriculture sector in the RMI have been frustrating and challenging. In addition to problems associated with climate change and climate variability, a number of other factors also contribute to the vulnerability of the sector. They include the following:

10.1. Rapid Population Growth

The high population growth rate of the RMI is already putting considerable pressure on the islands' limited land and sea resources and there is no reason to believe that there will be any significant reduction in the population growth rate this century as a large number of children enter the fertile age groups. Indeed, just over half the population (51 per cent) are aged 14 or under demonstrating the potential for further growth. Unless more serious effort is made to control population growth, the idea of a self-sufficient RMI will remain an impossible target for the government to achieve, even without the impacts of climate change.

10.2. High Population Density

Associated with the rapid population growth is high population density especially in the urban centers of Majuro and Ebeye. In 1988, Ebeye's population density of 23,500 people per square kilometer was considered one of the highest in the world. Such high population concentrations have led to environmental problems (high water usage resulting in the pollution of water lenses, slow replenishment of water lenses, waste disposal, vegetation clearing) which in turn make the islands more vulnerable to natural hazards. Resettling some of these people within Majuro and Ebeye is a difficult option as there is already little land available for this purpose. Improving the socio-economic situation of the outer islands on the other hand might encourage some of these people to return to their home islands. Whatever decision is taken, it is quite clear that the population density in the urban centers is unsustainable and there is therefore an urgent need to address this problem as a matter of high priority.

10.3. Low Priority Accorded to Agriculture Development

Although early development policies favored a movement towards self-sufficiency in the agriculture sector, considerable constraints to expansion of the sector still exist and as long as these constraints remain, government priority has and will be redirected elsewhere. Land shortage, high labor costs, minimal taxation on imported goods, limited marketing infrastructure, inadequate and expensive transportation systems frustrate developments in the sector and will in turn, cause government to invest in other more worthwhile development activities.

10.4. Destruction of Coral Reefs

The ongoing destruction of coral reefs particularly through dredging, channel blasting and boat anchoring represents a serious environmental challenge to the government of the RMI. In addition to their crucial supportive role in the maintenance of healthy reef fisheries and uniquely biodiverse ecosystems, living reefs are also essential wave-breakers which help to avert coastal erosion and storm flooding, and are suppliers of organic matter which build up the atolls. If these destructive activities are not stopped, then the impacts of climate change induced events such as storms and wave surges will become more severe. Beach and soil erosion are also affecting coral growth as so are pollution from waste and waste water run-off.

10.5. Changing Patterns of Food Consumption

Since the post-war years, diets have been transformed away from one based on local foods (breadfruit, taro, banana, pandanus) to one in which rice has now become a staple; even in the outer islands where imported foods are now the major component of peoples' diet. In some places, local fish costs more in stores than imported chicken, hence there is a disincentive to the expansion of artisanal fishing. The same is true of other imported food stuff like rice, flour, tinned and frozen meat which are often cheaper than local produce but of less nutritional value. These changes in food consumption, coupled with the limited and impoverished lands for agriculture make it very difficult for government to encourage and promote further development in this sector.

10.6. Lack of Capacity to Deal with Climate Change Issues

There is an acute shortage of skilled agriculturalists and fisheries specialists in the RMI and the situation will not be helped by an education system oriented to "white collar" occupations rather than agricultural development. Compounding the problem is the lack of local capacity to deal with climate change related issues and concerns. The RMIEPA and other relevant government agencies are trying to help as much as they could within the limits of the resources available to them but it is noted that the activities of these agencies have over the years, remained responsive rather than prospective. Improving inter-agency cooperation will go a long way in addressing the lack of capacity to deal with climate change issues that exists in the RMIEPA today.

11. Climate Change Related Activities of Other Organizations in the RMI

A number of regional and international agencies have provided financial and technical assistance to the RMI to deal with climate change related issues affecting the country over the past several years. The major projects and programmes of relevance to the agriculture sector are summarized in the following paragraphs.

11.1. The National Environment Management Strategy (NEMS)

The NEMS was the first ever government-wide effort to evaluate environmental management needs of the Marshall Islands and to establish future priorities for improving national management capabilities. Developed as a product of a lengthy and highly consultative process with government leaders, the private sector and local communities, the NEMS provided the impetus which saw the implementation of follow up projects and activities that focused on the priorities and needs identified through the NEMS process. The NEMS was funded by the ADB through the Regional Environment Technical Assistance (RETA) project in 1991. Additional funding was provided by the World Conservation Union (IUCN) and the UNEP. The RETA was coordinated at the regional level by SPREP. The NEMS identified global climate change and the accompanying potential for a devastating rise in average sea level as "the most threatening long-term environmental issue facing the Republic of the Marshall Islands".

11.2. Potential Impact of Expected Climatic Changes on the Natural Environment, Socio-economic Structures and Activities of the RMI

In 1992, SPREP, under the general supervision and guidance of the Chairman of the Association of the South Pacific Environmental Institutions (ASPEI) commissioned the development of a proposal for a programme of assistance to undertake an in-depth study of the potential impact of expected climatic changes (primarily sea-level and temperature rise) on the natural environment and the socio-economic structures and activities of the Marshall Islands. The mission, amongst other things, carried out a preliminary assessment of the available demographic, social and economic data, identified the most vulnerable components and sites of the natural environment, as well as socio and economic structures which may be most critically affected by expected climatic changes, and developed a proposal for a joint programme of assistance with the host country for consideration by a number of organizations including SPREP and UNEP.

11.3. Effects of the 1998 Drought on the Freshwater Lens in the Laura Area, Majuro Atoll, Republic of the Marshall Islands

Lower than average rainfall during late 1997 to early 1998 resulted in a drought which in turn raised public concern about the condition of the freshwater lens in the Laura area because of increased pumpage in response to water shortage. The U.S Geological Survey, in cooperation with the RMI government and in collaboration with the Federal Emergency Management Agency (FEMA), assisted the Majuro Water and Sewer Company (MWSC)

determined the condition of the lens at Laura during the drought. The study suggested that seasonal variations in rainfall and recharge, pumpage and washover from storm waves and tsunamis can cause temporal and spatial variability in the thickness of freshwater lens. The shape of the land mass and the variability of the lithology within the land mass also affect lens thickness. Chloride concentrations increased during the drought and that the freshwater nucleus (the part of the lens with chloride concentrations less than 500 milligrams per liter) was thicker on the northern end and the middle of Laura in 1984 than 1998 and thinner on the southern end, the ocean side, and the lagoon side (Presley 2005).

11.4. Water and Sanitation Sector Strategy and Action Plan

Under the UNDP-funded Pacific Water and Sanitation Program, the SOPAC, in 1996 prepared a Water and Sanitation Sector Strategy and Action Plan for the RMI. The Action Plan is a nation-wide document to implement the Strategy and include all sector requirements, studies, actions, activities, institutional strengthening, legislative requirements, financial requirements, demand management, training requirements, critical constraints and evaluations. It addresses needs for a 20 year period presented in priority actions to be implemented in 5 to 10 year periods.

11.5. Pacific Islands Climate Change Assistance Program

With support from the Pacific Islands Climate Change Assistance Program (PICCAP), the government of the RMI through a task team comprising experts from relevant government agencies, NGOs and the private sector prepared the RMI's First National Communication report to the UNFCCC in 1998. The PICCAP was funded by the GEF, administered by the UNDP and implemented by SPREP. The National Communication included information on the vulnerability of the RMI to climate change as well as the nation's capabilities and needs for adapting to the adverse effects of climate change. PICCAP also provided funding for a vulnerability assessment simulation exercise; review of the GHG emission report; a mitigation workshop; capacity building for international negotiations and awareness programs involving government and various sectors of the community.

11.6. A Framework for Action 2005 – 2015: Building the Resilience of Nations and Communities to Disasters

The 2005-2015 Framework for Action was prepared by the SOPAC in response to increased national and regional commitments to disaster risk reduction and disaster management. It also directly supports the development and implementation of policies and plans for the mitigation and management of natural disasters, which is one of the key initiatives of the *Kalibobo Roadmap*, which reinforces the objectives of the Pacific Plan. The framework also complements other relevant regional frameworks, declarations and policies including those relating to climate change, ocean resources, freshwater, health, HIV/AIDS and agriculture.

11.7. Pacific Islands Renewable Energy Project

The RMI, together with a number of other Pacific island countries took part in the Pacific Islands Renewable Energy Project (PIREP) which started in 2003. This project was carried out over a period of 18 months and had as its main goal the removal of barriers to the

development and commercialization of renewable energy in the PICs that influence country efforts to reduce the long term growth of greenhouse gas emissions from fossil fuel uses, especially diesel.

11.8. Regional Program for Food Security in the Pacific Islands (RPFS)

In addition to many other programs and projects supported by FAO in the region, this RPFS program, endorsed at the Sixth and Seventh FAO South West Pacific Ministers of Agriculture Meetings, aims to address agriculture trade, food quality and safety, and climate change focusing on the urgent need for preparedness, and putting in place adaptation and mitigation strategies and actions. The Sub-Program 2.3 (Natural Disasters and Climate Change Preparedness, Adaptation and Mitigation) has four components dealing with (i) Agriculture Diversification; (ii) Integrated Coastal Management; (iii) Land and Water Management and Use; and (iv) Technical Coordination Support. Interventions of the expanded program will target:

- Enhancing food production;
- Rural infrastructure development; and
- Strengthening agriculture trade and policy, climate change adaptation and mitigation and support for project planning and program development.

FAO has supported pig development and improved home gardening in the RMI under this project.

11.9. South Pacific Sea Level and Climate Monitoring Project (SPSLCMP)

With funding from AusAID, the SPSLCMP has from 1992, installed a number of SEAFRAME stations on several Pacific island countries including the RMI to provide accurate and long term sea level records. The SEAFRAME gauges record sea level, air and water temperature, atmospheric pressure, wind speed and direction. The SPSLCMP was a response to concerns raised by the FORUM leaders over the potential impacts of an enhanced greenhouse effect on climate and sea levels in the Pacific region.

11.10. Action for the Development of Marshall Island's Renewable Energy (ADMIRE)

The ADMIRE builds on the work done by the GEF-funded Pacific Island Renewable Energy Project (PIREP) which resulted in the design of the Pacific Island Greenhouse Gas Abatement through Renewable Energy Project (PIGGAREP). Following a national Renewable Energy (RE) assessment under PIREP, the RMI decided to implement its own national RE project which could still address regional priorities but would better suit its own national circumstances and sustainable development aspirations and goals. The ADMIRE was therefore designed with the goal to reduce GHG emissions from unsustainable use of fossil fuel (primarily diesel fuel oil) through the utilization of the country's RE resources. The objective of the project is to remove barriers to the utilization of available RE and the application of Renewable Energy Technology (RET). The objectives will be achieved through (i) increased number of RE hardware installations on the ground which enhances

productivity and income generation; (ii) enhance institutional capacity to coordinate, finance, design and maintain RE installations; (iii) improve accessibility of capital for RE business; (iv) strengthen legal and regulatory instruments to support RE dissemination, financing and marketing; and (v) improve awareness, skills and knowledge.

11.11. Pacific Adaptation to Climate Change (PACC) Project

The PACC is a regional project implemented by SPREP involving 13 PICs. The main objective of the project is to build PIC capacity to adapt to climate change. In the Marshall Islands, the PACC is focusing on ways to reduce pressure on the water supply system including more effective irrigation systems (example, bucket irrigation) and increasing capacity of rainwater catchment facilities in order to reduce dependency and pressure on ground water sources. The SPC, SOPAC and JICA have all shown interest in improving the water supply situation in the RMI.

12. Existing Institutional Mechanisms and Policies

12.1. Policies

The principal policy instrument guiding the sustainable development of the RMI till 2018 is the Strategic Development Plan (SDP) 2003-2018 more commonly known as the Vision 2018. The SDP was prepared in June 2001 and approved by the Nitijela in October 2001. It links ten major challenges the country has faced over the last 15 years with ten broad national goals and objectives aimed at fostering sustainable economic development. The SDP envisions that a review of the progress of the SDP be carried out after 5 years, that is in 2007.

The SDP includes two key goals of the environmental sustainability policy, namely: a) developing a regulatory system that can be enforced with a high degree of compliance at all levels, in order to achieve the sustainable development of natural resources while protecting the environment from any adverse impacts; and b) strengthening the relevant institutions and improving the procedural mechanisms so as to be able to secure the optimum support from international and regional efforts in mimizing the adverse impact of climate change.

In addition to the SDP, the National Planning Office (OPS) was revitalized into the new Economic, Policy, Planning and Statistics Office (EPPSO) which is mandated to monitor and evaluate the progress and development of the country. New priorities and action plans have been established but the environmental sustainability development priorities as set out in the SDP have yet to be mainstreamed into the current strategic development plans of government ministries and agencies (ADB 2005).

Until 2004, there had not been a formally appointed government body tasked to monitor and report on the status of the Millennium Development Goals (MDGs). Hence, the begin developing a framework for MDG monitoring and reporting, EPPSO in 2004 formed a

partnership with UNDP to establish a program office within EPPSO with the Program Manager providing assistance to EPPSO to monitor and report on the MDGs and to provide technical support to the National MDG Task Force, when established.

The necessary institutional structures to deal with climate change and other environmental concerns are in place although despite some recent notable improvements in environmental performance, in many areas and respects practical reality falls far short of the potential the above frameworks allow and should facilitate. Like other PICs, most organizations in the Marshall Islands have limited capacity in terms of staff numbers, numbers of technical staff, access to technical equipment and financial resources. Government agencies focus on immediate and practical priority issues and have difficulty maintaining current levels of services in key sectors including agriculture. While many government agencies recognize the importance of reducing GHG emissions and preparing for climate change, it is difficult for government to take the longer term economic decisions necessary. Consequently, little is being done to curtail the impact of development activities that are contributing to the vulnerability of the islands to the effects of climatic events.

At the national level, RMI has legislation related to environmental protection, coastal conservation, planning and zoning, management of marine resources, preservation of cultural and historic properties, protection of public health and safety and of endangered species. In most cases the legislation allows Ministries to pass and enforce regulations, usually on approval of a representative authority or council. In many cases, legislation also gives a mandate to Local Government Councils to pass and enforce ordinances that are consistent with national legislation and regulations.

At the international level, the RMI is a party to many international and regional environmental and resource management agreements including the UNFCCC, the UNCCD and the Convention on Biodiversity. RMI is also a member of several international and regional organizations including the FAO, ADB, SPREP, Forum Secretariat, SOPAC, and SPC to name a few.

12.2. Local Agencies and Institutions

A number of government agencies and institutions play key roles in addressing climate change concerns and agriculture issues in the RMI. The following are particularly important.

(i) The Republic of the Marshall Islands Environment Protection Agency (RMIEPA).

The RMIEPA is the enabling agency for the 1988 Coast Conservation Act which amongst other things called for the development of a *National Coastal Management Framework* to review current coastal conditions and activities including dredging and sand mining, seawall construction, reclamation and landfills, coral reef degradation, solid waste management, human and animal waste management, shipwrecks and natural disasters among others. The Framework also recommended proposals for action and policy in 2006 to achieve sustainable future development and remedy past development in and around the costal zone of the RMI. The RMIEPA has programs for regulating the quality of fresh and coastal

waters, waste disposal monitoring, environmental sanitation, earthmoving and public awareness.

An extensive survey of the coastal zone of the RMI has been carried out primarily through the development of Geographic Information System (GIS) databases from satellite imagery and on the ground data collection on Majuro, Ebeye, Jaluit and Wotje. Current land-use, infrastructure, coral reefs (and benthic habitat in general), aggregate resources, recreational and religious areas, wetlands, and research areas are all included in the survey. RMIEPA works closely with the Coastal Management Advisory Committee (CMAC) and MIMRA's Coastal Fisheries Program in the implementation of the Framework.

(ii) Office of Environment Planning and Policy Coordination (OEPPC)

The OEPPC under the Office of the President was created by Cabinet in early 2003 and further established by legislation on September 1, 2003. The OEPPC Act 2003 requires the development of plans, policies and long term strategies for climate change, sea level rise, biodiversity, land degradation, amongst other things. The establishment of the OEPPC was part of government's efforts to integrate economic, social and environmental issues to help ensure sustainable development for the RMI. The OEPPC has responsibility for all Multi-lateral Environmental Agreements the RMI is party to including the UNFCCC, the Biodiversity Convention and the UNCCD. OEPPC is the center responsible for climate change policies and provides advice to the National Government. OEPPC works collaboratively with a number of other relevant government agencies in the development and coordination of environmental activities in the RMI and is the main contact for SPREP.

(iii) Marshall Islands Marine Resources Authority (MIMRA)

The MIMRA Act of 1988 established the MIMRA to coordinate and regulate the exploration, exploitation, and management of biological and physical resources. Prohibiting the use of fishing techniques which significantly damage reef ecosystems, such as the use of dynamites or chemicals, the Act defines standards for fishing equipment and prohibits foreign fishing vessels from fishing within the EEZ without licensure. The MIMRA has developed a National Action Plan which accounts for all the policy measures and strategies for the conservation and sustainable use of terrestrial and marine biodiversity, in particular endemic species, including protection from introduced non-indigenous species. A specific provision of the Act allows the MIMRA to delegate responsibility to each local government to manage and protect their own marine resources within their 5 mile zones and to this end, the Authority is currently implementing a coastal resource management program in two atoll communities, Mejatto and Likiep to develop their fisheries management plans and ordinances. These community-owned plans include the establishment of community-owned marine protected areas, regulation of seasonal catches and size limits as stipulated in the MIMRA Act. MIMRA is also engaged in developing technology for the cultivation of black-lip pearl oysters and in farming of giant clams and trochus. Plans are also envisaged for similar work on other species such as sea cucumbers, seaweed, sponges and algae.

(iv) Ministry of Resources and Development (MRD)

The MRD is responsible for Agriculture, Energy, Trade and Investment in the RMI and is assisting the development of these sectors through activities that foster sustainable food production, provide alternative energy resources and generate alternative income opportunities for people of the RMI. Together with its development partners and other stakeholders, the MRD is providing facilitation and information to farmers, individuals, groups, potential and existing businesses and investors. FAO, European Union, ROC Taiwan and the US government have provided support through the MRD for various activities and projects in the RMI. Of particular note and relevance are the solar electrification projects which are expected to include a significant number of small atolls in the RMI and will hopefully alleviate the current high demand for diesel fuel. MRD's programs in the agriculture sector have an overall objective of raising the living standard of the Marshallese people. It supports strategies for increasing food security, protecting plants, animals and the environment, and increasing food quality, quantity, and variety of food grown on the islands.

(v) Majuro Water and Sewer Company (MWSC)

The MWSC operates the Majuro reticulated water supply system which uses a combination of airport runway rainfall catchment and groundwater wells as its source. Treatment includes sand filtration and chlorination. Apart from the main rainwater reservoir, groundwater wells especially on Laura are an important source of water supply for Majuro. Except for the capital building and the hospital which are supplied on a daily basis, MWSC distributes water only 3 days a week to residents and commercial enterprises on Majuro. The reservoir has a capacity of 36 to 38 million tones and pumps an average of 800,000 gallons a day for households from the airport to Rita. About 200,000 gallons is estimated to be lost from the reservoir through evaporation. MWSC hopes to at least double the current capacity of the reservoir and has received a grant from the government of Japan for expansion of the existing facility.

(vi) Office of Disaster Management (ODM)

The ODM is mainly charged with the management of relief operations after an emergency event. This task falls on the National Disaster Management Committee which usually meets every month or as the Chairperson decides. ODM works closely with SOPAC in the implementation of the Framework for Action 2005 – 2015 (a Regional Disaster Risk Reduction and Disaster Management Plan) but has an extremely limited capacity to do much. The SDP goals for environment sustainability are expressed in terms of a number of objectives which include the development of a contingency plan/adaptation plan to counter the emerging threats resulting from the adverse effects of climate change including a National Disaster Plan. Unfortunately, such a plan has not been developed and a National Policy Coordination Committee (NPCC) that was to be given the mandate to integrate the development policies into national planning and budgeting were not established. Instead the EPPSO was formed.

(vii) Economic, Policy, Planning and Statistics Office (EPPSO)

The EPPSO came about as a revitalized form of the former National Planning Office. It has the mandate to monitor and evaluate progress and development of the country. Some new

priorities for the environment have been established but these have yet to be mainstreamed into the current strategic development plans of government. EPPSO with assistance from UNDP is also tasked with the monitoring of progress in the implementation of the MDGs and to provide technical support to the MDG Task Force. EPPSO over the years has compiled an impressive collection of reports, information and data on the social and economic status of the RMI which would aid future planning and development in the country. Sadly, not many government agencies appear to be making good use of this wealth of information.

(viii) Marshall Islands Weather Service

The Weather Service has a new state of the art office funded by NOAA. The Office provides technical advice on climatic issues but is not involved in decision-making discussions. It liaises closely with NOAA and is the focal point for the Pacific Climate Change Programme and a member of the NAPA Task Force as well as the National Disaster Committee. Climatic data dating back to 1951 is available for almost all the atolls of the RMI and this information suggests that there has been a 1.5°C increase in temperature since about 30 years ago. Local weather forecasts are produced by the Weather Office however regional forecasts are distributed out of Guam and Honolulu. RMI has an Advanced Warning System which is available to all islands of the group.

(ix) Land Grant Program (LGP)

The Land Grant Program through its Extension Center in Majuro implements projects in agriculture, aquaculture, water and water quality, food and nutrition, and youth. Under its agriculture projects, the LGP promotes traditional crops and vegetables and carries out agro-forestry research in collaboration with the SPC. It also receives help from SPC with its activities relating to the control of agriculture pests and diseases. The LGP teaches agriculture at the certificate and diploma levels at the College of Marshall Islands (CMI) and has the technical capacity to undertake applied research and implement additional climate change related projects. The LGP work collaboratively with a number of different Ministries and the Farmers Association and has a facility for training. It also collaborates with the ROC Mission on Majuro who provide most of the seeds for the Program. LGP provide matching funds (1 : 1 ratio) for most of its projects.

(x) College of the Marshall Islands (CMI)

The CMI is the only institution apart from the USP Majuro-based Center providing tertiary education in the Marshall Islands. The CMI began in 1989 as the College of Micronesia-Majuro under a charter granted by the College of Micronesia. In 1993, CMI became an independent post-secondary institution and is accredited by the Accrediting Commission for Community and Junior Colleges of the Western Association of Schools and Colleges (WASC). CMI offers two or three year Associate of Arts (AA) and Associate of Science (AS) degrees in majors such as Business, Computer Science, Education, Mathematics, Nursing, Psychology and Social Sciences. It has 3 staff teaching science and others carrying out research projects including studies on the impact of land reclamation on the marine environment. CMI is intentional in providing education that will allow graduates to begin

employment in the RMI or transfer to another college or university to complete a four year Bachelor degree.

13. National Strategy to Mitigate and Adapt to Climate Change

13.1. Mitigation

Mitigation refers to the measures that will reduce the national release of GHGs. The Marshall Islands is a very minor producer of GHG emissions both in terms of total emissions and emissions per head of population. Mitigation measures will enable the RMI to further minimize any increase in its GHG emissions, however due to existing needs for social and economic development, a reduction in releases would appear to be a lower priority for the RMI government.

Most mitigation measures either reduce peoples' demand for GHG emitting products or else control their supply. They can incorporate education and awareness raising initiatives, fiscal measures such as financial incentives, taxes and charges, legislation to prohibit certain activities and policy measures. Some mitigation options believed to be of relevance to the current situation in the RMI are discussed below.

a) Decrease dependency on fossil fuel. Diesel generators provide the majority of electricity in the RMI, particularly in the two urban centers of Majuro and Ebeye. RMI however has the potential to use a range of other alternatives for generation of electricity such as solar and wind. In fact, solar energy has already been seen as the best option for the outer islands and the government has received considerable assistance to promote and expand its use in several outer islands. Work on biofuel from coconut oil has started on a very small scale although there is considerable interest especially from the private sector in this area. While the government has touted interest in the revitalization of the coconut industry, it is not clear how much of this interest is influenced, if at all, by the biofuel debate. It is noted though that any major investment in the production of coconut oil for biofuel as a substitute for diesel in the transport sector will have to be matched by a large scale replacement program for the thousands of senile palms that represent the majority of existing coconut stands on the islands.

b) Decentralize services and economic activities. Increased decentralization of services and economic activities coupled with greater development of the local markets would do much to reduce current dependence on inter-island transport between Majuro and Ebeye as the hubs. Such change would be facilitated by economic incentives for skilled workers and entrepreneurs to establish themselves locally rather than being based in one of the two urban centers. The majority of small farmers are in the outer islands and will benefit from not having to go far to sell their produce and hence, there will be gains from reduced-emissions from inter-island travel.

c) Improve efficiency of heavy equipment and appliances. While the value of the mining and quarrying sector is continuing to grow (from $192,600 in 1995 to about $300,000 in 2000), the resultant damage to the land and marine environment of the RMI from this sector has been significant. The size and capacity of equipment used in the sector far exceeds the need and their operation and maintenance places a heavy burden on the government's budgetary resources. In addition, many government offices are air-conditioned while a ceiling fan or opened windows would have been quite adequate. Improvements to the operating efficiency of the heavy equipment and appliances will require greater awareness of the cost savings that results to the user and training of technical personnel in the operation, maintenance and repair of heavy machinery and appliances.

d) Enhancing the enabling environment for better environmental management. There is a need to recognize in the performance-based budgeting process the need to strengthen program outputs and performance standards to provide greater focus on core environmental and resource management functions. Ensuring that legislation and regulations are not providing perverse incentives that result in environmental degradation but are encouraging decision making and actions that result in good environmental outcomes is an important challenge. Improving the use of information management systems to improve the quality and environmental outcomes of decision making as well as compliance and enforcement including open access to information and sharing data bases and other information resources can go a long way in understanding and supporting actions to mitigate against climate change.

13.2. Adaptation

Adaptation refers to changes in technology, practices and policies that can prepare a country for the impacts of climate change resulting from GHG emissions. While the RMI's vulnerability to climate change and sea level rise will be determined by the decisions and actions that are made today with respect to the management of the country's resources and the nature of its social and economic development, the RMI is nevertheless in a position to adopt pro-active adaptation strategies that can be implemented immediately and sustained over the years to effectively reduce its vulnerability. However, there are three main obstacles to b considered:

- In the present socio-economic climate, it has been difficult to identify national resources that could be redirected to climate change adaptation activities from immediately pressing social development needs;
- Climate change issues are, in general, poorly understood; and
- Despite efforts to make climate change planning multi-sectoral, it has not been incorporated into the mainstream planning activities of governments and sectoral organizations (ADB 2005).

Given the poor state of knowledge and understanding of climate change issues that exist today, coupled with the limited financial resources and low levels of technology, the RMI, like many other PICs faces a formidable challenge to adapt to climate change. Some adaptation opportunities that are considered to be appropriate and achievable in the RMI are discussed below.

a) Improve research and understanding of subsistence root crops. The productivity, growth requirements and pathogens of the RMI's main subsistence crops are not well understood. Application of new technical know-how and skills to improve soil conditions, crop yields, animal husbandry and management, and improvement of agricultural facilities will help refocus attention on local resources and support current efforts to revive interest in these crops as substitutes for imported foods.

b) Improve land use and physical planning mechanisms. Land use and physical planning that take into consideration the possible impacts of climate change and sea level rise provides a powerful tool for reducing vulnerability. Planning mechanisms can be used to direct or regulate all new investments in infrastructure, housing construction and agriculture outside hazard zones to minimize vulnerability, reduce repair costs and decrease disruption to economic activities. Involving the landowners in such planning exercises will endear them to the plans thus ensuring their long term success.

c) Prohibit extractive activities from vulnerable sites of the coastal areas. Given the atoll nature of the RMI, it is unrealistic to impose a general ban on all extractive activities that are largely responsible for the destruction of coastal areas of the country. However, there are some areas that are more vulnerable than others and it is these most vulnerable sites that warrant immediate drastic measures in order to stop any further damage. Construction of coastal protection infrastructure will certainly be an option but there is a need to first investigate and identify the most suitable and feasible options.

d) Improve capacity and management of Majuro's rainwater catchment and reservoir. Increasing the capacity of the existing rainwater catchment and reservoir coupled with better management of existing water resources will go a long way in meeting the increasing demand for water from Majuro's growing population, maintain water quality and decrease the pressure on groundwater resources. Providing a cover to the existing facility will help decrease water loss due to evaporation. These efforts, if implemented will in turn help minimize the impacts of climate change on water resources while providing immediate benefits to drought prone areas and those that are already suffering from seasonal shortages of water.

e) Promote agro-forestry and other tree planting initiatives. Promoting agro-forestry regimes that enable the maintenance of the standing biomass will be an appropriate adaptation measure for areas that are already experiencing soil and vegetation loss through erosion. Replanting of littoral vegetation will help

stabilize eroded coastal areas and protect settlements from wave and wind actions.

f) Improve monitoring of water extraction from groundwater lens. The introduction of policies that allow the extraction of freshwater from wells to exceed certain levels only where there are no feasible alternatives would reduce the vulnerability of the local communities to water shortages during drought. Controlling human waste seepage from septic tanks in Laura would help prevent pollution of underground aquifers.

On the basis of the vulnerabilities identified and the adaptation options discussed in the preceding section and elsewhere in this report, a national strategy for the RMI to mitigate and adapt to climate change and climate variations is proposed in Annex 2.

14. Success Stories and Lessons

Except for the lessons learned from its IWP project, there has not been a lot of effort put into documenting lessons learned from the various projects implemented in the RMI. However, from the review of reports and documents made available during this assignment and through consultations held during the course of the country visit, the following can be deduced to be the lessons from the RMI's experience in dealing with climate change issues as they relate to agriculture.

i) Population planning and control should be made an integral part of any national strategy to adapt to climate change. The extremely high population growth and density in the urban centers of Majuro and Ebeye are already frustrating national efforts to sustain supply services especially during natural disasters. More and more people are putting pressure on the coastal ecosystems, water supply and infrastructure making them more vulnerable to extreme climatic events. Government is already struggling to provide for the current population and will be in an even worse situation in ten to twenty years from now as the population continues to grow. Unless government takes serious actions to control population growth especially in the urban centers, RMI will face massive costs in terms of money and lives resulting from natural disasters.

ii) Strengthen partnerships for effective project implementation. With several islands scattered over long distances of ocean, implementation of national projects in the RMI will always be a difficult challenge. Government services are extremely limited or absent on most islands except the urban centers of Majuro and Ebeye and this will compound the problem. Conversely, a handful of agencies and NGOs have been active in the outer islands and are best placed to assist government carry out some of its projects in these locations. To do this would require the establishment of effective working partnerships between the parties to ensure that their roles and responsibilities are clearly identified and understood. Similar arrangements with local communities may also prove beneficial.

iii) Enhance public awareness and understanding of climate change and its likely impacts on peoples' livelihood. While public awareness about global warming is improving through the media, public awareness about the impact of climate change on the peoples' livelihood is somewhat limited. Such awareness and understanding is crucial to fostering effective partnerships with local communities on efforts to adapt to climate change.

iv) Reduce complexity of programs and project designs. While the RMI now has some capacity to implement enabling environmental projects, it does not yet have adequate technical capacity to design and implement complex, long term science-based initiatives that often require careful research and data collection. In this regard, projects and programs for the RMI should therefore be designed from the outset to be flexible and to match local capabilities to implement and manage. They should be less complex and more focused. Expected outputs should be prioritized, transparent, clear and measurable.

v) Strengthening service delivery to the outer islands is crucial to nation-wide efforts to minimize the impacts of climate change on the environment and people. Poor and unreliable transport and communication networks are hampering efforts to engage outer island communities in climate change adaptation initiatives. As a result, past climate change activities have concentrated on urban areas while those in the outer islands miss out on training and other benefits from such initiatives. Improving transport and communication links to the outer islands is crucial to the success of climate change adaptation efforts in areas that are often neglected by government programs and extension services.

vi) Engage local communities from the outset of climate change adaptation initiatives. Involving local communities from the outset in the planning, design and implementation of climate change adaptation projects is crucial to their success. The development of an appropriate consultative and participatory mechanism for the government and the communities to consult with each other is an important step in formulating an efficient and effective working relationship between them.

vii) Mainstream climate change mitigation and adaptation into physical planning and development initiatives. Although the SDP (or Vision 2018) has provided the mandate for the development of a Master Plan and accompanying Action Plans for achieving national goals and objectives to the year 2018, no such plans have been developed and as a result, environmental sustainability development priorities as set out in the SDP have yet to be mainstreamed into the current strategic development plans of government ministries and agencies. Unless climate mitigation and adaptation are fully integrated into the planning and budgeting processes of government, these issues will continue to be addressed in a piecemeal fashion as has been in the past.

15. Recommendations

15.1. General

The following recommendations are considered appropriate for consideration by the government of the RMI, its development partners and other stakeholders with interest in the RMI.

a) Pay more attention to population growth. Although the RMI's average population growth rate is about 1.4%, the growth rates varies widely with some atolls experiencing rates of less than 1% while others are experiencing high rates of about 4.8%. Majuro and Ebeye have some of the highest population densities in the world and the situation will worsen as the population continues to grow. Existing services and facilities will not be able to cope with the demands of a growing population in the next few years and it is therefore recommended that government give more attention to controlling population growth as an important part of any strategy to adapt to climate change.

b) Given the RMI's limited financial and technical resources, it will be impossible for the government to effectively address the wide range of issues and actions necessary to respond and adapt to climate change. Hence it is recommended that the government should strategically address a limited number of clearly identified priorities and actions based on the greatest needs and risks from climate change. Examples are water supply, coastal erosion and renewable energy.

c) Financial constraints, coupled with poor transport and communication networks are hampering efforts to reach out to the farmers in the outer islands who are especially in need of support during natural hazards such as droughts and cyclones. In this regard, it is recommended that government should consider improving service delivery and communication to outer islands as explicitly clear priorities for donor-funded development projects in future. Decentralization of agriculture services such as plant breeding, extension and veterinary support of the MRD should inevitably follow improvements to outer island transport and communication systems.

d) GEF-funded national and regional climate change related projects in the past decade have provided a wide variety of training and human resource development in the RMI. FAO, SPC, SOPAC and the EU have also supported capacity building initiatives in the agriculture and these have contributed enormously to building the RMI's overall capacity to address environmental and agricultural related national concerns while at the same time also meeting the country's obligations under international regional and international agreements. However, due to the high rate of occupational mobility, retirement and migration, it is recommended that human resource development initiatives need to be continued and expanded if the RMI is to be able to deal with the growing and complex issues associated with climate change.

e) Local markets for traditional crops are very limited not only in the urban centers but also in the outer islands. Many Marshalleses are said to have lost the taste for local food and it is uncertain therefore if extra efforts to revive interest in traditional crops will result in increased consumption. In light of this uncertainty, it is recommended that government should to consider the local processing of food crops into more marketable commodities such as chips, flour, etc., that have longer shelf-life and are easier and lighter to transport. Processing can also create job opportunities for the large number of Marshallese who are presently unemployed.

f) The most immediate threat to the health of the marine environment of the Marshall Islands especially in Majuro and Ebeye at present comes from the impacts of dredging and soil erosion. How much of this threat is already taking place is not known thus it is recommended that there is an important need to carry out comprehensive studies and surveys to determine how and to what extent coral and coral reefs are being affected. Equally importantly, it is desirable to determine on the basis of the findings of the studies how future climate change and sea level rise would add to the existing situation.

g) Some farmers and local residents have noted slight changes not only to the fruiting seasons but in the yields of traditional root crops in recent years. Whether these changes are directly related to climate change and climate variability is not known although many speculate that there is a connection. Establishing the links between climate change and changes in crop production and behavior will go a long way in improving peoples' understanding of climate change issues and in enhancing efforts to involve local communities in the implementation of climate change adaptation strategies and plans. To this end, it is recommended that climate change awareness and training be continued and expanded to include communities in the outer islands.

15.2. Potential Projects for FAO Consideration and Implementation

The following projects were identified during consultations with officials in the RMI for recommendation to FAO.

h) Support beach restoration initiatives and measures to curtail soil erosion. Supporting such efforts would not only help stop beach and soil erosion which has resulted in the loss of significant areas of land, it would also help protect agricultural plots that are being seriously threatened by rising sea levels and wave surges.

i) Provide technical and financial support for the local processing and packaging of traditional food crops. Additionally, assist the identification and development of suitable local and overseas markets for these processed products.

j) Undertake a study on the impact of pollution from dredging, sand mining and other coastal development activities on the marine resources and environment of the two urban centers Majuro and Ebeye.

k) In collaboration with relevant local and regional agencies, support water conservation and irrigation practices and projects that contribute to the sustainable use of the RMI's water resources.

l) Support RMI's efforts to revitalize the coconut industry through the provision of technical advice and support for:

- The undertaking of a cost-benefit analysis of a country-wide coconut replanting scheme;
- Identify suitable products and markets for a revitalized coconut industry;
- Study the impacts of a coconut industry on the environment and natural resources of the RMI

m) Help develop the capacity of MRD, MIMRA and other relevant agencies to better manage land and marine resources of the RMI

n) Collaborate and provide support where necessary with activities of the Land Grants Program and the College of the Marshall Islands that help promote agriculture research, management and training in the Republic.

16. Conclusions

Although the RMI has already begun action and put in place the necessary structures and processes for integrating environment into sustainable development policies, much still needs to be done. The political level of support has increased as can be seen from the creation of the OEPPC to have overall coordination of all Multilateral Environmental Agreements under the Office of the President. However the lack of human and financial resources is a serious constraint to local efforts to adapt to climate change and the RMI will therefore continue to rely on donor support to develop and implement plans and strategies to address climate change issues.

The inter-related nature of climate change and agriculture production suggests that both short and long term views must be taken into account when considering adaptation measures for the RMI. While the desirable would be to address the original causes of global environmental changes and sea level rise, the reality is that small islands like the RMI that contribute so little to the cause of the problem and have the least capacity to deal with it, is being forced to deal with the effects. For this reason, the international community has an obligation to the RMI and other small island nations to assist them with the development and implementation of plans and activities that will, to the extent possible, alleviate the adverse impacts associated with climate change and sea level rise.

Climate change may cause chronic and or sporadic contractions in the food people are able to access through agriculture, fisheries and in the market place. Thus through impacts on food production, the ability of people and the country to import food, and its effect on

human health, climate change puts at risk the very basic and universal need of the people of the RMI to have access to sufficient, safe and nutritious food at all times.

Adapting to climate change, variability and sea level rise is a serious and urgent need for the RMI. And the ideal approach for adaptation for the RMI at this time is a pro-active, "no regrets" approach that encompasses measures and strategies that can be implemented now with the aim of reducing vulnerability in the future.

The coastal areas of the RMI especially in Majuro and Ebeye are already under serious threat from beach and soil erosion and this situation will be exacerbated by climate change related events such as storm surges and sea level rise. RMI lacks the capacity to deal with these problems now and there is a not a lot of effort being made to address these problems as a matter of priority. The determination of the impacts of existing coastal development activities on the marine environment would be a good start as this would provide a useful baseline from which the resilience of marine resources to future climatic events could be measured.

The main problem with assessing the impact of climate change and in identifying a cost-effective response is the uncertainty surrounding estimates of the time and magnitude of the changes to be expected. The difficulty lies in the complexity of predicting the changes, the short history of the variability of the historical data, and the problem of clearly distinguishing between cyclical effects (climate variability) and long-run climate change from which there would be no escape. Given these uncertainties, the "no-regrets" measures as proposed here for the RMI make sound economic sense.

17. Annexes

Annex 1. Terms of Reference

1. Background

At the 6th Meeting of the FAO South West Pacific Ministers for Agriculture (Cook Islands, June 2005), Ministers agreed that analytical studies would be conducted within the agricultural sub-sectors to facilitate the development of more specific policy recommendations, and that priority attention would be given to the following specific issue: Impact of climate variability on agriculture and food security in the Pacific.

At the 7th Meeting of the FAO South West Pacific Ministers for Agriculture (Marshall Islands, May 2007), Ministers recommended FAO to pursue a study to assess the impact of climate change on agriculture and food security in the Pacific islands region.

Pacific islands countries are extremely vulnerable to climate change, climate variability, and sea level rise. They are among the first to suffer the impacts of climate change and among the first forced to adapt or abandon or relocate from their environment. Some Pacific islands are low lying or have coastal features and characteristics that make them particularly vulnerable to climate change, variability and sea level change. In addition to significant coastal impacts, climate change affects biodiversity, soils and the water supplies of small islands. Most small island states find it extremely difficult to adapt to these changing conditions. The impacts will be felt for many generations because of the small island states' low adaptive capacity, high sensitivity to external shocks and high vulnerability to natural disasters. Failure to adapt to climate change now could lead to high social and economic costs in the future. Most of Pacific island counties vulnerable people live in rural areas, where the main source of livelihood is in the agriculture sector, including livestock, forestry and fisheries. For the low lying atolls, the economic disruption could be catastrophic, even to the extent of requiring population relocation into other islands or increasing the number of people emigrating from the islands. Public pressure is mounting for action on adaptation. There is growing community and government concern about the need to reduce the islands' vulnerability and manage the risks posed by extreme events and long-term change.

2. Objective of the study

The overall objective is to deepen the understanding of the consequences of climate change on agriculture and food security in the Pacific, with a specific focus on the RMI. The specific objective is to increase the institutional capacity of the Marshall Islands to adapt, mitigate and respond to challenges posed by changing climate variability patterns on agriculture and food security. The output will be the preparation of a national assessment on the impact of climate change and variability on agriculture and food security, and the formulation of national strategy and recommendations to adapt, mitigate and respond to the challenges posed by climate variability on agriculture and food security.

3. Terms of Reference for the country-case study in Vanuatu

Under the overall supervision of FAO Sub-Regional Representative for the Pacific Islands and the technical supervision of FAO Sub-Regional Office for the Pacific Islands (SAPA) Policy Assistance Unit, in close collaboration with FAO Natural Resources Management and Environment Department, including the Environment, Climate Change and Bioenergy Division, the Consultant will have the following responsibilities:

- Carry out a desk analysis of the RMI's national reports prepared under the UNFCCC, in order to compile: main issues, adaptation/mitigation responses and measures on current and future climate changes having an impact on agriculture and food security. Agriculture shall be understood as also covering crops, forestry, fisheries, livestock and natural resources management, impacts on each sub-sector, inter-linkages and consequences/adjustments in rural/marine livelihood systems shall be assessed.

- Carry out a desk analysis of the UN, CROP agencies and relevant governmental-and-non regional bodies' projects, activities and consultations on climate change and variability in the RMI that have an impact on agriculture and food security. The purpose will be to compile: success stories such as adaptation plans and early warning systems; lessons learnt; existing efforts and collaborations; and the sharing of experiences;

- Assess the material and data collected, identifying main issues and trends; in particular, develop a typology of likely climate change impacts on agriculture and food security in the RMI. The typology will be based on nature of the dominant threat (frequency of cyclones, sea level rise, drought, etc.), the agroecological/agroeconomic zones recognised in the region and the socio-economic response potential;

- Once the above information is collected and analysed, carry out a field mission to RMI, in order to identify and assess national institutional mechanisms and policy frameworks to respond, adapt and mitigate climate variability on agriculture and food security. Strengths, weaknesses and effectiveness of identified mechanisms and frameworks shall be analysed, and recommendations on the way forward and implementing measures made. Discussions, consultations, data collection with relevant institutions/stakeholders shall be made as appropriate;

- Formulate a national strategy to respond to the challenges and opportunities identified for the agriculture sector and food security. Once completed, the national strategy shall be submitted for clearance to FAO, which reserves the right to request amendments, refinement or clarifications if and when considered necessary by the Organization. The Consultant shall revise the national strategy accordingly to FAO specifications, until the national strategy will be considered technically satisfactory by the Organization.

4. Requirements

The Consultant should have a degree in agricultural and/or environmental sciences or natural resources management, and at least 10 years professional experience in the field of climate change and its impact on agriculture and food security. He/she should also have a good knowledge of the Pacific region and regional agricultural/food security issues.

5. Length of the assignment/duty station

The overall length of the assignment will be 30 working days distributed over WAE (When Actually Employed) basis.

Entry on duty: as soon as possible
Not to extend: 14 April 2008
Remuneration: (to be confirmed)

The duty station will be the country of residence of the consultant and the assignment will include a duty travel to RMI for approximately 10 days.

6. Working Language

English

Annex 2. Proposed Strategy to Mitigate and Adapt to Climate Change

Climate Change Issues and Vulnerabilities	Mitigation Strategy	Adaptation Strategy
ROOT CROPS		
Declining crop production (including coconut)	• Support agriculture research and breeding of fast growing crop varieties • Increase public awareness about potential impacts of climate change on agriculture and food security • Promote adaptive management approaches • Encourage and support local processing of food crops (e.g. breadfruit flour and chips, coconut oil, etc) • Support and expand membership of Farmers Association especially in the outer islands • Increase support for the early warning system and especially the outer island radio network for better exchange and sharing of information between the islands	• Increase support for plant breeding program • Replace senile palms and trees • Adopt agro-forestry practices using traditional crops • Research on farming systems including soil/land/animal husbandry • Identify and select cultivars that are tolerant to abiotic stresses • Identify alternative food sources including imports • Broaden genetic base of traditional food crops • Decentralize services and economic activities including market outlets for farmers on outer islands. • Revitalize traditional gardening practices and integrate with modern practices where feasible and profitable. • Conduct negotiations with neighboring countries on possibility of joint efforts to promote biofuel from coconut oil
Increased pest activities due to changes in temperature and rainfall	• Promote adaptive management and risk-coping production systems • Review quarantine control measures for local distribution and propagation of food crops • Strengthen research capacity of MRD, Land Grant Program and CMI • Raise public awareness about risks from introduced pests and diseases	• Focus on crops and cultivars with pests and disease resistance traits • Avoid monoculture and promote agro-forestry practices instead • Broaden genetic base of traditional food crops • Build capacity of border control agencies such as quarantine, customs and police • Increase collaboration with neighboring countries (i.e. Guam, FSM, Kiribati) on control of invasive species issues in the sub-region
Salt spray and rising sea levels affecting home gardens and crops	• Impose restrictions on clearing of coastal vegetation • Develop and adopt a national land use plan • Develop coastal infrastructure management plans • Develop policy to guide development on coastal areas	• Move gardens away from vulnerable/exposed sites • Plant littoral vegetation as buffers against salt spray • Regulate activities along the coastline • Control mining of sand and aggregates • Undertake cost/benefit analysis of various coastal protection measures • Adopt agro-forestry practices using traditional crops
Shifts in weather patterns affecting planting and harvesting regimes	• Improve exchange and sharing of information between the Weather Service, MRD and outer islands • Develop and apply adaptive	• Adjust planting and harvesting timetables to prevailing conditions of past 3-4 years • Undertake assessment of impact of changing weather patterns on traditional

	management and risk-coping production systems • Raise public awareness about changing weather patterns and impact on agriculture production	crops • Support crop improving program focusing on climate change adaptation • Monitor changes in crop behavior in relation to shift in weather patterns
	LIVESTOCK	
Increased temperature could affect health, productivity and reproductive efficiency of livestock	• Training of local farmers in caring for their livestock • Monitor health of livestock especially during extreme weather conditions	• Focus on locally adapted livestock breeds • Keep pigs in covered pens away from coastal areas • Improve capacity of Taiwan Agricultural Mission to raise and sell livestock on a more commercial basis • Strengthen veterinary services to reach outer islands
	WATER SUPPLY	
Increased salinity of ground water sources resulting from salt water intrusion, overuse and droughts	• Develop water management and conservation policies that are specifically tailored for periods of droughts and severe water shortages • Promote sustainable water conservation and utilization practices • Include water storage measures in design of major buildings	• Increase capacity of airport rainfall water catchment and provide cover to reduce evaporation • Restrict vegetation clearing near Laura wells • Increase rainwater storage capacity of main buildings in Majuro and Ebeye • Carry out regular tests for water quality from ground wells around Majuro
Prolonged dry spells may affect capacity of water supply to meet dry-weather demand	• Develop policies to enforce rainwater harvesting, storage and conservation • Promote water efficient appliances	• Incorporate and enforce rainwater harvesting into building designs • Build capacity of MWSC to effectively manage water distribution facility • Regulate use of irrigation systems • Increase catchment and storage capacity of all major buildings in Majuro • Conduct water conservation awareness workshops and training
	FISHERIES	
Increased sea temperature could affect biological properties and distribution of fish species thereby affecting fish catches and food security	• Provide support to enable implementation of MIMRA's policies and strategies relating to conservation and sustainable use of marine resources • Expand research on RMI's marine biodiversity • Monitor impact of dredging and sand mining on marine biodiversity	• Generate and maintain buffer stocks or gene banks of biogenetic resources for reintroduction into natural habitats similar to original surroundings • Modify fishing efforts and allowable catches according to the state of the stocks • Promote and enforce sustainable coastal management practices • Promote alternative sources of protein for communities during low productivity periods
Increased pollution from beach erosion, land based	• Improve public awareness and understanding about connection	• Continue monitoring of incidence of ciguatera outbreaks

activities and other factor may increase incidence of ciguatera	between climate change and ciguatera	• Identify and document linkages between ciguatera and climate change and disseminate information nation-wide
Negative impacts from more frequent storm surges, decreased salinity during high intensity rainfall events and increased coastal erosion on marine ecosystems	• Develop adaptation strategies to any reduction in harvests of marine resources • Impose restrictions on clearing of coastal vegetation	• Promote aquaculture • Promote replanting of coastal vegetation on eroded soils • Provide alternative sources of protein during periods of low catches • Impose greater control on developments on the coastal areas
Limited understanding of the long term trends in climate change especially related to global warming in fisheries	• Develop climate change awareness programs based on existing knowledge targeting politicians, schools and local communities • Incorporate climate change science in school curricula	• Continue studies on the impact of El Nino conditions on tuna stocks and oceanic fishery in general • Collect and document evidence of changes in fisheries to enable better understanding of climate change on the fisheries sector
	FORESTS AND TREES	
Increased pest activities due to changes in temperature and rainfall	• Promote adaptive management and risk-coping measures • Review pest control measures and species selection practices	• Apply appropriate pest control measures and techniques • Adopt multi-cropping • Enhance the preservation and use of local tree species • Promote tree species with pest and disease resistance traits
Loss of vegetation due to coastal erosion and land clearing	• Raise awareness about role of forest and trees in protecting islands and peoples	• Replant littoral vegetation to stabilize eroded lands • Promote tree planting with local communities

Annex 3. List of People Consulted

Hon. Frederick H. Muller	Minister, Resource and Development
Mr. Thomas Kijiner	Secretary, Resource and Development
Ms. Rebecca Lorennij	Acting Secretary, Resource and Development
Mr. Glen Joseph	Director, Marshall Islands Marine Resources Authority (MIMRA)
Mr. Casten Nemra	Chief Secretary, Ministry of Internal Affairs
Mr. Clemen Capelle	Director, National Emergency Management & Coordination
Mr. Carl Hackard	Director, EPPSO
Ms. Deborah Barker	Deputy Director, OEPPC
Mr. Henry Capelle	Chief of Agriculture & Staff
Mr. Albon Ishoda	Integrated Marine Resource Manager, MIMRA
Hon. Titus Langrine	Acting Mayor, Majuro Atoll Local Government
Mr. Monono Dawoj	Acting Secretary Internal Affairs
Mr. Terry Mellan	Manager, Majuro Water and Sewer Company
Mr. Alington Robert	Administrative Manager MWSC
Mr. John Bungitak	Manager, Environment Protection Agency
Ms. Diane Myazoe-Debrum	Dean, Cooperative Research & Extension, Land Grant Program
Dr. Nat Tuivavalagi	Soil Specialist, Land Grant Program
Mr. Wilson G. Hess	President, College of the Marshall Islands
Mr. Steve ?	Consultant, College of the Marshall Islands
Mr. Lee Z. Jacklick	Supervisory Weather Service Specialist
Ms. Mereseini Seniloli	Participatory Extension Officer (Micronesia), Secretariat of the Pacific Community
Mr. Finau Pone	FAO Consultant
Mr. Taito Nakalevu	Climate Change Specialist, SPREP

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An Assessment of the Impact of Climate Change on Agriculture and Food Security in the Pacific

A Case study in Vanuatu

Prepared for

FAO SAPA
Apia, Samoa

By
Muliagatele Joe Reti
Pacific Environment Consultants Ltd (PECL)

November 2007

Content

Acronyms and Abbreviations

AusAID	Australian Assistance for International Development
CBDAMPIC	Capacity Building for the Development of Adaptation Measures in Pacific Island Countries
CIDA	Canadian International Development Assistance
CRP	Comprehensive Reform Programme
CROP	Council of Regional Organizations in the Pacific
EEZ	Exclusive Economic Zone
ENSO	El Nino Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Green House Gases
GoV	Government of Vanuatu
HDI	Human Development Index
HPI	Human Poverty Index
INC	Initial National Communication (to UNFCCC)
LDC	Least Developed Country
MLE	Ministry of Lands and Environment
NACCC	National Advisory Committee on Climate Change
NAPA	National Adaptation Programme for Action
NBSAP	National Biodiversity Strategy and Action Plan
NIP	National Implementation Plan
NOAA	National Oceanographic and Atmospheric Agency
PICCAP	Pacific Islands Climate Change and Adaptation Project
PIGCOS	Pacific Islands Climate Observing System
PIGGAREP	Pacific Island Greenhouse Gas Abatement through Renewable Energy Project
PIREP	Pacific Islands Renewable Energy Project
POPs	Persistent Organic Pollutants
SEAFRAME	Sea Level Fine Resolution Acoustic Measuring Equipment
SLR	Sea Level Rise
SNC	Second National Communication (to UNFCCC)
SOPAC	South Pacific Geoscience Commission
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
TC	Tropical Cyclone
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VANGO	Vanuatu Association of Non-Governmental Organizations

Executive Summary

Vanuatu is highly vulnerable to all natural hazards including tropical cyclone, storm surge, coastal flood, river flood, drought, earthquake, land-slide, tsunami and volcanic eruption. Impacts from these events will be inequitably spread throughout the islands, with localized areas on low-lying islands and areas experiencing subsidence due to tectonic and volcanic processes being the most severely affected.

The impacts of climate change and increased carbon dioxide concentrations on plant growth, productivity and the nutrient value of crops commonly grown in Vanuatu is not well understood. However, general knowledge of possible impacts suggests changes may be detrimental to agricultural production and hence national food security.

Both commercial and subsistence agriculture in Vanuatu are based on rain-fed agricultural production systems. Changes in rainfall, and in particular the projected scenario of overall rainfall decline, a greater proportion of rainfall falling in association with high intensity storm events during the wet season, increased evaporation and more pronounced dry seasons, could have severe impacts on agricultural production. Intense rainfall during planting seasons could damage seedlings, reduce growth and provide conditions that promote plant pests and diseases. More pronounced dry seasons, warmer temperatures and greater evaporation could cause plant stress reducing productivity and harvests.

The alternate scenario of increased rainfall could have equally severe impacts, with water-logged soils decreasing agricultural production, while increased humidity and rainfall could provide ideal conditions for the proliferation of a number of plant pathogens.

Some agricultural crops are already showing signs of stress under current climatic conditions. Water scarce areas and small islands that depend entirely on rainwater and under groundwater sources are also experiencing severe water shortages. Coastal erosion and inundation are reported from coastal communities and fish poisoning has been an emerging problem in recent years. These problems will be aggravated by any further changes to current climatic conditions. And while some progress has been made in recent years to understand and appropriately address climate change issues, there is currently limited data to enable Vanuatu to plan effective responses to climate change impacts.

Although Vanuatu has benefited from participation in a number of regional and national climate change projects in the past ten years or so, these have had limited long term impacts due to the lack of government funding to maintain staff positions and continue awareness raising at all levels. Government agencies focus on immediate and practical priority issues and have difficulty maintaining levels of service necessary to effectively address long term issues such as climate change. Hence, while recognizing the long term importance of reducing GHG emissions and preparing for climate change, it has been difficult for the government to take the longer term economic decisions necessary to effectively deal with the issue. This situation is unlikely to change soon and as a consequence, Vanuatu will continue to look at its development partners and UN Organizations for assistance to adapt to climate change.

Summary of Recommendations

1. The government should pay more attention to controlling population growth rate as an important part of any strategy to reduce the impact of climate change on the social and economic wellbeing of the country and its people.

2. The government should strategically address a limited number of clearly identified priority issues and actions based on the greatest needs and risks from climate change.

3. The government should continue to support the work of the National Advisory Committee on Climate Change (NACCC) as an effective means of advocacy for the UNFCCC and other climate change related agreements.

4. Human resource development initiatives need to be continued and expanded if Vanuatu is to be able to deal with the growing and complex issues associated with climate change.

5. Improving service delivery to rural areas should be made an explicitly higher priority for donor-funded developments in future.

6. Efforts should continue to improve the awareness and understanding of rural communities and farmers about the impact of climate change on their livelihood.

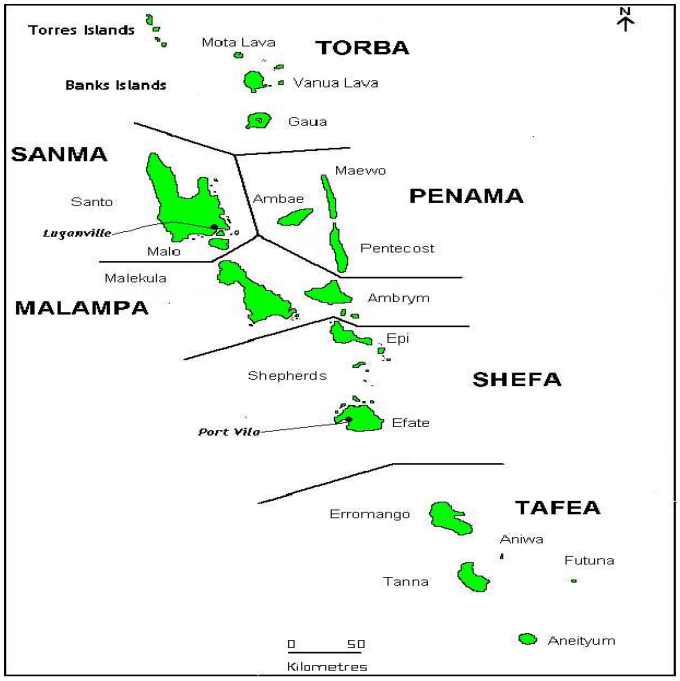
7. In the absence of site specific data and information, the findings and lessons learned from studies already completed in Vanuatu should be used to guide future efforts to plan for climate change.

8. Efforts should continue to increase the number of smallholders, promote the use of traditional food crops and provide support to make food gardens more sustainable.

9. The Ministry of Agriculture should improve and expand its plant breeding programme by decentralization and by broadening the genetic base of traditional crops as well as by providing basic training for rural farmers.

10. Government should provide support to NGOs and Civil Society Organizations (CSOs) to strengthen their accountability and general project management skills and knowledge especially in locations where government service is limited or absent. Care should however be taken to make sure that this support is not done in a way or scale that will overwhelm them.

Map of Vanuatu



Source: (i) Vanuatu Map - National Statistics Office, Port Vila (ii) Pacific Island Map – IMF 2000

1. Introduction

At the 6th Meeting of Ministers of Agriculture from the South West Pacific region held in the Cook Islands from 1-3 June 2005, the Ministers, in reaffirming their commitment to enhancing food security in the region, noted the increasing need for prudent policies based on more in-depth analyses of the prevailing macroeconomic conditions and taking into account non-economic concerns. The meeting recommended that studies be carried out to assess the impact of climate variability on agriculture and food security in the region and the capacities of countries to implement international and regional agreements relating to agriculture. This recommendation was again reinforced during the 7th Meeting of Ministers (Majuro, Marshall Islands 29-31 May 2007) which amongst other things, urged FAO to pursue a study to assess the impact of climate change on agriculture and food security in the Pacific Islands region.

This study was undertaken in accordance with the above recommendations of the 6th and 7th Meetings of the Ministers of Agriculture from the Pacific Islands. A desk review of existing climate change related reports and publications on Vanuatu was undertaken from October 8 to October 20 and an in-country consultation carried out from 22 October to 8 November 2007. The terms of reference for the study are described in Annex 1 and the list of people consulted in Annex 2.

2. Physical and Natural Environment of Vanuatu

2.1. Location

The Republic of Vanuatu is an archipelago comprised of some 80 islands scattered over a distance of 1,300 kilometers from north to south in the Western Pacific Ocean. The islands lie west of Fiji and north of New Caledonia between latitudes 12° and 23° south and longitude 166° to 173° east. The Vanuatu islands have a combined land area of 12,190 square kilometers and a maritime exclusive economic zone (EEZ) of 680,000 square kilometers. The two largest islands of Espiritu Santo and Malekula comprise nearly 50% of the total land mass while the two main urban centers, Port Vila and Luganville support 16% and 6% of the population respectively.

2.2. Population

The population of Vanuatu is estimated at 209,920 people, with an annual population growth rate of 2.6% distributed amongst 36,415 households. This represents an increase of 6,897 households from 1999 when the national population was 186,678 (Agricultural Census, 2006). About 80 percent of the country's population live in rural villages ranging from one family to several hundred people on the seven islands of Efate, Espiritu Santo, Tanna, Malekula, Pentecost, Ambae and Ambrym.

The ni-Vanuatu people, a Melanesian race, dominate the population which includes French, British, Australian, New Zealand, Vietnamese, Chinese and other Pacific Island races.

Inter-island and intra-island travel and communication is difficult and expensive. The large volcanic islands with rugged terrain and tropical forests mean that villages tend to be scattered and separated over large distances. The number of telecommunication facilities is often very limited on islands with national radio reception lacking in many areas.

The limited road networks are confined to the larger islands, mainly around the major population centers situated on the coasts. There are regular shipping services to the central islands, but the outer islands are serviced irregularly. Air Vanuatu, the locally-owned company which operates domestic and international flights, provide daily passenger and cargo flights between Efate, Tanna, Malekula and Santo, but many of the smaller islands are served only 2 or 3 times per week. Many of the smaller islands do not even have airstrips. In terms of infrastructure, Vanuatu has 29 airports, (5 paved and 24 unpaved) and approximately 1,894 km of roadways (111 km paved and 1,783 km unpaved), and two main ports and terminals, Port Vila and Santo (NACCC, 2007).

2.3. Geology

Vanuatu's islands are young in geological terms, small and highly disturbed as a result of natural cyclones, seismic and volcanic activity. Tectonic uplift is well documented in many areas of the country, while a few islands demonstrate subsidence. Active volcanism also impact on a number of islands. Because of the extent of tectonic activity affecting Vanuatu, it is difficult to attribute apparent changes in sea level to the effects of climate change. However, for much of the country, it is assumed that tectonic uplift of islands will proceed at a greater rate than sea level rise. Nevertheless, there are concerns that sea level rise might have locally severe impacts in the Torres Group, Aneityum, East Ambae, Shepherds Islands and the two towns of Port Vila and Luganville (GoV, July 1999).

The islands of Vanuatu are located along the **Rim of Fire**, the circum-Pacific volcanic belt which hosts most of the larger porphyry copper-gold deposits in the world. In the Southwest (SW) Pacific, the Rim of Fire extends from Papua New Guinea via the Solomon Islands, Vanuatu, Fiji and Tonga to New Zealand. This major plate boundary separates the Pacific Plate from the Australia-India Plate, and is physiographically marked by subduction-related oceanic trenches, partly emergent volcanic arcs, and back arc and intra-arc basins. The complex and multiphase history of the arc volcanism indicates that the two plates have been interacting from the early Tertiary (probably Late Eocene) to Recent[1].

2.4. Climate

Two distinct seasons influence the Vanuatu archipelago; a hot and wet season from November to April, known as the cyclone season, and a cold and dry season from May to October. Rainfall often peak during the earlier season as a result of heavy rainfall associated with cyclones or depressions in that period annually.

There is limited historic climatic data for Vanuatu with records back to 1949 for Efate and 1973 for Luganville, the country's two urban centers. Average temperatures range between 21°C and 27°C and average humidity ranges between 75% and 80%. Average rainfall

[1] Vanuatu Mineral Exploration Initiative: Information Sheet.

declines from over 4000mm in the north to less than 1500mm in the south (Mourgues, 2005). Trends suggest a gradual increase in temperature that is more marked in the south and a gradual decline in rainfall overall. There has also been a significant increase in the frequency of tropical cyclones in the country as a whole over the record period, although this trend could be influenced by improved recording of such events since the introduction of satellite tracking technology.

Vanuatu is prone to a broad range of natural disasters. Cyclones often occur during the warmer months from November to April, although cyclones have recently shown signs of development outside this season (Cyclone Rita, May 1991 and Cyclone Gina, June 2002). Vanuatu is also vulnerable to long dry spells and prolonged wet conditions associated with the El Nino (warm phase) and La Nina (cool phase) of the El Nino-Southern Oscillation (ENSO) phenomenon. The country is highly vulnerable to other extreme climate events including storm surges, coastal and river flooding, landslides and hailstorms.

Earthquakes frequently occur in Vanuatu and they often originate at considerable depth and are therefore not too destructive (large magnitude but low density). Nevertheless, some earthquakes have caused extensive damages in the past. Some fault movements have also produced changes in shoreline elevations of up to 2 meters as islands have tilted. Destructive tidal waves (tsunami) occur occasionally as the result of earthquakes (ibid).

In a report to the International Decade for Natural Disaster Reduction for the Pacific Island Countries, Vanuatu was classified as highly vulnerable to all natural hazards: tropical cyclone, storm surge, coastal flooding, river flooding, drought, earthquake, landslide, tsunami and volcanic eruption (UNFPA, 1996).

On the basis of climate scenario modeling[2] and historical records available, it has been predicted that climate change over the next century will lead to warmer and drier conditions in much of Vanuatu with the size of the change increasing away from the equator (NACCC, 2007). However, the possibility of increased rainfall should not be dismissed. These effects will be accentuated by more frequent and severe cyclone events. Heavy rainfall is a normal component of cyclonic storms so a greater proportion of rain will be associated with the passage of storms. Indications are that there will be more frequent El Nino type conditions which are usually associated with prolonged dry seasons.

2.5. Biological diversity

Although Vanuatu's biodiversity has been widely reported as less rich than its neighboring countries, New Caledonia and Solomon Islands, recent studies have suggested that Vanuatu's biodiversity was in fact richer than was previously estimated (Environment Unit, 1999). Vanuatu is in fact an important faunal crossroad in the Pacific. The three main streams by which it is believed wildlife colonized the SW Pacific (Papuan, Australian and Polynesian), meet here.

[2] Climatic scenarios for Vanuatu have been modeled on the SCENGEN scenario generator with two Global Circulation Models: HADCM2 and CSIRO9M2. For more information, refer to the Vanuatu National Communication to the Conference of the Parties of the UNFCCC, July 1999.

Of all the islands in Vanuatu, Espiritu Santo has the greatest species richness with 49 native species of land and freshwater birds found here. This represents 75% of Vanuatu's native land and freshwater birds and 85% of land and freshwater birds that breed in Vanuatu. Seven of the eleven species of bats found in Vanuatu are also present in the Santo region (Nari et al, 1996).

Vanuatu's 200 nautical miles exclusive economic zone is extensive and encompasses mangrove, sea grass, lagoon, coral and pelagic habitats. Mangroves, sea grass and other coastal ecosystems provide protective buffers that shelter land and human settlements from the full impact of storm events but are under pressure from subsistence and commercial land use.

3. Economy

Vanuatu was accorded UN Least Developed Country (LDC) status in 1995 and is still in this group despite the fact that its per capita GDP now exceeds the LDC threshold. This situation has occurred due to the adjustment based on the 'vulnerability index' which takes into account the vulnerability of Vanuatu's economy to natural disasters (Mourgues, 2005). Adult literacy was estimated at only 33.5%, with life expectancy at birth of 66 years. The Human Poverty Index (HPI) ranked Vanuatu number 13 of 15 Pacific Countries and 140 on the UNDP Global Human Development Index (HDI). Vanuatu was also ranked the most vulnerable state of 110 small developing countries by a 1998 Commonwealth Secretariat report. The most devastating recent natural disasters were cyclone Prema in April 1993 which affected 20,000 people and caused damages estimated at US$60 million and the Penama Earthquake and Tsunami of November 1999 which killed 10 and affected 23,000 people.

The country's economic performance has been characterized by generally low rates of economic growth, although there has been an upturn in the last three years. This has been compounded by rapid population growth leading to a decline in per capita income by 18% between 1994 and 2003 (GoV, 2006).

The economic and social situation in Vanuatu reflects a narrow income base, with almost 65% of GDP being generated by the service sector; just under 25% from agriculture; and 10% from manufacturing. Tourism is the main foreign exchange earner but is still largely centered on Port Vila while the majority of the rural population is engaged in agricultural production for subsistence with limited cash cropping.

The economy of Vanuatu is primarily agricultural based with beef, copra and fish being the primary exports. Commercial logging also occurs as well as a small industrial sector that is found in Port Vila.

The subsistence economy and the cash economy operate side by side in Vanuatu. Over 70% of the population live on their traditional lands, growing food crops and harvesting forest and marine resources for personnel consumption, exchange and gifting. All the necessities of life are available locally. Rural villagers' participation in the cash economy is a minor component of their economic activity. They do however earn cash income from marketing

copra, cocoa, other cash crops, shells and handicrafts, or by granting logging company access to their timber. Cash income is primarily directed to school fees, transport to school and purchases of household items and other needs.

The cash economy is centered on two urban areas: Port Vila and Luganville. It is dominated by services and a limited range of agricultural commodities. The service sector includes government services, an off-shore finance center, and tourism. Although the agricultural sector contributes less to GDP than services, it is the principal economic activity and source of income for the majority of people and makes the largest contribution to domestic exports. The industrial sector is small. Its contribution to GDP rose steadily from 8% in 1983 to over 13% in early 1995 but has since stabilized. Vanuatu is heavily reliant on imported manufactured goods and fuels.

The narrow economic base and the small local market makes Vanuatu's cash economy particularly vulnerable to external influences such as world commodity downturns or fluctuations in tourism. The value of imports exceeds export earnings and this situation is unlikely to change in the near future. Further development of the cash economy is constrained by distance from international markets; limited natural resource base; high cost of infrastructure and energy; limited and unstructured internal market; and damage to crops and infrastructure by cyclones, earthquakes and volcanic eruptions.

In an effort to address several structural problems within the economy, Vanuatu began implementing a Comprehensive Reform Programme (CRP) in July 1998. The CRP is based on three categories of reforms: public sector reform, economic reform, and reforms aimed at promoting equity and social development. An integral part of the CPR was the identification of five priority objectives with accompanying strategies. The priorities are: (i) improving the lives of the people in rural areas; (ii) supporting private sector growth; (iii) restoring good governance; (iv) improving participation by civil society; and (v) closing the gap between the rich and the poor and disadvantaged groups (UN, March 2002). These priorities were adopted as the goal for the United Nations Development Assistance Framework[3] (UNDAF) for Vanuatu for the period 2003-2007.

4. Social and Cultural Setting

The ancestors of indigenous ni-Vanuatu arrived in a series of migrations from the northwest several thousand years ago. They settled throughout the archipelago practicing subsistence agriculture, hunting and gathering. Due to the difficult terrain and open seas between islands, there was limited contact and trade between settlements and as a result, complex cultures and languages were developed. In 1989, more than 110 languages were used by a population of about 177,400 people making Vanuatu the country with the highest number of languages per capita. Bislama, a pidgin language based on the English and French languages is the common lingua-franca of ni-Vanuatu from different language groups although English and French are both used by government, business and education today.

[3] The UNDAF serves as the common frame of reference for UN cooperation in Vanuatu. It is a strategic document that gives effect to UN reform in Vanuatu, as an instrument to promote cooperation and enhanced coordination between UN agencies and with the government of Vanuatu.

From 1906 to 1980, Vanuatu (previously known as New Hebrides) was governed as a Condominium of both Britain and France. This arrangement led to costly and at times confusing duplication of government and administrative services. It also led to competition between the two European nations as they sought to strengthen their individual interests and spheres of influence. The legacies of the Condominium include expensive duplication of services in both English and French language mediums, and a social and political division between Francophone and Anglophones.

Political independence for Vanuatu was obtained in 1980 and despite and initial period of political stability there have been a number of changes of government between elections over the past decade. Government changes between elections reflect shifts in party coalition loyalties often based on family, regional and ethnic ties.

The social and cultural setting in the capital area of Port Vila on the island of Efate is heavily influenced by both British and French cultures. To a lesser extend, the larger island of Espiritu Santo maintains many vestiges of European colonial life. The outer islands retain strong aspects of traditional life or *kastom* mixed with the influences of the missionaries. In the northern islands, women's roles are stronger and more dominant because of the traditional matrilineal culture. The opposite is true in the southern islands where males dominate society.

There is growing concern over the number of people facing a poverty of opportunity faced by those living in rural areas and the vulnerable groups living in or near the urban centers of Vanuatu. Political instability as well as weaknesses in governance institutions and the application of good governance principles has hampered sustainable economic development and the implementation of sound resource management policies, regulations and decisions. In many instances, the urban elite have been the major beneficiaries of many economic progress made to date.

There is a pressing need to address the disparities in the delivery of and access to quality basic social services and income earning employment opportunities between men and women and between urban and rural areas. There are specific issues relating to the increased migration from rural to urban areas, with the unemployed poor and squatter settlements of urban areas also facing problems of inadequate housing, poor infrastructure and lack of access to water and sanitation services.

Vanuatu's Melanesian society does not have hereditary leadership with the result that the position a person attains is more closely linked to how successful they are in accumulating wealth and prestige. While this system is considered egalitarian, it does not necessarily engender an egalitarian society. It is also clear that while some women have achieved success in both the private and public sectors, there remain many cultural and social constraints to gender equality in the family, employment and decision making (UN, 2002).

The legal system recognizes and enforces private rights where those rights are granted under title or agreement. However, difficulties arise when the ownership of the property or right is either communal or uncertain. In these cases, it can be difficult to obtain and enforce rights and use.

5. The Agriculture Sector in Vanuatu

The economy of Vanuatu is comprised of a large smallholder subsistence agriculture sector and a small monetized sector. Small-scale agriculture provides for over 65% of the population while fishing, off-shore financial services and tourism also contribute to government revenues. In 2003, the national gross domestic product (GDP) was estimated at US$580 million with per capita GDP at US$2,900. As a proportion of GDP, agriculture accounted for 14.9%, industry 8.5% and the service sector 76.6%. Real GDP per capita is still lower than in the early 1980s due largely to the lack of long-term growth in the agriculture and fisheries sectors. Since 2003, the agriculture sector has grown at an annual rate of 3.3% compared to the 2.8% growth for the economy and average population growth rate of 2.6% (NACCC, 2005).

Immediately following Independence in 1980, smallholders were encouraged to satisfy the demands of the export market with commodities such as copra, cocoa, coffee and meat and the promotion of these commodities was the focus of agricultural policies at that time. Market prices for all these commodities have since declined and understandably, farmers are now reluctant to reinvest in these commodities. Under these circumstances, government was left with two important challenges to either (i) continue efforts to increase agricultural production or (ii) increase food import. Government decided to tackle the first challenge and has approached this by increasing efforts to improve productivity of household food gardens 68% of which were for subsistence only and the rest for sale and subsistence needs. According to the Agriculture Census (1999), 68% of the households grow coconut, 50% grow kava, 39% raise cattle, 24% grow cocoa and 2% grow coffee. 61% of the households regularly go fishing. It can be seen from these statistics that the small farmers of Vanuatu play a very important role in food production and food security in the country.

The specific situation pertaining to the various sectors of the agriculture industry is summarized in the following sections.

5.1. Crops

The majority of the rural population of Vanuatu is engaged in agricultural production for subsistence with limited cash cropping. The main agricultural products are copra, kava (*Piper methysticum)*, cocoa, coffee, taro, yams, fruits and vegetables. Low productivity and small holdings are identified as the key constraints towards expansion and commercialization of crop production in Vanuatu. There is little incentive to enhance productivity through the use of modern methods and technology and to compound the problem changes in world prices are also affecting this sector.

While large commercial farms and plantations are making a significant contribution to the cash economy of Vanuatu, approximately 80% of the population reside in rural areas and depend on small agricultural plots for their livelihood. Productivity of these plots are however quite low and the challenge for the sector therefore is to increase productivity by introducing sustainable and affordable management practices for traditional crops. Increasing the number of small plots (i.e. getting more rural dwellers involved) is a strategy favored by the Ministry of Agriculture as opposed to increasing the sizes of existing

farmlands. This is because most small farmers are isolated and separated from each other by long distances of poorly maintained access roads that make transportation of products and equipment extremely difficult and expensive for them. Small plots that are able to provide for their subsistence needs and allow for a small surplus for the local markets on the other hand are well within the capacity of small farmers to manage on a sustainable basis.

The increasing incidence of extreme events and climate change could add further stress to this sector. There is little additional information on the effect these changes will have on the cash crops such as yams, taro and sweet potatoes that are important to the sustenance of the ni-Vanuatu people. Mechanisms to enhance food storage to meet shortfalls during times of disasters are also lacking.

5.2. Livestock

Vanuatu's environment is ideally suited to raising beef cattle. The production of beef, pork, poultry, sheep and goat for local consumption forms an essential part of the rural economy. There is however still scope for improving the production, processing and marketing in this sector in order to increase its contribution to the overall economy of the country. The 1999 Agriculture Census placed the number of cattle in Vanuatu at 150,000 animals.

Increased demand for land and the enhanced degradation due to climate extremes and other hazards have added to the challenges in livestock production. In the 1990s, most of the beef was supplied by the small farmers. This has changed in recent years with the commercialized operations now providing the bulk of the beef consumed locally (Timothy, pers. com). Most of the cattle are grazed under coconut plantations.

Climate change is likely to have far greater effects on the small farmers compared to the larger commercial operations. Small farmers often rely on streams for their water supply and do not have the means to set up adequate water storage facilities. Hence, when the streams dry up, as they are doing more and more nowadays, the farmers would find it hard to cope.

Incidence of diseases is also reported to be on the increase especially intestinal problems which are believed to be associated with pasture feed. The Veterinary Service provided by the Department of Agriculture is limited to Efate and Espiritu Santo leaving farms on the outer islands to fend for themselves.

5.3. Forestry

Some 36% of Vanuatu's total land area is forested, 27% of which is merchantable forests (Department of Forests, 1999). Rugged terrain prevents access to the rest of the forested areas.

Vanuatu possesses excellent soil and climate that are conducive to timber production. In 1996, the forestry sector earned around 13.2% of the total export revenue for Vanuatu. Landowners received about US$0.36 million in log royalties and US$0.27 million in sandalwood royalties during the same period. In recent years, there has been an increased interest in sandalwood harvesting and plantation. This high valued species has potential to make a significant contribution to the forestry sector and the national economy as a whole

but if not managed properly, could result in large scale clearing of other valuable forested areas.

The importance of Vanuatu's forests can not be judged on economic benefits alone. Apart from providing job opportunities, income, and badly needed infrastructure, the development of the forest resources also stimulates activities within the whole economy. The balancing of the need for environmental protection and the development of the forestry sector must therefore be an important goal for the government of Vanuatu.

Vanuatu's vision for the management of the forestry sector is an arrangement whereby the government will work cooperatively with the landowners and the forest industry to achieve the sustainable management of the forest resources and thereby encourage revenue generation for the landowners, the wider community and the national economy while at the same time conserving Vanuatu's forest biodiversity.

The concept of sustainable forest management in Vanuatu must be tempered by the fact that there is no government-owned forest land, and that it is an inalienable right of landowners under the Constitution to manage their land as they see fit. However, given the decreasing forested area and the threat of further damage through extreme climatic events, a sustainable forest industry for Vanuatu can only be achieved through a collaborative effort by the government, the landowners and the industry.

5.4. Fisheries

The fisheries sector contributes approximately 1% to the overall GDP and makes up 5.5% of the primary production sector (Statistics Office, 2000). The fisheries sector has good potential for exploitation but is not being properly exploited at present. The reef fisheries are over-fished in some areas, notably in the coastal areas of Efate but are generally under-exploited near the outer islands. The coastal fisheries which contributes significantly to the rural income, nutrition and self-reliance, is particularly vulnerable to the impacts of climate change due to enhanced coastal erosion, sedimentation and over-exploitation. In addition, there is a perceived threat to marine resources given the demand from the growing coastal population.

As for most islands, the sea, oceans and coastal areas play an important part in the lives of the people in Vanuatu, as a source of food, transport and livelihood. Most coastal people rely on fishing as an important source of protein and income but these are likely to be affected through the destruction of marine ecosystems such as mangroves and reefs. There is also some concern about the possible increase in ciguatera poisoning due to increased temperatures of the ocean, marine pollution from land-based activities and sedimentation. It is also reported that after Cyclone Ivy which caused considerable damage to coral reefs around Efate, there have been several outbreaks of the Crown of Thorns which is contributing to the destruction of corals and reefs (Jimmy, pers. com).

The Fisheries Division in an attempt to have a better understanding of what is happening to the coastal areas of the country has established a number of coral monitoring sites around Port Vila to monitor the health of the corals and reefs and to determine the impacts of

bleaching and ground water run-off on coastal ecosystems. A number of similar sites are expected to be established around the other islands in the future.

At present, Vanuatu has a fishing fleet of about 150 to 160 boats whose catches are landed in Fiji for onward shipment to canneries around the region. This arrangement is unsatisfactory to government whose share of the sales is far less than could have been. It is not surprising therefore that plans for the establishment of a landing facility for tuna in Vanuatu is already in an advanced stage and it is expected that this facility will be operational in 2008 (ibid).

6. Significance of Global Climate Change to the Pacific Island Countries

Climate change is likely to have substantial and widespread impacts on Pacific island countries including Vanuatu. Among the most substantial damages would be losses of coastal infrastructure and coastal lands resulting from inundation, storm surges, or shoreline erosion. Climate change could also cause more intense cyclones and droughts, the failure of subsistence crops and coastal fisheries, and the spread of malaria and dengue fever.

The South Pacific has experienced the highest numbers of cyclones in a season during El Nino events. For example, in 1992/93, there were 16 cyclone events and in 1997/98, there were 17 events. The average (mean) for the South Pacific is between 9 and 10 cyclones per season (Vanuatu, undated).

During October 2007, rainfall was extremely high in areas under the active South Pacific Convergence Zone (SPCZ) with over 200% or more of normal in parts of Vanuatu, Fiji, central French Polynesia, and also well above normal in parts of New Caledonia, Niue and parts of Samoa. Heavy rainfall and flooding occurred in parts of Vanuatu at the end of the month with Aneityum recording a record high of 443.8 mm during the month. In contrast, rainfall was 50% or less of normal over much of Kiribati and parts of the Cook Islands (NIWA et. al 2007).

Mean air temperatures for October were 1.5°C or more above normal in parts of Tonga and the Southern Cook Islands, and 1.0°C or more above normal in New Caledonia and parts of Fiji (the warmest October on record in Nadi, with records at several other sites). Temperatures were also above normal in Vanuatu and Samoa (ibid).

Changes in climatic conditions would affect most Pacific islanders, but have its greatest impact on the poorest and most vulnerable segments of the population – those most likely to live in squatter settlements exposed to storm surges and disease and those most dependent on subsistence fisheries and crops destroyed by cyclones and droughts.

A World Bank study in 1999/2000 concluded that climate change is likely to affect coastal areas of the Pacific in three major ways: through a rise in sea level, leading to erosion and inundation; through more intense cyclones and storm surges; and through higher sea surface temperatures, leading to a decline in coal reefs.

Climate change is most likely to affect agricultural production through changes in rainfall. Agricultural crops could also be affected by rising temperatures, climate variability – such as more intense cyclones and El Nino/La Nina conditions – and sea level rise. If wetter conditions prevail in the future, water-sensitive crops such as coconut, breadfruit and cassava would likely benefit. A decline in rainfall by contrast, would hurt most crops, especially the traditional crops such as yam and taro.

Tuna fisheries in Central and Western Pacific is also likely to be affected by climate change in two major ways: by rising ocean temperatures to levels currently experienced during medium-intensity El Nino and by increasing year-to-year climate variability (Timmermann et al, 1999). The impact on tuna – the most valued deepwater fishing species in the region - is predicted to include the following:

- *Decline in primary productivity*. Primary productivity in the central and eastern Pacific could decline due to the increased stratification between warmer surface waters and colder, deeper water (and resulting reduction in upwelling). Primary production in the western Pacific could conversely increase.

- *Decline in tuna abundance*. The decline in upwelling could lead to a decline in the big eye and adult yellowfin population (the species targeted by the longline fleet). By contrast, the abundance of purse-seine-caught skipjack and juvenile yellowfin tuna is not expected to be affected.

- *Increased pressure on longline fishing*. Given the continued high demand for sashimi in Japan, it is likely that longline fishing pressure on yellowfin tuna will increase to compensate for the decline in adult bigeye tuna, leading to unsustainable exploitation.

- *Spatial redistribution of tuna resources*. The warming of surface waters and the decline in primary productivity in the central and eastern Pacific could result in spatial redistribution of tuna resources to higher latitudes (such as Japan) and towards the western equatorial Pacific.

- *Higher impact on domestic fleets*. While distant water fishing fleets can adapt to stock fluctuations, domestic fleets would be vulnerable to fluctuations of tuna fisheries in their exclusive economic zones. Countries in the Central Pacific would likely be more adversely affected than those in the western Pacific (World Bank, 2000).

Climate change could also increase the incidence of ciguatera poisoning in some areas of the Pacific like Kiribati that already has one of the highest rates of ciguatera poisoning in the Pacific. It is predicted that the rise in temperatures will increase the incidence of ciguatera poisoning in that country from 35 per thousand people to about 160-430 per thousand in 2050 (Lewis & Ruff, 1993).

More intense cyclones and droughts are likely to increase nutrition-related deficiencies as experienced in Fiji during the 1997/98 drought when US$18 million in food and water rations had to be distributed (UNCAD 1998). Loss of agriculture and fisheries could result

in malnutrition and deterioration in standards of living. And the loss of infrastructure could lead to increased crowding conditions, exacerbating problems of urban management. These diffuse effects could well prove to be among the most important impacts of climate change on the livelihood of peoples in the Pacific in future years.

7. Climate Change Scenario in Vanuatu

Climate change is likely to impact on all sectors that are pertinent to the sustainable development of Vanuatu (NACCC, 2007). Vanuatu is highly vulnerable to the effects of natural disasters including climate change. A total of 124 Tropical Cyclones (TC) had affected Vanuatu since 1939. Forty-five of these were categorized as having hurricane force winds (>64 knots), twenty-six were of storm force winds (48 – 63 knots) and twenty-five were of gale force winds (34-47 knots). The remaining 28 were not categorized. TC Prema (1993), Paula (2001) and Ivy (2004) all caused considerable damage to property and the environment in Vanuatu.

Vanuatu is also prone to tsunamis and two in particular (1999 and 2002) caused loss of life and property. On November 1999, a magnitude Mw7.3 undersea earthquake occurred 140 km to the northwest of Port Vila. A tsunami was generated which caused destruction on Pentecost Island where maximum tsunami heights reached 6m. The tsunami claimed 3 lives, although many were saved when some residents recognized an impending tsunami as the sea receded and managed to warn people to seek higher ground. On January 2002, an earthquake of magnitude Mw7.5 occurred 100 km west of Port Vila. Several people were injured and there was widespread damage on the island of Efate (AusAID, 2006).

Sea level trend to date is estimated at + 3.1 mm/year but the magnitude of the trend continues to vary widely from month to month as the data set grows. Accounting for the precise leveling results and inverted barometric pressure effect, the trend is estimated at + 2.2 mm/year[4] (Ibid). The scenarios for temperature and rainfall as predicted by the SCENGEN generator for Vanuatu are presented in Tables 1 and 2 and for sea level rise in Table 3. These results are compared with analogue predictions based on observation of past trends presented in figs. 1 to 5.

Table 1: Temperature scenario

TEMPERATURE		
SCENARIO	Yr. 2050	Yr. 2100
CSIRO9M2		
IS92a(mid)	0.9°C	1.5°C
IS92e(high)	1.5°C	3.0°C
HADCM2		
IS92a(mid)	1.4°C	2.4°C
IS92e(high)	2.2°C	4.5°C

[4] Data from SEAFRAME which started measurement of sea level trend in Vanuatu since 1993.

Table 2: Precipitation scenario

PRECIPITATION		
SCENARIO	Yr. 2050	Yr. 2100
CSIRO92		
IS92a(mid)	7.4%	13.5%
IS92e(high)	12.1%	25.2%
HADCM2		
IS92a(mid)	-6.6%	-11.8%
IS92e(high)	-10.6%	-22.0%

Table 3: Sea Level Rise Scenario

SEA LEVEL RISE		
	2050	2100
IS92a(mid)	19.8 cm	48.9 cm
IS92e(high)	39.7 cm	94.1 cm

Historical climate trends – temperature

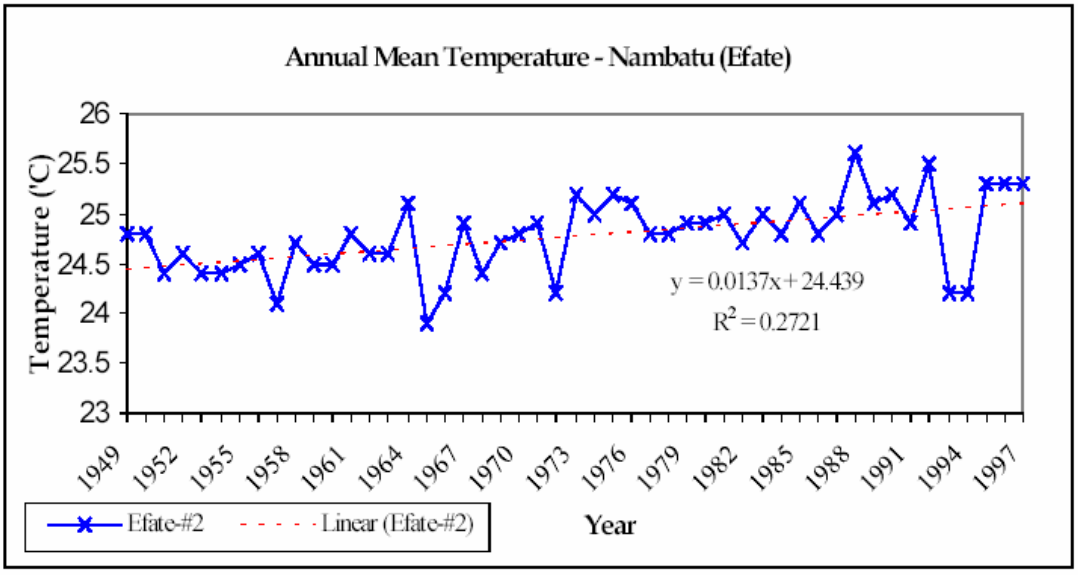


Figure 1: Efate Annual Mean Temperature

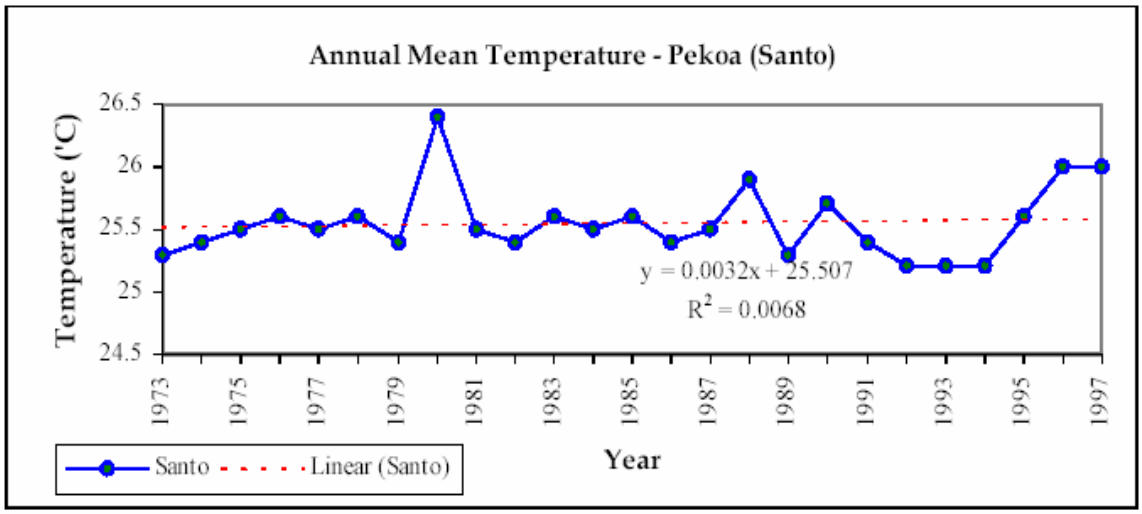


Figure 2: Santo- Annual Mean Temperature

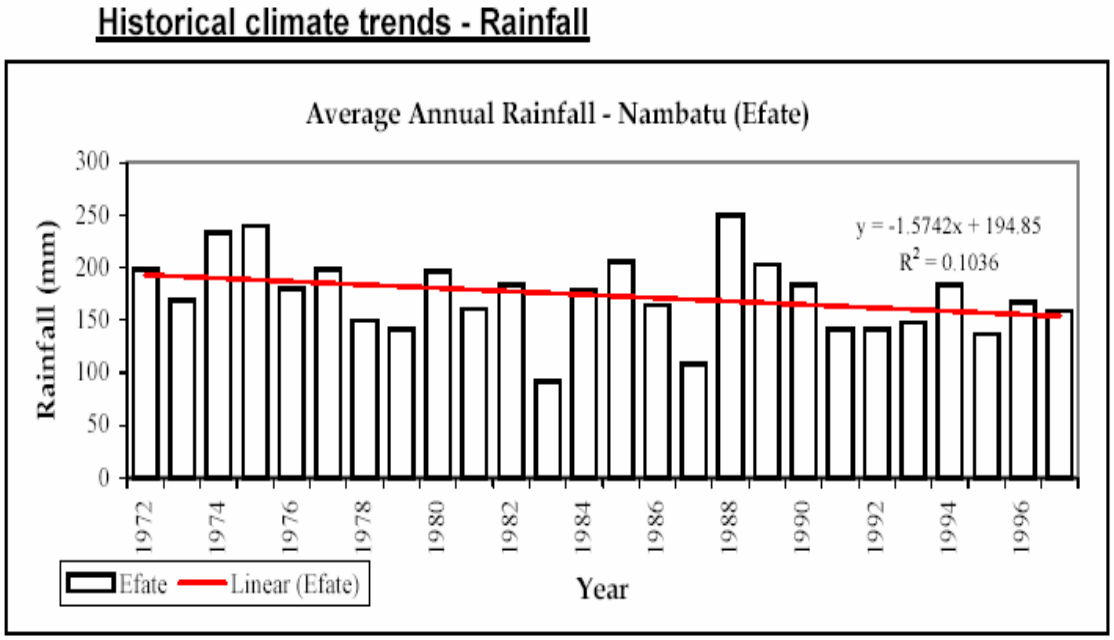


Figure 3: Efate-Average Annual Rainfall

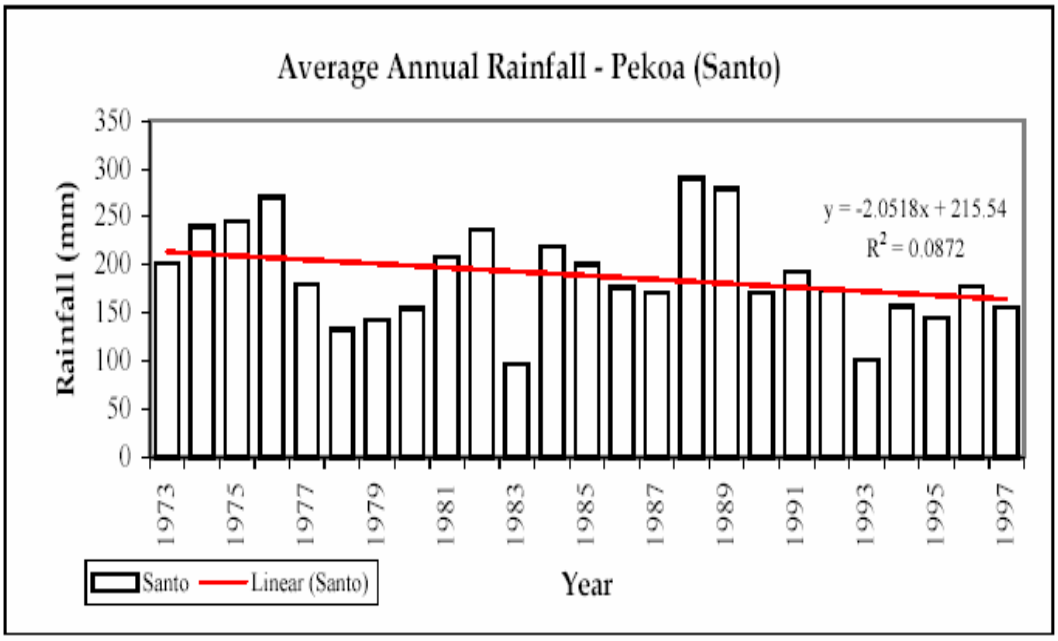


Figure 4: Santo-Average Annual Rainfall

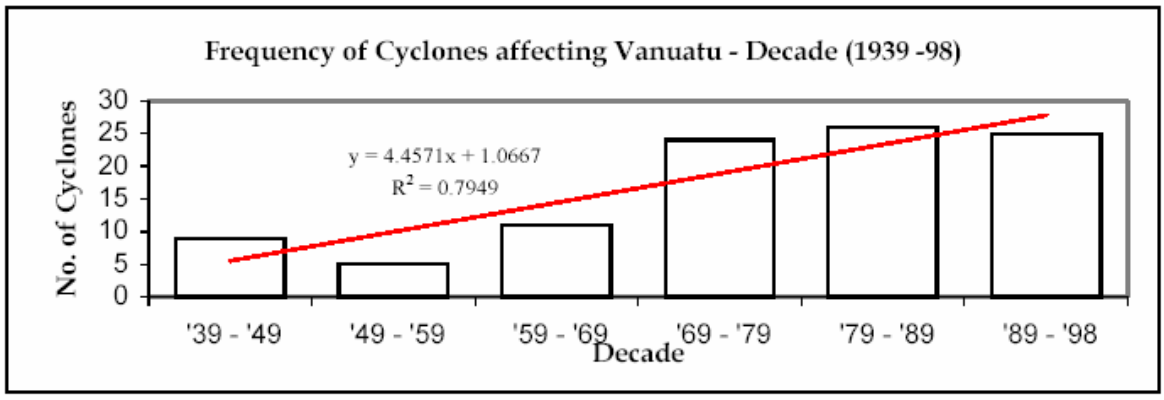


Figure 5: Vanuatu's cyclone Frequency

8. The Likely Impacts of Climate Change and Climate Variability on Agriculture and Food Security in Vanuatu

According to FAO (2007a) the croplands, pastures and forests that occupy 60 percent of the Earth's surface are progressively being exposed to threats from increased climatic variability and, in the longer run, to climate change. Abnormal changes in air temperature and rainfall and resulting increases in frequency and intensity of drought and flood events have long term implications for the viability of these ecosystems.

Although there is limited historic data on which to base a more reliable assessment of the likely impacts of climate change on the agriculture sector and on food security in Vanuatu, a

review of a number of reports and publications suggest that the following impacts are likely to be realized for the various components of the agriculture sector and for food security in Vanuatu. A clearer assessment of the likely impacts of climate change and climate variability on small islands of Vanuatu is presented in Annex 3.

8.1. Crops

Although the impacts of climate change on agricultural crops in Vanuatu are not well understood, general knowledge and anecdotal observations suggest that changes may be detrimental to agricultural production and hence national food security.

Climate related incidences are already affecting crop production. Increased temperatures, more frequent and prolonged dry conditions, increased variability of rainfall, salt water intrusion, droughts, soil erosion and cyclones have been experienced in the past few years. Pest activities have also increased with yams being the crop most affected. With projected temperature increases to 28.8 degrees and 29.7 degrees in 2050 and 2080 respectively, heat tolerance thresholds of crops are likely to be reached and this will most likely induce heat stress, wilting and crop failure. Subsistence crop production may fall as a result and in turn threaten food security on the island.

Both commercial and subsistence agriculture in Vanuatu are based on rain-fed agricultural production systems. Changes in rainfall, high intensity storm events, increased evaporation and more pronounced dry seasons, could have severe impacts on agriculture crop production. Intense rainfall during planting seasons could damage seedlings, reduce growth and provide conditions that promote plant pests and diseases. More pronounced dry seasons, warmer temperature and greater evaporation on the other hand could induce plant stress reducing productivity and harvest and subsequently, affect food security.

The alternate scenario of increased rainfall could have equally severe impacts with water-logged soils decreasing agricultural production, while increased humidity and rainfall could provide ideal conditions for the proliferation of a number of plant pathogens. These conditions could lead to declining agricultural production and this would adversely affect both the country's economy and food security.

The farmers interviewed during the undertaking of this study commented on some plants flowering earlier than usual while others are fruiting much later than normal during the past 3-4 years. Another farmer referred to the south east trade winds that was still blowing at end October when traditionally this would have ended in August/September each year. Whilst these farmers agree that climate change may have something to do with these changes, it was difficult for them to determine the extent such changes were influenced by climatic conditions and variations. As these changes have only been observed in the past three to four years, the farmers suspect that the changes may be part of a cyclic event that could return to normal sometimes soon (Gordon, et al, pers.com).

The findings from the study carried out by the CBDAMPIC project involving the communities of Lateu, Luli and Panita as well as the Vulnerability Assessment of islands in the Torres, Tafea and Shepherd Groups highlighted the impacts of climate change on water supply, agricultural activities and health of these communities (refer Annex 3). Salt spray,

water shortages due to prolonged dry spells, flooding and contamination of ground wells, and erosion of the foreshores are having a serious impact on the safety and health of these communities and these problems are likely to get worse as temperature and sea level rises. The seriousness of these problems has already caused a number of communities to abandon their villages to resettle elsewhere. This scenario is likely to happen again in other low-lying areas of Vanuatu as the government and rural communities have limited capacity to deal with these kinds of situations.

8.2. Livestock

It is predicted that increased carbon dioxide concentrations in the atmosphere and warmer temperatures will be conducive to rapid growth of green matter rather than crops and this might affect seasonal food security (NACCC, 2007). Rapid growth could reduce the nutritional value of pastures which could in turn result in fewer animals supported per unit area of pasture land and this could have a detrimental effect on beef production, both for export and for local consumption.

The Ministry of Agriculture has reported an increased incidence of intestinal problems in cattle often associated with pasture. Similar problems (worm and infections) have been encountered by the piggery farmers.

The Ministry offers a limited veterinary service to farmers on Efate and Espiritu Santo only and is ill-equipped to offer much assistance during any major outbreak of animal diseases whether climate change-related or otherwise. Hot temperatures could result in the relocation of stocks to cooler climates (an adaptation measure) and this could entail significant costs to the farmers especially given the poor state of most of Vanuatu's roads. Local farmers with knowledge of which breeds or varieties can best adapt to changing conditions can provide invaluable input to any effort aimed at mitigating the negative impacts of climate change to the livestock industry.

Small scale livestock farmers will be mostly affected by increased temperatures and drought as these could cause soil compaction and dry up the streams on which the farmers depend for their primary source of water. Overstocking and overgrazing could result from dried conditions and this would in turn result in loss of animal weight and further degradation of pasture lands.

8.3. Water Management

Water is vital to agriculture development and production in Vanuatu. Population growth, particularly in urban areas, is already placing pressure on water resource and supply services. Climate change is likely to increase the demand for water and yet reduce the quality and affect water sources. This will have implications for water source management and water use especially for industries and agriculture which are heavy water users.

Vanuatu has limited surface water and villagers on many islands and residents of both urban areas (Port Vila and Luganville) are dependent on ground water. Increased temperatures are likely to increase the demand for portable water, however increased heat, greater run-off

from high intensity rainfall events, decreased rainfall and an associated increase in evaporation could reduce the rate of ground water recharge and decrease surface water flows. Water shortages that are already apparent in dry seasons would become more pronounced and may require more sophisticated water distribution networks to maintain human populations and agriculture production in severely affected areas.

Any increase in sea level could cause salt-water intrusion into the shallow ground water lens in coastal areas, particularly if ground water recharge was reduced or water over-extracted. Increased rainfall often associated with cyclones could also cause flash floods, soil erosion and further pollution of freshwater and marine environments. Increasing population will place additional pressure on the already stressed water supply systems and any further pressure resulting from climate change and climate variability would be extremely hard for the government and people of Vanuatu to cope with.

8.4. Soil and Land Management

Increased rainfall could result in water-logged soils unsuitable for agriculture and other uses. It could lead to soil erosion and loss of soil nutrients important for plant growth.

Climate change could influence to the way land is managed in Vanuatu. Changes in rainfall could see the introduction of less water-demanding species and varieties or the introduction of new land management regimes that are better tailored to cope with the changing weather or rainfall patterns. Monoculture plantations may no longer be suited to the changing conditions in certain parts of the country and changes in rainfall and temperature could result in the proliferation of new or dormant pest and diseases that could cause considerable damage to agriculture crops and hence food security for the people of Vanuatu.

Agriculture crops like wild yams that used to act as soil cover against run-off is reported to be sprouting during the wet season as opposed to the past when they usually sprout before the wet season. This means that this crop has lost its soil protective function as a result of shifts in weather patterns (Brian, pers. com). The promotion of multi-cropping system which are likely to increase the resilience of agricultural crops to climatic events and prevent the spread of pests and diseases that is often associated with increased temperatures and high rainfall may be an appropriate approach to managing soil and land in response to future changes and shifts in weather patterns.

8.5. Forestry

The loss of forests, whether from agriculture land clearing or from climate related activities can have devastating effects for the people and economy of Vanuatu. While almost 70% of the country's land area remains under forest, less than 30% is of merchantable value. Non-forested lands are used primarily for agriculture, gardening and settlement. The rapid increase in population growth, coupled with the effects of cyclones and agriculture on the remaining land would inevitably result in the rapid decrease in total forested areas.

Most island forest species have small ranges, which in turn leaves them particularly vulnerable to land use changes because these changes can easily affect the species' entire

range. (Fonseca et al, 2006). Clearing of forest leaves areas open for invasion by alien species that then dominate secondary forests.

Vanuatu Forestry staff reported changes in the flowering and fruiting patterns of certain forestry crops and there appears to be an increase in the incidence of pest and diseases in species such as sandalwood, white wood (caterpillar attack) and mahogany (shoot porous). Invasive species are said to be more wide spread and seed collection from major species has been particularly low compared to past years (Viji, pers.com). Salt spray in certain islands of Vanuatu is causing forest dieback and the slash and burn method used for agriculture land clearing is a common threat to forest areas.

Very little is known about the likely impact of climate change on forest wildlife in Vanuatu. Birds and bats play an important role in propagating forest species and are often excellent indicators of the health of forested areas.

Reforestation plans may need to be reviewed in light of changing climatic conditions. Increased temperatures in the northern islands may require research into the use of species that are resilient to the hot weather conditions in that part of the country. Increased rainfall in the other areas of the country would likewise deserve the choice of species that can do well under the wet conditions.

8.6. Fisheries

Vanuatu, like other Pacific island countries depend heavily on subsistence fisheries for their food security. Seafood comprises a very high percentage of the animal protein consumed by Pacific Islanders, much higher than the world average of 17 percent. If the subsistence fisheries ceased to exist, Vanuatu may have to spend US$7-$15 million a year for substitutes with similar protein content (World Bank, 2000).

The impact of long-term trends in climate change, in particular related to global warming, is less well-understood in fisheries but is beginning to receive attention (FAO, 2007a). Climate change and rising sea levels are likely to impact on marine resources through their effects on corals and reef ecosystems. Coral bleaching could increase as a result of increased temperatures and there are concerns about the possible increase in ciguatera poisoning due to increased temperatures of the oceans, marine pollution from land-based activities and sedimentation of the coastal areas and water run-off.

Changes in ocean circulation patterns, may affect fish populations and the aquatic food web as species seek conditions suitable for their lifecycle. Higher ocean acidity (resulting from carbon dioxide absorption from the atmosphere) could affect the marine environment through deficiency in calcium carbonate, affecting shelled organisms and coral reefs (ibid).

The damage to coral reefs from cyclone events can be considerable as was the case with reefs around Efate from TC Ivy in 2003. Several outbreaks of the crown of thorns have been reported since the cyclone but it is difficult to say if this was directly related to the cyclone damage.

8.7. Mangroves

Mangroves are productive ecosystems that are important to the livelihoods of coastal communities. Many fish and other marine species breed and live in mangrove areas and yet, many such areas are being destroyed or converted to other uses.

Mangrove forests also play an essential role in protecting the coast against storms and inundation. Mangrove areas are believed to be declining in Vanuatu, even in certain isolated areas where population densities remain low. Pollution from land-based activities is perceived as the most common threat to mangrove areas although land clearing is also a threat.

Mangrove ecosystems will certainly be affected by climate change events. Sea level rise could affect growth and productivity while storms and associated heavy rain can cause pollution thereby affecting breeding and spawning grounds for many fish species that live in mangrove areas.

9. Typology of Likely Climate Change Impacts on Agriculture and Food Security

The likely impacts of climate change on agriculture and food security in Vanuatu has been discussed extensively in the foregoing parts of this study. The following matrix presents a summary of such impacts and the socio-economic response potential to the identified impacts.

Potential Impacts of Climate Change on Agriculture & Food Security

Threat	Impact	Potential Response
Cyclones	• Wind damage to agricultural crops and forest trees. • Erosion of coastal areas due to wave surges and flooding. • Damage to crops from salt spray and rising sea levels. • Inundation of groundwater sources by salt water. • Destruction of farm shelters and rainwater storage facilities • Loss of animals due to falling coconut trees. • Damage to corals and reefs. • Outbreaks of crown of thorns • Outbreaks of invasive species • Low fish catches	• Introduce wind resistant crops and varieties • Replant and protect coastal vegetation • Introduce salt tolerant species. • Broaden genetic base of traditional crops • Improve rainwater catchments and storage capacity • Apply groundwater protection measures • Relocate farms if necessary. • Strengthen quarantine and invasive species control measures.
Sea level rise	• Salt water inundation and	• Introduce adaptive

	flooding of agricultural lands • Inundation of habitats for coconut crabs • Inundation of coastal springs and underground water sources • Erosion of soil and coastal areas. • Increase salinity of agricultural lands	agriculture management approaches • Introduce salt tolerant species • Broaden genetic base of traditional crops • Apply groundwater protection measures • Replant and protect coastal vegetation • Develop coastal management plans
Increased rainfall (including precipitation)	• Erosion of soil and soil nutrients • Flooding of agricultural lands • Pollution of underground water sources and coastal areas • Alleviate water shortage especially on small islands • Create favorable conditions for growth of less desirable pasture species • Create conditions favorable for spread of pest and diseases • Sedimentation of reefs and lagoons affecting fishery	• Restore degraded lands • Introduce tolerant varieties • Apply groundwater management and protection measures • Improve rainwater catchments and storage facilities • Apply pasture management techniques • Apply pest management control • Construct coastal protection infrastructures.
Drought (including increased temperature and declining rainfall)	• Plant and animal stress • Water shortages for agriculture purposes • Affect health, production and reproductive capacity of animals • Slow growth and low yields from food crops • Low productivity of farmers • Increased risk of fires	• Introduce tolerant varieties and crops • Broaden genetic base of traditional crops • Local processing of food products • Increase/improve water storage capacity • Apply water conservation measures • Adopt risk/adaptive management approaches

10. Other Factors Contributing to the Vulnerability of Agriculture and Food Security in Vanuatu

Vanuatu possesses significant land and marine resources. It has areas of fertile soil, substantial (though declining) forest cover, attractive and diverse landforms and productive coastal environments. Moreover, climatic conditions in Vanuatu are ideally suited to the development of its agriculture sector. Vanuatu therefore places a heavy emphasis on the sustainable development of agriculture, forestry and fisheries, all of which are reliant on the natural environment.

However, Vanuatu is vulnerable to natural disasters that can affect the sustainable management and rational use of natural resources. There is evidence of environmental degradation through the over-exploitation of land-based resources such as timber. On the basis of information available, it is suggested that there will be a gradual increase in temperature that will be more pronounced in the south of the country. A gradual decrease in rainfall has also been predicted for Vanuatu. Under these circumstances, the future management of the use of the country's resources will need to take into account the impacts of climate change on the natural environment, human health and the development sector. The other factors that are likely to contribute to the vulnerability of the agriculture sector and are likely to impinge on food production and food security in Vanuatu are discussed below.

(a) *Declining productivity of small farms*. Vanuatu is a highly diversified group of islands. For this reason it is extremely difficult to service the large number of small farms scattered over the islands from Port Vila especially given the poor road conditions, the long distances and the irregular air and boat links that exist at present. These linkages will be disrupted in times of natural disasters and this will seriously affect agriculture production and trade and subsequently food security in the entire country.

(b) *Loss of traditional farming techniques*. There are a number of traditional crops in Vanuatu that the people have depended on for their needs particularly during times of natural disasters. Wild yams, taro and sweet potatoes have been stable food crops for ni-Vanuatu for ages but have not been yielding as much as they used to in recent years. Apart from changes in climatic conditions, the loss of traditional planting techniques is believed to be largely responsible.

(c) *Resistance to change*. Small scale local farmers know from experience the best seasons to plant and harvest certain species and varieties of traditional food crops. Some of these farmers now realize that the seasons are shifting but are still planting and harvesting during the same periods they are used to. There is resistance to change the way they farm and harvest believing that what they are going through now is just a "cycle" that will return to normal in a year or two.

(d) *Influence of large scale, single crop farming*. It is difficult to travel around the larger islands of Vanuatu such as Efate, Santo and Malekula without being impressed by the sight of some of the biggest cattle farms and gardens in the Pacific islands.

Compared to the small farms that are common but struggling throughout the country, the large, self-sustained farms are the symbol of success and understandably, influences the way small farmers do business.

(e) *Loss of interest in traditional crops such as coconuts, etc.* Declining local and international market prices for commodities such as copra, cocoa and coffee have seen the loss of interest by local farmers in the development and harvesting of these crops. People are not collecting coconuts except to feed their pigs and this has resulted in a loss of income for small farmers who used to sell dried copra as an additional source of income for the family. Climatic events such as cyclones and sea level rise will add to the demise of these traditional crops unless there is a significant effort to revive interest through alternative profitable uses.

(f) *Poor understanding of the country's forest resources.* Knowledge of Vanuatu's forest resources is based on outdated forest inventories that have not been updated in recent years. Detailed, up-to-date inventories of the nation's forests do not exist and this will make planning for the effective management of this valuable resource difficult. The effects of recent cyclones and other natural disasters on the forest resources are poorly understood and it is feared that the latest estimates of areas still under forest may be grossly overstated.

(g) *Lack of a sustainable forest management plan.* For many years, the forestry industry has been operating in an unplanned manner and while some logging plans have recently been developed, considerable work needs to be done to ensure current and future plans are sustainable and that they meet the standards expected in the Code of Logging Practice. Forest management plans should provide a strategic overview of how the nation's forests will be managed including the economic use of salvaged timber or other forest products from cyclones and other natural or man-made causes.

(h) *Imbalance between forest utilization and reforestation.* At present, there is very little effort to replant logged or cyclone-damaged forest areas in Vanuatu. Knowledge of the survival and growth of natural forests is at best very limited and this will continue to hamper future efforts to manage indigenous forest areas in a sustainable manner. While there is considerable interest in commercial plantations of the fast growing and highly-valued sandal wood, there has so far been little interest in replanting other local species such as white wood which is believed to be highly resistant to natural disasters.

(i) *Lack of understanding of the impact of climate change on fisheries resources.* While there are a number of projections and forecasts about how fisheries and coastal resources will be affected by climate change and variability, it has been difficult for local officials to establish the connection between what is happening now and climate change. This is particularly so as there has been, until recently, no attempt to monitor changes to the health of marine ecosystems and to establish the connection between such changes and climatic events that affected the country over the years.

(j) *Destruction of productive coastal ecosystems.* Mangroves, corals and coral reefs are subjected to the effects of land-based development, pollution and poor land management in many parts of Vanuatu. If continued unchecked, these productive ecosystems will be totally destroyed and converted to other uses. This will in turn affect food production and subsequently food security for the many people and communities that depend on the coastal ecosystems for their daily subsistence.

(k) *Lack of understanding of the impact of climate change on livestock.* How climate change and climate variation actually impact on livestock is less understood compared to other sectors. Increased precipitation and rainfall may improve pasture growth but could also enhance the growth of less desirable and less nutritive pasture species that may over time, dominate and replace the desired species.

(l) *Lack of capacity to service the livestock industry.* At present, the Livestock Division of the Ministry of Agriculture is unable to provide veterinary service to small farmers on the outer islands due to limited capacity and resources. Given this situation, a major outbreak of any animal disease will be disastrous for Vanuatu's livestock industry. Any climate change induced health risks to farmed animals in the country could pose severe risk to animal production and food security in the country.

(m) *Limited ground water supply.* Despite the abundance of rainfall that average about 2200 millimeters per year, Vanuatu has few perennial streams probably as a result of the islands small size and rugged topography. Prolonged dry spells and droughts can easily result in the exhaustion of the limited supply of water available, especially on the small outer islands in the northern part of the country. Data collected by the Department of Geology, Mines and Water Resources (DGMWR) suggest that increased rainfall does not necessarily result in increased ground water recharge and this must surely be a concern for the country's overall development.

(n) *Destruction of ground water sources.* Many underground water sources on the outer islands of Vanuatu have been rendered useless by salt water intrusion, flooding or through overuse. Water levels in the few rivers that exist on the larger islands are also reported to be declining and this trend will continue in light of projected declines in rainfall. Such situation will adversely affect agricultural production and food supply in Vanuatu and calls for urgent attention by the government and its development partners.

11. Climate Change Related Activities of other UN, CROP and Other Agencies in Vanuatu

A number of climate change related projects and activities have been implemented in Vanuatu in the past few years. Those that are of relevance to the agriculture sector are summarized below.

a) Regional Programme for Food Security in the Pacific Islands (RPFS). In addition to many other programmes and projects supported by FAO in the region, this RPFS program, endorsed at the Sixth and Seventh FAO South West Pacific Ministers of Agriculture Meetings, aims to address agriculture trade, food quality and safety, and climate change focusing on the urgent need for preparedness, and putting in place adaptation and mitigation strategies and actions. The Sub-Programme 2.3. (Natural Disasters and Climate Change Preparedness, Adaptation and Mitigation) has four components dealing with (i) Agriculture Diversification; (ii) Integrated Coastal Management; (iii) Land and Water Management and Use; and (iv) Technical Coordination Support. Interventions of the expanded programme will target:
    - Enhancing food production;
    - Rural infrastructure development; and
    - Strengthening agricultural trade and policy, climate change adaptation and mitigation and support for project planning and programme development.

    The RPFS has an indicative budget of US$72 million for a period of 7 years. Sub-programme 2.3 (see Annex 4) is estimated to cost about US$5.07 million (FAO, 2007b).

b) Global Environment Facility (GEF). The GEF has funded a number of enabling activities in Vanuatu in the past few years and is continuing its support for activities identified by the government as priorities for GEF support. In a recent communication to the government of Vanuatu, the CEO and Chairperson of the GEF indicated that the RAF allocations inGEF-4 will offer increased opportunities for the 15 Pacific island countries including Vanuatu. GEF's current programming priorities in the climate change focal area include support for energy efficient buildings and appliances, energy efficiency in industry, on-grid renewables, sustainable biomass for energy, and sustainable transportation (Barbut, 2007). It is understood that government is currently in the process of identifying its priorities for GEF-4 financing.

    To increase efficiency and effectiveness of GEF support to Pacific island countries thereby enhancing the achievement of both global environment and national sustainable development goals, a GEF-Pacific Alliance for Sustainability (GEF-PAS) program has been proposed. The GEF-PAS is a comprehensive regionally coordinated and nationally executed strategic investment program that reflects country priorities for achieving sustainable development goals. It would deliver significant global and local environmental benefits, reflecting the importance of the Pacific in terms of conservation of biological diversity, prevention of land degradation, protection of international waters, sound management of chemicals and mitigating and adapting to the effects of climate change. The GEF-PAS will bring together the GEF Secretariat, the Implementing Agencies and the regional organizations to define and deliver an investment program to achieve the above benefits. The GEF-PAS will help build PIC capacity to more effectively access GEF resources.

c) Capacity Building for the Development of Adaptation Measures in Pacific Island Countries (CBDAMPIC). The CBDAMPIC is a climate change adaptation project funded by the Canadian International Development Assistance (CIDA) and executed by SPREP in 4 Pacific Island Countries: Cook Islands, Fiji, Samoa and Vanuatu. It is a continuation of the previously concluded SPREP-funded Pacific Islands Climate Change and Adaptation Project (PICCAP) which involved several Pacific island countries. In Vanuatu, the CBDAMPIC was piloted in three selected locations namely, Lateu Community in the Torres Group of islands, Luli Community on Paama island, and Panita Community on Tongoa in the Shepherds Group of islands. The CBDAMPIC was the first step towards building the capacity at the institutional and community levels to better understand the adverse impacts of climate change and how to improve local capacity to adapt to any adverse impacts. The project carried out assessments of the likely impacts of climate change on agriculture and other sectors of the three communities and looked at adaptation options the government and communities could consider.

d) Development of a National Forestry Policy Statement. This policy was completed in June 1999 following wide consultations carried out in 1996 and 1997. Many recommendations of the Policy Statement have since been implemented and the Policy continues to guide the work of the Department of Forests to the present date.

e) The Pacific Islands Renewable Energy Programme (PIREP) is executed by the Department of Energy with funding from the GEF. Under this project an assessment of the key energy issues, barriers to the development of renewable energy to mitigate climate change, and capacity building development needs for removing the barriers was undertaken.

f) The Pacific Islands Energy Policies and Strategies Action Planning (PIEPSAP) Project aimed to assist Pacific Islands with the development of national energy policies and action plans to implement these policies. The project was funded by the Danish Government and was implemented through the SOPAC. An Energy Policy for Vanuatu was developed under the project and has been approved by the Vanuatu Cabinet.

g. The Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project (PIGGAREP) was funded by the GEF and executed by the Department of Energy. It aimed to reduce growth of GHG emissions from fossil fuel use in the Pacific Island Countries through widespread and cost-effective use of renewable energy resources.

h. The Pacific Islands Global Climate Observing Systems (PIGCOS) was funded by the NOAA and implemented by SPREP. The project was designed to enhance observation of climate change and provide more comprehensive data base for more accurate predictions and decision making. Due to funding constraints, there has been little work done on this project in Vanuatu.

i. With financial assistance from GEF and UNEP, Vanuatu is developing its National Implementation Plan (NIP) through the enabling activities of the Stockholm

Convention. The NIP seeks to control the importation, use and release of Persistent Organic Pollutants (POPs) in Vanuatu.

j. With funding from the GEF, the National Advisory Committee on Climate Change (NACCC) is in the process of developing Vanuatu's Second National Communication report to the UNFCCC. The NACCC is under the chairmanship of the Director of Meteorology and comprises representatives from a number of government Ministries and Departments. The SNC will highlight actions taken to meet Vanuatu's obligations under the UNFCCC.

k. Through an Italian/Pacific SIDS Cooperation arrangement, a US$10 million Climate Change and Vulnerability project has been developed for implementation in 2008 (Philips, pers.com). Vanuatu intends to participate fully in this project.

l. The Live and Learn NGO has Climate Change as its Thematic Program Area 5 that aims to heighten climate change awareness and advocacy. Activities under this Program Area focus on the mobilization of long term carbon credit programs involving climate change education, reforestation and regional networking. It also involves the provision of information and education to local groups to advocate nationally and internationally for responsible policies on climate change.

m. With funding from AusAID, the South Pacific Sea Level and Climate Monitoring Project (SPSLCMP) has from 1992, installed a number of SEAFRAME stations in several Pacific island countries to provide accurate and long term sea level records. A SEAFRAME gauge was installed in Port Vila in January 1993. It records sea level, air and water temperature, atmospheric pressure, wind speed and direction. The SPSLCMP was a response to concerns raised by FORUM leaders over the potential impacts of an Enhanced Greenhouse Effect on climate and sea levels in the Pacific region.

12. Success Stories and Lessons Learned

The successes

Although Vanuatu has made important strides in its efforts to address climate change issues and concerns, mush still remains to be done. It is however encouraging that government has recognized the importance of the issue to national development and is well on its way to making sure that climate change issues and concerns are taken into consideration in the development and implementation of national projects and plans.

It is particularly difficult to identify 'successes' from completed climate change projects and activities in Vanuatu firstly because such successes if any have not been documented and secondly, because there has been a relatively short history of climate change initiatives in the country. Nevertheless, it is possible to highlight some of the achievements and decisions that have been made which could, with a bit more effort and support, pave the way for success in preparing the country for the adverse impacts of climate change and sea level rise.

12.1. The "no-regrets" approach. In January 2005, His Excellency, the President of the Republic of Vanuatu, declared that the "ideal approach to adaptation in Vanuatu is a pro-active, no-regrets approach which encompasses measures and strategies which can be implemented in the present with the aim of reducing vulnerability in the future". This approach has guided local efforts to address climate change, climate variability and sea level rise initiatives over the past few years. For a country whose people and economy are interwoven, shaped and driven by climate sensitive sectors, the effects of climate change and sea level change are already very real and pose a tangible threat to the future socio-economic well-being of Vanuatu. By reducing the vulnerability of Vanuatu's vital sectors and communities now to current climate related risks (the no-regrets approach), the country will be in a better position to adapt to future climate change impacts.

12.2. Establishment of the NACCC. The Lack of coordination amongst government agencies, NGOs, the private sector and communities has been identified as the major stumbling block to the effective implementation of environmental projects in the past. The establishment of the National Advisory Committee on Climate Change (NACCC) by government to oversee the coordination of all climate change initiatives and programmes emanating from the UNFCCC process was a timely response to this situation. The Committee is operating effectively and is drawing the necessary expertise available to advise on key issues and concerns discussed by the Committee.

12.3. Prioritized list of projects for NAPA Implementation. Through an extensive consultative and participatory process, a prioritized list of projects for NAPA implementation was finalized. From an original list of about 20 proposals, the following five projects were considered priorities for implementation. They are: (i) agriculture and food security; (ii) water management policies; (iii) sustainable tourism; (iv) community-based marine resource management; and (v) sustainable forestry management. The prioritization process enabled the verification of what the stakeholders believed were the most urgent and immediate concerns of Vanuatu in relation to adaptation to climate change and was a solid basis for planning and allocating the limited national resources available for this work.

12.4. Improved capacity to undertake climate change impact assessment. Vanuatu, through the Meteorological Division and Working Groups formed under the NACCC has shown that it now has the capacity to undertake preliminary assessment of the impacts of climate change on the environment. Assessments have been completed on a number of small islands under the CBDAMPIC and the Vanuatu Vulnerability and Adaptation projects and these will form the basis for future assessments in other parts of the country. More investment in human resource development is still needed to cater for future staff movement and this is anticipated through future projects and programmes of government and funding agencies.

12.5. Advanced work on alternative energy sources. While Vanuatu has potential to use a range of alternatives as substitutes for fossil fuel, work on coconut oil as a substitute for diesel in the transport sector is particularly encouraging. Declining market prices have resulted in people turning away from collecting coconuts as it was no longer

economical for them to do so. The production of coconut oil as a substitute for or supplement to diesel could potentially see the revival of the coconut industry which will in turn benefit the nut collectors and farmers especially in the rural areas.

The Lessons

Except for the Lessons Learned from UN System Cooperation with Vanuatu (UNDAF 2003-2007), there has not been a lot of lessons documented from the various projects implemented in the country. However, from the review of reports and through consultations held during the course of this study, the following lessons can be drawn from the Vanuatu's experience in dealing with climate change issues.

(i) Make population planning an intricate part of national strategies to adapt to climate change. It is very obvious that the high population growth rate of Vanuatu has not been considered a serious problem to future efforts to deal with the impacts of climate change. With a population that is expected to double every 20 years, a lot more pressure will be placed on coastal ecosystems, water supply systems and infrastructure making them more vulnerable to extreme events. Moreover, many more people will be affected by climatic events such as cyclones, flooding, and drought. Government does not have the resources to adequately provide for the current population and will be in an even worse state to provide for twice as many people 20 years from now.

(ii) Reduce complexity of programmes and project designs. While Vanuatu now has some capacity to implement technical projects, it does not yet have the expertise to design and implement complex and complicated initiatives. Projects and programmes for Vanuatu should therefore be designed from the outset to be flexible and to match local capabilities to implement and manage. They should be less complex and more focused. Expected outputs should be prioritized, transparent, clear and measurable.

(iii) Build partnerships for effective project implementation. With 80 islands scattered over a huge area of open waters, implementing national projects in Vanuatu will always be a difficult challenge. Government services are extremely limited or absent on some islands and this will compound the problem. On the other hand, some NGOs have been active in rural areas and are best placed to assist government carry out some of its projects in such areas. To do this would require the establishment of a working partnership between the parties to ensure their roles and responsibilities are clearly identified and understood. Similar arrangements with local communities may also prove beneficial.

(iv) Enhance public awareness and understanding of climate change and its likely impacts on their livelihood. While public awareness about global warming is improving through the media, public awareness about the impact of climate change on the peoples' livelihood is very extremely limited. Such awareness and understanding is crucial to fostering effective partnerships with local communities on efforts to adapt to climate change.

(v) Mainstream climate change adaptation into physical planning and development initiatives. Previous initiatives to adapt to climate change in Vanuatu have had limited success because they were planned and carried out in an ad hoc manner. While the NACCC has ensured that this will not happen again, there still remains the need to mainstream climate change adaptation into the physical and development plans of the country as a whole. There is also a need for key sectors like agriculture, tourism, forestry and fisheries to integrate adaptation measures into their own sector plans and programmes.

(vi) Importance of regional and sub-regional climate change initiatives. Climate change will affect all Pacific island countries. Vanuatu should therefore continue to explore with its Pacific neighbors opportunities for regional or sub-regional initiatives through which additional support for local implementation of climate change adaptation projects could be secured. Working with UN agencies (such as FAO, UNDP and UNEP) and regional organizations such as the FORUM Secretariat, SPREP, SOPAC and SPC will be useful in this regard.

(vii) Importance of working with local communities. Involving local communities in the planning and implementation of climate change adaptation projects will be key to the long term success of such projects. The development and inclusion of an appropriate consultative mechanism for the project proponents and the communities to consult with each other is an important step in formulating an effective and efficient working relationship between them.

(viii) Strengthening service delivery to rural areas is crucial to nation-wide efforts to minimize the impacts of climate change on the environment. Poor transport and communication networks are hampering efforts to engage rural communities in climate change adaptation initiatives. As a result, past climate change initiatives have concentrated on urban areas while those in rural areas miss out on training and other benefits from such initiatives. Improving access (land, air and boat links) to rural communities is crucial to the success of climate change adaptation efforts in areas that are often neglected by government programmes.

13. Existing Institutional Mechanisms and Policy to Respond to Climate Change and Climate Variability in Agriculture and Food Security

Institutional arrangements

Although the government of Vanuatu is continuing to implement a comprehensive reform programme (CRP) designed in 1997 to address key governance issues with emphasis on improving the transparency and accountability of the public sector, much remains to be done to strengthen key institutions of government to promote community participation in the decision-making processes.

Most of the necessary institutional structures to deal with climate change and other environmental issues are in place although many have become ineffective because of lack of resources or delays in staff appointments. An important example is the Environment Unit of the Department of Lands and Environment which has shrunk to just two staff and without a Principal Officer to lead its activities. Other relevant agencies are not much better off and this is a problem the government will have to look into as a matter of urgency in order to ensure that it has the required capacity to deal with the broad range of climate change issues that are likely to impact on the country's development in the long term.

As a developing country, most organizations in Vanuatu have limited capacities in terms of staff numbers, numbers of technical staff, access to technical equipment and financial resources. Government agencies focus on immediate and practical priority issues and have difficulty maintaining current level of services in key sectors such as agriculture. While recognizing the long term importance of reducing GHG emissions and preparing for climate change, it is difficult for government to take the longer term economic decisions necessary.

There are several government agencies, NGOs and other organizations in Vanuatu who are and should continue to play key roles in addressing climate change concerns in Vanuatu. The roles of the following agencies and organizations are particularly relevant to the agriculture sector.

(i) The NACCC[5] is the principal body responsible for all climate change activities in Vanuatu. The NACCC was established by decision of the Council of Ministers and brings together the range of expertise that is available in various government and non-government agencies to plan and develop strategies and actions necessary to address climate change issues affecting Vanuatu. The NACCC has been responsible for the preparation of the INC and is now working on the Second National Communication (SNC).

(ii) Until recently, the Environment Unit of the Ministry of Lands and Environment (MLE) has been the principal agency responsible for environmental issues in Vanuatu. However, staff departures and limited resources have seen the downsizing of the Unit to just three staff members with limited experience in the disciplines under the Unit's mandate. Government's intention with regards the role of the Unit remains unclear but it is unlikely that the situation will improve much in the next year or so. An assessment of Vanuatu's capacity to meet its obligations under the CBD, UNFCCC and UNCCD was implemented by the Unit in the past three years.

(iii) The Meteorology Department has played a key role in the implementation of climate change projects and activities in Vanuatu. It currently holds the chair of the NACCC and has participated fully in the preparation of the NAPA and Vanuatu's INC. Through the NACCC, the Department is actively involved in all climate related activities in Vanuatu and has carried out vulnerability assessments

[5] Members of the NACCC include: Meteorological Services (Chair), Ministry of Foreign Affairs, Environment Unit, Department of Agriculture, Department of Forestry, Department of Fisheries, Department of Energy, Ministry of Health, and Department of Lands.

of more than ten small islands in the country. The impact of climate change on the agriculture sector received important emphasis in these studies.

(iv) The current emphasis of the work of the Agriculture Department is increasing productivity of small farms around the country and the development of efficient domestic and export marketing systems for traditional food crops, livestock and high value specialty crops. The Department has not been directly involved in implementing climate change related projects but is well aware of the potential impact of climate change on its efforts to increase productivity and marketing systems. There is work underway looking at selection programs for crops and varieties that are more resistant to changing weather patterns as well as pests and diseases that are likely to become prevalent due to more favorable breeding conditions.

(v) Although it has not been directly involved in implementing any climate change projects in Vanuatu, the Fisheries Department has played an important role in supporting a number of projects and activities that are important to understanding the impact of climate change on fisheries habitats. The Department has recently established monitoring sites to assess the impact of pollution from land-based activities on coastal ecosystems around Efate and is looking at replicating this work in other islands of Vanuatu. The Department is also involved in the NACCC and provides technical advice to the NACCC's working group on matters pertaining to fishery.

(vi) The Forestry Department has participated in a number of environmental projects in Vanuatu including climate change through the NACCC. In 1997, the Department produced a National Forest Policy Statement "to ensure the sustainable management of Vanuatu's forests in order to achieve greater social and economic benefits for current and future generations". The Conservation Unit of the Department formulates and coordinates environmental projects that are compatible with the interests of climate change projects and in this way contributes to national efforts to address climate change issues in the country.

(vii) The Department of Geology, Mines and Rural Water Supply is charged with the responsibility to conserve, protect and manage the minerals and ground water resources of Vanuatu. The Department has been working with other government departments to monitor the condition of the bay and lagoons around Efate and has been looking to secure equipment for carrying out heavy metal residue tests on bivalves and gastropods within these areas. Through a UNESCO-funded initiative, the Department has been implementing water resource and land-use monitoring activities with the communities of Epule (on Efate), Fanafo (on Santo) and Talise (on Maewo). Ground water monitoring work is particularly important to understanding the impact of climate change and it is expected that this Department will continue to play a key role in future efforts to address the impacts of climate change on Vanuatu's water resources.

(viii) Although not involved with the NACCC, the Foundation for People of the South Pacific (FSP) Vanuatu has a long history of involvement in resource

management and training especially with rural communities throughout Vanuatu. Some of the projects the FSP has carried out that are of relevance to climate change include (a) a disaster management project; (b) community vulnerability reduction training; and (c) participatory natural resource management.

(ix) The Vanuatu Association of NGOs (VANGO) was established in 1994 as an umbrella NGO for all locally registered NGOs. VANGO promotes and supports NGO efforts to achieve equitable and sustainable human development within Vanuatu and currently hosts the Pacific Islands Association of Non-Governmental Organizations (PIANGO). With a grant of 3 million vatus, VANGO coordinated emergency relief for victims of an earthquake that affected the Tafea and TORBA provinces.

(x) The Wan Smol Bag Theatre (WSBT) is well known throughout Vanuatu and the Pacific for its popular dramas and plays with environmental themes. WSBT plays are based on needs and concerns raised by communities, government and other groups. Past plays have focused on waste management awareness, river management and turtle monitoring. Other plays have focused on AIDS and other social issues affecting youths in the Pacific. The WSBT remains an effective avenue for raising understanding and awareness of climate change issues provided it is given the financial support it requires.

While the national government lacks capacity to respond to climate change, capacity at the Provincial level is even more limited. Provincial administrators have few trained technical staff, none have dedicated environmental officers or planners, and all have extremely limited resources. However, the need for participation at this level in implementing decisions and plans that help people prepare for climate change is crucial to the success of national initiatives to adapt to climate change. As more information becomes available, it will be important to develop skills and support for the preparation of climate change action plans for Vanuatu on both provincial and island by island level.

At the community level, there is very little understanding of the concepts of greenhouse gas induced climate change. Although several programmes had focused on public and community awareness in the past, these have not been followed up due to limited resources. It is unlikely that the general public will have the scientific literacy to fully understand concepts underpinning the climate change and sea level rise issues. Hence activities that are specifically focused at the community level where the transfer of skills in disaster preparedness, community planning and adaptation to climate change are promoted will, in many cases be more productive than attempts to raise understanding.

Policies and Legislation

Article 7 (d) of Vanuatu's Constitution categorically states that every person has a fundamental duty "… to protect Vanuatu and to safeguard the national wealth, resources and environment in the interest of present and future generations". In March 1993, the Republic of Vanuatu ratified the UN Framework Convention on Climate Change (UNFCCC) and submitted its INC in October 1999. Following the preparation of the INC,

initial efforts to create an institutional set-up that seeks to mainstream climate change issues into the national frameworks were initiated.

At the Seventh Conference of the Parties to the UNFCCC (COP 7), it was resolved that the work programme for least developed countries (LDCs) to prepare and implement National Adaptation Programmes of Action (NAPA) be supported, including meeting the full cost of preparing the NAPAs. As an LDC, Vanuatu took advantage of this support and in October 2004, NAPA activities for Vanuatu commenced.

The objective of the NAPA project for Vanuatu was to develop a country-wide programme of immediate and urgent project-based adaptation activities in priority sectors, in order to address the current and anticipated adverse effects of climate change, including extreme events. The NAPA also served as an avenue to raise understanding at all levels in society, with respect to vulnerability and adaptation issues of greatest significance to the country. At the completion of nation-wide consultations, the final list of projects for implementation under the NAPA was determined as follows:

- Agriculture & food security (preservation/processing/marketing, modern and traditional practices, bartering);
- Water management policies/programmes (including rainwater harvesting);
- Sustainable tourism;
- Community-based marine resource management programmes (modern & traditional aquaculture); and
- Sustainable forestry management.

The NAPA provides a comprehensive listing of climate change issues and vulnerabilities as well as adaptation options for the various provinces of Vanuatu and as such, is seen as a key guide to government and all other sectors in addressing the impacts of climate change in the country.

In addition to the NAPA, efforts have also been made to prepare sector-specific policies for dealing with climate change. The following initiatives are worth noting.

(i) Climate Change Policy for Vanuatu. Because climate change will affect most sectors, it is important and appropriate that Vanuatu takes an integrated, short and long term approach to dealing with climate change issues affecting the country. A Climate Change Policy Framework paper has been prepared for consultation purposes but it is expected that the final policy will be considered and approved shortly.

(ii) National Forest Policy Statement. Published in June 1999, the National Forest Policy Statement serves to guide the work of the Department of Forestry, to provide signals to both the investors and donors about how forestry will be managed in Vanuatu and to provide the direction for a much needed review of the Forestry Act. Sadly, the Policy Statement makes no mention whatsoever of impact of climate change on the sector and what actions, if any, will have to be

taken to minimize any impacts on the industry and people who depend on the sector for their livelihood.

(iii) Vanuatu National Communication to the UNFCCC. The National Communication is the primary mechanism through which Vanuatu's international commitments will be met. Implementation of the Initial National Communication (INC) has fostered better understanding and guidance in policy and planning developments towards achieving national objectives consistent with meeting international commitments. The INC demonstrates Vanuatu's commitment to bear its fair share of the burden in the worldwide effort to combat Global Climate Change while recognizing that national interest lies in protecting jobs and improving the quality of life for all ni-Vanuatus.

(iv) The Environment Bill 2002 strengthens the policy development and advisory roles of the Environment Unit. The functions of the Director include amongst others, the development of national environmental policies and plans for the sustainable management of the environment. Unfortunately, with its limited capacity at present, it is unlikely that the Unit will be able to carry out its functions without a substantial injection of funding and qualified staff.

(v) The Water Resource Management Act (2002) provides the option for the development of a Water Resource Management Policy and a National Water Resource Management Plan should the Minister consider these instruments appropriate for the efficient and effective planning and development of the nation's water resources. It also provides for the declaration of water protection zones – both rural and urban – where action is necessary to prevent or restrict development and expansion into areas from which water supply is drawn.

(vi) Comprehensive Reform Programme (CRP). In an effort to address several structural problems within its economy, Vanuatu began implementation of a comprehensive reform programme in July 1998 following its adoption by a broad range of community representatives at a national summit in Port Vila in July 1997. Environmental issues are given some prominence under the CRP. Key environmental issues can be classified as those arising as a consequence of human impact and those that fall under the areas of environmental conservation and enhancement. Issues falling under human impact include population pressure and urban development, waste management and global warming and sea level rise.

(vii) Research Priorities for Agriculture, Forestry and Fisheries in Vanuatu. Although the official status of this document is not known, it refers to several policy recommendations that have been formulated while attempting to draft an action plan for the development of the agriculture sector in Vanuatu. The exercise enabled the stakeholders to reach consensus on six major issues:

- the area of agriculture with the greatest potential to benefit the majority of the ni-Vanuatu, as well as the nation, lies in improving the production and market access to smallholders producing traditional crops;

- the expansion of the market for traditional foodstuffs and for high value specialty niche products depend on improving smallholder productivity and domestic market systems;

- there is a limited number of crops that are candidates for further development;

- increasing the production of traditional food crops and livestock and improving the marketing systems for these is an important priority considering the future doubling of the population;

- despite the falling prices of copra, it is necessary to refocus attention on the development of the coconut and non-copra uses;

- there is an urgent need to control the quality and to put in place conditions conducive to increased smallholder production of kava.

(viii) National Adaptation Plan for Action (NAPA). As pointed out elsewhere, the NAPA is perhaps the most important plan of action there is for addressing urgent adaptation issues in Vanuatu. Its main objective was to develop a country-wide programme of immediate and urgent project-based adaptation activities in priority sectors in order toe address the current and anticipated adverse effects of climate change, including extreme events. After extensive consultations and field visits, the NAPA has identified the priority projects for Vanuatu as follows:

- Agriculture and food security (preservation/processing/marketing, modern and traditional practices, bartering);
- Water management policies/programmes (including rainwater harvesting);
- Sustainable tourism;
- Community-based marine resource management programmes (modern & traditional, aqua-culture); and
- Sustainable forestry management.

14. National Strategy to Mitigate and Adapt to Climate Change Challenges and Opportunities for Agriculture and Food Security

14.1. Mitigation

Mitigation refers to measures that will reduce the national release of GHGs. Vanuatu is a very minor producer of GHG emissions both in terms of total emissions and emissions per

head of population. Mitigation measures will enable Vanuatu to minimize any increase in its GHG emissions, but due to existing needs for social and economic development, a reduction in releases is not an immediate goal for the government.

Most mitigation measures either reduce people's demand for GHG emitting products or else control their supply. They can incorporate education and awareness raising initiatives, fiscal measures such as financial incentives, taxes and charges, legislation to prohibit certain activities and policy measures. Some mitigation options of relevance to the agriculture sector are discussed below.

(i) Decrease dependency on fossil fuels. Diesel generators provide the majority of electricity in Vanuatu, particularly in the two urban centers, Port Vila and Luganville. Vanuatu however has potential to use a range of alternatives for generation of electricity such as geothermal, hydro, solar and wind. Both hydro and solar systems require substantial initial investment and this will make them less attractive. Increased use of biofuel (e.g. coconut oil) in the transport sector has shown promise in Vanuatu while promoting the use of fuel wood as a substitute for cooking gas would benefit rural areas where fuel wood is in abundant supply.

(ii) Promote forest conservation. Forests can be considered sinks for GHG. Vanuatu remains almost 70% forested, with non-forested areas primarily used for agriculture, gardening and settlements. Government policies and changing economic needs in recent years had resulted in large tracks of forested lands being converted to agriculture and other uses. Further conversions are inevitable and will be hard to stop. The option therefore is to promote agro-forestry and multi-cropping on converted lands as opposed to single crop monoculture systems that involves wholesale clear felling of forest areas.

(iii) Improve operating efficiency of agriculture equipment and appliances. Many farming / forestry machinery, vehicles and appliances operate at less than optimal conditions due to rugged conditions, and poor maintenance and repair. Improvements in operating efficiency will require greater awareness of the cost savings that result to the user and training of technical personnel in the maintenance and repair of heavy machinery.

(iv) Decentralize services and economic activities. Increased decentralization of services and economic activities coupled with greater development of the local markets would do much to reduce the current dependence on inter-island transport between Port Vila and Luganville as the hubs. Such a change would be facilitated by economic incentives for skilled workers and entrepreneurs to establish themselves locally rather than being based in one of the two urban areas. The majority of small farmers are rural-based and will benefit from not having far to go to sell their produce. Gains from reduced emissions from inter-island transports are, however likely to be offset by increased vehicle use as local cash economies become better established.

14.2. Adaptation

Adaptation refers to changes in technologies, practices and policies that can prepare a country for the impacts of climate change resulting from GHG emissions. While Vanuatu's vulnerability to climate change and sea level rise will be determined by the decisions and actions that are made today with respect to the management of the country's resources and the nature of its social and economic development, Vanuatu is nevertheless in a position to adopt pro-active adaptation strategies that can be implemented immediately and sustained over the years to effectively reduce its vulnerability. However, there are three main obstacles to be considered:

- In the present socio-economic climate, it is difficult to identify national resources that could be redirected to climate change adaptation activities from immediately pressing social development needs;
- Climate change issues are, in general, poorly understood; and
- Despite efforts to make climate change planning multi-sectoral, it has not been incorporated into the mainstream planning activities of governments and sectoral organizations (GoV, 1999).

Given the poor state of knowledge and understanding of climate change issues that exist today, coupled with limited financial resources and low levels of technology, Vanuatu, like many other SIDS face a considerable challenge to adapt to the impacts of climate change. Some adaptation opportunities considered appropriate and achievable for Vanuatu's agricultural sector are discussed below.

(i) Diversify root crops. Vanuatu's subsistence and commercial agriculture are based on a small number of crops. Diversification of root crops will help increase the resilience of agriculture systems to climatic extremes.

(ii) Improve research and understanding of subsistence food crops. The productivity, growth requirements and pathogens of many of Vanuatu's subsistence food crops are poorly understood compared to commercial horticultural crops. Better understanding of the horticulture of the subsistence food crops will provide a foundation for adaptation by enabling the selection and promotion of crop varieties suited to changed climatic conditions or resistant to particular pathogens. Crops of particular interest include yam, taro, manioc, kumara, banana and island cabbage.

(iii) Improve land use and physical planning mechanisms. Land use and physical planning that take into consideration the possible impacts of climate change and sea level rise provides a powerful tool for reducing vulnerability. Planning mechanisms can be used to direct or regulate all new investments in infrastructure, housing construction and agriculture outside hazard zones to minimize vulnerability, reduce repair costs and decrease disruption to economic activities.

(iv) Prohibit extractive activities from vulnerable sites such as coastal areas. The destruction of mangroves and sand extraction from coastal areas leave them

vulnerable to the impacts of wave surge and sea level rise. Replanting littoral vegetation in cleared or degraded coastal areas on the other hand would restore their protective functions.

(v) Promote agro-forestry regimes. Preventing further large scale conversion of forest areas would reduce GHG emissions but would be difficult for economic and political reasons. Promoting agro-forestry regimes that enable the maintenance of standing biomass would be a more appropriate option.

(vi) Improve management of water catchment areas. Better management of Vanuatu's water catchment areas will help maintain water quality and maximize ground water recharge. This will in turn help minimize the impact of climate change on water resources while providing immediate benefits to areas that are already suffering from seasonal shortages of water.

(vii) Regulate the extraction of freshwater from coastal aquifers. The introduction of policies that allow the extraction of freshwater from coastal aquifers only where there are no feasible alternatives would reduce the vulnerability of coastal communities and reduce the need to replace infrastructure should salt water intrusion occur.

In light of the vulnerabilities identified and the adaptation options discussed above, a national strategy to mitigate and adapt to climate change is suggested below.

A National Strategy to Mitigate and Adapt to Climate Change

Climate Change Issue and Vulnerabilities	Mitigation strategy	Adaptation strategy
ROOT CROPS		
Declining crop production as a result of changing climatic conditions	• Promote adaptive management approaches. • Increase public awareness about potential impacts of climate change on agriculture and food security • Review breeding strategies and regulations concerning varieties release and seed distribution • Support agriculture research especially on traditional food crops • Encourage and support local processing of food crops (e.g. cassava chips & flour, coconut oil, etc)	• Diversify root crops • Select crops and cultivars that are tolerant to abiotic stresses • Increase support for plant breeding program • Broaden genetic base of traditional food crops • Develop locally-adapted crops • Adopt agro-forestry practices • Promote low tillage and permanent soil cover on agriculture lands • Construct safe food storage facilities. • Identify alternative food sources including imports. • Research on farming systems including soil/land husbandry
Increased pest activities due to changes in	• Promote adaptive management and risk-coping	• Select crops and cultivars with pest and disease resistance traits

temperature and rainfall	production systems • Review quarantine control measures for local distribution and propagation of food crops • Strengthen research capacity of Ministry of Agriculture.	• Adopt agro-forestry practices • Identify alternative crops for specific ecologies. • Broaden genetic base of traditional food crops • Identify and document pests and pest activities.
Salt spray and rising sea levels affecting home gardens and crops	• Impose bans on clearing of coastal vegetation • Develop national land use plan • Develop coastal infrastructure management plans.	• Move gardens away from low-lying areas • Plant littoral vegetation as buffers against salt spray • Undertake cost-benefit analysis of various coastal protection measures. • Identify and select suitable species for coastal rehabilitation
Shifts in weather patterns affecting planting and harvesting regimes	• Put in place early warning and risk management systems. • Apply adaptive management and risk-coping production systems.	• Adjust planting and harvesting timetables to prevailing conditions of past 3-4 years. • Revive traditional food preservation techniques. • Undertake assessment of impact of shifting weather patterns of traditional food crops. • Crop improving programs focusing on climate change adaptation
FORESTRY		
Increased pest activities due to changes in temperature and rainfall	• Promote adaptive management and risk-coping production systems • Review quarantine control measures for local distribution of tree seeds and seedlings. • Increase research capacity of Department of Forestry	• Select tree species with pest and disease resistance traits for plantation purposes • Adopt multi-cropping as against mono-cropping. • Enhance the preservation and use of local genetic resources. • Carry out silvicultural research on main forestry species.
Loss of forests due to cyclones and wind damage	• Reduce GHG emissions from deforestation through more effective management of forest resources. • Review forest policy to make replanting of logged over forests a condition of logging licenses. • Carry out feasibility studies of salvage logging of cyclone affected forests.	• Expand genetic selection to include other priority species such as *Santalum austro caledonicum (*sandalwood), *Agathis Macrophylla (*kauri), etc. • Select seed provenances for altered climatic conditions • Promote mixed species plantations. • Carry out salvage logging in wind-damaged forest areas.
Limited understanding of the impact of climate change on forests	• Develop media and public awareness campaigns • Incorporate climate change science in school curriculum.	• Intensify forest assessments and monitoring and establish new tools and indicators to rate forests and species vulnerability.
FISHERIES		

Increased sea temperature could affect biological properties and distribution of fish species thereby affecting fish catches and food security.	• Develop resilient and adaptive fishery management systems • Prepare awareness raising initiatives to help communities make appropriate decisions about their management of marine resources. • Increase research capacity of Fisheries Division.	• Promote marine or freshwater aquaculture. • Modify fishing effort and catches according to the state of the stocks. • Promote alternative sources of protein and economic activities for communities during lower productivity phases. • Promote coastal area management approaches.
Increased ciguatera incidences	• Improve public awareness and understanding about connection between climate change and ciguatera	• Continue monitoring of incidences of ciguatera outbreaks • Identify and document linkages between ciguatera and climate change.
Negative impacts from more frequent storm surges, decreased salinity during high intensity rainfall events and increased coastal erosion on mangroves, sea grass and other near shore ecosystems.	• Develop adaptation strategies to any reduction in harvests of marine resources including replacing fishing with alternate sources of protein. • Impose ban on clearing of coastal vegetation.	• Promote alternative sources of protein during lower fishery productivity phase. • Promote marine or freshwater aquaculture. • Modify fishing effort and catches according to the state of the stocks.
Limited understanding of the long term trends in climate change, especially related to global warming, in fisheries.	• Develop awareness programs based on existing knowledge targeting politicians, schools and coastal communities.	• Collect and document evidence of changes in fisheries to enable better understanding of climate change on the fishery sector
LIVESTOCK		
Increased temperatures could affect health, productivity and reproductive efficiency of livestock.	• Consider animal husbandry changes such as ruminant diets and stocking ratios. • Increase research capacity of Livestock Division.	• Promote animal breeds or varieties that can best resist changing conditions. • Promote locally adapted livestock breeds.
Climate variability could enhance growth of less nutritious pastures.	• Monitor fodder and pasture effects on livestock.	• Identify and support appropriate pasture management practices.
WATER SUPPLY		
Variability in river flows and aquifer recharge resulting from climate change.	• Develop appropriate water management regimes. • Encourage mulching and zero tillage in areas where there is intense rainfall • Develop laws to protect watershed areas. • Awareness raising programs.	• Promote land and forest conservation techniques. • Increase rainwater catchment and storage capacity • Establish appropriate water distribution facilities • Control issuance of logging licenses. • Formulate land and water use policies
Increased salinity of ground water sources	• Develop water management policy especially for small	• Increase rainwater catchment and storage capacity

resulting from salt water intrusion, overuse and flooding.	islands in the group • Promote water and forest conservation	• Establish water distribution facility • Regulate use of irrigated systems
OTHER FACTORS		
Loss of traditional farming techniques	• Revive use of traditional farming techniques • Promote research on traditional food crops	• Conduct training workshops on use of traditional farming techniques • Document traditional farming techniques for future use
High population growth rate	• Promote public awareness and education campaigns to draw attention to the impact of a fast growing population on the socio-economic development of the country.	• Develop and enforce a population policy for Vanuatu. • Introduce family planning initiatives especially in rural areas. • Provide incentives to control family sizes.
Resistance to change	• Support public awareness raising initiatives • Develop incentives programme in support of change.	• Improve understanding of the need for change in accordance with changing conditions and circumstances. • Carry out demonstrations in support of need for change
Influence of large scale, single crop farms	• Increase support for small scale farming • Consider incentive scheme (e.g. subsidy) in support of small farmers. • Support establishment of a small farmers association	• Diversification of crops • Concentrate on traditional crops • Decentralize food crop breeding program • Increase support for small farmers.
Loss of interest in traditional crops such as coconuts	• Review and promote sustainable use of traditional crops • Support local processing of certain food crops (cassava, taro, coconut, etc)	• Invest in alternative economic use of traditional crops (e.g. coconut oil as an alternative to fossil fuel) • Improve genetic material from traditional crops • Improve market access for small farmers • Build national capacity and knowledge on plant propagation techniques and agro-forestry systems.
Lack of a sustainable forest management plan	• Support development of a national sustainable forest management plan • Increase research capacity of Forestry Division	• Update existing information on the country's forest resources. • Prepare sustainable forest management plan taking into account potential impact of climate change.
Imbalance between forest utilization and reforestation	• Support development of a sustainable forest management plan • Encourage agro-forestry practices.	• Set sustainable cut targets • Include reforestation as condition of logging licenses • Support replanting of fast growing high value species such as sandalwood, whitewood, etc.
Lack of capacity to service livestock industry	• Build capacity of veterinary unit within Ministry of	• Expand and decentralize veterinary service

	Agriculture	• Offer training in animal husbandry for small farmers • Seek support from regional institutions such as SPC

15. Recommendations

The following recommendations are considered appropriate for consideration by the government of Vanuatu, its development partners and other stakeholders in order to improve the capacity of Vanuatu to adapt to climate change and climate variations especially in relation to their impacts on agriculture and food security in the country.

1. More attention to population growth. Vanuatu's population is growing at an average rate of 2.6% per annum. At this rate, it is predicted that the current population of almost 210,000 will double in 20 year's time. As the population increases, more and more people will be concentrating on coastal areas putting more pressure on these vulnerable locations, increasing the demand on the limited services available there. It is recommended that the government give more attention to controlling the population growth as an important part of its strategy to reduce the impact of climate change on the social and economic wellbeing of the country.

2. Need to focus on fewer, better defined priorities. Given Vanuatu's limited financial and technical resources, it will be impossible for the government to effectively address the wide range of issues and actions necessary to respond to climate change. It is therefore recommended that the government strategically address a limited number of clearly identified priorities and actions based on the greatest needs and risks from climate change.

3. Value of the National Coordinating Committee. In Vanuatu, the National Advisory Committee on Climate Change (NACCC), a multi-disciplinary team that draws its membership from different government agencies, civil society and other relevant stakeholders is mandated by government to oversee the coordination of all climate change initiatives emanating from the UNFCCC process. The NACCC has been very effective in performing this role and it is recommended that the government should continue to support the work of this Committee as an effective means of advocacy for the UNFCCC and other climate change related agreements.

4. Need for continued human resource development. GEF-funded regional and national climate change related projects have provided a wide variety of training and human resource development in past years. FAO, SPC and the European Union have also supported capacity building initiatives in the agriculture sector and these have contributed enormously to Vanuatu's overall capacity to address environmental concerns and to meet its obligations under international conventions. However, due to the high rate of occupational mobility, retirement and migration, it is recommended that human resource development initiatives need to be continued and expanded if Vanuatu is to be able to deal with the growing and complex issues associated with climate change.

5. Difficulty of servicing remote, rural farmers. Financial constraints and poor transport and communications are hampering efforts to reach out to the rural farmers particularly the smallholders that are in most need of support especially during natural hazards such as droughts and cyclones. It is strongly recommended that improving service delivery to rural areas be made an explicitly higher priority for donor-funded development projects in future. Decentralization of the plant breeding programme and the veterinary services of the Ministry of Agriculture should inevitably follow the improvement of transport and communication services to rural areas of the country.

6. Improve awareness and understanding of local communities about the connection between climate variability and agriculture crop productions. Several farmers have noted significant changes to the fruiting and flowering seasons of a number of traditional plants and crops while others have complained about low productions over the past few years. Most if not all speculate that the changing weather patterns have something to do with this but do not quite understand or appreciate the connection. To ensure that local communities and farmers do understand and appreciate the relevance of climate change to the products of their labor, it is recommended that efforts be continued to improve their awareness and understanding of the impacts of climate change on their livelihood.

7. Need to apply lessons from within Vanuatu. The government, with assistance from bilateral and international projects and programmes, has carried out assessments of the impacts of climate change on a number of locations throughout Vanuatu. The studies also identified appropriate adaptation strategies to respond to such impacts. The studies showed that climate change impacts on agriculture were almost identical for all the targeted locations and it is therefore recommended that in the absence of site-specific data and information, the findings and lessons from the studies already completed be used to guide future efforts to develop responses to climate change in other relevant parts of the country.

8. Increase the number of smallholders, not the size of existing farms. During the formulation of a draft action plan for the development of the agriculture sector in Vanuatu, the Ministry of Agriculture, Forestry and Fisheries together with the other stakeholders involved in the exercise agreed that (i) improving the production and market access for the smallholders producing traditional crops has the potential to benefit the greatest number of ni-Vanuatu, and the country as a whole; (ii) the expansion of the market for traditional foodstuff and of high value specialty niche products depend on improving smallholder productivity and domestic market systems; and (iii) increasing the production of traditional food crops and livestock and improving the marketing systems for these is an important priority considering the future doubling of the population. In view of the priority given to the role of smallholders in ensuring food security in Vanuatu, it is recommended that efforts be made to increase the number of smallholders while at the same time, promote traditional food crops, and provide support to make food gardens more sustainable.

9. Improve and expand plant breeding programme. Poor roads coupled with irregular air and sea linkages between the islands have a significant effect on the distribution of planting materials from the Ministry's headquarters in Vila to other parts of Efate and to other islands in the archipelago. All food crops distributed by the Ministry are asexually propagated and some of them (e.g. sweet potato) do not last a boat voyage to the outer islands. Airfreight is safer but extremely expensive. Given these conditions, it is recommended the plant breeding programmes by the Ministry of Agriculture be improved and expanded by decentralization (see 5 above) and by broadening the genetic base of traditional crops as well as by providing basic training for rural farmers, especially those in outer islands.

10. Value of NGOs. In Vanuatu, NGOs are required to register in order to be recognized by government and to have better access to external assistance. A number of NGOs (e.g. VANGO, FSPI and Live and Learn) are already working well with government but there is still some way to go for other NGOs to establish such relationships. Despite the presence of some NGOs in remote islands and areas where government services are limited or absent, only a few government-managed projects in these areas have involved NGOs. This is due in part to weak financial accountability even where service delivery is adequate. Local NGOs are unlikely to be effective in supporting projects in remote islands unless they are supported by government. In this regard, it is recommended that government provide support to NGOs and CSOs to strengthen their accountability and general project management skills and knowledge especially in areas where government service is limited or absent. Care should however be taken to make sure that this support is not done in a way or scale that will overwhelm them.

16. Conclusions

Changing weather patterns are already having a negative impact on agriculture production in Vanuatu and most evidence point to the fact that they will be exacerbated by climate change related events in future. Vanuatu has already taken some preemptive measures to address the various threats to, amongst others, the agriculture sector and the government is to be congratulated for its foresight. However, much still needs to be done to ensure that Vanuatu is able to reduce the impact of climate change on areas that are already vulnerable and at the same time effectively protect others that are at risk from future changes.

Information on population growth and distribution as well as land use data are important for future planning irrespective of the precise nature and pace of climate and sea level change. Such data would facilitate the identification of not only the number of people but also the types of land-based development likely to be affected by a particular event. Collecting and analyzing these data should form an important part of future efforts to address climate change impacts in Vanuatu.

The inter-related nature of climate change and agriculture production suggests that both short and long term views must be taken into account when considering adaptation measures for Vanuatu. While the desirable approach would be to address the original causes

of global environmental changes and sea level rise, the reality is that small islands like Vanuatu that contribute so little to the cause of the problem and have the least capacity to deal with it, is being forced to deal with the effects. For this reason, the international community has an obligation to Vanuatu and other small island nations to assist them with the development and implementation of plans and activities which will, to the extent possible, alleviate the adverse impacts associated with climate change and sea level rise.

Adapting to climate change, variability and sea level rise is a serious and urgent need for Vanuatu. And the ideal approach to adaptation for Vanuatu at this time is a pro-active, no-regrets approach which encompasses measures and strategies that can be implemented now with the aim of reducing vulnerability in the future. As the President of the Republic said in his opening address during the first National Conference on National Adaptation Programme of Action in January 2005, "a no-regrets approach is one which would be beneficial to Vanuatu even in the absence of climate change and sea level change".

The main problem with assessing the impact of climate change and in identifying a cost-effective response is the uncertainty surrounding estimates of the time and magnitude of the changes to be expected. The difficulty lies in the complexity of predicting the changes, the short history and variability of the historical data, and the problem of clearly distinguishing between cyclical effects (climate variability) and long-run climate change from which there would be no escape. Given these uncertainties, the "no-regrets" measures adopted by the government of Vanuatu make sound economic and financial sense.

Vanuatu, like many rural Pacific Islanders combine selling products or labor for cash, and gardening, fishing and sometimes hunting, to meet their food needs. Such diversity of livelihood assures a degree of food security, as it means one or two of these activities can still meet basic food needs even if one activity ceases to do so. This is why severe disasters do not result in mass mortality, even in the poorest communities of the Pacific, as is often the case in other less developed regions of the world. But climate change may cause chronic and or sporadic contractions in the food people are able to access through agriculture, fisheries and in the market place. Thus, through impacts on food production, the ability of the country to import food, and its effect on human health, climate change puts at risk the very basic and universal need of the Vanuatu people to have access to sufficient, safe and nutritious food at all times.

ANNEXES

Annex 1: Terms of Reference for the Vanuatu study

Approach to assess the impact of climate change on agriculture and food security in the Pacific

Country-case study in Vanuatu

1. Background

At the 6th Meeting of the FAO South West Pacific Ministers for Agriculture (Cook Islands, June 2005), Ministers agreed that analytical studies would be conducted within the agricultural sub-sectors to facilitate the development of more specific policy recommendations, and that priority attention would be given to the following specific issue: Impact of climate variability on agriculture and food security in the Pacific.

At the 7th Meeting of the FAO South West Pacific Ministers for Agriculture (Marshall Islands, May 2007), Ministers recommended FAO to pursue a study to assess the impact of climate change on agriculture and food security in the Pacific islands region.

Pacific islands countries are extremely vulnerable to climate change, climate variability, and sea level rise. They are among the first to suffer the impacts of climate change and among the first forced to adapt or abandon or relocate from their environment. Some Pacific islands are low lying or have coastal features and characteristics that make them particularly vulnerable to climate change, variability and sea level change. In addition to significant coastal impacts, climate change affects biodiversity, soils and the water supplies of small islands. Most small island states find it extremely difficult to adapt to these changing conditions. The impacts will be felt for many generations because of the small island states' low adaptive capacity, high sensitivity to external shocks and high vulnerability to natural disasters. Failure to adapt to climate change now could lead to high social and economic costs in the future. Most of Pacific island counties vulnerable people live in rural areas, where the main source of livelihood is in the agriculture sector, including livestock, forestry and fisheries. For the low lying atolls, the economic disruption could be catastrophic, even to the extent of requiring population relocation into other islands or increasing the number of people emigrating from the islands. Public pressure is mounting for action on adaptation. There is growing community and government concern about the need to reduce the islands' vulnerability and manage the risks posed by extreme events and long-term change.

2. Objective of the study

The overall objective is to deepen the understanding of the consequences of climate change on agriculture and food security in the Pacific, with a specific focus in Vanuatu. The specific objective is to increase the institutional capacity of Vanuatu to adapt, mitigate and respond to challenges posed by changing climate variability patterns on agriculture and food security.

The output will be the preparation of a national assessment on the impact of climate change and variability on agriculture and food security, and the formulation of national strategy and recommendations to adapt, mitigate and respond to the challenges posed by climate variability on agriculture and food security.

3. Terms of Reference for the country-case study in Vanuatu

Under the overall supervision of FAO Sub-Regional Representative for the Pacific Islands and the technical supervision of FAO Sub-Regional Office for the Pacific Islands (SAPA) Policy Assistance Unit, in close collaboration with FAO Natural Resources Management and Environment Department, including the Environment, Climate Change and Bioenergy Division, the Consultant will have the following responsibilities:

- Carry out a desk analysis of Vanuatu national reports prepared under the UNFCCC, in order to compile: main issues, adaptation/mitigation responses and measures on current and future climate changes having an impact on agriculture and food security. Agriculture shall be understood as also covering crops, forestry, fisheries, livestock and natural resources management, impacts on each sub-sector, inter-linkages and consequences/adjustments in rural/marine livelihood systems shall be assessed.

- Carry out a desk analysis of the UN, CROP agencies and relevant governmental-and-non regional bodies' projects, activities and consultations on climate change and variability in Vanuatu that have an impact on agriculture and food security. The purpose will be to compile: success stories such as adaptation plans and early warning systems; lessons learnt; existing efforts and collaborations; and the sharing of experiences;

- Assess the material and data collected, identifying main issues and trends; in particular, develop a typology of likely climate change impacts on agriculture and food security in Vanuatu. The typology will be based on nature of the dominant threat (frequency of cyclones, sea level rise, drought, etc.), the agroecological/agroeconomic zones recognised in the region and the socio-economic response potential;

- Once the above information is collected and analysed, carry out a field mission to Vanuatu, in order to identify and assess national institutional mechanisms and policy frameworks to respond, adapt and mitigate climate variability on agriculture and food security. Strengths, weaknesses and effectiveness of identified mechanisms and frameworks shall be analysed, and recommendations on the way forward and implementing measures made. Discussions, consultations, data collection with relevant institutions/stakeholders shall be made as appropriate;

- Formulate a national strategy to respond to the challenges and opportunities identified for the agriculture sector and food security. Once completed, the national strategy shall be submitted for clearance to FAO, which reserves the right to request amendments, refinement or clarifications if and when considered necessary by the Organization. The Consultant shall revise the national strategy accordingly to FAO

specifications, until the national strategy will be considered technically satisfactory by the Organization.

4. Requirements

The Consultant should have a degree in agricultural and/or environmental sciences or natural resources management, and at least 10 years professional experience in the field of climate change and its impact on agriculture and food security. He/she should also have a good knowledge of the Pacific region and regional agricultural/food security issues.

5. Length of the assignment/duty station

The overall length of the assignment will be 30 working days distributed over WAE (When Actually Employed) basis.

Entry on duty: as soon as possible
Not to extend: 15 November 2007
Remuneration: (to be confirmed)

The duty station will be the country of residence of the consultant and the assignment will include a duty travel to Port Vila, Vanuatu, for 10 days.

6. Working Language

English

Annex 2: List of People Consulted

Name	Designation	Department/Organization
Johnny Koanapo	Head, UN Division	Foreign Affairs
Frazer Bule Lehi	Head, Extension Division	Agriculture
Doresthy Kenneth	Director	Agriculture
Yoan Viji	Director	Forestry
Rexon Moli	Forester	Forestry
Ross Gordon	Owner / Farmer	Bouma Farm
Robert A. Jimmy	Acting Director	Fisheries
Timothy Tumukon	Acting Director	Livestock
Brian Philips	Director	Meteorology
Dr. Vincent Lebot	Scientist Root Crops	Agriculture
Charles Rogers	Manager, Farmers Support Association	Montemart
Dr. Graham Semms	Consultant for 2nd National Communication	Private Consultant, NZ
Robbie Henderson	Head	Live & Learn, Vanuatu
Gina Tari	Senior Officer	Live & Learn, Vanuatu
Cornelia Wyllie	Manageress	Rainbow Garden
Ericsson Mole	Acting Director	Geology, Mines & Water Resources
Jim Paty	Owner / Farmer	Devil's Point
Jessy Benjamin	Energy Officer	Energy Unit
Leah Nimoho	Manager, GEF Small Grants Programme	Vanuatu Association of Non-Government Organizations (VANGO)
George Kanegai	Food Processing Project Manager	Department of Agriculture
Albert Williams	Principal Consultant	Environment Unit
Taito Nakalevu	CBDAMPIC Coordinator	SPREP

Annex 3: Vulnerability Assessment of Some Small Islands of Vanuatu to Climate Change and Climate Variability[6]

Hiu Island (Torres Group)					
Sector	**Likely Impact**				
	Temperature	**Precipitation**	**Rainfall**	**Sea Level Rise**	**Cyclones**
Agriculture	Increased temperatures will induce heat stress, wilting and crop failure. Wild yam used to grow wild and abundant but is no longer widespread. Wild yam is resilient to drought. Yams planted in normal planting season (Nov to March) no longer do well due to shifts in weather patterns.	Increases could also see increase in average rainfall, causing flooding and pollution of coastal waters.	Increased rainfall would increase water availability for agriculture and other uses. Decline in rainfall will cause plant stress, reducing productivity and harvest and affect food security.	Vulnerability is low as most cultivation is concentrated on raised plateau away from the coast.	A major threat to agriculture. Increased rainfall associated with cyclone events can lead to flooding and loss of fertile top soil - an invaluable commodity on islands.
Forestry	Warm temperatures may cause plant stress. Fall in agriculture production could see increase in deforestation as more people resort to logging as alternative revenue source.	Increased precipitation is seen as largely beneficial for forest crops. Forest degradation is also contributing to the decline in coconut crab populations.	Increased rainfall may induce plant growth but could also encourage invasion by less desirable species. Decline in rainfall will affect forest growth.	Coastal forests have been severely affected, however inland forests are safe as they are concentrated on raised plateau.	Cyclones and associated wave surges have contributed to the loss of coastal forests which in turn leave coastal communities and environments exposed to future events.
Fisheries	Warm temperatures could increase incidence of coral bleaching.	Increased precipitation could lead to erosion of coastal areas.	Increased rainfall could lead to increased sedimentation and pollution of coastal areas affecting subsistence fishing.	Increased sea levels have resulted in inundation of coconut crab habitats on island causing numbers to drop. Coconut crabs are the major source of income for the community.	Past cyclones have destroyed coral and reefs which are important fishing grounds for the community.

[6] Tables constructed with information extracted from Climate and Sea Level Change Vulnerability and Adaptation Assessment of the Torres, Shepherds and Tafea Groups by Brian Philips and the CBDAMPIC report by CIDA and SPREP.

Livestock	Warm temperatures may affect growth, production and reproductive efficiency of livestock animals by causing body temperature to rise above animal's zone of comfort.	Increased precipitation could lead to availability of more water for livestock.	Increased rainfall could lead to more water but may result in rapid growth of less nutritious pasture for livestock. Reduced rainfall could affect growth and production.	Impact is minimal or nil due to high island elevation.	Limited to damage of infrastructure and some pasture land.
Water supply	Increased temperatures may lead to availability of more water but may cause flooding of rivers and streams.	Increased precipitation, coupled with future La Nina conditions and increase in cyclone frequency may increase average rainfall.	Increased rainfall may lead to flooding, soil erosion and pollution of groundwater supplies. Low rainfall will compound water shortage problem.	Rises in sea level will cause inundation of coastal water springs which are an alternative source of water during low tide.	Past cyclones have caused considerable damage to coastal areas including coastal springs that communities used to depend on.

Loh (Torres Group)					
Sector	**Likely Impacts**				
	Temperature	**Precipitation**	**Rainfall**	**Sea Level Rise**	**Cyclones**
Agriculture	Increased temperature likely to increase rainfall causing additional areas of coconut patches to become inundated. Warmer temperatures could also cause plant stress, wilting and decrease production which in turn threatens food security.	Likely to increase water-logging of productive land. Could cause erosion and create favorable conditions for pests and diseases.	Flooding from heavy and prolonged rain is common occurrence in last 5-10 years. 4-5 ha of coconut patches permanently inundated as a result. Reduction in rainfall on the other hand would cause plant stress and low production.	Part of island subsided as result of 1998 earthquake causing coconut patches on northern coast to submerge. Rise in sea level will add to the problem of soil and coastal erosion.	Remain a major threat to agriculture crops and government facilities on island.

Forestry	Increased temperatures could cause plant stress and reduced growth.	Increase soil moisture needed for forest tree growth. May create conditions favorable for pests and diseases.	Increased rainfall could cause inundation affecting coastal vegetation of mangroves, casuarinas and sea oaks. Drop in rainfall could affect forest growth.	Part of vegetation on northern side already submerged and will be further affected by SLR.	Northern part of island where vegetation are dying particularly vulnerable to cyclones and SLR.
Fisheries	Commercial fishery unlikely to be affected. Coral bleaching may increase with warmer temperatures.	Unknown but likely to be minimal	Apart from inundation of mangroves from flooding, impact of increased rain is considered minimal.	Sedimentation causing muddy conditions perfect for Caledonian crabs and small fiddler crabs to flourish.	Exposed areas on northern side of island are likely to be seriously affected by future cyclones.
Livestock	Except for pigs and chickens, no livestock are raised on island. Dry conditions could affect pig fodder.	Wet conditions may increase incidence of intestinal infection of free roaming pigs.	May increase incidence of water borne diseases by free roaming pigs. Less rain however could affect pasture growth.	Minimal due to high elevation of island.	Minimal.
Water supply	Likely to increase rainfall causing further flooding and pollution of ground water supplies.	Likely to increase availability of water for local community.	Increased and prolonged rainfall already causing flooding of coconut plantation. Could also cause pollution of ground water. Prolonged dry spells could affect ground water lens.	SLR will exacerbate problems for northern part of island that is already submerged.	Water supply for exposed northern part of island will be seriously affected by future cyclones.

Tongariki Island (Shepherd Group)					
Sector	**Likely Impacts**				
	Temperature	**Precipitation**	**Rainfall**	**Sea Level Rise**	**Cyclone**

Agriculture	Suspect to cause die-back of island cabbage after one or two harvests. Usually species die after several harvests. Warm temperatures could cause stress and wilting of root crops and vegetables and thus threaten food security.	Could lead to water-logging, erosion and loss of soil nutrient. Could create favorable conditions for pest and disease outbreaks.	Impact is expected to be positive for plant growth but could also cause inundation of food crops and induce growth of pathogens. Dry spells will affect plant growth and food production.	Impact is low to medium due to basalt bolder rocks which make up most of coastline. There is interest in mining the rocks which could leave island vulnerable to SLR.	Vulnerability of sector to cyclones is high.
Forestry	Warmer temperatures could be favorable for growth and spread of invasive species *mikania spp* which could cause considerable damage to forest areas.	Increased precipitation could lead to spread of pest and diseases affecting forest species.	Increased rainfall could create conditions favoring spread of invasive species and low value species. Prolonged dry spells will affect forest growth.	Minimal except for salt spray associated with strong winds and cyclones.	Could cause forest damage and salt spray to coastal vegetation.
Fisheries	Could cause coral bleaching and reduce productivity of reef systems.	Could result in erosion and pollution of coastal areas.	Induce flooding and pollution of coastal areas important for subsistence fishing.	Could enhance coastal erosion although impact will be limited due to natural protection of basalt bolder rocks.	Strong wave action associated with cyclones could cause recession of coastline and damage to fishing grounds.
Livestock	Goats are the main livestock on island although there are also a small number of singly-raised cattle. Warmer temperatures could affect growth and reproductive efficiency especially of cattle.	Increased precipitation could create conditions suitable for grazing livestock.	Increased rainfall could enhance pasture growth but could also cause water-logging of graze land. Low rainfall will affect animal growth and productivity.	Impact is limited to salt spray affecting coastal vegetation that serves as shade for free roaming goats.	Cyclones pose a threat to animals raised under coconut trees.
Water supply	Increased temperatures will add to current problem of water shortage.	Increased precipitation might improve water supply situation.	Increased rainfall will be beneficial to island if catchment and storage facilities are improved. Low	Salt spray may affect water storage on island.	Cyclones could cause damage to storage facilities.

			rainfall will add to water shortage problem.		

Buninga Island (Torres Group)					
Sector	**Likely Impacts**				
	Temperature	**Precipitation**	**Rainfall**	**Sea Level Rise**	**Cyclones**
Agriculture	No surface water so increased temperature will compound problem. Manioc the only root crop that grows abundantly on island but monoculture practice may heighten vulnerability to pests and diseases. Island soil can only support specific crops.	Increased precipitation likely to be beneficial to water-starved island.	Increased rainfall will alleviate water shortage for agriculture and may increase food production and security. Projected drop in rainfall will have serious implications for agriculture on island.	Relatively safe from SLR due to solid bolder coast.	TC a major threat and may cause short term food shortages resulting in short term dependence on imported food from other islands.
Forestry	Increased temperature may cause heat stress and heighten vulnerability to forest pests and diseases.	Increased precipitation is likely to have a positive effect on forested areas.	Increased rainfall will help forest growth especially after periods of severe water shortage. Reduced rainfall will have reverse effect.	Impact will be minimal to nil as island is well protected by bolder coast.	TC can still cause severe damage to secondary forests on island.
Fisheries	Increased temperature could cause coral bleaching and fish poisoning in some areas.	Not known but any impact is expected to be minimal.	Increased rainfall could cause water run-off affecting coastal fisheries.	Could cause coral and reef damage thus affecting coastal fisheries. Coastal erosion will be minimal due to solid bolder coast.	TC will remain a threat to coastal areas and hence fishery.
Livestock	Due to small size and topography of island, no livestock animals are reared on island.	n.a	n.a	n.a	n.a
Water supply	There is no surface water on island so increased	Positive impact expected as	Heavy and persistent rain could cause	Could increase salinity of existing ground	Heavy rain associated with cyclones could

	temperatures will only add to water problem. Rainwater is the sole source water as ground water sources are not safe for use.	this will help alleviate water shortage.	water run-off affecting fisheries. Dry spells will have serious impact on water supply.	water but island is generally safe from SLR due to solid bolder coastline.	cause water run-off affecting coastal fishery.

Makira Island (Shepherd Group)					
Sector	**Likely Impacts**				
	Temperature	**Precipitation**	**Rainfall**	**Sea Level Rise**	**Cyclones**
Agriculture	Periods of prolonged drought has resulted in poor growth and harvest of root crops and fruit trees. Agriculture sector highly vulnerable to increased temperatures and El Nino episode. Slash and burn has been abandoned while legumes have are being integrated with root crops.	Sector could benefit from increased precipitation as this will increase soil moisture necessary for plant growth.	Village has moved twice in last 80 years due to inundation during cyclone events in 1940 and 1972. Increased rainfall will cause further inundation, but declines in rainfall repeat problems encountered during drought.	Loss of coastal vegetation has given way to salt spray and coastal erosion. Impact on agriculture will be low as gardens are situated on high grounds.	Cyclones remain a major threat to agriculture. Several invasive species are well established following previous cyclone events.
Forestry	Increased temperatures could affect forest growth and production.	Impact is likely to be positive given experience with droughts in the past.	Increased rainfall will be beneficial for forest growth although heavy rainfall associated with cyclone events could have adverse effects.	Except for coastal vegetation, most forests are on high grounds safe from SLR.	Past cyclones have had devastating effects on coastal vegetation. Invasion of open forests by less desirable species is evident after cyclones.
Fisheries	Increased temperatures could result in coral bleaching which in turn could affect fisheries.	Impact if any is likely to be minimal.	Increased rainfall could cause further coastal erosion.	Coastal erosion resulting from SLR could cause pollution of coastal areas affecting fisheries.	Cyclone damage to coastal vegetation could result in coastal recession and pollution affecting fishing grounds around the island.

Livestock	Livestock is limited to pigs, goats and chicken. Pigs and goats are reared while chickens are free roaming. Increased temperatures will affect growth and reproduction efficiency and hence food security.	Increased precipitation is likely to benefit livestock but may create conditions favorable for spread of diseases by free roaming animals.	Increased rainfall would improve water availability for animals. Dr conditions on the other hand could affect animal growth and availability of local feed.	SLR is likely to impact on water supply for people and their livestock.	Salt spray associated with wave action during cyclone event could affect fodder for animals on island.
Water supply	Increased temperature could lead to dry conditions affecting water supply for the island.	Expected increase in precipitation could result in more rain alleviating water problems.	Increased rainfall caused landslides that partly buried underground springs the community depended on. Reduce rainfall will affect rain water supply.	SLR could cause further inundation of ground water and coastal springs.	Heavy rainfall associated with cyclone events could cause pollution of water source.
Emae Island (Shepherd Group)					
Sector	**Likely Impacts**				
	Temperature	**Precipitation**	**Rainfall**	**Sea Level Rise**	**Cyclones**
Agriculture	Increased temperature believed to be responsible for decreased crop production. Wild yam is not doing well under current conditions and grows to only about 1 meter nowadays. Warmer temperatures will affect plant growth, cause heat stress and reduce production.	Increased precipitation could result in greater availability of water for the sector. This could help boost crop production.	Mavae and another village have moved from original sites due to inundation resulting from heavy rain associated with cyclone event in 1944. Old village sites are permanently under water. Drop in rainfall could affect plant growth and production.	SRL could threaten coastal settlements and their crops. Could also cause soil erosion thus affecting agriculture crops.	Believed to contribute to introduction of invasive species harmful to agriculture such as African snail and "mile a minute" vine. A. snail first appeared after 1919 tidal wave but widespread invasion was seen after recent cyclone when food was sent from other islands.
Forestry	Increased temperatures could affect forest growth and production.	Given the paucity of water supply on island, increased precipitation will be of	Increased rainfall will be beneficial given dry conditions on island. Prolonged dry conditions will	SLR could cause damage to coastal forests. Tree planting are undertaken to curb coastal	TC is a major threat to forestry. Cyclone-damaged forests are vulnerable to

		benefit.	have serious impact of forest and vegetation.	recession.	invasion by creepers and less desirable species.
Fisheries	Increased temperatures could cause coral bleaching reducing productivity of corals and reefs.	Increased precipitation could add to coastal erosion during wet season.	Increased rainfall could result in pollution of coastal fisheries areas.	SLR may affect coastal fisheries as result of damage to fringing reefs.	Wave action associated with cyclones could cause damage to coral reefs and coastal fisheries.
Livestock	Cattle (raised singly) and pigs are the main livestock on island. Warmer temperatures will affect growth and reproductive efficiency and will in turn affect food security.	Increase precipitation is likely to be beneficial to animals which are raised under coconut plantations.	Increased and prolonged periods of rain could cause inundation of more land available for agriculture and animal grazing.	Animals are raised on high grounds and should be safe from impact of SLR.	Like in the past, the aftermath of future cyclones could see the introduction of more invasive species to the island.
Water Supply	Increased temperatures could result in serious water shortage on island.	Could help alleviate water shortage.	Rainfall will certainly alleviate water shortage on island.	SLR may increase salinity of ground water and destroy coastal springs.	Wave action associated with cyclones could result in salt water intrusion into ground water sources.

Aniwa Island (Tafea Group)					
Sector	**Likely Impacts**				
	Temperature	**Precipitation**	**Rainfall**	**Sea Level Rise**	**Cyclone**
Agriculture	Cultivation of sweet orange is vital to island economy but drop in production has led to extensive clearing of land resulting in introduction of leucaena and other invasive spp. Increased temperature blamed for low production of oranges.	Increased precipitation may help alleviate water shortage problems although prolonged wet conditions will affect rock salt production.	Increased rainfall will help improve water situation on island and increase availability of water for agriculture purposes. It could also create conditions favorable for the growth and spread of pests and diseases.	SLR will enhance soil erosion especially of low-lying areas suitable for village gardens.	Wave action associated with cyclone events could result in inundation of village gardens, increase soil salinity and cause erosion of valuable top soil.
Forestry	Cleared forest areas are invaded by leucaena. Increased temperatures will	Increased precipitation and rainfall will enhance growth of	Increased rainfall may help forest growth. However,	Likely to affect coastal forests.	A major threat to forestry causing damage and defoliation making trees

	enhance growth of such species and may lead to smothering of valuable forest species.	forest species along with less desirable invasive species.	decreased rainfall could affect forest growth and production.		vulnerable to pests and diseases.
Fisheries	Introduction of conical mangrove shellfish led to displacement of *Cardisoma carnifax*. Drop in numbers may also be caused by increased temperatures. Decline in reef fisheries mainly due to poor management and contemporary techniques.	Increased precipitation may contribute to coastal erosion during periods of heavy rain.	Prolonged wet conditions could result in erosion of coast causing pollution of productive fishing grounds.	Could enhance coastal erosion affecting corals and reef systems.	Heavy rainfall associated with cyclone events could result in coastal erosion. Wave action could cause coastal recession and damage to mangroves.
Livestock	Cattle and pigs are the main livestock. Cattle farming integrated with coconut plantations which could provide shade during hot and dry spells.	Increased precipitation could help alleviate water supply problem.	Increased rainfall could enhance growth of less desirable pasture feed while decreased rainfall could affect animal growth and production.	SLR will add to water supply problem on island which is affecting livestock production.	Salt spray associated with wind and wave action during cyclones could affect grazing land for livestock.
Water supply	Increased temperatures add to water supply problem on island. Dry spells in 1992/93 saw shipment of water from Tanna and Port Vila. All groundwater sources are brackish and unsafe for use.	Increased precipitation will be beneficial given water shortage on island.	Could alleviate water shortage frequently experienced on island. Reduced rainfall will compound water problem on island.	SLR will likely increase salinity of groundwater sources and inundation of coastal springs.	Wave surge associated with cyclones may result in inundation of groundwater sources.

Aneityum Island (Tafea Group)					
Sector	**Likely Impacts**				
	Temperature	**Precipitation**	**Rainfall**	**Sea Level Rise**	**Cyclone**
Agriculture	Shifts or changes to climate conditions causing delays in planting seasons	Increased precipitation could increase erosion which ultimately	Extensive rain could cause flooding and erosion which is a major	SLR could enhance soil erosion and threaten coastal infrastructure.	Cyclones are a big threat to agriculture on island .

	resulting in low production. Increased temperatures could result in more rain causing erosion and leaching of soil nutrients.	affects crop production.	problem for agriculture on the island. Locals noted increase in flooding during last 10 years.		
Forestry	Logging in the 50s and 60s left most of island bare of natural vegetation. Increased temperatures could lead to hot conditions affecting growth of plantation forests that were planted to curb soil erosion problem.	Increased precipitation could cause erosion of barren soils left after logging.	Heavy rainfall will accelerate soil erosion which is still a major problem for the island despite considerable efforts to re-vegetate logged areas. Reduction in rainfall will affect plantation growth.	SLR could enhance damage to coastal forests as a result of increased water salinity and inundation.	Cyclones are a threat to pine plantations established after logging in the 1950s and 1960s.
Fisheries	Increased temperatures could cause coral bleaching which could in turn affect coastal fisheries. Seaweed cultivation has been introduced as an alternative food source but may be affected by increased warm temperatures.	Increased precipitation may enhance soil erosion and pollution of productive fishing grounds.	Heavy and prolonged rainfall could cause erosion affecting productivity of reef systems. Mass death of corals due to soil erosion has been reported.	SLR could enhance coastal erosion affecting productivity of reef systems.	Cyclones and associated wave action could cause damage to reefs and coastal fishery.
Livestock	Increased temperature may affect growth, production and reproductive efficiency of livestock. May also create conditions favorable for spread of diseases.	Increased precipitation is likely to have positive impact on livestock and pasture.	Increased rainfall may lead to increased growth of less low valued pasture. May also create conditions favorable for spread of animal diseases.	Limited impact on livestock but may affect pasture land close to coast.	Limited impact on livestock but may cause damage to pasture land.
Water supply	Increased temperatures expected to have minimal impact on water supply	May add to soil erosion, a major problem for the island.	Water is abundant on island so increased rainfall could	SLR could cause salt water intrusion of ground water sources.	Heavy rainfall associated with cyclones will cause flooding and pollution

	which is plentiful on the island.		lead to contamination of water sources.		of ground water sources.

Lateu, Luli & Panita Islands					
Sector	**Likely Impacts**				
	Temperature	**Precipitation**	**Rainfall**	**Sea Level Rise**	**Cyclones**
Agriculture	Crop production has decreased as result of increased temperatures. More frequent and prolonged dry conditions have affected yields of stable food crops such as yam and manioc in past 5-10 years.	Increased precipitation will be beneficial to agriculture especially during dry season. However this might create favorable conditions for the tuber-eating beetle that induces rot in yams and other root crops.	Increased variability of rainfall observed. Prolonged rain resulted in falls in yield of fruit trees. Landslide a major threat during heavy rainfall. Volcanic induced acid rain has been destructive to vegetable gardens.	Salt spray is a major concern especially during cyclones. Salt spray render iron roofing impractical for rainwater catchment and this reduces water availability for agricultural purposes.	Cyclones and strong winds affect agriculture crops. Heavy rains and salt spray associated with cyclones are particularly harmful to agricultural crops.
Forestry	Warm temperatures may cause plant stress thereby affecting forest yield.	Projected increase in humidity and wet conditions may create favorable conditions for weed growth, invasive species and pests.	Increased rainfall will help forest growth including those of invasive species. Forest pests and diseases may also flourish in wet conditions.	Coastal forests are affected by salt spray and sea level rise.	Coastal erosion will be heightened during cyclones and storm surges affecting coastal forests.
Fisheries	Increased temperatures are likely to induce coral bleaching of reef systems that may trigger a decline in productivity levels and affect the physical functions of the systems.	Increased precipitation could lead to erosion of the coastal areas important for fishing in the islands.	Severe and rapid erosion of the coastal areas is a major problem for the islands and this will worsen with increased and prolonged rainfall.	Increased sea levels will affect coral growth and this will impact on fisheries. Coastal erosion may increase as a result of rising sea levels.	Coastal erosion will be heightened in the event of storm surges associated with cyclones. Anecdotal data suggest loss of coastal land as high as 100 meters in some areas during past 50 years.
Livestock	Increased temperatures may affect growth, production and	Projected increase in humidity and wet conditions	Increased rainfall could cause soil erosion and	Sea level rise could affect pasture growth. Salt spray may	Cyclone induced storm surges and flooding could

	reproductive efficiency of livestock animals on the islands.	may create favorable conditions for animal pests and diseases and induce growth of less nutritive pasture species.	leaching valuable soil nutrients important for pasture growth.	affect pasture land and water supply for livestock.	result in inundation of farm lands while cyclones can cause destruction to infrastructure and equipment.
Water supply	Increased temperatures coupled with incidences of El Nino episode may result in possible water shortages given the high dependence of island communities on rainwater. Prolonged drought in the past had resulted in people traveling by canoe as far as Liro to fetch water.	Increased precipitation could help water shortage often experienced on the islands especially dry season.	Increases in rainfall will alleviate water shortage provided there is adequate capacity to capture and store water effectively. However increased rainfall could also cause pollution of underground wells and creeks that are important during dry season.	Sea level rise will cause salt water intrusion into underground wells and coastal springs.	Salt spray associated with storm surges and cyclones have rendered iron roofing impractical for rainwater catchment and storage. Flooding associated with cyclones may result in the pollution of wells and other water sources on the islands.

Annex 4: FAO RPFS Sub-programme 2.3: Climate Change Preparedness, Adaptation & Mitigation

Main Thrust	Sub-programme Results
Improving coordination among regional and national disaster mitigation and management institutions and systems, with a focus on information flow and capacity building among farmers to prepare and respond to natural disasters and adapt to and mitigate the impacts and threats of climate change. Build on the work being initiated by SOPAC aimed at assisting PIF countries to develop their National Disaster Management Plans and by SPC Land Resource Division (LRD) to ensure that PICs can access crop, forestry an agro-forestry PGR that will help them manage natural disasters and climate change, protection of ecosystems vulnerable to natural disasters and climate change, and appropriate irrigation technologies. Participatory methods, such as Landcare concept and approach of mobilizing local communities at grassroots level in care of the land, to be promoted actively in partnership with the successful ongoing Landcare movement in Australia. Attention to improved land management and soil fertility improvement strategies, participatory development of land use plans and action frameworks, and the development and use of GIS tools, towards improved sustaining soil fertility and agricultural productivity.	**Intermediate Outcomes:** (i) Wider choice of agricultural technologies (e.g. drought resistance/salt tolerance options) (ii) Adoption of appropriate natural resource management regimes by major stakeholders (in coastal area and other critical ecosystems). **Immediate Outcomes:** (i) Agricultural research and development activities focused on increasing the range of crop species and varieties, with resistance or tolerant traits, initiated and/or sustained at national and regional levels. (ii) Integrated coastal management processes set in motion and action plans at national, sub-national and community levels prepared and under implementation. (iii) Land and water use strategies and action plans prepared and implemented at national and local levels, including environmental hotspots such as degraded areas, critical watersheds and wetlands. (iv) Close coordination and harmonization of sub-programme activities with climate change mitigation and adaptation initiatives of other regional and national institutions, including disaster preparedness and mitigation programmes. **Main Outputs:** <u>Component 1: Agricultural Diversification</u> (i) Enhanced regional and national knowledge base on the issues, potentials, opportunities and constraints relating to crop diversification, covering existing crop and tree genetic resources and resistant/tolerant traits of crops and trees (pest, drought and salt) identified. Skill gaps, training needs and capacity building strategy and programme determined. (ii) Laboratory and equipment of the MPPC in Kosrae and CePaCT in Fiji upgraded and operational. (iii) A climate change adaptation collection (crops and trees) from sources in PICs and internationally possessing desired tolerant traits established in MPPRC or CePaCT. (iv) Research and development personnel with enhanced knowledge and skills in: a) tissue culture and macro-propagation techniques for selected crops and varieties for utilization in climate change adaptation strategies; b) farming systems development, including soil amelioration/land husbandry and multiple cropping practices tailored to specific circumstances within the region/sub-region. (v) National crop improvement programmes focusing on climate change adaptation provided, enhanced PGR collection, and screening, monitoring and performance evaluation procedures in place. <u>Component 2: Integrated Coastal Area Management</u>

	(i) Enhanced regional and national knowledge base on the issues relating to unsustainable use and management of coastal ecosystems, including coastlines, coral reefs, mangroves and critical watersheds/catchments. (ii) Suitable species for the rehabilitation of coastal areas and integration into agro-forestry system identified and evaluated, including for salt tolerance, pest and disease resistance, and fat growing characteristics. (iii) National professionals with enhanced knowledge and skills on plant propagation techniques and maintenance of planting areas under coastal rehabilitation and agro-forestry systems. (iv) A regional tree seed bank of timber, fruit and nut trees established and made operational through CePaCT. (v) Integrated coastal area management (ICAM) approaches for coastal protection piloted and tailored to economic, social and environmental characteristics of the region/sub-regions. <u>Component 3: Land and Water Management and Use</u> (i) Enhanced regional and national knowledge base on the issues relating to unsustainable use of land and water resources, as basis for identifying mitigation and/or adaptation options and frame needed actions. (ii) National professionals with enhanced knowledge and skills on sustainable land management approaches, soil conservation methods, watershed management and efficient use of water for agriculture. (iii) Institutional framework developed for participatory management of land and water resources, focusing on rehabilitation of environmental hotspots like degraded areas, critical watershed and wetlands. This includes formation and/or facilitation of grassroots organisations such as Landcare Groups, steering committees and focal points. (iv) National Land use policies formulated or enhanced. (v) Land resource database and GIS established, and national soil laboratories upgraded. (vi) Research and development programmes on land and water use issues initiated. <u>Component 4: Technical and coordination support to sub-programme</u> (i) Strategic and operational plans of the entire sub-programme prepared and communicated to all key regional and national organisations and other partners in the region. (ii) Regular interaction with regional and national institutions responsible for nature resource and environmental management and for disaster preparedness and mitigation (including SOPAC and SPC/LRD).

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