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

A CASE STUDY IN THE REPUBLIC OF THE MARSHALL ISLANDS

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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 Niño season of 1997–1998, significant reductions in most crop yields was reported. It is not

known if El Niño 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 RMI has implemented a number of projects and programmes in various phases of development including solid and hazardous waste management, water quality, nature conservation, coastal erosion, public education and staff development. It has also put in place a number of policies and strategies aimed at addressing environmental problems, including climate change that are likely to adversely affect the environment and people of 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 and to resolve other national environmental concerns. It is noted however that the magnitude of the environmental problems facing the RMI necessitates a cross-sectoral approach, calling for a long term commitment and involvement by the range of authorities and local groups. This will be a long and difficult challenge for the atoll nation and the international community is therefore duty-bound to assist the RMI with its future efforts to address its environmental concerns and especially to respond to changes brought about by global climate change and rising sea levels.

SUMMARY OF RECOMMENDATIONS

- Pay more attention to population growth as an important part of any strategy to adapt to climate change.
- The government should strategically address a limited number of clearly identified priorities and actions based on the greatest needs and risks from climate change.
- Government should consider improving service delivery to and communication with the outer islands as explicit priorities for donor-funded projects in future.
- 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.
- 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.
- 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.
- Climate change awareness and training should be continued and expanded to include outer island communities and other stakeholders.
- 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.
- 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.
- FAO should support the RMI's efforts to revitalize the coconut industry by providing sound advice on scale of operation, appropriate breeding and replanting programme, products and marketing.
- Build capacity of MRD, MIMRA, Land Grant Programme and College of Marshall Islands to jointly promote and carry out agriculture research, management and training in the Republic.

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 to 29 February 2008 and an in-country consultation carried out from 8 to 22 March 2008.

PHYSICAL AND NATURAL ENVIRONMENT OF THE RMI

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 (1 130 km) West to East, from 4°34'W to 14°43'E, and about 800 miles (1 230 km) North to South, from 160°48'N to 172°10'S.

Isolated by ocean, the RMI is more than 2 000 miles (3 230 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 (6 511 square km), and its Exclusive Economic Zone (EEZ) encompassing 750 000 square miles (1.2 million square km) of the Pacific Ocean.

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).

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.

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 percent at night to a low of 76 percent 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 1 750 mm. The northern most atolls (Wake, Taongi and Bikar) are drier, 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 Niño 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.

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 percent 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[1]).

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).

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; among 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

1 OPS (Office of Planning and Statistics) was restructured and renamed in 2003 as the new Economic, Policy, Planning and Statistics Office (EPPSO).

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.

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 and 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 percent 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).

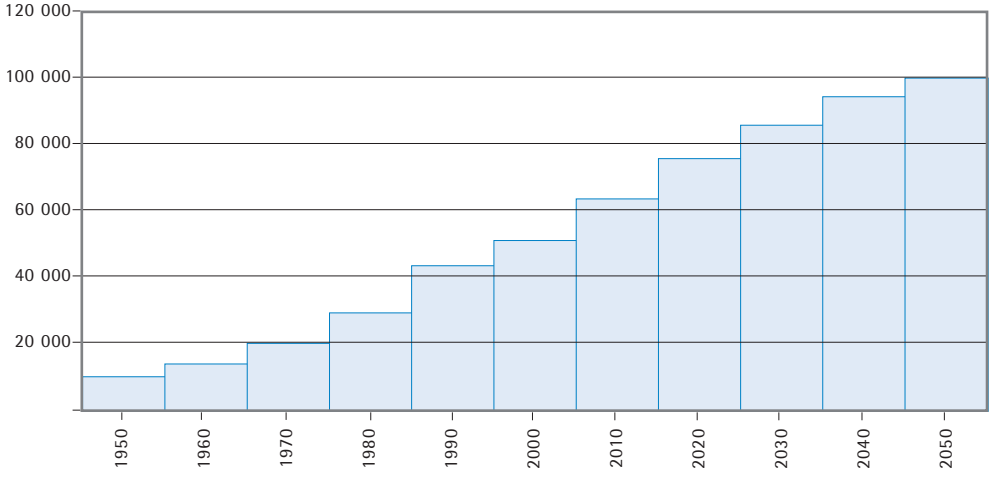
Between 1988 and 1999, the average growth rate for the RMI was 1.4 percent. This equates to an increase of 7 460 people in the 11 years. Majuro and Kwajalein experienced relatively low annual growth rates of 1.9 percent and 1.6 percent respectively compared to the previous inter-censal period when Majuro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

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.

FIG. 1: **RMI TOTAL POPULATION PROJECTION: 1950 TO 2050**



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

POPULATION MIGRATION AND URBANIZATION

Approximately two-thirds of the RMI's population lives in one of the two urban centers-45 percent on Majuro and 21 percent on Ebeye. The combined land area of the two urban centers is 11.4 percent 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 USA 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 USA 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 and 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 percent or more of their population.

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[2] 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).

2 Malayo-Polynesian family of languages.

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.

THE ECONOMY

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).

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 percent, although actual year-to-year growth rates were extremely variable. For example, the reported growth rate was 0.2 percent in 1985, 24.5 percent in 1986 (the year of Compact implementation), and 5.4 percent 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 percent (Pacific Magazine, 2008). Per capita GDP according to the 1988 Census was nearly $1 600 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 percent of GDP for the period 1981–1988. Private sector wages accounted for 38 percent of GDP in 1988, up from 25 percent in 1981. Overall, total employee compensation for both public and private sectors increased by approximately 14 percent per annum from 1981 to 1988.

The small production sector accounts for approximately 5 percent of GDP, with agriculture, fisheries, and handicraft production being the major contributors. As demonstrated by the 1988 census which indicated that fewer than 3 percent 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.

FOREIGN AID

The economy of the RMI is significantly inflated by foreign aid. In 1991, roughly 78 percent 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 percent of the government's recurrent expenditures in 1987, and 58 percent 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 in the future.

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 percent 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 percent of total commodity imports. In 1990, the purchase of food was estimated to constitute 58 percent of urban and 51 percent 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 percent 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.

LABOR FORCE

According to the 1999 Census, the national unemployment rate for the RMI was 31 percent, or 4 536 people; the rates for Majuro and Ebeye were 31 percent and 32 percent respectively (SPC, 2007). Recent estimates places the national unemployment rate at 33.9 percent (The Pacific Magazine, 2008). In urban areas, unemployment is exceptionally high among youths, averaging 57 percent for youth aged 15–19, and accounting for 62 percent 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,* reported that in 1988 the average grade of educational attainment was 10.7 for males and 11 for females employed in the public sector. Even so, the majority of positions filled by women were clerical or janitorial in nature (Booth, 1989).

THE AGRICULTURE SECTOR IN THE RMI

RMI's natural resources underpin agriculture, fisheries and mining. As shown in Table 1, these have varying levels of importance to the national economy.

TABLE 1: **SIGNIFICANCE OF THE ENVIRONMENT AND NATURAL RESOURCES IN THE RMI'S ECONOMY (CURRENT PRICES, $000's)**

ECONOMIC SECTOR	1997		1998		1999		2000		2001	
	GDP	%	GDP	%	GDP	%	GDP	%	GDP	%
Agriculture	12 963.2	14.1	11 403.8	11.9	8 274.4	8.7	9 715.1	13.4	10 296.1	10.4
a) copra	1 915.4	2.1	1 636.6	1.7	1 578.5	1.7	2 186.0	2.2	1 638.2	1.7
b) food crops	2 010.0	2.2	1 165.3	1.2	994.3	1.0	1 716.5	1.7	2 139.1	2.2
Livestock	2 136.3	2.3	1 804.8	1.9	1 855.7	1.9	1 892.3	1.9	2 251.8	2.3
Agriculture services	175.2	0.2	163.0	0.2	165.9	0.2	166.7	0.17	208.7	0.2
Fishing	6 726.3	7.3	6 634.1	6.9	3 680.0	3.9	3 753.6	7.3	4 058.3	4.1
Mining / quarrying	322.2	0.3	282.7	0.3	289.5	0.3	284.3	0.4	291.4	0.3
Hotels and Restaurants	4 535.0	4.9	4 389.0	4.6	4 456.0	4.7	4 458.0	6.1	4 421.0	4.5

Source: Key Economic Statistics for the Republic of the Marshall Islands

Agriculture production is relatively small but important to the livelihood of people and the economy of the RMI. The Agriculture Sector contribution to the GDP decreased from 6.8 percent in 1997 to 6.3 percent in 2001. The sector 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 USA 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.

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 percent 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.

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 32 000 tons per year in 1913 when the Jaluit Gesellschaft administered the Marshall Islands on behalf of the German government. Annual copra production declined by 15.1 percent

between 1979 and 1988 and was at its lowest at 2 653 short tons in 2001 due to non-collection of copra from outer islands mainly due to increased fuel prices which in turn reduced shipping services to once every two months. In addition, about 60 percent of the coconut trees are over 60 years old and almost one-third of the tress are non-bearing (US Army Civil Affair, 2003). Copra prices in late 90's ranges between 20 and 22 cents/lb and ADB estimated that a price of 25 cents/lb at the time could have seen people leaving jobs in Majuro for the outer islands.

Dwindling copra production has been attributed to three main causes:

- depressed price of copra in world markets;
- reduced productivity of aging coconut plantations; and
- 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 percent 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.

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.

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 pens. 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.

FISHERIES

The Fisheries sector's contribution to RMI's GDP during the period 1997 to 2001 increased from 3.6 percent to 7.3 percent. All tuna catches were exported overseas for processing until a tuna loining plant was established on Majuro. The plant employed about 400 workers, 80 percent of whom were women.

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. Several black-lip pearl farms were also established although most were unsuccessful. 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).

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 Niño Southern Oscillation (ENSO) weather pattern has changed its behavior noticeably since 1976 with more El Niños, fewer La Niñas, the two biggest El Niños on record (1982–83 and 1997–98) and the longest El Niño on record. These changes in El Niño patterns significantly affected Pacific tuna catch volumes, resulting in substantial reductions in seasonal tuna catches for many Pacific island countries. El Niño 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 Niño 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 percent 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 percent 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 Niño/La Niña 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 Niño 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 and 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).

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 have 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 USA Federal Emergency Management Agency (FEMA), noted that 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 is 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.

McGregor (1990) projected that by the year 2060 for all equatorial and sub-equatorial locations in the Pacific, there will be year round conditions of severe discomfort and thermal stress as a direct result of greenhouse induced climate changes. These projections are also true for the RMI.

- Increased temperatures is causing severe discomfort with associated increase in heat stress while working outdoors means that the pattern of work especially for outdoor workers had to be changed so that people can avoid being outdoor during the hottest part of the day. These changes have economic implications but since subsistence activities are currently of limited significance in the RMI, such effects have been minimal.
- Increased thermal discomfort also means that some changes have to be made in commercial or office building design to encourage air circulation and

avoid the need for expensive and energy consuming air-conditioning. This is particularly important for the RMI where energy costs are high and many buildings are air-conditioned.

- An increase in storm surges and higher energy wave action generated by intensified cyclone activity in higher latitude areas to the north of the RMI has been observed.
- A change in the pattern of temporary high sea level stands as the ENSO pattern changes. Reduction in El Niño events would decrease temporary higher sea level stands round the RMI and partially offset the impacts of world-wide rise in sea level.
- A direct change in local ocean water temperature of 1° to 2°, could cause coral die-back. Bleaching and death of coral colonies have other implications notably a resultant increase in the energy of coastal wave action, and hence a greater propensity for erosion and flooding to occur.
- A 2°C average rise in ambient air temperature could result in a change in the agricultural potential of some food crops and a consequent change in crop variety which may be able to be grown. However, rainfall patterns also change, this is unlikely to be of significance in the RMI where existing food crops are likely to be able to withstand higher temperatures.

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 below.

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.

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.

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 Niño 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.

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 Niño 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 percent 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 Niño 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.

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 Niño 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.

TABLE 2: **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 ~ Loss of agriculture land ~ Cause plant stress ~ Contamination of ground water lens and wells ~ Inundation and flooding of settlement areas and gardens	~ Construct coastal erosion protective measures ~ Consider/apply appropriate fisheries management approaches ~ Move gardens to higher grounds ~ Resettle populations from highly vulnerable islands ~ Promote water conservation practices ~ Plant coastal vegetation and control dredging and sand mining
Typhoons / cyclones and associated wave surges and salt spray	~ 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 ~ Change building designs to include water storage facilities ~ Desalination ~ Adopt bucket irrigation method by small farmers
Increased rainfall	~ Increased 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	~ Apply ground water management techniques ~ Apply pests and diseases management approaches ~ Improve rain water catchment and storage facilities ~ Apply coastal protection measures ~ Beach nourishment

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 are summarized below.

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 percent) 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.

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.

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.

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 animal waste and flood water run-off.

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.

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 RMI today.

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 below.

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".

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.

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 USA 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) determine 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).

WATER AND SANITATION SECTOR STRATEGY AND ACTION PLAN

Under the UNDP-funded Pacific Water and Sanitation Programme, 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.

PACIFIC ISLANDS CLIMATE CHANGE ASSISTANCE PROGRAMME (PICCAP)

With support from the Pacific Islands Climate Change Assistance Programme (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 programmes involving government and various sectors of the community.

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.

PACIFIC ISLANDS RENEWABLE ENERGY PROJECT (PIREP)

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.

REGIONAL PROGRAMME FOR FOOD SECURITY AND SUSTAINABLE LIVELIHOODS IN THE PACIFIC ISLANDS

In addition to many other programmes and projects supported by FAO in the region, this programme, 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 agriculture trade and policy, climate change adaptation and mitigation and support for project planning and programme development.

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

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.

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.

PACIFIC ADAPTATION TO CLIMATE CHANGE PROJECT (PACC)

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.

EXISTING INSTITUTIONAL MECHANISMS AND POLICIES

POLICIES

In January 1998, the RMI held its first National Economic and Social Summit (NESS) bringing together participants from throughout the Republic to discuss issues facing its people. The Communiqué emanating from the NESS recognizes the need to "have a long term plan to combat climate change problems and the possibility of sea-level rise, including a continued campaign on the global stage and work with other countries and regional and international organizations to support and encourage other countries to ratify the Climate Change Convention and meet reduction targets for greenhouse gas emissions by industrialized nations" (NESS, 1998). The Communiqué called on the Government, traditional leaders, the private sector, churches, NGOs and community organizations and all the people of the RMI to implement the recommendations of the Summit.

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 minimizing 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 programme office within EPPSO with the Programme 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.

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.

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 programmes 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 Programme in the implementation of the Framework.

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 1st September, 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.

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 programme 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.

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 USA 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 programmes 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.

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.

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.

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.

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.

Land Grant Programme (LGP)

The Land Grant Programme 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 Programme. LGP provide matching funds (1 : 1 ratio) for most of its projects.

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.

NATIONAL STRATEGY TO MITIGATE AND ADAPT TO CLIMATE CHANGE

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.

- 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 programme for the thousands of senile palms that represent the majority of existing coconut stands on the islands.
- 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.
- 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.

~ Enhancing the enabling environment for better environmental management. There is a need to recognize in the performance-based budgeting process the need to strengthen programme 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.

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 be 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.

- 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.
- 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.
- 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.
- 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.

- 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.
- 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 Table 3.

SUCCESSES 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.

- 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.

~ 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.

~ 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.

~ Reduce complexity of programmes 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 programmes 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.

- 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 programmes and extension services.
- 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.
- Mainstream climate change mitigation and adaptation into physical planning and development initiatives. Although the Strategic Development Plan (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.

RECOMMENDATIONS

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.

- Pay more attention to population growth. Although the RMI's average population growth rate is about 1.4 percent, the growth rates varies widely with some atolls experiencing rates of less than 1 percent while others are experiencing high rates of about 4.8 percent. 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.
- 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.
- 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.
- 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.

~ 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.

~ 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.

~ 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.

POTENTIAL PROJECTS FOR FAO CONSIDERATION AND IMPLEMENTATION

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

- 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.
- 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.
- 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.
- 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.
- 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;
  - identifying suitable products and markets for a revitalized coconut industry;
  - Studying the impacts of a coconut industry on the environment and natural resources of the RMI.
- Help develop the capacity of MRD, MIMRA and other relevant agencies to better manage land and marine resources of the RMI.
- Collaborate and provide support where necessary with activities of the Land Grants Programme and the College of the Marshall Islands that help promote agriculture research, management and training in the Republic.

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 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.

The former President of the RMI, Mr. Amata Kabua, pointed out in his address to the United Nations in September 1991, that "global warming is the most formidable problem facing the Republic, but there is little that can be done by the country to alleviate the problem other than continue to raise the issue with the international community". The international community has been listening but has been very slow in acting.

TABLE 3: **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 programme ~ 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 Programme 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

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[→] Table 3 continued

CLIMATE CHANGE ISSUES AND VULNERABILITIES	MITIGATION STRATEGY	ADAPTATION STRATEGY
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 management and risk-coping production systems ~ Raise public awareness about changing weather patterns and impact on agriculture production	~ Adjust planting and harvesting timetables to prevailing conditions of past 3-4 years ~ Undertake assessment of impact of changing weather patterns on traditional crops ~ Support crop improving programme 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

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[→] Table 3 continued

CLIMATE CHANGE ISSUES AND VULNERABILITIES	MITIGATION STRATEGY	ADAPTATION STRATEGY
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 activities and other factor may increase incidence of ciguatera	~ Improve public awareness and understanding about connection between climate change and ciguatera	~ Continue monitoring of incidence of ciguatera outbreaks ~ 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

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[→] Table 3 continued

CLIMATE CHANGE ISSUES AND VULNERABILITIES	MITIGATION STRATEGY	ADAPTATION STRATEGY
Limited understanding of the long term trends in climate change especially related to global warming in fisheries	~ Develop climate change awareness programmes based on existing knowledge targeting politicians, schools and local communities ~ Incorporate climate change science in school curricula	~ Continue studies on the impact of El Niño 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

BIBLIOGRAPHY

ADB. 1991. Economic Report to the Republic of the Marshall Islands. Asian Development Bank, Manila, Philippines.

ADB. 2005. Republic of the Marshall Islands. Country Environment Analysis Asian Development Bank.

Booth, H. 1989. The Marshalls: a Statistical Profile of the Men and Women. United Nations Development Programme / UNIFEM

Callies, D.L. and Johnson, C. 1989. Legal Business and Economic Aspects of Cobalt, Rich Manganese, Crust Mining and Processing in the Republic of the Marshall Islands. East West Center, Honolulu, Hawaii.

Connell, J. and Maata, M. 1992. Environmental Planning, Climate Change and Potential Sea-level rise: Report on a Mission to the Republic of the Marshall Islands. SPREP Report and Studies. Apia, Samoa.

Darwin, C.R. 1842. The Structure and Distribution of Coral Reefs. London, Smith Elders.

Doig, K.D. 1996. Water and Sanitation Sector Strategy and Action Plan. SOPAC Technical Report 236.

FAO. 2007. Regional Programme on Food Security and Sustainable Livelihoods Expansion Phase: Programme Brief. SAP.

Fosberg, F. 1990. A Review of the Natural History of the Marshall Islands. Atoll Research Bulletin 330. 1–100.

Hezel, F.K. and Levin, M. 1989. Micronesian Emigration: the Brain Drain in Palau, Marshalls and Federated States. In: J. Connell, ed. Migration and Development in the South Pacific. National Center for Development Studies, Canberra.

Lewis, R.J., and Ruff, T.A. 1993. Clinical Aspects of Ciguatera: An Overview. Pacific Health Dialogue Vol.4. No.2, pp. 119–127.

Marshall Islands. 1991. United Nations Conference on Environment and Development. National Report. RMIEPA, Majuro.

Marshall Islands. 2004. Republic of the Marshall Islands. Updated Report on the Barbados Programme of Action (BPOA)

Ministry of Resources and Development. Progress Reports for Fiscal Years 2004, 2005 and 2006.

NEMS. 1992. National Environment Management Strategy, Part A: State of the Environment Report, 1992.

NIWA. 2007. The Islands Climate Update No. 86, November 2007.

OPS. 1988. Statistical Abstract. Office of Planning and Statistics, Majuro, Republic of the Marshall Islands.

OPS. 1989a. Census of Population and Housing, 1988. Office of Planning and Statistics, Majuro, Republic of the Marshall Islands.

OPS. 1989b. The Marshall Islands: a Statistical Profile for Men and Women. United Nations Development Programme / UNIFEM.

OPS. 1990. Situation Analysis of the Marshallese Child. Office of Planning and Statistics. Majuro, Republic of the Marshall Islands.

OPS. 1991. Second Five Year Development Plan 1992–1996. Office of Planning and Statistics, Majuro, Republic of the Marshall Islands.

Pacific Magazine. 2008. Pacific Almanac 2008. In: Pacific Magazine January/February 2008.

Presley, T.K,. 2005. Effects of the 1988 Drought on the Freshwater Lens in the Laura Area, Majuro Atoll, Republic of the Marshall Islands. USA Geological Survey Scientific Report, 2005.

Republic of Marshall Islands. 1998. First National Economic and Social Summit. 13–17 January 1998. Final Report.

RMI EPA. 2006. Coastal Management Framework, Republic of the Marshall Islands, November 2006.

Schlenger, S.O. 1963. Subsurface Geology of Enewetak Atoll. U.S Geological Survey Paper No. 260-B, Washington. In: J. Connell, Environment Planning, Climate Change and Potential Sea-level rise: a Report on a Mission to the Republic of the Marshall Islands, 1992.

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

SPC. 2007. Marshall Islands Population Atlas. Phil Bright and Emi Chutaro. Secretariat of the Pacific Community, Noumea, New Caledonia.

SPREP. undated. Pacific at Risk. Our Knowledge, the Reality.

Sullivan, M. and Gibson, L. 1991. Environment Planning, Climate Change and Potential Sea-level rise: a Report on a Mission to Kiribati. SPREP Reports and Studies No. 50. Noumea.

UNDP. 1991. Towards Sustainable Development of Atolls and Other Small Islands. UNDP, Suva.

Wiens, H.J. 1962. Atoll Environment and Geology. Yale University Press, New Haven and London.

Williamson, I. and Sabath, M.D. 1982. Island Population, Land Area and Climate. Human Ecology.

World Bank. 2000. Cities, Seas and Storms. Managing Change in the Pacific Island Economies. Volume 1, Summary Report.