UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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GOVERNMENT OF THE REPUBLIC OF THE MARSHALL ISLANDS

INITIAL COMMUNICATION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

September 2000

REPUBLIC OF THE MARSHALL ISLANDS ENVIRONMENTAL PROTECTION AUTHORITY

Majuro, Marshall Islands

- ***Republic of the Marshall Islands***

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National Analysis of UNFCCC Obligations

In June 1992 the Republic of the Marshall Islands joined world leaders and citizens of 176 countries at the Earth Summit in Rio de Janeiro, in signing the UN Framework Convention on Climate Change (UNFCCC or FCCC). This instrument was designed to start the process of controlling emissions of greenhouse gasses so as to reduce global warming and its resultant predicted sea level rise. The potential threats and risks from climate changes, especially when combined with the already existing environmental problems, are of grave concern for the Republic of the Marshall Islands. In 1994, the RMI ratified the convention. The RMI noted at that time that the FCCC in its present form would not be a sufficiently robust instrument to meet the ultimate objective of article 2 of the Convention (statement by H.E. The Hon. Tom D. Kijiner to the 48th UN GA). The FCCC needed firm emissions reductions targets, and for this reason the RMI supported vociferously the Protocol Proposal of the Alliance of Small Island States (AOSIS).
The RMI Government also noted that countries like RMI has a primary responsibility to fully explain the climate change concerns, to show how the RMI would seek to address those concerns, and where international support would be required.
This initial communication is a first step in this direction.

The National Communication to the UNFCCC

As noted, one of the obligations under the UNFCCC is to submit a National Communication to the Conference of the Parties (COP). This requirement was reaffirmed at the 1st Conference of the Parties (COP1) in Berlin, Germany. Guidelines for the contents were developed at subsequent Conferences. The National Communication is to include information on the vulnerability of the Party to climate change and its capabilities and needs for adaptation to adverse effects.

RMI Response to the UNFCCC

The RMI recognizes that the success of the FCCC relies heavily on cooperation among all nations in reducing greenhouse gas emissions. Although the Marshall Islands is an insignificant contributor to the global emission of greenhouse gases, global climate change poses a serious threat to the nation's environment and economic development. Because the Republic consists of low-lying, coral atolls, there is great concern that changed climatic conditions by way of more extreme storm events or any rise in sea level may have significant and profound effects on the economy and on the living conditions of citizens of the RMI. Moreover, some of the most important national institutions can be found in one of the most vulnerable sections of the country. The Parliament, the

Government Ministries, Post Office, banks and many schools are located in a section of Majuro that is on average 4 feet above sea level. These institutions would therefore be the first to be affected by sea level rise, creating a massive problem for the effective functioning of the RMI Government in the face of climate change.

In order to develop and implement appropriate response strategies, it is essential that:

- the RMI has a clear understanding of the effects of being vulnerable to climate and sea-level change; and

- the RMI has the capacity to adapt to these changes.

Support for Preparing the National Communication

The Pacific Islands Climate Change Assistance Programme (PICCAP) has given support to the activities carried out to enable the RMI to prepare its national communication. This programme is funded by the Global Environmental Facility (GEF), implemented by UNDP and administered by the South Pacific Environment Programme (SPREP). The support has been absolutely essential, given the meager resources available to the RMI Government for climate change activities. Under PICCAP, a Country Team, which includes, government departments, ngo's and the private sector, was established in July 1998.

National Activities

Prior to the preparation of the Initial National Communication, the Pacific Islands Climate Change Programme conducted studies listed below from 1998-2000:

- Review of the Greenhouse Gas Inventory for using base year 1994
- Vulnerability and Adaptation Case Study (on going)
- Regional Mitigation of all PICCAP Countries

These reviews have made it possible for the preparation of the Initial National Communications document for the Republic of the Marshall Islands. From these studies, five sectors have been identified as vulnerable to climate change and sea level rise. These sectors are:

- Water Resources
- Coastal Zones
- Marine Resources
- Health
- Agroforestry

As depicted in the draft national communications, the RMI is neither a significant user of fossil fuels nor a great emitter of greenhouse gasses. When the consumption and carbon emissions are compared on a Pacific region basis for 1990 the results are as summarized in Table 3.1.

Table 3.1 Regional Comparison of Consumption of Oil and Carbon Emissions

Consumption / Emissions	**RMI**	**Pacific Island Region**
Oil Consumption (millions of tonnes/annum)	0.029	1.411
Carbon Emissions (millions of tonnes/annum)	0.0025	1.194
Carbon Emissions (tonnes/person/annum)	0.54	0.21

Although the emissions of carbon per person in the RMI are over twice the regional level (RMI 0.54, Region 0.21) they are low on a world scale. Worldwide emission in 1990 were 6,012 million tonnes with an average of 1.14b tonnes/person. Emissions from the USA provide an interesting bases for comparison with the RMI, the Pacific Region and the world. The emissions for 1990 from US were 5.36 tonnes/person which is four and a half times the world average. From the figures available the island nation and the Pacific Island Region contributed only 0.02% of the carbon emission in 1990. On this bases, in 1990, the RMI would have only emitted some 0.0041% of the world's carbon load from fossil fuel.

As for copra, it is recommended that specifications to address the sink category be added to the IPCC guidelines in the future.

Mitigation Measures

The national government of the RMI recognizes that measures could be implemented to reduce the country's dependence on fossil fuel, improve energy efficiency, test new energy technologies and optimize available carbon sinks. The Government is interested in implementing a national policy on renewable energy and energy efficiency, and to seek a more sustainable energy future.

However, the Government of the RMI acknowledges that measures for mitigation of GHG emissions may need to be evaluated at a regional scale. To this end, the Government of the RMI will continue to participate in energy and mitigation studies with regional bodies with the aim of:

- identifying practical ways and cost effective measures that can be undertaken within the capacities and resources of the government, business, Marshall Islands Energy Company and the people of the Republic; and

- providing sites for projects where specific energy efficiency and mitigation technologies can be tested and trialed to prove their applicability to Pacific Island condition.

Social and Economic Change Scenarios

Given the nature of population growth it may also be anticipated that urban crowding will become more common. Demand for food, water, and space will become more pressing, especially on Majuro and Ebeye. As a consequence, the greater portion of the Marshal Islands population will be living on islands which have become severely environmentally stressed.

The outcomes of the demand situation likely to be increased are water supply and quality problems, further hardening of the coast as people seek to protect assets and infrastructure, and burgeoning waste production. The latter will arise not only from the growing population but also from increasing per capita waste production, which is in line with growing consumption patterns. Thus, it is quite likely that during the period of accelerated climate change and sea level rise that steps may need to be taken to slow down, reduce or even to reverse some of these trends. With the current level of socio-economic information it does not appear to be possible to either predict what these steps

might be or gauge how effective they are likely to prove and when they will be implemented.

The Government of the RMI believe that it will be on this template of social and economic change that the effects of climate change and sea level rise will be experienced in the Marshall Islands. On the basis that the human responses could compound existing social and economic problems it is likely that an already fragile atoll and island system will be rendered even more vulnerable by the time the projected effects of climate change are manifested.

- *Future Needs, Programs and Projects*

Immediate and Future Needs

Based on the result of the country studies, the following future needs have been identified. These needs must be addressed as a matter of urgency if the people of the RMI are to be able to effectively respond to the challenges arising from climate induced changes to the physical, biological, social, economic and cultural conditions on the atolls and islands of the Republic.

- ***Institutional Strengthening.*** Governmental and other institutional strengthening is needed to ensure that the government departments are adequately structured, equipped with the appropriate skills and tools and are capable of delivering an integrated response to the challenges arising from climate change and accelerated sea level rise.

- ***Management and Operational Training.*** Project management and operational training is needed for the governmental and non-governmental stakeholders involved in climate change programs and the implementation of adaptation projects.

- ***Applied Research Assistance.*** Specific applied research assistance is needed for the selection of representative atolls and islands and determining the parameters and indicators for the accurate documentation of base line conditions from which to measure climate induced changes to the shorelines, reef and island ecosystem and affected settlements and communities.

- ***Professional and Technical Support.*** Adequate support is needed at the professional and technical levels for: carrying out vulnerability and adaptation assessment; the preparation of integrated coastal zone management plans; and the implementation of projects to manage the physical, economic, social and environmental changes.

- ***Appropriate Funding.*** Financial support is needed for baseline bio-physical and socio-economic environmental research, monitoring changes to environmental conditions and implementing adaptation measures.

- ***Information Management Systems.*** Appropriate systems are needed for spatial and other data generated through vulnerability assessments, monitoring programs, integrated coastal zone management planning and the implementation of adaptation projects.

- ***Confidence and Capacity Building.*** Confidence and capacity building programs are needed for government departments, members of local councils and non-government organizations.

- ***Awareness and Education.*** Community awareness and education programs are needed that are aimed at students at elementary and high schools and the College of the Marshall Islands as well as public and private sector bodies and island residents and visitors.

- ***International Participation.*** Proactive participation and lobbying initiatives in international forums and meetings are needed with the aim of continuing to keep the issues confronting small island states, when they are responding to climate change, in front of representatives and citizens of the industrialized nations.

- ***PICCAP Country Team.*** An adequately resourced and trained RMI PICCAP Country Team is needed to ensure that the preparation of the National Communication and other reporting under obligations to the UNFCCC are met and that a whole of government approach is applied to resolving climate change issues. It is vital for the Country Team to continue its work, perhaps as a functioning body of the National Commission on Sustainable Development. Consideration must be given by the Conference of the Parties for financing the country teams in the interim period between national communications. The preparation of the Nation Communication is a considerable burden on the governmental resources of the RMI. A core component of capacity building will need to be the strengthening of the PICCAP Country Team and establishing linkages with relevant research and non-government bodies. Additionally, there needs to be the development of in-country expertise undertaking greenhouse gas.

Financial Assistance

Currently neither the national government nor the local councils of the RMI have the financial resources to be effective in either ongoing vulnerability and adaptation assessment or to deal with the degradation of the shoreline environments as a result of erosion. This situation needs to be rectified with donor assistance. The husbanding of the existing resources will be aided by focussing the climate change monitoring effort at reference islands. Notwithstanding, the current situation of environmental degradation, on some islands in the RMI, means that immediate financial assistance is needed to protect property and infrastructure and to safeguard human health and maintain agro-forestry productivity. It is therefore important to secure such financial assistance through

the financial mechanism of the Convention, supplemented by other donors. Consideration could also be given to regional cooperative arrangements for financing of the climate change response efforts of Small Island Developing States.

- Conclusion

It is important that policy-makers support continuous collection of data and the establishment of monitoring programs. Taking no actions, delaying them becomes a decision in itself, with costs multiplied in terms of future natural disasters such as an increase in cyclones and droughts, flood damages from storm surges, and a variety of other potential hazards resulting from climate change and sea level rise. In order that our immediate needs of programmes be supported by the international community, the initial national communications needs to be endorsed by the RMI government and before it is submitted to the UNFCCC Secretariat.

Glossary of Terms and Abbreviations

Acronyms

AOSIS	Alliance of Small Island States
COP	Conference of the Parties
FCCC	Framework Climate Change Convention
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel of Climate Change
NOAA	National Oceanic and Atmospheric Administration
OPS	RMI Office of Planning and Statistics
PICCAP	Pacific Islands Climate Change Assistance Programme
RMI	Republic of the Marshall Islands
SOPAC	South Pacific Applied Geoscience Comission
SPC	Secretariat of the Pacific Community
SPREP	South Pacific Regional Environmental Programme
UNFCCC	United Nations Framework Climate Change Convention

Chemical compounds

CH_4	Methane
N_2O	Nitrous Oxide
CO_2	Carbon Dioxide
CO	Carbon Monoxide
Nox	Nitrogen Oxides
NMVOC	Non-Methane Volatile Organic Compound
NH_3	Ammonia
ÇFCs	Chlorofluorocarbons
HFCs	Hydrofluorocarbons
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride
CCL_4	Carbon tetrachloride
$C2F_6$	Hexafluorethane

Chapter 1 National Circumstances

1.1 Historical and Geographical Context

1.1.1 Historical Background

Radiocarbon dating indicates that the Marshall Islands were first colonized by Micronesian people about 2000 years ago. The inhabitants of the islands developed and refined the skills and technologies that supported their adaptation to the atoll and oceanic environment. These skills and technologies encompass canoe building, navigation and fishing techniques as well as agricultural practices. Collectively, these skills and technologies underpinned the development and maintenance of a self reliant and sustainable society in the Marshall Islands.

European contact commenced in the 16th Century. During these early visits the people of the Marshall Islands were among the first Pacific Islanders to establish contact and trade with Westerners. With these first contacts came the new materials such as iron and other trade goods, which were integrated into the material culture of the island people.

The group of atolls and islands was first recognized as a region in 1788 with the visit of two British ships into these waters under Captains Marshall and Gilbert. Visits from missionaries, whalers and traders increased in the 19th Century. This phase of European contact culminated in the Marshall Islands becoming a German protectorate in 1885. This situation prevailed until October 1914 when Japanese military forces occupied the German protectorate. Japan was later granted the right to hold the former German protectorates as a Mandate under the League of Nations. The Japanese control over islands continued until 1944-45 when military personnel of the United States of America liberated Micronesia. The USA became the administering power of the UN Trust Territory of the Pacific Islands, which included the Marshall Islands, as well as the other island groups in Micronesia, until 1986.

Colonial occupation and administration together with the long history of Marshallese contact with other countries has left an interesting legacy. This encompasses matters as diverse as material goods and consumer patterns, social and cultural influences, economic and trading relations and legal and institutional arrangements. The hallmarks of this legacy are seen today in the buildings and infrastructure, the religious practices of the people, the diet and cuisine, the business affiliations, the structure of the governmental bodies and the range of educational facilities.

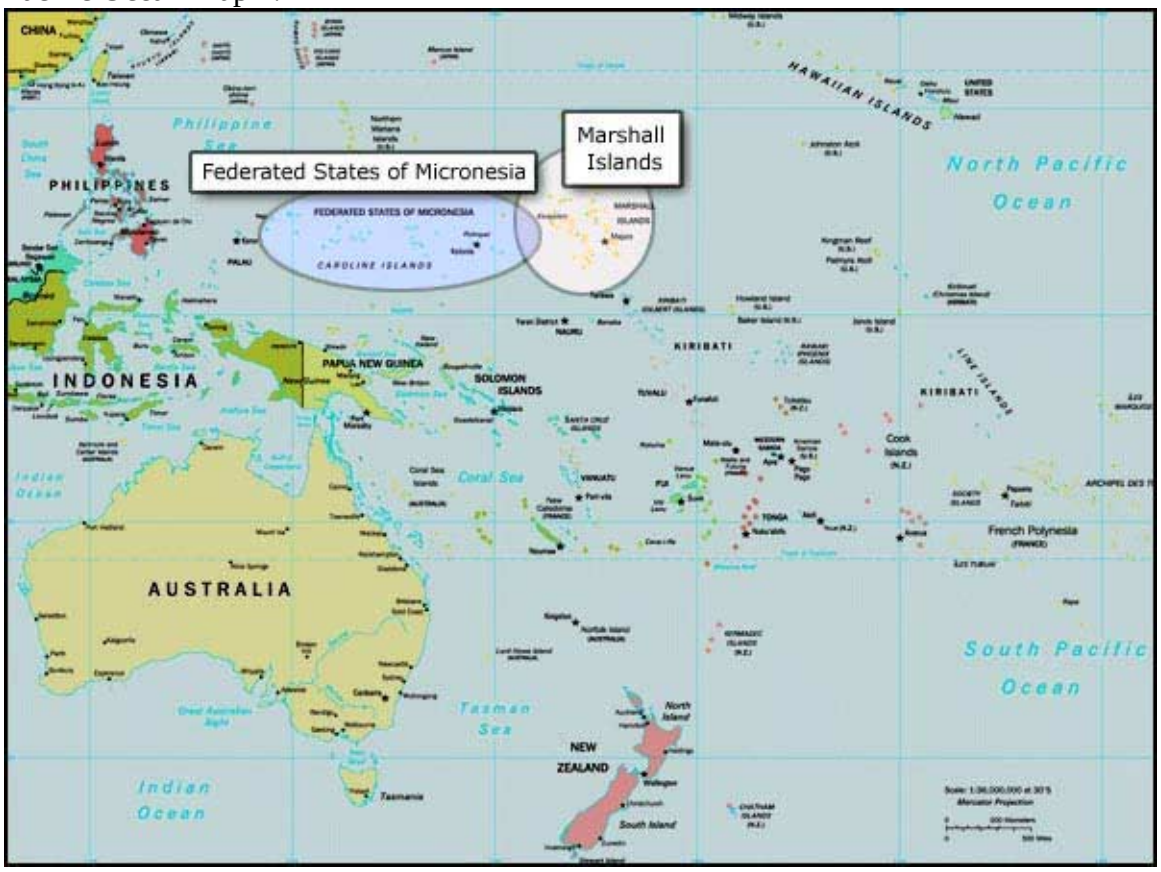
Since 1986 the Republic of the Marshall Islands has been a self-governing democracy through a Compact of Free Association with the USA. The RMI has been a member of

the United Nations since 1991 and a founding member of the Alliance of Small Island States**.** Since the late 1980's the RMI has worked closely with international bodies to ensue that climate change and related issues receive due consideration.

1.1.2 Geographical Setting

Geographic isolation shapes the life of the people and the economy of the Republic of the Marshall Islands, as it does other small island societies. The most compelling limitation imposed by geography is the small, fragmented and fragile land area of this least developed nation. The Republic is isolated from regional global transport routes as well as markets for both raw materials and finished goods. The regional location of the island nation in the north-central Pacific Ocean is shown in Map 2.1.

Pacific Ocean Map 2.1



The Republic of the Marshall Islands, scattered in an archipelago consisting of two roughly parallel island chains, the western "Ralik" (sunset) and eastern "Ratak"(sunrise) chains. There are twenty nine atolls and five reefs without lagoons which are made up of about 1,225 islands and 870 reef systems. Twenty-two of the atolls and four of the islands are inhabited. The atolls extend about 700 miles (1130km) north to south, from 14º 43əN to 4º 34əN, and about 800 miles (1290km) east to west, from 160º48ə E to 172º10ə E. Map 2.2 shows the structure of Majuro and Kwajalein the two most populated atolls.

While some of the islands are several kilometers long they rarely exceed a few hundred meters in width and are often considerably narrower. Land elevations are very low, with a mean height above sea level of only two meters (7 feet). The combination of small land areas and low land elevations contributes to the ecological vulnerability in the Republic. There is concern that any change in sea-level could seriously upset the fragile balance between the land and the sea.

The RMI consist of fragments of Islands or low Lying Atoll

Courtesy of MIVA

Isolated by ocean, the Republic is more than 2,000 miles (3230km) from the nearest trading centers, Honolulu and Tokyo. Geographically, the RMI's nearest neighbors are Kiribati to the south and the Federated States of Micronesia to the west. The Republic's Exclusive Economic Zone (EEZ) encompasses over 750,000 square miles (1.2 million sq km) of the Central Pacific.

1.2 Climatic and Oceanic Conditions

The climate of the Marshall Islands is moist and tropical. It is predominantly a trade-wind climate with north-easterly winds prevailing throughout the year. The trade winds are frequently locally interrupted during the summer months by the movement of the zone of inter-tropical convergence across the area. The annual average temperature is 27^0C (81^0F). Relative humidities range from 83 percent at night to 76 percent at midday (Connell and Maata 1992).

Surface ocean currents tend to drift westward with the prevailing winds. Tidal and topographic influences change the general patterns of drift.

The Marshall Islands is faced with considerable climate variability from north to south down the atoll chains as well as from east to west across the breadth of the nation. Conditions being drier in the north with annual rainfall averaging between 1000-1750 millimeters (40-70 inches) compared to the south with 3000-4300 millimeters (120-170 inches). Major extreme weather events such as tropical cyclones and droughts are experienced in the Marshall Islands. Although neither of these extreme events are frequent (Connell and Maata 1992) there have been cyclones which have resulted in loss of life. Contemporary observations show that both these types of hazards are experienced more often during El Nino events.

1.3 Population and Settlement

The Republic of the Marshall Islands is a nation of approximately 55,000 people. The first recorded census in the Marshall Islands was in 1920 and the total population was 9,800. By 1988 the population had therefore increased more than fourfold. The overall trend was one of fairly low growth up to 1958, followed by a dramatic escalation to 3.4 percent per annum during the period from 1958 to 1967.

The population projection for the period 1988 to 2012 is given in Figure 2.1. The distribution of the population by island of residence at the time of the 1988 census is summarized in Table 2.1.

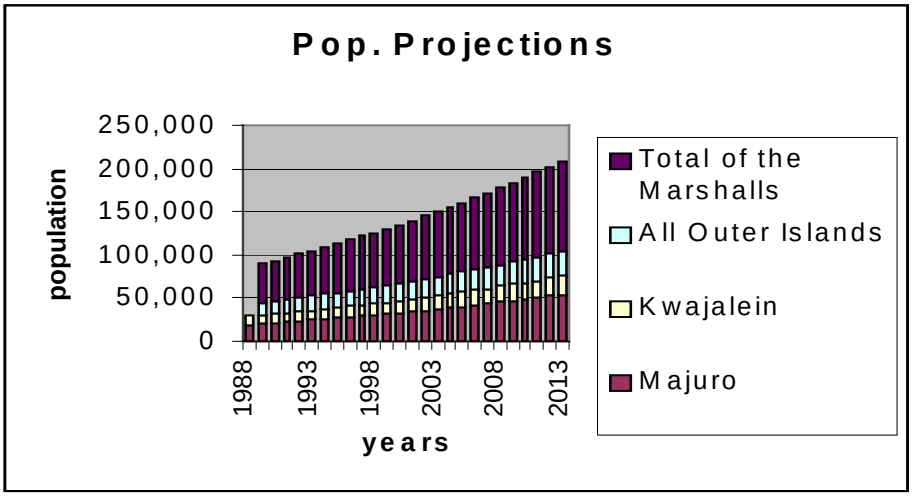


Table 1.1 Population by Residence (1988 census)

Majuro	26,603
Kwajalein Atoll (excluding US Army Kwajalein Atoll)	9,311
Outer Islands	14,404

The Marshall Islands has a high fertility rate, children under 15 years of age constitute more than 50 percent of the total population. This percentage has been increasing during

the period from 1973 to 1988. Thus, the Marshall Islands has a very young population. In most developing countries the population under 15 years is around 40 percent. The median age has slightly decreased from 14.8 years in 1980 to 14.0 years in 1988. This trend is expected to continue into the 21st Century.

The population of the Marshall Islands has been growing rapidly since the 1960's. Currently, the population growth rate is around 4.0 percent per annum, one of the highest rates in the Pacific region. In addition to the rapid growth of population is the increasing trend of migration from the outer islands to Majuro and Ebeye. At both centers the population increase rates are exceptionally high. If current trends continue, Majuro and Ebeye will become increasingly densely populated. It is on these two islands that population pressure on resources may well reach a point where any externally generated changes such as sea level rise or climate change, may have serious social and economic consequences. Plans for redistributing the population of Ebeye to other islands in the Kwajalein Atoll, through the construction of causeways to link six islands, have yet to be implemented.

Projections prepared by the RMI Office of Planning and Statistics indicate that the population in 2010 will total almost 95,000 people (see Figure 2.1). While it might be anticipated that the population growth rate will decline there should nevertheless be substantial further growth in the national population through the 21st Century. That is, when climate change effects are most manifest there will be considerably greater population pressure on the land and sea resources of RMI.

1.4 Land Utilization Issues

Directly and indirectly, the society and culture of the people have been adversely affected by the rapid change in the size of the population and the density of settlement. Issues resulting from the impacts of population growth, include:

- limited available land;
- the expansion of informal settlements and overcrowding of household;
- sanitation problems;
- land ownership disputes; and
- social and health problems.

Moreover, growing problems of waste disposal have emerged. Atolls have little space for the location of landfill sites and the fragile environments, particularly ground water and coral reef ecosystems, are easily degraded. These associated problems are particularly acute for Majuro and Ebeye, and are contributing factors to the stresses placed on the coral reef.

During the 1997-1998 drought Kwajalein Atoll

Ebeye residents return home from Kwajalein Military base with a day's supply of water.

FEMA

Population growth and economic change have been accompanied by changes to the landscape of the Marshall Islands. The two urban islands, in particular, have seen major changes to their patterns of land use including roads, complex water supply systems, large commercial and government buildings and considerable shoreline development and ad hoc shore protection works. The growing population and the infrastructure development have resulted in beach erosion and damage to the natural reefs, disruption of hydrological processes and loss of vegetation. Consequently the islands have become increasingly sensitive to environmental change by way of rising sea level and the frequency and/or intensity of extreme climatic events.

1.5 Socio-economic Overview

The contemporary economy of the RMI relies to a large extent on foreign aid, expertise and imports. For this reason, the importance of the nation's subsistence agriculture has declined on the urban islands. However, the outer islands still rely on subsistence agriculture and fishing combined with cash from copra. As a whole, the Marshall Islands is still heavily dependent on imported foods to meet the demands of the urbanized component of the population.

Factors contributing to the nation's slow economic growth are:

- the inadequate supply of skilled labor;
- an underdeveloped manufacturing sector

- geographical isolation from world markets; and

- a relatively narrow resource base.

Faced by a rapidly expanding population, the Republic has declared fisheries as one of the key sectors for future economic independence. The tuna fishery generates the largest export earnings for the RMI. Exploitation of the tuna resource is mostly carried out by overseas fishing vessels licensed by the Government of the Marshall Islands. Tuna appear to be sensitive to variations in sea temperatures. During the most recent El Nino the volume of tuna caught in the territorial waters was substantially higher than normal, while in other parts of the Pacific catches were very low.

A cultural fishing method .	The family outings
	

COURETESY OF MIVA

US rent and aid, as well as aid from other sources are used to buy most of the country's needs from overseas while its primary income source, domestic production of goods from domestic resources, has remained limited. The relatively large flows of funds from overseas especially the US, make consumption far larger than domestic production and contribute to high levels of trade deficits in the usual sense. In 1996, exports amounted to $23.4 million, nearly three times the amount of the year before. Not withstanding, they fell short of imports which totaled $71.4 million in 1996. The large import-export gap shows what a challenge it is for RMI to meet its import demand without external funding.

1.6 Buildings and Infrastructure

Considerable investment has been made on buildings and infrastructure. Buildings includes private residences, churches and meeting places, commercial and governmental offices, schools and other public structures, wholesale and retail premises and tourist and

Kwajalein Atoll, Queen of Peace School	Students from Ebeye Elementary School
	

Photos by: Y. Crisostomo

recreational facilities. Infrastructure encompasses roads, electric power generation plants, water and bulk fuel storage, sewerage waste discharge points, solid waste transfer and disposal sites and airport and marine port facilities. Much of the seaward and lagoon shorelines of the highly populated islands has an ad hoc array of seawalls and other structures built to protect specific public and private buildings and infrastructure.

The building of private shoreline protection accords with land ownership practices. Land is divided into strips and is owned from the seaward edge of the coral reef across the island to include the sea bed on the lagoon side. This practice has the effect of compounding the erosion of the shoreline, which imposes even greater threat to the buildings and infrastructure.

1.7 Transport and Communications

The Marshall Islands are heavily dependent on air and sea transport as well as tele-communications networks. Air, shipping and road transport use considerable amounts of imported fuel. Private vehicle ownership is growing on the highly populated islands and there is increasing pressure to improve roadways. Tele-communications includes telephone and facsimile links, web-sites and networking and an increasing demand for email hook-up.

Cultural canoe race. Reviving our culture	A connection between Ebeye to near Islets
	

Courtesy of MIVA **Photo by: Y. Crisostomo**

1.8 Atoll Ecosystems and Biodiversity

Habitats of the Marshall Islands range from the well vegetated and biologically diverse atoll, reef and marine areas in the south to the coral sand and rubble based drier less vegetated atoll islands to the north. According to the book *Marshall Islands: Living Atolls Amidst the Living Sea* (in prep), the coral reef systems are home to over 800 species of fish, 1500 species of mollusks and more than 250 species of algae and stony corals. Additionally, there are seagrass and mangrove species in some atoll lagoons. The biodiversity of the land areas of the islands encompasses a complex array of ecosystems which are home to a wide array of endemic and introduced species of plants and animals.

MIVA	The richness of the deep, Coral RMI
	

The above photos are some of the many marine animals and beings living under the rich ocean of RMI.

In addition to coconuts, pandanus and breadfruit trees make up the main subsistence agriculture

Pandanus Fruit	Breadfruit
	

Courtesy of MIVA

There are some 80 species of land plants of which one is endemic to these islands and another two are endemic to Micronesia. Insects are the most common animal found in the islands and most of the 600 species are found on the land. Of the 106 species of birds, about 19 nest in the island as native species. All 9 species of mammals found in the Marshall Islands are introduced.

The combination of increased population pressures on the scarce land resource and climate induced change could have severe adverse impacts on the biodiversity of the atoll and reef ecosystems. The implementation of the *National Environmental Management Plan* (RMI 1992), (*Biodiversity Management Plan* (RMIEPA in prep) and the *Coastal Zone Management Plan for Majuro Atoll* (Interagency Working Group 1998) should assist in minimizing the adverse effects.

1.9 Human Health and Environmental Change

Climate-related health issues of concern to the government of the RMI are: diarrhoeal and other water-borne diseases; dengue fever, a vector-borne disease; disaster-related fatalities, injuries and illnesses; heat stress and conjunctivitis (pink-eye).

The dengue fever vector reached the Marshall Islands in 1998. This is a new health problem for the nation. The normal survival range of the vector is well within the Republic's existing temperature. Therefore, with the scenario of increasing temperature and precipitation, there is a potential for epidemic outbreaks of dengue exacerbated by an increase in breeding sites associated with higher rainfall conditions, a warmer climate and increasing trends of urban settlement and higher density population.

For diarrhea and other water-borne illnesses, together with disaster-related health impacts, the effects will depend largely on how extreme events will change in the future. Nonetheless, the scenarios of socio-economic changes suggest that the vulnerability of human health to such extreme events will increase in the future. There is currently limited knowledge in the Marshall Islands on the ways in which such health problems are affected by climate variability and change.

The continuous shift from traditional diet to western diet has great impacts on the population, the social system and culture. In one sense, the shift from the traditional diet is a result of the increased population and western influence. The increase in population together with the unique history of the colonization of the RMI, resulted in the people becoming dependent on other countries to subsidize its limited resource base. In particular, both Majuro and Ebeye are heavily dependent on imported food. The shift in diet has resulted in increased lifestyle diseases.

1.10 Our Nation

The key characteristics of the RMI are summarized in Tables 2.2 and 2.3. these data cover physical, social and economic conditions on the nation. The material has been drawn from a range of governmental and non-governmental sources.

Table 2.2

Natural Resources

Resources	
Natural Resources	Phosphate deposits, marine products, deep seabed minerals
Flora & Fauna	180 species of coral found on Arno Atoll, 156 on Majuro Atoll alone.
Marine Turtles	All five of the world's species found in the Marshalls, two of which nest in the Islands
Marine Mammals	As many as 27 species of whales, dolphins and tortoises
Fish	Over 250 species of reef fish. Tuna and game fish are abundant
Marine Flora	238 species of green, brown, red and blue-green algae. Several beds of sea-grasses
Terrestrial Vegetation	60% of land area covered by Coconut Palms
Birds	70 species have been identified, 3 species of seabirds of which 15 breed in the islands

Reptiles	7 species of lizards, 1 species of blind snake
Arthropods	Numerous species of insects, spiders and land crabs; coconut crabs are common and prized for their meat
Endangered Species	Blue whale, sperm whale, Micronesian pigeon, leatherback turtle, hawksbill turtle. Crimson-crowned fruit dove and Wake rail are now believed extinct.

Table 2.3

• Table of Characteristics	
Capital	Majuro
Urban Centres	1. Majuro Atoll (DUD: Darrit, Uliga, Delap) 2. Kwajalein Atoll (Ebeye Island as its Core)
Political Status	Self-Governing Democracy in free association with the U.S.
Official language	Marshallese, English as a second language
Currency	US Dollar
Population	Approximately 58,000 (1997)
Time Zone	GMT +12
Land Area	70 square miles (171 square kilometers)

Chapter 2 National Inventory of Greenhouse Gasses

2.1 Background

Prior to the report prepared by Magruder and Meier (1996) a national inventory of greenhouse gas (GHG) emissions for the RMI did not exist. The IPCC guidelines provided in the Workbook (Volume 2) were used in planning and conducting the inventory. The step-by-step instructions provided for calculating emissions of carbon dioxide and methane from three major source categories: energy, agriculture, and waste were calculated; and land use change addressed. The IPCC computer software provided by the PICCAP National Global Climate Change Inventory Programme was used with limited success. The tables from Magruder and Meier (1996), which summarize the tabulated results of the inventory, are at Annex A of this communication.

2.2 Inventory and Reporting Methodology

2.2.1 Approach

The IPCC "Reference Approach" was used as the primary means of preparing the inventory. This approach provides an upper bound to CO_2 emissions inferred from the country's supply of fossil fuels by identifying the carbon content, subtracting from it the carbon stored in non-energy products and products made from fuels used as raw material, adjusting for carbon with remains unburned and multiplying by 44/12. It is an upper bound because some of the carbon will be emitted in forms other than CO_2, in part because fuel combustion in not always complete, and also because fuels may leak or evaporate. Consequently, the CO_2 emissions figure obtained from this approach include carbon emitted as CH_4, CO or NMVOC.

2.2.2 Scope

GHG emissions and removals that result as direct result of human activities or are the result of natural processes that have been affected by human activities were studied. Emissions of carbon dioxide and methane from three major source categories: energy, agriculture, and waste were calculated; and land use change addressed. Calculation of nitrous oxide (N_2O) emissions were not provided by IPCC guidelines for studies using the reference approach, and were therefore not available. Gases contributing to the greenhouse effect in an "indirect" way: carbon monoxide (CO)nitrogen oxides (NOx), and non-methane volatile organic compounds (NMVOCs) were excluded, due to a lack of data and the small scale of RMI emissions.

While of major importance in relative terms, data from Kwajalein, the US Military missile test range, were not included in the RMI study. Although the RMI Secretary of Foreign Affairs and Trade requested permission for the Global Climate Change Inventory Team to visit Kwajalein, entry was refused (Magruder and Meier 1996). It is recommended that statistics on GHG emissions for Kwajalein be included in the United States inventory.

Data emissions based upon fuel sold to ships or aircraft engaged in international transport have been included in the national totals, as the data for these activities could not be isolated.

Agricultural and land use data is based primarily on subjective estimates or not estimated. With the exception of copra production from copra production from coconut (Cocos nucifera) palms, agriculture is primarily subsistence level, and the RMI currently has no system of agricultural surveys.

2.2.3 Data Collection and Quality

The Marshall Islands Statistical Abstract 1993 and 1994, published by the RMI Office of Planning and Statistics (OPS), prepared largely from public sector administrative records was the primary data source. Two companies import nearly all fuel into the RMI. Energy statistics were obtained from the following:

- Office of Planning and Statistics
- Air Marshall Islands
- Mobil Oil
- Marshalls Energy Company

The data available to estimate GHG emissions resulting from energy were of a more reliable quality than the data available to estimate emissions and removals in the areas of agriculture and land use. In most cases, published data were in a form not accepted by the IPCC guidelines. For example, liquid fuel data was available in gallons, while the guidelines called for weight. Most data for livestock production were provided in weight in (pounds), rather than number of livestock, as required by the guidelines.

Many of the estimates for emissions were calculated with a large range of uncertainty. However, the study provides a single point estimate for each gas and emission/removal category, in order to allow comparison and evaluation with other national reports possible.

2.3 Discussion of Results of Inventory

2.3.1 Energy

Only liquid fossil fuels are used in the RMI. All fuel is imported, and almost all liquid fossil fuels are imported by two companies: Marshall Energy Company and Mobil Oil. All data in fuel consumption worksheets were provided directly by these companies and found to be reasonably consistent with imported data found in the Marshall Islands. Statistical Abstract 1993 and 1994, published by the Office of Planning and Statistics. All calculations are based on the year 1994, as good data were available for this time period. With the exception of LPG, all commerce in fossil fuels is measured in US gallons as the sale and reporting unit. Because no conversion factors were given in the IPCC Guidelines, all data expressed in US gallons were first converted to pounds using a default weight of 7.2 lbs/US gallon and then converted to Kilotonnes for datasheet entry.

2.3.2 Industrial Processes

There are no data available for activities in the RMI which fall into the industrial processes category for the data year 1994.

2.3.3 Agriculture

Methane from livestock- Methane production from herbivores as a by-product enteric fermentation, a digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream. Both pigs and chicken produce methane. As with nearly all agriculture (with the exception of copra), livestock in the Marshall Islands is raised mainly by families for personal consumption. Most livestock consists of pigs or chickens. Estimated of animal numbers are subjective assessments published in the Statistical Abstract (OPS 1994). Some of these figures were provided in pounds produced yearly and were converted to numbers of individuals at the ratio of 3 pounds weight (lbs) per chicken and 200 lbs per pig.

2.3.4 Land Use

No estimates for land use and forest change are available at the present time. Most of the land area in the RMI is cultivated or partially cultivated in coconut, banana, breadfruit and pandanus. There has been some clearing of forested areas for taro and vegetable production, but it is primarily subsistence agriculture. The RMI Government currently has no system of agricultural surveys.

2.3.5 Waste Management

Landfills The data used is based on population estimates of the densely populated urban areas of Majuro and the island of Ebeye. Solid waste is managed only in these two areas. Landfills in the Marshall Islands are about 80ft wide on reef flats.

Domestic and commercial wastewater The data used is based on population estimates of the densely populated urban areas of Majuro and the island of Ebeye. Wastewater is managed only in these two areas. After primary treatment, wastewater is discharged into the deep ocean on the outer reef slope.

2.6 Discussion

2.6.1 Comparative Picture

The RMI is neither a significant user of fossil fuels nor a great emitter of greenhouse gasses. When the consumption and carbon emissions are compared on a Pacific region basis for 1990 the results are as summarized in Table 2.1.

Table 2.1 Regional Comparison of Consumption of Oil and Carbon Emissions

Consumption / Emissions	RMI	Pacific Island Region
Oil Consumption (millions of tonnes/annum)	0.029	1.411
Carbon Emissions (millions of tonnes/annum)	0.0025	1.194
Carbon Emissions (tonnes/person/annum)	0.54	0.21

Although the emissions of carbon per person in the RMI are over twice the regional level (RMI 0.54, Region 0.21) they are low on a world scale. Worldwide emission in 1990 were 6,012 million tonnes with an average of 1.14b tonnes/person. Emissions from the USA provide an interesting bases for comparison with the RMI, the Pacific Region and the world. The emissions for 1990 from US were 5.36 tonnes/person which is four and a half times the world average. From the figures available the island nation and the Pacific Island Region contributed only 0.02% of the carbon emission in 1990. On this bases, in 1990, the RMI would have only emitted some 0.0041% of the world's carbon load from fossil fuel.

2.6.2 Removals and Sinks of Greenhouse Gasses

Carbon dioxide can be temporarily removed from the atmosphere through increases in standing by a mass stock due to forest management, logging, fuel wood collection, etc.

In the year where regrowth exceeds harvest or destruction, the change in vegetation will result in a net "sink" or removals of CO_2. Methods for calculating CO_2 removals for copra plantation are not provided in the IPCC guidelines. More detailed records of production, sales and replanting over a long period of time will be necessary to determine the value of copra production as a sink.

The most important CO_2 removal mechanism in the RMI is undoubtedly the uptake of CO_2 by planktonic marine plants, as there is nearly twelve thousand times as much ocean as land**.** However, it is not clear to what degree one can measure direct human-induced actions to enhance this particular category of sink. Furthermore, certain current practices could be categorized as being detrimental to the coral reef, and may need to be counted as having created an emission, or a reduction of the capacity to sequester carbon. Instructions for dealing with ocean areas as a removal mechanism were not provided in the IPCC guidelines.

2.6.3 Mitigation Measures

The national government of the RMI recognizes that measures could be implemented to reduce the country's dependence on fossil fuel, improve energy efficiency and test new energy technologies. The Government is interested in implementing a national policy on renewable energy and energy efficiency, and to seek a more sustainable energy future.

However, the Government of the RMI acknowledges that measures for mitigation of GHG emissions may need to be evaluated at a regional scale. To this end, the Government of the RMI will continue to participate in energy and mitigation studies with regional bodies with the aim of:

- identifying practical ways and cost effective measures that can be undertaken within the capacities and resources of the government, business, Marshall Islands Energy Company and the people of the Republic; and

- providing sites for projects where specific energy efficiency and mitigation technologies can be tested and trialed to prove their applicability to Pacific Island condition.

The types of mitigation measures that could be considered by PICCAP countries are discussed briefly in Chapter 4. These measures are drawn from the regional intergovernmental approach documented in the by Dialogue Consultants and the South Pacific Applied Geoscience Commission (Ellis and Fifita 1998).

Chapter 3 Greenhouse Gas Mitigation

3.1 Regional Intergovernmental Context

Ellis and Fifita (1999) reported that the ten countries participating in the Pacific Islands Climate Change Assistance Programme (PICCAP) recognize the importance of greenhouse gas mitigation and are committed to meeting their obligations under the United Nations Framework Convention on Climate Change (UNFCCC). The participating countries being Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Samoa, Solomon Islands, Tuvalu, Vanuatu. Tonga is also now a member of PICCAP but joined too recently to be included in the 1998 study undertaken by Dialogue Consultants (Ellis and Fifita 1999).

This commitment has been expressed in a number of forums. These include the Roundtable of Pacific Island Ministers on Sustainable Development. At its meeting on 17th November 1998, the Roundtable agreed to *"emphasise the critical importance of steps to reduce greenhouse gas emissions"*. Ministers also noted the need to develop *"comprehensive Pacific-wide renewables and energy efficiency adoption projects to achieve economies of scale"*. The 1998 study reported by Dialogue on mitigation options forms part of the PICCAP programme.

Based on inputs gathered from visits to six of the ten PICCAP countries and a wide-ranging review of research and programmes in the related to energy efficiency and greenhouse gas mitigation, the study:

- evaluated a wide range of measures which could reduce greenhouse gas emissions in the participating countries; and
- defined a set of criteria to select measures which might be included in a regional programme of greenhouse gas mitigation.

These criteria and the findings of the study were reviewed at a Regional Mitigation Meeting held in Port Vila, Vanuatu, from 30th November to 4th December 1998 attended by representatives of all participating countries. Also attending were two additional South Pacific countries not members of PICCAP (Niue and PNG) and the three regional organisations involved in this area (SPREP, SOPAC and SPC). Dialogue 1998 report that this meeting concluded that the programme should comprise:

- **demand side** options covering labelling schemes, appliances designed for tropical islands, training and education programmes, and various measures directed at ground transport;
- **supply side** options related to increasing efficiency in existing energy systems; the use of biomass for heat and electricity, coconut oil fuel, wind power, and photovoltaics (PV); and

- a **forestry** programme designed to provide a sustainable supply of fuel, and the dissemination of information on income opportunities through forestry (while not allowing forestry to be used to enable other countries to avoid their mitigation responsibilities).

The majority of these measures are directed at non-transport energy. While transport as a sector is too important to ignore, it is also very difficult to influence. The most effective measures involve taxation, and hence can only be implemented nationally. Ellis and Fifita (1999) note that a regional program can do little more than provide assistance with policy analysis and education programs.

The Regional Mitigation Meeting also identified short-term measures for inclusion in parallel national programs covering:

- **demand side**: education on air conditioner and refrigerator installation and operation, and in-country assessment of ground transport; and
- **supply side**: wind energy assessment, sustainable photovoltaic (PV) management, and options for efficiency increase in power supply.

The recommendations from the Regional Mitigation Meeting set out two major initiatives following on from the study by Dialogue. These are to:

- develop feasible management structures for renewable energy implementation; and
- design a package of mitigation options for submission to financial institutions.

3.2 Regional Program Elements

The participants at the PICCAP Regional Mitigation Workshop held in Port Vila from 30 November to 4 December 1998 selected a range of measures and initiatives for inclusion in a regional GHG mitigation programme. All PICCAP member countries were represented at the meeting. In addition representatives from Niue and PNG attended and participated. The selected measures were identified with a view to meeting the criteria above, while being consistent with the other political and cultural objectives of the member countries.

The selection was made after considering the wide range of possibilities described by Ellis and Fifita (1999). For convenience, the grouping of measures into demand side, supply side and sink enhancement is used.

Preferred Demand Side Options The selected demand-side options are:

- Efficiency labelling schemes

- Appliances designed for tropical islands
- Training and education programmes
- Ground transport
  - *mixture of measures needed*
  - *varies by country*

Preferred Supply Side Options The selected supply-side options are:

- Efficiency increase in existing systems
- Biomass for heat and electricity
- Coconut oil fuel
- Wind power
- Photovoltaic

Preferred Forestry Options The selected forestry options are:

- Sustainable supplies of fuel
- Information on income opportunities
  - *not to be used to allow other countries to avoid their mitigation responsibilities*

3.3 Implementation Mechanisms

The preferred program outlined by Ellis and Fifita (1999) contains a variety of elements, with a wide range of characteristics. No single implementation mechanism is suited to all of these. Past experiences in implementing many projects and measures provide a guide to the requirements for successful mechanisms.

From those experiences, and particularly the causes of failed projects, the criteria for a successful implementing agency are that it should:

- be, or represent, the beneficiaries;
- have a clear mandate for its programme;
- possess adequate technical and managerial skills;
- have, or have access to, adequate funding to complete the programme;
- be acceptable to all other parties involved;
- be free from confounding incentives; and
- be subject to effective external financial control.

Given the range of elements selected for a regional mitigation program, some suggestions can be made regarding the elements that would be appropriately handled by a variety of potential implementing agencies.

(1) Electricity utilities, including IPP's

- renewable energy supplies, including wind and large scale biomass to electricity, to be fed into central grid systems;
- efficiency improvements to power stations and distribution systems.

(2) Government energy departments

- setting policy frameworks;
- appliance efficiency labelling programmes – local implementation;
- appliances designed for tropical islands – local co-ordination;
- training and education programmes – local implementation;
- advice to planning, works and treasury departments on ground transport fiscal measures, road and traffic management improvements, and regulatory controls; and
- encouragement for increased uptake of renewable and efficient technologies once commercialised.

(3) Government forestry departments

- programmes to enhance fuelwood supplies - local implementation; and

(4) Regional organizations

- appliance efficiency labelling programmes – design, organisation and management;
- appliances designed for tropical islands – initiation, negotiation, and management;
- training and education programmes – design of programmes and preparation of materials;
- design, acquire funding and implement projects for coconut oil fuel, wind and PV;
- dissemination of information on carbon offset opportunities in forestry;
- execution of donor funded programmes; and
- co-ordination of programmes.

(5) Private and co-operative sector

- supply and promotion of energy efficient appliances;
- own and operate large and small IPP's;
- construction and operation of schemes to use biomass for heat and electricity;
- ownership and operation of plant to extract coconut oil for use as fuel; and
- design and implement projects under contract.

Not able to be clearly slotted into any of the above categories is a sustainable mechanism for the ownership and maintenance of PV equipment. Ellis and Fifita (1999) report that many different mechanisms have been employed, but none have yet proved fully sustainable. Some innovation seems to be required. The character of an organization that would be able to meet all the requirements for long term sustainability is not yet clear, but some likely elements of such an organization would seem to be that it:

(1) be a special purpose utility business, so that it operates on a commercial basis and is not distracted by other lines of business, or confounding objectives;
(2) be a multi-country operation to obtain economies of scale in building strong technical and managerial capabilities;
(3) operate under contract to a regional organization, so that donor funding can be accessed for initial capital, and financial oversight and control provided;
(4) have funds to meet replacement costs built up in a secure trust fund; and
(5) possibly be partly or wholly privately owned to instill financial discipline.

3.4 Integration With Other Initiatives

Ellis and Fifita (1999) report that the 15 projects which comprise the SOPAC/SPC Joint Regional Energy Programme Design (JREPD) overlap to a degree with the components of the regional mitigation program. Specifically, the JREPD projects are at a slightly more advanced stage of development, being individually profiled but not yet designed. The Joint Communiqué announcing the JREPD initiative stated that "*we envisage that this programme would be based at the Pacific Community's headquarters in Noumea*." However direct integration of the two programs is complicated since SOPAC, and even more so SPC, have many more member countries and territories than does PICCAP.

This problem may be ameliorated by the recommendation, if accepted, that the jointly (Australia and France) funded program comprise renewable energy implementation projects restricted to rural electrification with PV systems, wind and mini/micro hydro development, solar thermal and biomass. The Government of the RMI is confident that regional integration of mitigation measures can be achieved.

Chapter 4 Vulnerability and Adaptation

4.1 Assessment Activities

4.1.1 Vulnerability Assessment, Resources and Other Studies

Information on the vulnerability of the two most populated atolls of the Marshall Islands (Majuro and Kwajalein) to climate change and accelerated sea level rise is presented in:

- the SPREP mission report of Connell and Maata (1992); and
- the vulnerability assessment reports prepared by Holthus et al(1992) and Crisostomo (in prep).

Supporting information on the physical, biological, social economic and cultural environmental conditions of Majuro and Kwajalein is contained in a range resource studies. Although there is as diverse array of material it is highly variable in terms of its use for assessing vulnerability to climate induced change. There are no literature sources that adequately describe the environmental conditions of the RMI as a whole. Nonetheless, the available material can help provide a qualitative biophysical overview of two islands that are most at risk.

Majuro Atoll	Nene, Kwajalein Atoll
	
MIVA	PHOTO by Y. Crisostomo

Material on the stability of the shorelines has been presented in coastal atlases and inventories (Manoa Mapworks 1989; Marago et al 1990; Sea Engineering Inc and RM Towhill Corp 1998). No topographic maps or time series aerial photograph sets are available that will assist with the long term documentation of either shoreline or other changes to the land surface.

Reports on either the sources of materials or the effects of extraction of sand and gravel from the lagoon (Smith, 1995; Chunting Xue, 1997; Woodward and Howorth, 1997; Woodward, 1998). Shoreline profiles are provided for selected sites. These profiles provide an essential record of change in the shoreline and should be re-surveyed as frequently as possible.

Information on groundwater conditions is contained in Hamilin and Anthony (1987) and the South Sea Marine Company (1996). These two field data reports demonstrate the limited knowledge of the hydrogeological conditions of the atolls. Workshop activities undertaken at the regional scale in Kiribati in March 1999 have highlighted the vulnerability of ground water supplies to climate change (Kiribati Project Steering Committee ,1999)

Climatic data has been collected and collated by the National Oceanic and Atmospheric Administration (NOAA) and the RMI Office of Planning and Statistics (OPS), as for example OPS (1996). Tidal and hydrodynamic data has been collected and modeled for the Majuro Atoll lagoon by the National Tidal Facility at Flinders University of South Australia. Sea current data and sea temperature data for the Central Pacific region have been collated by the USAQ National Center for Environmental Prediction and the National Oceanographic Data Center, respectively. These data are only suitable for broad scale qualitative evaluations of the existing oceanographic conditions.

Economic and social information has been prepared by the Asian Development Bank (ADB) and the OPS. Socio-economic data has also been summarized in Connell and Maata (1992) and Chunting Xue (1997). Collectively the statistical and descriptive information is sufficient to obtain an overview of the demographic, economic and social conditions of the RMI.

The two vulnerability assessments (Holthus etal 1992 and Crisotomo in prep) draw together much of the available environmental information. As an aid to ongoing vulnerability assessment, other available sources of information should be reviewed in the context of climate change impacts and any usable information extracted. The relevant information would be incorporated into an environmental information management system.

4.1.2 Climate Change Scenarios

IPCC emission scenarios, IS92a and IS92e, were used to develop scenarios for the year 2025, 2050, and 2100. Table 5.1 shows the temperature scenarios using two different General Circulation Models (GCMs). While the magnitudes of the various model scenarios differ, it is important to note that they all indicate that there will be an increase in temperature. By the end of the next century the models used here show that

temperatures may have increased by between 1.6 and 4.3^0C over those presently experienced.

GCMs are not yet able to reliably indicate how rainfall patterns might change in the region. Some show wetter conditions will prevail while others indicate that there may be drier conditions in the future. Preliminary work by some climate scientists has indicated the possibility that rainfall might be characterized by high intensity events on the one hand, and prolonged droughts on the other.

It should also be noted that while the projected increases in temperature, especially those from the middle range scenario, do not seem particularly large, they would be superimposed on what is already a hot climate. From this perspective, any slight increase in temperature becomes significant. In addition to the temperature related stresses, new research indicates that increased levels of carbon dioxide in the oceans may have a detrimental effect on the health of coral reef. While the Marshall Islands is aware of this research, the concrete findings have not been made available, nor have they been tested out in the field. Marshall Islands in interested in learning more about this factor, and how it will affect the scenarios in relation to coral bleaching.

Table 4.1 Temperature Scenarios for the RMI Region of the Pacific Ocean

Scenario	2025	2050	2100
CSIRO9M 2			
IS92a (mid)	**0.5C**	**0.9C**	**1.6C**
IS92e (high)	**0.8C**	**1.4C**	**2.9C**
HADCM2			
IS92a (mid)	**0.7C**	**1.3C**	**2.3C**
IS92e (high)	**1.1C**	**2.1C**	**4.3C**

Notes; 1. CSIRO09M-------. 2. HADCM2------.3.IS9a and IS9e

4.1.3 Sea Level Change Scenario

There is a lack of sufficient regional information on scenarios of possible future climate and sea levels in the Pacific region. Therefore, scenarios are presented based on the projections released by the Intergovernmental Panel on Climate Change (IPCC)

combined with output from a number of general circulation models (GCMs). It must be emphasized that these scenarios form the basis for asking "what if" questions about the effects of climate and sea level change and how sensitive a country is to the changes.

Evidence of erosion to the already very narrow

1st picture taken 20 years prior	2nd 20 years later
	

Courtesy of MIVA

Table 5.2 provides a broad indication of what might be expected over the next century, based on best guess scenarios of sea-level change published by IPCC. The scenario assumes that the Marshall Islands are tectonically stable and does not take into account local variations in sea level. The sea level change projections given in Table 5.2 are consistent with the temperature projections.

Table 4.2 Sea Level Change Scenario for the RMI Region of the South Pacific 2025-2100

Sea Level Change Projection Sources and Years			
Projection Source	2025	2050	2100
IS92a	9.3cm	19.9cm	48.9cm
IS92e	19.7cm	39.7cm	94.1cm

Note: IS92a and IS92e .

4.1.4 Social and Economic Change Scenarios

Economic trends in the RMI indicate that the cash economy will become increasingly important. Hence, it may be anticipated that lifestyle diseases associated with increasing consumption might become more prevalent. Given the nature of population growth it may also be anticipated that urban crowding will become more common. Demand for food, water, and space will become more pressing, especially on Majuro and Ebeye. As a consequence, the greater portion of the Marshal Islands population will be living on islands which have become severely environmentally stressed.

The outcomes of the demand situation are likely to be increased water supply and quality problems, further hardening of the coast as people seek to protect assets and infrastructure, and burgeoning waste production. The latter will arise not only from the growing population but also from increasing per capita waste production, which is in line with growing consumption patterns. Thus, it is quite likely that during the period of accelerated climate change and sea level rise that steps may need to be taken to slow down, reduce or even to reverse some of these trends. With the current level of socio-economic information it does not appear to be possible to either predict what these steps might be or gauge how effective they are likely to prove and when they will be implemented.

The Government of the RMI believe that it will be on this template of social and economic change that the effects of climate change and sea level rise will be experienced in the Marshall Islands. On the basis that the human responses could compound existing social and economic problems it is likely that an already fragile atoll and island system will be rendered even more vulnerable by the time the projected effects of climate change are manifested.

4.2 Issues and Constraints

4.2.1 Issues Relating to the Assessment Activities

Methodological and operational issues were identified in the course of critically reviewing the work of Connell and Maata (1992) and the two vulnerability assessments (Holthus etal 1992 and Crisostomo, in prep). Collectively, these two areas of issues have implications for:

- the ongoing assessment of the vulnerability of the different types of islands; and
- the adaptations needed to respond to existing and projected environmental change.

Methodological issues arise from the differences in the approach and techniques employed in1992 and1999 for the two studies. During this time the focus of the vulnerability assessment has shifted. Initially the approach was to document the impacts of accelerated sea level rise on the shorelines. This reflected the 1991 IPCC Common Methodology with an emphasis on determining the cost to the nation of the responses (see IPCC 1991).

Currently, the assessments take a more expansive look at a broader spectrum of physical, biological, social, economic and cultural effects on the coastal margins that are due to the impacts of changing climatic conditions. This approach (which follows that outlined in the 1994 IPCC Technical Guidelines) takes into account some of the particular problems being confronted by the small island nations. Nevertheless, the IPCC (1994) approach

requires considerable resources and time to undertake the assessment. Such studies are not readily repeatable in the RMI due to the lack of resources and baseline information.

Methodological issues also arise from the variability and the availability and quality of data and information that can be used in the assessment process. This encompasses aerial photographs, topographic maps as well as material on the natural and the socio-economic systems. For example, severe methodological problems arise when trying to assess the current and future rates of shoreline erosion on some islands in the RMI because there are no appropriately scaled and contoured topographic maps and no meteorological, tidal and ocean-state data. Similarly, it is difficult to determine the impacts of climate induced changes on the pattern of human settlement if there are neither land use or land ownership maps nor any detailed information on the population in terms of settlement pattern and distribution, growth rates and type of economic activities.

The variability of the information, coupled with the complete lack of suitable topographic maps and other background materials for many of the atolls and islands of the RMI, can seriously limit the extension of the assessments. This is because the methodologies have been developed to meet the resources and capabilities of government departments or research institutions of larger more experienced nations.

The operational issues relate to the geographic spread of the atolls and islands and the availability of resources and competent people in the RMI to undertake the assessments. These areas of issue are no different to other small island nations. However, for the RMI the cost of travel for field work is considerable. Also , scarce staff resources are absent from their main place of work for long periods of time due to the infrequency of flights or the slowness of ships travelling between the islands. This latter factor is a hidden cost to state and national governments.

The limited number of professional staff available to the national and the local governments often means that unless it is specifically funded the work associated with vulnerability and adaptation assessment will have a lower priority than more pressing environmental management tasks. That is, those areas of issue such as water supply, sanitation, municipal waste management and shoreline erosion, which are currently pressing problems, will be dealt with first.

The National Government of the RMI recognizes that there are important gaps in knowledge of the relationship between human health, social change and environmental problems arising from climate induced change. To date only limited attention has been paid to:

- gaining understanding of the specific ways in which changes in population size and settlement density, economy and traditional practices are creating heightened vulnerability to health problems arising from climatic variations; and

- determining what adjustments could be made to national environmental and development policies to lessen the health impacts arising from vulnerability to climate change.

4.2.2 Constraints

Four key constraints have been identified which effect the ongoing ability of the RMI to continue to assess the adverse impacts of climate change and to plan and implement feasible adaptations. The four interrelated constraints are discussed as follows.

Level of understanding of the natural variability inherent in the environmental systems of the atolls and islands. Understanding the variability of the natural systems is essential for appreciating the sensitivity and the resilience of the physical and biological environments of the atolls and islands of the RMI to cope with climate induced changes.

Due to the serious lack of essential background information there is no opportunity for the government of the RMI to document the variability in the natural systems of the atolls or the reef islands. Of particular importance is the variability in prevailing climatic conditions (eg the direction of prevailing winds, the rainfall pattern in terms of the number of rainy days and the amount of rainfall recorded [daily, monthly, annually], the frequency and duration of droughts and the intensity and duration of storms). Understanding of climatic variability is essential for assessing the possible impacts on water supply, groundwater recharge, agricultural production and community health.

Variability of the ocean-state conditions by way of tides and the direction of waves and oceanic swell is also important because of the erosion and sediment transportation forces. Understanding the variability in these conditions is essential if the cumulative effects of climate induced changes are to be fully appreciated in the RMI. Increases in sea level coupled with and more intensive and persistent storms and storm surge can bring irreversible changes to both high islands and atolls. As the environmental changes (natural and climate induced) are occurring slowly it is necessary to have bench mark or base line conditions firmly established. From this perspective it is also essential to understand the variability in the patterns of shoreline change in the RMI by way of erosion and deposition on the beaches and the growth and the break down of the reef systems.

Scale of the existing shoreline stability problems. For the highly populated atolls the scale of the existing erosion problems is considerable. For example, shoreline changes in excess of 0.30 metres have been measured on at selected sites on the sensitive shorelines of Majuro atoll between February 1997 (Chunting Xue 1997 and Woodward and Howorth 1997) and April 1998 (Woodward 1998). High levels of shoreline erosion have been observed on other atolls of the RMI especially in relation to areas affected by human activities as illustrated by Ebeye on the Kwajalein Atoll (Crisostomo in prep). Nationally, much of the limited funds and human resources available to the affected local communities are now used on addressing existing shoreline erosion problems on the most

populated islands. These resources are not available for developing and implementing long term adaptation strategies and action responses.

Inadequate baseline information from which to measure change and assess impacts. For example, baseline information is particularly important for the sand and coral rubble shorelines of the atolls and the high islands. For both these situations there is a need for plans of the beaches at scales of 1:2000 or less than 1:1000, showing the changes in the position of the high water level, shoreline protection works and the beach and storm berms over time. Topographic maps are needed for all inhabited atolls with contour intervals in the order of 0.3 metres (one foot). Historical beach and atoll profiles are also needed to document the patterns of erosion and deposition on natural and engineered shorelines and to illustrate the nature of the elevation and landforms. The type and level of vegetation cover on the shoreline should also be recorded as part of the plans and profiles.

Another information deficiency is the uncertainty in the position of mean sea level across and between the atolls and islands of the Republic. This specific information requirement effects the accurate plotting of the topography of the beach forms of the remote atolls. The lack of historic and time series data on the mean sea level conditions for the islands of the RMI is a major factor in the poor level of understanding the existing rates of change of the shoreline and the dynamics of the ground water lens.

Limited professional and technical capability and financial support available to the national government, local councils and affected communities. Although this human and financial resource constraint is common to all of the small island nations of the Pacific the RMI has specific problems. These are reflected in the operational issues discussed earlier. For example, the geographic extent of atoll and island complex coupled with the concentration of the population on a few islands of two atolls means that most of the resources tend to be centralized. Resolving the resource constraint is the key to reducing the problems that arise from the other three constraints outlined above.

4.3 Findings and Projections

4.3.1 Overview of General Findings

Connell and Maata (1992) and the case studies at Majuro and Kwajalein provide initial qualitative assessments of the vulnerability of the atolls of the RMI to climate change and related effects including accelerated sea level rise. Because of the differences in the approaches taken for each of the studies this overview concentrates on the general conclusions drawn. Quantitative information is quoted as it applies to particular cases. The two case studies document the current environmental conditions and make

projections on the impacts of climate change on the physical and the socio-economic systems.

Although the findings of each study vary in specific details, collectively the various studies provide perspectives on the sensitivities of the most highly populated islands of the RMI to:

- the existing climatic forces which result in erosion of the shorelines, expansion of the mangrove habitats and patterns of drought which have health and nutrition effects; and

- ongoing climate related changes which are cumulative with the existing pattern of impacts on the water, coastal, agricultural and fisheries resources of the RMI.

The findings of the two RMI studies are best overviewed in terms of:

- the projected changes in climatic conditions (temperature, rainfall, extreme events);

- the types of atolls and islands; and

- the key sectors covered by the Majuro, Kwajalein and other assessments (Connell and Maata 1992; Holthus et al 1992; Crisostomo, in prep).

The key socio-economic sectors considered in the Kwajalein assessment are water resources, coastal resources, agricultural resources, marine resources and human health. The adaptations and responses identified in the studies are included in the findings.

The key findings with regard to climate and physical conditions (from the two vulnerability assessment case studies and projections from literature sources) are summarized as follows.

Climatic Conditions The projected changes in the climate pattern for the RMI are regionally generalized from literature sources and broad regional climatic modeling. The projections are that:

- temperatures will continue to rise on all atolls with the highest increases in the northern areas;

- there will be an increase in severe droughts especially in the northern atolls; and

- the intensity and frequency of extreme events (storms and storm surge) will increase.

The current state of knowledge is such that climate scientists are currently unable to predict whether the frequency and/or intensity of tropical cyclones (typhoons) will

increase as a consequence of global warming. Nonetheless, the possibility of such an increase cannot be ruled out. Should they increase in future, they are likely to have devastating effects on the shorelines, land surface, the biodiversity, the agricultural productivity and the human settlements of the Marshall Islands. Although such events are currently relatively rare in the RMI, when they have occurred in the past the effects have been catastrophic.

Mili Island	***Kwajalein Atoll***
	

Atolls and Reef Islands Without Lagoons The atolls and reef islands are already being effected by a combination of shoreline erosion and human activities. The erosion is common on the reef platform and lagoon sides of the atolls. Erosion rates in the order of 0.3 metres per year have been recorded (see Woodward 1998). Human activities that are compounding the shoreline erosion problem include the collection of reef rocks, removal of sand from the beaches, dredging coral sand and gravel from the lagoons and the ad-hoc construction of shore protection walls and other works. Ample evidence is available of the effects of storm damage and localized inundation in relation to the existing patterns of settlement following extreme events.

Atolls and reef islands are expected to suffer severely as a consequence of accelerated sea level rise and associated impacts. These features mostly have elevations up to about 5.0 metres with an average of 2.0 metres above present mean sea level. The shoreline erosion will be considerable (in some cases in the order of 15.0 metres over a 50 year time line) Therefore, habitable land will be scarce.

Most infrastructure on the atolls will be affected in the event of storm surges and sea levels predicted under the climate change scenarios. Notwithstanding, in view of the existing levels of shoreline sensitivity high-tide and storm events are expected to result in considerable damage to protection works, roads in low-lying areas and the causeways which connect the islands of some of the atolls.

Jabor Island, Jaluit

The projected future changes in climate and sea level also cause inundation and exacerbate coastal storm flooding. All of these factors can result in land loss. This is a major concern to the people of the Marshall Islands. Sea level is likely to alter sediment depositional patterns in the lagoons, decrease the amount of light reaching the seabed and threaten coral systems.

4.3.2 Sectoral Findings

Although the whole of the Marshall Islands is sensitive to climate and non-climatic changes, there are sectors that are particularly sensitive to climate change and sea level variability. The identified sectors are water resources (supply and quality), coastal resources, agricultural resources (subsistence and commercial), marine resources (fisheries) and human health.

Table 4.3 provides examples of the possible effects of climate change and sea level rise on a selection of socio-economic sectors in the RMI. The relationship between climate change impacts and the socio-economic sectors is summarized in Figure 4.1.

Water Resources The water resources of the atolls are under threat from the projected changes in the regional climate. This would arise from a combination of drought, lower rates of recharge of the groundwater lens and the reduction in the size of the freshwater

lens as a result of shoreline erosion. Public health and nutrition problems may arise from the intrusion of salt water and the general reduction in the quality of the ground water resources of the more highly populated atolls (Kiribati Study Team 1999).

Water supplies and resources are limited and often do not meet the demand from the growing population, especially in the urban centers. Fresh surface water is rare in the Marshall Islands. For the most part, fresh water resources are limited to a sub-surface "lens", generally located on larger islands. Such lenses consist of fresh water "floating" on a denser sea water layer just below the surface. Regularly replenished by rainfall, the lenses can usually be accessed by digging down 25-200 centimeters (1-8 feet). Although the water is often limey, it is not brackish. As these lenses are not uniformly present, most of the inhabitants rely heavily on rooftop rainwater catchment systems to help meet fresh water needs. With limited natural water resources, management of this sector is one of the most complex issues facing the country (RMI NEMS, 1992).

Future changes in climatic conditions are likely to affect water supply and quality in the following three major ways. First, through a rise in sea level that may increase problems of salt intrusion to the ground water system. The quality of the water system will thereby decrease and the quantity of fresh water will be reduced.

Second, a scenario in which rainfall decreases and droughts increase in frequency implies adverse effects on groundwater quality and quantity. Such a climate change would reduce the natural replenishment of the groundwater lens, and would reduce the amount of water captured from catchments.

Third, a scenario in which typhoons increase in frequency implies increased incidences of temporary contamination of water supplies as a consequences of storm surge flooding.

Finally, environmental pressures associated with population increase, including pollution from liquid and solid waste, will have additional adverse effects on the quality of the limited groundwater resources. The rise in population means higher per capita use of water. Therefore, the ability to support the demand for water will decrease resulting in poor water quality and quantity. This will in turn exacerbate the effects resulting from climate and sea level changes.

As noted previously, the Marshall Islands are particularly affected by prolonged droughts which can be especially serious during El Nino events. During the most recent El Nino event (1997-1998), many in the community were forced to use the ocean to bath and to drink the ground water. In some situations this source of water was polluted due to:

The pictures show the demand for water during the drought season 1997-1998

Ebeye, Kwajalein	Majuro, the Capital City

Ebeye residents return home from Kwajalein Military base with a day's supply of water.

Hundreds of Marshallese residents await the unloading of Water Purification Units(ROWPUS) at the Majuro airport. April 3, 1998.

FEMA

During the 1997-1998 drought assistance was provided from the United States Federal Emergency Management Agency (FEMA). The emergency management was undertaken in cooperation with the RMI Government. This action was necessary to provide food, desalinization plants and loans to use for purchasing roof catchments. The impacts of the 1997-98 drought are still being felt in many of the islands. For example, Ebeye has not recovered and Majuro is still recovering.

In rural and urban areas alike, limitations of water collection, storage and pumping facilities contribute to the problems of water quality. The primary deficiencies are capacity-related in urban areas, and design-related in rural areas. In general, he present inadequacies lead to the use of alternative water sources, including private catchments and wells, which are easily contaminated in high population density areas.

- saltwater penetrating the groundwater lens;
- sewerage and sullage water discharges entering the groundwater aquifers;
- proximity to burial sites; and
- materials being leached from animal droppings and domestic solid waste.

Coastal Resources As already indicated, the coastal resources of the atolls and reef islands are already at severe risk from a combination of shoreline erosion and human activities. Without integrated coastal management the resource base of the most highly populated islands will continue to degrade and the shorelines and land surfaces of the less populated islands will become more at risk. This situation will be exacerbated by the impacts of climate change through further loss of the natural resources and amenity of the productive land, reefs and beaches.

Picture 1 showing signs of erosion	Same place 20 years later

Photo by MIVA

Land is a critical resource and is currently under threat from erosion, inundation, and flooding from storms. Because of their small size and narrow shape, the islands are classified by many scientists to be entirely coastal in their characteristics. For the Marshallese people, however, there is a distinction not only between the shoreline areas and the centers of the islands, but also between the contrasting seaward and lagoon side coasts. It is at these boundaries between the land and the sea that dynamic physical processes take place that are important in building and maintaining atoll land areas. Ongoing processes of sediment accretion and erosion maintain island land areas. Human interference with these processes on the highly populated islands has been shown to have serious effects.

The development of infrastructure, commercial development and increased housing density has led the "hardening" of the boundary between the land and the sea. This has interfered with the natural patterns of sediment flows and often results in erosion. At the same time many activities such as fishing, dredging, anchoring of boats, dynamiting passageways, waste dumping and pollution are contributing to the damage of coral, reducing an essential supply of sediment for land replenishment and diminishing the value of reefs as a natural defense against waves and storm surge.

Healthy coral in the Marshall Islands could grow at a rate of 5-8 mm/yr. As already indicated, the scenarios of future sea level rise provided in Section 4.1.2 imply an average rage of sea level rise of 4-8 millimeters per year. Thus, under ideal conditions, the coral might well keep up sea-level rise. However, two major factors could effect the health of coral and reduce its ability to keep up with the rising sea level.

First, sea-surface temperatures will increase. According to the scenarios presented above, there is an increase of temperature of 0.5-0.8 ^{0}C by the year 2025. The present average sea temperature of the Marshall Islands is currently 29 degrees, the threshold at which coral growth begins to be adversely affected. The consequence is that the ability of coral to produce sediments for land accretion and to serve as a barrier to storm surges may be impaired. Both these effects may increase the net erosion of land in the decades to come.

Second, the direct degradation of coral by human activities. This includes dredging, coral mining and waste dumping Observations indicate that if continued such activities could further reduce the resilience of coral to respond to the changes in its physical environment.

Studies have shown that coral bleaching and mortality can occur with relatively slight increases in water temperature. The tolerance range for coral reefs is 25^0C-29^0C. The average sea temperature in the Marshall Islands is 29^0C. If the global warming involves a substantial increase in seawater temperature for an extended period considerable coral mortality may ensue. Projected increases in seawater temperatures may be considered a major threat to coral reefs system of the Marshall Islands.

Agricultural Resources Prolonged periods of drought over the past twenty years have been observed to have adverse effects on the agricultural productivity of the atolls and reef islands. Both taro and breadfruit production have been affected by the changes to the water table under adversely dry conditions. This situation is expected to worsen with future climate change events such as reduced rainfall and more frequent and intensive droughts. As such, it has the potential to adversely impact on those people who are wholly or partially dependent on taro and breadfruit for subsistence needs.

The RMI government has identified the development of subsistence agriculture as a key strategy for the support of the rapidly growing population. The most important food crops are copra, breadfruit, and pandanus. These food crops are usually abundant during their seasons but harvests can be severely disrupted by climatic extremes such as typhoons and droughts. Copra is by far the only agricultural product that is commercialized, although recently, breadfruit chips have entered their infant stage of being marketed as well.

	The three main crops of the RMI, with breadfruit as the main traditional starch.

There has been a steady shift away from the use of traditional subsistence crops, especially in the urban islands. Increased dependence on imported foods places stress on the national economy and has implications for nutrition and health. It is possible that the emphasis on subsistence agriculture may place pressure on the limited land resources in the Republic, especially on the urban islands where there is competition for land for housing, infrastructure development and commercial purposes.

There is not a clear understanding of whether increasing temperature will directly affect subsistence and commercial crops in the Marshall Islands. The scenarios of future temperature change for the middle of the next century indicate a rise of 1.6-2.9 ^{o}C, implying a climate regime that is considerably different from that of the present. Whether crops will be adversely affected by such a large change in temperature is not known with certainty. This is an important gap in knowledge, especially in relation to agro-forestry activities, that needs to be filled.

On the other hand, there is strong evidence in the Marshall Islands that rainfall variations directly affect crop yields and production. For example, during the El Nino season of 1997-1998 there were significant yield reductions in most crops. During prolonged dry periods even coconuts were affected, and many trees died, an impact from which many of the islands are still recovering. In future, it is uncertain whether such El Nino events will increase in frequency or intensity, or whether average rainfall will decrease. However, if they do, it is highly likely to affect agricultural production adversely, with the possibility of greater reliance on imported foodstuffs.

Furthermore, 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 foods. This impact could have particularly severe effects on pit taro (*iaraj*), which is an important subsistence crop grown throughout the Marshall Islands.

Finally, increasing population, particularly in the urban centers, is already reducing the land available for subsistence agriculture. The scenario of continued population growth into the future would greatly reduce the already limited land resource. This could result in reduced productivity and negative effects on both the infant cash and subsistence

economy. If climate change leads to low production there could be serious effects on the economy, health and the environment.

Marine Resources The tuna fishery of the Exclusive Economic Zone (EEZ) of the RMI is one of the mainstays of the nations economy. The limiting factors for the continuing viability of this fishery are the sustainable yield of the fish stock, the world market for the product and the effects of climatic phenomena such as El Nino and ENSO. The potential impacts of this latter factor are still to be fully evaluated. This will need to be done in the context of increasing ocean temperatures as projected under different climate change scenarios. The assessment will also need to cover reef fish stocks as well as those components of the tuna fishery on which the people of the RMI are dependent for subsistence.

Fishing method	
	

Subsistence fisheries are also very important and include reef and lagoon, as well as oceanic fish. There is concern that damage to the coral reef ecosystem may have negative effects on fish stocks as the coral ecosystem plays an important role in the life cycles of many fish species. The Republic's reef and lagoon resource base is broad, with a combined area exceeding 6511 square kilometers (4,037 square miles). These resources need to be managed properly through a mechanism such as Integrated Coastal Zone Management or an Environmental Management System as specified under the International Standardization Organization (ISO) Series of Standards.

Human Health Contemporary health issues in the Marshall islands focus on the growing incidence of lifestyle diseases as the population, especially on the urban islands, becomes more dependent upon imported foods and living conditions in the settlements become increasingly crowded. There are, however, some aspects of health in the Republic that are linked to climatic conditions. These include enteric diseases which often occur after water supply has been disrupted by droughts or typhoons, fatalities, injuries and other aspects of ill health are often recorded as a consequence of extreme climatic events.

Ebeye, living seconds away from the sea	The 1997-1998 drought and impacts

Photo: Y. Crisostomo

FEMA

The range in temperature in the Marshall Islands is currently 28^0C -32^0C. According the scenarios of climate change, this range could increase by as much as 1.4^0C by the year 2050. This rise in temperature would undoubtedly cause additional heat stress in the working environment and thus to the people. There is also concern that illness from heat stress may become more common as overcrowding in poorly ventilated non-traditional dwellings on the urban islands. Outbreaks of conjunctivitis have been associated with the occurrence of droughts.

The projected rise in population growth and densities would enhance the spread of communicable diseases and possible increase the potential for the dengue vector resulting in outbreaks. The already increased dependency on less nutritious, imported food could accelerated as a consequence of the effects of climate change. Continued economic and social changes could lead to breakdown of extended family and traditional coping mechanism such as sharing and reciprocity, in times of trouble, for instance a drought season or funeral. The increase in population density and overcrowding are likely to worsen the risks of the diseases that are related to climate change.

4.4 Adaptations

4.4.1 Responding to Shoreline Changes

When responding to the challenges of shoreline change, limited retreat is an adaptation option for some of the larger islands in less inhabited atolls. This form of adaptation by the relocation of the large proportion of the coastal population can only occur with the concurrence of the owners of the less affected land. Such adaptation will require long term land use planning which would be accompanied by changes to traditional patterns of land tenure. This may be difficult to achieve without appropriate compensation mechanisms.

The retreat adaptation may not be an option for people of some of the more highly populated atolls. Where there has been considerable investment in housing and

infrastructure the provision of costly shoreline protection works may be one important option. However, this raises several inter-connected questions: who is going to pay for the protection works, who will undertake the construction of the protective structures and where will the materials for the defensive works come from.

For some people resettlement off-island may be another option. However, this will need to be accommodated without disruption to the new host communities and with due sensitivity for the traditional values of the island peoples. This applies to both the relocated and host communities.

4.4.2 Adaptation Strategies

Overall, the most appropriate and effective adaptation measures and strategies are most likely to be those that will be beneficial even in the absence of climate and sea-level change. Such measures and strategies could be considered as "no regrets" adaptation options. Therefore, in the first instance, the capacity of the Marshall Islands to adapt to the effects of climate and sea-level change will largely be determined by its ability to address on-going environmental, social and economic problems.

Adaptation includes three main types of activities. First, there are adaptive actions that include activities targeted at specific sectors where climate change effects have been identified. Second, another group of adaptive measures are equally important and include general policies and actions by government to address some of the social driving forces of environmental problems which will heighten vulnerability to climate change effects. Third, it is also important to increase the capabilities of the Marshall Islands to effectively implement adaptations. This topic is considered in more detail under the heading of capacity building in Section 5.2 of Chapter 5.

4.4.3 Sectoral Adaptations

The type of adaptations that can be taken to reduce the impact of climate induced changes on the key socio-economic sectors are summarized in Table 4.4. These measures can be directly compared to the effects summarized in Table 4.3. The Government of the RMI will need assistance if these adaptation responses are to be integrated into the operations of national departments and authorities, local councils, non-government organizations and communities as well as the activities of the private sector. This assistance will be sought during the second phase of the PICCAP activities

4.4.4 Integrated Assessment of Effects and Responses

The limited number of studies to date provide some indication of the likely direct, and possible indirect, effects of climate and sea-level change on particular aspects of the biophysical and socio- economic conditions of the Marshall Islands. However, the sectoral effects should not be considered in isolation and nor should the climate and sea-

level changes be considered separately from the socio-economic forces of change. The overall impacts are most likely to be cumulative and determined by the interaction between the physical and biological environmental impacts and the continuous social economic and cultural changes. An overview of key socio-economic sectoral effects is provided in Table 4.4, and the major linkages between climatic and social drivers of change are shown in Figure 4.1.

There is a clear need for better information aimed at providing a more ***holistic*** understanding of effects. Responses to the effects should be integrated to ensure that all issues are addressed. Integrated responses are also needed to ensure that the resources of the nation can be effectively harnessed to address the sectoral issues arising from climate driven changes. Thus, it is important that integrated assessment methodologies are developed which are appropriate to the complex biophysical, social and economic components of the environment of the Republic of the Marshall Islands.

4.5 Policy Implications

Responding to climate change and adapting to changed conditions has implications for a range of national land use, planning, natural resources and environmental protection policies of the RMI. As well, there are significant policy implications with regard to foreign affairs. These policy implications reflects the complex array of issues confronting the national government, the local councils (in both urban and more remote island situations) and the wider community including the business interests and external aid and assistance organizations.

Policy implications of the potential impacts of climate change and accelerated sea level should be formally examined through a wide ranging review of current administrative, planning, natural resources and environmental policies, legislation and regulations. This review could be externally supported and facilitated. The review would seek to achieve the following objectives.

- ***Land Use and Planning*** Amend land use and planning policies to ensure the implementation of mechanisms needed to deal with the increased loss of shorelines and the threats imposed to private property and public infrastructure.

- ***Environment and Natural Resources*** Strengthen environmental and natural resources policies, legislation and regulations to include matters relating to climate change and accelerated sea level rise.

- ***Natural Hazard Management*** Enhance natural hazard management policies to enable urban and remote communities to deal with extreme events by way of droughts and storms.

- ***Administration and Management*** Initiate administrative arrangements and management policies to deal with the core sectoral concerns in terms of water resources, coastal resources agricultural resources, marine resources and human health.

- ***Human Health*** Develop a comprehensive suite of human health policies to address water borne diseases and other sicknesses that are related to climate induced change including those arising from poor water quality and nutrition.

- ***Solid and Liquid Waste Management*** Provide broad management policies for domestic solid waste and discharges of liquid effluent including consideration of a strategy to convert solid domestic and some industrial wastes to saleable energy.

- ***Foreign Affairs*** Enhance foreign policy frameworks to: further the role of the RMI as a partner in proactively addressing climate change issues in the Central Pacific; facilitate ongoing participation in regional and international forums and programs and meet the obligations under the UNFCCC.

- ***Center of Excellence*** Develop policy to facilitate the establishment of a **Centre of Excellence** which will expand the role of the RMI in the international as well as national issues of Climate Change.

- ***Technology Exchange*** Provide technology exchange policies to address applied research and monitoring, information management (including geographic and other spatial information), technology exchange to cover adaptation measures and engineering responses to rapid shoreline erosion.

- ***UNFCCC National Communication*** Formalize the policy initiative for the PICCAP Country Team to ensure that the preparation of the National Communication and other reporting under obligations to the UNCCC are appropriately resourced.

4.6 Capacity Building Needs and Implementation Requirements

Capacity building is the key to the RMI being able to respond to the threats imposed by the climate induced changes discussed in the preceding sections of this Chapter. The key needs are summarized in Chapter 4.

4.7 Possible Programs and Projects

Possible programs and projects to further assist the RMI to respond to the inherent vulnerability of the atolls and islands to climate induced changes, including accelerated sea level rise, are outlined in Chapter 5.

Table 4.3 Climate Change Effects

SOCIO-ECONOMIC SECTOR	EXAMPLES OF EFFECTS OF CLIMATE INDUCED CHANGES
Water Resources	♦ Changes in freshwater lenses and other groundwater resources ♦ Salt intrusion of groundwater resources ♦ Changes in surface water resources ♦ Changes in surface run-off, flooding and erosion
Coastal Resources	♦ Inundation and flooding of low-lying areas ♦ Coastal erosion ♦ Possible increase in cyclone related effects ♦ Changes in sediment production due to changes in coral reef systems ♦ Coral bleaching and coral degradation (also possible increased upward coral growth) ♦ Changes in mangrove health and distribution ♦ Degradation of sea grass meadows
Agricultural Resources	♦ Changes in commercial crop yields ♦ Changes in subsistence crop yields ♦ Changes in plant pest populations ♦ Possible changes associated with changes in ENSO, drought and cyclone patterns ♦ Changes in soil quality
Marine Resources	♦ Changes in distribution and abundance of offshore fish species ♦ Changes in productivity of inshore fisheries ♦ Changes in fish breeding sites
Human health	♦ Increased incidence of vector borne diseases such as dengue fever ♦ Increased heat stress and heat related illnesses ♦ Indirect effects on nutrition and well-being secondary to effects in other sectors such as agriculture and water resources ♦ Deaths, injuries and disease outbreaks related to possible increases in extreme events such as cyclones, floods and droughts

Table 4.4 Specific Adaptation Measures Based On Possible Direct Impacts In Key Socio-Economic Sectors

Socio-economic	Impacts	Measures /Considerations

Sector		
Water Resources	**Water shortages** (lower rainfall averages, longer more intense droughts, groundwater salt intrusion)	**Increase / improve supply:** Groundwater protection Increase water storage facilities Rainwater catchment Desalination Water catchment protection **Decrease demand:** Water conservation measures Leakage reduction Duel water supply systems Type of economic development
	Flooding (from run-off) (higher average rainfall, more tropical storms and cyclones)	Watershed protection Watershed management Positioning of infrastructure and buildings Design of infrastructure and buildings Protection of infrastructure and buildings
Coastal Resources	**Inundation and flooding**	Coastal protection Positioning of infrastructure and buildings Design of infrastructure and buildings Protection of infrastructure and buildings
	Coastal erosion	Coastal protection Coastal Vegetation Beach nourishment

Table 4 (continued)

Sector	Impacts	Measures / considerations
Agricultural Resources	**Decreased crop yields due to low rainfall / pest outbreaks**	Drought resistant varieties Change crop types Diversify crops Maintain subsistence sector Avoid monoculture strategies

	Decreased crop yields due to salt intrusion (e.g. taro)	Salt resistant crop varieties
	Storm damage	Maintain subsistence sector Crop diversity
Human **Health**	**Increase in vector borne disease risk (dengue fever and malaria)** (raised average temperature)	**Decrease mosquito breeding sites:** Decrease artificial breeding sites (litter, solid waste, other potential containers) Cover water containers **Prevent entry of mosquitoes:** Port controls Quarantine regulations **Prevent exposure:** House design Mosquito nets Etc
•	**Heat stress / comfort** (higher temperatures)	Building design / materials Traditional building styles Shade trees
•	**Disease outbreaks** (floods, cyclones)	Optimise sanitation infrastructure design Disaster preparedness Town planning / land use planning

Chapter 5 Future Needs, Programs and Projects

5.1 Immediate and Future Needs

On the basis of the discussion in Chapters 2, 3 and 4 the following future needs have been identified. These needs must be addressed as a matter of urgency if the people of the RMI are to be able to effectively respond to the challenges arising from climate induced changes to the physical, biological, social, economic and cultural conditions on the atolls and islands of the Republic.

- ***Human Resources:*** It is vital that the issues of climate change both politically and technically are met with an understanding by RMI. There needs to be adequate personnel given full attention to making sure that RMI understands the international issues in the negotiations and the technical issues to be able to make proper decisions and respond to the effects of climate change.
- ***Institutional Strengthening.*** Governmental and other institutional strengthening is needed to ensure that the government departments are adequately structured, equipped with the appropriate skills and tools and are capable of delivering an integrated response to the challenges arising from climate change and accelerated sea level rise.

- ***Management and Operational Training.*** Project management and operational training is needed for the governmental and non-governmental stakeholders involved in climate change programs and the implementation of adaptation projects.

- ***Applied Research Assistance.*** Specific applied research assistance is needed for the selection of representative atolls and islands and determining the parameters and indicators for the accurate documentation of base line conditions from which to measure climate induced changes to the shorelines, reef and island ecosystem and affected settlements and communities.

- ***Professional and Technical Support.*** Adequate support is needed at the professional and technical levels for: carrying out vulnerability and adaptation assessment; the preparation of integrated coastal zone management plans; and the implementation of projects to manage the physical, economic, social and environmental changes.

- ***Appropriate Funding.*** Financial support is needed for baseline bio-physical and socio-economic environmental research, monitoring changes to environmental conditions and implementing adaptation measures.

- ***Information Management Systems.*** Appropriate systems are needed for spatial and other data generated through vulnerability assessments, monitoring programs, integrated coastal zone management planning and the implementation of adaptation projects.

- ***Confidence and Capability Building.*** Confidence and capability building programs are needed for government departments, members of local councils and non-government organizations.

- ***Awareness and Education.*** Community awareness and education programs are needed that are aimed at students at elementary and high schools and the College of the Marshall Islands as well as public and private sector bodies and island residents and visitors. This area needs to be developed and strengthened.

- ***International Participation.*** Proactive participation and lobbying initiatives in international forums and meetings are needed with the aim of continuing to keep the issues confronting small island states, when they are responding to climate change, in front of representatives and citizens of the industrialized nations.

- ***PICCAP Country Team.*** An adequately resourced and trained RMI PICCAP Country Team is needed to ensure that the preparation of the National Communication and other reporting under obligations to the UNFCCC are met and that a whole of government approach is applied to resolving climate change issues. It is vital for the Country Team to continue its work, perhaps as a functioning body of the National Commission on Sustainable Development. Consideration must be given by the Conference of the Parties for financing the country teams in the interim period between national communications.

Aspects of these needs have been flagged Section 4. 5 of Chapters 4 as they are the cornerstones of the future climate change mitigation and adaptation policy initiatives of the National Government of the RMI. Needs provide the momentum for addressing capacity building and education requirements outlined and provides a focus for the programs and projects outlined in Section 5.4 of this Chapter.

5.2 Capacity Building and Training

5.2.1 Priority Requirements

Capacity building encompasses a wide range of topics. The Draft Decision by the Group of 77 and China outlines nine core areas of capacity building for developing countries. These are listed in Annex B. Not all of the areas are of high priority to meet the immediate needs of the Government and people of the RMI. The priority areas for capacity building in the RMI are discussed briefly as follows.

Institutional Capacity Building. Strengthening the institutional capacities and capabilities of the departments agencies who are either responsible for climate change activities or need to respond to the effects of such changes, is an essential requirement for the RMI.. The key departments being the RMIEPA, the Weather Service and the Ministry of Resources, Development and Works, the Ministry of Health Services and

Natural Disaster Management. This will require further educational and training support for professional and technical support staff (see Section 6.3). Coordination and cooperation programs at international, regional, national and local levels is viewed as an integral part of institutional capacity building.

Human Resource Development. Capacity building effort can build on the success to date from the PICCAP initiative as well as SPREP and other internationally organized and funded programs.. Human resources capacity building for the RMI should be aimed at the provision of workshops, in-country training programs, regional exchange programs and the establishment of a pool of expertise that can be drawn on from either the region (specifically SPREP member countries) or from elsewhere overseas. For example, the topics and expertise required could include:

- decision making;
- hazard and risk assessment and management;
- integrated coastal and oceans management;
- environmental impact assessment;
- the development and implementation of environmental management systems;
- marine and terrestrial biodiversity; and
- the sustainable use of water, agro-forestry and marine resources.

Vulnerability Assessment and Adaptation. This includes tidal and meteorological monitoring as well as the establishment of surveyed topographic benchmarks for the representative and other atolls and islands in the RMI. As necessary, aerial photographic and mapping capacity may be required. Where there are high levels of shoreline erosion engineering assistance will be required in the development and implementation of cost effect and environmentally sustainable response strategies. Also, the further development of the skills necessary for vulnerability assessments, especially field measurements of coastal and marine changes and the development of appropriate indicators of climate induced change. The identification and promotion of traditional and local knowledge, skills and practices must be in integral part of adaptation.

Technology Transfer. Technology transfer is needed as an essential component of responding to the current suite of climatically induced environmental management issues that are confronting the Government and the people of the RMI. These include shoreline erosion, the effects of prolonged drought and the ability to be able to cope with a cyclonic event. Information management and exchange is seen as an essential aspect of technology transfer.

National Communications. The preparation of the Nation Communication is a considerable burden on the governmental resources of the RMI. A core component of capacity building

will need to be the strengthening of the PICCAP Country Team and establishing linkages with relevant research and non-government bodies. Additionally, there needs to be the development of in-country expertise undertaking greenhouse gas inventories, including data collection, analysis and archiving. The preparation of physical, biological, social, economic and cultural baselines is an essential capacity requirement for the PICCAP Coordinator and Country team members.

5.2.2 Financial Assistance

Currently neither the national government nor the local councils of the RMI have the financial resources to be effective in either ongoing vulnerability and adaptation assessment or to deal with the degradation of the shoreline environments as a result of erosion. This situation needs to be rectified with donor assistance. The husbanding of the existing resources will be aided by focussing the climate change monitoring effort at reference islands. Notwithstanding, the current situation of environmental degradation, on some islands in the RMI, means that immediate financial assistance is needed to protect property and infrastructure and to safeguard human health and maintain agro-forestry productivity. It is therefore important to secure such financial assistance through the financial mechanism of the Convention, supplemented by other donors. Consideration could also be given to regional cooperative arrangements for financing of the climate change response efforts of Small Island Developing States.

5.3 Public Awareness and Education

5.3.1 Public Awareness

There is an immediate requirement to increase public awareness on the theme of climate change and sea level rise in general, and vulnerability and adaptation in particular. Awareness raising should also encompass energy matters including the mitigation of greenhouse gas emissions and waste to energy initiatives (see Chapters 2 and 3).

Climate change impacts need to be understood by all sectors of the community. As well, communities need to be fully aware of the ways in which people can cause erosion and other problems in the coastal environment. Additionally, communities need to know what they can do to reduce the problems of coastal degradation that will be further effected by the impacts of changed climatic conditions.

5.3.2 Education

There is an immediate need to expand the professional and technical education and training of government personnel and key non-government stakeholders in climate

change and vulnerability and adaptation assessment. This would include the office and field work techniques necessary to measure and monitor changes to the physical, biological, social, economic and cultural components of the environment of the atolls and the settlements. Climate change education programs will entail close collaboration with national and overseas educational institutions and bodies.

Education also encompasses the education system of the RMI as well as the non-government sector. Educational materials pertinent to the RMI climate change situation are need for the elementary and secondary school levels. These materials are needed in the Marshallese language. Short course material is also needed for College of the Marshal Islands and the University of the South Pacific, Marshall Islands Extension. These materials will need to be in English and Marshallese and aimed at environmental studies and social science students.

5.4 Possible Programs and Projects

Two program areas have been identified. They are capacity building and training, public awareness and education, and integrated environmental management. Suggested priority projects under each of these headings are as follows.

5.4.1 Capacity Building and Training

The four projects under this program are summarized as follows.

Institutional Strengthening. This initial project should focus on the needs of the RMI PICCAP Country Team and other key stakeholders. The project would be undertaken in country with external experts working with RMI people in workshops and on the job exercises. Great benefit can be gained by having a train the trainer approach which involves the College of the Marshall Islands and the University of the South Pacific Extension. The topics to be covered in the project would include:

- project management training;
- inter-agency cooperation and coordination;
- decision making;
- an introduction to technical environmental research skills;
- baseline measurement and monitoring;
- environmental hazards and assessment; and
- preparing the National communication to the UNFCCC.

Vulnerability Assessment and Adaptation. This project aims to build on the strengths developed with the Kwajalein Case Study (Crisostomo in prep) and extend the knowledge of the vulnerability of the atolls and reef islands. The project should be carried using in-country on the job training which is facilitated by either a regional or an overseas expert. The core focus of the project will be on: skills development including:

- mapping, aerial photograph interpretation and shoreline profiling;
- data interpretation and analysis; and
- reporting and report writing.

Representative Islands Monitoring Project. This project acknowledges that climate induced changes across the RMI can be monitored by using specific atoll islands as reference stations. The coverage would include those with large populations, small populations and no population. Also, the level of modification to the shoreline and the overall patterns of settlement would be taken into account. The future work would build upon the information already assembled for representative islands (eg the two case areas Majuro and Kwajalein Atolls). This means that scarce resources can be expended wisely. It would also result in greater knowledge of the natural variability in the environmental systems of the different atolls and islands on both the north-south and east-west axis of the country.

Technology Transfer. This project aims to move forward initiatives under the Clean Development Mechanism (CDM). Other technology transfer activities under the broad heading of integrated environmental management will be incorporated into the project structure as the needs are identified. That is the execution of this project is seen as being iterative. The key training topics would be:

- identifying and facilitating CDM projects;
- in-country facilitation of CDM activities;
- greenhouse gas inventory and analysis;
- solid and liquid waste management strategy;
- waste to energy systems;
- integrated coastal zone management; and
- application of information management systems to integrated environmental management.

5.4.2 Public Awareness and Education

The two projects envisaged they are a specific to public awareness project and an education project.

Public Awareness. This should be long term and be implemented by expanding the resources of the RMI EPA. The materials prepared to address public awareness should include:

- basic information on climate change;
- what efforts are needed now to reduce the adverse impacts of climate induced change;
- how to deal with extreme events;
- the reasons why sea walls and other shore protection works should be carefully planned and sited;
- the reasons why rock and rubble should be left on the shore platforms;
- why the reef platforms should not be used as land fill sites for domestic and other solid and liquid wastes;
- the ways in which people can secure themselves against the effects of drought;
- the public health issues relating to climate change; and
- the ways changes in the climate can effect agricultural and fisheries productivity.

Community Education. This project should also be long term and be a collaborative venture involving all components of the RMI` education system and non-government organizations. The approach should be train the trainer, with the carriage of the training activities being with the College of the Marshall Islands. Materials could be sourced from throughout the Pacific Region and amended to the RMI situation and language.

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ANNEX A

GREENHOUSE GAS INVENTORY TABLES

ANNEX B

LIST OF CAPACITY-BUILDING NEEDS OF DEVELOPING COUNTRY PARTIES

1. Institutional Capacity Building

- Strengthening of national FCCC Focal Points or national authorities designated to coordinate climate change activities.
- Strengthening of relevant and key academic, research and NGO institutions.

2. Capacity Building under the CDM

- Establishment of institutional linkages required for implementation of the CDM.
- Project identification, formulation and design.
- Monitoring, verification, auditing and certification of project activities.
- Development of criteria including for sustainable development indicators, e.g. for adaptation.
- Development of baselines.
- Project negotiation skills.
- CDM demonstration projects to enhance capacity building (learning by doing), including assessment of costs/risks (long and short-term).
- Data acquisition and sharing.

3. Human Resource Development

- Fellowships and scholarships for formal training at higher levels, specialized training and informal training.
- Development of a "pool" of expertise and skills.
- Climate change and other relevant studies such as climate change detection and climate variability, impact assessment, vulnerability and adaptation studies, policy analysis.
- Workshops (including workshops to discuss the implementation plan).
- Exchange programmes among Parties.
- Integration of climate change into educational curricula.
- Networking and coordination at local, national, regional and international levels.

4. Technology Transfer

- Identification and assessment of appropriate technologies.
- Appropriate technology information needs including support for office and other relevant equipment.
- Analysis of constraints to the transfer of technology (non-Annex I and Annex I).
- Exchange programmes

5. National Communications

- Development of local emission factors.
- Data collection, analysis and archiving.
- Establishment of a Technical Assistance Group, e.g., non-Annex I expert group.
- Vulnerability assessments, including scoping, modeling, analysis, method selection and reporting.

6. Adaptation

- Development of Adaptation project guidelines.
- Case studies of extreme weather events, documentation and dissemination of study reports.
- Capacity-building/enhancement in the marine sector, such as coastal zone management.
- Identification and promotion of traditional knowledge, skills and practices which enhance adaptation.

7. Public Awareness

- Develop public awareness programmes.
- Development and production of public awareness materials.
- Workshops.
- Involvement and consultation.

8. Coordination and Cooperation

- Coordination programmes at the individual, community, local, Government, non-government, national and regional levels.
- Involvement and consultation.
- Linking and learning.

9. Improved Decision Making

- Awareness and knowledge.
- Research, data and information.
- Technical and policy.
- Integrating climate change policies into national development strategies/plans.

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