REPUBLIC OF PALAU

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First National Communication to the United Nations Framework Convention on Climate Change

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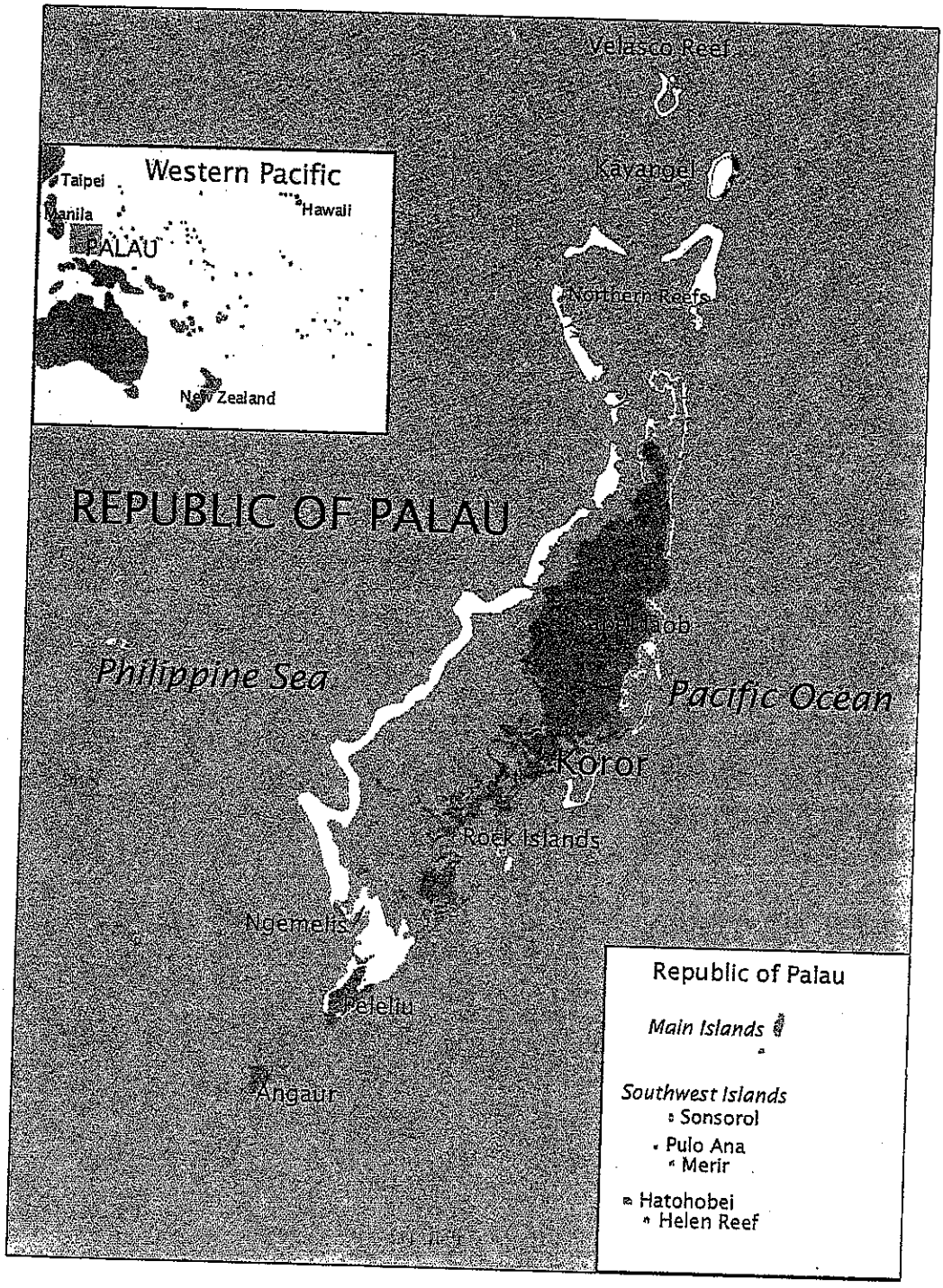

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GREENHOUSE GAS MITIGATION

Manta birostris - This is one of the largest fishes common to Palau's inshore waters. This species is especially numerous during the first quarter of the year and is a major ecotourism draw.

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Figures

Graphs

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Pyrroglaux podargina - The Palau owl is rare endemic often heard during the early evenings throughout the islands.

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Acronyms

BLS	Bureau of Land and Survey
BMR	Bureau of Marine Resources
BoFA	Bureau of Foreign Affairs
BPS	Bureau of Planning and Statistics
BPW	Bureau of Public Works
CASO	Conservation Area Support Officer
CIP	Capitol Improvement Projects
CITES	Convention on International Trade in Endangered Species
CFC	Chlorofluorocarbon
CoP	Conference of the Parties
Compact	Compact of Free Association
COTS	Crown-of-Thorns Seastar
CRRF	Coral Reef Research Foundation
CSIRO	Commonwealth Scientific and Industrial Research Organization
EEZ	Exclusive Economic Zone
ENSO	El Nino Southern Oscillation
EQPB	Environmental Quality Protection Board
GCM	Global Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
ICZM	Integrated Coastal Zone Management
IUCN	International Union for the Conservation of Nature and Natural Resources
IPCC	Intergovernmental Panel on Climate Change
LPG	Liquid Petroleum Gas
MCT	Ministry of Commerce and Trade
MoH	Ministry of Health
MoJ	Ministry of Justics
MoS	Ministry of State
MRD	Ministry of Resources and Development
NECC	North Equatorial Counter Current
NEMO	National Emergency Management Office
NTU	National Tourism Unit

Blenniella chrysospilos - The red spotted blenny is one of over 1,300 species of fishes that inhabit Palau's waters.

OEK	Olbiil Era Kelulau (National Congress)
OERC	Office of Environmental Response and Coordination
OTEC	Ocean Thermal Energy Conversion
PALARIS	Palau Automated Land and Resource Information System
PCAA - IESL	Palau Community Action Agency - Informal Employment & Sustainable Livelihood
PICRC	Palau International Coral Reef Center
PICS	Pacific Island Countries
PPUC	Palau Public Utilities Corporation
SOI	Southern Oscillation Index
SST	Sea Surface Temperature
USGS	United States Geological Service
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
V&A	Vulnerability and Adaptation
VMS	Vessel Monitoring System
WPWP	Western Pacific Warm Pool

Foreword

Tommy E. Remengesau, Jr.
President
of the
Republic of Palau

The island nations of this world are under siege — not by our enemies and not by military forces. The attack comes from our friends, our neighbors and our regional and international partners. Unfortunately, the attackers and their weapons are invisible, even unto themselves. This is because more and larger cars, cooler houses and more convenient home products represent the attack.

This assault is of unprecedented proportion and is expanding every moment. Degraded environments and economies in small island states are merely the first indicator of the potential destruction that this world will face if it does not begin to recognize the problem and take concrete responsive measures.

Global Warming is here. It is not a myth or merely a theory of the scientific community. The climate is changing now, both in the islands and on the Continents. No country and no individual will be immune from its broad and dramatic impact. It is time for the world to see the islands' climate change issues as an omen for the entire planet. The failure of the international community to view the islands as windows into their own futures will ultimately result in their own destruction.

In 1997 and 1998, at least one third of Palau's reefs were destroyed due to climate change related weather events. In some areas, up to 80% of our reefs were lost. Most of our taro crops were also destroyed because of drought and extreme high tides during the same period. These were not theoretical scientific losses. These were actual losses of the livelihoods and potentials of the Palauan people. Soon such devastation will be reflected in the countries of the developed world. I am sure that the industrialized nations will listen and desire to become involved at that point. But, will there be any time left for mitigation, and will there be anything left to preserve?

The solution to global warming is a difficult one. It requires that each of us, from both developing and developed states, be willing to make sacrifices for the good of all. It requires that we simultaneously reflect on what is best for our neighbors, as well as for ourselves, over the long term. For the developing nations, it will require a more rational approach to growth than what was previously enjoyed by the rich nations of this world. For affluent nations, it will require that many of the expenses of the solution be borne out of their pocketbooks.

We must think hard and ask ourselves in what state do we want to pass the Earth on to our children and grandchildren? If we can only acknowledge that we are all part of a single world community, we may come to realize that we currently hold the planet's inheritance in our hands.

Sincerely,

Tommy E. Remengesau, Jr.
President of the Republic of Palau

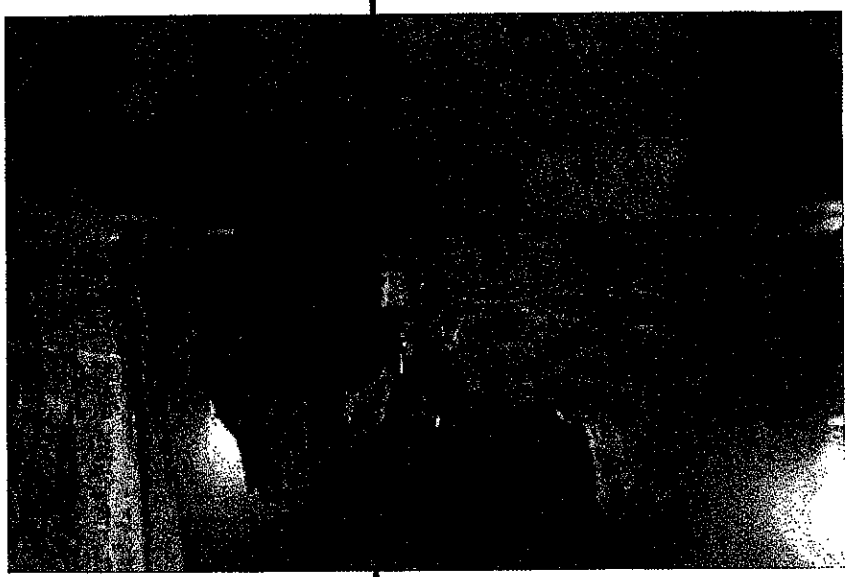
Executive Summary

The Republic of Palau First National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) was developed with the assistance of the Global Environment Facility (GEF) Enabling Activity project.

The Project was initiated in January 2001 and entailed a series of community workshops and a national symposium to: 1) create public awareness regarding the causes of climate change and its impacts on Palau; 2) conduct a greenhouse gas inventory for the period of 1994 to 2000; 3) execute a vulnerability and adaptation assessment to determine the affects of climate change on Palau, identify high areas of vulnerability, and develop a mitigation and adaptation framework to address projected climate change trends; and 4) prepare the Republic of Palau First National Communication to the UNFCCC.

National Circumstances

The Republic of Palau is the westernmost island cluster in the Caroline Island Group. Located in the western Pacific Ocean between 7 degrees North latitude and 134 degrees East longitude, Palau is approximately 800 kilometers east of the Philippines and 800 kilometers north of Papua New Guinea. Due to its location in the Pacific, in combination with other factors, Palau is considered the most biologically rich island group within Oceania. The Palau archipelago stretches over 400 miles in a north-south direction from the atoll of Kayangel to the islet of Hatohobei. Palau consists of 586 islands, of which only twelve are continuously inhabited. Total land area is 535km^2, with 25 percent of Palau's landmass below ten meters above sea level (MoA, 2001). Palau's natural resources consist of one of the largest tropical rainforests in Micronesia, minerals, fossil fuel, natural gas deposits, marine products, and deep-seabed minerals



Chandalier Cave is an example of a limestone cave that was once completely terrestiral. It has since been flooded by water as sea levels have risen over geologic time.

Palau is hot and humid throughout the year, averaging between 74-83°F. Average annual rainfall is approximately 3,810cm, or 150 inches, per year under normal conditions.

Three ocean currents converge in Palau's waters and bring a rich diversity of nutrients that attract a large variety of marine life. These currents also transport larvae of many marine species to the archipelago making Palau's underwater environment one of the most diverse places on Earth.

Cassarina trees grow amongst many of the nutrient poor limestone islands.

Renown as one of the top dive destinations in the World, Palau has developed its adventure tourism sector as its main industry. 1996 figures show that Palau derived US$67 million, or 47 percent, of its Gross Domestic Product (GDP) from its tourism industry. From 1992 to 1997 tourist arrivals doubled from nearly 30,000 to 73,719 (PVA, 2000). However, due to several factors such as the recent Asian economic crisis and the 1998 coral bleaching event, Palau's tourism arrival numbers have been on a gradual decline. This loss is reflected in a 3.3 percent drop in the GDP in 1998. 1998 figures show a 12.9 percent decrease in arrivals, totaling 64,194 for the year. The first nine months of 1999 showed an additional 9.3 percent drop in tourism arrivals when compared to the same period in 1998 (MoA, 2001).

The population of Palau as of 2000 is 19,129, and consists of 13,209 resident Palauans and 5,920 non-Palauan foreign residents (Cencus, 2000). Over the past 10 years, the annual growth rate has fluctuated between 2.3 to 2.6 percent, primarily due to immigration and not from an increase in birth rates within the Palauan community. However, the population is seen to have leveled off at about 2.3 percent in the past two years. Approximately 80 percent of the total population resides in Koror Island, the provisional capitol of Palau. However, a high percentage of the population is expected to shift to Babeldaob once the Compact Road and the new National Capital are completed. The expected completion date of the Compact Road is 2005.

National Greenhouse Gas Inventory

Palau's Greenhouse Gas Inventory shows that Palau was a carbon sink in 1994, meaning that Palau retained more carbon in its forests and vegetation than it emitted during that year. The National Greenhouse Gas Inventory also illustrates that Palau is a minor emitter of greenhouse gases, in both a relative and absolute sense. Consequently, any steps taken to reduce its greenhouse gas emissions, and enhance its carbon sinks, will have a negligible effect on the enhanced greenhouse effect and global warming.

Regardless of any remaining gaps and inconsistencies in the GHG inventory, the message is clear and incontrovertible – the Republic of Palau, and its citizens, are minor players when it comes to greenhouse gas emissions, on either a national or per capita basis. This does not mean that Palau can, or should, sit back and rest on the reputation of being a minor emitter of greenhouse gases. Instead, Palau should strive to be a showcase for the rest of the world by reducing any potential impacts, however minor they may be, on the global climate and related systems.

Definitions

Adaptation is generally referred to by climate change experts as the degree to which systems can adjust in response to, or in anticipation of, changing conditions.

Climate change is the gradual warming of the earth's atmosphere caused by emissions of heat-absorbing "greenhouse gases." The term is generally used to reflect longer-term changes, such as higher air and sea temperatures and sea level rise.

Climate variability reflects shorter-term extreme weather events, such as ENSO. While there is some evidence that climate variability will increase as a result of climate change, many uncertainties still remain.

Greenhouse effect is the combination of greenhouse gases, which together produce a "natural greenhouse effect" that keeps the planet some 30°C warmer than it otherwise would be - essential for life as we know it. Levels of all key greenhouse gases (with the possible exception of water vapor) are rising as a direct result of human acitivity.

Greenhouse gases include water vapor, carbon dioxide, ozone, methane, nitrous oxide, and the chlorofluorocarbons (CFCs). With the exception of CFCs, all the greenhouse gases occur naturally.

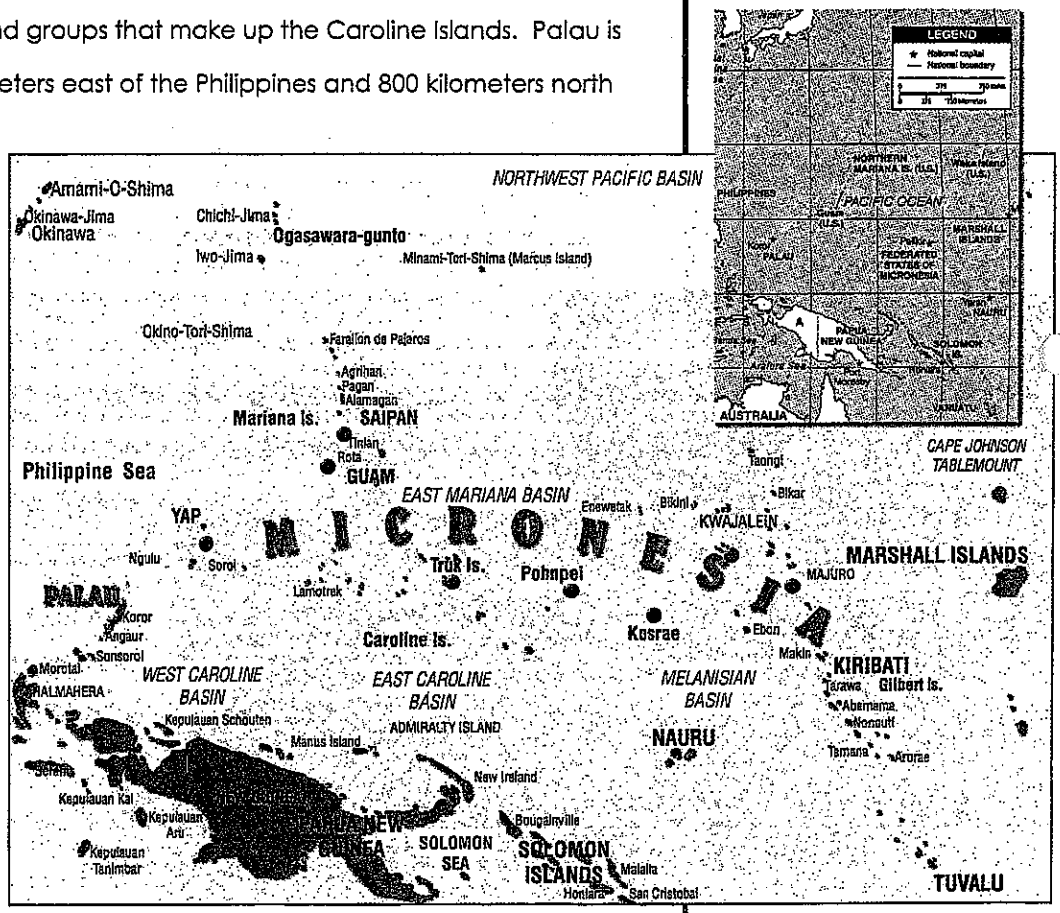
Mitigation is generally referred to by climate change experts to efforts that reduce greenhouse gas emissions.

Vulnerability defines the extent to which climate change may damage or harm a system; this depends not only on the system's sensistivity, but on its ability to adapt.

National Circumstances

1.1 Geography

The Republic of Palau is an archipelago in the Western Pacific Ocean between 7 degrees North latitude and 134 degrees East longitude. Palau is the westernmost island cluster of the six major island groups that make up the Caroline Islands. Palau is located approximately 800 kilometers east of the Philippines and 800 kilometers north of Papua New Guinea.



Although recognized as part of the Caroline island group which features both volcanic and coralline islands, the western Carolines islands are exposed peaks of undersea ridges stretching between Japan and New Guinea and are not located on the Pacific Plate. The Palau islands originated on the now dormant southern section of the volcanic Palau-Kyushu Ridge, which formed about 43 million years ago (mya) in a complex series of rifting and boundary shifts of the Pacific Plate margin during the formation of the Philippine Basin (Kroenke, 1984).

Part of the Oceania group, Palau is located on the eastern edge of the Philippine tectonic plate close to the western edge of the Pacific plate. The Palau, Yap, and Mariana Trenches that mark the subduction zone, where the Pacific plate is being driven under the Philippine plate, are some of the deepest waters on earth. When the islands that make up Palau first emerged above sea level is unknown. However, the

oldest organic limestones have been dated to the early Miocene, which suggests tha the volcanics were emergent sometime before that, perhaps by late Oligocene, som 30 million years ago (Crombie, 1999).

The Palau archipelago stretches over 400 miles in a north-south direction from the ato of Kayangel to the islet of Hatohobei. Palau consists of 586 islands, of which only twel are continuously inhabited. Total land area is 535km^2, with 25 percent of Palau's landmass below ten meters above sea level (MoA, 2001).

The islands of Palau represent five geological island types, volcanic, high limestone, l limestone, atolls, and a combination of volcanics and limestone (Crombie, 1999). The largest islands were formed by Eocene volcanic activity and are composed of basalt and andesite. They tend to have a high profile, well-developed perennial stream systems, and a high diversity of terrestrial flora. Babeldaob island has severely leached and highly acidic soils, unsuited f large-scale agriculture. The world famous "Rock Islands" are of limestone formation. Peleliu and Anguar islands, located at the southern end of the main archipelago, ar low platform and reef islands. The Southw group of islands, located approximately 2 km from the capitol, is made up of reef flo that have been subjected to uplift. Kayangel Island, at the northernmost tip of the archipelago, is a classic coral atoll.

The Rock Islands are comprised of uplifted limestone reefs. They have subsequently been eroded over millions of years by physical, chemical, and biological factors.

Babeldaob island is the largest in the Palau island chain and the second largest islan Micronesia. Babeldaob constitutes 75 percent of Palau's total landmass. At its great

width, Babeldaob reaches fifteen miles across (APCC, 2001). With the exception of Kayangel, Angaur, and the Southwest islands, all of the Palau islands are located within one barrier reef. Palau's exclusive fishing zone is 12 nautical miles, 3 nautical mile territorial seas, with a 200 nautical mile extended fishing zone, which comprises an area of approximately 600,900 square kilometers (Sant/Hayes, 1996).

1.2 History

The date of first human arrival to the Palauan islands is not known, though pottery uncovered in Babeldaob has been carbon dated to about 4,000 years ago. First foreign contact of significance occurred in 1783, with the arrival of the vessel Antelope under the command of English Captain Henry Wilson. Foreign governance of the Palau islands officially began when Pope Leo XIII asserted Spain's rights over the Caroline Islands in 1885. In 1899, Spain sold the Caroline Islands to Germany after Spain's defeat in the Spanish American War. Under German administration, three major economic industries were developed, phosphate and bauxite mining in Anguar and Babeldaob respectively, as well as copra production.

An American tank left behind after World War II serves as a reminder of the thousands who died in Palau during the invasion of Angaur, Peleliu, and Ngedebus Islands.

At the outbreak of World War I, the Japanese government assumed control over Palau in 1914. The League of Nations officially gave Japan control over Micronesia, including Palau in 1920. In 1922, Koror island became the administrative center for all Japanese possessions in the South Pacific. The population reached a record high of 40,000 people, of which fewer than 10 percent were Palauans. During the 1920s and '30s, Japan further developed the phosphate mining industry, and expanded agriculture and fish exports.

In 1947, following World War II, Palau became one of six island districts as part of the United Nations Trust Territories of the Pacific under United States Administration. After thirty years as a United Nations Trust Territory, Palau opted for independence status, in

1978, rather than join the Federated States of Micronesia. A Compact of Free Association with the United States was approved in 1986, but not ratified by the Olbiil Era Kelulau (Palau National Congress) until 1993. The Compact of Free Association, establishing Palau as an independent nation, entered into force on October 1, 1994. The country was admitted to the United Nations (UN) on 15 December 1994 and has since become a Party to a number of international conventions and agreements.

1.3 Climate

The Republic of Palau boasts a maritime tropical rainy climate. Annual mean humidity level is 82 percent. However, temperatures rarely vary more than ten degrees throughout the year. Annual mean rainfall is about 3,810mm per year with seasonal variation (National Climatic Data Center et al, 1996). Palau has two seasons during the year, wet and dry. The wet season typically begins in May and peaks in September. Dry season prevails from February to April and October to December. February, March, and April are the driest months of the year (NOAA, 1991). Although not located within the main tropical cyclone track, Palau has experienced its share of destruction from typhoons and severe storms. Several million dollars of damage was done to Palau's infrastructure as Typhoon Utor swept several hundred miles north of Palau during the summer of 2001.

Surface water is vital to local communities. Approximately three-quarters of Palau's population depends on one watershed for fresh water. Palau's major dam, Ngirikiil (shown above), was severely damaged during Tropical Storm Utor in 2001.

1.3.1 Temperature

Palau's mean temperature is 82°F and fluctuates on a daily basis no more than 10°F (National Climatic Data Center et al., 1996). January and February are generally the coolest months but differ from the warmest month, April, by only 1°F. Seawater temperatures in the main harbor, Malakal, averaged above 29°C for 2000 and 2001

(CRRF, unpublished). The maximum mean sea surface temperature between 1985 and 1999 was 29.55°C (CRRF, unpublished).

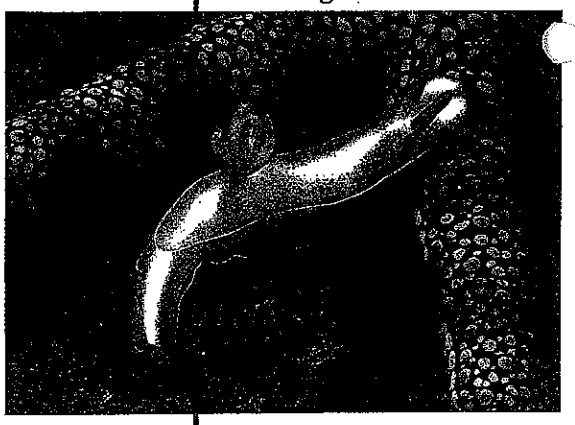
1.3.2 Rainfall

Over the past fifty years, freshwater has been relatively plentiful in Palau. The mean precipitation is 3,810 mm, or 150 inches, per year (National Climatic Data Center et al., 1996). February, March, and April are the driest months with an average of 6 to 8 inches per month. The rest of the year averages between 10 and 20 inches per month. The relative humidity averages 90 percent in the morning and 76 percent in the afternoon (National Climatic Data Center et al., 1996). Predictions indicate that the Caroline Islands, along with some South Pacific Islands may be a region of decreased precipitation in the near future due to the enhanced greenhouse effect, though other model projections predict increased rainfall by 2099 (Morrissey and Graham, 1996; Shea et al., 2001).

1.3.3 Current and Tides

The Palauan archipelago lies in an area influenced by the North Equatorial Counter Current (NECC) and the Mindanao Eddy (Rapaport and Moshe, 1999). Both the NECC and the Mindanao Eddy affect Palau's overall biodiversity by carrying coral and fish larvae originating in the Philippines, Irian Jaya, and Indonesia to Palau (Meyers, 1999). Terrestrial flora and fauna have reached Palau via wind, rafts, or drifting with the NECC.

Hypselodoris bullocki - This nudibranchs' ancestors where originally brought to the archipelago via oceanic currents, as were many marine species. Climate change may alter existing oceanic currents throughout the world, thereby affecting future recruitment of marine organisms.

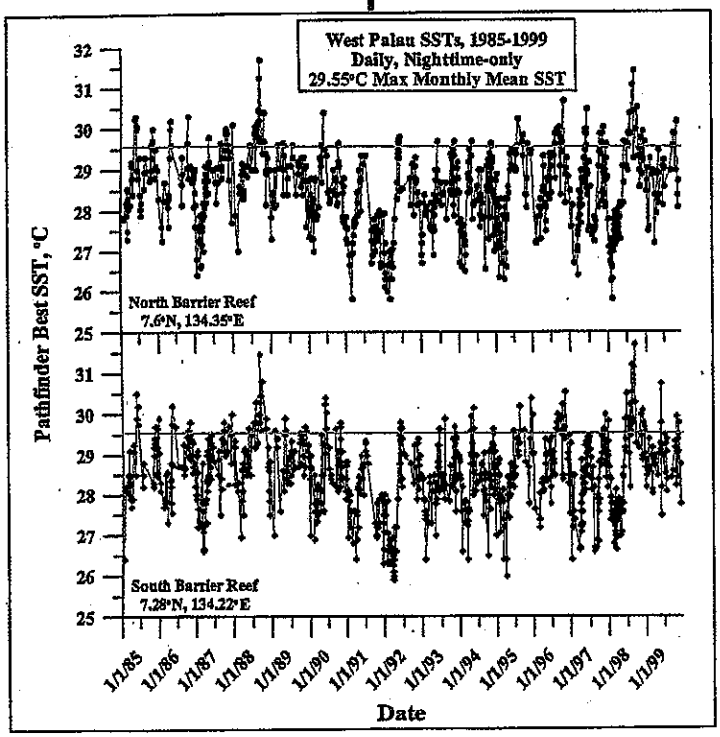


Lunar periodicity dramatically affects the behaviors of fishes and invertebrates throughout the archipelago. Palau experiences semidiurnal tides, or two high and two low tides daily. Spring tides can cause as much as seven feet of exchange, while neap tides may cause as little as two feet of exchange. Over millions of years, tidal currents

have also been one of the factors that have helped shape the physical structure of existing coral reefs around the archipelago.

1.3.4 ENSO Events

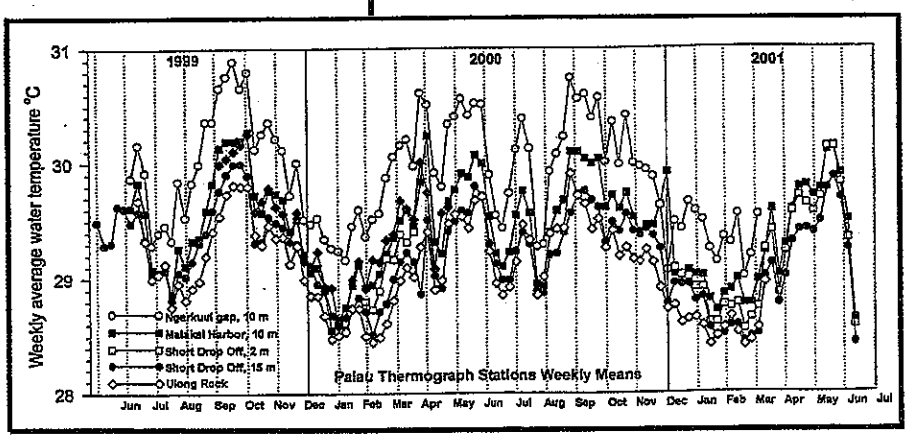
The El Nino-Southern Oscillation phenomenon is an ocean-atmosphere circulation that effects Palau significantly on a regular basis. During an El Nino year, Palau generally experiences drought conditions from weeks to months, and the entire island must ration fresh water. Since little irrigation is done in Palau the agricultural sector absolutely depends on regular rainfall. During the 1997/98 El Nino Palau not only experienced a severe drought but also a significant rise in sea water temperature (Bruno et al., 2001). Over several weeks during August and September of 1998, sea surface temperatures exceeded 30°C (CRRF, unpublished). The unusually warm water caused widespread coral bleachin and had a negative effect on the viability of subsistence fishing.



Graph 1.1: West Palau Sea Surface Temperatures between 1985-1999 show the SST increase during 1998 which caused massive coral bleaching.

Source: Coral Reef Research Foundation

Using model-based climate change scenarios, potential changes in natural climatic variability in the Pacific are predicted over the next century. These changes include the possible emergence of a persistent El Nino-like condition that could affect rainfall, tropical storms and ocean conditions, and, in turn, economically important fisheries and cor reefs (Shea et al., 2001).



Graph 1.2: Natural Variation in Water Temperature. The graphs shows natural variation in water temperature over-time between different geopgraphic sites within Palau's waters.

Source: Coral Reef Research Foundation

1.3.5 Typhoons

There is a potential for the increased occurrence of tropical cyclones, or typhoons, in or near Palau due to climate change. Present tropical cyclone paths, that currently pass about 900 miles north of Palau on average, may be modified due to large-scale changes to circulation patterns (Shea et al., 2001; Pittock et al., 1995). An increase in the number and proximity of typhoons would negatively impact the diversity of Palau's reefs, as well as negatively affect fisheries, which some Palauans still rely on for food security. Many vertebrates and delicate forms of invertebrates that currently habituate in shallow reef areas and related marine ecosystems would be damaged or destroyed by more intense wave action caused by more persistent and frequent storms.

1.4 Biological Diversity

The Republic of Palau is best known for its marine diversity though it also hosts a wide variety of terrestrial flora and fauna, including many endemics. Numerous marine ecosystems exist including mangrove forests, seagrass beds, fringing reefs, patch reefs, barrier reefs, and marine lakes. These ecosystems provide a plethora of marine habitats and even more niches for a huge variety of species to habituate in. Terrestrial habitats include nine types of forests and savannah (Otobed & Maiavia, 1994, Cole et al., 1987). The numerous ecosystems found in Palau provide many goods and services that are crucial to rural communities dependent upon food, fiber, fuel and energy, medicines, clean water, as well as the spiritual, aesthetic and recreational values derived from nature.

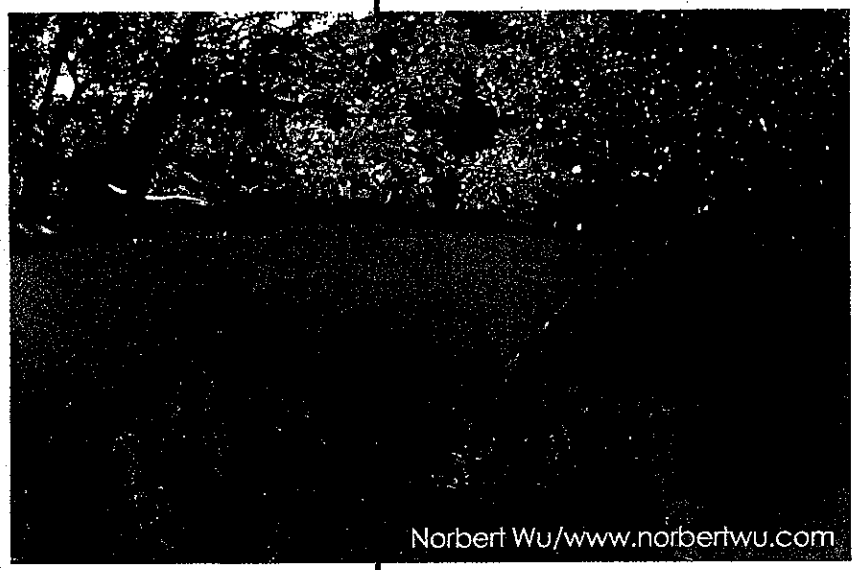
Figure 1.1: Terrestrial and Marine Species List.

Species	Approx. Total	Endemic	Introduced	Endangered
Terrestrial Flora & Fauna				
Plants	1,260	109		
Insects	5,000	500		
Birds	141	16	3	1
Freshwater fish	40	3		
Terrestrial snails		300	1	
Amphibians & Reptiles	46	12		
Frogs	*2*	*1*	*1*	
Lizards	*30*	*10*	*2*	
Snakes	*7*	*1*		
Turtles	*1*			
Bats	3	2		
Marine Habitat & Biota				
Marine Lakes	62			
Soft corals	200			
Stony or scleractinian	385			
Mangrove species	18			
Marine fishes	1,387	11		
Sea grass	9			
Macro-invertebrates	>600	1		
Turtles				2
Saltwater Crocodile	<200			1
Dugon dugon	50-200			1

As of 2002 there are still many unknowns as to the number of marine and terrestrial organisms that reside in and around the Palauan archipelago. This information gap is mainly due to inaccessibility and the lack of capacity for further research. Palau's natural resources, especially its wealth of biodiversity, are subject to many anthropogenic and natural pressures. These pressures include increased demand for resources; selective exploitation or species; land-use and land-use change; anthropogenic nitrogen deposition; soil and water pollution; introduction of invasive species; and fragmentation of ecosystems. Climate change is an added pressure on Palau's ecosystems.

1.4.1 Mangrove Forests

One of the most significant ecosystems found in Palau are mangrove forests. Mangrove cover over 48 km² of Palau, accounting for 11 percent of vegetation growth (Crombie and Pregill, 1999). The most extensive areas of mangrove occur along the west coast o Babeldaob. Mangroves are obligatory halophytes, needing to live in the tidal zones of protected coastlines.



Eighteen plant species are found amongst mangrove habitats in Palau. Mangrove roots often reach above the anoxic substrate in order for each tree to exchange gases.

This type of forest is a vital link between terrestrial and marine ecosystems (Maragos et al., 1994a,b). They act as a filter for significant amounts of sedimentary deposits washed off th islands, especially during the rainy season, keeping the fringing, patch, and barrier reefs from being smothered. Mangroves also protec the islands' shores from erosion caused by wind and waves.

Eighteen species of tree are found in Palau's mangroves, seventeen of them having traditional uses such as medicines, building materials, and handicrafts (Duke, 1999). Th

most common genera include *Rhizophora, Avicennia* and *Sonneratia.* Many reef fishes use mangroves for food and shelter at some point in their life histories (Robertson and Alongi, 1992). Mangroves also provide habitat for Micronesia's only resident population of Indo-Pacific crocodiles (*Crocodilus porosus*), as well as for numerous resident and migrating birds and invertebrates, including the economically valuable Mangrove crab.

1.4.2 Seagrass Beds

Palau contains some of the most extensive seagrass beds in the world, evident along the east coast of Babeldaob. Seagrass slows currents and filters runoff from the islands; thereby keeping fringing and patch reefs relatively clean of sediment. Nine species of seagrass occur in Palau, which provide large areas of primary production (Ogden and Ogden, 1982). Seagrass beds provide vast areas for fish nurseries where many families of food fish preside and feed. Several other organisms important as food sources are found within seagrass beds including *Tridacna* clams, sea cucumbers, urchins, and crabs. The endangered *Dugong dugon* also feeds on seagrasses.

Plectorhincus species - Juvenile reef fishes often use mangrove and seagrass habitats as nurseries. As adults, these fishes move to the outer reef and become part of a more complex food web.

The effects of climate change on this productive ecosystem is not known, though increases of diseases affecting seagrasses in the Caribbean has been reported in recent decades. Diseases and toxicity may negatively impact seagrass beds in Palau due to changes in precipitation frequency and intensity, pH, water temperature, dissolved CO_2, and salinity, combined with anthropogenic disturbances (Gitay et al., ed., 2002).

1.4.3 Coral Reefs

The reefs of Palau include fringing, patch, barrier, and atoll reefs. Reefs cover an approximate area of 1169.4 km² and include a lagoon of 1136.5 km² (Maragos et al., 1994a,b). The immense reef systems were built over millions of years by hermatypic corals. The exact number of scleractinian corals found in Palau is not known but estimates run between 300 and 425 species (Maragos et al., 1994; Veron, 1995; Randall, 1995; Colin, 2001).

There are at least 200 species of cnidarians other than Scleractinia, with many smaller, less conspicuous species undocumented. Over 300 species of sponge have been document, though the total number may be upwards of 500 once the minute and burrowing species are accounted for (Kelly-Borges and Valentine, 1995). The number of marine worms is n known. The total number of Molluscan fauna is not known, though at least 185 species of Opisthobranchs are known and probably over 400 should be expected based on species numbers from Guam, Philippines, and Papua New Guinea (Gosliner, unpublished). Seven species of giant clam (*Tridacna* species) and the endemic *Nautilus belauensis* exist in Palau (Golbuu, 2000). The Crustacean phylum is well represented but it is not known how many species exist in the area. Echinoderm numbers are undocumented, though 21 crinoid species have been documented (Mey and McKurda, 1980). Well over 100 ascidians are found in Palau and up to 150 specie: are expected (CRRF, unpublished).

Amphiprion melanopus - This species of anemonefish became rare in Palau after the sea surface temperature rise during 1998. Its host anemone was bleached and many individuals did not survive the climatic event.

Climate change can potentially affect coral reefs in many ways. A few of the most devastating effects are coral bleaching, the increase of diseases and severe storms, sedimentation, among others. Each of these changes can reduce the overall biodiversity associated with Palau's reefs, thereby causing socioeconomic changes ar creating health issues for the islanders.

1.4.4 Reef and Freshwater Fishes

There are expected to be a total of over 1500 species of fish, marine and freshwater, i Palauan waters, the richest fish fauna in Micronesia (Myers, 1999). Eleven of these are endemic (Myers, 1999). Freshwater endemic species include *Redigobius horiae, Sicyopus fehlmanni, Stiphondon pelewensis,* and *Stenogobius fehlmanni.* The seven

endemic marine species include *Evipes percinctus, Pseudanthias* sp. A, *Cirrhillabrus* sp. A, *Epibulus* n. sp., *Gobidon acicularis, Pleurosicya carolinensis,* and *Kraemaeria cunicularia.* Most species found in Palau are diurnal reef fish (41%). The second most abundant are the cryptic reef fishes (29%), then nocturnal fishes (9%), sand, rubble fishes (9%), mid-water reef fishes (8%), and lastly, pelagic fishes (4%) (Myers, 1999).

Climatic factors affect the biotic and abiotic elements that influence the numbers and distribution of marine organisms, especially fish (Gitay et al., 2002). Variations (with cycles of 10-60 years or more) in the biomass volume of marine organisms are dependent on water temperature and other climatic factors (Gitay et al., 2002).

1.4.5 Marine Reptiles

Marine reptiles in Palau include the Green, Hawksbill, Olive Ridley, and Leatherback turtles (Maragos et al., 1994b; Crombie and Pregill, 1999). Only the Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) turtle populations maintain resident and nesting populations (Maragos et al., 1994b). The Green turtle is listed as threatened and the Hawksbill is listed as endangered by the International Union for the Conservation of Nature and Natural Resources (IUCN). Both species are protected by the Convention on International Trade in Endangered Species (CITES), though both species are hunted for subsistence purposes during particular seasons in Palau.

Crocodylus porosus - The endangered Indo-Pacific crocodile has become a rare site in Palau due to over-hunting in the 1960's and 70's and habitat loss. Vigorous protection in recent years has led to a population increase.

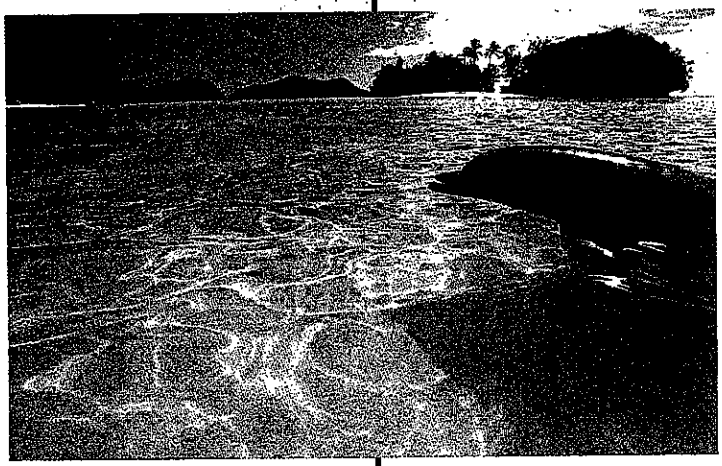
Palau is the only island group in Micronesia that has a resident population of saltwater crocodiles (*Crocodylus porosus*) (Maragos et al., 1994b). This species is on the U.S. Fish and Wildlife endangered species list and protected by CITES (Maragos et al., 1994b). The population was estimated at about 200 individuals in 1991, though local residents

believe there are many more (Messel and King, 1991; Crombie and Pregill, 1999). A new survey of the crocodile population is planned for 2003. Two species of sea snakes, the common banded sea snake, *Laticauda columbrina*, and the extremely rare *Pelamis platurus*, have been recorded in Palau (Crombie and Pregill, 1999).

The major threat to marine reptiles in Palau is habitat loss, both by man-made causes and climate change. Turtle nesting beaches are at risk as sea level is projected to rise between 0.2-0.9m over the next century (IPCC, 2001). Mangrove forests, traditional habitat for crocodiles, are also at risk from sea level rise, increased ferocity and frequency of storms, runoff, and clearing.

1.4.6 Marine Mammals

Palau's dugong (*Dugong dugon*) population is the most isolated in the world (Marsh et al., 1995). The dugong was listed as vulnerable to extinction by the IUCN and protectec by CITES. Dugongs are prone to extinction because they are large, highly prized for food, restricted to localized habitats, and have low biotic potential. The last populatio survey was done in 1991, which found the population to be between 50 and 200 individuals (Marsh et al., 1995).



Marine mammals are frequently encountered passing through Palau's waters. Resident spinner dolphins are often seen near Peleliu and Ngemelis Islands.

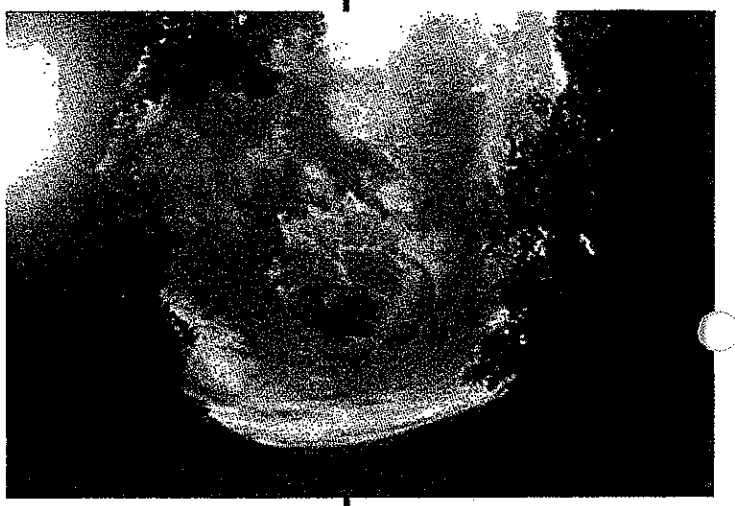
Other marine mammals habituating in Palauan waters include resident Spinner dolphin pods and various other cetaceans. Species that are regularly sited include Pilot Whales, Melon-headed Whales, Risso's Dolphins, Pygmy Killer Whales, False Killer Whale Sperm Whales, and occasionally Orca.

1.4.7 Lake Systems

Palau contains the highest number of marine lakes within a given area than anywhere else known on Earth. Over 60 marine lakes have been created in the Rock Islands via geologic weathering. Each of these lakes is isolated distinct from the next, some being

connected to the lagoon with tunnels or narrow channels. Others are more isolated and completely enclosed by the limestone islands and have little water exchange with the lagoon. The waters in the more isolated lakes have become stratified due to the physical geography, limited tidal mixing, and limited mixing by wind.

Mastigias species of jellyfish inhabit several marine lakes in Palau. These lakes are unique enclosed ecosystems and provide an ideal setting to study climatic events.



Three of the most unusual stratified lakes are popularly known as the Jellyfish Lakes. Each of these lakes contains millions of two species of Scyphozoan, *Mastigias* species and *Aurelia aurita*. The largest Jellyfish Lake is open to the public and receives thousands of visitors per year, while the other two are closed for public use.

Elevated seawater temperatures, caused by the 1998 El Nino-Southern Oscillation (ENSO) event, destroyed millions of the *Mastigias* jellyfish. Fortunately, the *Mastigias* population has rebounded to over eight million during the past two years (CRRF, unpublished). An endemic anemone, *Entacamaea medusivor*, is also found in one of the Jellyfish Lakes. These lakes are extremely important as simplified ecosystems to the scientific community for studying short-term climatic events in the tropics (Hamner & Hamner, 1998).

There are several freshwater lakes found in Babeldaob including the largest in Micronesia, Lake Ngardok. Freshwater organisms found in Palau's lakes and streams include gobies, flagtails, eels, shrimps, crabs, snails, bivalves, and sponges (Rapaport and Moshe, 1999). Saltwater crocodiles are also commonly found in these habitats and Lake Ngardok is considered to be a significant breeding ground for them (Messel and King, 1991).

Climate change may affect freshwater lakes in Palau by reducing oxygen concentrations, usually reducing diversity (Gitay et al., 2002). Eutrophication is another worry via erosion

caused by man-made and natural land degradation. Freshwater ecosystems will be affected by alterations in the hydrological processes. Depending upon the increase or decrease of precipitation in Palau over the next century, productivity in streams and rivers may decrease. Drying of streambeds, due to drought, could reduce ecosystem productivity because of the restricted aquatic habitat and water quality (O_2 concentration) could be reduced (Gitay et al., 2002).

1.4.8 Terrestrial Forests

Nine types of forests are found throughout Palau including Upland Native Forest, Low Coral Island Forest, Raised Limestone Island Forest, and Mangrove Forest. Forests cover 77,248 acres (Otebed and Maiava, 1994; Cole et al., 1987). Agro-forest covers over 2,700 acres and is dominated by coconut stands (Otebed and Maiava, 1994; Cole et al., 1987). Palau's forests are highly valued as watershed areas, for preventing soil erosion, sources of firewood, medicines, building materials, and areas to forage and hunt for food.

Palau is home to the greatest amount of undisturbed forest area in Micronesia. There are over 75,000 acres of forest cover throughout the islands.

Non-forested urban, grassland, and marsh areas cover 21,068 acres (Otebed and Maiava, 1994; Cole et al., 1987).. Grassland/savannah, characterized by a mix of grass (Sword grass) and trees (*Pandanus* species) living in nutrient-poor soil is thought to be the result of human cutting and burning of forests over thousands of years.

Approximately 1,260 species of flora exist in the archipelago, 830 of these being native (Merlin and Keane, 1989; Fosberg et al., 1980). Several hundred species of flora are known endemics. Over 400 specie of alien plants are found in Palau (Otobed and Maiavc 1994). One hundred forty one species of bird exist in Palau, the richest avifauna in Micronesia. Fifty of these species are resident and the others are either migratory or vagrant species.

Several other subspecies of bird may soon be revised as endemics (Pratt, 2001). More endemic skink and gekko species are expected from the Rock Islands due to allopatric speciation (Crombie, personal communication). A number of Palau's endemic species of flora and fauna should be considered prone to extinction as they have specialized habitats, breeding sites, or foods, and some have high economic value.

Some endemics must also compete against introduced alien species for the same resources. Amphibians, in general, can be used as a good yardstick of ecosystem health. Amphibians are extremely sensitive to the environment due to their porous skin and reproductive behaviors.

The frequency of fires are expected to increase in the Pacific due to the effects of warmer temperatures and increased growth of small shrubs and grasses. Climate change is also expected to increase the frequency of pest outbreaks in warm regions (Gitay et al., 2002). Overall, much of Palau's biological diversity is at risk of extinction due to pressures arising from natural processes and human activities. Climate change can only put more pressure on organisms, especially vulnerable and threatened species, though it may relieve some of the existing pressures for a few species (Gitay et al., 2002).

Figure 1.2: Palau Terrestrial Certebrate Endemic Fauna (Crombie and Pregill, 1999; Otebed, 1997)

Common Name	Scientific Name
Gray Duck	*Anas superciliosa*
Palau Ground Dove	*Gallicoluma canifrons*
Palau Scops Owl	*Pyrroglaux podargina*
Palau Bush-Warbler	*Cettia annae*
Palau Fly Catcher	*Myiagra erythrops*
Palau Fantail	*Rhipidura lepida*
Palau Morningbird	*Colluricincla tenebrosa*
White-Breasted Wood Swallow	*Artamus leucorthynchus*
Palau Greater White-Eye	*Megazosterops palauensis*
Blue-Faced Parrotfinch	*Erythrura trichroa*
Palau Fruit Dove	*Ptilinopus pelewensis*
Palau Frog	*Platymantis pelewensis*
Palau Tree Snake	*Dendrelaphis lineolatus*
Pandanus Skink	*Aufacoplax leptosoma*
Rock Islands Gekko	*Gekko sp.*
Gekko species (2)	*Lepidodactulus spp.*
Micronesian Fruit Bat	*Pteropus mariannus pelewensis*
Palau Fruit Bat	*Pteropus pilosus* (probably extinct)
Palau Sheath-Tailed Bat	*Emballonura semicaudata palauensis*

Figure 1.3: Palau Alien Terrestrial Fauna (Otebed, 1997)

Common Name	Scientific Name
Giant African Snail	*Achatina fulica*
Red Junglefowl	*Gallus gallus*
Greater Sulpher-crested Cockatoo	*Cacatua galerita*
Eclectus Parrot	*Eclectus roratus*
Chestnut Mannikin	*Lonchura malacca*
Marine Toad	*Bufo marinus*
Indian Monitor Lizard	*Varanus indicus*
American Cameleon	*Anolis carolinensis*
Non-native Skink sp.	*Carlia sp.*
Polynesian Rat	*Rattus exulans*
Norway Rat	*Rattus norv egicus*
Black Rat	*Rattus rattus*
Himalayan Rat	*Rattus nitidus*
Common Mouse	*Mus musculus*
Asiatic Musk Shrew	*Suncus murinus*
Pig	*Sus scrofa*
Goat	*Capra hircus*
Domestic Pig	*Canis familiaris*
Domestic Cat	*Felis catus*
Crab-eating Macaque	*Macaca fascicularis*

1.5 Population

Palau's current population is 19,129 with an annual growth rate of 2.3 percent (MoA, 2002). The 2002 estimates for the average rate of natural increase is 1.2 percent. Infant mortality is 16.2 for every 1,000 births and the population density per square mile is 110 (MoA, 2002).

1.6 Socio-Cultural Characteristics

The origins of the Palauan people are not known. However, due to linguistic similarities, is generally believed that the islands of Palau were first settled by people migrating fror Southeast Asia and Indonesia around 2,500 BC (Barbour, 1996). Radiocarbon dating of the oldest known village sites located in the Rock Islands and the terraces of Babeldaol date the first to about 1,000 BC (Babour, 1996). There is also evidence of early migratio of Melanesians from New Guinea and Polynesians to Palau (PNM, 2001). The Palauans are believed to be a composite of Polynesian, Malayan, and Melanesian races.

1.6.1 Tradition

By the first foreign contact in 1786, Palau had already developed a sophisticated and highly organized social system. The matrilineal civilization was based on clans and chiefdoms, and these traditions are still carry on in modern society. Original Palauan villages had been situated away from the coast, with piers on waterways leading to the reef-protected tidal flats. Villages were organized by clanships through the female line and subdivided into two political statuses (PNM, 2001). Councils of chiefs from the ten ranking clans of the community governed the villages. Women had an important advisory role and were particularly influential in the control of lanc and money.

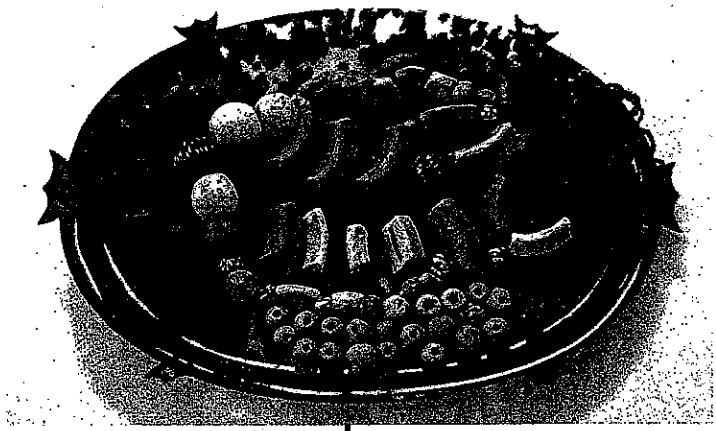
Airai Bai - Traditional mens houses are still used for community discussions amongst 'rubak' and village chiefs.

There were three major facets to the Palauan culture: prestige orientation, competition between individuals and clans, and reciprocity and the manipulation of gifts, money, goods an services. Kinship was the major determinant of social behavior, and each individual in Palauan society, from the moment of birth, had a definite rank in the village, clan, and family. This rank was based on family background and clan ranking, but achievement through individual merit was possible and aggressively sought.

1.6.2 Social System

Present day society in Palau is a complex blend of old traditions and western concepts. Palau has maintained much of its traditional values, but life has changed dramatically with the introduction of western technology and money. Koror State, the provisional capital of Palau, is equipped with westernized infrastructure, such as paved roads, modern stores, and numerous concrete structures. Every residential and commercial structure in Koror State also has access to electricity, sewerage, piped water, and telecommunications.

The central importance of land and money as the root of wealth and power within Palauan society has not diminished with the various foreign occupations of Palau. Palau's intricate system of bead-like money is still actively used both economically and socially in inter-clan payments for important events such as birth, marriage, divorce, and death. Although Palauan money is still used today for ceremonial purposes, land and other commodities are typically purchased using Palau's current means of economic exchange, the U.S. Dollar. Land, for the most part, is considered to be owned by an entire clan and law prohibits foreign ownership of land (Palau Constitution).



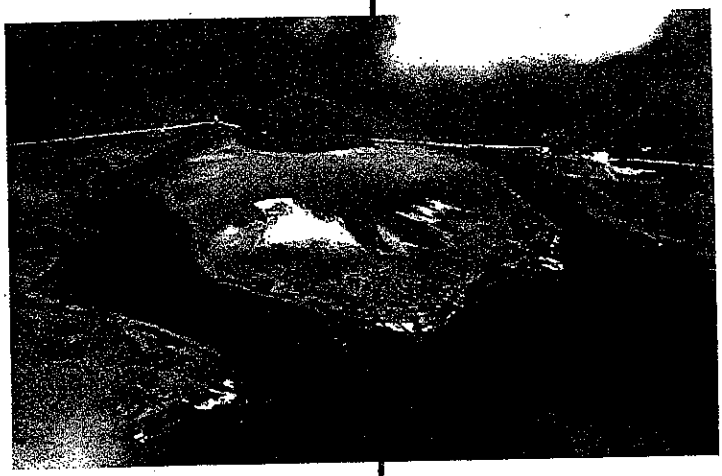
Traditional money beads and Toluk (female money) are still used today for Custom purposes. Traditional money is still highly valued and prized within Palauan society.

1.7 Transportation

Palau currently has 61 kilometers of highways, with 36 kilometers of paved road (CIP, 2002). The major port, Malakal Harbor, is located in Koror Island, the provisional capital city. At present, the country has three airports, but only the Palau International Airport located in Airai State, has paved runways. The Palau International Airport is currently under expansion to accommodate additional air traffic. The completion date of the expansion project is projected for late 2004 (CIP, 2002).

Palau has a series of low-laying causeways connecting several islands to the provincial capitol of Koror. Three of Palau's major causeways that are considered of high economic importance will be severely affected by climate change and sea level rise.

- the causeway connecting Koror to Airai where the Palau International Airport is located;
- the causeway connecting Koror to Ngerkebesang where the Executive Branch of the National Government and National Hospital are located; and
- the causeway connecting Koror to Malakal island where Palau's national maritime port is located.



Causeways connecting the islands are vital to local transportation and economic acitivity. They are at risk from sea level rise and storm damage as climate change

Over the past two decades, the number of cars on-island has increased at a rate of nearly 300 vehicles per year (MoA, 2000). Importation of car parts and accessories, appliances, and prepackaged goods has nearly tripled i the past decade. Currently, only car batteries are reclaimed by the Environmental Quality Protection Boarc (EQPB) and stored until an economically viable means tc export these batteries becomes available. Currently one beverage can recycling operation exists in Palau.

1.8 Energy Sector

Palau currently has one public utilities corporation, Palau Public Utilities Corporation (PPUC), that supplies electrical services to all the inhabited islands. The PPUC is a sem private corporation that manages all of Palau's on-island energy production. PPUC operates an eighteen megawatt and a six megawatt energy plant located in Aimiliik State and Malakal island respectively .

The Aimiliik Power Plant services the islands of Babeldaob, Airai, and parts of Koror; w the Malakal power plan services the islands of Malakal, Arakabasng, and parts of Kc PPUC also services the more remote islands of Kayangel, Peleliu, Anguar, and the Southwest via generators. The PPUC is also exploring other alternative energy option a more cost effective means to provide energy to the outer islands.

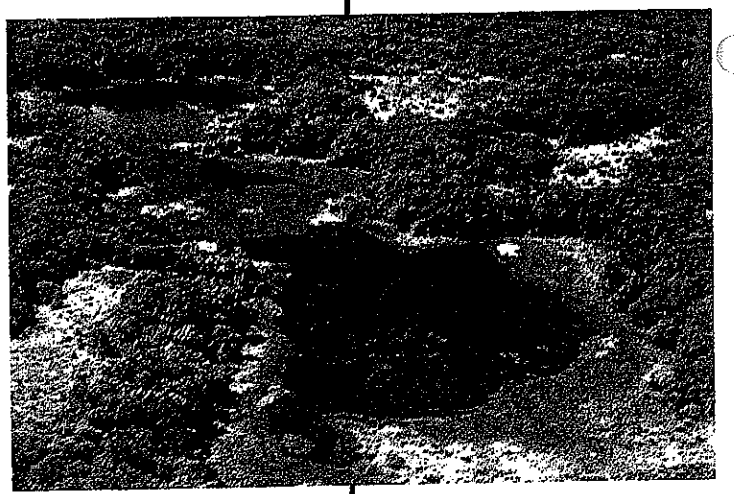
There are two major gas companies in Palau. Both Shell Oil and Mobil Micronesia store fuel near Malakal Harbor and provide bunkering services to various airlines and international fishing vessels. Additionally, three private companies provide Liquid Petroleum Gas (LPG), which is highly used for domestic cooking.

1.9 Water Resources

The primary source of fresh water in Palau is from the atmosphere in the form of precipitation. The pattern of late afternoon rain, rainy seasons, and yearly variations related to global climatic changes such as the ENSO, all affect the availability of rainwater as a resource. Groundwater is found in Palau, though the groundwater lens is thought to be fairly thin and most water pumped from the ground is non-potable. The majority of freshwater used is surface water.

Lake Ngardok is the largest freshwater lake in Micronesia encompassing 0.18km^2 with a storage capacity of 15,000,000 gallons. The longest river in Palau, Ngerdorch River, drains from Lake Ngardok and flows 10km to its mouth. The Ngermeskang River is the second largest river and part of the Ngeremeduu, the largest watershed on the west coast of Babeldaob. The Ngirikiil watershed, located in southern Babeldaob is the main source of water for Palau's population, supplying 4 million gallons of water a day. These watershed areas are highly valued due to freshwater that is collected here. They are also ecologically valuable, supporting wetland vegetation, freshwater species of fishes and invertebrates, nesting birds, and crocodile breeding areas.

Lake Ngardok is considered to be a major breeding ground for the endangered Indo-Pacific crocodile. It is the largest natural freshwater lake in Micronesia.

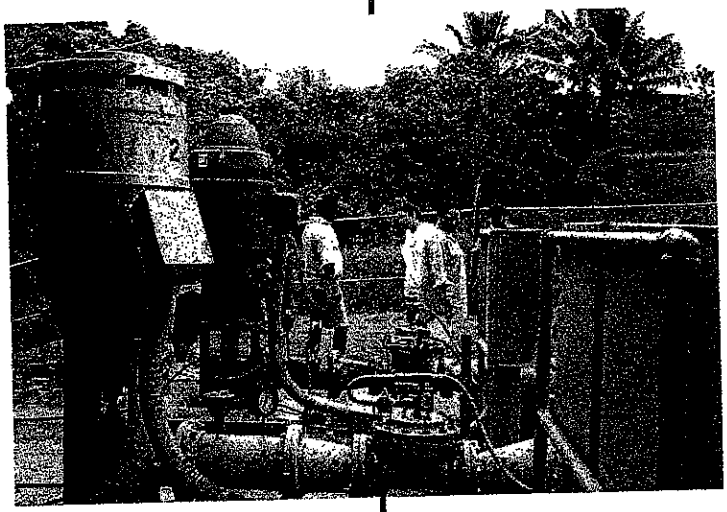


Threats to Palau's water resources include man-made contamination and climate change. Uncontrolled development, poor land uses, and deforestation in combination with intense rainfalls may lead to rapid soil stripping and severe land degradation. There is also the potential a decrease in precipitation over the next century.

The use of fertilizers, herbicides, fungicides, and pesticides are not yet widespread.

1.9.1 Usage

Palau produces 300 billion gallons of water per year from surface water runoff and about 40 billion gallons of water annually from groundwater recharge in Babeldaob. Approximately 110 billion gallons is produced from the re on Palau. A total of 450 billion gallons of internal renewable water is available in Palau (Gonzales, Winzler and Kelly, 2001). The mean rate of water usage per cap per day is 100 gallons per person per day, a consumptio rate of approximately 6.9 million gallons per year for Palau's current population.



Freshwater management remains as the most critical component to the sustainability of Palau's long-term health.

Constraints on water usage are inadequate storage capacities and lack of well-established infrastructures fc distribution. The current water treatment plant in Airai pumps 4 million gallons per dc which 35 to 45 percent is lost through transmission (Marek, personal communication).

1.10 Agriculture

Palau lost an estimated 20 percent of its forests, grasslands, and farmlands due to uncontrollable fires during 1997/98 (MoJ, 2000). During the same year, Palau experienced a 100 percent loss of taro crops (traditional food supply) on the islands Anguar, Pelelliu, and the western side of the big island of Babeldaob (Bishop, 1999). date, the taro patches have not recovered and indicators show that Palau is expec to see an increase in duration and intensity of events such as El Nino and La Nina (IP 2000).

Changing migratory patterns of certain species are causing havoc to Palau's natur environment and social interaction. Invasive alien species have been responsible f decreased production of fruits and vegetable for local consumption and potential export. A 1995 agricultural survey showed that the introduction of the Oriental Fruit

caused up to 100 percent damage to the mountain apple and carambola and 80 percent damage to guava and bananas plants (MoA, 2001).

Although agriculture production has fluctuated since 1995, population has steadily grown at a rate of 2.5 percent from 1995 to the present time. For example, in 1995 fruit and vegetable production totaled 555,964 pounds, 1996 total production was 752,956 pounds, and 1997 total agriculture production was 764,814 pounds. Palau experienced a large increase in agriculture production from 1995 to 1996. Similarly, marginal production change from 1996-1997 shows only a 1 percent increase. However, this 1 percent growth in agriculture production is not compatible with Palau's 2.5 percent population growth rate, which has consistently increased over this period (MoA, 2002). Due to financial and human resource limitations, 1998 was the last year data was collected on Palau's agricultural production.

Palau's agricultural sector, including traditional taro farming, has been negatively impacted in recent years by increased intensity and frequency of droughts, storms, and sea level rise.

During the past ten years, there has been a significant shift from a traditional subsistence lifestyle to a more western style economy. A high percentage of young Palauans are professionally employed in trade and industry. This shift has escalated the growth of foreign labor commercial farming companies that conduct large-scale agricultural production.

1.10.1 Import Dependency

Palau imports all its energy generating requirements. In 1990/2000, there was sharp increase in imports reaching nearly 110 percent of GDP. This sharp increased was primarily due to capital improvement goods such as metal products, machinery, and equipment (IMF, 2002). Imports of fuel, food, and beverages, together accounted for 28 percent of total imports. This figure also increased to about 45 percent during 1999/2000. Imports are estimated to have declined by 25 percent in 2000/2001, as most construction-related goods have already been imported.

In comparison, Palau's exports, accounting for about 10 to 15 percent of GDP, consist mostly of fish (sashimi-grade tuna) and one foreign-owned garment manufacturing company.

1.11 Health

Palau has a comprehensive health care system. Basic public health and medical care is available at the Palau National Hospital. The Bureau of Public Health also services the outlaying States with seven satellite medical facilities. Two additional private medical clinics also provide comprehensive health care. Palau also has a well-developed health care referral program to hospitals in the Philippines, Guam, and Hawaii.

1.12 Economy

As with many small island countries, Palau faces many economic constraints deriving from geographic isolation, a small domestic market, lack of adequate infrastructure, high vulnerability to external and natural stresses, and a narrow resource base in terms of its natural, financial, and human assets.

Due to its past status as a UN Trust Territory under United States administration, Palau's currency is based on the US Dollar. Palau's main income sources are from the Compact of Free Association (the Compact) payments, tourism, trade, subsistence fishing and agriculture production, and services mainly derived by the public sector (BOH, 2000). The Compact payments, which are scheduled to end in 2009, constitute the largest income for the Republic.

Figure 1.4: Palau's Major Economic Indicators.

Indicator *(even years)*	1994	1996	1998	2000
Population	16,783	17,680	18,500	19,129
Population growth (%)	2.6	2.6	2.0	2.3
Life expentacy	69.5	68	70.9	70.5
Crude birth rate (per 1,000 population)	22.28	20.17	15.14	13.45
Infant mortality (per 1,000)	21.98	18.55	9.82	18.25
Life expectancy at birth (both sexes)	69.46	68.02	70.89	70.48
Total fertility rate (average)	2.7154	2.441	1.8081	1.535
Non-resident workers	...	...	4,269	6,786
GDP (in million U.S. Dollars)	84.6	108,204	117,320	118,206
GDP per capita	5,042.60	7,028.40	6,986.60	6,127.00
Average wage rate ($yr/per worker)	7,101	7,193	7,687	8,520
Unemployment (%)	2	2.1	2.1	2.3
Forest cover (%)	76	76	76	...

Sources: Bureau of Budget and Planning

1.12.1 Compact of Free Association

The Compact of Free Association is a 50-year political, strategic, and economic treaty between the Republic of Palau and the United States. Under the Compact, Palau conducts its own domestic and foreign affairs as any sovereign nation, while the United States retains control of defense and security matters as well as exclusive strategic access to Palau's waterways. In return for this access, the United States agreed to pay the Republic approximately US$630 million during the first 15 years of the Compact (1994-2009). However, this sum is not completely monetary, but a combination of economic and technical support. To date, over half of the Compact payments have already been paid to the Republic.

1.13 Tourism

Currently the main industry in Palau is adventure tourism. In 1996, Palau derived US$67 million, or 47 percent of the GDP, from its tourism industry. From 1992 to 1997, tourist arrivals doubled from nearly 30,000 to 60,000. However, due to several factors, including global warming, Palau's tourism numbers have been in decline since the 1998 coral bleaching event. This loss is reflected in a 3.3 percent drop in the GDP in 1998. In 2001, Palau started to see a slight increase in tourism arrivals. However, the numbers of tourists visiting Palau annually are still far below 1997 tourist arrivals.

Figure 1.5: Palau's Tourism arrival trends for the period between 1994-2000.

	1994	1995	1996	1997	1998	1997/98 % change	1999	2000
Tourists			58,022	63,601	59,780		45,462	42,470
Business			2,697	2,840	3,876		3,708	3,462
Employment			3,347	3,425	3,926		3,746	5,064
Other			5,264	3,853	1,346		3,944	5,506
TOTAL	44,073	53,229	69,330	73,719	68,928	-12.9	56,466	56,502

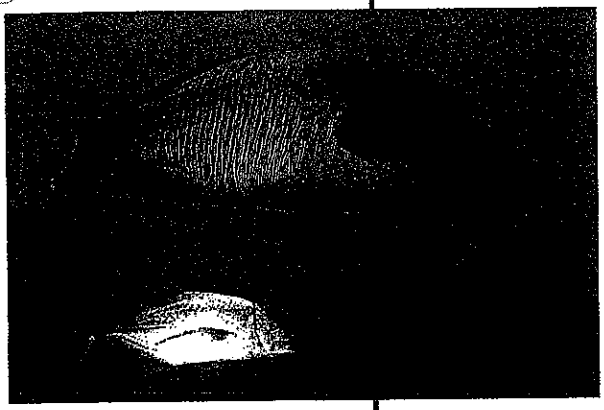
Source: Palau Visitors Authority

To address this issue, the Executive Branch initiated the 2002 National Committee on Sustainable Tourism Policies and Action Plans to review the various strategic and management plans for the development of Palau's tourism sector. The major outcome of the Committee was the development of the National Tourism Unit (NTU), under the Office of the President. The NTU is mandated to facilitate change by implementing a program of coordinated growth, developing policies, and establishing new tourism management activities within

the context of sustainable development. The NTU has a two-year programmatic framework to implement the outcomes of the Committee.

1.14 Fisheries

Palau's commercial fishing industry is quite small, with an average annual income of approximately US$3.5 million (BOH, 2000). The commercial fishing industry largely consists of foreign long-lining fishing vessels , mainly targeting tuna, in Palau's exclusive economic zone (EEZ). The sale and processing of the fish is done off-island.



Cheilinus undulatus and *Caranax melampygus* - The Napolean Wrasse and Bluefin Trevally are commonly found along Palau's reefs. Reef fisheries continue to be the major source of protein in the Palauan diet.

Fish exports declined in 1997/98 by about 20 percent as compared to 1995/96. This was primarily due to the government requirement that all fishing vessels install Vessel Monitoring Systems (VMS), as well as the 1997/98 El Nino event (IMF, 2002). Subsequently, fish exports rose by 23 percent in 1998/99 as several neighboring countries also began to require that fishing vessels install VMS. In 2000/01, fish exports are estimated to have fallen again by 33 percent to approximately US$7 million, compared to a peak of US$13 million in 1994/95 (IMF, 2002).

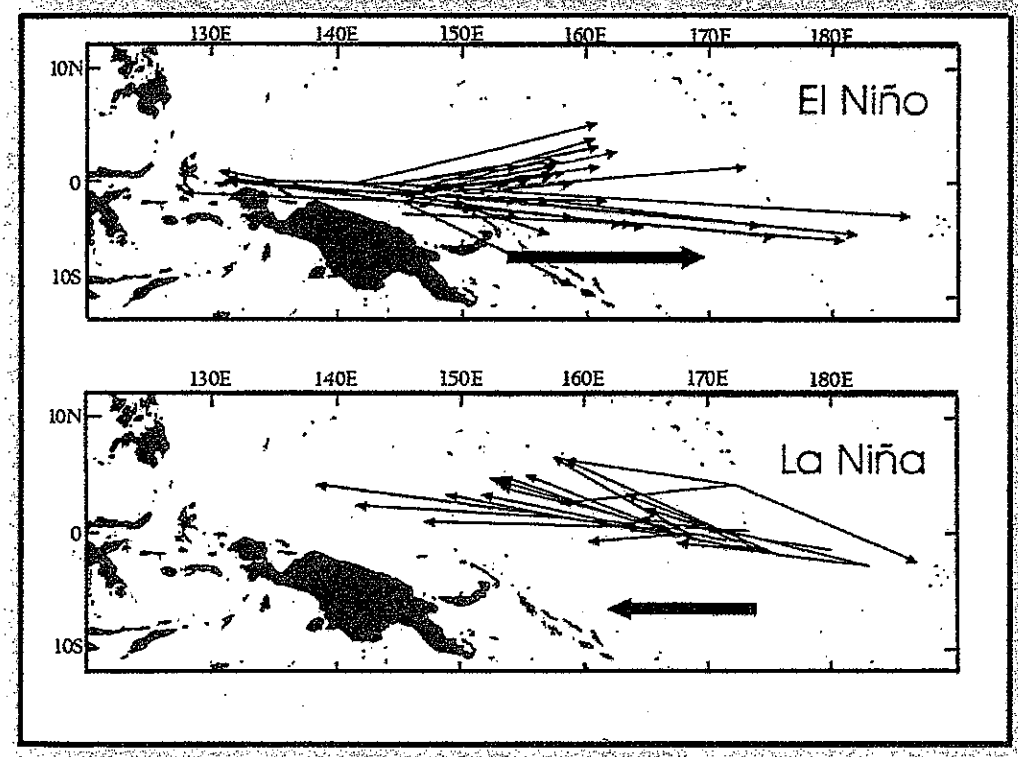
As stated above, it is possible that climate change may affect the migratory fish populations in Palau's waters. The future distributions of these wide-ranging species are difficult to predict. However, climate change may affect regional tuna fisheries in two major ways: by raising average ocean surface temperatures to levels currently experienced during medium-intensity El Ninos and by increasing year-to-year climate variability (World Bank, 2000). The likely impacts are expected to be pervasive, affecting distribution, abundance, and catchability of tuna and other pelagic species.

Primary productivity of tuna in the central and eastern Pacific ocean would decline due to the increased stratification between warmer surface waters and colder deeper water. The decreased upwelling may induce a decline in bigeye and adult yellowfin populations. However, skipjack and juvenile yellowfin tuna are not expected to be affected.

Tuna Fisheries and Climate Variability

The distribution of tuna fisheries is affected by the location of the Western Pacific Warm Pool (WPWP), an area of warm surface water that produces virtually all the tuna caught by purse seine, a fishing method used to collect surface tuna for canning. By itself the WPWP is nutrient poor. By contrast, the colder waters of the central equatorial Pacific generate an upwelling of colder, nutrient-rich waters, that produce the deep water sashimi grade tuna across the whole tropical and sub-tropical ocean. These two oceans areas meet in a zonal band called the "cold tongue," the primary productivity of which is strongly influenced by ENSO variability. During El Nino years, the WPWP can extend eastward into the central Pacific by nearly 4,000 kilometers.

Movement of Tagged Skipjack Tuna in the Central and Western Pacific



Source: Lehodey et al. (1997)

Greenhouse Gas Inventory

2.1 Introduction

As a non-Annex I Party to the United Nations Framework Convention on Climate Change (UNFCCC), the Republic of Palau is required to develop, periodically update, and publish its national inventory of anthropogenic emissions and removals of all greenhouse gases not controlled by the Montreal Protocol on Substances that Deplete the Ozone Layer.

2.2 Methodology, Assumptions, and Data

In accordance with decision 10/CP.2 of the Conference of the Parties (CoP) to the UNFCCC, the inventory was prepared using 1994 as the base year. Except were noted, the methods and default values under the revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories were used to determine Palau's greenhouse gas emissions.

Figure 2.1: Completeness of Data for Palau's Greenhouse Gas Inventory

	1994	1995	1996	1997	1998	1999	2000
Energy	✔	(✔)	(✔)	(✔)	(✔)	(✔)	(✔)
Industrial Processes	✔	✔	✔	✔	✔	✔	✔
Agriculture	✔	✔	✔	✔	✔	✔	✔
Land-Use Change and Forestry	✔						
Waste	✔						

Figure 2.2: Integrated Inventory of Annual Emissions for Palau in 1994

		Carbon Dioxide (Gg CO_2)	Methane (Gg)	Nitrous Oxide (Gg)	Nitrogen (kg)	NMVOC (Gg)
Energy		82.11				
Industrial Processes						0.195
Agriculture		3.48		0.02	180.6	0.046
Land-Use	Removals	-424.03				
	Emissions	6.84				
Waste			0.55	<0.01		
Total		-331.6	0.55	0.02	180.6	0.241

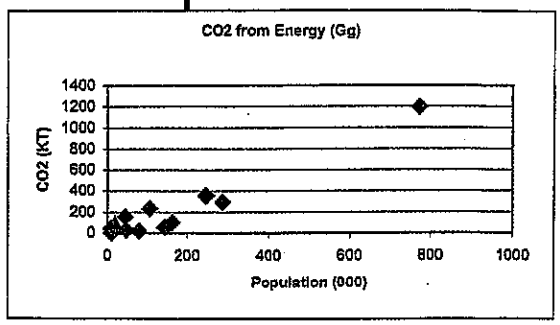
Due to insufficient data availability to carry out a more detailed sectoral approach, the IPCC Reference Approach was used to estimate greenhouse gas emissions from the energy sector. No consideration was given to the sector "Solvents and Other Product Use" as no methodology is provided in the IPCC Guidelines. Additionally, in the case of Palau, emissions from this sector are assumed to be insignificant.

2.3 Results and Analysis

Figure 2.2 quantifies the estimated emissions of GHGs by Palau in 1994. Emissions of CO_2 by the energy, agriculture, and land-use sectors were substantially offset by removals associated with changes in stocks of forests and other woody biomass.

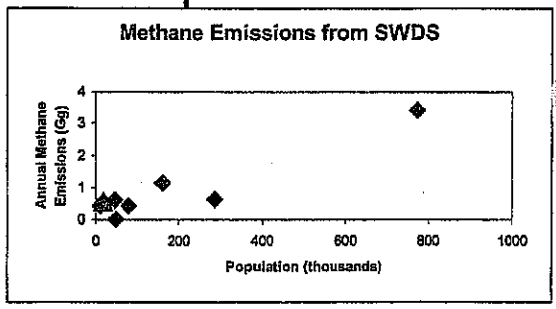
2.4 Quality Assurance

It was possible to assess the level of confidence in some of the emissions estimates by following the procedures used by Hay and Sem (1999). For example, CO_2 emissions from Palau's energy sector are consistent with those of ten other Pacific Island countries, when assessed relative to the national population (Graph 2.1).



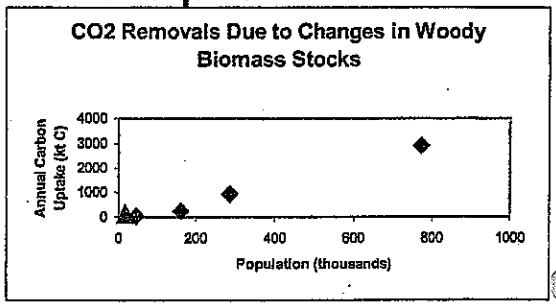
Graph 2.1: Estimated CO_2 emissions from Palau's energy sector in 1994 (shown by red triangle) relative to its national population. Comparable values are shown for ten other Pacific Island countries (after Hay and Sem, 1999).

Similarly, consistent results are found for emissions of methane (Graph 2.2) and for total carbon uptake due to changes in forest and other woody biomass stocks (Graph 2.3).



Graph 2.2: Estimated methane emissions from Palau's solid waste disposal site in 1994 (shown by red triangle) relative to its national population. Comparable values are shown for six other Pacific Island countries (after Hay and Sem, 1999).

It was not possible to undertake compared estimated CO_2 emissions from the energy sector using the IPCC Reference Approach and the more detailed sectoral approach. Insufficient data were available to estimate emissions from the energy sector using the more detailed sectoral approach.



Graph 2.3: Estimated carbon uptake due to changes in forest and other woody biomass stocks in 1994 (shown by red triangle) relative to its national population. Comparable values are shown for six other Pacific Island countries (after Hay and Sem, 1999).

2.5 Uncertainties

The summary overview table in the Revised 1996 IPCC Guidelines was used to report the levels of confidence in the emissions estimates, as well as the status of the emissions estimates, the level of disaggregation of the estimates, and the completeness of the documentation.

In general, reported emissions are for total emissions for all sources (there is no disaggregation), there is medium to high confidence in each estimate.

Figure 2.3: Apparent Domestic Consumption of Fuel and Associated CO_2 Emissions in 1994.

	Apparent Domestic Consumption		CO_2 Emitted
	Tons	TJ	Gg CO2
Gasoline	5966	267.26	18.34
Other Kerosene	316	14.16	1.01
Gas/Diesel Oil	19388	840.07	61.6
LPG	130	6.18	0.39
Lubricants	267	10.73	0.78
Solid Biomass	53	0.83	0.09

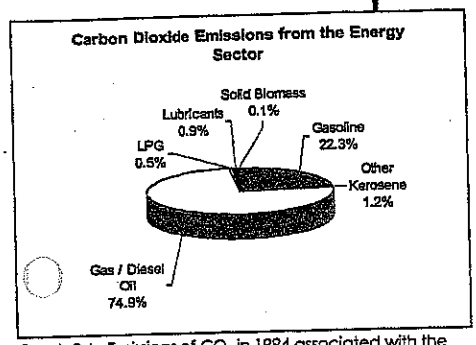
2.6 Greenhouse Gas Emissions by Sector

The national greenhouse gas emissions and removals for all sectors for the baseline year of 1994 and from 1994 to 2000 for

the selected greenhouse gas emissions related to the following sectors: energy, industrial processes, agriculture, and land use and forestry.

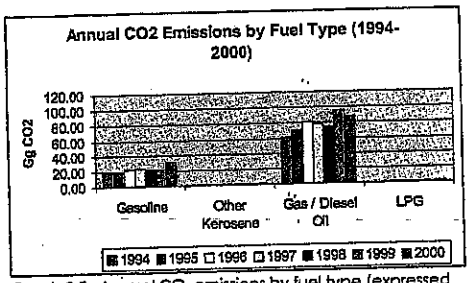
2.6.1 Emissions From the Energy Sector

Figure 2.3 depicts the apparent domestic consumption (i.e. imports combined with domestic production less international bunkering) of fuels consumed within the energy sector of Palau in 1994, including transportation. Graph 2.4 shows apparent domestic consumption (imports combined with domestic production less international bunkering) for 1994 and indicates that the dominant fuels consumed domestically in Palau are gas and diesel oil, followed by gasoline. Other fuels collectively comprise a small portion of national fuel consumption.



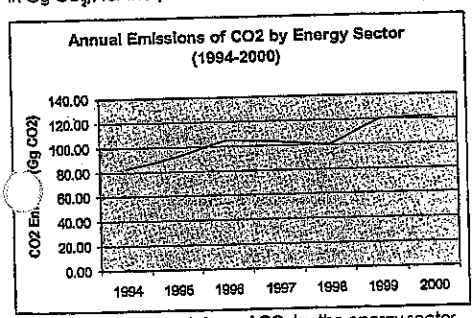
Graph 2.4: Emissions of CO_2 in 1994 associated with the domestic consumption of fuels (expressed in percent).

Total emissions of CO_2 in 1994 amounted to 82.11 Gg CO_2. This is equivalent to emissions of 4.69 tons of CO_2 per capita. A range of 0.23 to 4.60 tons of CO_2 per capita was reported by Hay and Sems (1999) for ten Pacific Island countries and a value of 4.02 tons of CO_2 per capita for the entire world in 1994.



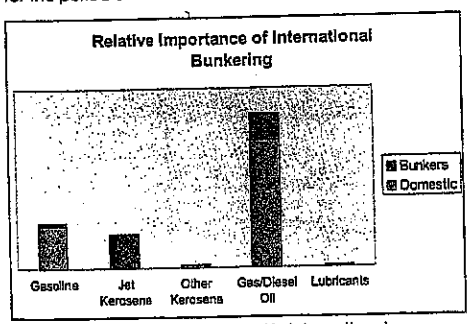
Graph 2.5: Annual CO_2 emissions by fuel type (expressed in Gg CO_2), for the years 1994 to 2000, inclusive.

Annual emissions of CO_2, by fuel type for the period of 1994 to 2000, are shown in graph 2.5. This indicates a substantial and relatively consistent increase in CO_2 emissions by the energy sector over time, a situation that is also demonstrated in Graph 2.6. By 2000, total annual CO_2 emissions from the energy sector had risen to 121.88 Gg CO_2, an increase of 32.6 percent over 1994 values.



Graph 2.6: Annual emissions of CO_2 by the energy sector, for the period of 1994-2000, inclusive.

Graph 2.7 shows the amounts of fuel used for international bunkering, relative to that imported for domestic consumption. Data are for 1994. Similar annual data are available for 1995 to 2000, inclusive. Absolute values are not provided due to confidentiality requirements. All jet kerosene is used for international aviation. Smaller portions of gas/diesel oil, gasoline and lubricants are also used for international bunkering. None of the "other kerosene" is bunkered.



Graph 2.7: Quantities of fuel used in international bunkering in 1994, relative to those imported for domestic consumption.

2.6.2 Emissions from Industrial Processes

Figure 2.4 presents annual emissions estimates associated with soda ash use, road paving with asphalt, alcoholic beverage, bread and other food production, for 1994 to 2000, inclusive. Quantities produced are also shown. Some values may be revised after additional quality controls are applied. Soda ash use was not recorded prior to 1999 and beer production commenced in 1998. In all cases the emissions are small on both a relative and absolute basis, and with varying trends over time.

Figure 2.4: Quantities Involved in Soda Ash Use, Road Paving with Asphalt, and with Alcoholic Beverage, Bread and other Food Production, and the Associated Emissions of Greenhouse Gases.

		1994	1995	1996	1997	1998	1999	2000
Soda Ash Use	Amount (t)						17.9	35.8
	CO2 (Gg)						0.01	0.01
Asphalt	Amount (t)	600	502	712	427	143.5	635	505.5
	NMVOC (Gg)	0.19	0.16	0.23	0.14	0.05	0.2	0.16
Beer	Amount (hl)					70	244	283
	NMVOC (kg)					2.45	8.54	9.91
Spirits	Amount (hl)	17.03	17.03	42.58	42.58	42.58	58.9	80.73
	NMVOC (kg)	255.45	255.45	638.7	638.7	638.7	883.5	1210.95
Cakes etc	Amount (t)	160.81	160.81	160.81	160.81	167.14	167.14	196.19
	NMVOC (kg)	160.81	160.81	160.81	160.81	167.14	167.14	196.19
Bread	Amount (t)	307.34	307.34	307.34	307.34	321.54	320.82	320.82
	NMVOC (kg)	2458.72	2458.72	2458.72	2458.72	2572.32	2566.56	2566.56

2.6.3 Emissions from the Agriculture Sector

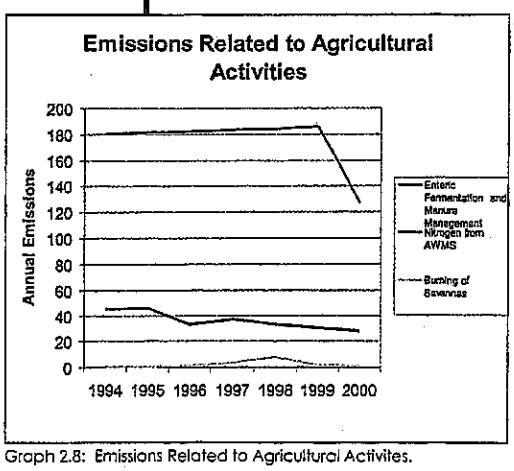
Figure 2.5 depict emission estimates associated with methane emission from enteric fermentation and manure management, nitrogen emissions from animal waste management systems, carbon emissions from the burning of savannas and from the field burning of agricultural residues and of direct N_2O emissions from agricultural soils. Other emissions due to agricultural activities have been estimated and are well within the margin of error and are not reported here.

Figure 2.5: Emissions Related to Agricultural Acitivites.

		1994	1995	1996	1997	1998	1999	2000
Enteric Fermentation and Manure Management	Tons Methane	46.02	46.08	33.54	37.76	33.45	31.38	28.79
Nitrogen from AWMS	kg/N/yr	180.6	181.5	182.4	183.3	184.2	186	126.9
Burning of Savannas	Gg Carbon	0.89	0.54	1.19	3.58	7.75	1.79	1.19
Field Burning of Agricultural Residues	Gg Carbon	0.06	0.06	0.02	0.14	0.07	0.12	0.23
Direct N2O Emissions from Agricultural Soils	Gg N2O	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Graph 2.8 shows emission estimates associated with methane emissions for enteric fermentation and manure management (tons of Methane), nitrogen emissions from animal waste management systems (kg/N/yr), and carbon emissions from the burning of savannas (Gg Carbon).

Graph 2.8 demonstrates the temporal trend of the main emissions associated with agricultural activities, for the years 1994 to 2000, inclusive. In all cases



Graph 2.8: Emissions Related to Agricultural Acitivites.

the emissions are small on both a relative and absolute basis, and with varying trends over time.

2.6.4 Emissions from Land-Use Change and Forestry

Figure 2.6 shows the annual removals of atmospheric carbon associated with land-use activities in Palau, based on a three-year average (ending in 1994), except for the decay of above ground biomass where a ten-year average is used. The release of carbon as a consequence of forestry activities could not be estimated due to the lack of relevant activity data. However, annual emissions are likely to be small due to the low level of forestry activity in Palau. The data for Palau indicate that, in terms of land-use activities, there is a net uptake of carbon.

Figure 2.6: Annual Removals of Atmospheric Carbon Associated with Land-Use Change in Palau and Selected Other Pacific Island Countires.

	Units	Palau	Cook Is	Fiji	Samoa	Solomon Is
Land-use - Carbon Removal	kt Carbon	115.65	42.12	2902	240.19	920.19
	Gg CO_2	424.03	154.44	10641	880.7	3374.03
Biomass Burning – Carbon Released	kt Carbon	0.08		375		
Decay of Above-Ground Biomass – Carbon Released	kt Carbon	1.78		55		
Total Annual Carbon Released from Burning and Decay	Gg CO_2	6.84		2149	125.21	7674

2.6.5 Emissions from Waste

Figure 2.7 presents the annual methane emissions from the solid waster disposal site (SWDS) and as a consequence of wastewater treatment and annual emissions of N_2O from human sewage. Also shown in Figure 2.7 are equivalent data fro other Pacific Island countries for which data are available.

Figure 2.7: Emissions Associated with Waste and Waste Treatment in Palau and Selected Other Pacific Island Countries.

	Units	Palau	Cook Is	Fiji	Kiribati	Marshall Is	Nauru	Samoa	Solomon Is
Methane from SWDS	Gg	0.55	0.01	3.4	0.43	0.62	0.43	1.15	0.63
Methane from Wastewater Treatment	kg	0.11							
N_2O from Human Sewage	Gg	0.0018							

2.7 Comparison with Other Countries

In 1994, emissions of CO_2 by Palau's energy sector amounted to only 0.0004 percent of the global emissions of CO_2 due to energy production. In comparison, Palau has only 0.0003 percent of the global population, reflecting that emissions of CO_2 by Palau's energy sector are above the global average on a per capita basis. By way of contrast, OECD countries had per capita emissions of 11.09, resulting from having 54 percent of the global emissions

despite having only 19 percent of the global population.

Figure 2.8: CO_2 Emissions from the Energy Sector in Comparison with the Rest of the World.

Country/Region	Population (thousands)[1]	CO_2 Emissions from Energy Sector (MT CO_2)[2]	1990 Petroleum Consumption Expressed as Equivalent CO_2 Emissions (MT of CO_2)[3]	CO_2 Emissions per Capita for Energy Sector (tones of CO_2 per capita)[4]	% of Global Emissions	% of Global Population
Palau	17	0.082	0.083	4.69	0.0004	0.0003
Pacific Islands	7100	6.82		0.96	0.0301	0.123
OECD	1092300	12117.05		11.09	54	19
World	5624400	22620.46		4.02		

1 Data sourced from SPREP (1999) and IEA (1998)
2 Data sourced from Palau Inventory, Hay and Sems (1999) and IEA (1998)
3 Data sourced from Johnston (1995)
4 Data sourced from Palau Inventory and Hay and Sems (1999)

Palau is a minor emitter of greenhouse gases, in both a relative and absolute sense. Thus, any steps Palau takes to reduce its emissions, and enhance its carbon sinks, will have a negligible effect on the enhance greenhouse effect and global warming. However, steps should be taken to increase efficiency of existing energy supply systems. Increased efficiency in the current energy supply system, combined with alternative energy, would equate to increased cost savings to the Republic over the long term.

The inventory data collected and analyzed over time should provide an opportunity to quantify the extent to which land use change and changing use of fuels for Custom in Palau are contributing to net increases or decreases in atmospheric greenhouse gas concentrations. Although the magnitude of the resulting changes will be small from the global perspective, the findings will be instrumental in guiding national policies, and implementing plans that achieve larger reductions in global net emissions. Thus baseline and subsequent inventories are fundamental to being able to track the benefits and costs of mitigation strategies that have been implemented over time.

2.8 Data Gaps

Preparation of Palau's first national greenhouse gas inventory identified several gaps and difficulties in applying the Revised 1996 IPCC Guidelines. Many of these culminated in uncertainties in the estimated emissions and removals. To date, the inventory has been completed for all five sectors for 1994. The greatest constraint to compiling the GHG inventory in Palau was insufficient data to adequately calculate actual emissions.

2.8.1 Energy Sector

The IPCC Reference Approach was used to estimate emissions from the energy sector since there is no breakdown of fuel by source category, meaning that detailed technology-based (Tier 1) calculations could not be undertaken at this time. Changes in stock and amount of carbon stored could not be estimated as the required data are not available. In the absence of locally developed values, default values were used for carbon emission factors and for the fraction of carbon oxidized.

There are two major power plants currently supplying Palau's energy needs. Reducing dependance on fossil fuels is a priority of the present Administration.

To date, one of two major fuel importers, has made annual data available for the years 1994 through 2000 for gasoline, jet kerosene, other kerosene, gas/diesel oil, and lubricants. However, data have not been made available by the other fuel importers, requiring these imports to be estimated. This presents a major gap, and hence a significant shortcoming in the confidence of the inventory. Data on imports of LPG for the period of 1994-1999 were estimated using IPCC defaults. LPG data for 2000 was made available for the inventory.

Estimates of biomass consumption were made using procedures in accordance with IPCC guidelines, and relates only to firewood used for lime production, funerals, births, and other Custom. While the number of births and deaths were available from official census records, all other variables represent crude estimates at best.

2.8.2 Industrial Processes

The assumption that emissions relate only to four industrial activities (soda ash use, asphalt production, alcoholic beverage production, and production of baked foodstuffs, relevant to Palau must be verified. In the absence of locally developed values, default values were used for all emission factors and for other relevant variables. It was assumed that the only domestic use of soda ash was for the Koror-Airai Water Treatment Plant. Data was available for 1999 onwards, when the Plant went on-line. However, annual consumption data of soda ash used at the Water Treatment Plant must be reconciled with important records.

The inconsistency in activity data related to road paving with asphalt needs to be reconciled, rather than rely on information provided by one domestic construction company.

At this time, emissions arising from alcoholic beverage production and bread production and other food production are small on an absolute and relative basis.

2.8.3 Agriculture

In the absence of locally developed values, IPCC default values were used for all emission factors and for other relevant variables. Numbers of animals for each livestock type are available for 1996 and 1999 only, requiring forward and backward extrapolations for 1994, 1995, and 2000. Emissions estimates will need to be revisited for 2000 when the official statistical data for that year becomes available.

In the absence of formal data pertaining to forest and savanna fires, the National Fire Department provided estimates for the period of 1994 through 2000. Estimates of the amounts of agricultural residues burned in the field were based on crop data available for 1995 to 1997, only. This necessitated extrapolations for 1994, 1998, and 2000.

Estimates of emissions of nitrogen from agricultural soils also require considerable activity data, as well as the use of default values in the absence of locally derived values. To estimate emissions for Palau, the principal data requirements relate to the amount of nitrogen fertilizer applied annually. Data are available for 1998 and 1999 only. There was no other viable option than to assume similar levels of fertilizer use for earlier years.

Taro (above) and tapioca are traditional sources of carbohydrates in the Palauan diet.

2.8.4 Land-Use Change and Forestry

In the absence of locally developed values, IPCC default values were used for all emission factors and for other relevant variables. The areas of forest and other woody biomass stocks were estimated using information from the 1979 Vegetation Survey of the Republic of Palau. No information was available on commercial harvest of forests and other woody biomass stocks. Traditional fuel wood consumed has been estimated under Energy. Estimates of CO_2 emissions from biomass involved in forest and grassland conversion required information on the area converted. In the absence of more substantive data, a value was prepared using information contained in the

Environmental Quality Protection Board permits issued for developments in Koror and Airai States.

Quantifying the carbon released by decay of biomass requires an estimate of the area converted, averaged over ten years. In the absence of more substantive data, a value was prepared based on the advice of the Bureau of Agriculture. No attempt has been made to estimate non-CO_2 gas emissions resulting from on-site burning of forests. It was assumed that the quantities involved are likely to be insignificant and within the margin of error.

2.8.5 Waste

In the absence of locally developed values, default values were used for all emission factors and for other relevant variables. Currently there is only one solid waste disposal facility that handles solid waste generated by the urban population in Koror State. Methane emissions from this site were estimated, but not those from the several rural and unmanaged solid waste disposal sites that exist in other parts of Palau.

The country's landfill is a major contributor to Palau's GHGs. An effort to develop an effective recycling program is currently underway.

Population census data for 1995 and waste characterization data obtained in 1999 were used to estimate population and waste amounts and composition for 1994. This was the most appropriate and expedient approach, in the absence of other more relevant data. No methane is recovered from the disposal site in Koror State. The methane correction factor was estimated on the basis that the landfill is unmanaged, with the waste being at least 5 meters deep.

The emissions of methane from the treatment of domestic and commercial wastewater used 1994 national data on BOD in wastewater, with the calculated BOD value being the same as the IPCC default value for Oceania. Industrial wastewater is not treated separately, and is included in the total calculations.

The estimate of indirect nitrous oxide emissions from human sewage used the estimated population of Palau in 1994 and annual average per capita protein consumption for th country. The estimated emissions are small and within the margin of error.

Greenhouse Gas Mitigation

3.1 Introduction

The results of the National Greenhouse Gas Inventory provides a comprehensive set of national data that can be used in the preparation of national sustainable development strategies and for assessing the success of these strategies over time. For example, the inventory can assist Palau recognize opportunities to increase the efficiency of existing energy supply systems and to consider opportunities for substituting less costly fuels.

3.1.1 Economic Factors

Economic factors may influence the decision to reduce emissions through increased efficiency of existing energy supply systems and to consider opportunities for substituting less costly fuels. The information available as a result of the greenhouse gas inventory will help determine the cost effectiveness of various options and, in turn, guide the decision-making process as it relates to investment and other initiatives.

3.1.2 Political Factors

Political factors may influence the decision to reduce emissions through improved efficiencies and/or use of fuels that produce emissions with a lower global warming potential. For example, the international standing and credibility of Palau will be enhanced if there is a demonstrated willingness to act in concert with other countries, rather than pleading special circumstances.

3.2 Energy Demand and Use

Palau imports all its energy supplies to meet the demand of its private and public sectors. Palau's social and economic development is highly dependant on its current sources of energy. This aspect of Palau's growth combined with its economic isolation makes large-scale mitigation options difficult at best. However, mitigation measures related to energy consumption in Palau can be subdivided into demand side and supply side options.

3.2.1 Demand Side Options

Demand side options would include improved efficiencies and fuel substitutions in the transport and industrial sectors, labeling schemes, and education and awareness programs. Such measures can be further targeted to foster accurate costing mechanisms if the information provided by a national greenhouse gas inventory is available to decision makers and planners.

Energy Efficient Products

Measures should be taken at the national level to develop mechanisms to require the government procurement process to purchase energy efficient appliances and equipment for public sector buildings. This can include 'energy star' equipment and products such as double pane windows. Additionally, private sector incentive programs aimed at energy efficient goods for construction purposes may be developed to encourage market demand for energy efficient products and services.

On-going training in various technical fields is an important initiative of Palau's human resource capacity building.

The use of such products as high-intensity discharge lamps, which provide the highest efficacy and longest service life of any lighting type, can save 75 to 90 percent of lighting energy. This in turn reduces lighting costs by 30 to 60 percent while at the same time enhancing lighting quality and reducing environmental impacts.

Training Programs

Short-term efforts to reduce Palau's greenhouse gas consumption may focus on education and training programs related to the installation and operation of air conditioning and refrigeration systems and in-country assessments of ground transportation. Long-term measures may include improving the design of education and awareness raising programs targeting energy consumption practices geared at preschool children and youth.

Building Codes

The development of a nationally endorsed set of comprehensive building codes that incorporate energy efficient requirements will facilitate the use of energy efficient products by both the public and private sectors. The cost savings associated with energy efficient products would encourage increased use of such products over the long term. For example, 25 percent of an average household's energy bill is spent on heating water. By requiring all buildings, both residential and commercial, be equipped with solar water heaters, owners will see a cost savings of about 50 to 85 percent on their utility bills as compared to the cost of electric water heaters (DOE, 1996).

3.2.2 Supply Side Options

Supply side options include increased efficiencies and fuel substitution in existing energy systems. Again the feasibility, costs, and benefits of such options are more readily assessed if reliable and comprehensive greenhouse gas inventory data are available.

Alternative Energy Options

Short-term measures to mitigated greenhouse gas consumption levels might include wind energy assessments and the establishment and operation of sustainable photovoltaic projects. Longer-term measures might include fuel substitution in the transport sector, the development of renewable energy from waste and biomass, and the use of ocean thermal energy conversion as a possible option for a supplementary renewable energy source.

Reconditioned Vehicles

Palau has a high number of reconditioned vehicles because they are relatively inexpensive. During the past ten years, the number of cars imported into Palau has increased by 400 percent, and a high percentage of these imports are reconditioned cars. Because of this trend, Palau has severe traffic problems during peak rush hours. To reduce traffic problems and ensure air quality, the

Palau has an unusually high number of cars per capita. Vehicular transportation is a large component of the island's CO_2 emissions.

government should ban vehicles produced prior to 1994 and reconditioned vehicles with an engine capacity of less than 150cm³ into the country.

3.3 Promotion of Carbon Sinks

New (i.e. incremental) tree growth has the potential to provide greenhouse gas mitigation through the use of wood as a cooking and industrial fuel and through increases in the standing biomass. Hence the reestablishment of forests is an effective mitigation measure. While a mature forest with stable biomass is neutral in terms of emissions and removals, forests that are being harvested, cleared for agriculture or damaged by fire are net emitters of greenhouse gases.

The above area was once completely deforested during World War II. It has since regrown into a healthy limestone forest habitat supporting thousands of species.

The inventory data collected and analyzed over time should provide an opportunity to quantify the extent to which land use changes and changing use of fuels for Custom in Palau are contributing to net increases or decreases in atmospheric greenhouse gas concentrations. Though the magnitude of the resulting changes will inevitably be small from a global perspective, the findings may well be instrumental in setting national policies, and implementing plans that achieve larger reductions in global net emissions.

3.4 Solid Waste Management

Developing an integrated waste management system incorporating CH_4 recovery from landfills is an option that may be used to mitigate GHG emissions. Not only will the development of an integrated waste management system aid the Republic in the reduction of solid waste and facilitate the recovery of CH_4, but will also aid in alleviating undue stress to the natural environment, decrease pollution, and decrease health related problems derived from improper waste treatment. Development of an effective waste management system would also greatly further the Republic's goals for sustainable development over the long-term.

3.5 Coral Reefs

Palau's coral reefs supply an abundance of food, building materials, and protect the islands from wave action. Palau's coral reefs are also renown as some of the most biologically diverse marine habitats in the world and are a major component in its tourism product mix. In addition, studies have shown that healthy reefs are also a natural sink for carbon dioxide.

In order to reduce the anthropogenic and natural stresses on the reefs of Palau, measures need to be taken to reduce fishing and recreational diver impacts, diminish or ban coral dredging, ensure untreated solid waste is not discharged onto the reefs, and most importantly, reduce the amount of sediment/runoff produced from poor land-use practices.

Sphaeramia nematoptera - The juvenile pajama cardinalfish may often be found inhabiting protected reefs of the inner lagoon.

3.6 Capacity Building

Analysis conducted during the first National Greenhouse Gas Inventory suggest that the priority areas relate to ensuring that the necessary information is readily available and there is the required expertise to process and analyze it is limited. A close second would be improved methodologies, especially with respect to their applicability to the circumstances, needs, and capacities of Palau.

Future inventories will have value only if individuals who have the expertise to apply and adapt the internationally approved inventory methods conduct them. In order to make maximum use of the information acquired through the present inventory process, and to ensure that future inventories are comparable yet improved, it is important that expertise continue to be built in-country. Palau must also further develop its capacity to interpret the findings of the inventory and ensure that the information is reflected in national policies, plans, decisions, and in international negotiations.

Improved information acquisition and management systems must be an integral part of the national information gathering procedures, operating under that authority and in a way that ensures consistency and completeness in the records.

In summary, there is a need to strengthen the relevant information acquisition and management systems, address limitations on resources (financial, technical and human), strengthen institutional arrangements and address inadequacies in the methodologies. Increasing the capacity of Palau to be a more active and fruitful partner in addressing climate change issues requires a comprehensive effort across a variety of fronts.

3.6.1 Human Resources Development

Further plan, develop, and implement targeted, in-country, training which will ensure that key individuals in government ministries and agencies, State-owned and private sector enterprises are able to collect, process, and exchange specific information required to strengthen existing, and complete subsequent, National Greenhouse Gas Inventory.

3.6.2 Cross-Sectoral and Cross-Institutional Strengthening

Plan, develop, and implement an institutional strengthening program aimed at government ministries, official agencies, and State-owned enterprises to ensure each stakeholder has the policies, procedures, and commitment that will enable the necessary collection, processing, and exchange of information required to complete the National Greenhouse Gas Inventory.

President Remengesau addresses the Nation at the National Symposium on Climate Change in 2001. Issues relating to climate change were highlighted as priorties to the entire Republic.

3.6.3 National Greenhouse Gas Inventory Manual

Scope, develop, and disseminate to all relevant stakeholders a National Greenhouse Gas Inventory Guidelines for collecting, processing, exchanging information, and reporting of data required to develop the annual National Greenhouse Gas Inventory.

3.6.4 Awareness Raising and Participation

Plan, develop, and implement a holistic awareness program that will result in raised community and political awareness and participation, including the private sector, for follow-up the findings of the greenhouse gas inventory. This initiative should include integrating the findings into national development planning processes and addressing the requirements and opportunities for sustainable development at all levels.

3.6.5 Integrated Assessment of Environmental Pressures

Develop tools, methodologies, and appropriately trained national experts that will facilitate integrated assessments of State and National level policy options that address the pressures and resulting impacts of social, economic, and global changes. The initial focus may be on integrated assessments that identify the most appropriate policy options and implementation plans related to the mitigation of greenhouse gas emission in Palau, especially those highlighting energy production, supply and consumption, and to the transport and tourism sectors.

As development proceeds, there is a continuous need to monitor and mitigate impacts on Palau's natural resources.

Vulnerability to Climate Change

4.1 Introduction

The recently completed Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2001), recognizes that climate change and sea-level rise pose a serious threat to small island states. Characteristics that increase island vulnerability include their small physical size in proportion to the ocean, limited natural resources, relative isolation, the extreme openness of small economies that are highly sensitive to external shocks, highly prone to natural disasters and other extreme events, rapidly growing populations with high densities, poorly developed infrastructure and limited funds, human resources and skills.

The Third Assessment Report of the IPCC states that:

- There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities;
- Human influences will continue to change atmospheric composition throughout the 21st century;
- Projected increases in global mean temperature to 2100 lie between 1.4C and 5.8C;
- The projected increase in mean annual temperatures for the Pacific Islands region to 2050s is 1.6C and 2.5C to 2080s;
- Projected rises in global mean sea level to 2100 lie between 9cm and 88cm;
- Past long-term trends in sea level in the Pacific Islands region (2mm per year) are consistent with global changes; while there will be regional changes in sea level in the future, it is likely that region wide sea levels will continue to track global trends in the longer term;
- Regional trends in precipitation are difficult to predict, but scenarios suggest for the Pacific Islands region an increase of about 5 percent by the 2050s and 7 percent by the 2080;
- There is insufficient information to provide conclusive statements as to how tropical cyclones will respond to global warming; and
- Current projections show little change or only small increases in amplitude of El Nino events over the next 100 years, though recent trends indicate surface temperatures in the tropical Pacific are becoming more El Nino like - the eastern

tropical Pacific has warmed more that the western tropical Pacific, with a corresponding eastward shift in rainfall; many models project that these trends will continue.

However, the following findings documented by IPCC (2001) are perhaps of even greater significance to Palau:

- Many of the recently observed and now well documented changes in aquatic, terrestrial and marine environments globally (e.g. poleward and altitudinal shifts of plant and animal ranges, lengthening of mid to high latitude growing seasons, decline of some plant and animal populations, earlier flowering of trees, emergence of insects, egg-laying in birds, shrinkage of glaciers, thawing of permafrost, later freezing and earlier breakup of ice on rivers and lakes) are consistent with recent changes in the global climate system
- Similarly, the Pacific Islands region is already experiencing disruptive changes, again consistent with many of the anticipated consequences of global climate change, including:
    - extensive coastal erosion;
    - coral bleaching;
    - persistent alternation of regional weather patterns;
    - decreased productivity in fisheries and agriculture - higher sea levels are making some soils too saline for cultivation of crops such as taro and yams;
    - coastal roads, bridges, foreshores and plantations suffer increased erosion, even on islands that have not experienced inappropriate coastal development;
    - recent devastating droughts have caused severe crop damage and serious water shortages in many Pacific island countries; and
    - more widespread and frequent occurrence of mosquito-borne diseases.

Coastal erosion is reducing beach areas throughout the islands. As sand is stripped away the strand vegetation becomes impacted.

The combination of current and anticipated impacts of climate variability and change for Palau are of great and urgent concern, given the extensive and growing evidence of

the vulnerability of Palau to climate change and the limitations the Republic has for adapting to climate change.

Palau is already experiencing the adverse effects of the current, large inter-annual variations in oceanic and atmospheric conditions and are also encountering impacts that are consistent with the anticipated effects of climate change and sea-level rise.

4.2 Vulnerability Assessment

As an island nation, it is essential to understand how climate change and sea level rise will affect and impact Palau's coastal ecosystems, marine resources, subsistence and commercial agricultural developments, domestic and industrial developments, human health, water resources, population, and the national economy at large. In order to develop and implement appropriate response strategies, it is essential to establish a comprehensive baseline of the current situation in Palau and an understanding of the anticipated effects of climate change, the degree of vulnerability, and the national capacity to adapt.

Figure 4.1: Sectors and Case Studies Analyzed by the Vulnerability and Adaptation Team.

Sector	Case Study
Agriculture	Taro Patches
Forestry	Mangroves
Water Resources	Ngerikiil Catchment
Health	Human Exposed to Vector borne Diseases

The initial vulnerability assessment detailed four sectors and for specific case studies within each of those sectors. The case studies involved:

- Scoping the Assessment
- Developing Baselines (environmental and socioeconomic)
- Constructing Scenarios (environmental and socioeconomic)
- Assessing Impacts and Vulnerability – field-based and desk top studies
- Preparation and Submission of the National Statement

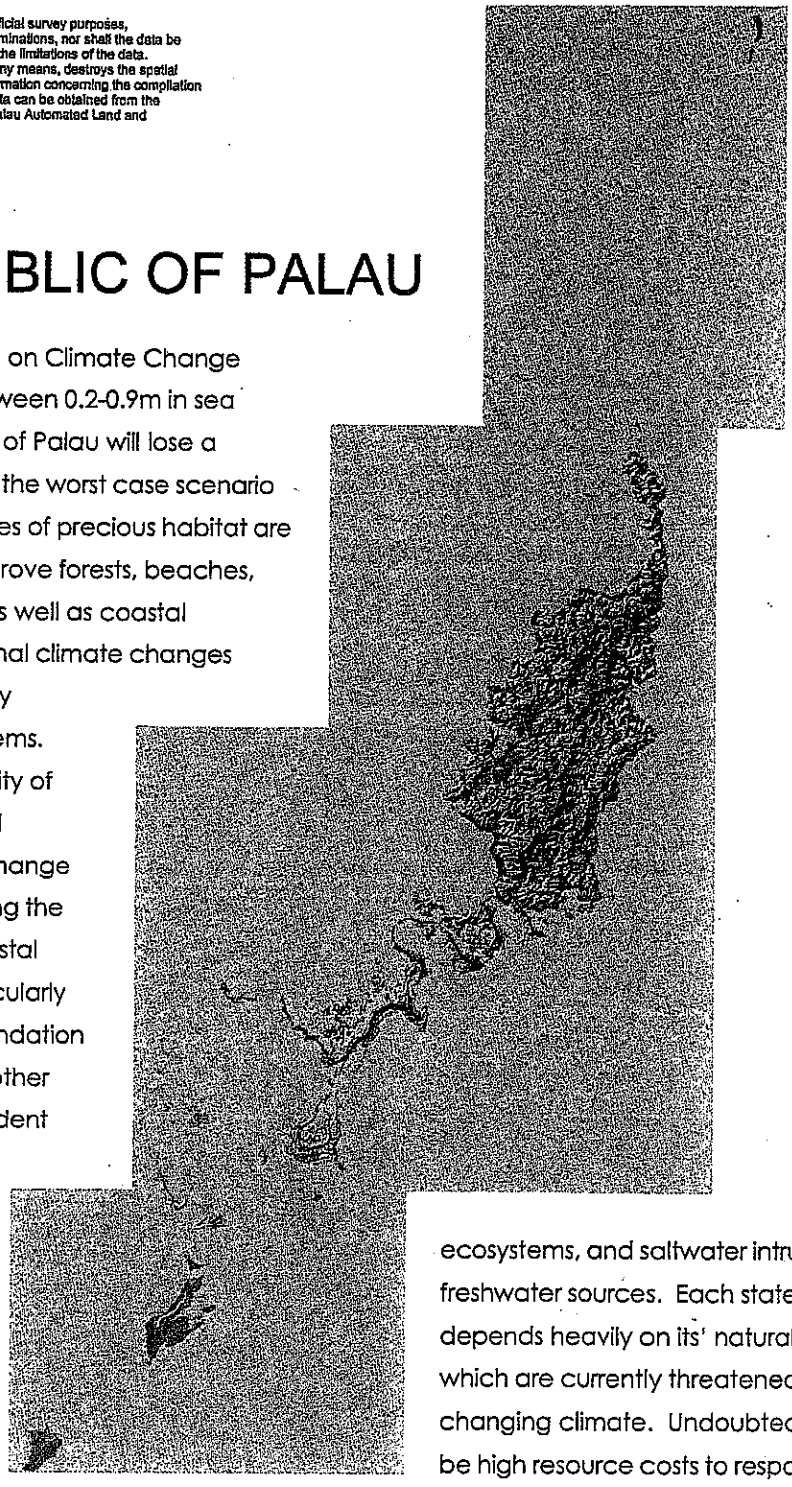
While this provides a reasonable opportunity to document the vulnerability of Palau to climate change, it is clear that sectors and exposure units of major significance have not been considered in this initial and preliminary assessment. These would include tourism, living marine resources, biodiversity and coastal systems, and relevant exposure units within each of these sectors.

In a preliminary investigation, based on published material and expert judgement, the vulnerability assessment team identified the following sectors as being particularly

This map shall not be used for official survey purposes, boundary interpretations or determinations, nor shall the data be used for spatial analysis beyond the limitations of the data. Enlargement of this product, by any means, destroys the spatial integrity of the data. Further information concerning the compilation methods and limitations of the data can be obtained from the Bureau of Lands and Surveys, Palau Automated Land and Resource Information System.

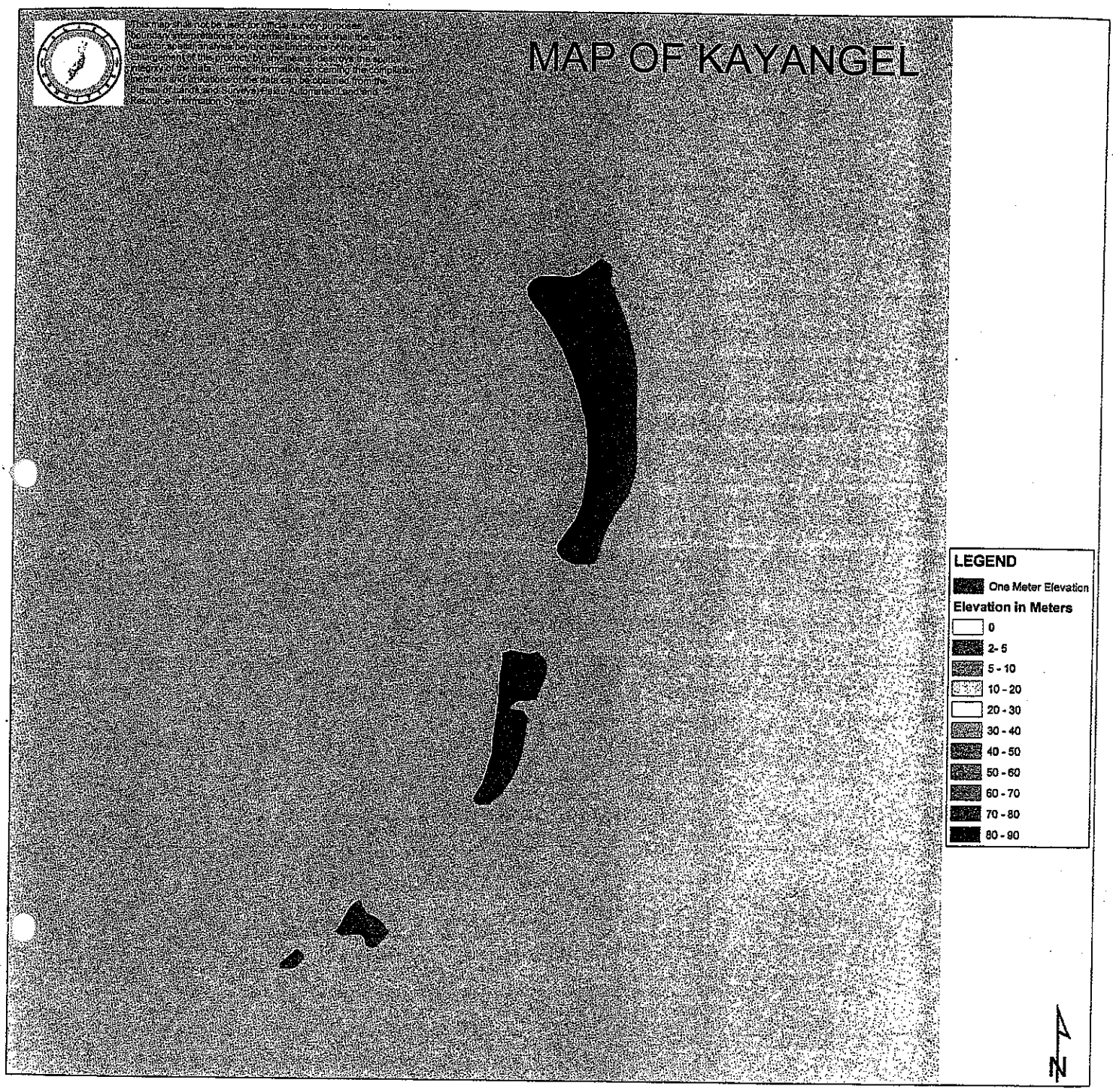
THE REPUBLIC OF PALAU

The 2001 International Panel on Climate Change (IPCC) predicts a rise of between 0.2-0.9m in sea level by 2100. The Republic of Palau will lose a significant amount of land if the worst case scenario develops. Thousands of acres of precious habitat are threatened, including mangrove forests, beaches, low-lying agricultural sites, as well as coastal infrastructure. Recent regional climate changes have already affected many physical and biological systems. The sensitivity and vulnerability of many of Palau's natural and human systems to climate change have been identified. Among the vulnerabilities, low-lying coastal areas are identified as particularly threatened. Erosion and inundation are major risks to Palau but other threats will also become evident with even slight increases in sea levels, such as the reduction in the volume of fresh-water lenses, and further stressing of fresh-water resources by reduced rainfall.

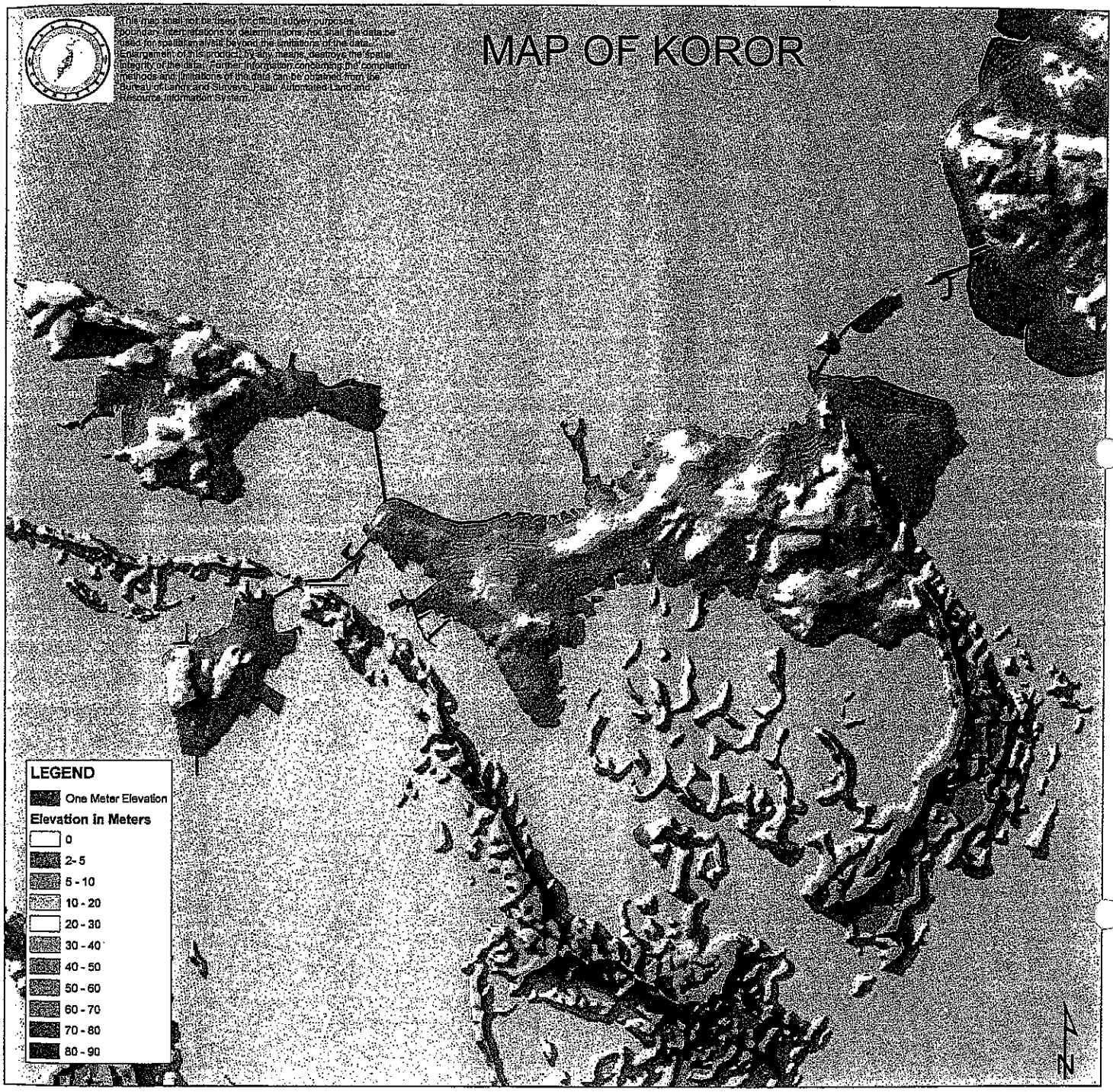


Areas in red on the following maps indicate land with an elevation of less than one meter. These areas are not only at risk from sea level rise but also the possibilities of increased tropical cyclone frequencies and intensities, and storm surges. There will be enhanced coastal erosion, loss of land and property, dislocation of people, reduced resilience of coastal ecosystems, and saltwater intrusion into freshwater sources. Each state in Palau depends heavily on its' natural resources which are currently threatened by the changing climate. Undoubtedly, there will be high resource costs to respond to and adapt to these changes.

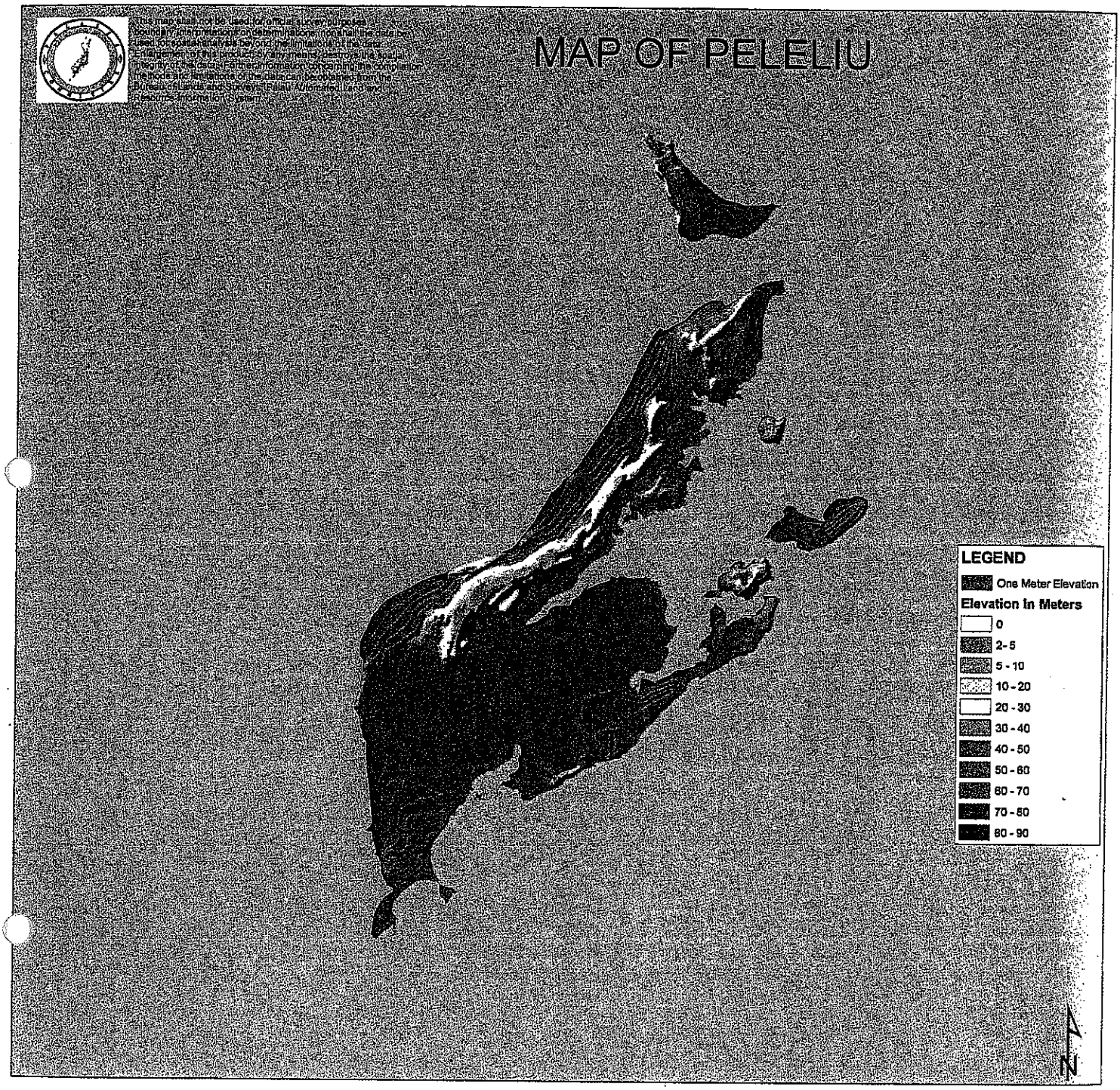
More in depth studies of sea level need to be carried out in the Pacific region in order to more accurately model sea level rise extremes. More accurate data would allow for better adaptation plans for all of the Pacific Islands.



While a rise in sea level will disrupt coastal areas around much of Palau, atolls are particularly vulnerable to the phenomenon. Kayangel State is at severe risk to even a relatively small rise in sea levels as the Earth's climate proceeds to change. The entire land area of Kayangel State is comprised of four low-lying limestone islands located on the winward side of a small atoll. The State will be inundated by sea water and cease to exist by 2100 if sea levels rise close to one meter from its current level. Hundreds of people will be displaced as their homes, land, and farms are swept away.

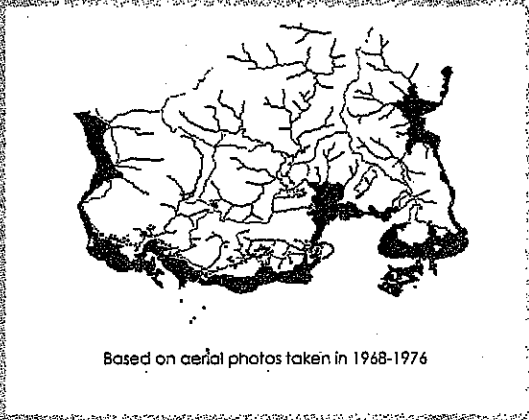


Koror is the most populated State in the Republic. Two-thirds of Palau's residents live and/or work in the State. Palau's most lucrative industry, tourism, is primarily based in Koror. Tourism, by far, is the largest contributor to Palau's GDP and will face severe disruption from climate change and sea level rise. The 1997/98 El Nino caused a significant decline in tourism due to damages to natural ecosystems throughout the islands. Much of the State's infrastructure is built around the coastal areas and is therefore in jeopardy.



Peleliu State is another example of an island that has much at stake as the climate changes. Peleliu will lose a significant amount of resources as sea levels rise, including large expanses of mangroves, which not only act as a nursery for a large variety of reef fishes and marine invertebrates, Indo-Pacific crocodile habitat, and a source of valuable wood, but also protect the island from storm surges and erosion. World War II historical sites, such as Orange Beach and White Beach, which are large tourist attractions will also be lost. Peleliu has a limited amount of arable land and all farms are located at low elevations where the soil is most fertile. Soil salinization will make agriculture difficult to sustain into the next century.

Case Study: Airai Taro Patches



Distribution of taro patches on Airai and their relationship to other land features.

Characteristics:

1. Soil type 408 with 0-2% slope, occurring near mangroves, prone to salt water intrusion.
2. Taro patches on valley bottoms near sea level, prone to salt water intrusion.
3. Soil type 426 with 0-2% slope, occurring near rivers, vulnerable to high precipitation causing flooding and sedimentation of the taro patch.
4. Flood plains adjacent to rivers and to the coast, vulnerable to high precipitation events causing flooding of the taro patch, along with possible saltwater intrusion.
5. Taro patches adjacent to steep slopes, highly vulnerable to landslides and erosion causing a build up of sediment in the taro patch.

Direct Effects of Climate Change on Airai Taro Patches:

1. 75% of all taro patches on Airai were damaged during the 1998 El Nino event (NEMO/IESL)
2. 100% of the taro crops in lowland areas near mangroves (soil type 408) were damaged during the 1997/98 drought.
3. 10% of the taro patches were flooded during Tropical Storm Utor (Damage Assessment Final Report, MRD, July 2001).
4. Landslides from heavy rains as well as fires from drought also occurred.
5. An increase in pests and invasive weeds were also observed as a result of changes in temperature and precipitation.

Adaptation Options:

1. Utilize open land areas by planting hedgerows and ground cover.
2. Reinstitute traditional methods of ditch and dike construction.
3. Construct or upgrade dikes and flood gates to prevent saltwater intrusion.

4. Develop program emphasizing the planting of salt tolerant plants such as betel nut, coconut, and Tahitian chestnut.
5. Increase the use of mulch.
6. Plant healthy and drought resistant plants.
7. Diversify crop species.
8. Institute management mechanisms to prevent and manage fires.
9. Enhance management of invasive weeds and pests.

Constraints:

1. General lack of interest in agriculture.
2. No existing state master plan (land use plan).
3. Insufficient manpower, equipment, and funding for agriculture programs.
4. Limited land ownership.
5. Weak enforcement of environmental policies.
6. Lack of public awareness.

sensitive to climate change and of special importance to the socioeconomic development, and environmental conditions of Palau:

- coastal margins, including lagoons, reefs, marine ecosystems and fisheries;
- freshwater and terrestrial ecosystems;
- water resources;
- agriculture and forestry;
- tourism;
- communities and human health; and
- infrastructure.

Due to the short duration and limited resources of the initial assessment, the team identified the following high exposure areas for further study:

- Agriculture – Taro;
- Forestry – Mangroves;
- Water Resources – Ngerikiil Catchment; and
- Human Health - humans exposed to vector borne diseases.

Case Study: Ngerikiil Watershed

Ngerikiil Watershed, Airai State
(highlighted in circle)

Characteristics:

1. Primary water supply to Koror and Airai States.
2. Ngerikiil River is located in Airai State and is approximately 13 sq. miles.

Effects of Climate Change:

1. Severely decreased water volume in 1994 and 1998.
2. Water rationing during the 1997/98 El Nino event.

Non-Climatic Effects:

1. Increased population growth.
2. Slash and burn farming methods.
3. Uncontrolled and poorly managed development.
4. Misuse of water.

Adaptation Options:

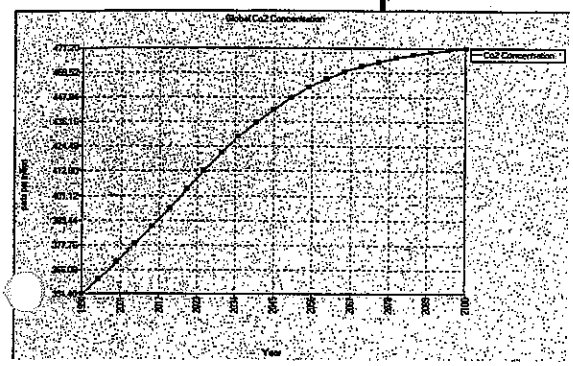
1. Upgrade current water system to avoid leaks and water loss during delivery.
2. Increase rainwater catchment by requiring that all structural development have a water catchment tank.
3. Locate and secure other potential watershed options.
4. Enhance public awareness and education on the benefits of water conservation.
5. Develop farming methods incorporating water efficiency technology.

Constraints:

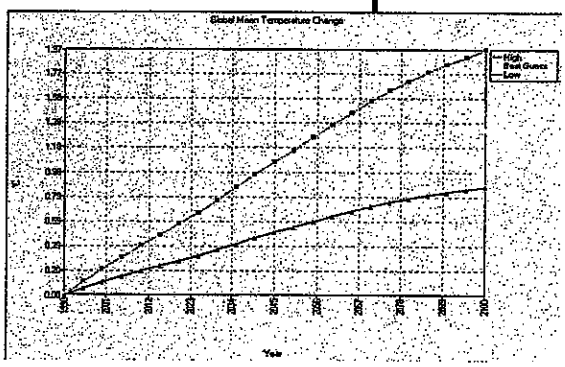
1. No existing master plan (land use plan).
2. Lack of resources to conduct sedimentation monitoring.
3. General lack of data regarding the effects of sea level rise, drought, and unsustainable resource practices on Ngerikiil watershed.
4. General lack of public awareness on water conservation practices.
5. Proper sewerage management systems not in existence in the area.

4.3 Methodology

The methodology used in this assessment is based on the IPCC technical guidelines for assessing climate change impacts and adaptation (Carter et al, 1994). Firstly, the present conditions were examined and key sectors identified. Future climatic and non-climatic scenarios were then used to examine the possible impacts of climate and sea-level changes on the various sectors identified, in addition to those anticipated to occur as a result of continued economic development.



Graph 4.1: Global mean concentration of CO_2, based on the IPCC greenhouse gas emissions scenario 92c, amended for IPCC 1995 and SO_2 regionalized aerosol effects.



Graph 4.2: Corresponding scenario of global mean air temperature for high, best guess and low sensitvity of the earth-atmosphere system to changes in GHG concentrations.

The total absence, or incomplete nature, of relevant data was a severe impediment to completing the vulnerability assessment. Baseline conditions were thus poorly defined, even in the best of situations. This makes it exceedingly difficult to determine the incremental effects of climate change. Because of the present gaps in data, and the fact that this study focused on only four sectors and exposure units, the findings should be seen as a starting point for an on-going process of vulnerability assessment in Palau.

Both the development of scenarios and assessment of impacts were aided by the use of the PACCLIM Regional Scenario Generator (Kenny *et al.*, 1999a) and by a generic integrated assessment model known as VANDACLIM (Kenny *et al.*, 1999b).

This chapter will identify both the current resilience and vulnerability of natural and human systems in Palau, while also demonstrating the linkages between climate, other environmental conditions and the prevailing socioeconomic conditions.

4.4 Climate Change and Sea Level Scenarios

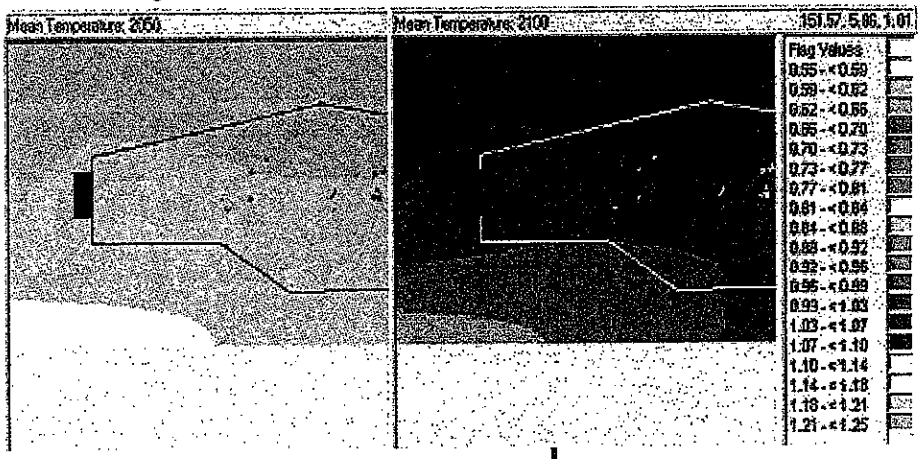
Scenarios are used as a basis for asking "What If?" questions about the effects of climate and sea-level change. Scenarios are not predictions. Global and regional climate change scenarios were prepared using the PACCLIM Scenario Generator, as described above.

Based on the emission scenario and patterns generated by the CSIRO Regional GCM for the area surrounding Palau indicates that the mean annual temperature may increase by about 0.5^{c} in 50 years and by around 1.0^{c} by the end of the Century.

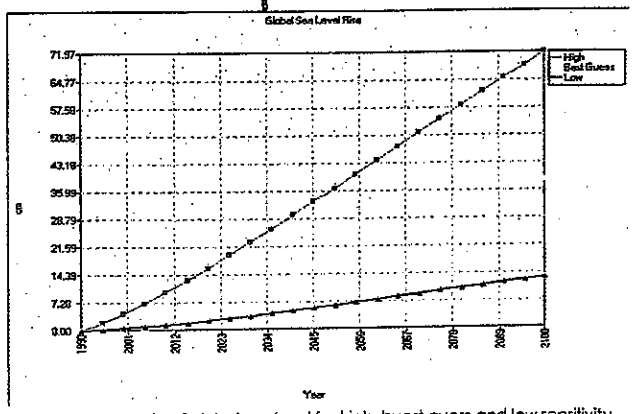
The projected increase, from 1990 to 2050 and to 2100, in mean annual precipitation for the area surrounding Palau is Regional GCM. It indicates that the mean annual precipitation may increase by about 20 millimeters per year by 2050 and by about 30 millimeters per year by 2100.

Evidence based on the emissions scenario and patterns generated by the CSIRO suggest that global warming may lead to an increased frequency of extreme events such as storms, floods, and droughts (IPCC, 2001). Based on the evidence indicating the seriousness of such events on Palau in recent years, these changes may well prove to be the most difficult to accommodate and most damaging to Palau's social, economic, and environmental health.

Figure 4.2: Projected incremental change, from 1990 to 2050 (left) and to 2100 (right), in mean annual temperature for the area surrounding Palau.

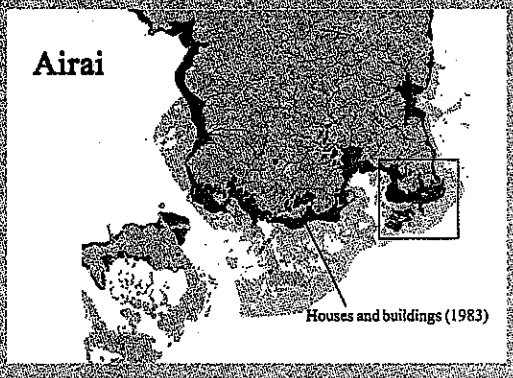


Sea level rise or fall is difficult to measure. Some regions may experience rise while others may experience lower sea level over certain time spans. The IPCC TAR has projected an overall sea level rise of 5mm per year for the next 100 years which would cause enhanced coastal erosion, loss of land and property, dislocation of people, increased risk from storm surges, reduced resilience of coastal ecosystems, saltwater intrusion, and high resource costs to respond to and adapt to these changes (Salinger et al., 2001). The mean sea level trends at Malakal in Palau since 1969 has been about 0.2 ± 1.8cm/decade, or a total change of 0.6 ± 5.8cm (Shea, 2001).

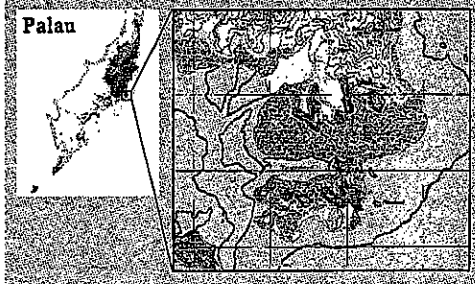


Graph 4.3: Scenario of global sea level for high, buest guess and low sensitivity of the earth-atmosphere system to changes in greenhouse gas concentrations.

Case Study: Mangroves in Airai State



Study area: Oikull, Airai



Air temperature, rainfall, and storms are the three climate-related factors having a direct impact on the mangrove ecosystem of Palau.

Characteristics:

1. Airai State has approximately 7.9 sq. km. of mangroves.
2. The area is comprised of steep hills.
3. Ras Mak to the east is the highest area in eastern Babeldaob.
4. The water that flows down from these hills forms the Ngerikiil River. Its tributaries nourish the extended mangroves, which form the largest mangrove area in eastern Babeldaob.
5. The Airai mangroves provide crabs, clams, and the adjacent lagoons and reefs provide other fish and seafood essential to the Palauan diet.

Direct Effects of Climate Change and Sea Level Rise on Mangroves in Oikull:

1. Steep slopes in study area will prevent mangroves from moving to most inland areas when flooding increases.
2. Increasing storms will physically destroy the mangrove trees.
3. Increasing temperatures will cause wet areas to dry up and will cause changes to the area's hydrology.
4. Decreased precipitation may result in less sedimentation in mangrove areas.
5. Increased sea and surface water temperatures may impact mangrove ecosystems.

Indirect Effects of Climate Change and Sea Level Rise on Mangroves:

1. Possibility of increased insect pests.
2. More invasive plant species.
3. If swamp forests and freshwater marshes dry up due to increased drought, the mangroves will suffer from too much salinity.
4. Coral reefs that are destroyed by increased seawater temperatures will no longer protect mangrove areas from storms.
5. Sea level rise combined with greater storm frequency will accelerate the speed of mangrove coastal erosion.
6. Destruction of mangroves will result in increased current activity along the shore.

7. Increased current activity may accelerate coastal erosion.
8. Rainfall regulates salt concentrations in soil and plants as well as providing a source of freshwater for the mangroves. This is an important factor when propagules begin to take root and also in their season of blooming and fruiting. If high rainfall occurs over a short period and other months of the year are prone to drought, the conditions can be considered unfavorable for the growth and distribution of mangroves.

Effects of Non-Climatic Changes:

1. Development: proposed 18-hole golf course and resort project that will destroy 67,000m² of Oikull's mangrove forest, dam freshwater streams, discharge wastewater into streams, remove large amounts of water for irrigation, alter drainage patterns and surface water flow in the area, and may increase the use of pesticides and fertilizers in Palau by 10 times the current level. All development in the area will increase the erosion and sedimentation, which may compromise the overall health and resilience of the mangroves in Oikull.
2. Population Growth: 2000 population data reports 19,129 residents; projections for 2010 are 23,548, and for 2020, are 28,987. Increased population will create more demand for land, water, food, and building materials, which may place added pressure on the mangrove ecosystem. Increased demand for land may result in an increase in the number of leases in mangrove areas, above those that have already been issued in Aimeliik State.

Adaptation Options:

1. Establish long-term monitoring system.
2. Conduct hydrology study.
3. Establish mangrove replanting program.
4. Delineate land ownership.
5. Establish zoning regulations, including buffer zones.
6. Assess artificial reef feasibility.
7. Enhance public awareness and education on the value of mangroves.
8. Encourage and educate State officials to protect their mangroves and ban property lease agreements in mangrove forest.
9. Reinstitute the traditional "*bul*" system on mangroves.

Constraints:

1. Current size of mangrove areas in Palau (all estimates are based on data from 20 years ago).
2. Specific, long-term studies on Palauan mangroves.
3. Climate models with data specific to Palau.
4. Conclusive studies that show specific climate related impacts on mangrove ecosystems.

4.4.1 Increased Drought and Storm Activity

Palau is a tropical country and the climate changes little seasonally. The annual average temperature is approximately 83° F. Heavy rainfall occurs from May to January. Short periods of torrential rain produce 150 inches (3,800mm) of water per year on average. Inter-annual variability in rainfall amounts, as well as other environmental parameters, is influenced by the El Nino-Southern Oscillation (ENSO). An indicator of ENSO is the Southern Oscillation Index (SOI).

Figure 4.3: Seasonal Rainfall Variations in Palau During El Nino.

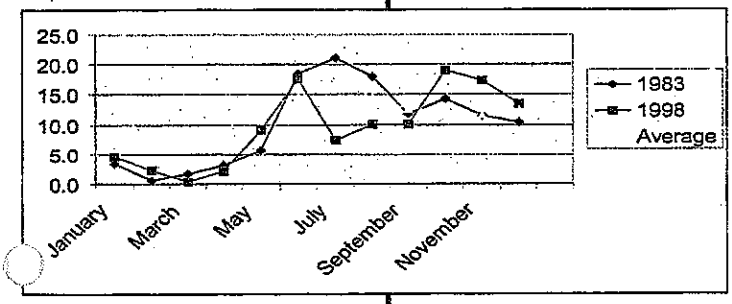
Palau Seasonal Rainfall Variations During ENSO *(values are % of normal)*								
	Year (0)				Year (+1)			
El Nino	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
	85%	100%	102%	79%	88%	82%	107%	103%
	Year (0)				Year (+1)			
La Nina	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
	80%	95%	92%	122%	128%	111%	81%	95%

Source: NOAA, Palau National Weather Service

A major issue is the impact of global warming on the El Nino Southern Oscillation regime. There is still no clarity on this matter, so a precautionary approach is advocated. A similar situation exists for tropic cyclones (typhoons).

However, rainfall during two significant drought years (1983 and 1998) is shown in Graph 4.4. The data demonstrate one significant effect of El Nino events for Palau. Droughts and floods are among the climate extremes of most concern as they affect the quality of the water supplies in the communities, often with significant human health consequences. For example, during the 1997/98 ENSO event Palau experienced a nine-month drought. In March 1998, Palau had the lowest monthly total rainfall recorded during the past 100 years.

Graph 4.4: Rainfall Patterns for 1983 and 1998.



Severe tropical storms also have the potential to substantially impact both the marine and terrestrial ecosystems, and communities in Palau. For example, Tropical Storm Utor brought heavy rains and strong winds to Palau between July 1 and 2, 2001. Damage assessments for Ngardmau State revealed:

85 percent damage to both young and mature cassava plants, including broken stems, stripped leaves and uprooted plants; young plants were especially badly damaged by strong winds and minor flooding;

- 85 percent damage to banana plants, with most mature fruit bearing plants damaged by uprooting; young plants were also affected;
- 85 percent of taro patches were flooded, including some being affected by salt water intrusion;
- 50-60 percent damage to betel nut – most old bearing plants and some young bearing plants were damaged; young plants were often damaged by falling trees;
- 25 percent damage to papaya, with both mature and young plants affected; and
- 10 percent damage to pineapple and sugar cane – most plants on upper hill areas were damaged, and some in lower areas, including valleys, were also damaged.

Large-scale infrastructure damage was caused by Tropical Storm Utor. The intesity and frequency of storms is predicted to increase during this century, putting a heavy financial burden on Palau.

Three recent events highlight this vulnerability to extreme events:

Tropical Storm Utor 2001 – Storm surges caused severe coastal and terrestrial erosion conditions, landslides, and damage to essential infrastructure (water, sewer, and communications).

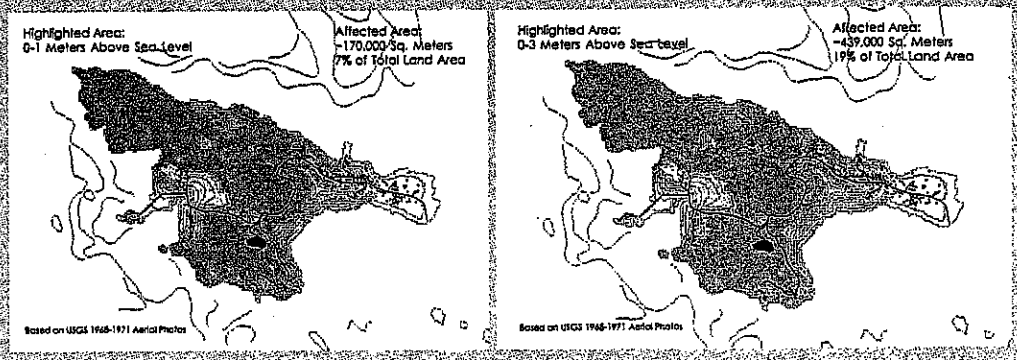
The 1998 El Nino – The population suffered serve drought conditions, crop losses, lack of water resources for human and animal consumption, temperature increases, etc. The coral reefs of Palau were impacted due to the increased water temperatures causing losses of many coral species.

Typhoon Opal in 1967 – One of the most destructive typhoons ever experienced in Palau struck the islands of Palau in March of 1967. The storm caused loss of crops, trees, housing units, and infrastructure.

4.4.2 Extreme High Tides

Another condition associated with ENSO events of concern to Palau is extreme high tides. Two recent periods of abnormally high tides occurred in 1989 and in 1998, with serious economic and social implications. In 1998 saltwater intrusion associated with abnormally high tides caused extensive damage to taro patches (traditional food supply) throughout Palau.

Case Study: Sea Level Rise Impacts to Arakebesang Island



Characteristics:

1. Limited land mass.
2. Increasing population, both local and through immigration.
3. Majority of infrastructure is located in low-laying areas.

Effects of Climate Change and Sea Level Rise:

1. Increased drought and storm events.
2. Coastal erosion from continued sea level rise.
3. Habitat fragmentation.

Non-Climatic Effects:

1. Increasing population growth.
2. Increasing development along the coast and in low-laying areas.

Adaptation Options:

1. Develop State response plans to address sea level rise.
2. Incorporate sea level rise projects into National and State master development plans.
3. Enhanced public awareness.

Constraints:

1. No existing master plan (land use plan).
2. Limited resources for long-term monitoring and enforcement.
3. Lack of awareness regarding the diverse affects of climate change.

Highest tides in Palau normally occur from September through October, and every few years some low-lying taro patches will experience some damage due to saltwater intrusion. But as early as August 1998 large areas of low-lying and inadequately maintained taro patches were inundated with salt water. Salt water acts like a poison to taro, with crop losses as high as 75 to 100 percent. Other problems related to high tides are the elevation of the fresh water lens, causing flooding and poor drainage (i.e. stagnant water conditions). Both may also have adverse effects on taro and other crops.

Figure 4.4: Taro Loss During the 1998 High Tide Event.

Calculation of Taro Crop Loss in 1998	
35 taro patches	17,800 square feet
Average production per plot	28.3 pounds
$29.00 loss per plot x 4 plots	$116.00
$116.00 loss per farmer x 35 farms	$4,060.00
$4,060.00 x 3 crop cycles	$12,180.00
$12,180.00/35 farms	$3,194.10 per family
19,000 (Palau population average)	$737,200.00
1998 Agriculture production loss	30%
1998 GDP loss	0.50%

Preliminary damage assessments conducted between September and December 1998 indicated that taro losses approached 100 percent on the islands of Peleleiu, Angaur and Kayangel, with less impact on Koror and Babeldaob. A total of 1407 taro patches were affected by adverse water conditions, with 2927 people (around one-third of Palau's population) affected adversely as a consequence (Bishop, 2001).

4.4.3 Sea Level Rise

Related to periods of abnormally high tides are periods of above average sea levels. Approximately 25 percent of Palau's landmass is below 10 meters above sea level, while 7 percent of Koror is less than 1 meter above sea level. Such low-lying areas are where most infrastructure (including residential homes) are located. The situation is complicated by the fact that northern Palau's seabed is sinking while southern Palau's seabed is rising.

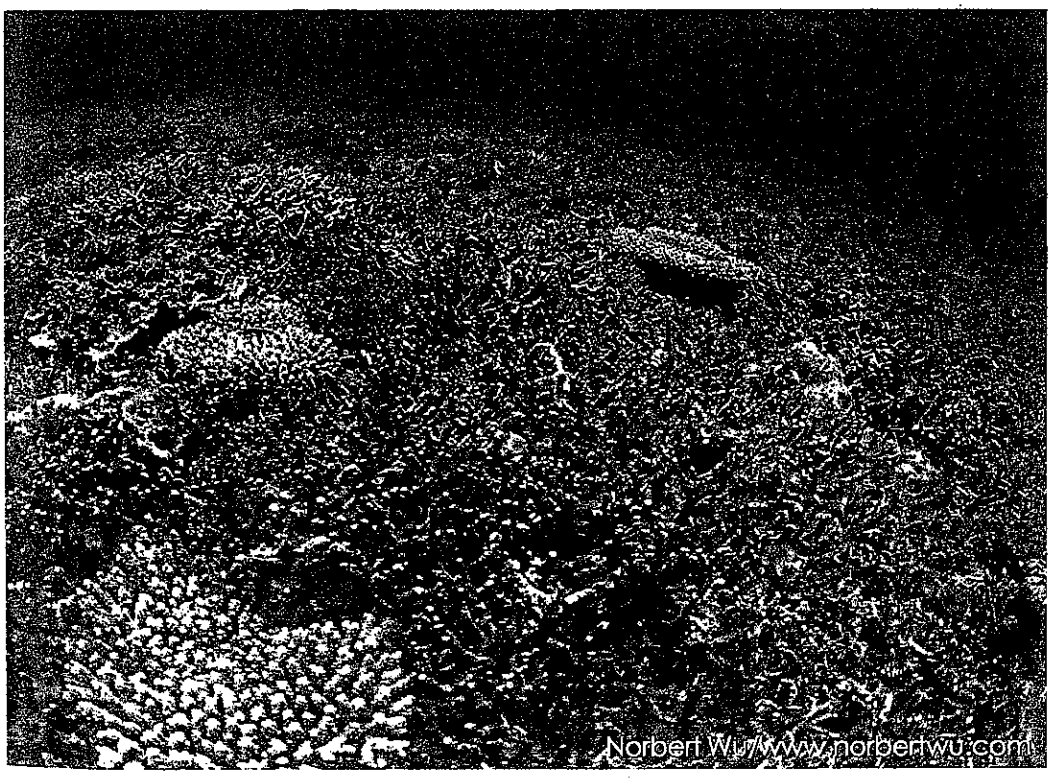
4.4.4 Sea Surface Temperature and Coral Bleaching

Palau has experienced a variation of 3°C in sea surface temperature over the past five years (MoA, 2001). The 1998 El Nino event increased seawater temperatures in Palau 1.0-1.25°C higher than average for several weeks (August-September 1998) and was the most probable cause of a massive coral bleaching event (Bruno et al., 2001; Golbuu, 2000). High water temperatures capable of inducing coral bleaching occurred to depths of 90 m in Palau during September 1998. Almost 70 percent of scleractinian corals were bleached at a 10-12 m depth throughout Palau (Bruno et al., 2001).

A significant amount of land area will be lost over the next 100 years as sea level rise and strong storms continue to effect the islands.

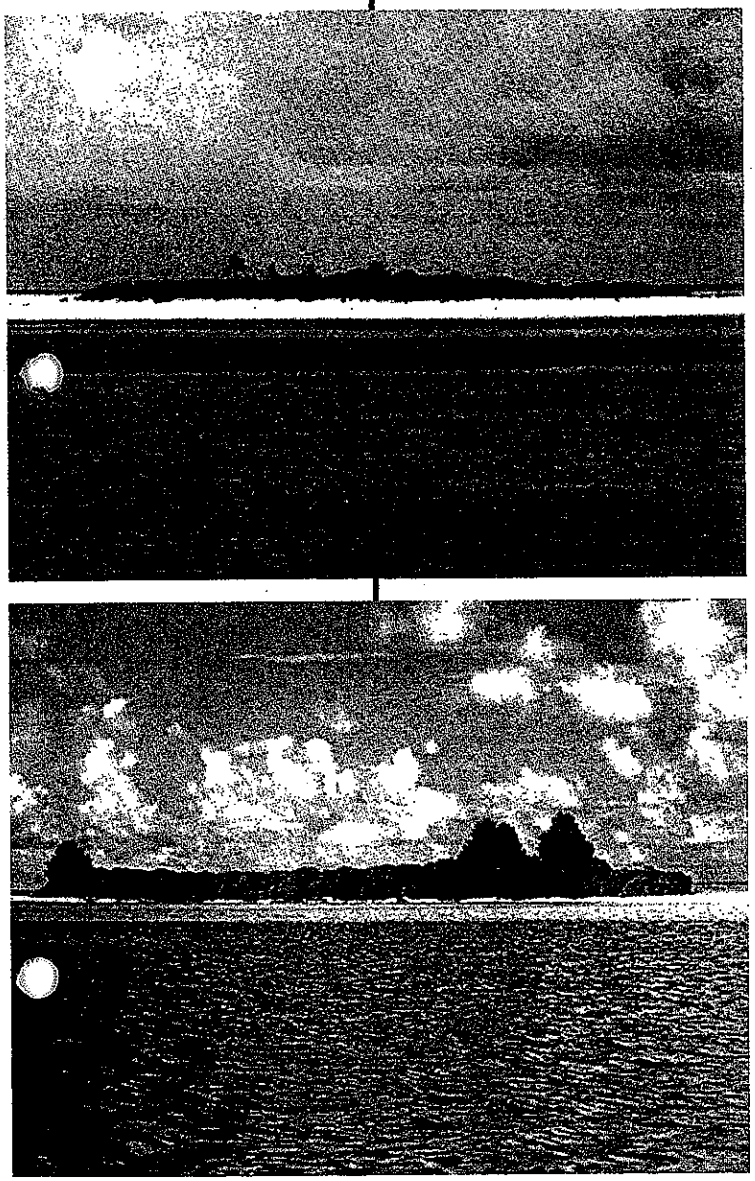
Beaches and other low-lying areas are extremely vunerable to climate change. Palau's beaches have been used by sea turtles as nesting areas for thousands of years.

When sea surface temperatures (SST) elevate, corals lose their symbiotic algae, zooxanthellae, and begin to starve for nutrients. The future health of Palau's coral reefs is in question as El Nino-like conditions are predicted to become more common.



Bleaching has reduced coral diversity over vast areas of the archipelago. Coral colonies grow at approximately 1-10 cm per year, depending upon the species. Palau is just beginning to recover from the massive coral mortality that was the result of the 1997/98 El Nino.

While no species became locally extinct, some populations fell as much as 99 percent below pre-bleaching levels (Golbuu, 2000). The associated economic loss was estimated at approximately US$91 million, based on a value of US$6,000/ha/yr (Costanza et al., 1997). As climate change proceeds, coral reefs throughout the Pacific are expected to be further degraded (Shea, 2001). Even a slight increase in seawater temperature over long periods will cause coral bleaching, leading to a high percentage of mortality (Bruno et al., 2001).



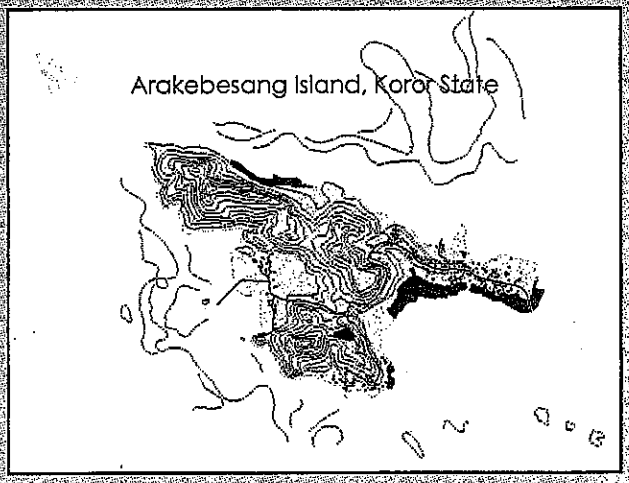
The above pictures show Helen Reef (part of the Southwest Island group). The top picture was taken in 1991 and the bottom picture in 2001. The island has lost more than 50% of its beaches to sea level rise and associated coastal erosion over the past decade.

As tropical sea temperatures elevate, Palau's reefs may not be able to maintain their current role as habitat providers to the many reef-dependent fauna (Bruno et al., 2001). Reef building corals will have a more difficult time removing Ca^{+} and CO_3 ions from seawater thereby reducing calcification rates. Therefore, reef structures will grow more slowly, if at all. Ocean circulation patterns may also be altered by climatic changes, causing the loss of transport and recruitment of coral larvae to Palau (Westmacott et al., 2000).

Finally, severe weather events may increase in frequency, which would put additional stress on Palau's biodiversity (Westmacott et al., 2000). Development along Palau's coastline and unsustainable watershed management are also relevant to the health of local reefs. A total of 544,919 m^2 of exposed area is the result of the Compact Road being built on Babeldaob (USACOE, unpublished). As of December 2001, over 310,000 m^3 of coral has been dredged for road base from several sites along the coast (USACOE, unpublished). Poor land use and deforestation can cause elevated sedimentation that can suffocate corals. Terrestrial runoff has also been linked to COTS outbreaks around

the Pacific (Birkeland, 1982). The use of particular pesticides, waste disposal, and overexploitation are also serious threats to Palau's coral reefs.

Case Study: Arakebesang Island Exposure to Vector Borne Diseases



Based on USGS 1968-1971 Aerial Photos

Characteristics:

1. Limited land mass.
2. Increasing population, both local and through immigration.
3. Land clearing for development.

Direct Effects of Climate Change and Sea Level Rise:

1. Increased drought and storm events.
2. High temperatures will decrease mosquito incubation time.

Indirect Effects of Climate Change and Sea Level Rise:

1. Increased potential for dengue outbreaks and other vector borne diseases.
2. Changing migratory patterns of species due to changing temperatures and increasingly fragmented habitats may result in introduced diseases.

Non-Climatic Effects:

1. Increasing population growth.
2. Increased land clearing activities to accommodate growth.

3. Lack of land use planning.

Adaptation Options:

1. Improve living conditions.
2. Divert standing water.
3. Treatment of vector prone areas with pesticides.
4. Strengthen Division of Customs.

Constraints:

1. No existing master plan (land use plan).
2. Weak enforcement of environmental policies.
3. Limited resources for long-term monitoring and enforcement.

Adaptation to Climate Change

5.1 Introduction

The previous section highlighted Palau's high sensitivity to climate change. Based on the evidence indicating the serious impacts climate change has had on Palau in the recent past, it may well be these changes that prove to the most difficult to accommodate and most damaging to Palau's social, economic, and natural environments.

Many climate change response strategies are the same as those that would apply to sustainable development, sound environmental management, and wise resource use practices. Therefore, "no regrets" strategies are beneficial even in the absence of climate change. Given that the UNFCCC also calls for Palau to promote sustainable management, there is a strong overlap and synergy between initiatives taken under the Convention and those that represent best practice in sustainable development.

5.2 Agriculture

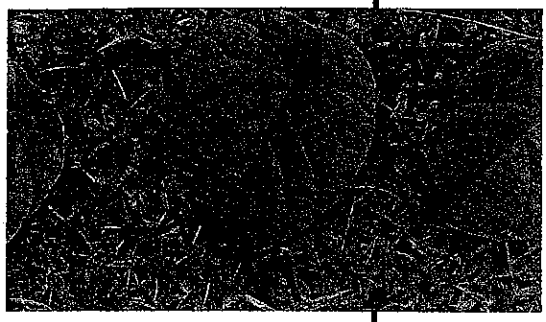
The uses, potential uses, and the preferred growing environment of tree and plant species should be identified and documented. An effective adaptation strategy would be to develop a formal plan related to the use of plants and trees, and to selectively plant species that are best suited to a particular physical environment, and which have a particular use.

Where agriculture is practiced in vulnerable, low-lying areas, the breeding and introduction of salt-tolerant root crops is seen as an effective measure. Alternatively, different cultivation practices might have to be considered, such as the use of irrigated, raised-bed systems.

5.2.1 Susceptible Areas

For drought prone upland areas, the breeding of more drought resistant cultivars and crops is advocated. Improved soil and water conservation practices in both drought and flood prone areas are important means of maintaining productivity, and hence food security. Intercropping and increased diversity of crops is also a good strategy for increasing the resilience of the agriculture sector in both coastal and upland areas. Thus, diversification to a wider range of plantation crops would spread the risk of loss from climate change, including increased incidence of extreme events. Likewise, it would be

prudent to extend the planting of plantation crops to other land areas, or islands. This would again spread the risk of production losses due to extreme events such as typhoons.



Mikania peltata - this native vine acts as an invasive species, out-competing surrounding vegetation, reducing diversity. Over 400 alien species of plant have been identified in the Republic.

The resilience of traditional agricultural systems could be enhanced by undertaking projects to preserve and disseminate traditional knowledge, diversifying subsistence crops, promoting agro-forestry, encouraging sustainable practices and developing economic opportunities. Reevaluation of the traditional value system of the products and uses of trees and other plants is advocated for appropriate areas.

5.2.2 Invasive Species

Quarantine surveillance should be increased against introduced and invasive species that may become adapted to environments at higher elevations. Although we cannot predict which species will become invasive, the uncertainty that global warming poses exacerbates the potential for far more rapid changes in the natural environment and how species will adapt to those changes.

Data Gaps: Present Conditions in Palau

1. Strengthen the national resource database to enhance the ability to document current environmental and socioeconomic conditions in Palau, on a spatial basis;
2. Generate detailed high resolution contour and land cover/use data and vertical land movement data;
3. Improve understanding of the effects of land practices and change in watersheds;
4. Develop better understanding of the interactions between land use practices and the coastal marine environment;
5. Enhance understanding of the effects of sequential extreme events on communities and ecosystems;
6. Develop understanding of the interactions and linkages between various sectors;
7. Enhance understanding of the effects of human activities on sensitive ecosystems; and
8. Strengthen understanding of the factors that make communities vulnerable to climate events.

5.2.3 Incentive Measures

Introduction of appropriate disincentive policies related to the consumption of imported staple foods (such as price controls on rice and flour) should be reconsidered, and incentive policies for the production and consumption of local foods should be given priority. Additionally, emphasis should be given to actively maintaining existing agricultural specie variety. This will enhance the security of food supplies.

Economic agricultural policies, such as subsidies on cash crops, should be evaluated and monitored to ensure they do not undermine the cultural and social systems and the traditional values underlying subsistence agricultural systems. Such considerations will enhance the resilience of these systems to climate change and other stresses.

5.3 Coastal Systems

Enhanced protection and reducing anthropogenic stresses on mangrove areas and sensitive coral reef systems is an effective means to ensure these systems can better cope with impacts arising from climate change and sea level rise. Such progress would help maintain the natural storm and erosion protection these systems offer and also help sustain their productivity.

Integrated catchment and coastal management planning would produce a variety of outcomes that collectively increase the resilience of coastal systems.

5.3.1 Foreshore Protection

n heavily populated areas, or those associated with high value infrastructure or economic activity, foreshore protection measures including revegetation and establishment of setback zones, are considered to be cost effective adaptation measures to protect against flooding and erosion. Measures to protect existing foreshore vegetation and encourage revegetation would help reduce the vulnerability of coastal areas. Moreover, the replanting of littoral forests would help protect sensitive coastal environments. On the other hand, sea walls are seen as a high cost adaptation option that would only be of value for very specific areas, and impractical on a large scale.

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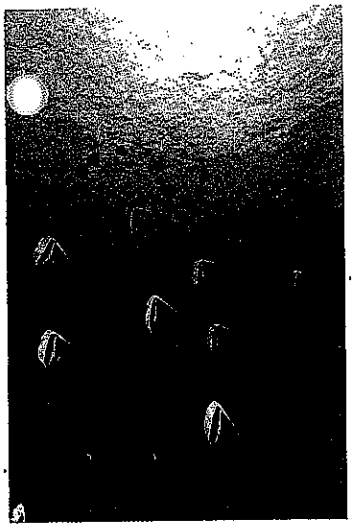
Mangrove forests protect both the reef, from sediment overload, and the coast, from wave and wind action. This ecosystem is highly productive, housing a wide variety of flora and fauna, including the economically valuable Mangrove Crab.

5.3.2 Pollution Control

Preventing the discharge of pollutants in coastal and marine areas is identified by the Vulnerability and Adaptation Team as a priority measure to enhance the resilience of coastal and marine ecosystems.

In some areas an appropriate response may be to reestablish traditional systems of ownership and specific rights on coastal areas such as reef patches and shoals.

Measures to control the removal of materials for construction and other uses would also help reduce the risk of erosion and other undesirable impacts of climate change and sea level rise. Similarly, reclamation should be actively discouraged.



Zanclus cornuta - many reef fishes aggregate to spawn on a lunar cycle. Palauans have long known that management of spawning aggregation sites is vital to protect local fish stocks for the future.

5.3.3 Resettlement

Resettlement options may become necessary for some areas, but the high social, economic, and environmental costs associated with resettlement make it an option of "last resort".

5.4 Living Marine Resources

The development and extension of marine breeding and restocking programs, for both fish and corals, are an effective means of increasing the resilience and sustainability of inshore marine resources. Similarly, further expansion of marine reserves and other conservation instruments would help protect subsistence fish stocks and coastal marine resources. Creating new and expanding currently existing reserves would enhance the ability of marine resources to withstand the added stresses arising from climate change. Such measures will increase the resilience of the marine ecosystem and can reduce overall anthropogenic impacts on marine resources.

5.4.1 Monitoring and Enforcement

Enhanced enforcement of legislation to prevent the use of destructive fishing methods is also advocated as a no-regrets response option. To facilitate agreement to alternative methods, community participation in the development, implementation, compliance, and enforcement programs is a priority.

Monitoring and quota management systems for migratory fish stocks must be enhanced and strengthened. Not only would these measures prevent over-exploitation of these resources, but they are also considered to be effective ways of ensuring there is a buffer against climate related stresses.

Data Gaps: Climate and Sea Level Change and Non-Climate Scenarios

1. Develop detailed regional/national scale projections of future changes in climate and sea level;
2. Synthesis information about possible changes in cyclone frequency and/or intensity in the future and possible changes in features of climate variations such as the El Nino and La Nina phenomena; and,
3. Develop robust projections of relevant socioeconomic and demographic variables, for time periods consistent with the national policy framework for climate change.

5.5 Biodiversity

Conservation of biodiversity is considered to be a viable, no-regrets adaptation measure. It should be associated with a sharpened recognition of the values of both marine and terrestrial flora and fauna. Emphasis should be given to further the development of the Marine Protected Areas Network as well as the National Protected Areas.

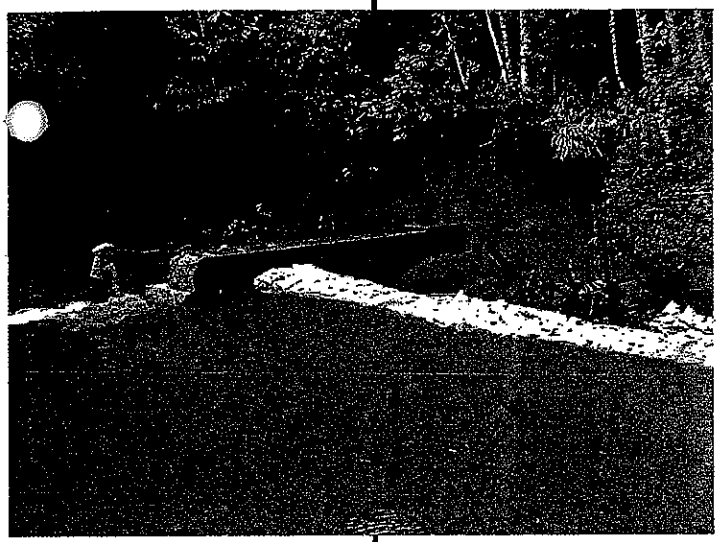
In light of the uncertainties associated with climate change, community based forest conservation projects can improve the resilience of managed and natural forest systems. Forest management should place a high priority on land and soil conservation, water conservation, nature conservation, wood production, and the quality of the human living experience. In this way there will be added resilience to the effects of global warming. The introduction and enforcement of appropriate legislation and policies for the conservation and sustainable use of living resources will also enhance the ability to adapt to climate change.

Rhipidura lepida - the Palau Fantail is a common forest resident with an estimated population of over 25,000. This endemic species has an unusual call with many notes and can often be seen guarding its territory.

5.6 Water Resources

Improved management and maintenance of existing water supply systems is a high priority response measure, due to the relatively low costs associated with reducing system losses and improving water quality.

Centralized water treatment to improve water quality is considered viable for most urban centers, but at the village level it is argued that more cost effective measures need to be developed. User pay systems may have to be more widespread.



Watershed management is another high priority of the National Government. The development of a comprehensive watershed management plan is currently underway.

Catchment protection and conservation are relatively low cost measures that would help ensure that supplies are maintained during adverse conditions. Such measures would also have wider environmental benefits, such as reduced erosion and soil loss and maintenance of biodiversity and land productivity. Drought and flood preparedness strategies should be developed and strengthened, as appropriate, including identification of responsibilities for predefined actions.

While increasing water storage capacity through the increased use of water tanks and/or the construction of small-scale dams is expensive. Further study would better determine if the added security in the supply of water might well justify such expenditure.

Data Gaps: Adaptation Response

1. Further research and information are needed about the effectiveness of proposed adaptation measures in reducing vulnerability; and
2. Identify mechanisms that allow development policies and plans to incorporate climate change considerations so that risks are minimized.

Development of runways and other impermeable surfaces as water catchments is seen as possible, but an extreme measure in most instances. Priority should be given to collecting water from the roofs of buildings.

5.7 Human Health

Public awareness programs related to malaria, dengue fever, and other diseases are an essential, low-cost method for reducing the public health risk. Such programs have already been initiated and are considered to be relatively effective, as is the use of bed nets and mosquito screens.

Failed programs in the region suggest that mosquito eradication is not a practicable option, due to the high financial and environmental costs, and no guarantee of success. However, biological control may become a viable option some time in the future.

Data Gaps: Determining Effects of Climate and Sea Level Change

1. Strengthen understanding of the effects of climate and sea level change on, and possible responses of, important ecosystems such as coral reefs, mangrove swamps, coastlines and living marine resources;
2. Review and summarize information about the relative climate sensitivity of various key sectors (e.g. tourism, agriculture) and of key economic production and consumption systems;
3. Enhance understanding of the interactions and feedbacks between sectors and exposure units and their interactions with the effects of non-climatic changes, including an understanding of indirect social and economic effects and cumulative effects;
4. Enhance understanding of how communities will be affected by climate and sea level change and how they may best respond to the range of possible future effects;
5. Develop an improved understanding of cumulative impacts of extreme events and of the strategies, which enable communities to cope under such conditions; and
6. Development of options for enhancing adaptability and resilience of Marine Protected Areas.

Moreover, reduction of mosquito breeding sites within towns and villages (e.g. informal waste dumps, open water tanks, discarded containers such as cans, tires) is already considered to be an effective method for reducing local malaria risk. There are also other benefits from such actions. Enhanced quarantine measures are also suggested as a priority response.

5.8 Housing

Measures to "typhoon-proof" houses and other buildings have been identified as desirable. This would include consideration being given to both structural design and the materials used in construction.

Reductions in heat stress and discomfort may be achieved through the planting of shade tress and by building houses with improved insulation and ventilation. Air-conditioning is not considered to be a viable, cost-effective response, in general.

5.9 Policies and Planning

It is important for Palau to develop an overall vulnerability and adaptation strategy that goes beyond specific sectoral measures and addresses wider development, social, and environmental issues at a policy and planning level. Effective implementation of no-regrets adaptation options will require a coordinated national initiative and significant resources. The four most important components of such a national initiative are: 1) development of a national policy framework for adaptation; 2) capacity building and institutional strengthening; 3) public awareness and education; and 4) community-based management.

The National Environmental Protection Council was created in 2002 to address the Nation's environmental challenges, including climate change, biodiversity, ozone, and land degradation, among others.

5.9.1 National Policy Framework

The national policy framework should place a high priority on monitoring and managing the effects of environmental and social change within development planning. This will allow the future development trajectory of Palau to be one that increases resilience to

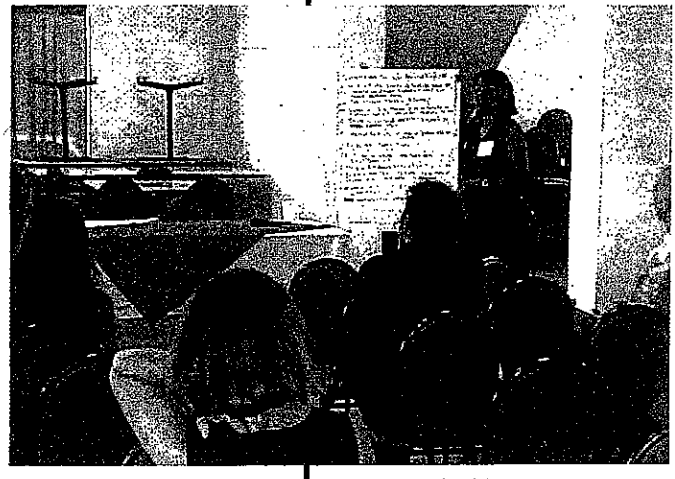
climate change and decreases the vulnerability of communities and natural ecosystems.

Such a framework should be explicitly designed to ensure that implementation of no-regrets adaptation measures are incorporated in development planning. Some of the key priorities for inclusion in a national policy framework and as mechanisms through which adaptation options could be implemented would be:

1. An integrated watershed management plan.
2. An integrated coastal zone management (ICZM) plan.
3. A complementary land use plan to support both of the above.
4. A Disaster Management and Preparedness program which includes climate change adaptation.
5. Effective environmental and social impact assessments for all development policies, projects and plans.
6. Establishing a National Climate Change Vulnerability and Assessment group with clearly defined roles.
7. Establishing an effective monitoring mechanism to coordinate national resource surveys, develop indicators and monitoring programs, and consolidate the involvement of stakeholders in terms of data collection and information dissemination.

5.9.2 Capacity Building

Institutions important for effective implementation of adaptation options should be strengthened through on-going capacity building. This will ensure continued development of expertise and skills necessary to further understanding of vulnerability and adaptation to climate and sea-level change as well as facilitating implementation of adaptation options. In addition, there is a need to improve management and access of information by mandating and resourcing existing institutions to enhance

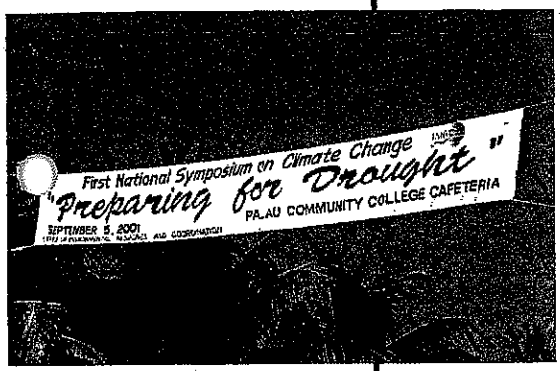


Capacity building training programs are a major component to many sustainable resource use initiatives within the Republic.

monitoring, collation and analysis of data, and to coordinate information dissemination to stakeholders and interested parties.

5.9.3 Public Awareness and Education

A national policy framework and strengthened institutions will only be effective if they have support from the public. For the public to provide such support, it is important that they actively participate in the decision-making process at the community level to ensure that their social and cultural well-being is taken into account. A national policy framework should be as much driven by the needs of local communities as it is by the needs of the country at large.



Several agencies conduct on-going public awareness programs dealing with sustainable energy and water consumption. However, to create greater awareness and reduce costs, the development a wholistic and continuing public awarness and education program incorporating climate change issues is currently under way.

The traditional knowledge and wisdom of local communities should be made use of as much as possible. Community awareness and education programs need to be developed and implemented, to facilitate an understanding of climate and sea-level change and how it relates to sustainable management of community resources, in the present as well as in the future.

Data Gaps: Institutional and Policy Responses

1. Establish a coordinated national climate and sea-level change program for Palau, with the overall aim to improve the understanding of the vulnerability of Palau to climate and sea-level change, and to ensure the development and effective implementation of appropriate adaptation options and strategies, including development of local skills and expertise and strengthening of institutions which will be involved in ongoing climate change related activities;

2. Centralize and strengthen existing (e.g. POLARIS), and develop new, information gathering and management systems - although there is a need to develop new information, there is also a need to identify and improve accessibility to existing information and databases; information is required to understand the various sectoral sensitivities to climate and sea-level change; information requirements include identification of sensitive areas and ecosystems; information on land use change and practices; information on natural ecosystems including forests, mangroves and coral reefs;
3. Development of fine resolution contour data; and better understanding of the present effects of social and economic change on the environment;
4. Developing integrated assessment methods - there is a need for new and improved tools and methodologies that would facilitate integrated assessment of the effects of climate and sea-level change in Palau; and
5. Improve communication and dissemination of useful and relevant information to the public, policy makers, and other decision makers on vulnerabilities and adaptation.

Response to Climate Change

6.1 Introduction

Developed countries are responsible for two thirds of historical greenhouse gas emissions and approximately 75 percent of current annual emissions. Due to past and present greenhouse gas emissions, whether or not action is taken now to stem the tide of global warming, the simple fact is that we are already committed to some level of climate change. The debate is now only a matter of how much damage will the earth incur before the developing countries take action to reduce climate change trends. The bottomline is that climate change will have economic consequences for all of us.

Although immediate action may sometimes seem more expensive than waiting, delays could lead to greater risks and therefore greater long-term costs. The cost of climate change policies can be minimized through "no regrets" strategies. No regrets strategies make economic and environmental sense whether or not the world is moving towards rapid climate change. For example, raising energy efficiency not only reduces greenhouse gas emissions, but can also reduce government and private sector energy costs by 30 to 50 percent. While no regrets policies are certainly justified, the precautionary principle and the level of net damage expected from climate change justify adopting policies that go beyond no regrets.

6.2 National Implementation Strategy

International Participation					
Objective	**Activities**	**Resources**	**Lead Agency**	**Timeline**	**Indicator**
A strong and consistent message to the international community regarding climate change impacts on Palau	Ensure continued active participation in regional and international climate change activities and meetings	Finance	MoS - BoFA OERC	Immediate	Greater international awareness regarding the impacts of climate change on Palau
	Dissemination of climate change meeting outcomes to all decision makers and stakeholders	None	MoS - BoFA OERC	Immediate	Greater domestic awareness regarding regional and international decisions and their potential impacts on Palau
Regulatory Process					
Objective	**Activities**	**Resources**	**Lead Agency**	**Timeline**	**Indicator**
Integration of climate change mitigation and adaptation into regulatory processes	Develop National Land Use plans incorporating climate change and sea level rise projections	Finance Technical assistance	MRD - BLS	Immediate	Comprehensive Land Use Legislation and guidelines enacted
	Establish National Building Codes incorporating incentive measures for energy efficiency, alternative energy options, and energy efficiency criteria within the government procurement process	Finance Technical assistance	National Planning Commission	Immediate	National Building Code adopted and implemented
	Incorporation of climate change trends into the environmental impact assessment process for proposed development	Technical assistance	EQPB	Immediate	Comprehensive environmental impact assessment process
	Strengthen EQPB Act	None	EQPB	Immediate	Updated EQPB Act ratified by the OEK (Senate)
	Strengthen enforcement of GHG emissions controls and standards	None	MRD- BPW MOJ	short-term	Reduced GHG emissions
	Strengthen minimum standards for wastewater and solid waste disposal and management	Finance Technical assistance	EQPB	short-term	Effective wastewater treatment and dumpsite management, and national recycling program established
	Establish Watershed Protection Law	Technical assistance	EQPB	Immediate	National watershed legislation adopted and enforced
	Update, adopt, and implement Forest Management Plan and Mangrove Management Plan	Finance Technical assistance Human resources	MRD-BoA	Immediate	National Forest Management Plan and Mangrove Management Plan adopted and implemented

Financing for Climate Change Mitigation and Adaptation					
Objective	**Activities**	**Resources**	**Lead Agency**	**Timeline**	**Indicator**
Access to funding assistance	Identify financial and technical assistance for climate change related initiatives and disseminate information to all stakeholders	None	MoS OERC	Immediate	Stakeholders aware of regional and international climate change opportunities
	Annual allocation of funding for climate change programs within all relevant government agencies	None	All agencies Olbill Era Kelelau	Immediate	Annual agency budgets incorporate climate change mitigation and adaptation initiatives
National Capacity Building					
Objective	**Activities**	**Resources**	**Lead Agency**	**Timeline**	**Indicator**
Human Resources	Incorporation of climate change and sustainable resource use practices into national education curriculum	Technical assistance	MoE	Medium	Enhanced awareness regarding climate change and sustainable resource use amongst the youth
	Enhance national capacity for emergency disaster management and relief	Technical assistance	NEMO	Immediate	Greater preparedness to respond and manage natural disasters
	Enhanced training for the annual collection and analysis of GHG data and V&A process	Finance Technical assistance	MoA-BPS	Immediate	Annual reporting of National GHG Inventory and Vulnerability Index
	Sustain National Environment Protection Council	Finance	Office of the President	Long-term	To ensure on-going information dissemination and activities relating to climate change
Institutional Strengthening	Improve coordination among stakeholders	None	National Planning Commission	Immediate	Multi-sectoral approach to climate change and sustainable resource use initiatives
	Facilitate effective information and resource sharing among stakeholders	None	National Planning Commission	Immediate	Decision makers and stakeholders knowledgeable of climate change causes and effects
	Establish standard procedures for data collection, management, analysis, and reporting	Finance Human resources	MoA-BPS	Immediate	Annual National GHG Inventory and Vulnerability Index
	Integration of climate change vulnerability assessments in agency work programs	Finance Human resources	MoA-BPS Relevant agencies	Medium	Increased capacity to monitor climate change vulnerability in-country
	Upgrade relevant agency equipment for data collection and monitoring	Finance	MoA-BPS Relevant agencies	Short-term	Increased technical capacity for data collection, monitoring, and assessments

Research and Monitoring					
Objective	**Activities**	**Resources**	**Lead Agency**	**Timeline**	**Indicator**
Scientific data	Establish or enhance linkages with other research and monitoring institutions both locally and abroad	Finance Technical assistance Human resources	PICRC, MRD, MoJ-DFWP, PCC, EQPB	Medium	Increased research and monitoring of climate change impacts on Palau's ecosystems
	Develop and impliment research and monitoring of the impacts of climate change on fisheries, terrestrial ecosystems, and human health	Finance Technical assistance Human resources	PICRC, MoH, MRD-BoF	Immediate	Scientific data available on the impacts of climate change on Palau's fisheries, terrestrial ecosystems, and human health
National Awareness					
Objective	**Activities**	**Resources**	**Lead Agency**	**Timeline**	**Indicator**
Create awareness of climate change and its impacts at all levels	Develop and implement an on-going public awareness program focusing on the benefits of managed areas and sustainable resource use	Finance	MRD-CASO	Medium	Increased national awareness on the benefits of managed areas and sustainable resource use
	Develop and implement strategy to promote alternative modes of transportation and associated infrastructure	Finance Technical assistance Human resources	MRD-CIP PPUC	Immediate	Strategic plan adopted and implemented
	Coordinate a wholistic approach to existing energy conservation public awareness programs	Finances	MRD-BPW MRD-Energy Office PPUC	Immediate	A national and on-going energy conservation program developed and implemented
National Development Planning					
Objective	**Activities**	**Resources**	**Lead Agency**	**Timeline**	**Indicator**
Coastal Zone Management	Provide incentive measures to reduce coral dredging in construction activities	Finances	MRD-CIP	Short-term	Reduction of coral dredging for construction
	Develop and implement on-going fish/other in-shore marine food sources inventories and monitoring	Finances Technical assistance Human resources	MRD-BoF	Short-term	Data on the fish and inshore food sources available, on-going monitoring of in-shore marine habitats
Managed ecosystems	Ratification of the Protected Areas Network legislation	Technical assistance	MRD	Short-term	Protected Areas Network ratified by the OEK
	Development of criteria for potential sites under the Protected Areas Network	Finance Technical assistance	MRD, NEPC	Short-term	Criteria for site identification under the Protected Areas Network established and implemented

	Expand Marine Protected Areas management to include data collection, monitoring, and analysis of climate change related trends	Finance Technical assistance Human resources	PICRC All relevant agencies	Immediate	MPAs incorporating monitoring and data collection and analysis relating to coral bleaching
	Development of dive site management plans	Finance Technical assistance	National Tourism Unit	Short-term	Implementation of effective dive site management plan
Infrastructure protection	Discourage development below 10 meters above sea level	None	National Planning Commission	Immediate	Reduced development activities sea level rise critical areas
	Upgrade existing causeways against sea level rise and increasing storm activity	Finance Human resources	MRD-CIP States	Immediate	Causeways constructed at high elevation and fortified against storm activity
Water Resource Management	Develop and implement long-term water resource management strategy incorporating climate change, sea level rise, and ground water salinity	Finance Human resources	MRD-DoA MRD-BPW	Medium	Effective long-term water management strategy implemented
	Strengthen protection of current groundwater resources through infrastructure development guidelines (sewerage, wastewater management, solid waste management, and buffer zones)	Finance Technical assistance Human resources	MRD-CIP EQPB	Immediate	Development guidelines strengthened and enforced
	Develop and implement effective storm water management	Finances Human resources	MRD-BPW	Medium	Storm water harnessing and storage plan implemented
	Review and recommend the viability and usability of desalination technology	Human resources	NEPC	Medium	Review of the potential of desalination available to decision makers
Food security	Promote sustainable use of local agriculture, fisheries, and aquaculture production	Finances Human resources	MRD-BoA	Immediate	Increased agriculture and aquaculture production, and fisheries management
	Establish and promoted the use of new technologies for loca food production	Finances Technical assistance Human resources	MRD-BoA	Medium	New agriculture, fisheries, and aquaculture technology available to stakeholders

Economic strategies	Identify and develop mechanisms for tourism product diversification to reduce stress and industry reliance on marine environment	Finances Technical assistance Human resources	NTU PVA	Short-term	Increased diversification of tourism product
	Develop and establish incentive measures for sustainable economic diversification in other non-tourism related economic sectors	Finances Technical assistance Human resources	MCT	Long-term	Increased economic diversification across all sectors
Human health	Identify and incorporate climate change impacts on human health in national health management plans.	Finances Human resources	MoH	Immediate	national health management plans reflect climate change trends
Energy options	Identify and disseminate alternative energy and energy efficient technology options to decision makers	Technical assistance Human resources	MRD-Energy Office	Immediate	Decision makers and stakeholders knowledgeable of alternative energy and energy efficient options
Greenhouse Gas Mitigation					
Objective	**Activities**	**Resources**	**Lead Agency**	**Timeline**	**Indicator**
Demand side	Establish requirements for government procurement process to purchase only energy efficient products for public sector infrastructure	None	MoA	Immediate	Increased national awareness of energy efficiency and usage, reduction of GHG emissions
	Promote energy efficiency through the establishment of building codes	Technical assistance	MRD-CIP EQPB	Medium	National building code regulation developed, adopted, and implemented
	Develop and implement national energy efficient usage program	Finance Technical assistance Human resources	MRD-CIP PPUC	Immediate	Increased national awareness of energy efficiency and usage, reduction of GHG emissions
	Establish incentive measures for private sector to promote energy efficient products	Finances Technical assistance	MoA PPUC	Medium	Increased product availability
	Enhance the efficiency of existing energy technologies	Finances Technical assistance	PPUC	Medium	Increased efficiency of existing energy technologies
	Identify and promote viable energy efficient public transportation	Finances Technical assistance	MRD-Energy Office	Long-term	Establishment of energy efficient public transportation

Supply side	Identify and introduce technologies for increased energy efficiency	Finances Technical assistance	MRD-Energy Office	Medium	Increased awareness of new technologies options
	Establish OTEC facility	Finances Technical assistance Human resources	MRD-Energy Office	Long-term	OTEC facility established and in operation
	Source and introduce other viable alternative energy options such as hybrid technology	Finances Technical assistance	MRD-Energy Office	Long-term	Awareness of alternative sources of energy made available to decision makers and stakeholders
Carbon sinks	Implement effective forest management and protection measures	Finances Technical assistance	MoA-DoF	Medium	Forest management and mangrove management plans developed, adopted, and implemented
	Strengthen coral reef protection measures through marine protection areas network	Finances Technical assistance Human resources	PICRC	Medium	Increased protection and monitoring of coral reefs
	Develop and implement vegetation cover programs	Finances Human resources	MRD-DoF	Short-term	Increased vegetation cover

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