Republic of Palau

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

September 2013

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List of Acronyms

ADB	Asian Development Bank
BoA	Bureau of Agriculture
EEAP	Energy Efficiency Action Plan
EESP	Energy Efficiency Subsidy Program
EEZ	Exclusive Economic Zone
ENSO	El Niño Sothern Oscillation
EQPB	Environmental Quality Protection Board
ESSAP	Energy Sector Strategic Action Plan
FAO	Food and Agriculture Organization
GCCA	Global Climate Change Alliance
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
LEAP	Long-range Energy Alternative Planning
LUCF	Land-use change and forestry
MPA	Marine Protected Areas
NAP	National Adaptation Plan
NDMAP	National Drought Mitigation Action Plan
NEHAP	National Environmental Health Action Plan
NEHSAP	National Environmental Health Strategic Action Plan
NEMO	National Emergency Management Office
NEP	National Energy Policy
OTEC	Ocean thermal energy conversion
PACC	Pacific Adaptation to Climate Change
PALARIS	Palau Automated Land and Resource Information System
PAN	Protected Areas Network
PECS	Palau Energy Conservation Strategy
PICRC	Palau International Coral Reef Center
PIREP	Pacific Islands Renewable Energy Project
PPUC	Palau Public Utilities Corporation
PWSC	Palau Water and Sewage Company
RESP	Renewable Energy Subsidy Program
SEDREA	Sustainable Development through Renewable Energy Applications
SIDS	Small Island Developing States
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
US AID	United States Agency for International Development
VAA	Vulnerability and Adaptation Assessment

Executive Summary

The Republic of Palau Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC) was developed with the financial support of the Global Environment Facility (GEF) and technical and project management support of the United Nations Environment Programme (UNEP).

National Circumstances

The Republic of Palau is a Pacific island nation with a population of approximately 20,000 people. Though Palau consists of 586 islands, only 12 islands are inhabited, and the majority of the population live on the islands of Koror and Babeldaob. Civilization in Palau is estimated to have begun as early as 1,000 BC. During the early 20th century, Germany and Japan governed Palau. Following World War II, Palau became a trust territory under the administration of the United States, and in 1994 Palau gained independence.

Palau is well known for its exceptional terrestrial and marine biodiversity, especially its coral reefs. As a result, its reefs have been recognized as one of the Underwater Wonders of the World, and its Rock Islands are listed as a World Heritage Site. In 2012, 118,754 tourists visited Palau. Palau has a maritime tropical climate due to its location near the equator. Though Palau is south of the normal typhoon belt of the western Pacific, Typhoon Bopha hit Palau in 2012 followed by Typhoon Haiyan in less than a year causing extensive damage.

Palau is working towards the goal of producing at least 20% of its total energy from renewable sources and 30% through energy efficiency and energy conservation by the year 2020. Currently, diesel generators produce the majority of Palau's energy, with only 3% of energy coming from renewable sources.

National Greenhouse Gas Inventory

For this Second National Communication, Palau carried out a greenhouse gas (GHG) inventory covering the years 1994 to 2005. In 2005, Palau's GHG emissions, including land-use change and forestry, totaled 248.02 Gg-CO_2 eq. The uptake of CO_2 from land-use change and forestry in 2005 was estimated to be 98.57 Gg. Palau's total GHG emissions increased by 248.84 Gg-CO_2 eq. between 1994 and 2005. CO_2 is the major GHG emitted, followed by N_2O and CH_4. For the years covered, the energy sector accounted for 84%-96% of Palau's GHG emissions.

Vulnerability and Adaptation Assessment

The Vulnerability and Adaptation Assessment addresses five sectors—coastal communities, coastal zones, water resources, human health, and food security. The coastal communities section focuses on Melekeok state and tourism. The coastal zones section addresses mangroves, seagrass, and coral reefs. The water resources section focuses on Ngerikiil watershed. The human health section focuses on vector-borne diseases. The food security section focuses on taro.

Mitigation Assessment

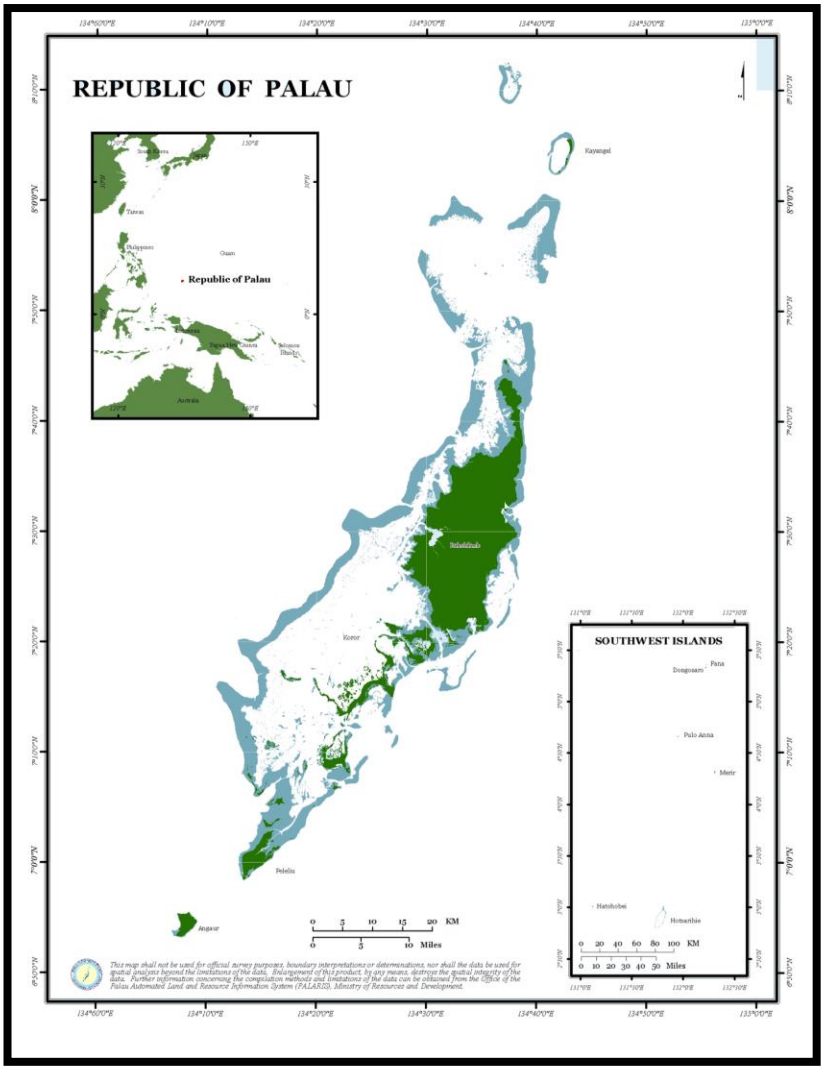
The mitigation assessment carried out a descriptive assessment of mitigation activities in Palau. The assessment focuses on the energy sector and carbon sinks. Palau is already implementing numerous energy efficiency and renewable energy projects but will require funding to implement projects in the pipeline. Palau's forestry activities benefit from the Protected Areas Network (PAN) but will require more data collection to adequately assess Palau's forests in their capacity as carbon sinks. This chapter also includes a plan to collect data so that formalized modeling can be conducted for the Third National Communication.

Chapter 1: National Circumstances

1.1 Geography

Established as an independent country on October 1, 1994, the Republic of Palau is situated 7 degrees north latitude and 134 degrees East longitude and approximately 550 miles (885.14 kilometers) from the Philippines, 813 miles (1308.4 kilometers) from Guam, 450 miles (724.21 kilometers) from Indonesia and Papua New Guinea, and 2,500 miles (4023.36 kilometers) from Japan. Palau is the westernmost island group of the Caroline Islands archipelago in the western Pacific Ocean.

Figure 1: Map of Palau



Palau is distinct in its ecological origin and creation, with four types of islands existing in the archipelago—volcanic, reef and atoll, low platform, and high limestone.

The Republic of Palau is an island chain consisting of about 586 islands, twelve of which are inhabited. The total land area is 188 square miles (486.92 square kilometers) and encompasses more than 560 square miles (1450.39 square kilometers) of lagoon

areas. Babeldaob, the largest island in the Palau archipelago, has an area of 332 square kilometers. Babeldaob came into being about 70 million years ago, resulting from volcanic activity, and is composed of basalt and andesite (Collins, 2004). Situated to the south of Koror, Palau's world renowned Rock Islands are formed from limestone. Peleliu and Angaur, located at the southern end of the Palau island chain, are low platform and reef islands. The southwest group of islands—Sonsorol, Hatohobei, Merriil, and Pulo Anna—are located about 500-700 kilometers off the main archipelago and are made up of low platform islands and one atoll, Helen Reef.

Figure 2: Palau's Rock Islands

Babeldaob is the second largest island in Micronesia, comprising 80% of Palau's total landmass. Babeldaob spans 153 square miles (396.27 square kilometers) (OPS, 2008). Babeldaob is home to Mt. Ngerechelechuus, the highest point in Palau at 795 feet (approximately 242 meters) above sea level.

Babeldaob contains five major watersheds—Ngeremeduu, Ngerdorch, Ngerikiil, Diongradid, and Ngerbekuu. Most of the rivers and streams found in Babeldaob have limited flow. An average of 500 million gallons of freshwater flow out of Babeldaob streams each day. Ngeremeduu watershed is the largest watershed in Palau with the size of 31 square miles (80.29 square kilometers). Lake Ngardok, the largest natural lake in the entire Micronesian region, is located in Babeldaob.

All of Palau is located within one barrier reef with the exception of Kayangel, Angaur, and the Southwest Islands. Palau has 12 nautical miles (22.22 kilometers) of territorial seas with 200 nautical miles (370.4 kilometers) of exclusive economic zone, which encompass 237,850 square miles (613.83 square kilometers) (OPS, 2008).

1.2 History

Today's Palauans are distant relatives of the Malays of Indonesia, the Melanesians of New Guinea, and Polynesians. Based on carbon dating of artifacts from the oldest known village sites on the Rock Islands as well as the spectacular terraces on Babeldaob, civilization in Palau is estimated to have begun as early as 1,000 BC.

Figure 3: Stone monoliths in Babeldaob

The first foreign contact took place in 1783 when the vessel Antelope, under the command of English Captain Henry Wilson, was shipwrecked on a reef near Ulong, a Rock Island located between Koror and Peleliu. With the assistance of Koror's High Chief Ibedul, Wilson and his men stayed for three months to rebuild their ship. From that time onward, many foreign explorers visited Palau, and the islands were exposed to further European contact.

Foreign governance of Palau officially began when Pope Leo XIII asserted Spain's rights over the Caroline Islands in 1885. Two churches were established and maintained by two Capuchin priests and two brothers, resulting in the introduction of the Roman alphabet and the elimination of inter-village wars. In 1899, Spain sold the Caroline Islands to Germany, which then established an organized program to exploit the islands' natural resources.

Following Germany's defeat in World War I, the Caroline Islands were formally passed to the Japanese under the 1919 Treaty of Versailles. The Japanese influence on the Palauan culture was immense as it shifted the economy from a level of subsistence to a market economy and shifted property ownership from the clan ownership to individual ownership. In 1922, Koror became the administrative center for all Japanese possessions in the South Pacific. The town of Koror was a stylish metropolis with factories, shops, public baths, restaurants, and pharmacies.

Following Japan's defeat in World War II, the Caroline, Mariana, and the Marshall Islands became United Nations Trust Territories under U.S. administration. Palau became one of six island districts. As part of its mandate, the U.S. was to improve Palau's infrastructure and educational system in order for Palau to become a self-sufficient nation. This finally came about on October 1, 1994, when Palau gained independence.

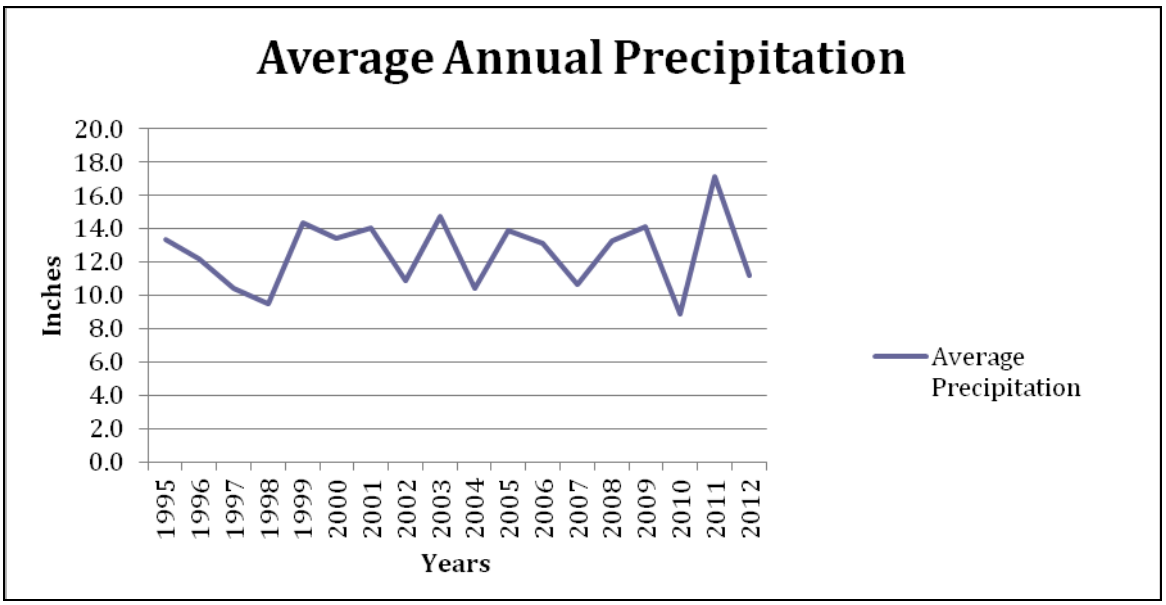
1.3 Climate

Palau boasts a maritime tropical climate due to its closeness to the equator. Therefore, precipitation is heavy, though it varies from month to month and year to year as well as by area. The temperature has minimal seasonal variation. The average daily temperature throughout the year is 82° Fahrenheit, and the average relative humidity is 82% (PCCSP, 2011). The annual rainfall in 2011 was 205.86 inches (NOAA, 2012). The wet season extends from May to October, and the driest season is February, March, and April (PCCSP, 2011).

Palau is south of the normal typhoon belt of the western North Pacific. Consequently, typhoons rarely hit Palau (PCCSP, 2011). However, on December 2, 2012, Typhoon Bopha—a category five typhoon—passed just south of Angaur, destroying 92 houses and damaging houses, schools, agriculture, and infrastructure in Palau (OCHA, 2012). The states of Ngaraard, Ngiwal, Melekeok, Peleliu, and Angaur sustained extensive damage from the storm. Though there were no casualties from the typhoon, electricity, drinking water, and communications were heavily impacted. Following Typhoon Bopha, Palau's National Emergency Management Office (NEMO) began developing a recovery plan both to restore damaged areas and to minimize impacts from

future disasters (NEMO, 2013). In addition, a few times per year tropical storms and typhoons pass north of Palau, usually several hundred kilometers away, bringing heavy rains and winds. Such storms may generate heavy surf in Palau, which can damage reefs (PCCSP, 2011).

Graph 1: Annual Precipitation in Koror 1995-2012 (National Weather Service, 2013)



1.4 Biological Diversity

Palau is known for its unique terrestrial and marine biodiversity and has been named one of the Underwater Wonders of the World (OERC, 2012). Palau is home to more than 12,000 terrestrial species and at least 3,000 marine species (Kitalong, 2013). Palau has one of the highest portions of endemic species in the world. Palau is also home to Ngermeduu Bay, the largest estuary in Micronesia, and Lake Ngardok, the largest lake in Micronesia. Other habitats in Palau include tropical rainforests, mangrove forests, seagrass beds, fringing reefs, barrier reefs, and marine lakes. In 2012, the World Heritage Committee approved the inscription of Palau's Rock Islands Southern Lagoon as a mixed natural and cultural World Heritage Site (UNESCO, 2012).

1.5 Marine Resources

The marine environment of Palau includes coral reefs with exceptional biodiversity, mud and sand flats, mangrove swamps, and seagrass beds (PICRC, 2007). The Palau International Coral Reef Center (PICRC) has collected and identified 222 coral species from Palauan waters. Palau has more fish diversity than other Micronesian islands, including approximately 1,450 species of fish (PICRC, 2007). Palau protects certain fish species—including napoleon wrasse, bumphead parrotfish, grouper, and rabbit fish—through closed-season management and protection of aggregation sites. In addition, Palau created the world's first shark sanctuary in 2009, prohibiting the fishing of sharks within Palau's exclusive economic zone (EEZ). The marine environment of Palau also includes marine lakes, which are connected to the ocean via channels in their rock basins. Many tourists visit "Jellyfish Lake," a marine lake famous for its large population of golden jellyfish.

Figure 4: Exhibit at Palau International Coral Reef Center

Palau's marine environment has come under pressure in recent years due to natural and human-induced impacts. Such disturbances have resulted in impacts such as coral bleaching and crown-of-thorns starfish outbreaks (PICRC, 2007). Disturbances include soil runoff, introduction of non-indigenous species, overfishing, and ship grounding. PICRC is currently conducting research on reef resilience in order to identify which reefs are most resilient to these disturbances.

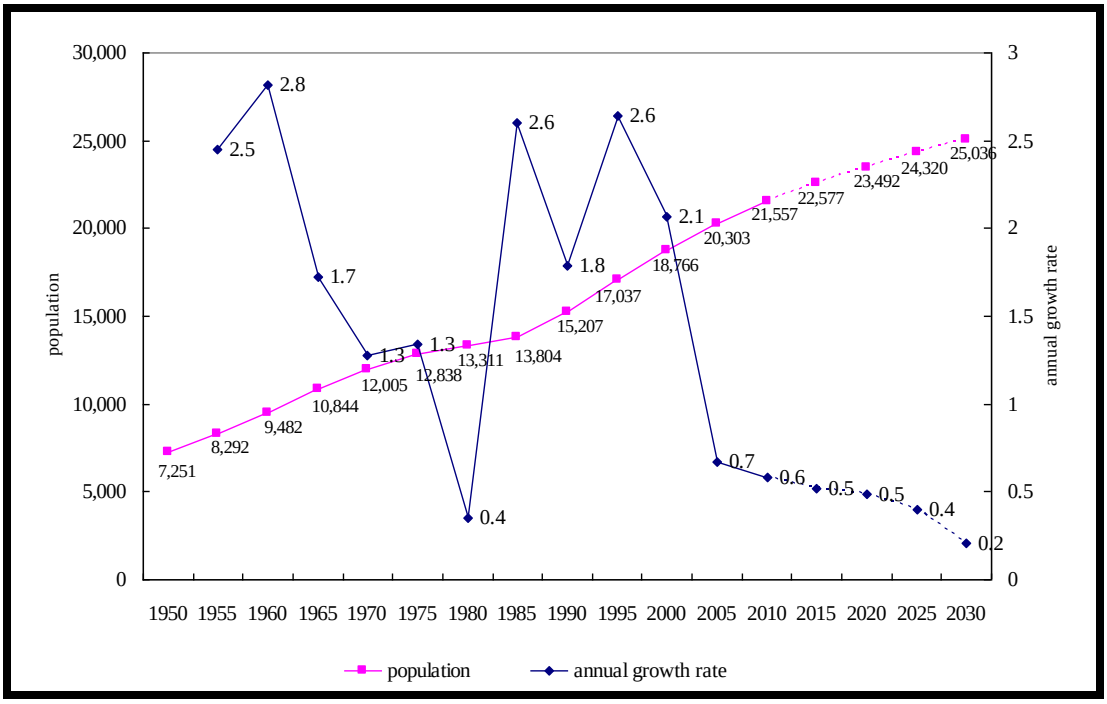
1.6 Population

Palau's 2005 Census revealed a total population of 19,907—an increase of 778 since 2000 (Palau 2005 Census). This reflects a growth rate of slightly more than 0.8% in the last five census years. In the 2005 Census, there were 10,699 males and 9,208 females, or 116 males per 100 females. The median age in 2005 was 32.3 years, up from 30.8 years in 2000. Only

5.7% of the population was 65 years old or older, and 24.1% of the population was under 14 years old. Those aged 15-64 made up 70.2% of the population.

According to the 2005 Census, 73% of Palau's population was ethnically Palauan, 23% was Asian, 3% was Carolinian or other Micronesian, and less than 1% was White. The majority of the Asian population in Palau was Filipino, and approximately 14% of the Asian population was Chinese and Vietnamese. The most prevalent religions in Palau were Catholicism, Protestantism, Seventh Day Adventist, and Modekngei—a religion that originated in Palau.

Graph 2: Palau Population Projections (U.S. Census Bureau, 2005)



The states of Koror and Airai continued to be the largest states with a combined 78% of Palau's total population (Palau 2005 Census). Koror remains the center of activity, and—having key public services, schools, a hospital, and a community college—it has attracted in-migrants and immigrants pursuing employment and educational opportunities. However, Airai saw a 3% increase in population between 2000 and 2005 and is expected to continue to grow as its residents continue to relocate from Koror. Airai's growth is attributed to its proximity to Koror

and the availability of land leases. On the other hand, Koror's population dropped 6% between 2000 and 2005. With the completion of the Babeldaob Compact Road—which facilitates access to the ten states in Babeldaob—and the construction of the Capitol Complex in Melekeok, the population will likely continue to shift to Babeldaob as people move back to their ancestral homes.

Palau's population growth rate of 0.8% between 2000 and 2005 was lower than in previous years, partly due to low fertility rates. The 2005 Census data indicate that this low fertility trend may continue as females move into the labor force and either delay having children or increase the time between adjacent children or both. The total fertility rate was already among the lowest in the Pacific and is likely to decrease even more as older women with large families are replaced with younger women with smaller families. In 2005, Palau's unemployment rate was 4.2%. Of employed persons 16 years or older, 34.7% are government employees and 27.6% work in the service industry. Only 5.7% of employed persons work in farming, forestry, and fishing occupations. The median family income in 2004 was $18,730.

1.7 Culture

Although in the past few decades Palau has adapted to an international economy, Palauans for the most part strongly identify with their traditional culture. Several of the traditional ceremonies—such as the *omesurch,* first birth ceremony, and the *kemeldiil,* funeral service—are widely practiced, and the beliefs adopted by Palauan forefathers are still revered today.

Probably the most noticeable aspect of Palauan culture is the people's connection with the environment. As the sea was the main source of livelihood, men developed a close relationship with the waters of Palau, becoming versed in the currents, the phases of the moon, and the behavior of the fish. Women generally stayed on land or along the shallow reefs surrounding the islands, rather than combat the open ocean, providing the foundation for the family. Their days were primarily spent tending to their homes, family, and fields where they grew taro.

Figure 5: Palauan "bai" or men's meeting house

Gender roles were equally valued as important functions necessary to sustain Palauan culture, society, and people. Decision-making power, leadership, and authority were organized around a matrilineal heritage. As a matrilineal society, important functions were distributed between males and females in order to ensure the harmony and welfare of the community. Women were often responsible for food production, which made them the logical guardians and managers of land use and natural resources. Men, on the other hand, were responsible for the protection and maintenance of their respective communities, ensuring adequate infrastructure as well as providing fish and other meat products to the community. Traditionally, men and women played key roles in various decision-making capacities with enormous influence placed on women's decision-making authority in all spheres of life. 21st century Palau illustrates that major decision-making authority regarding land use and land management now rest in modern government positions that are often occupied by men (Ngiraingas, 2011).

Traditionally, history, lore, and knowledge were passed down through the generations orally as there was no written language until the late 1800s. Palauans still practice that traditional method, and one can often find pockets of Palauans excitedly engaged in the telling of the stories of the more recent past.

1.8 Transportation

According to the 2005 Census, Palau has an average of 1.2 vehicles per household. In 2004, there were 14,165 non-government vehicles and 202 government vehicles registered in Palau.

Most of the 12-mile (19.31-kilometer) main road from the airport in Airai to Palau Pacific Resort in Ngerkebesang, Koror is paved, though many side roads remain unpaved. The 53-mile (85.30-kilometer) long Compact Road was completed in 2007. With the completion of the Compact Road, Palau is experiencing a drastic increase in the importation of used cars, which directly relates to fuel and energy consumption and exhaust gas emissions on the island. From 2004 to 2005, Palau imported 20,942,377.56 gallons of fuel, up from 11,903,800.10 gallons between 2002 and 2003 (Palau Division of Customs, Bureau of Revenue, Customs & Tax).

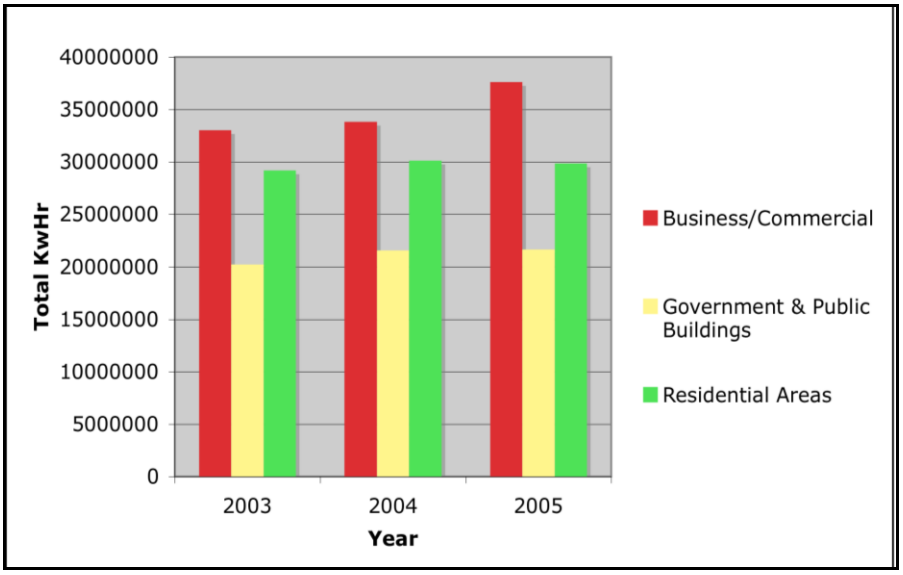
Several airlines fly to the Palau International Airport from Guam, Hawaii, Japan, Taiwan, the Philippines, South Korea, and the Federated States of Micronesia. Established in 2011, Palau Airways flies between Palau and Taipei and has plans to expand services to Hong Kong. In 2007, funding from the Federal Aviation Authority (FAA) allowed the Palau International Airport to resurface its runway to improve safety. While the government is addressing airport safety, it also recognizes that a permanent management structure must be identified that would best facilitate the required maintenance for efficient operations of the airport facilities. The tourism industry depends on this management structure. This will also enhance opportunities to establish and expand direct flights to major airport hubs. Privatization and private financing initiatives should be considered in order to ensure adequate funding sources for operations and maintenance.

1.9 Energy

The Energy Office within the Ministry of Public Infrastructure, Industries, and Commerce regulates energy in Palau and works with Palau Public Utilities Corporation (PPUC) on implementing energy projects. PPUC, established in 1994, is the semi-autonomous energy agency of the Government of the Republic of Palau. The main islands of Koror and Babeldaob have an electrification rate of close to 100% and have an electrical capacity of 39.3 MW (IRENA, 2013). Currently, PPUC operates two main power plants in Malakal and Aimeliik, which supply power to Koror and Babeldaob. PPUC also provides energy services to Kayangel, Peleliu, Angaur, and the Southwest Islands. While the majority of power is produced from diesel generators, several solar energy projects have been installed in Palau, including grid-connected

solar PV projects at the Capitol Complex and the Palau International Airport (REP-5, 2010) (KYOCERA, 2011).

Graph 3: Consumption of Electricity (PPUC, 2006)



The Palau Public Utility Corporation conducts public awareness energy conservation programs through newspapers, radio talk shows, and flyers. In 2007, PPUC launched a prepaid metering system (REP-5, 2010). The system enables customers to read their energy consumption at home and see which appliances and lighting fixtures in their residence consume the most energy.

1.10 Agriculture

In Palau, there are 18 different types of soil, which vary in texture, natural drainage, fertility, depth, and other characteristics. Agriculture is mainly on a subsistence level, the principal crops being coconuts, taro, and bananas. Production of agricultural goods for subsistence or commercial use is not extensive. Agriculture accounted for 1% of GDP in 2005 (OPS, 2008). The lack of economies of scale of agricultural production makes it less expensive to import food supplies from overseas than to produce similar produce domestically. The low output of agriculture production may also be attributed in part to the traditional system of land

ownership, lack of funding, lack of studies to identify soils arable for type-appropriate farming, lack of market studies, and lack of market structure to export produce.

Today, Palau must balance conservation and sustainable development. In 2005, the Bureau of Agriculture (BoA) with the collaboration of local agencies of interest prepared a two-year Strategic Plan, which aims to provide a framework ensuring sustainable development of land to meet Palau's needs now and in the future. The strategy details the roles and duties of each unit within the BoA in ensuring sustainable development. The role of the Forestry Unit of the Bureau is assisting each state in addressing its development and natural threats. The role of the Protected Areas Network Act (PAN) is to establish a nationwide network of protected areas that will allow the national government to assist the states in the protection of significant areas of biodiversity, significant habitats, and other valuable resources that are important to the future stability and health of Palau. The role of the Quarantine Unit is to prevent the introduction or further spread of injurious insects, pests, and diseases into and within Palau. The role of the Horticulture and Extension Unit is to promote and increase production of traditional and non-traditional crops.

BoA is working with international organizations such as the Secretariat of the Pacific Community (SPC), the Food and Agriculture Organization (FAO), US Agency for International Development (US AID), the US Forest Service, and the Secretariat of the Pacific Regional Environmental Programme (SPREP) to enhance agricultural activities in Palau. Other local agencies are collaborating and working with the Bureau to ensure the balance of conservation and development of Palau. These include Palau Conservation Society, The Nature Conservancy, Palau Community College-Cooperative Research and Extension, the Taiwanese Mission, and Natural Resources Conservation Services.

The 2020 Palau National Master Development Plan recommended the establishment of a central market where produce and other commodities could be sold. The marketplace at Bethlehem Park in Koror serves as a market for local produce and goods, and functions as a stimulus for growth in farming, fishing, and small craft industries.

1.1.1 Health

The Government plays a significant role in health service delivery. All citizens enjoy a constitutional right to health care, irrespective of their ability to pay. This has resulted in significant health care costs borne by the Government, which has led to increased calls for improved self-sustainability in services. The Ministry of Health recognized non-communicable disease as the most prevalent health ailment due to poor lifestyle habits, and the Ministry continues to place great emphasis on health promotion and disease prevention. Community awareness programs, as well as health education campaigns, continue to improve health through physical activity and nutrition, to prevent HIV/AIDS, to limit substance abuse, and to inform the community of Avian Flu and non-communicable diseases. Environmental health has also stepped up its efforts to improve sanitation and reduce threats to public health through increased inspection of restaurants and food processing locations as well as food inspection and inspection of waste disposal sites (ROP, 2006).

1.1.2 Education

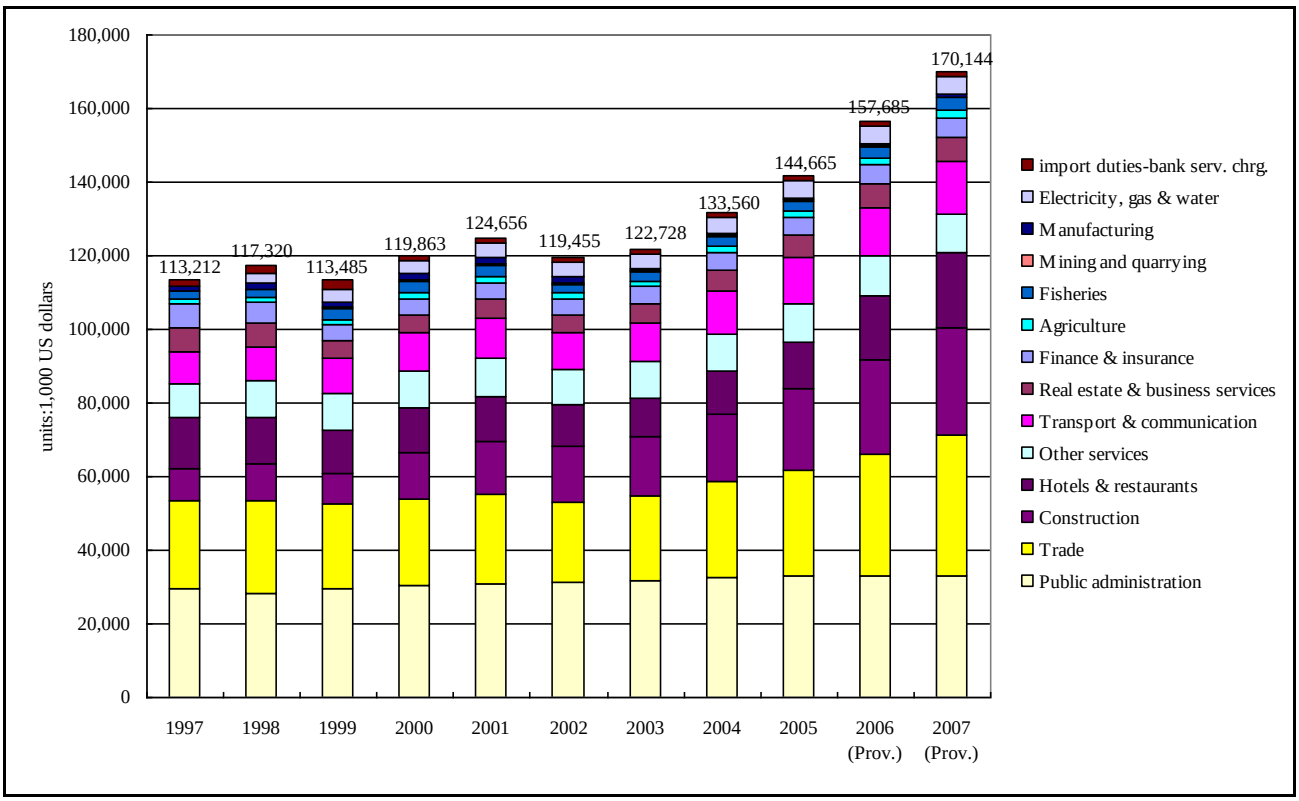
Palauan law requires that all children from age six to seventeen years of age must attend school until graduation from high school. Palau has 20 elementary schools, six high schools, and one community college. Sixteen of the elementary schools and one of the high schools are public schools. The others are private schools. Schools are distributed throughout Palau with each of the 16 states having at least one public elementary school. Special education addresses the individual needs of students with disabilities. This allows disabled students to participate in and benefit from the education system.

The Palau Community College is the only tertiary institution of higher education in Palau. The College offers a one-year certificate of achievement and an associate degree in many fields of studies as well as bachelor and masters cohort programs with San Diego State University. An adult education program continues to provide educational opportunities to those who dropped out of the school system and to improve parent literacy as a means of supporting the achievement of those students in the school system (ROP, 2006).

1.1.3 Economy

In 2009, Palau's Gross Domestic Product (GDP) was $204 million (UN Data). In 2009, Palau's economy grew 2.9%, compared to 5.5% growth in 2005. The high number of visitor arrivals and construction activity fueled by public sector spending attributed strong economic growth in 2004 and 2005. The table below presents Palau's GDP estimated figures by sector for the period of 1997 to 2007.

Graph 4: Palau GDP 1997-2007 (OPS, 2008)



Palau's primary economic activities—services with retailing and wholesaling, hotels and restaurants, and public administration—contributed over 50% of the economic output in 2005. In 2005, construction contributed 12% of the GDP and remains to be the most important industrial activity. With the implementation of major public sector infrastructure projects, construction is anticipated to show strong growth.

Hotels and restaurants contributed close to 11% of 2005 GDP (UN Data). With the strong growth in visitor arrivals, expanded airline schedules, the opening of Ngarachamayong Cultural Center (a conference hosting facility), and the opening of Palau Royal Resort hotel (a 5-star hotel), both the hotel and restaurant industries are anticipated to continue to grow.

The Government is diversifying the industry and is working with the State Governments and the private sector to promote and develop fish farming and other marine projects. Agriculture accounted for 1% of GDP in 2005. This is due to the lack of economies of scale in agricultural production, which makes imported food supply less expensive than produce grown locally. Manufacturing accounts for less than 1% of GDP in 2005 that are mainly from the production of processed foodstuffs and locally produced furniture and handicrafts.

Palau has endeavored to overcome the challenges it faces as a small island economy. Palau faces development constraints common among the Pacific island countries, including geographic isolation, a large public sector, a narrow productive base, a small domestic market, limited private sector activity, scarce skilled labor, poor infrastructure, and vulnerability to external shock. Economic reform has been challenging in the midst of the transition to a modern democracy, and strong political leadership has sought to foster a broad consensus for excellence in economic management and for safeguarding Palau's unique ecosystem for future generations (ROP, 2006).

1.1.3.1 Compact of Free Association

Under the 1994 Compact of Free Association, the United States provided over $600 million in assistance to Palau between 1994 and 2009, including the construction of the $149 million-Compact Road (OIA, 2011). The Compact agreement also established a trust fund, which was intended to provide the Palau Government $15 million per year from 2010 to 2044. However, the trust fund has suffered significant losses and is unlikely to provide the intended amount of money. Following the 2009 Compact review, the United States and Palau were unable to reach an agreement on extending 15-year financial arrangements of the Compact, although the

United States has continued to provide annual assistance comparable to its 2009 levels (OIA, 2012).

1.1.3.2 Tourism

In 2012, 118,754 tourists visited Palau (PVA, 2013). This represents an increase of 8.89% from 2011. The largest number of tourists came from Taiwan and Japan, representing more than one third each of the total number of tourists visiting Palau. Increasing the number of high-end visitors continues to offer the greatest potential in supporting sustainable economic development for Palau. Under Palau's Green Fee program, each tourist leaving Palau must pay a fee of $30, which goes towards conservation efforts as well as support towards the water and sewer infrastructure in Palau. Between November 2009 and March 2012, the Green Fee program raised over $2.2 million (SPREP, 2012). However, given Palau's unique natural and cultural environment and the potential adverse impacts of mass tourism, a more coordinated and cohesive approach should be aimed simultaneously, and be done in a way that builds economic progress, while preserving the pristine ecosystem.

Graph 5: Number of Visitors 1998-2012 (PVA, 2013)

1.1.4 Climate Change Policy Framework

As part of the European Union (EU) Global Climate Change Alliance (GCCA) initiative in partnership with the Secretariat of the Pacific Community (SPC), Palau is set to develop a climate change policy framework. This process includes a community engagement strategy as well as gaps and needs analysis, both of which will inform the climate change policy framework. The inception workshop for this project took place on April 2013 and is scheduled to be completed by 2015.

Chapter 2: National Greenhouse Gas Inventory

2.1 Introduction

As a Party to the United Nations Framework Convention on Climate Change (UNFCC), Palau is obligated to provide information on its national emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol.

2.2 Methodology

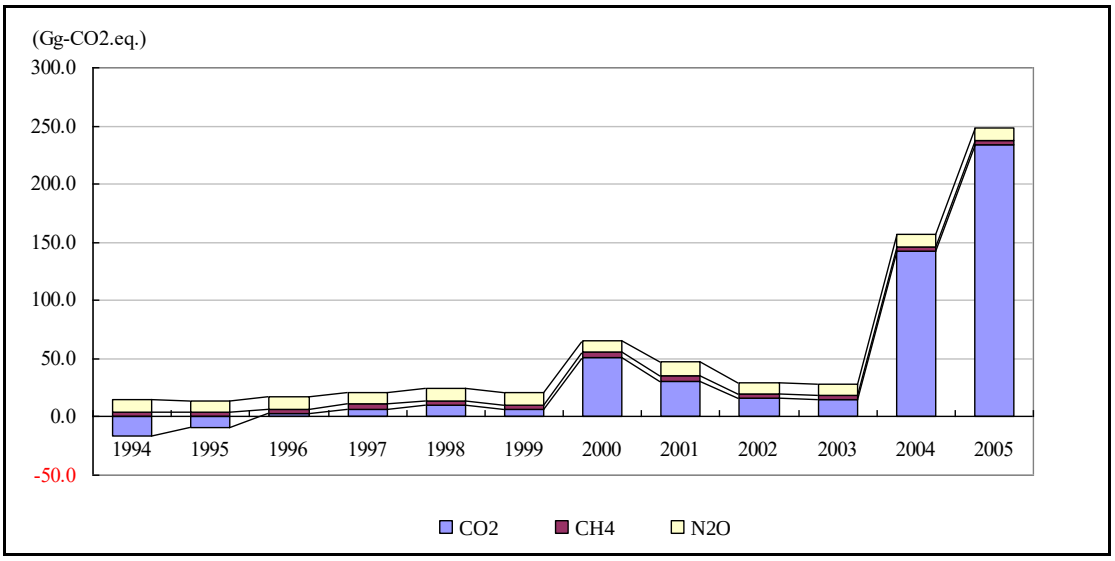
In compiling the greenhouse gas inventory, the *Revised 1996 IPCC Guidelines* and the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* were used for estimating and reporting national greenhouse gas inventories, in accordance with Decision 17/CP.8 of the Conference of the Parties to the UNFCCC. No consideration was given to the sector "Solvents and Other Product Use" as no methodology is provided in the *Revised 1996 IPCC Guidelines,* and emissions from this sector are assumed to be insignificant in the case of Palau.

2.3 Results Overview

The greenhouse gas emissions from the Republic of Palau in 2005 were 248.02 Gg-CO_2 eq (including land use change and forestry). This is an increase of 249 Gg-CO_2 eq. compared to 1994 and an increase of 91 Gg-CO_2 eq. compared to 2004. Emissions from the energy sector represent the majority of emissions in Palau for all years measured, ranging between 84%-96%

of total emissions (not including land use change and forestry). CO_2 is the major greenhouse gas emitted, followed by N_2O and CH_4. The emissions have a decreasing trend from 2002 to 2003 but sharply increase in both 2004 and 2005 due to the increase in energy consumption.

Graph 6: Emissions Trends by Gas

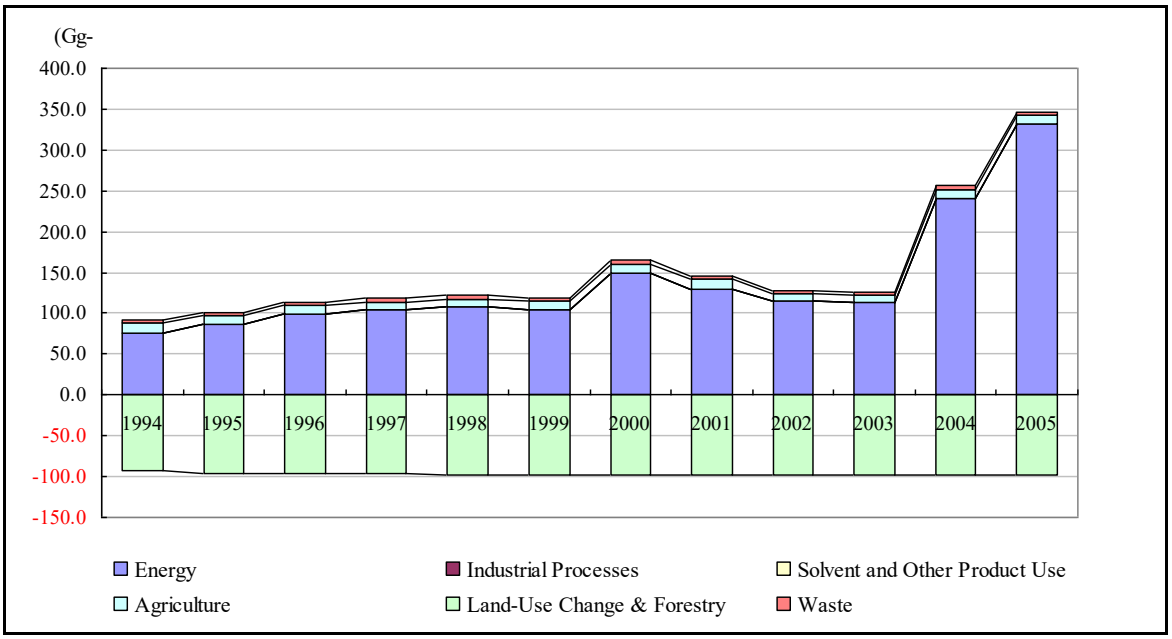


2.4 Improvements Made in Second National Inventory

As a result of having participants commit two weeks to emission/sink estimations, the inventory improved significantly from the First National Inventory in all sectors. The major improvement made was the collection of official data, especially for the Energy sector, which now covers all fuel consumption in the Republic of Palau. All raw data used in the inventory are archived in the Office of Environmental Response and Coordination (OERC), and all relevant information (such as methodology, activity data, emission factor, and assumptions) are documented in the inventory to facilitate future inventory.

2.5 Emissions by Sector

Graph 7: Emission Trend by Sector

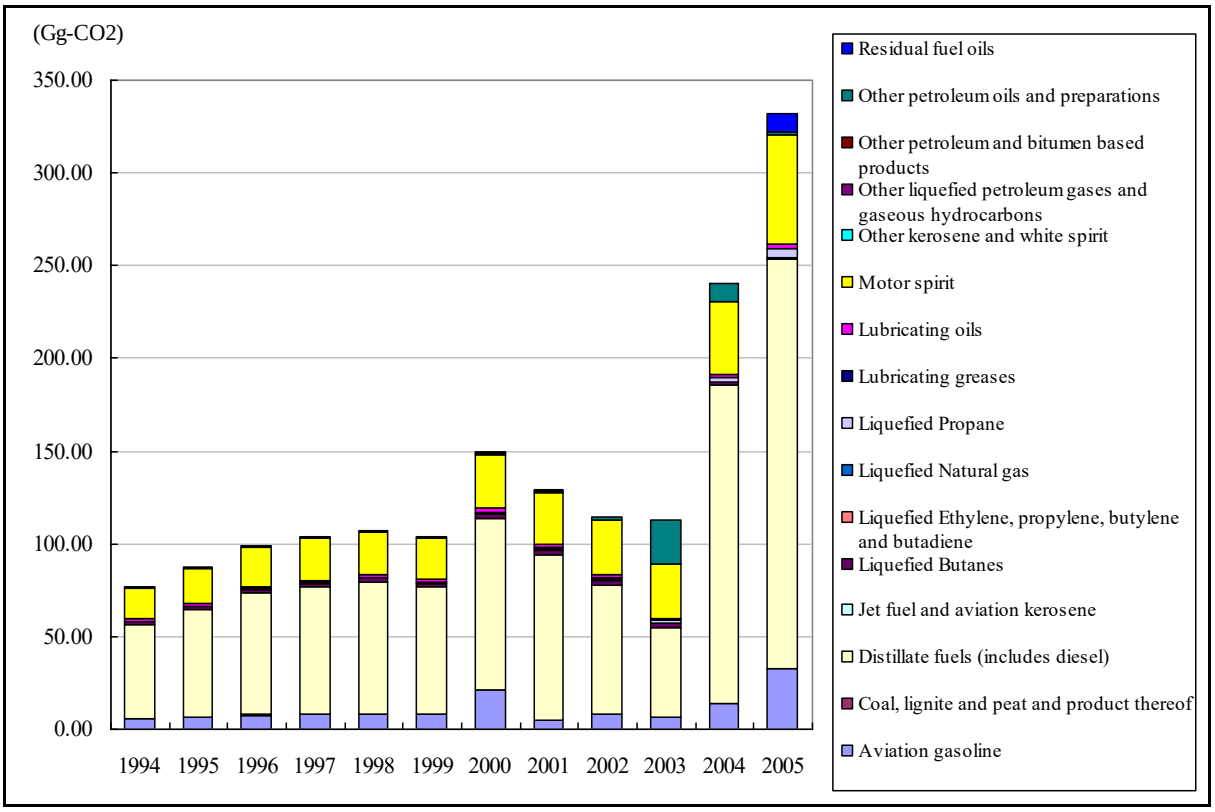


2.5.1 Energy Sector

As there is no fuel production in the Republic of Palau, all fossil fuel is imported from other countries. They are used and combusted in various sectors for power generation, industry, for residential use, and transportation. Fuel consumption drastically increased in 2004 and 2005 due to the construction of roads and the installation of new generators.

CO_2 emissions from fuel combustion in the year 2005 were 331.74 Gg-CO_2. This is an increase of 334% compared to the year 1994. The emissions from 2003 to 2004 show a sharp increase because of the increase of distillate fuel (including diesel) consumption. The largest emission source in fuel combustion is distillate fuels, which is mostly used in the power generation plants, manufacturing plants, trucks, and buses. The second largest source is motor spirit, which is mostly used for passenger vehicles.

Graph 8: Emissions from fuel combustion activities



2.5.2 Industrial Processes

2.5.2.1 Lime Production

Lime—or "ash"—production is a process of taking dead crushed coral and burning the coral over open fire until it forms a powder. Lime is produced in the States of Kayangel, Koror, Ngarchelong, and Peleliu. Kayangel produces the most lime. The estimation of lime production was based upon data provided in the Persistent Organic Pollutant's Data Inventory Information study. Manufactures produce 900 to 1,050 pounds of lime every two weeks in a furnace using virgin wood. Other locations produce approximately 150 lbs in 3 months using 55-gallon drums. The amount of lime produced is assumed to be constant throughout the time series.

Carbon dioxide emission from lime production was 0.01 Gg-CO_2 for each year between 1994 and 2005. The assumption was made so that the same amount of lime was produced each year, based on what little data was available. However, according to lime producers,

consumption of lime may be increasing over the years and is expected to continue to increase for the coming years.

Figure 6: Emissions from Lime Production

	unit	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Quantity of Lime Produced	t	12.68	12.68	12.68	12.68	12.68	12.68	12.68	12.68	12.68	12.68	12.68	12.68
Emission Factor	tCO_2/t	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
CO_2 Emissions	Gg CO_2	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**	**0.010**

2.5.2.2 Soda Ash Production and Use

The Republic of Palau does not produce soda ash, but imports and consumes soda ash to treat the main public source of water. Palau's Water Treatment Facility began operation in 1999. The total carbon dioxide emission from soda ash use for 1999 and 2000 was 0.083 Gg-CO_2. 'NO' has been reported for years 1994 to 1998 because soda ash was not used to treat water during that time period. The activity data was estimated according to information provided by the Water Treatment Plant operators. The Water Treatment Plant uses 24 bags of soda ash weighing 60 pounds each per day.

Figure 7: Emissions from Soda Ash Use

	unit	1994	1995	2000	2001	2002	2003	2004	2005
Quantity of Soda Ash Used	t	NO	NO	199.09	199.09	199.09	199.09	199.09	199.09
Emission Factor	kg CO_2/t	415	415	415	415	415	415	415	415
CO_2 Emissions	Gg CO_2	**NO**	**NO**	**0.083**	**0.083**	**0.083**	**0.083**	**0.083**	**0.083**

2.5.2.3 Road Paving with Asphalt

Temporary asphalt batch plants have been located in Peleliu, Airai, Ngchesar, and Ngaraard. Three temporary batch plants were located in Airai State for construction of the Compact Road and the national airstrip. The Compact Road is a 53-mile (85.30-kilometer) loop road in Babeldaob that was paved in 2005. The National airstrip was resurfaced in 2006. The temporary batch plant in Peleliu was transferred to Airai, but is currently non-functional.

The total non-methane volatile organic compound (NMVOC), CO, NO_X, and SO_X emissions from asphalt production from 1994 to 2000 were relatively stable. There was a decrease between 1994 and 1995, followed by a slight increase in 2000-2004. A significant increase in asphalt production occurred during 2005, causing emissions from these sources to rise significantly. The construction of the Compact Road and resurfacing of the national airstrip caused this significant increase in emissions. Upon completion of the airstrip and the Compact Road, asphalt production is expected to decrease.

Figure 8: Emissions from Road Paving

	unit	1994	1995	2000	2001	2002	2003	2004	2005
NMVOC Emissions from Asphalt Plants	Gg NMVOC	**0.00001**	**0.00001**	**0.00001**	**0.00005**	**0.00005**	**0.00005**	**0.00005**	**0.00143**
NMVOC Emissions from Road Surfaces	Gg NMVOC	**0.192**	**0.161**	**0.162**	**0.640**	**0.640**	**0.640**	**0.640**	**19.940**
CO Emissions from Asphalt Plants	Gg CO	**0.00002**	**0.00002**	**0.00002**	**0.00007**	**0.00007**	**0.00007**	**0.00007**	**0.00218**
NO_X Emissions from Asphalt Plants	Gg NO_X	**0.00005**	**0.00004**	**0.00004**	**0.00017**	**0.00017**	**0.00017**	**0.00017**	**0.00523**
SO_2 Emissions from Asphalt Plants	Gg SO_2	**0.00007**	**0.00006**	**0.00006**	**0.00024**	**0.00024**	**0.00024**	**0.00024**	**0.00748**

Estimation of asphalt production was based upon production from temporary batch plants from DAEWOO and Socio, Inc. In 2004, Socio produced 2,000 tons of asphalt. In 2005, DAEWOO produced 59,313.96 tons, and Socio produced 3,000 tons. No activity data were reported from 2001 to 2003, and it was assumed that production was similar to 2004.

2.5.2.4 Food and Drink

Production of cakes, biscuits, and breakfast cereals began in 1994 in Palau. Bread production began around 1920, but data was not recorded until 1994. The NMVOC emissions for food and drink are still incomplete due to lack of data collection. Thus, NMVOC emissions for the years after 2001 have the same values as the year 2000. The data for 1994 to 2000 were extrapolated from the First National Communication to the UNFCCC due to lack of data.

Figure 9: Emissions from Production of Food and Drink

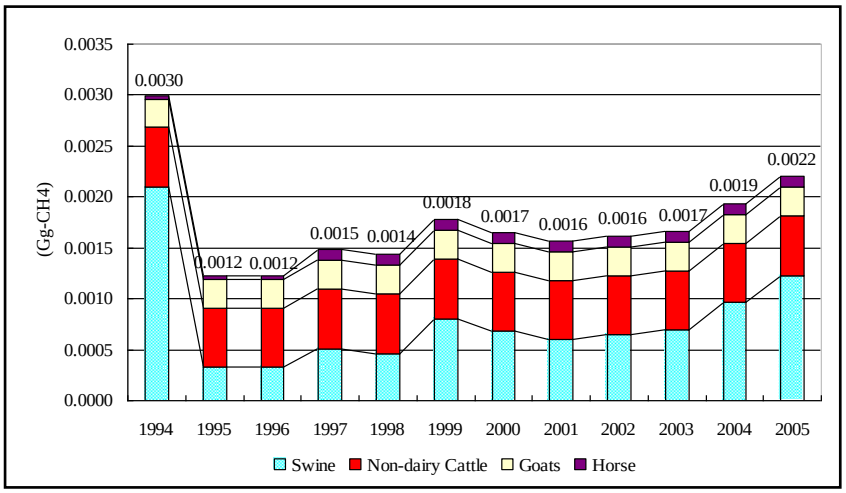
	unit	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Beer	Gg NMVOC	NO	NO	NO	NO	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sprits	Gg NMVOC	0.0003	0.0003	0.0006	0.0006	0.0006	0.0009	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Cakes, biscuits and breakfast cereals	Gg NMVOC	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Bread	Gg NMVOC	0.0025	0.0025	0.0025	0.0025	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026

2.5.3 Agriculture

2.5.3.1 Enteric Fermentation

Introduced livestock in Palau—including non-dairy cattle, goats, swine, and horses—emit CH_4 from enteric fermentation. In Palau, pigs are an important source of protein during cultural events. Horses were not brought in to the Republic of Palau for commercial use but for personal pleasure. In 2005, 27 people commercially raised pigs, one family owned a horse ranch, three people owned goats, and five people raised non-dairy cattle that were introduced to Palau as a source of protein.

Graph 9: Methane (CH_4) Emissions from Enteric Fermentation

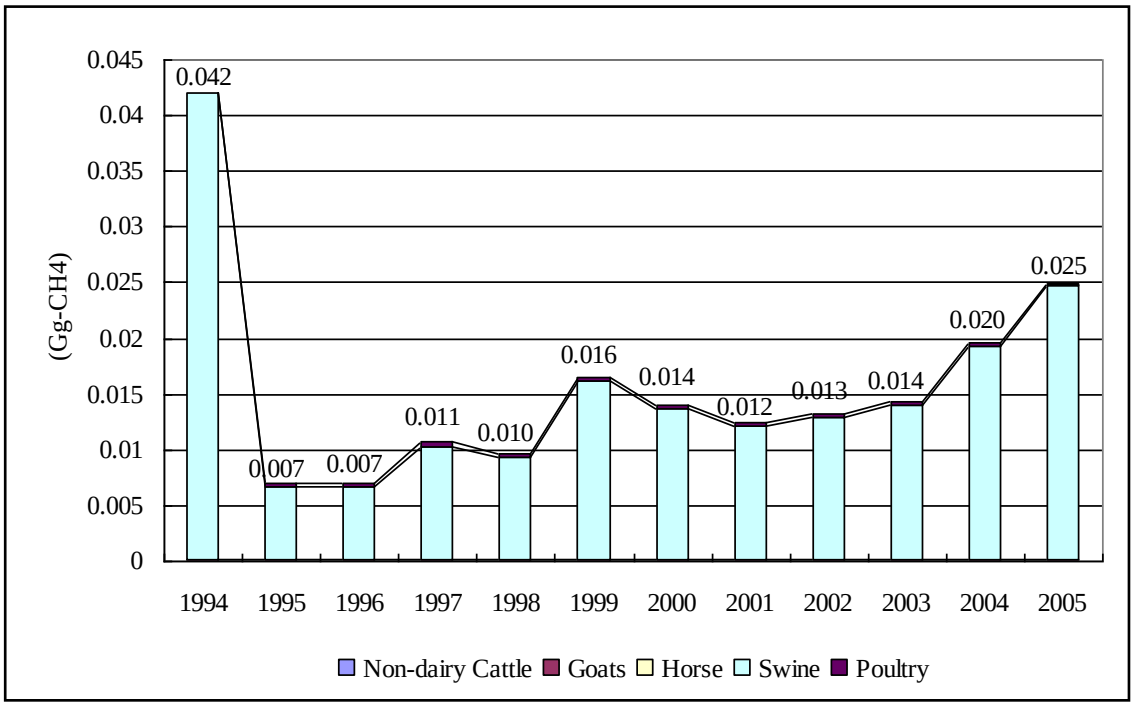


In 2005, CH_4 emissions from enteric fermentation from livestock totaled 0.002 Gg CH_4. This is a 27% decrease from the year 1994 and a 14% increase from the year 2004. Emissions from this category have generally increased since 1995 due to the increase in livestock, particularly the number of swine.

2.5.3.2 Manure Management

The types of livestock are covered in this category are non-dairy cattle, goats, swine, and poultry. The CH_4 emission trend for manure management fluctuated from 1994 to 2005. In the year 2005, the CH_4 emissions totaled 0.0250 Gg-CH_4, a 27% increase from 2004 and a 41% decrease from 1994. Methane emissions from swine contributed the most to the total methane emission from livestock.

Graph 10: CH_4 Emissions from Manure Management

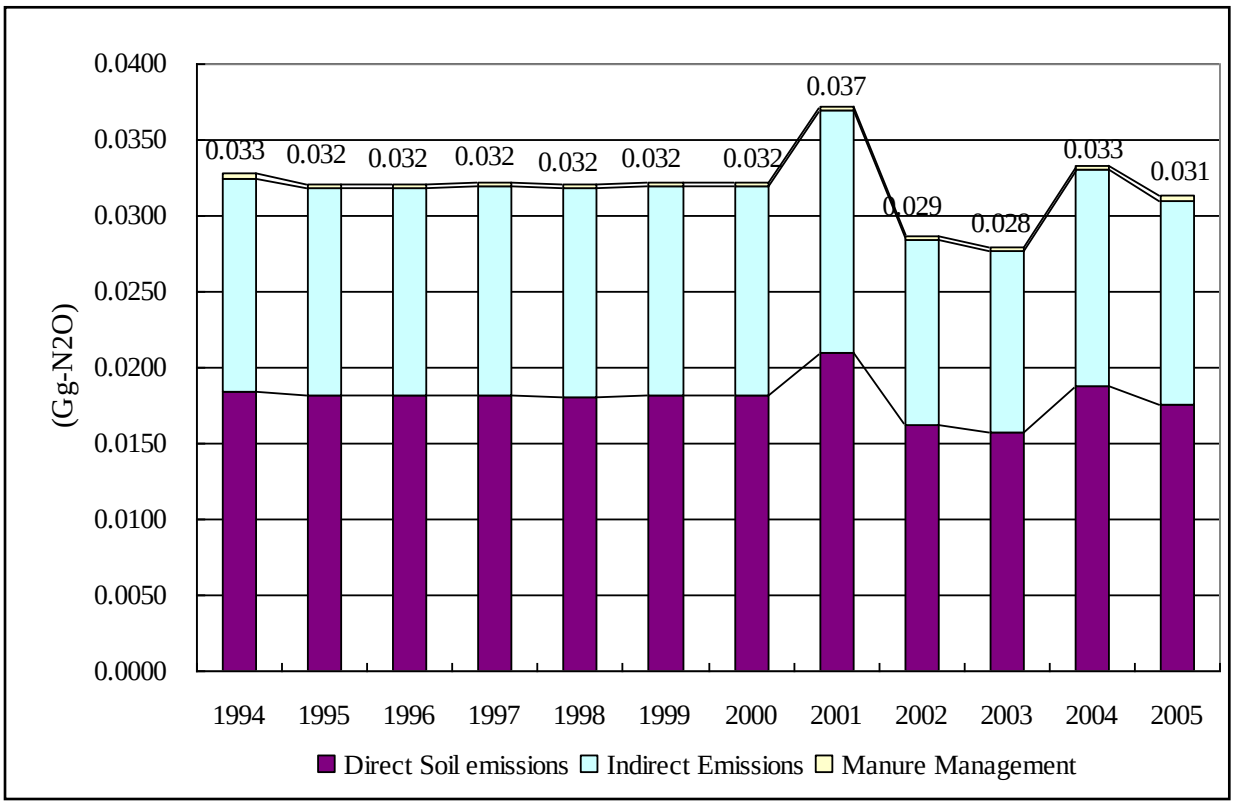


2.5.3.3 Direct Soil Emissions

In Palau, the use of fertilizers is regulated through permits issued by the Environmental Quality Protection Board (EQPB). However, the EQPB does not keep data on how much fertilizer is being used. The Division of Customs provided the data on fertilizers. Nitrous oxide emitted from animal manure is estimated in this category. Emissions from cultivated organic soils are reported as 'NE' due to the lack of data. Emissions from N-fixing crops are reported as 'NO' as soybeans and pulses are not grown in Palau.

In the year 2005, the N_2O emissions were 0.031 Gg N_2O, a 6% decrease from 2004 and a 4.5% decrease from 1994. The data provided was not the quantity, but the dollar value of all imported fertilizers. Therefore, the activity data is estimated using the total value of fertilizer imported divided by the average cost of fertilizer per pound, provided by Mason's Hardware Store in Koror. It was assumed that all fertilizer cost an equal amount.

Graph 11: Emissions from Agricultural Soils



2.5.3.4 Prescribed Burning of Savannahs and Field Burning of Agricultural Residues

The EQPB regulates open burning through permit issuance. Though the EQPB keeps record of the number of permits issued per year, no data is recorded regarding the content or quantity of burned material. According to national authorities from Bureau of Agriculture (BoA), savanna burning does occur in Palau, but, since there is no method to estimate the areas of savannas burned, 'NE' is reported for Prescribed Burning of Savannas. The BoA also states that field burning of agricultural residues could occur in Palau, but since there is no method to estimate the number of agricultural residues burned, 'NE' is reported for Field Burning of Agricultural Residues.

2.5.4 Land Use Change and Forestry

Much of the land area of the Republic of Palau is forestland, but little data is available on forest area in Palau. As there was no local data available on the forest area in the Republic of Palau,

international data from the FAO's *Global Forest Resources Assessment 2005* was used. The CO_2 uptake in 2005 was 98.57 Gg-CO_2, which represents a 3% increase from 1994.

For determining the type of forests in Palau, the data from the *1979 Vegetation Survey of the Republic of Palau* was used. The fraction of each type of forest from the *1979 Vegetation Survey* was used for areas of mixed hardwood forest area (Plantation forest), mixed softwood forest area (Coconut plantation), and moist forest area (Forest + Agroforest – Hardwoods – Softwoods). The major change from the previous inventory is the use of updated data for forest area from the FAO. The allocation of type of forest was changed for this inventory to improve transparency. The annual growth rate for moist forest was changed because the previous inventory used an incorrect parameter.

Figure 10: Uptake from Biomass Stock

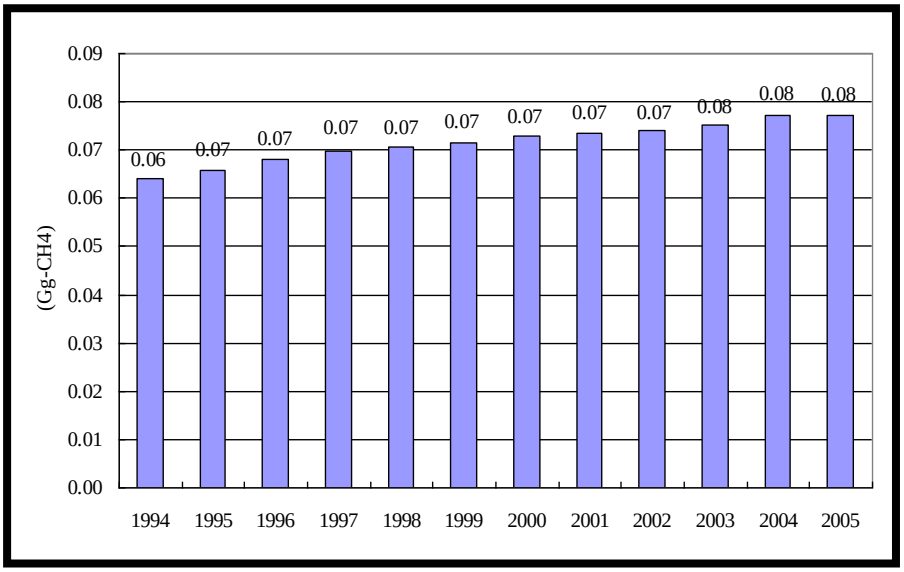
	unit	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Carbon Uptake Increment (Hardwood)	kt C	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Carbon Uptake Increment (Softwood)	kt C	7.06	7.09	7.13	7.16	7.19	7.23	7.29	7.29	7.29	7.29	7.29	7.29
Carbon Uptake Increment (Moist)	kt C	18.86	18.95	19.04	19.13	19.22	19.30	19.48	19.48	19.48	19.48	19.48	19.48
Annual Carbon Uptake from forest/biomass stock	kt C	26.03	26.15	26.27	26.39	26.52	26.64	26.88	26.88	26.88	26.88	26.88	26.88
Annual CO_2 Uptake from forest/biomass stock	Gg-CO_2	95.44	95.88	96.33	96.78	97.23	97.68	98.57	98.57	98.57	98.57	98.57	98.57

2.5.5 Waste

2.5.5.1 Solid Waste Disposal on Land

Most of the states in Palau dispose wastes—such as kitchen wastes, garden wastes, papers, and textiles—in open dumpsites, except for Koror. In Koror, solid wastes are disposed at a landfill in M-Dock. M-Dock is the only dumpsite in Palau that has been rehabilitated and upgraded from being on open dumping ground to a landfill (JICA, 2009). Data used to make estimations for emissions are derived from residential wastes and visitors' wastes in Koror. Methane emissions from Solid Waste Disposal on land in 2000 were 0.07 Gg CH_4, representing a 21% increase compared to 1994.

Graph 12: Emissions from Solid Waste Disposal on Land

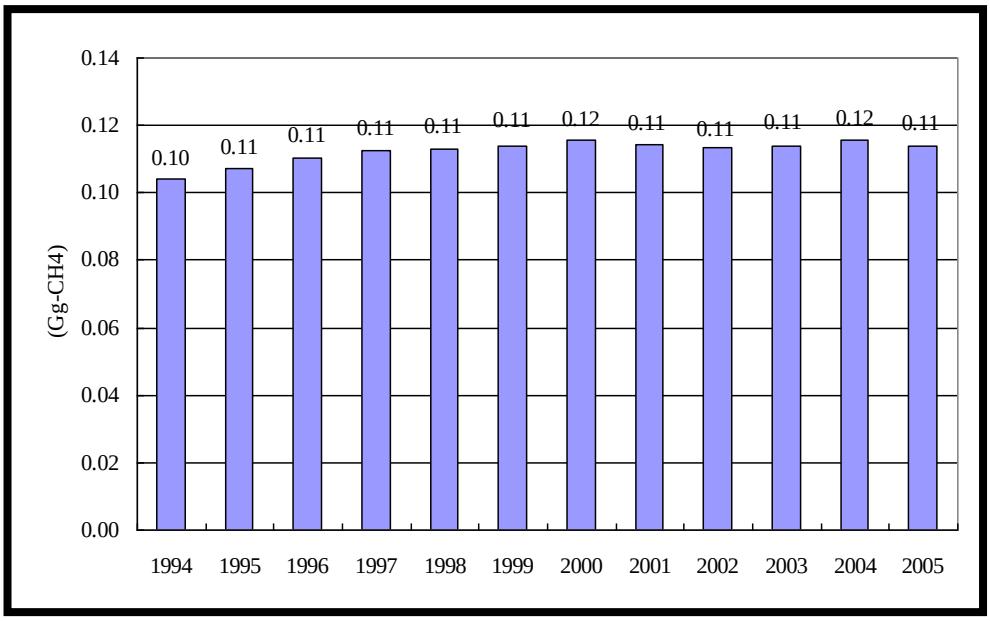


The total population of the Republic of Palau was used to estimate CH_4 emissions. The Office of Planning and Statistics provided data for the years 1995, 2000, and 2005. The other years were estimated by interpolation and extrapolation. The total number of visitors was taken from data provided by the Palau Visitors Authority. The average length of stay for visitors was assumed to be five days.

2.5.5.2 Domestic Wastewater

In Palau, domestic wastewater includes storm runoff, grey water waste from kitchens and laundromats, and leachates from paper and textile wastes. Methane emissions from domestic wastewater in 2005 were 0.11 Gg CH_4. This represents a 9% increase compared to 1994. The total population size of Koror State that was used to estimate methane emissions were taken from the Office of Planning and Statistics for the years 1995, 2000, and 2005. The other years were estimated by using interpolation and extrapolation. Moreover, computation of emissions estimates were only in Koror State since it is the only state with available data. Taking note that a majority of the population (70%) reside in Koror, the state serves as a proxy to Palau's overall emission generation. The total number of visitors was taken from the Palau Visitors Authority. The average length of stay for visitors in Koror was assumed to be five days.

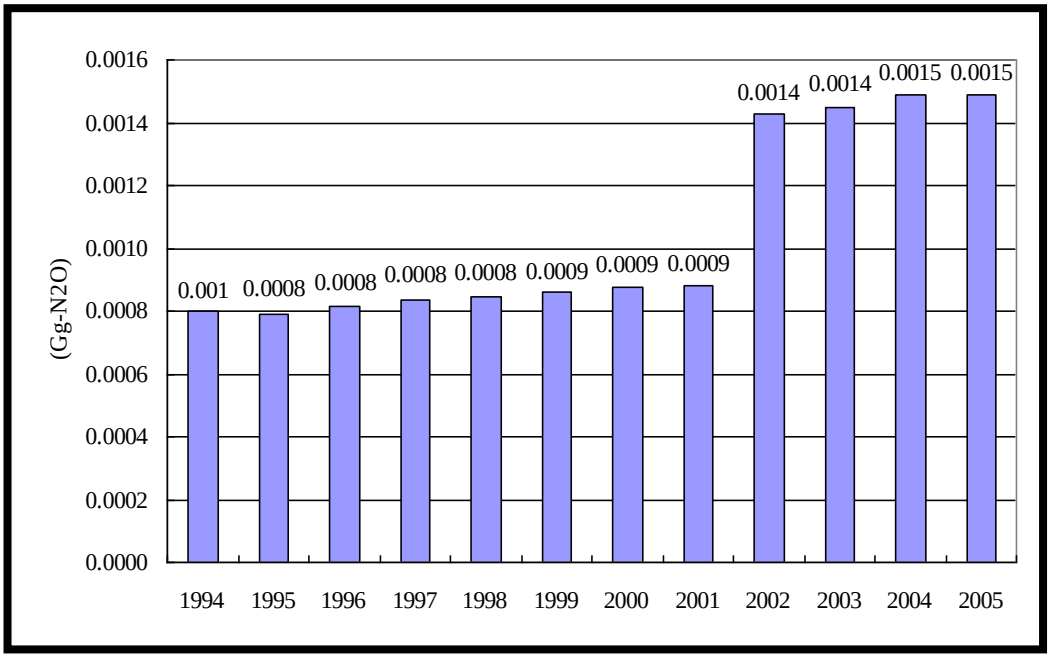
Graph 13: Emissions from Domestic Wastewater



2.5.5.3 Human Sewage

In Palau, there is a centralized domestic wastewater treatment plant located in Koror. There are also homes with open-pit toilets in Koror. All other islands of Palau have septic tanks, open-pit systems, or composting toilets for wastewater. The main tourist area, the southern lagoon of Palau, has composting toilet systems in at least five designated tourist area sites. N_2O emissions from the human sewage in 2005 were 0.0015 Gg N_2O, an increase of 86.1% compared to 1994. The main reason for this increase is the increase in average protein uptake by the people in the Oceania region. Per capita protein consumption from 1994 to 2005 was taken from the FAO STAT Dietary Protein Consumption (Oceania). The total population of Palau used to estimate the emissions were taken from the Office of Planning and Statistics for the years 1995, 2000, and 2005. The other years were estimated by interpolation and extrapolation. The total numbers of visitors were taken from the Palau Visitors Authority. The average days for visitors to stay in Koror, Palau was assumed to be five days.

Graph 14: Emissions from Human Sewage



2.5.5.4 Waste Incineration

There are incinerators in Palau in the states of Koror, Peleliu, Ngiwal, and Airai. The Peleliu and Ngiwal incinerators have been shut down. Airai has recently acquired an incinerator that is currently not in operation. Two incinerators that are still working are located in Koror. The incinerator at the Belau National Hospital is used to burn hazardous waste (used syringes and surgical equipment), pharmaceutical wastes (expired medicine), and clinical wastes (wastes generated from surgical operations). The incinerator located in Malakal, Koror at the Bureau of Agriculture is used to burn confiscated plants and animals illegally entering Palau. This includes fruits, vegetables, and wood products. The amount of CO_2 emissions from the years 2002 to 2005 was 0.007 Gg of CO_2 emissions.

Figure 11: Emissions from Waste Incineration

	unit	1994	1995	2000	2001	2002	2003	2004	2005
CO2 Emissions	Gg CO_2	**NO**	**NO**	**NO**	**NO**	**0.01**	**0.01**	**0.01**	**0.01**

2.6 Future Improvements

The most pressing issue for the Republic of Palau is the lack of necessary resources - human, financial, and technical capacity to collect, interpret, and report data and information. These are key to ensure improved delivery of national reporting. Moreover, the absence of institutional commitment and strengthening to compiling inventories, continuous improvements will remain a challenge. Participants from relevant offices formed an informal network to improve efforts on data collection for the preparation of the next inventory. Improving the greenhouse gas inventory will enhance the inventory's usefulness, not only for assessing the efficacy of current national policies and international agreements but also for guiding development planning at the national level.

Chapter 3: Measures to facilitate adequate adaptation to climate change

3.1 Introduction

Climate Change has been recognized as a global threat that will have severe consequences and adverse impacts on natural resources affecting vulnerable ecosystems, human life and health, and socio-economic sectors. Small Island Developing States (SIDS), like the Republic of Palau, are especially vulnerable to these impacts, which can cause damage to coastal land and infrastructure, failure of subsistence crops, loss of fisheries, loss of coral reefs and mangroves as well as increased vulnerability to vector-borne diseases (IPCC AR 4, 2007).

Although climate change impacts are global in scale, the impacts on islands are more severe due to their unique geographical, socio-cultural, and economic characteristics. Based on the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007), impacts to small island states include:

1. Vulnerability to the effects of climate change, sea-level rise, and extreme events

(very high confidence).

2. Sea-level rise is expected to exacerbate inundation, storm surge, erosion, and other coastal hazards, thus threatening vital infrastructure, settlements, and facilities that support the livelihood of island communities (very high confidence).
3. There is strong evidence that under most climate change scenarios, water resources in small islands are likely to be seriously compromised (very high confidence).
4. Climate change is likely to heavily impact coral reefs, fisheries, and other marine-based resources (high confidence).
5. It is very likely that subsistence and commercial agriculture on small islands will be adversely affected by climate change (high confidence).
6. New studies confirm previous findings that the effects of climate change on tourism are likely to be direct and indirect, and largely negative (high confidence).
7. There is growing concern that global climate change is likely to impact human health, mostly in adverse ways (medium confidence).

Although there are uncertainties related to climate change impacts, it is still important to take immediate measures to limit a soon as practicable (University of Hawaii, 2007). As stated in Principle 15 of the United Nations Rio Declarations “In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation”.

Figure 12: Coastal erosion in Melekeok State

Palau lacks much baseline information for understanding the complex relationship between and within natural and human systems. This is a considerable gap in information on likely changes in climate and human systems at the small-island scale. Consequently, most SIDS have not yet been able to undertake in-depth, nationwide climate change impact and vulnerability assessments in an integrated manner. Without such national assessments as a sound basis for designing and planning effective adaptation policies, strategies and programs, decisions on adaptation will remain tentative.

3.2 Methodology

The methodology used in this assessment is based on the IPCC technical guidelines for assessing climate change impacts and adaptation (Carter et al, 2007). Present conditions were examined, and key sectors identified. Future climatic and non-climatic scenarios were then used to examine the possible impacts of climate change on various sectors, in addition to those anticipated to occur as a result of development. These potential impacts formed the basis for

identifying possible adaptation response measures for endorsement, adoption, and implementation by Palau.

The five sectors addressed in this Vulnerability and Adaptation Assessment (VAA) are coastal communities (pilot study), coastal zones (mangrove, seagrass, and coral reefs), water resources (Ngerikiil watershed), human health (vector-borne diseases) and food security (taro). For assessments of the sectors, the following steps were taken:

1. Identify the risks on assets
2. Develop baselines (socio-economic, environmental, and climate)
3. Construct scenarios (socio-economic, environmental, and climate)
4. Assess impacts and vulnerability
5. Identify and assess adaptation options

3.3 Coastal Communities

The Palau Archipelago is composed of several hundred islands that vary geologically from the mountainous main island of Babeldaob to low-lying, coral islands fringed by barrier reefs. Twenty percent of Palau's landmass is below 10 meters above sea level. This is significant due to sea level rise and the considerable potential for coastal erosion. Most of Palau's infrastructure and economic development activities are located near the coast, making them acutely vulnerable to storm surges and sea level rise.

In this section, findings from a recent program sponsored by the Asian Development Bank (ADB) will be presented. This Regional Technical Assistance Program (7493-REG), was put forth to help developing member countries address climate change issues through adaptation, taking into account country-specific needs. With Palau's limited resources and institutional capacity to assess and manage possible impacts from climate change, this project sought to build capacity and develop an appropriate, nationally recognized, approach to adaptation planning. This provides a solid foundation for decision-making in a way that is easily replicable by government agencies and local partners in Palau.

The project methodology was developed to ensure an integrated approach to climate change adaptation and development planning. It includes five steps for adaptation planning:

- defining project scope
- conducting a baseline assessment
- determining climate change threats
- undertaking an impact and vulnerability assessment
- developing adaptation measures

3.3.1 Socioeconomic and Environmental Impacts

Melekeok state was chosen as the target area with tourism as the sector of focus. The State was chosen for the following reasons: 1) as Palau's capital, it has strategic political and economic importance, 2) was in the process of developing its State Master Development Plan, and 3) it was an ideal representative state for Babeldaob, as it shared many similar geographical, ecological and social features with other states, as well as the development challenges and vulnerabilities to climate change.

Tourism was identified as the target sector for several reasons. It is the largest private sector contributor to Palau's economy, accounting for around 45% of GDP, and it has great potential for growth. Melekeok State has a wide range of tourism assets and is a priority area for the implementation of the national tourism action plan. The Palau tourism sector is highly dependent on water supply, sanitation, communication, and transport infrastructure as well as healthy natural systems.

A baseline study was undertaken to establish an understanding of past and current trends in natural, social, and built systems linked to Melekeok State and tourism. From this assessment, it was possible to define climate change trends and ranges for use in the vulnerability assessment and the design of adaptation options.

3.3.2 Climatic Impacts

Four categories of climate threats were identified in the baseline assessment. This included temperature, rainfall, sea level, and extreme events. These categories were refined to describe practical events that the local community could identify with. Climate change threats were defined as:

(i) **Storm surge** – Offshore depression or storm leading to high waves of greater than 1m;

(ii) **High-intensity rainfall and flooding** – Rainfall events of extreme intensity resulting in flash floods and pooling flooding;

(iii) **Sea level rise** – Incremental increase in sea level by 2100 (estimate: 59cm)

(iv) **Typhoon**– A combination of intensive rainfall, storm surges, and high winds;

(v) **Extreme drought** – Periods of unusually low rainfall; and

(vi) **Temperature increases** – A projected increase in air temperature of more than 2°C by 2050 and sea temperature of more than 1°C.

Strategic assets in the target sector and area were identified. Those assets and the climate change threats formed the basis of the vulnerability assessment.

3.3.3 Results of the vulnerability assessment

It was necessary to establish an accurate picture of how current and projected sea level rise coupled with storm surge and wave action might impact Melekeok's coast using inundation maps. Preparing accurate inundation maps for past and projected sea level rise involved the national team and stakeholders in determining a sea level baseline, conducting high resolution topographic survey of the coastal zone, mapping existing and planned infrastructure and then using GIS analysis to determine areas and specific assets at risk of flooding. One key trend identified for the project area was increasing coastal erosion and flooding.

Priority for adaptation planning focused on the most vulnerable assets across the built, social, and natural systems. The infrastructure, housing, and community buildings along the coastal strip would be seriously impacted by projected storm surge, wave action, sea level rise, and typhoons. Most residential dwellings, tourist accommodations, and supporting infrastructures

such as power, telecommunications, sewer, and water lines are within 30m of the high water line and were found to be highly vulnerable.

The wastewater treatment plant (WWTP) located at the south end of the coastline was a priority asset found to be extremely vulnerable. Its low elevation on the edge of mangroves puts it at risk of inundation from projected sea level rise and storm surge. Seawater inundation would damage or destroy the electric components and machinery as well as release sewage into the surrounding area.

In the upper area of Melekeok, the Ngardok Nature Reserve (NNR), the water supply intake and surrounding areas were identified as priority assets at risk. The NNR covers approximately one-third of Melekeok State. It is the State's only source of drinking water and is a unique tourism destination. Climate change risks identified for the NNR included flooding of the pump station during extreme rainfall events and increased turbidity and sedimentation of the Ngerdoch River and lake due to erosion of the surrounding landscape. The area has a high vulnerability to typhoon and flooding, leading to additional sedimentation in streams and marshlands. Severe and prolonged drought poses the greatest threat to the natural system.

3.3.4 Implemented Adaptation Strategies

No adaptation strategies implemented for this project. The next section provides adaption options.

3.3.5 Recommendations

Seven adaptation actions were defined with the following expected results Based on the Vulnerability Assesment:

Coastal Area

Output 1 – Melekeok State has a climate resilient wastewater treatment system

Output 2 – Increase resiliency to coastal erosion and inundation by protecting manmade and natural assets

Upper Area

Output 3 – Have in place climate change strategies that promote sustainable tourism and economic self-sufficiency for Melekeok State that are integrated into the management of the NNR and surrounding area

Output 4 – Adaptive capacity is increased for Melekeok State's water supply infrastructure and watershed management

Institutional Context

Output 5 –Develop Palau's national climate change policy and strategies to promote integration of adaptation action by sectors and states

Output 6 – Support the Melekeok State Government to prepare a climate change adaptation strategy addressing economic sectors such as tourism, agriculture, and fisheries as an integrated component of the next state master development plan

Output 7 – Implement national climate change adaptation strategies by replicating the adaptation planning methodology in other States in an exchange and learning process and develop basic baseline information for Palau

Each output would be achieved through implementation of activities which would first be vetted through a detailed design concept stage.

The main output of this project was the development and demonstration of a methodology for climate change vulnerability assessment and adaptation planning that is suited for Palau, considering the data, resources, and capacity available. The approach adopted, used a combination of best available science, field surveys, GIS analysis, and local knowledge in conjunction with expert judgment.

3.4 Coastal Zones

3.4.1 Mangroves

In Palau, mangrove forests can be found along coastlines, riverbanks, coral islands, and along marine lakes. Palauans rely on the mangroves for food, medicine, building materials, and

firewood. Mangroves also act as a filter for sediment to keep the reefs and fish stocks healthy and as a buffer against strong winds and waves, preventing the coastlines from eroding. Monitoring of mangrove forests, or for any land use, is not regularly conducted in Palau, and therefore, basic data such as a time series of the area of mangroves in Palau is lacking. According to the Food and Agriculture Organization of the United Nations (FAO) (2007), Palau has approximately 4,708 hectares of mangrove. This value is based on a 1985 survey.

3.4.1.1 Socioeconomic and Environmental Impacts

Economic development has had a significant impact on mangroves in Palau. Recent studies show that the loss of Mangroves are largely due to land reclamation activities associated with infrastructure improvements and tourism-based developments along the coastal shorelines. Clearing and filling of mangrove areas for development has affected much of the Babeldaob. In some instances, mangrove areas are leased out by municipal States for housing or other rural development projects, and this is because land tenure of mangroves are often seen as to lesser extent uncomplicated as compared to upland areas.

Solid waste disposal sites are also of concern for the state of mangroves in Palau. While development projects and solid waste disposal sites have destroyed mangroves, there is also evidence of an increase of mangrove forest in Palau. As described in the water resource section of this report, sedimentation is identified to have major impact on the Ngerikiil watershed. Major infrastructure developments in Babeldaob, such as the Compact Road, are causing significant amounts of sediment-laden runoff reaching the watershed areas. Studies show that the mangrove systems fringing the estuaries in some watersheds can only trap about 30% of the sediment (Victor et al, 2004). In some areas, mangroves are no longer good fish nurseries because of excess sedimentation and siltation.

Increased sedimentation in Airai Bay has provided additional substrate for mangrove propagates to grow, which has caused accelerated growth of mangroves in Airai Bay. According to an estimate by the Palau Automated Land and Resource Information System (PALARIS) office

(2007), mangrove forest area within Airai Bay has nearly doubled in size from 420 to 794 hectares from 1968 to 2005.

Increases in population and further development in Babeldaob will create more demands for land, water, food, and building materials, which may negatively impact the mangrove ecosystem. The increased demand for land may result in an increase in the number of leases in mangrove areas, over and above those that are currently being issued to developers in Babeldaob. Unplanned development may increase the erosion and sedimentation, compromising the overall health and resilience of the mangroves in Palau.

3.4.1.2 Climatic Impacts

Four climate-related factors have an impact on the mangrove ecosystem of Palau. These are rainfall, rise in air temperature, rise in sea level, and intensification of extreme weather events. Rainfall regulates salt concentrations in soil and plants and provides a source of freshwater for the mangroves. This is an important factor when propagation 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 unfavorable for the growth and distribution of mangroves.

Increased air temperatures, along with drought conditions, may contribute to poor growth and distribution. Tropical storms not only destroy mangrove habitats, but may also change conditions that create habitats for invasive species. There are both direct and indirect relationships between climate change and the mangrove ecosystem, through changes in sea level. Sea-level rise combined with greater storm frequency will accelerate the speed of coastal erosion in and around mangrove areas. This erosion results in impacts on mangrove ecosystems by destroying the shelter of many tidal species as well as the spawning grounds of marine species. Inundation is only one of the effects. As sea level rises, coastal erosion and the severity of coastal flooding will increase, and coastlines will recede unless they are stabilized with some mitigative efforts. Saltwater intrusion into groundwater, rivers, bays, and estuaries will increase.

Changes in rainfall patterns and temperature will modify salinity gradients in estuaries and alter rates of river delta sedimentation. Coastal currents and upwelling patterns are likely to shift geographically and change in intensity. All of these marine changes will affect the biodiversity in coastal zones.

3.4.1.3 Implemented Adaptation Strategies

The following are adaptation strategies concerning mangroves that have been implemented since the First National Communication:

The Micronesia Challenge is a commitment by the Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Palau, Guam, and the Commonwealth of the Northern Marianas Islands to preserve natural resources that are essential to the survival of traditions, culture, and livelihood of the islands. The overall goal of the Challenge is to effectively conserve at least 30% of near-shore marine resources and 20% of the terrestrial resources across Micronesia by 2020 (MC, 2006).

Figure 13: Mangrove Root System

The 2000 Palau Mangrove Management Plan recommended establishing conservation and reserve areas under the Heritage Act. The Environmental Quality Protection Board (EQPB)

proposed Marine and Freshwater Quality Regulations (Chapter 2401-11-09) in order to enforce buffer zones for the protection of coastal waters and mangroves. The Mangrove Management Plan was prepared for the Bureau of Marine Resource and Development, but it has not been implemented. The plan now needs to be updated to reflect current conditions in Palau and to take into account the impacts of climate change.

In 2003, the Protected Areas Network (PAN) Act was passed and signed into law. The Act provides a framework for Palau's national and state governments to establish a nationwide network of terrestrial and marine protected areas that will protect areas of biodiversity significance, important habitats, and other valuable resources that are essential to future social, cultural, economic, and environmental stability and health of Palau.

The PAN Act provides an opportunity for the national and state governments to work together to build on the existing suite of protected areas and to develop a PAN that meets the dual objectives of protecting the country's terrestrial and marine biodiversity and ensuring sustainable use of the natural resources.

3.4.1.4 Recommendations

The following are adaptation strategies concerning mangroves for future consideration:

1. Establish a mangrove monitoring program

There is little available quantitative information on trends in area or health of Pacific Island mangroves due to limited monitoring, and many of the above area estimates are based on dated primary sources. To ensure that estimates are up-to-date, it is recommended that Palau design and implement a mangrove wetland monitoring system to regularly assess the health and status of the mangroves in Palau. Palau should review existing institutional capacities to enable recommendation of the mandate an agency with responsibility for quantitative collection, monitoring, and management of mangroves data. This is a high priority issue.

2. Develop mangrove ecological systems plan

The existing environmental assessment process for development does not require post-development monitoring to determine direct and indirect impacts of mangrove forests after construction of projects such as the Compact Road Project and the Capitol building in Melekeok or large-scale aquaculture projects such as in Ngatpang. There is no long-term sustainability plan for mangrove ecological systems.

It is recommended that Palau conduct seminars or meetings to encourage and educate the public on the importance of mangroves for environmental quality and also for economic benefits. Local communities can also assist in monitoring of mangroves.

3.4.2 Seagrass

Seagrasses are marine flowering plants that form extensive and highly productive ecosystems. There approximately sixty species worldwide with about ten found in Palau. (Green and Short, 2003, Victor et al.). These biologically diverse habitats provide a number of important ecosystem services:

- Breeding habitats for fish, turtles, and dugongs
- Habitat for fish and invertebrates that are prized locally
- Nursery and shelter for fish species
- Protection of coastline from extreme weather events and erosion
- An important source for carbon dioxide sequestration
- High primary productivity, supporting coastal marine food chains
- Stabilization of coastal sedimentation

Seagrass beds have twice the ecosystem service value as that of mangrove complexes and five times the ecosystem service value of coral reefs (Constanza et al. (1997). Seagrass beds, although less publicized than mangroves or coral reefs, thus play an important ecological function for Pacific Island ecosystems and communities.

3.4.2.1 Socioeconomic and Environmental Impacts

There is growing evidence that seagrasses are in global decline due to anthropogenic threats (Duarte, 2002). The rate of loss may be as high as seven percent of their total global area per year (Di Carlo and Mckenzie, 2011). The loss of seagrass is largely due to increasing human populations and associated destructive activities in coastal regions (Green and Short, 2003).

Increased Eutrophication: More nutrients mean more epiphytes, and increased shading, which cause weaker seagrass and less growth.

- Runoff: Water runoff containing chemicals, fertilizers, silt, and debris is a major threat to seagrass.
- Overfishing: Evidence also suggests that overfishing of top predators could indirectly increase algal growth by reducing grazing control performed by mesograzers.
- Careless Boating: Boat propellers can rip up seagrass and dig trenches through seagrass beds, thereby destroying habitat for fish and animals that depend on them.
- Dredging, Landfill, and Building: Direct loss of seagrass are caused by dredging and fill projects, construction of marinas and building of docks and bridges also cause damage to seagrass. Often, this is followed by a residual impact on seagrass bed habitats resulting from turbidity and shading from silt.

Natural disturbances such as storms and floods can also cause adverse effects on seagrass beds. Resilience to disturbances by human activity and natural occurrences can be enhanced through concerted conservation efforts, such as the focus of the work on the PAN Sites.

3.4.2.2 Climatic Impacts

In addition to current anthropogenic and naturally induced pressures, the following climate change impacts may have an adverse effect on seagrass beds.

- Rising Sea Surface Temperature: Higher water temperatures will change the growth rates and distributions of seagrass species.
- Ocean Acidification: Higher levels of carbon dioxide (CO_2) in the oceans will alter the ecological balance between seagrass and its habitat competitors.

- Climate Variability: More frequent or intense extreme weather events will change the composition of seagrass communities.
- Precipitation Change: Heavier or more frequent precipitation in coastal areas may lead to increased runoff of nutrients causing eutrophication and death of seagrass beds.

3.4.2.3 Implemented Adaptation Strategies

Net is a global ecological monitoring program that investigates and documents the status of, and threats to seagrass resources. Locally, this program is spearheaded by the Palau International Coral Reef Center (PICRC), which has nine sites and several years of data.

As described above, the Micronesia Challenge and the PAN are currently implementing mitigation actions that also include seagrass protection.

3.4.2.4 Recommendations

It recommended that seminars and meetings be conducted and tailored to different groups to raise awareness on the importance of seagrasses and the vital role that they play in the overall health of coastal ecosystems. Such an effort may stimulate interest in improving behavior in the way seagrass are managed at the community level.

3.4.3 Coral Reefs

Palau has the most diverse species of coral fauna in Micronesia and the highest density of tropical marine habitats of comparable geographic areas around the world. Palau's coral diversity is comparable to the Philippines, Indonesia, and Australia. Maragos *et al*. (1994) estimated Palau's coral diversity at 425 species belonging to 78 genera.

In addition to corals, fish and other invertebrate groups are highly diverse in Palau. More than 300 species of sponges were documented in Palau (Kelly-Borges and Valentine, 1995). About 200 species of Cnidarians are known to exist, with many other species yet to be documented. Echinoderms are not as well documented, but there are at least 21 species of crinoid fauna (Meyer and Macurda, 1980). Palau has the highest diversity of reef fish in Micronesia, with a total of 1,278 known species. Data gaps suggest that reef fish in Palau may number closer to 1,449 species (Myers, 1999).

3.4.3.1 Socioeconomic and Environmental Impacts

During the 1997-1998 El Niño event, Palau experienced massive coral bleaching and mortality. The bleaching event in Palau was widespread and the degree of mortality was variable among sites (Bruno et al., 2001). In some areas, mortality was as high as 90 percent. It devastated Acroporid corals (Staghorn corals), which suffered the highest mortality of observed coral species. Corals that were found in estuaries closer to shore survived better than corals farther from shore (Golbuu et al., 2003a).

Coral bleaching events have occurred periodically at various sites in Palau, but none at the level of the 1997-1998 event. These bleaching events are most likely due to disease or other stress inducing phenomena at the microhabitat level (Bruno et al., 2001).

Increased development activity in the Ngerikiil watershed has caused increased sedimentation, which can destroy seagrass and coral habitats. Evidence, in the form of currently measured sedimentation rates in the bay (Golbuu et al., 2003b) and observations from local fishermen, suggests that a large portion of the reefs in Airai Bay has already been degraded due to sedimentation resulting from construction and poor farming practices within the Ngerikiil Watershed.

3.4.3.2 Climatic Impacts

Coral reef ecosystems are particularly sensitive to global warming. Increased ocean surface temperatures will continue to intensify coral bleaching events on coral communities. Other impacts such as change in ocean chemistry (ocean acidification) and increased storm events will also have major impacts on the corals and many organisms that rely on coral reefs.

Corals thrive within a relatively narrow temperature range. Rising sea temperatures are one of the main drivers of coral bleaching. Coral bleaching is expected to occur more often and with greater severity in the future, thus, making it difficult for corals to recover between bleaching events. As a result, the abundance of living corals on reefs is expected to decline in the years to come.

Acroporids (Staghorn corals) and other branching corals are especially sensitive to bleaching. It is expected that coral communities will be dominated by massive type corals that are more tolerant of temperature changes. Reefs dominated by bleaching-resistant corals have less three-dimensional structure than healthy coral reefs. Such reefs provide fewer shelters and refuges for the many animals that rely on certain types of reef systems for their habitat.

Coral reefs are acutely sensitive to ocean acidification. Primary reef builders, hard coral, and coralline algae make their skeletons from calcium carbonate.

Acidification shifts the equilibrium of carbonate chemistry in seawater, reducing pH and the abundance of carbonate ions available for corals and other marine organisms to use to build their skeletons. Since reef-building corals need carbonate to build their skeletons, decreasing carbonate ion concentrations will likely lead to weaker, more brittle coral skeletons and slower coral growth rates.

For a healthy reef to be maintained, the growth of corals and encrusting algae has to keep pace with the rate of erosion. Continuing ocean acidification will ultimately contribute to coral loss and a weakening and collapse of limestone reef structures.

Reef recovery from such severe storms is slow because fewer corals survive to colonize affected areas. An increase in severe typhoons could, therefore, contribute to the degradation of reefs structures already weakened by coral bleaching and ocean acidification.

3.4.3.3 Implemented Adaptation Strategies

In 2001 PICRC launched the National Coral Reef Monitoring Program for Palau. The purpose of the program is to:

- Determine the status of coral reefs around Palau
- Determine spatial and temporal changes occurring in reefs around Palau
- Access recovery after the 1998 coral bleaching event
- Provide information to relevant stakeholders to be used for management and policy development

The program started with 14 sites and has since increased to 21 sites. Site selection was based on geographic location, reef type, and level of human impact.

As described above, the Micronesia Challenge and the PAN are currently-implementing adaptation strategies that are also applicable to coral reefs.

3.4.3.4 Recommendations

Provided below are marine ecosystem management adaptation strategies and recommendations that could be integrated into current adaptation programs. These strategies were put forth by the U.S. Climate Change Science Program (2006), as proactive approaches to enhance ecosystem resilience to climate change impacts.

1. **Reduce existing impacts stressors and other factors that disrupt marine ecosystems**
    - This approach is logical but requires further research using adaptive-management approaches to determine best practices.
    - Reduce causes of coral reef disturbances that occur at local scales.
    - Integrated coastal zone management could be adopted to address land-based sources of nutrients, sediments, and pollutants.
2. **Protect naturally resistant or resilient areas**
    - Examples include coral reefs in areas of upwelling that reduce thermal stress.
    - Reefs that still have high coral cover merit protection while investigations are conducted to determine factors contributing to reef health.
    - Physiological and ecological factors contributing to resistance and resilience are not well understood and require additional research and monitoring.
3. **Establish additional highly protected marine zones**
    - Sites with high coral cover and low disease prevalence should have a high priority for protective measures as a precautionary approach to management.
    - No-take zoning can alleviate ecosystem impacts from overfishing.
    - Areas with threatened species should receive special consideration.

- Marine reserves, in conjunction with comprehensive fishery regulations, appear to be a wise strategy for sustainability irrespective of climate change.

4. **MPA Network**
    - Protect critical areas such as nursery habitat, spawning grounds, and aggregations, and apparent climate refugia could enhance resilience.
    - Have network designs that incorporate connectivity – larval dispersal, juvenile, and adult movements.
    - Replicate efforts in multiple habitat types to spread protection, and adequate representation of all habitats should be considered in designing networks.
5. **Support research on connectivity & effectiveness of existing networks of highly protected zones**
    - Most highly protected zones are small, and many were not designed to form a network, so research efforts should concentrate on appropriately designed MPA networks.
    - In addition to modeling connectivity, empirical approaches such as population genetics, genetic markers, and chemical signatures will be particularly beneficial to managers.
6. **Integrate climate change into marine protected area (MPA) planning, management & evaluation**
    - MPA monitoring and research that is planned to test the efficacy of MPA design and management is central to adaptive management in the context of climate change.
    - Rapid response strategies should be in place to assess extreme events, such as typhoons and tropical storms.
    - Locations isolated from local anthropogenic stressors as well as locations with a history of exposure to different anthropogenic stressors are key in order to identify factors that are induced by changing climatic conditions and factors that are a result from human activity.

- Education and outreach programs need to support community awareness of potential climate change impacts and ways to respond.
- Stakeholder participation with MPA managers, e.g., Sanctuary Advisory Councils, is central to building social resilience.

Given the uncertainties associated with climate change and the level of impacts on coral reefs, managers need the flexibility to apply dynamic management approaches that can be revisited and adjusted as new information becomes available.

3.5 Water Resources: Ngerikiil

The primary source of freshwater in Palau is from precipitation, and the majority of freshwater used in Palau is surface water. A major water source in Palau is the Ngerikiil watershed, located on the southeast shore of Airai State on the island of Babeldaob. It covers over 28,466 hectares (70,341 acres) and supplies approximately four million gallons of water per day (Hay et al., 2007). It is the primary potable water supply area for Airai State and the city of Koror, supplying 75% of the population of Palau with freshwater.

Groundwater is found in Palau, though the groundwater lens is fairly thin and most water pumped from the ground is non-potable. Groundwater has also not been extensively developed because of well maintenance problems, water quality problems (chlorides, iron, manganese, taste, and odor), and limited well yields in certain areas.

Although Palau has a small resident population, water consumption is relatively high due to its expanding tourism industry and limited water management infrastructure. Road construction, housing, and agricultural activity contribute to erosion and sedimentation in the area, particularly along the lower Ngerikiil River tributaries and into its estuarine system in Airai Bay. Intense drought and storm activity are causing land degradation and sedimentation problems in or near the watershed.

3.5.1 Socioeconomic and Environmental Impacts

In 2005 the Palau Natural Resources Council and Airai Community sponsored a study on the Ngerikiil watershed. Five critical resource concerns were identified through the resource assessment. In order of their level of threat to the main watershed objectives, the critical resource concerns are of the following:

Soil erosion and sedimentation: Sediment laden runoff, reaching the river and ultimately the ocean, is presently the most serious resource concern within the Ngerikiil watershed. This is affecting both Palau's primary drinking water source and coral reef health within Airai Bay. The following are primary sources: sediment laden runoff from unprotected roads, sediment laden runoff from housing and other development; erosion from agricultural land lacking conservation practices; erosion from burned savannah areas; stream bank erosion. The Ngerikiil watershed area has experienced an increase in development activity and has a sedimentation rate that is 10 to 19 times higher than Ngerdorch watershed, which is relatively pristine (Victor *et al.*, 2004).

Nutrient, fertilizer, and pesticide pollution: Three specific concerns were identified in the Ngerikiil watershed: animal manure from confined animal feeding operations, runoff of excess fertilizers, and pesticide leaching and runoff.

Solid waste disposal: While solid waste disposal is not yet a serious pollution concern within the Ngerikiil watershed itself, population pressures and the increased use of plastics and other non-biodegradable waste will result in a growing issue for Palau. Residents and businesses in Airai transport their own garbage to non-regulated dumps. Solid waste reaches the rivers and oceans via stormwater runoff, storm drains, sewer overflows, landfills or dumps, rivers and streams, and trash discarded by boats.

Wildlife habitat loss: Wildlife habitat loss due to the recent development in Babeldaob is also identified to have harmful impacts on the Ngerikiil Watershed.

In addition to the socio-economic and environmental impacts identified above, there are critical issues regarding the infrastructure of water resources in Palau. The lack of an efficient water distribution system is a major factor in the inability for Palau to effectively conserve water at the source. Another major contributor includes high leakage of water from water distribution lines and fittings. The current water treatment plant pumps four million gallons per day, of which 35-45% is lost through transmission (Hay, et al., 2007). In the future, increases in freshwater demand related to population and economic growth—tourism in particular— will only place more stress on existing water resources.

3.5.2 Climatic Impacts

Although rainwater is a renewable source of water, it is subject to seasonal and yearly variations, and Palau has inadequate water storage capabilities. This was evident during the El Nino event in 1997 and 1998. In March of 1998, the peak of El Nino, Palau had the lowest rainfall on record. The result was a depleted water supply that caused over 50% decrease in agricultural production and fires burning out of control throughout many islands. Water shortages are a frequent event in the main town of Koror, and rationing is implemented whenever a prolonged drought period occurs.

In most regions of small islands, projected future changes in seasonal and annual precipitation are uncertain, although in a few instances precipitation is likely to increase slightly during December, January, and February in the Indian Ocean and southern Pacific (Christensen et al., 2007). The amount of rainfall could either rise or fall. Most models predict an increase of 8-10% by 2050 and about 20% by 2100, leading to more intense floods or droughts. Burns (2002) has also cautioned that with the rapid growth of tourism and service industries in many small islands, there is a need for both augmentation of the existing water resources and for more efficient planning and management of those resources. Measures to reduce water demand and promote conservation are also especially important on small islands. Infrastructure deterioration resulting in major leakage is common, and water pollution from soil erosion, herbicide and pesticide runoff, livestock waste, and liquid and solid waste disposal results in high costs (Hajkowicz, 2006).

Given the limited water supply, and the dependency on rainfall, Palau is vulnerable to future changes and distribution of rainfall. Lower rainfall typically leads to a reduction in the amount of water that can be physically harvested, as well as a reduction in river flow and a slower rate of recharge of the freshwater lens, which can result in prolonged drought impacts. Since most of the islands are dependent upon surface water catchments for water supply, it is highly likely that demand could not be met during low rainfall periods. Increases in sea level may also shift water tables close to the surface resulting in increased evapotranspiration, thus diminishing the resource. The problem would be exacerbated due to lack of adequate infrastructure such as reservoirs and water distribution networks in most islands.

3.5.3 Implemented Adaptation Strategies

The following are adaptation strategies concerning water resources that have been implemented since the First National Communication:

In 2001, the National Drought Mitigation Action Plan (NAP) was developed and implemented from 2002 to 2003. The NAP assessed Palau's current water resources and potential infrastructure development options to manage and expand, where possible, water storage capabilities. It also included the assessment of agricultural practices and identification of salinity resistant crops and potential agricultural sites to sustain nationwide food security during the ENSO event and associated droughts.

The 2002-2003 ENSO Action Plan recommended an incentive program for residential water catchment tanks. The program is assisting residents in building their own freshwater catchment systems, which helps to reduce the pressure on the national water supplies. The tanks serve as a means to have additional water supply should there be disruptions to water supply from the public water system. They can also be holding tanks where water can be delivered during times of drought. Water catchment tanks were installed in schools to serve the same purpose.

The Ministry of Public Infrastructure, Industries, and Commerce (MPIIC) works with various States to identify water pipe leakages and water tank damage in the existing water systems, assist them in identifying additional water resources that can be used during times of drought, and work with them to create awareness on the importance of water conservation. Despite these efforts, however, water storage efficiency continues to be an issue as of 2007.

The Government of Palau reduced water subsidies to decrease its overhead and facilitate repair of expansion of current water treatment and distribution facilities. This policy encourages customers to stop leaks within their premises and practice water conservation. It has been found that even with the water pricing updated it has not raised sufficient revenue to cover the total costs for the Koror/Airai system, requiring an ongoing subsidy by the National Government. Moreover, some customers do not pay their water bill but remain connected to the system. Estimates suggest that revenue raised is about $500,000 against operating costs in excess of $1.5 million (Hay *et al*., 2007).

The Palau Water Sector Improvement Program is a loan that was approved and funded by the Asian Development Bank (ADB) to help improve water operations, management, and upgrade the water and sewage system. This includes the replacement of the aged main pipe networks with new pipes, which will virtually eliminate leakage along the main distribution lines. The project is set to be completed by 2017.

3.5.4 Recommendations

The following are adaptation strategies for Palau's water resources:

1. Continue Assessment of water resources

The Palau Water and Sewage Company (PWSC) is responsible for collecting and monitoring water data used for managing water resources. However, the current level of capacity to effectively identify sources of water, how much volume is available, and the ability to measure recharge levels in Palau is insufficient. This makes it difficult for PWSC and other water resource managers identify and evaluate risks for water

shortages, and to translate those risks into water management plans. One of the main focus should, therefore, be on capacity building targeting the above areas of weakness.

2. Supplement water supplies

Continued efforts to improve and increase residential water catchment tanks is sensible. While increasing water storage capacity through the increased use of water tanks and/or the construction of small-scale dams is acknowledged to be expensive, the added security in the supply of water may well justify such expenditure. Development of runways and other impermeable surfaces as water catchments is possible, but an extreme measure in most instances. Priority should be given to collecting water from the roofs of buildings. PWSC may consider assessing the feasibility of tapping into other sources of water. Palau could also look into the feasibility of developing desalination facilities, especially for outlying states, for times of drought.

3. Improve the management of water resources

Palau should continue to improve the efficiency of existing water systems, identify additional water resources, have them be reserved for severe drought conditions, and create awareness on the importance of water conservation.

Programs to raise awareness and to educate people on appropriate watershed management will help foster best practices by transferring knowledge and ownership of water resource management to community level. Installation of environmentally sound water usage systems for farming (e.g. private reservoirs) is a priority. More broadly, introduction of effective land use planning and of land use zones should also be considered, as all these systems are inevitably linked.

Having an emergency management plan be developed is necessary, and it should include a section on water. The response measures detailed in the plan would be an important reference point in times of crisis.

4. Improving land use practices

Integrated land use and water management will help avoid contamination from entering water systems. Riparian or buffer zones should be implemented around the watershed to protect it from sedimentation from roads, farms and other development. As an additional measure to avoid contamination from entering water reservoirs used for drinking, it is recommended that land use restrictions be considered.

3.6 Health: Vector Borne Disease

The health of the Palauans seems to have improved a little as manifested in health indicators such as a decreased crude death rate, increased life expectancy at birth, and consistent zero maternal mortality ratio. Also, sanitation has improved with the entire population having access to excreta disposal facilities.

However, changing lifestyles have resulted in different health patterns, and new health problems have emerged. The key diseases in Palau are modern lifestyle-related diseases, such as circulatory diseases and cancer. At the same time, indicators for communicable diseases are continuing to increase at relatively high rates. This indicates a society that is experiencing diseases of both developing and developed nations.

3.6.1 Socio-economic and Environmental Impacts

It is expected that environmental problems will increase with more foreign investment and workers on the islands in the coming years. Water pollution is a major concern due to the lack of sufficient land area for proper waste disposal. Progressive industrial development will continue to worsen both air and marine quality. Marine life and reefs will be affected by the pollution.

Figure 14: Number of vector-borne diseases in Palau from 2005-2012 (DEH, 2012)

	2005	2006	2007	2008	2009	2010	2011	2012
Dengue	9	25	92	207	8	6	53	16
Leptospirosis	5	14	1	6	1	0	0	0
Scrub Typhus	3	No data →			0	No data	No data	No data
Zika	No data	No data		No data	No data	No data	No data	No data

*Source: DEH-EHIS 2012

3.6.2 Climatic Impacts

Many small island states currently suffer severe health burdens from climate-sensitive diseases, including morbidity and mortality, from extreme weather events, certain vector-borne diseases, and food- and water-borne diseases (Ebi *et al*., 2006).

Tropical storms, storm surges, flooding, and drought have both short- and long-term effects on human health, including drowning, injuries, increased disease transmission, decreased agricultural productivity, and an increased incidence of common mental disorders (Hajat *et al.*, 2003). Because the impacts are complex and far-reaching, the actual health burden is under-appreciated appreciated and understood.

Increased incidence of vector-borne diseases such as dengue expected to rise due to increases in:

- Heavy rainfall, as more standing water could lead to an increase in mosquito breeding sites;
- Higher temperatures, as this causes a reduction in the incubation time of mosquitoes, thereby allowing mosquitoes to survive in homes, especially in dark areas.

3.6.3 Implemented Adaptation Strategies

The following adaptation strategy has been implemented since the First National Communication:

The Palau National Environmental Health Action Plan (NEHAP) was developed during the Western Pacific Regional Workshop on Environmental Health Planning and Management, sponsored by the World Health Organization held in Koror in 2003. The NEHAP was a three-year strategic plan (2004-2007) to address nine key areas. The key areas are of the following:

1. Environmental Health Administration
2. Community Environmental Health Development
3. Consumer Safety

4. Vector Control & Health Quarantine
5. Emerging Issues
6. Health Education & Promotion
7. Environmental Health Information System
8. Epidemiology
9. Human Resource Development

In 2009, an updated plan—the National Environmental Health Strategic Action Plan (NEHSAP)—was formulated and implemented to continue the above work from 2009 to 2015.

3.6.4 Recommendations

The following are adaptation strategies concerning vector-borne diseases to consider in the future:

1. Monitoring and assessment

Implement regular monitoring and assessment of the state of mosquitoes in Palau. Should this be conducted regularly, the Ministry of Health in a better position to analyze the data and better understand the link between the shift on climate and vector-borne diseases.

2. Increase public awareness and outreach

Palau should conduct seminars or meetings to educate the public on the dangers and impacts of vector-borne diseases. Local communities can also assist in monitoring activities.

3.7 Food Security: Taro

Taro is an essential part of Palau's food base and plays a unique role in its culture. Taro is used as a major component of food exchange in all traditional customs. Palau has at least 70 varieties of taro of which many are resistant to specific pests and diseases. It is important that these varieties are safeguarded from sea level rise, drought, and land degradation.

3.7.1 Socio-economic and Environmental Impacts

Taro patches are usually found at lower elevations around a village and close to a water source. This increases the susceptibility of taro patches to saltwater inundations.

During Typhoon Bopha, farming areas along the coast in the states of Ngaraard, Ngiwal, Melekeok, Peleliu, and Angaur were inundated with seawater. Salinity test of taro patches after the storm showed values of 2000 parts per thousand. Crops can usually survive values of 35 parts per thousand. Value of lost taro crop was estimated to be USD 80,000.

3.7.2 Climatic Impacts

Since little irrigation is practiced in Palau, the agricultural sector solely depends on regular rainfall for crop production. Because of this, the 1997/98 El Nino caused complete destruction of taro patches in several islands and along the western coast of Babeldaob (OERC, 2002). The States of Angaur and Peleliu, as well as much of the western coast of Babeldaob, lost 100% of its taro crops during the 1998 ENSO event. This loss was caused by saltwater intrusion and prolonged drought stemming from sea level rise. Water storages must be improved, and efforts must be made to improve distribution of water for current and future droughts, as well as develop an action plan for fire prevention.

3.7.3 Implemented Adaptation Strategies

Palau is implementing a food security project under the regional Pacific Adaptation to Climate Change (PACC) project. Palau's project focuses on taro production in Ngatpang State, which has suffered from saltwater inundation in low-lying areas. Project activities include conducting a vulnerability assessment of coastal food production systems, creating guidelines to increase the resilience of food production systems, and completing a pilot project demonstrating the utilization of guidelines to increase resilience to climate change in local taro production.

Figure 15: Saltwater intrusion in taro patch

In 2001, the National Drought Mitigation Action Plan (NDMAP) was developed to adapt to the changing global climate, but funding is needed in order to implement the NDMAP. The NDMAP includes the assessment of agricultural practices and identification of salinity resistant crops and potential agricultural sites to sustain nationwide food security during the ENSO event and associated drought.

3.7.4 Recommendations

The following are adaptation strategies for strengthening food security in the Pacific (FAO, 2009):

1. **Adopt a coherent cross-sectoral approach:** Combating food insecurity in the Pacific Island Countries and Territories (PICTs) resulting from climate change, international economic crisis, growing populations, and urbanization will require a coordinated and cross-sectoral approach that explores the linkages between poverty, trade, gender, sustainable livelihoods, nutrition, and regional food production and distribution practices.
2. **Build an enabling environment for action:** The adoption of a strong approach to climate change and food security in the pacific region is critical. Policies should, therefore, be established and designed to enable actions that are robust and produce best-practices on adaptation measures.
3. **Mainstream food security into adaptation initiatives:** Reviewing policy is necessary to determine where it is necessary to mainstream food security into regional and national climate change adaptation and disaster risk reduction initiatives.

4. **Climate-proof existing food security initiatives:** Existing food security initiatives within the region should be assessed and, where necessary, amended to ensure that they adequately address the longer-term impacts of climate change.

Chapter 4: Measures to mitigate climate change

4.1 Methodology

Under Article 4.1 of the Convention, Parties are obligated to formulate and implement programs to mitigate climate change. Such programs may include measures to reduce greenhouse gas (GHG) emissions and/or enhance removals by sinks. While Palau, as a developing country, is not required to take on emissions reductions commitments, this chapter analyzes Palau's ongoing mitigation efforts.

The UNFCCC Reporting Guidelines set out several methods and models that non-Annex I countries may use to conduct mitigation assessments. These range from "a broad description of main development trends and statistics to formalized modeling at sector and macro-economic levels" (UNFCCC, 2004). As Palau lacks data to conduct formalized modeling, a descriptive mitigation assessment was conducted. In addition, the final section of this chapter includes a plan for collecting data in order to carry out a more detailed mitigation assessment (utilizing formalized modeling) in the future.

4.2 Energy Sector

4.2.1 Current Energy Use

As emissions from the energy sector have accounted for 84% to 95% of Palau's annual GHG emissions since 1994, it is the sector where Palau focuses its mitigation efforts. In 2005, the emissions from Palau's energy sector totaled 331.74 Gg-CO_2 eq. In 2009, 99.95% of Palau's energy consumption was derived from imported fossil fuels (SPC, 2012). Renewable energy, including grid-connected solar PV systems at the Capitol Complex and the airport, now contributes almost 3% to Palau's total energy supply (Energy Office, 2013).

The Energy Office (within the Ministry of Public Infrastructure, Industries, and Commerce) is Palau's energy regulatory entity. The Energy Office works with Palau Public Utilities Corporation (PPUC) on implementing energy projects. The Energy Office has three staff members—Director, Energy Planner, and Energy Specialist. All of these positions are grant-funded through the GEF-funded Sustainable Economic Development through Renewable Energy Applications (SEDREA) project and the EU. The Energy Office does not receive funding from the Palau national government.

4.2.2 Relevant National Policies

Over the past five years, Palau has developed ambitious policies, strategies, and targets to enhance energy efficiency and increase the utilization of renewable energy. In 2010, Palau endorsed the National Energy Policy (NEP) along with an Energy Sector Strategic Action Plan (ESSAP) to implement the NEP. The NEP calls for improved institutional arrangements, increased energy efficiency, and the promotion of renewable energy. The NEP sets national targets to reduce energy consumption 30% by 2020 and to produce a minimum of 20% of total energy from renewable sources by 2020. Currently, no entity is mandated to implement the NEP. Because of this, the EU's North REP project is funding the development of an Energy Sector Framework to strengthen the institutional arrangements for energy regulation in Palau.

In 2008, Palau endorsed the Energy Efficiency Action Plan (EEAP), which aims to reduce national energy consumption in both the public and private sectors. This plan recommends specific energy efficiency and energy awareness activities to be implemented by the Energy Planner. In addition, the Palau Energy Conservation Strategy (PECS), developed in 2007, provides an action plan to reduce governmental energy use in Palau.

While Palau has no comprehensive energy legislation, the Net Metering Act of 2012 encourages residential and commercial installation of grid-connected solar PV systems by allowing users to receive credits for excess energy generated by their solar systems (RPPL No. 8-39).

4.2.3 Current Activities

As set out in the 2008 EEAP, Palau is implementing an ambitious package of energy efficiency activities. These activities range from the distribution of Compact Fluorescent Lights (CFLs) to energy efficiency and renewable energy subsidy programs. These energy efficiency activities will save the government an estimated $300,000 or more a year in energy costs. The following activities have been or are currently being implemented in Palau:

- The CFL Distribution Campaign distributed 20,000 high-quality CFLs to replace less efficient incandescent light bulbs. Each household received two or three CFLs. This campaign saved an estimated 820 MWh, or approximately 29,000 gallons of fuel.

- An energy efficiency demonstration building was recently completed at the Public Works Building. Under the PECS project, this demonstration project showcased the energy efficiency upgrades based on an energy audit. The upgrades included replacing the lighting system, painting the roof white, and sealing air leaks around windows and doors. These upgrades will save an estimated $340 a month on electricity for the building. (Funded by the EU's North REP project and SPC.)

- Also, under the PECS project, energy efficiency upgrades were made at the Capitol Complex. These upgrades included improvements to the airconditioning system and limiting access to thermostats. These upgrades could save up to $120,000 annually in electricity bills. (Funded by the EU's REP 5 project.)

- Energy efficiency upgrades to other government buildings are currently under implementation. Such upgrades include lighting retrofits, roof painting, and window and door sealing. In addition to the Public Works Building demonstration project, the Finance buildings, Public Safety building, and Supreme Court building are slated for energy efficiency upgrades.

- The campaign to phase out the use of two-stroke outboard gasoline engines on boats has successfully led to replacement by more efficient four-stroke engines in the majority of boats, and especially in boats used in the tourism industry. Four-stroke engines consume less fuel and pollute less than two-stroke engines.

- The energy awareness campaign for the OEK (Palau's National Congress) led to the adoption of the National Energy Policy and the Net Metering Act. The campaign focused on educating members of the OEK on legislative options to reduce energy consumption in Palau.

- A program to reduce electricity consumption in outlying states focused on replacing larger, inefficient generators with generators that matched appropriately with the load of each island. Now that properly sized generators are in place, the government is seeking to introduce solar PV technology in these outlying states.

- Community workshops and home energy audits are part of an ongoing energy awareness campaign. PPUC offers household and business energy audits to all customers. Household energy audits are also an important part of the National Development Bank of Palau's Energy Efficiency Retrofitting program.

- The National Development Bank of Palau's Energy Efficiency Subsidy Program (EESP) (funded by the Governments of Austria and Italy in partnership with IUCN), Energy Efficiency Retrofitting Subsidy Program (funded by the EU's North REP project), and Renewable Energy Subsidy Program (RESP) (funded by GEF in partnership with UNDP) were established in 2008. The EESP provides home loans to families wanting to incorporate energy saving options into their new homes, which is estimated to reduce electricity usage in new homes by 15%. Under these programs, homeowner's may be eligible for subsidies on Energy Star appliances and solar water heaters. These subsidy programs recently gained recognition for Palau as runner up out of 30 countries for the Ashden Award for green energy solutions.

In addition to energy efficiency measures, Palau has implemented several renewable energy projects, including grid-connected solar PV systems.

- The 100 kW grid-connected solar PV system at the Capitol Complex was installed in 2008 as part of the EU's REP-5 program. This project is expected to generate enough energy to save the Government of Palau approximately $40,000 a year on electricity bills.

- Palau's largest solar project is the grid-connected PV system at the Palau International Airport. This project, funded by the Japanese government, was installed in 2011 and has a capacity of 226.8 KW. The project will offset an estimated 80 tons of CO_2 emissions per year.

- The Government of Taiwan funded two solar PV systems in Palau—one at the National Hospital and one in front of the Ministry of Education. These projects have been problematic due to lack of maintenance and upkeep. The solar PV system outside of the Ministry of Education is no longer functioning, and it is unknown whether the system at the National Hospital is still in operation.

- Other solar projects implemented in Palau include solar streetlights in Babeldaob (funded by the EU's REP 5 project) and solar streetlights in Koror (funded by the Government of Taiwan).

- The state of Angaur has solar panels on the roof of the port facility. The GEF Small Grants Programme funded this project.

- The state of Hatohobei installed stand-alone solar systems several years ago, but these systems are no longer functioning. Some of the problems identified with these projects included the use of technology inappropriate for the climate, lack of capacity to maintain the systems, and lack of funding for maintenance and parts.

The GEF-funded Sustainable Economic Development through Renewable Energy Applications (SEDREA) project is working to remove barriers to renewable energy integration in Palau. SEDREA has conducted an energy tariff review for PPUC and is working on feasibility studies, a report on marketing and bankable projects, providing training to the energy sector, and creating standards for renewable energy installations in Palau. SEDREA also contributes to the Energy Office's ongoing education and awareness programs on energy conservation and renewable energy.

4.2.4 Future Options

In 2004, the GEF-funded Pacific Islands Renewable Energy Project (PIREP) conducted an assessment of renewable energy potential in Palau (PIREP, 2004). The assessment found that Palau has strong potential for solar energy, with large-scale grid-connected solar PV technology identified as the most economically feasible renewable technology. Site-specific solar measurements should be taken in order to assess the economics of potential solar projects. The PIREP assessment concluded that other renewable resources—including hydro, geothermal, and biomass—have limited feasibility in Palau. However, the assessment recommended that landfill biogas and ocean thermal energy conversion (OTEC) technology should be studied and considered for use in Palau. The Energy Office is currently involved in a three-year study to measure the wind potential as an energy source for Palau.

The Energy Office has several projects in need of funding, which include:

- Upgrading of the Airai to Ngechesar connection to reduce high load loss;
- Upgrading of the Koror substation to reduce distribution loss; and
- Enhancing grid capacity and power distribution to Ngiwal and Ngaraard to reduce load loss.

4.2.5 Barriers to Mitigation

The International Renewable Energy Agency (IRENA) has identified high upfront costs, lack of capacity, and high price of imported parts as barriers to renewable energy development in the

Pacific (IRENA, 2012). In the past, solar projects in Palau have suffered due to insufficient capacity and the lack of spare parts and technical support (PIREP, 2004). Institutional barriers to renewable energy include lack of clear channels for renewable energy project development, fragmented implementation of renewable energy projects, and lack of experience with renewable energy technology (PIREP, 2004). Technical barriers to renewable energy include lack of knowledge of energy resources (especially wind resources) and a tropical marine environment, which can be damaging to mechanical and electronic equipment (PIREP, 2004).

Numerous multilateral and bilateral financing opportunities are available for climate change mitigation projects for Pacific Small Island Developing States (PSIDS) such as Palau. However, like many other Pacific SIDS, Palau has underutilized many of these resources. For example, Palau utilized only 33% of the $3.3 million GEF-4 allocation for climate change activities (GEF, 2013). Pacific SIDS face significant barriers in accessing bilateral and multilateral climate change funding. Pacific Island leaders discussed these barriers during the 2011 Pacific Climate Change Roundtable and identified lack of information on available funds, long timelines, and varied requirements for project development, implementation, and reporting as some of the most challenging barriers (Maclellan, 2011). In addition, the funding application process is often lengthy and complex and has been criticized as being tortuously complicated (Hemstock & Smith, 2012).

4.3 Promotion of Carbon Sinks

4.3.1 Carbon Sequestration from Land Use and Forestry

Palau is home to over 1,389 species of plants, including 60 endemic tree species (Kitalong, 2008). All forests in Palau are included in the general classification of “lowland tropical rainforests” (BoA, 2010). As of 2005, forest cover in Palau was estimated to be 82% (BoA, 2010). Though very little local data is available on land use and forestry in Palau, the GHG Inventory conducted for this National Communication utilized international data to estimate the CO_2 uptake of forests and biomass stock in Palau. In 2005, the uptake of CO_2 by forests and biomass was estimated to be 98.57 Gg-CO_2.

4.3.2 Current Activities

The Protected Areas Network (PAN) act, RPPL 6-39, was passed in 2002 that created a nationwide system to support States' efforts in protecting their natural resources. This support included technical assistance to the states from the national government through the PAN Office. The PAN office works with states to nominate and develop management plans for PAN sites and technical assistance to implement, monitor, and evaluate the progress of the implementation of each management plans. In 2011, the PAN Technical Committee was formed to provide technical assistance to the Minister of the Ministry of Natural Resources, Environment &Tourism (MNRET), specifically to review State nominations and management plans.

In order to support the work of PAN, sustainable financing was necessary to maintain PAN sites and therefore a financial mechanism, through the legislation RPPL 7-42, was created. In Palau, the Green Fee—a fee paid by non-residents departing Palau—funds the PAN. The fees collected are directed to PAN Fund—a non-profit organization with the purpose of administering, managing, investing, and disbursement of all funds for PAN. Funds are disbursed by the PAN Fund on a quarterly basis to each PAN State, based on their management plans. These funds are then used to implement the activities as set by each States' management plans for the purpose of protecting their natural resources.

PAN leads Palau's national efforts to support the Micronesia Challenge. Under the Micronesia Challenge, each jurisdiction has committed to conserve at least 30% of the near-shore marine resources and 20% of the terrestrial resources by 2020 (MC, 2012). States, communities, and private entities can apply to register a protected site under the PAN. A PAN site must have a detailed management plan and must establish a use category—restricted non-extractive use, non-extractive use, or sustainable use. As of 2011, Palau had established 40 protected areas covering 40% of near-shore marine areas and 20% of terrestrial areas (PCS, 2012).

4.3.3 Future Options

Data collection on forestry activities in Palau is lacking. This can be addressed by incorporating a collection of forest data into the PAN management plan. Beyond the PAN sites, forest data collection can be expanded by partnering with the Bureau of Forestry. The combined efforts would result in a better idea of the total forest coverage and area by forest type in Palau. Several states are in the process of developing land use management plans. As states undergo this process, states should balance development needs with the need to protect forest areas.

4.3.4 Barriers to Mitigation

One barrier to mitigation is the lack of a national guidance for the allocation of technical and funding resources. There is also a lack of technical capacity to measure GHG reduction of mangroves and public awareness on the role of mangroves as a means to mitigate climate change. Moreover, in recent years, the demand for firewood has increased, which has increased deforestation in Palau.

4.4 Planning for Subsequent Mitigation Assessment

Palau should begin collecting data in order to conduct a more detailed mitigation assessment in the future. The next mitigation assessment should utilize formalized modeling, specifically the Long-range Energy Alternative Planning (LEAP) system energy accounting model. The LEAP model can simulate the effect of selected mitigation options on overall costs and emissions (SEI, 2006). The LEAP model is likely the best option for Palau as it is a simple model, requiring fewer data and expertise than other modeling systems. As the data collection process for this type of modeling often takes a year to complete, Palau should launch a data collection initiative in the near future. This initiative should include relevant government ministries, Palau Public Utilities Corporation (PPUC), and private industry and businesses.

The data collection initiative should begin by analyzing the data requirements for the LEAP Model and identifying the relevant sources for each data set. Collection of data for each data set should be assigned to a specific entity, whether a government ministry, PPUC, or a private entity. The following data sets are required for the LEAP model (SEI, 2006):

- **Macroeconomic Variables**

  This category includes statistics such as GDP, population, household size, transport needs, and income distribution.

- **Energy Demand Data**

  This category includes activity level (the measure of economic activity in a sector) and energy intensity data. Data should be collected on historic, current, and future projections for each variable. Sources for this data may include energy consumption surveys and reports on sales of different forms of energy. This data set should be broken down by sector or consumer category.

- **Energy Supply Data**

  This category includes data on current and previously installed capacity, costs (including operation, maintenance, and fuel), actual dispatch, plans for capacity expansion, and data on transmission and distribution losses.

- **Technology Options**

  This category includes technology costs and performance (including renewable technologies), penetration rates, and emission factors.

Training for the LEAP model is available through the Stockholm Environment Institute (SEI) and generally takes about a week. Palau should consider sending a representative—possibly from OERC or the Ministry of Public Infrastructure, Industry and Commerce—to undergo training offered through the workshops. Following the training, this representative should monitor the data collection initiative to ensure all necessary data is being collected in order to run the LEAP model. The representative should be responsible for compiling data, running the LEAP model, and completing a mitigation assessment utilizing the results of the model.

Chapter 5: Other Information Considered Relevant

5.1 Steps taken to integrate climate change into relevant social, economic and environmental policies

In 2012, the House Joint Resolution 8-68-13, HD1, mandated that there be a development of a climate change policy framework to establish a clear plan of action that cuts across sectors at all levels (community, state, national, international) in all anticipated scenarios of climate change. Moreover, for the policy framework to contribute to lowering the country's greenhouse gas emissions, it would mandate low carbon emission development by fostering the development of energy efficiency and renewable energy systems and be designed to protect carbon sinks.

Efforts are now being mobilized for its development through the Office of Environmental Response and Coordination, Office of the President, with technical assistance from the Secretariat of the Pacific Community, and funding support from the European Union and the German Government.

5.1 Research and Systematic Observation

5.1.2 Introduction

The research and systematic observation of weather and climate-related events and systems are important elements of Palau's efforts to develop sustainably. These are also essential to determining the extent of the changes in weather and climate that affect the Republic of Palau. Nevertheless, efforts in this regard are constrained by a variety of technological, financial, and capacity barriers. This section is based on input from the Palau National Weather Service, government staff, and other experts from the field.

5.1.3 Palau National Weather Service

The centerpiece of Palau's climate research and systematic observation is the Palau National Weather Service with its headquarters at the Belau National Museum compound. The Weather Service fulfills a number of vital services for Palau. These include the systematic collection and analysis of meteorological data, providing information and data services to maritime and aviation interests, and serving as the official source of information on tropical storms. In fact, within the context of a micro-state with limited technical and scientific capabilities, the National

Weather Service is the agency regarded as having the mandate to provide information on a range of natural events and phenomena.

At present, data collected by the National Weather Service consists of hourly values of air temperature, atmospheric pressure, cloud conditions, rainfall events, significant weather events, humidity, wind direction and speed, and visibility. This data is entered into the global weather exchange database, as well as kept locally as climatological records. The National Weather Service has data extending back to the year 1951, as well as some earlier data (mainly on rainfall) collected by the National Weather Service and interested private individuals.

5.1.4 Predictions and Methodology

Quantifiable predictions have not been made due to the limited information. However, matching regional trends and changes with events provides a mechanism where prediction of future events enables Palau to better prepare for potential climate change impacts.

For Palau, predictions of climate change impacts are limited to the analysis of wider regional predictions. Palau's data collection and management systems are relatively limited in scope in terms of technical capacity, access to proper equipment, and human capacity. There is a need for technical training in data collection and management for Palau to be in a better position to make national predictions, as opposed to the current reflection on historical trends.

5.1.5 Other Research Efforts

Another effort towards research and systematic observation involves efforts by the Coral Reef Research Foundation (CRRF) to collect and analyze data on changes in the sea temperature and sea-level at various coastal sites. This has been an ongoing program for several years. As such, the CRRF is now able to determine warnings on EL NINO's and LA NINA occurrences. CRRF is also involved in the monitoring and assessment of natural ecosystems that are sensitive to changes and shifts in weather and climate patterns.

5.2 Education, Training and Public Awareness, and Capacity Building

The Public education and awareness campaign began in the Fourth Quarter of 2007 and continued through 2008 to build public awareness on climate change.

The campaign was set forth to build public literacy on climate change, putting forth a process to identify capacity gaps, and develop capacity priority actions. These became the bases to which action items were developed to bridge coordination of information and improve efforts. Figure 16 illustrates the steps to enhance public education and awareness and build capacity, which is currently ongoing.

Figure 16: Climate Change Campaign Priority Actions

Action steps: Education and Awareness
1. Create a body to coordinate implementation of the Public education and awareness campaign.
2. Organize and develop a comprehensive and coherent national plan for integration of the Energy Efficiency Action Plan as a mitigation component of Climate Change.
3. Continue to develop and strengthen the climate change core group to disseminate climate change information to the public.
4. Strengthen institutional capacity of government and organizations to enhance collaboration.
5. Promote public awareness aimed at stakeholders at all levels, ensuring all groups are aware of the various issues related to climate change.
6. Provide opportunities for education and training targeted at specific fields.
7. Refer to studies collected and provide baseline information on Palau's Greenhouse Gas Inventory, namely the Energy Sector, to better understand the need for EEAP.
8. Strengthen efforts through monitoring and evaluation of initiatives.
9. Incorporate and apply indigenous and traditional knowledge where possible.
10. Build capacity to conduct 'green accounting' (valuation of eco-services).
11. Continue to build capacity to enable expansion of outreach nationwide.
12. Advocate for the development of a Climate Change and Energy policy that reflects the needs of society at all levels.
13. Build capacity to collect baseline data, criteria, and indicators on Climate Change and Energy.
14. Develop expertise at the national level for Energy Efficiency and conservation practices.
15. Develop institutional structure to monitor and regulate the use of Energy Technology.
16. Explore mechanisms to effectively mainstream climate change priorities nationwide.

Chapter 6: Constraints, Gaps, and related financial, technical and capacity needs and Recommendations

6.1 Constraints and Gaps

Notwithstanding the progress already made to address constraints and gaps, a number of critical information gaps and key areas of research are needed, and are listed below:

- Monitoring of efforts, documentation of information, modeling climate scenarios at local, state, and nationwide remains to be a key constraint;
- Research and development of systems is inadequate in terms of monitoring and understanding meteorological/atmospheric, oceanographic, and terrestrial variables as they relate to climate change;
- Information on the nature and consequences of the changing climate conditions as well as patterns of natural variability and how they might change as a result of global warming is inadequate;
- Developing reliable projections of climate change and predictions of climate variability on various timescales are needed;
- Improving baseline information on human and built environments are needed to better support monitoring and assessment studies at local, state, national scales;
- In order to better contextualize climate change, observations and insights from scientific and traditional sources need to be incorporated and;
- A tracking mechanism to record and assess the changing patterns of resources, ecosystems, and animal species at local, state, and national levels, including information from local practitioners on habitat changes in areas traditionally used for subsistence gathering and fishing is a key constraint.

Specific gaps such as those listed above are notable; however, in general, adequate assessments on climate change stemming from financial and technical limitations (human, technological, and expertise) restrict Palau's research scope and scale to properly implement necessary measures.

6.2 Financial Needs

6.2.1 Finance on Adaptation

Indicative costs of climate change impacts were estimated based on the results of the vulnerability assessment and recommendations from chapter three of this report. The associated costs found below are the initial determination of the financial needs that are needed based on estimates from representatives who live and work in the affected areas. These will later be verified during the incoming consultations to develop the national climate change framework, which will be broader in scope, and where there will be opportunities to collect more data and information.

Figure 17: Indicative scale of financing needed to enhance resiliency

	Identified Vulnerabilities	Level of Risk	Adaptation Cost
Coastal area	Sea level rise, storm surge, temperature increase	High	$120,000,000
Water Resources	Changing rainfall patterns and limited access during drought	High	$15,000,000
Institutional Context	No climate change policy and strategies to promote integration and coordination of adaptation measures	High	$500,000
Health	Increased vector-borne diseases, decreased agriculture activities, injuries/casualties from extreme weather events	High	$12,000,000
Food Security	Sea level rise, flooding, drought	High	$10,000,000
		Total	$157,500,000

It is important to note that it will be necessary to establish an institutional framework to ensure a well-coordinated mechanism to mainstream climate change efforts when the climate change policy framework is developed. This may mean separating the two functions of OERC (National Environmental Planning and Climate Coordination) and put in place a stand-alone office on climate change. Should the institutional arrangements succeed, it will have an estimated cost to the national government $500,000 annually in operations (OERC, 2013).

6.2.2 Finance on Mitigation

Mitigation covers the energy sector and carbon sinks as referenced in chapter four of this report. The 2010 National Energy Policy (NEP) sets national targets to reduce energy consumption by 30% and produce a minimum of 20% of total energy production through renewable energy by 2020. The finance needed to reach these targets are not in the NEP, although it is estimated to cost within the range of $30 to $38million to put in place initiatives to reduce energy consumption by 30%. This will include upgrading power lines, substations, and power poles. The improvements made will enable the integration of 20% of total energy generation from renewable resources without destabilizing the grid system. With the current prices to purchase, ship, and install renewable energy resources, in particular solar, may be in the range order of $50-60m in order for Palau to reach its 20% target (Energy Office, 2013).

Further systemic analysis on the grid that takes the above figures into account will need to be undertaken to verify these estimates. This is reflected upon the current state of capacity, human and technical, to perform a robust analysis of the country's grid system. Palau is in communication with Japan Government aiming to obtain technical cooperation to assess the energy sector and develop recommendations on how to achieve the Republic's energy targets and the finance that is needed to undertake them (Energy Office, 2013).

Technical capacity building support is needed to develop Palau's ability to measure carbon sinks. Management frameworks can be enhanced by integrating their role into the overall management of ecosystems and natural resources. The PAN management plan is considered to

be an appropriate starting point as it is an already fully operationalized system with sites that are carbon sinks that exist in both land and sea, established in 40 sites, and is expected to grow as more states choose to participate in the program. Funding for PAN sites are collected from the Green Fee. It will cost an additional $250,000 to train the custodians (PAN Coordinators) so they may be able to integrate measurements to monitor and measure carbon sinks. The finance needed is expected to rise as the number of PAN sites increase along with operations required to manage them (MNRET, 2013).

6.3 Technical and Capacity Needs

6.3.1 National Circumstances

The National Circumstances chapter of this Second National Communication utilized information from Palau's 2005 National Census. Palau would benefit from a more up-to-date National Census to better understand the various factors at play that make up the current status of the country. Currently, it is unclear when national census will be conducted.

6.3.2 GHG Inventory

The Second National Communication has made significant steps in improving the quality of its greenhouse gas inventory. However, there are still critical issues that were identified. The identified gaps, needs, and shortcomings give rise to recommended activities Palau may wish to undertake in relation to its national inventory of greenhouse gases.

In many cases, official (or published) data were either not available or nonexistent. As a result, findings were estimated based on general assumptions. The Republic of Palau is encouraged to continue to improve the way data are collected. The collection of data for the LUCF sector is a priority as data is especially lacking for this sector.

All sources/sinks were estimated by the Tier 1 methodology and mostly using the default emission factors/parameters. There should be efforts to raise the Tier to improve the accuracy of estimations by collecting country/category specific factors that reflect the circumstances of the Republic of Palau.

For the energy sector, a more accurate methodology for estimating the amount of fuel imported between 1994 and 1998 should be examined. It is necessary to revise the density data for each fuel type used for converting the unit of the amount of fuel from kl to tons. A bottom-up approach may be considered as a long-term goal for Palau.

For industrial processes, official data on the amount of lime produced annually should be collected or gathered regularly from reliable sources. Updating lime production data is important especially because it is thought that lime consumption in the Republic of Palau has been increasing over the years. To improve the accuracy of inventories, it is recommended that the method to quantify the amount of soda used transition from estimation methods to more precise measurements. It is also recommended that data for food and drinks be collected or estimated and archived for this sector instead of using figures from the First National Communication.

An important part of the agriculture sector would improve if the process of collecting data for the amount of fertilizer used in Palau is developed. Currently, the data collection is estimated by using the total value of fertilizer imported divided by the average cost of fertilizer per pound, assuming that all fertilizers cost the same. While these estimates are indicative, there is room to improve how the sector can more accurately account for the total amount of fertilizer used in Palau.

Increase in greenhouse gas can result from land use change as forests are replaced by roads and buildings. Forests as a source of carbon sequestration combined with development as source of access for more driving and infrastructure powered by diesel gas have future compounding factors that contribute to increased carbon emission outputs. Therefore an inventory of land use changes needs to be tracked over time as a key part of Palau's GHG inventory.

6.3.3 Vulnerability and Adaptation Assessment

The Vulnerability and Adaptation Assessment for the Second National Communication was based on global climate models. While downscaling techniques would enable our understanding of localized climatic variations and impacts, such techniques were not used due to limited availability of tools, local data, and lack of human resources trained in this field. As with the GHG Inventory, the Vulnerability and Adaptation Assessment would benefit from the collection and utilization of local data.

6.3.4 Mitigation Assessment

As discussed in Chapter 4, Palau lacked the data to conduct formalized modeling for this National Communication. Instead, a descriptive mitigation assessment was conducted. In the Third National Communication, the mitigation assessment should include formalized modeling, likely using the LEAP model. A plan for collecting data should be implemented in order to carry out a more detailed mitigation assessment (utilizing formalized modeling) in the future.

6.4 Recommendations

During the validation workshop for this report, participants discussed recommendations to facilitate and make improvements for the Third National Communication. The participants agreed that one of the most valuable improvements to the National Communication process would be to implement a system of information sharing. In preparing this Second National Communication, obtaining information from different ministries and other entities delayed the completion of this report. Before beginning the process for the Third National Communication, an information-sharing system should be established in order to coordinate efforts and provide easy access to all reports and information relating to climate change in Palau. In addition, workshop participants identified capacity building as a priority for the next National Communication. Participants expressed a desire to build capacity so that more of the work for the Third National Communication could be conducted in Palau. For example, the workshop participants hoped that funding would be available to train staff from the Ministry of Natural Resources, Environment, and Tourism to run the LEAP model for the next mitigation assessment.

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Annex 1: Summary of Emissions for the Year 2000

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)				
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O
Total National Emissions and Removals	**149.99**	**-98.57**	**0.20**	**0.03**
1 Energy	**149.90**		**0.00**	**0.00**
A Fuel Combustion	149.90		NE	NE
1 Energy Industries	IE		NE	NE
2 Manufacturing Industries and Construction	IE		NE	NE
3 Transport	IE		NE	NE
4 Other Sectors	IE		NE	NE
5 Other (please specify)	IE		NE	NE
B Fugitive Emissions from Fuels	**0.00**		**0.00**	
1 Solid Fuels			NO	
2 Oil and Natural Gas			NO	
2 Industrial Processes	**0.09**		**0.00**	**0.00**
A Mineral Products	0.09			
B Chemical Industry	NO		NO	NO
C Metal Production	NO		NO	NO
D Other Production	NE			
E Production of Halocarbons and Sulphur Hexafluoride				
F Consumption of Halocarbons and Sulphur Hexafluoride				
G Other (please specify)	NO		NO	NO
3 Solvent and Other Product Use	**NE**			**NO**
4 Agriculture			**0.02**	**0.03**
A Enteric Fermentation			0.00	
B Manure Management			0.01	0.00
C Rice Cultivation			NO	
D Agricultural Soils			NE	0.03
E Prescribed Burning of Savannas			NE	NE
F Field Burning of Agricultural Residues			NE	NE
G Other (please specify)			NO	NO
5 Land-Use Change & Forestry	**0.00**	**-98.57**	**0.00**	**0.00**
A Changes in Forest and Other Woody Biomass Stocks		-98.57		
B Forest and Grassland Conversion	0.00		0.00	0.00
C Abandonment of Managed Lands		NE		
D CO2 Emissions and Removals from Soil	NE	NE		
E Other (please specify)	NO	NO	NO	NO
6 Waste	**0.00**		**0.19**	**0.00**
A Solid Waste Disposal on Land			0.07	
B Wastewater Handling			0.12	0.00
C Waste Incineration	NO		NE	NE
D Other (please specify)	NO		NO	NO
7 Other (please specify)	**NO**	**NO**	**NO**	**NO**
Memo Items				
International Bunkers	**24.08**		**NE**	**NE**
Aviation	24.08		NE	NE
Marine	NE		NE	NE
CO_2 emissions from biomass				

Total National Emissions (Gg-CO_2)	**149.99**	**-98.57**	**4.29**	**10.24**

65.96 **Gg-CO_2**

Annex 2: GHG Inventory

Detailed information/estimates should be provided here