FEDERATED STATES OF MICRONESIA

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

Empowered lives.
Resilient nations.

Front Cover Photograph: © David Kirkland, Image courtesy of the South Pacific Tourism Organisation.

# Foreward

Climate change is, without question, the gravest threat to my people's welfare, livelihoods, and general security. It is the survival issue of our time. Our sustainable development is threatened by the harmful effects of excessive greenhouse gas emissions in the atmosphere, effects which poison our root crops, destroy our reef systems, and drive many of our people from their ancestral homes. All of us, developed and developing countries, have a stake in finding ways that minimize manmade damage to Mother Earth.

Climate change is a global issue that must be addressed by the international community and thus the need for us to communicate to our sister States around the world in this report (Second National Communication) as a plea for our generation to work together and do what we must for the survival of our planet.

Since the last communication, FSM has made humble progress to do our part even though we do realize that success can only come with tangible reduction in greenhouse gases (GHG) by our big polluters. We will not stop advocating at national, regional and international level for emissions reductions in any way, shape or form to ensure our survival. At the local level, we have developed a climate change policy and are mainstreaming it into some of our key sectors and we will continue to do this. Despite negligible GHG emissions, FSM continues to strive to meet our targets for renewable sources of energy, ambitious though they may be to some.

This Second National Communication is not only an exercise to fulfill our reporting obligations under the UN Framework Convention on Climate Change (UNFCCC). More importantly, this report has confirmed with strong evidence that what our people have been facing is real and we will continue to face this should we continue neglecting our duty as stewards of our Mother Earth. It is without doubt that FSM emissions of greenhouse gases are negligible but that our people and our islands are most vulnerable to the multi-faceted impacts of climate change.

I hereby re-commit FSM Government to our national efforts to meet our goals in country and at the international level. I take this opportunity to thank the Global Environment Facility for financial and technical support to undertake the GHG inventory and assessments. I commend the efforts of the numerous staff and experts at national and state level.

And finally I wish to express gratitude to all the people of FSM and communities that welcomed us into your lands and shared your thoughts with us so as to successfully produce this important report.

[redacted]

**H.E. Manny Mori**
President
Federated States of Micronesia

# JOSEPH 'Joe' KONNO

November 4, 1954 – May 24, 2010

This publication is dedicated to the fond memory of Joseph (Joe) Konno in recognition of his life-long devotion to environmental protection and climate change in particular. He was well known not only in the Pacific region but globally, as a passionate advocate of issues on negative impacts of climate change.

Joe's passion on climate change issues might be because of his being an island boy, born on the low-lying atoll island of Polowat in Chuuk State. Although having lived in and visited many countries, his heart remained in the islands, bringing him back to his beloved State of Chuuk and serving in the Government for more than 10 years as Director and Advisor of the Environmental Protection Agency (EPA).

Although secure in his position as long-serving public servant, Joe was never hesitant to be part of new and emerging issues in environmental protection and conservation. He was always up for new challenges and never compromising his push for seeing the most effective way to address issues. Such an attitude and contagious energy enabled him to jump into things and push and pulled people towards success.

In 1991 when some of us were only just starting to see clips of climate change on TV, Joe was already taking the extra steps to learn the issues attending trainings and getting entrenched in the numerous workshops and conferences on the issue. Groundbreaking initiatives such as the Climate Change Adaptation Project (CLIMAP) saw Joe in the midst of it all and advocating for recognition of island vulnerabilities.

You can always count on Joe to do what needs to be done and especially to say what needs to be said and of course this sometimes gets him into trouble with the powers that may be but his reliability was unwavering. If he put his mind to it, he would make it work. Such commitment and enthusiasm is certainly missed as small islands continue to face up to the challenges of climate change.

As FSM is poised to launch its most comprehensive national communication, it is befitting that we take a moment to honor Joe and his legacy in this very important issue for the FSM.

# Executive Summary

The Federated States of Micronesia (FSM) submitted its Initial National Communication in October, 1999. This Second National Communication uses it as the baseline to document the increases in FSM's vulnerability to climate change, and changes in its greenhouse gas emissions, since the Initial National Communication was prepared. This National Communication also reports on the efforts FSM is making to reduce its emissions and to identify and implement adaptation options that reduce climate risks. Continuing and new information and research needs are also described, as are the ongoing efforts to strengthen FSM's capacity to manage climate risks by increasing awareness, enhancing knowledge and skills, strengthening institutions and preparing and implementing policies and plans designed to reduce climate risks.

FSM's environment and natural resources are considered to be the nation's living wealth. Maintaining the habitats and ecosystems that nurture these is vital for improving the quality of life of its people and sustaining the country's rich traditions. However, except for the offshore fisheries, there are limited financially exploitable resources in the FSM. As a result, a significant portion of FSM's revenue comes from Compact funding. Other sources of revenue include taxes, foreign aid and grants, and fishing fees. Agricultural production is relatively small, but is still the primary resource traded domestically. There is a small export market, mainly to the neighboring island groups, of the locally valued products of sakau (kava), betelnut and citrus.

Climate change remains an important policy priority for the FSM. In the past 10 years or so FSM has made considerable progress in documenting the climate-related risks faced by the nation. Substantial advances have also been made in developing relevant policies and plans, and in establishing and strengthening National and State institutions with mandates for managing climate and related risks, including disaster risk management. The Nationwide Climate Change Policy, the National Biodiversity Strategy and Action Plan, the National Energy Policy and State Action Plans, and the National Action Plan to Combat Land Degradation are but a few of the National and State-level plans and policies that the FSM is implementing in order to address major threats to the sustainability and economic and social viability of the country. FSM is presently preparing a Joint National Action Plan for climate change adaptation (CCA) and disaster risk management (DRM). FSM already has a Multi-State Hazard Mitigation Plan.

Considerable effort has been put into undertaking vulnerability and adaptation assessments, at a variety of spatial scales and for various sectors, with a focus on food security as a priority theme. However, there is still not a comprehensive understanding of vulnerability to climate change at National, State, island or community levels, assessments are not being informed by the results of systematic analyses of current let alone future risks, and identification of appropriate adaptation measures remains at a very generic level. FSM has yet to develop the full range of sector level policies and strategies that will ensure climate change considerations are reflected in a meaningful way in all its development and social economic plans and activities.

Successfully achieving climate change adaptation within the FSM may be facilitated by three initiatives: (i) establishing FSM as a National Implementing Entity in order to improve access to international funding, thereby increasing the flow of financial resources to the FSM and its States; (ii) forming international partnerships to aid adaptation efforts; and (iii) continuing the development of internal policies and legislation focused on building resilient and sustainable communities, including ensuring that development efforts do not make FSM more at risk to climate change and making a developer liable for actions that reduce the resilience of a community and/or island.

The second greenhouse emissions inventory for FSM used data from a 2000 survey, with 1994 data used as the baseline. The total amount of $CO_2$ emitted in the FSM as a result of fossil fuel combustion is estimated at 151.91 gigagrams, or 151,910 metric ton. $CO_2$ emissions have therefore decreased by 7.7% since 1994, when the amount of $CO_2$ emitted in the FSM was estimated to be 164.51 gigagrams. Significantly, FSM's contribution on a global scale is a mere 0.003% of global $CO_2$ emissions.

The goals in the FSM Energy Sector Policy and in the State Energy Action Plans are for FSM to be less dependent on imported fossil fuels by implementing energy efficiency and conservation measurements and including more environmentally sound renewable energy sources that are locally available; and by promoting sustainable socio-economic development through the provision and utilization of cost-effective, safe, reliable and sustainable energy services. Measurable progress has been made, especially with respect to the deployment of photovoltaic energy systems in communities and for buildings such as schools.

An interesting development is the formation of Ocean Energy Kosrae, a joint venture between Ocean Energy Industries Inc. and the Kosrae Utilities Authority. It has been established as an independent power producer in Kosrae State. The company's goal is to build a 1.5 MW power generating wave power farm. When fully operational this wave power farm will eliminate annual GHG emissions of at least 7000 tons.

# Table of Contents

# List of Abbreviations and Acronyms

| | |
|---|---|
| **A** | Atolls |
| **AMU** | Association of Micronesian Utilities |
| **BAU** | Business as Usual |
| **CCA** | Climate Change Adaptation |
| **CSIRO** | Commonwealth Scientific and Industrial Research Organization |
| **DRD** | Department of Resources and Development |
| **DRM** | Disaster Risk Management |
| **ENSO** | El Niño – Southern Oscillation |
| **EPA** | Environmental Protection Agency |
| **FAS** | Freely Associated States |
| **FEMA** | Federal Emergency Management Agency |
| **FS** | Forest Service |
| **FSM** | Federated States of Micronesia |
| **GCM** | Global Climate Model |
| **GDP** | Gross Domestic Product |
| **GHG** | Greenhouse Gas |
| **HV** | High Volcanic |
| **IDP** | Infrastructure Development Plan |
| **INC** | Initial National Communication |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **KUA** | Kosrae Utility Authority |
| **MCT** | Micronesia Conservation Trust |
| **MDG** | Millennium Development Goal |
| **MHMP** | Multi-state Hazard Mitigation Plan |
| **NAP** | National Action Plan |
| **NCCP** | Nationwide Climate Change Policy |
| **NCD** | Non-Communicable Disease |
| **NCSA** | National Capacity Self Assessment |
| **NEP** | National Energy Policy |
| **NEW** | National Energy Workgroup |
| **NGO** | Nongovernmental Organization |
| **ODA** | Overseas Development Assistance |

| | |
|---|---|
| **OEEM** | Office of Environment and Emergency Management |
| **PACC** | Pacific Adaptation to Climate Change (Project) |
| **PCEP** | Pacific Islands Climate Education Partnership |
| **PDA** | Post Disaster Assessment |
| **PV** | Photovoltaic |
| **RVA** | Risk and Vulnerability Analysis |
| **SDP** | Strategic Development Plan |
| **SEG** | State Energy Workgroup |
| **SHS** | Solar Home System |
| **SNC** | Second National Communication |
| **SPC** | Secretariat of the Pacific Community |
| **SPREP** | Secretariat of the Pacific Regional Environment Programme |
| **SWARS** | State-wide Assessment and Resource Strategies |
| **TNC** | The Nature Conservancy |
| **UN** | United Nations |
| **UNDP** | United Nations Development Programme |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **USA** | United States of America |
| **USDA** | United States Department of Agriculture |
| **USFS** | United States Forest Service |
| **WSO** | Weather Service Observatory |

## CHAPTER ONE

# INTRODUCTION

1

The Government of the Federated States of Micronesia (FSM) signed the United Nations Framework Convention on Climate Change (UNFCCC) on June 12, 1992. On November 18, 1993, the FSM Congress ratified this initiative. The Convention entered into force on March 21, 1994. Since that time the FSM has taken the necessary steps to fulfill its obligations under the Convention.

This included submitting FSM's Initial National Communication (INC) on 30 October, 1999. The INC covered such topics as the National inventory of greenhouse gas (GHG) emissions[1], mitigation analysis, assessments of vulnerability to climate change, adaptation options, and information and research needs, public awareness and education and capacity building. As such, it provides a baseline for subsequent assessments of the needs and opportunities related to both climate change mitigation and adaptation.

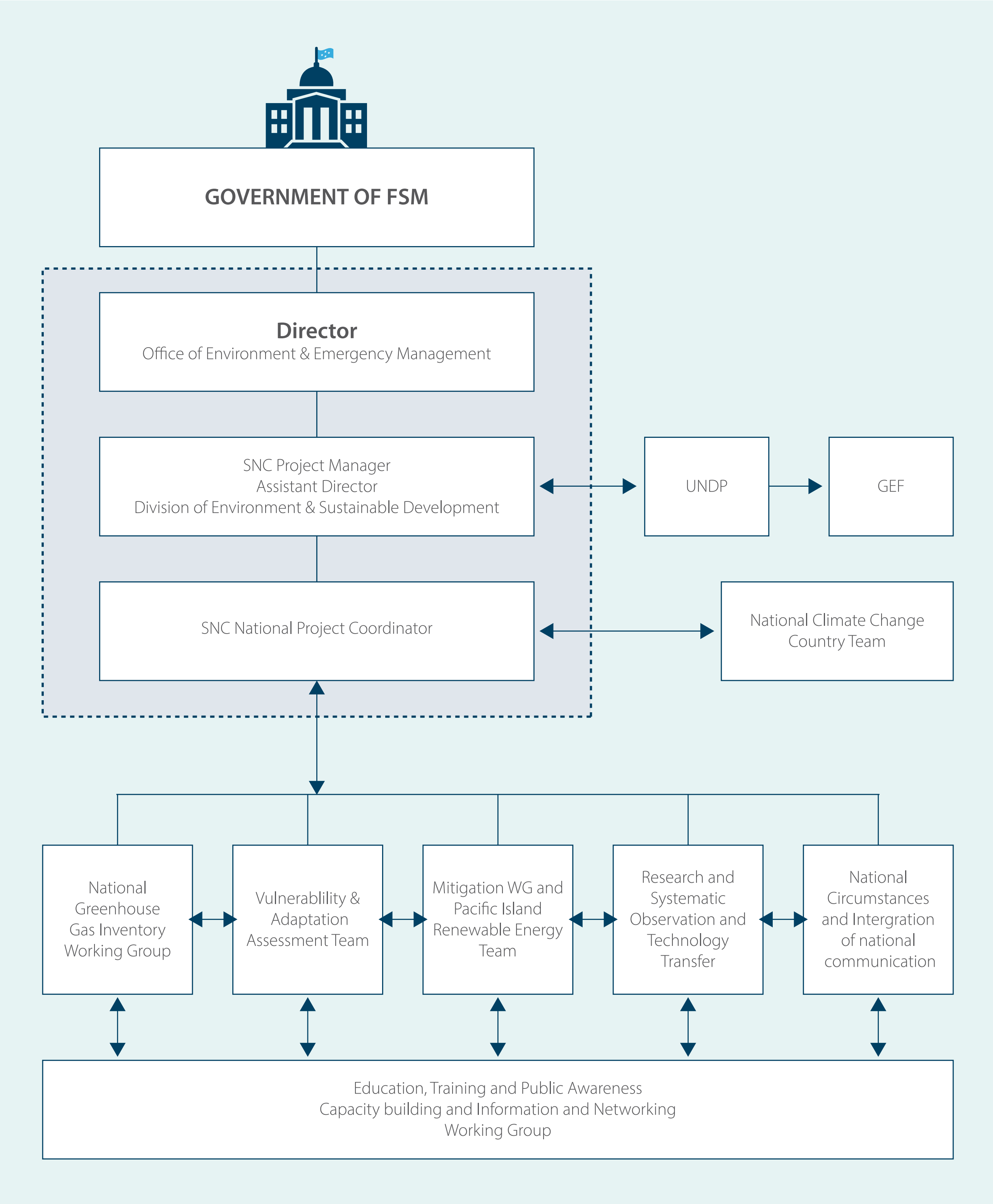
This Second National Communication (SNC) uses the baseline established in the INC to document the changes in FSM's vulnerability to climate change, and in its GHG emissions, since the INC was prepared. This SNC also reports on the efforts FSM has made to reduce its emissions and to identify and implement adaptation measures that reduce climate risks. Continuing and new information and research needs are also described, as are the ongoing efforts to strengthen FSM's capacity to manage climate risks by increasing awareness, enhancing knowledge and skills, strengthening institutions and preparing and implementing policies and plans designed to reduce climate risks.

The institutional arrangements for preparation of this SNC are shown in Figure 1. The technical and related studies were overseen by a Project Manager and Project Coordinator and undertaken by National working groups. These working groups covered the main themes of the SNC, as summarized above. Preparation of the SNC was funded by the Global Environment Facility, through the United Nations Development Programme as the implementing agency.

A list of key consultations, and the key stakeholders involved, during the course of preparing this SNC is provided in Appendix 1. Acknowledgements are in Appendix 2.

[1] Technical terms are defined in the Glossary.

**FIGURE 1** Institutional arrangements for preparation of FSM's SNC



CHAPTER TWO

# NATIONAL CIRCUMSTANCES

2

## 2.1 INTRODUCTION

The following description of the National circumstances highlights, amongst other points, the increased understanding of the linkages between climate change and the sustainable development of FSM, as well as the considerable progress made in preparing and implementing policies and plans to reduce climate-related risks and in strengthening the various Government institutions that are responsible for coordinating and implementing risk and GHG reduction initiatives.

## 2.2 NATIONAL CONTEXT

The independent, sovereign nation of the FSM, with a constitutional Government, was formed in 1979. FSM comprises part of what was generally known as the Eastern and Western Caroline Islands. It covers the largest and most diverse part of the greater Micronesian region. The federation is formed by the four States of Yap, Chuuk, Pohnpei, and Kosrae (Figure 2).

FSM consists of 607 small islands, 74 of which are inhabited. The islands are spread over a vast region in the Western Pacific, between one degree south and 14 degrees north latitude, and between 135 and 166 degrees east longitude. The distance between the eastern-most State (Kosrae) and the western-most State (Yap) is 1,700 miles (2,700 km). Much of FSM lies just above the equator, about 2,500 miles (4,000 km) southwest of Hawaii and about 1,900 miles (3,000 km) north of eastern Australia. While the total land area of the FSM is only 271 square miles (702 $km^2$), its vast exclusive economic zone (EEZ) covers an area of over one million square miles (2.5 million $km^2$).

***Political and Legislative***

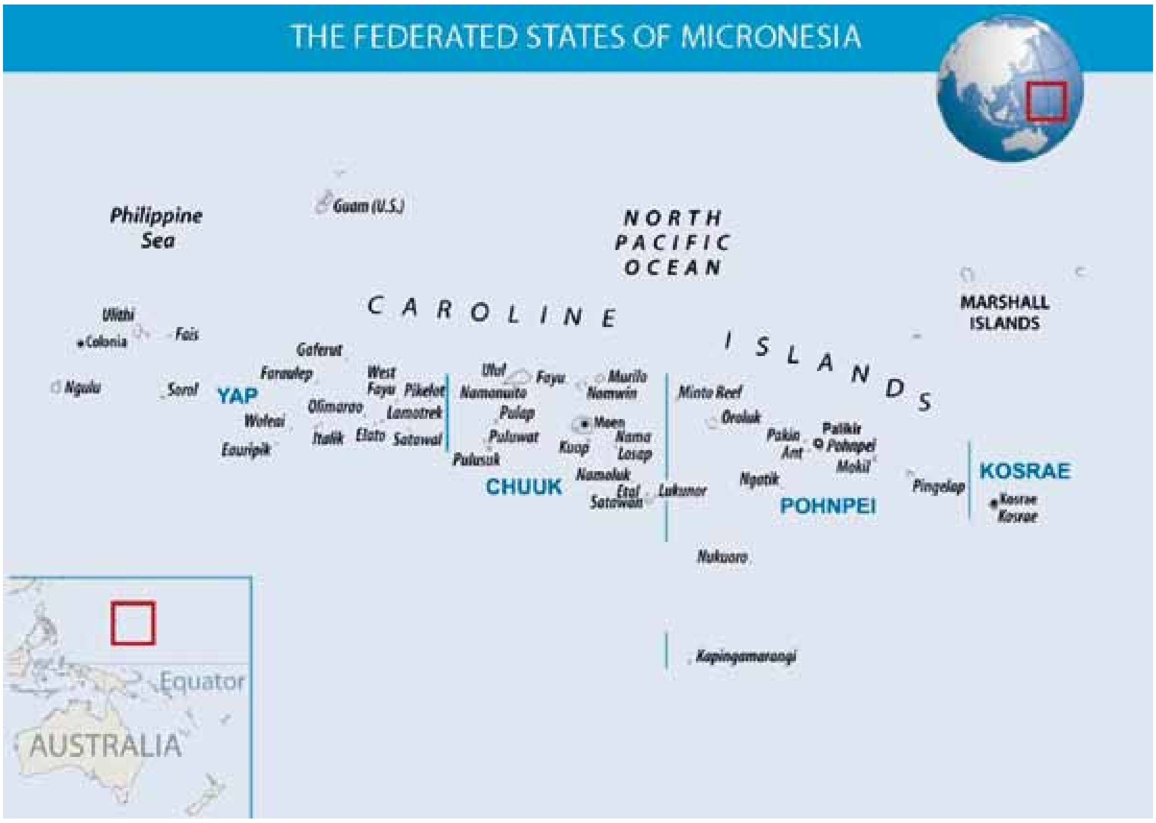
A Compact of Free Association (the Compact) was signed by the United States of America (USA) and FSM in 1986, leading to the trusteeship termination by the United Nations (UN) in 1991. This Compact agreement established a continuous close relationship between the FSM and the USA, through agreed mutual obligations and fiscal assistance. The Compact also grants FSM citizens access to USA federal programs, and favorable provisions for traveling to, and working in, the USA.

The FSM has four levels of governance – National, State, municipal, and traditional. The National Government, headquartered at Palikir on Pohnpei Island has three branches. Under FSM's Constitution, Article V, Section 3, Congress may establish a Chamber of Chiefs, but to date, this has not been implemented.

The legislative power of the National Government is vested in the Congress of the Federated States of Micronesia. The Congress is comprised of four members (one from each State) elected for four-year terms and ten members (allocated to the States based on population) elected for two-year terms. The Executive power is vested in the President and Vice-President, elected by the Congress from amongst members serving four-year terms. Judicial power is vested in the FSM Supreme Court, headed by a Chief Justice who is assisted by up to five Associate Justices.

Each of FSM's four State Governments has its own constitutional Government, consisting of the three branches: Executive, Legislative and Judicial. All States have a Governor and Lieutenant Governor. Executive offices are selected by the current Governor and approved by the State legislature. Each State may have fewer or more offices depending on their priorities and needs. Yap is the only State with a traditional leadership branch. This traditional leadership is made up of the Council of Pilung and the Council of Tamol, made up of the traditional chiefs of Yap Island proper, and from the neighboring islands and atolls in Yap State, respectively.

**FIGURE 2** Map of the Federated States of Micronesia




The National Constitution of the FSM is the foundation of all legal authorities and decision-making processes for the Nation. There are four States in FSM, which have their respective constitution. The state constitutions allow the states to enact state legislation consistent with state powers as provided for in the FSM Constitution. The FSM Constitution provides concurrent powers for the States to function as semi autonomous governments in enacting legislation that address concerns and issues related to managing natural resources and to achieving sustainable development.

Under the Compact II, Article VI and Section 161 of Title II, FSM is committed to applying the National Environmental Policy Act of 1969 and "to develop and implement standards and procedures to protect its environment". Responsibility for environmental and related issues is shared between the FSM National Government and the individual FSM State Governments.

Each FSM State has its own set of environmental and related laws and regulations geared to alleviate further damage to the nation's fragile environment that is caused either by excessive human activity or by climate change. States take the lead role in ensuring that development is avoided in vulnerable areas as well as ensuring that critical natural systems are protected. Each State has made efforts to control development and manage natural resources through the creation of land use plans, coastal zone plans, legislation and regulations. The National Government provides guidance and technical assistance to the States when needed and requested on matters related to planning, economic development, natural resources, fisheries, and the environment.

In June, 2012, FSM Environmental Protection Act became Public Law. Its purpose is to:

- reflect the current functions and responsibilities of the National Government in the area of environmental management and protection;
- eliminate duplication of responsibilities between the National and State Governments in the area of environmental management and protection; and
- provide the Office of Environment and Emergency Management (OEEM) with the necessary legal authority to implement, via regulation, the multilateral environmental agreements that FSM had already ratified, including the UNFCCC.

The FSM Environment Sector Plan 2010-2015, prepared in accordance with the FSM Strategic Development Plan (SDP) 2004-2023, identifies achieving higher rates of compliance with environmental laws as a high priority for FSM National and State Governments. Among the most serious problems of environmental governance in FSM is that the laws and regulations are not enforced consistently or effectively. The new Environment Protection Act endeavors to address this and related issues, in part by strengthening enforcement action and by requiring the Director of OEEM to provide, on an annual basis, an environmental quality report covering the status and conditions of the environment of FSM, and a review of the programs and activities of the National Government, State Governments, municipal Governments and non-governmental organizations (NGOs), with particular reference to their effect on the environment of the country.

Further information on relevant policies, plans and legislation is provided in Sections 3.9 and 3.10.

## ***Geography***

Each of the four States is centered on one or more main high islands (Table 1). All but Kosrae State includes numerous outlying atolls. The capital of FSM, Palikir, is located in Pohnpei State. Many of the islands in FSM are extinct shield volcanoes, with steep and rugged centers that are densely vegetated and eroded. Mangroves grow around the coastal fringes. Land elevations range up to about 2,500 feet (760 m). Other islands are relatively flat, small and swampy, with low-lying, forested atoll islets, typically one to five m above mean sea level (Table 2).

**TABLE 1 | Geography of FSM's Four States**

*(Sources: Namakin, 2008; FSM Division of Statistics, 2012)*

| State | # Island Groups | # Islands | # Inhabited Is. | Topography (HV = high volcanic; A = atolls) | Land Area Sq mi | Land Area Sq km | Lagoon Area Sq mi | Lagoon Area Sq km | Population (2010) | Population Density (Individuals per Sq mi) |
|---|---|---|---|---|---|---|---|---|---|---|
| Yap | 12 | 139 | 12 | HV + A | 46 | 119 | 405 | 1049 | 11,373 | 247 |
| Chuuk | 7 | 542 | 55 | HV + A | 49 | 127 | 823 | 2132 | 48,654 | 993 |
| Pohnpei | 6 | 26 | 6 | HV + A | 132 | 342 | 297 | 769 | 36,196 | 274 |
| Kosrae | 1 | 1 | 1 | HV | 42 | 110 | 0 | 0 | 6,616 | 156 |
| **TOTAL** | **26** | **708** | **74** | | **269** | **697** | **1525** | **3950** | **102,843** | **379** |

Sq mi = Square Miles
Sq km = Square Kilometers

**TABLE 2 | Characteristics of High and Low Islands in FSM**

*(Source: adapted from Campbell, 2006)*

| Volcanic High Islands | Atoll Islands |
|---|---|
| Remnants of extinct shield volcanoes | Coral rubble and sand deposited on shallow reefs |
| Large land area relative to length of coastline | Small land area, absolutely and relative to coastline |
| High and steep slopes, subject to erosion | Low elevation |
| Mix of shallow and deep, fertile soils | No or minimal (impoverished coral sand) soils |
| Fringing mangroves, lagoons and barrier reefs | Fringing reef, limited or no mangroves |
| Perennial and/or ephemeral streams | No or minimal surface water |
| Large groundwater resource | Shallow freshwater lens |
| Orographic rainfall, with flash flooding | Convectional rainfall |
| Relatively abundant natural resources | Narrow natural/economic resource base |
| Extensive stands of primary and secondary forest | Vegetation predominately herbaceous strand, or strand forest |
| High biodiversity | Relatively low biodiversity |
| Relatively high population numbers, concentrated in coastal areas | Low population numbers, but high concentrations |
| Transport and other infrastructure and services relatively well developed | Poorly developed transport and other infrastructure and services |

The major vegetation types in the FSM are native upland forest, agroforest, mangrove forest and savanna, other shrubs and grasslands (Table 3). About a third of FSM's land area is suitable for agriculture, but less than 5% of agricultural land is arable. About half is used for permanent crops, with the remainder being used for other agricultural purposes.

## TABLE 3 | Land Cover in FSM, 2005/06

*(Source: FAO, 2010)*

| | Chuuk | | Kosrae | | Pohnpei | | Yap | | FSM | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hectares | Acres | Hectares | Acres | Hectares | Acres | Hectares | Acres | Hectares | Acres |
| **Forest Types** | | | | | | | | | | |
| Upland Forest | 1678 | 4145 | 7378 | 18224 | 19546 | 48279 | 3129 | 7729 | 31731 | 78376 |
| Agroforest | 4295 | 10609 | 1492 | 3685 | 5912 | 14603 | 2731 | 6746 | 14430 | 35642 |
| Mangrove Forest | 1287 | 3179 | 1397 | 3451 | 5658 | 13975 | 1067 | 2635 | 9409 | 23240 |
| Palm Forest | 79 | 195 | 0 | 0 | 1832 | 4525 | 0 | 0 | 1911 | 4720 |
| Swamp Forest | 0 | 0 | 456 | 1126 | 99 | 245 | 25 | 62 | 580 | 1433 |
| Secondary Vegetation | 312 | 771 | 263 | 650 | 896 | 2213 | 398 | 983 | 1869 | 4616 |
| **Subtotal** | 7651 | 18898 | 10986 | 27135 | 33943 | 83839 | 7350 | 18155 | 59930 | 148027 |
| | | | | | | | | | | |
| **Non Forest Types** | | | | | | | | | | |
| Savanna/Other Shrub/Grass | 277 | 684 | 6 | 15 | 987 | 2438 | 1657 | 4093 | 2927 | 7230 |
| Cropland | 60 | 148 | 2 | 5 | 12 | 30 | 6 | 15 | 80 | 198 |
| Barren | 17 | 42 | 16 | 40 | 5 | 12 | 74 | 183 | 112 | 277 |
| Urban Builtup | 313 | 773 | 127 | 314 | 393 | 971 | 292 | 721 | 1125 | 2779 |
| Urban Cultivated | 213 | 526 | 177 | 437 | 178 | 440 | 121 | 299 | 689 | 1702 |
| Marsh | 222 | 548 | 61 | 151 | 134 | 331 | 125 | 309 | 542 | 1339 |
| Water | 57 | 141 | 23 | 57 | 33 | 82 | 9 | 22 | 122 | 301 |
| **Non Forest Subtotal** | 1159 | 2863 | 412 | 1018 | 1742 | 4303 | 2284 | 5641 | 5597 | 13825 |
| | | | | | | | | | | |
| **Grand Total** | 8810 | 21761 | 11398 | 28153 | 35685 | 88142 | 9634 | 23796 | 65527 | 161852 |

FSM's soils can be classified into two major groups, both with various subgroups. There are slight variations between one island and another. Soils in coastal mangrove swamps, on coastal strands and on bottom-lands are sometimes shallow and at other times very deep, and may be poorly drained. The soils are formed from inorganic deposits and coral sand. Soil fertility is also variable, but tends to be low. This group is used for the production of wood, coconuts and wetland taro and for urban development.

Soils on uplands also range between shallow and very deep, but most are well drained. They formed in residuum and colluvium derived dominantly from basic igneous rock. This group is used for subsistence farming. Soil fertility is generally relatively high.

The tropical climate of FSM is due to its geographical location in the Western Pacific, straddling and extending north of the equator, and the strong influence of northeast trade winds, thus generating consistently warm temperatures. The trade winds prevail from December through April. Periods of weaker winds and doldrums occur from May to November. Rainfall is generally plentiful (Table 4), especially on the high volcanic islands of Kosrae, Pohnpei and Chuuk. It can exceed 400 inches (1,016 cm) annually, or 22 inches (559 mm) in any one day (Table 4). The region is affected by storms and typhoons that are generally more severe in the western islands, as well as by periods of drought and excessive rainfall associated with different phases of the El Niño – Southern Oscillation (ENSO).

**TABLE 4 | Monthly and Annual Average and Maximum Daily Rainfall** (Inches)

*(Source: National Weather Service, FSM)*

| | J | F | M | A | M | J | J | A | S | O | N | D | Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Annual Average** | | | | | | | | | | | | | |
| Yap | 7.6 | 5.7 | 5.8 | 6.2 | 9.4 | 12.5 | 14.7 | 15.1 | 13.6 | 12.4 | 9.5 | 9.7 | **122.2** |
| Chuuk | 9.1 | 7.0 | 8.9 | 12.3 | 13.6 | 12.5 | 13.8 | 13.8 | 13.1 | 13.0 | 11.6 | 11.8 | **140.8** |
| Pohnpei | 12.1 | 10.6 | 14.4 | 18.0 | 19.3 | 16.6 | 16.8 | 16.0 | 15.4 | 15.6 | 16.0 | 15.8 | **187.0** |
| Kosrae | 15.9 | 15.2 | 17.4 | 20.2 | 18.4 | 16.2 | 16.5 | 15.2 | 14.9 | 12.4 | 14.7 | 19.5 | **203.3** |
| **Maximum Daily** | | | | | | | | | | | | | |
| Yap | 9.0 | 5.8 | 5.1 | 6.0 | 9.1 | 13.2 | 8.8 | 6.7 | 6.9 | 5.5 | 8.9 | 6.4 | **13.2** |
| Chuuk | 6.7 | 6.5 | 8.2 | 6.9 | 8.7 | 6.3 | 19.7 | 4.9 | 6.1 | 5.3 | 8.1 | 14.9 | **19.7** |
| Pohnpei | 9.6 | 8.9 | 9.7 | 12.6 | 7.2 | 4.7 | 7.1 | 10.0 | 9.2 | 7.8 | 22.0 | 7.2 | **22.0** |
| Kosrae | 7.1 | 11.0 | 9.6 | 6.4 | 7.6 | 6.7 | 9.5 | 6.6 | 6.3 | 6.2 | 9.9 | 11.9 | **11.9** |

From May to November the rainfall is extremely high on the volcanic islands of Kosrae, Pohnpei and Chuuk. Climatically, Yap lies in an area that generally experiences a monsoon climatic pattern, with more frequent periods of drought. The climate of Chuuk is hot and humid with an average temperature of 81 $^0$F (27 $^0$C), and little variation throughout the year. Average annual precipitation is 122 in (3,100 mm), with the months of January to March being drier. Pohnpei is generally hot and humid, also with a mean temperature of 81 $^0$F (27 $^0$C). Temperatures vary little from month to month. The mean annual rainfall is 190 in (4826 mm), with January and February being slightly drier than the average of all months. Kosrae's climate is characterized by high temperatures, heavy rainfall and high humidity. The average annual rainfall measured at the weather station in coastal Lelu is 203 in (5000 mm). In the mountainous interior rainfall is estimated to be as high as 300 in (7,500 mm) annually. Average temperature is again 81 $^0$F (27 $^0$C) at sea level. Average monthly temperatures vary from the annual average by no more than 0.5 $^0$F (1 $^0$C), and the difference between the average minimum and maximum temperatures is less than 14 $^0$F (8 $^0$C).

The weather and climate of FSM are discussed further in Chapter 3.

## *Demographics*

The population of FSM reached 102,843 at the last census taken in 2010 (FSM, 2012). This was a decline of 4,344 persons relative to the 2000 census total of 107,008. While declining fertility has contributed to the population decrease, out-migration to the USA and other parts of Micronesia is the primary cause of the negative growth. Long-range population projections suggest that little population growth can be expected in FSM for the foreseeable future. Projections to 2030 suggest virtually no population growth from 2010 onwards and less than 10% total growth up to 2050 (UNFPA, no date).

The median age of the population varies slightly; Yap 25, Chuuk, Pohnpei 22, and Kosrae 22 years. Demographically FSM is one of the youngest countries in the Pacific region, with the age group between 0-24 years constituting over 56% of the total population (FSM Division of Statistics, 2012).

The increased urbanisation in FSM, from 21.8% in 2000 to 22.3% in 2010 (FSM Division of Statistics, 2012) is largely a result of migration from the outer islands to the main population centre in each State.

The percentage of urban population in 2010 varies from 7.4% in Yap to 32.6% in Kosrae, with Pohnpei at 16.8% and Chuuk at 28.5% (FSM Division of Statistics, 2012).

## *Education and Employment*

As Trustee, the USA placed an early emphasis on basic education for FSM children. The United States Peace Corps provided an early cadre of teachers, which has been augmented increasingly in recent years by qualified Micronesians.

In 2002, FSM had 218 public schools and 25 private schools. Private educational facilities, such as the Xavier High School in Chuuk, are important elements of the overall education capacity. Almost all current Government leaders in the FSM are graduates of colleges in the USA. The College of Micronesia in Pohnpei has opened a new campus constructed with assistance from USA. It is the beneficiary of Land Grant status through the United States Department of Agriculture (USDA).

The elementary, junior high, and senior high school enrollment increased from 32,227 in 1998 to 33,886 in 2002. College enrollment in the FSM also increased by nearly 2,000 students from 1998–2003.

There are a total of nine languages spoken in the FSM, but every student learns English, the official language of the FSM. All children are required by FSM law to attend school through to the eighth grade, and many go on to college after graduating from high school. Pell grants and other USA education programs support many FSM college students to attend the College of Micronesia, the University of Guam, and other USA colleges.

In the 15-24 age group, literacy was already over 90% in 1980, and increased steadily to reach 95.7% in 2010 (FSM Division of Statistics, 2012). Education in FSM is compulsory up to age 14, including for children with special needs, but secondary schooling is not. Department of Education statistics indicate that the net primary school enrolment rate reached 96% in the 2008-09 school year, indicating that universal primary education was close to being achieved. Thus, the vast majority of the population in FSM achieves a basic level of education.

However, the quality of education is subject to question. For example, over 60% of eigth grade students failed to achieve competency in a comprehensive test conducted in the 2008-09 school year. The poor quality of learning and educational achievement is attributed to inadequate resourcing and a lack of qualified teachers (35% of teachers lack appropriate credentials (FSM, 2010). The lack of qualified teachers could explain the sharp drop in school enrolment after primary school, with secondary enrolment dropping to only 69% at the National level, although remaining quite high (83%) in Yap. Educational expenditure varies considerably across the States; Kosrae spends four times as much per capita as Chuuk, a disparity that is reflected in Kosrae's higher youth literacy rates.

Early childhood education has not been incorporated into the formal education system and Government has yet to formulate a related policy. Current early childhood education programs are operated with the support of a USA Federal grant. More vulnerable and disadvantaged children do not have preferred access to such education.

The quality of the FSM labor force, as measured by educational attainment, has not improved markedly between the last two censuses. Although the proportion of the population aged 25 and over with no education declined from 23% to 8% between 1999 and 2010, the proportion completing only elementary school has remained approximately constant, at around 30%. There has been an increase in the proportion of the 25 and over population completing a high school education (now 36%). Both the number and proportion of the 25 and over population with a Bachelor's degree has risen to 12%.

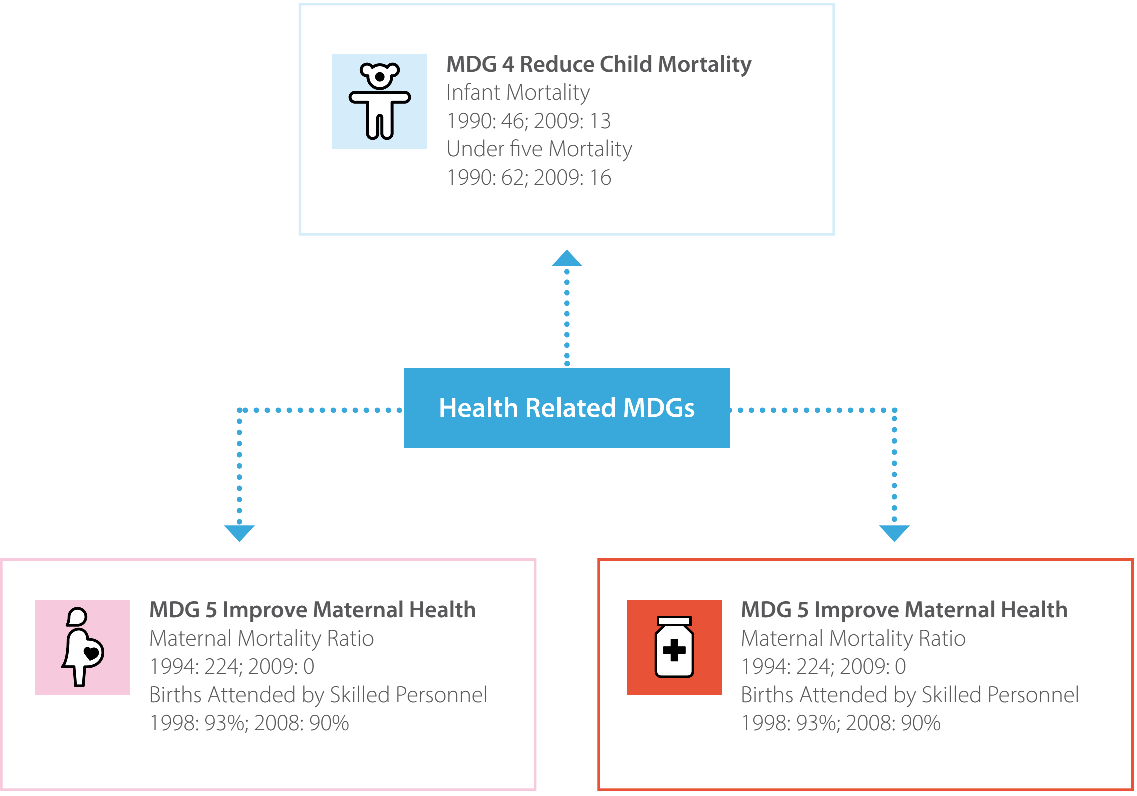
Unemployment as measured by the 1994 and 2010 censuses has increased in absolute numbers (from 4,216 to 6,130), but as a percentage of the labor force the level is unchanged at 16%. FSM needs to prepare and implement a post-secondary strategy to develop the skills needed to increase employment and support the economic development of the country. Some programs are being introduced by the College of Micronesia and linking with employment increases in Guam.

Further information on education and related topics is provided in Section 7.4.

## *Health*

Figure 3 shows the health indicators for relevant Millennium Development Goals (MDGs). Tuberculosis rates are high in FSM, and appear to be increasing still further, while non-communicable diseases (NCDs) are at epidemic levels. Eight out of every ten reported deaths are caused by a NCD (cancer, heart, disease, stroke, hypertension, or diabetes). A 2002 survey of the prevalence of disease and risk factors for Pohnpei found that 57% of adults (60% of men and 53% of women) had three or more risk factors for NCDs. The prevalence rate for hypertension is 21% and for diabetes is 32% (FSM, 2010).

**FIGURE 3** | Health indicators for relevant MDGs. Infant and under five mortality rates are per 1,000 live births, with 1990 rates from the census and 2009 rates from civil registration. The maternal mortality ratio is maternal deaths per 100,000 live births. Incidence of Tuberculosis is cases/rate per 100,000
*(Source: FSM, 2010)*




During the 11-year period from1999 to 2009 there were 42 maternal deaths, with the annual number ranging from zero (2008 and 2009) to 13 (2004). While Pohnpei and Chuuk reported moderate maternal mortality ratios, the rates in Kosrae and Yap were extremely high. The infant mortality rate has declined from 19.5 per 1000 live births in 1990 to 13 in 2009 (FSM, 2010).

Contraceptive prevalence has declined from 450 users per 1,000 women in 1990 to 400 users in 2009. Total fertility rates continue to drop steadily. Teen fertility rates have also declined, from 55.8 to 42.5 births per 1,000 women 15-19 years of age. Most births are preceded by at least one antenatal visit. Ninety percent of births take place in a health facility and 88% are attended by skilled health personnel. With 37 cases reported since the beginning of the HIV-AIDS epidemic in 1989, FSM has a low prevalence of HIV/AIDS. As of December 2009 the current prevalence rate (patients still living) was 8.3 cases per 100,000. Second generation surveys conducted in Pohnpei, Yap and Chuuk suggest that a significant number of people continue to place themselves at risk through unprotected sex with multiple partners (FSM, 2010).

## ***Employment***

Out of some 31,789 employed persons in 2000, 15,000 persons (52%) were engaged in farming and fishing, of whom over 10,000 (70%) were involved in 'subsistence' (household consumption only) activities, not selling or intending to sell any of their produce. Almost 5,000 (30%) were classified as 'market-oriented' farmers and fishermen. These numbers illustrate the importance of the subsistence sector in the FSM and the need to include subsistence workers in the labor force definition to reflect their contribution to domestic production in the country.

## ***Sanitation***

To date only limited areas in FSM have been provided with sewerage systems – five sewerage systems, serving Kolonia town in Pohnpei, Weno Island in Chuuk, Colonia town in Yap, Lelu town in Kosrae and the Tofol administrative area in Kosrae. The sewerage system in Weno Island, Chuuk State is non-functional and raw sewage is discharged into the Weno lagoon through a 2,000-foot (610 meter) long marine outfall. The dumping of solid waste, and human excreta in particular, is considered one of the FSM's foremost environmental health problems.

As a result of there being limited sewerage infrastructure a large number of households (43.5% for FSM as a whole) still have pit latrines or other unhygienic excreta disposal systems. While there has been a steady increase in improved sanitation facilities in urban areas across FSM, the rural areas have experienced a steady decline since 1990, with the proportion of improved sanitation facilities now well below 20% (Johnston, 2012).

Nearly 90% of households have access to improved water sources such as from a public water supply, community water supply, household tank and protected well. The rate varies from 82% in Chuuk to 98% in Yap (FSM Division of Statistics, 2012). Around 40% of people do not have access to electricity (ITP, 2010).

## ***Cultural***

FSM's States are unique and diverse in terms of both culture and language. Prior to western contact, the development of unique traditions, customs and languages within each of the four main island groups occurred as a result of isolation and hence lack of frequent interaction. Traditional, social and cultural institutions are still very strong in Micronesia, with traditional chiefs having strong control in all States other than Kosrae. Cultural groups are subdivided into tribes, clans and sub-clans, with their own diverse practices contributing to FSM's rich traditions and values. There is a significant relationship between these diverse cultural values and preservation of the country's natural resources and environment (Namakin, 2008).

While on the main islands of each State there are modern developing communities, on the atoll islets there are low-technology, traditional communities dependent on fishing, agro-forestry, groundwater, and rainfall. Both community types are vulnerable to climate-related changes in precipitation, sea level, storms and coastal erosion. Today there are 16 languages spoken in FSM. Because languages vary in each State, English has become the official language used by Government and in schools.

Micronesian society is based on the extended family, which is responsible for the family welfare, especially in relation to customary family land. All States have matrilineal clan systems in which lineage is passed on through the mother's line. However, Yap Island (i.e. not including the outlying atolls of Yap) is a more patrilineal society within a more structured caste system.

Traditional, social and cultural institutions are still very strong in Micronesia. For example, customary authority in Pohnpei resides with the island's traditional title holders, whose roles and responsibilities are allocated and organized within complex hierarchical systems that operate in each kouspaw and wehi. While the nahmwarki (paramount chief) is the symbolic owner of all land within a wehi, the kousapw is the centre of social organisation and culture. Traditional titles, while earmarked for men of particular matriarchal lineages, are earned through community service, displays of traditional skills and accumulation of traditional knowledge. Title holders were accountable to their constituents and titles could be revoked if the holders failed to perform their duties adequately. Historically, specific title holders were responsible for management of natural resources (Johnston, 2012).

Ownership of land and aquatic areas varies between States (Table 5). In Kosrae and Pohnpei, land is both State and privately owned, while aquatic areas are managed by the State as public trusts. In Chuuk, most land and aquatic areas are privately owned and acquired through inheritance, gift or, more recently, by purchase. In Yap almost all land and aquatic areas are owned or managed by individual private estates and usage is subject to traditional control. In all States, land cannot be sold to non-citizens of FSM. All waters located within 22.2 km of land are under the jurisdiction of the respective State Governments.

**TABLE 5 | Land Tenure by State and for FSM** (Percent of Total Land Area)

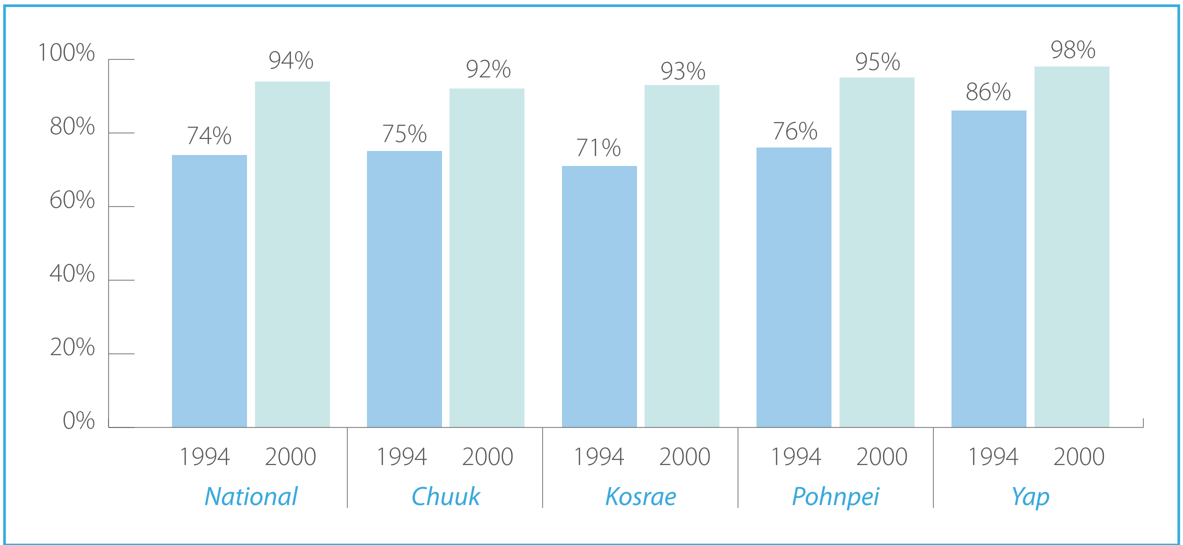
*(Source: Adapted from Perrin, 1996)*

| | Yap | Chuuk | Pohnpei | Kosrae | FSM |
|---|---|---|---|---|---|
| **Private Land** | 98.3 | 99.2 | 66.8 | 31.2 | 72.5 |
| **Public Land** | 1.7 | 0.8 | 33.2 | 68.8 | 27.5 |

The land and aquatic ownership patterns greatly influence the strategies and actions required to sustainably manage FSM's resources. It is widely accepted that every Micronesian has some land or sea use rights, even if he/she may not have ownership rights (Figure 4). However, given the growing population density observed in FSM, landlessness will become more of a problem in the future. In Pohnpei, squatting is already a major problem. Access to land is compounded by a low employment rate as well as low food production (Susumu and Kostka, 2011).

**FIGURE 4 | Percent of households with security of tenure**

*(Source: FSM, 2010)*




## *Economy*

FSM's environment and natural resources are considered to be the nation's living wealth. Maintaining the habitats and ecosystems that nurture these is vital for improving the quality of life of its people and sustaining the country's rich traditions. However, except for the offshore fisheries, there are limited financially exploitable resources in the FSM. Agricultural production is relatively small, but is still the primary resource traded domestically. There is a small export market, mainly to the neighboring island groups of the local demand products of sakau (kava), betelnut and citrus (ADB, 2005). As a result, most of FSM's revenue comes from Compact funding (Figure 5). Other sources of revenue include taxes, foreign aid and grants, and fishing fees.

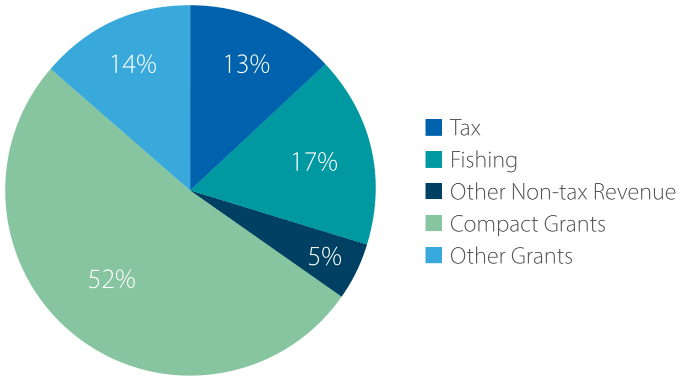



**FIGURE 5 | Sources of National revenue in 2010**

*(Source: U.S. Graduate School Pacific Islands Training Initiative, 2011)*

Financially, FSM has become very dependent on its links with the USA. The Compact results in the USA transferring financial assistance to support the Government's operations in the FSM. The economic assistance package, signed in 1986, covered the FSM for 15 years into its independence. Instead of cutting all funding in 2001, the USA and FSM reached agreement on a second compact package (Compact of Free Association II) that came into effect in June, 2004.

The Compact continues direct USA financial assistance to the FSM, but in place of budgetary support, funding is earmarked for six priority sectors: health, education, environment, private sector development, public sector development, and infrastructure development, with priority given to health and education. The value of assistance decreases most years, with the amount of the decrement deposited in a trust fund account that will help sustain Government operations at the end of the Compact in 2023. At that time the permanent interest-bearing trust fund aims to provide the same level of income that was available for the duration of the second Compact.

The absence of any sizeable traded goods production indicates the magnitude of the challenges facing the FSM in its strive to become more self-reliant. The remoteness of the islands and their relatively small markets, limited private sector development, and vulnerability to natural and economic external shocks all contribute to relatively poor economic performance. With 32% of the population, and the benefits of being the National capital, Pohnpei State is the largest contributor to the economy (Figure 6).

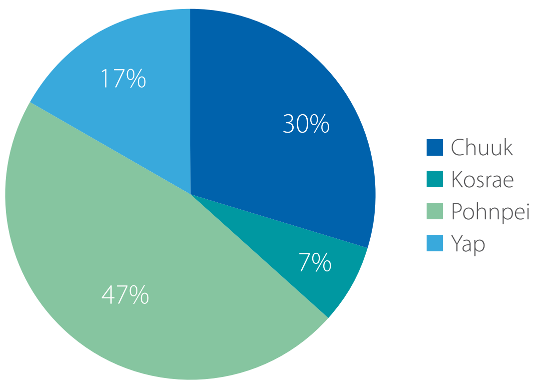



**FIGURE 6 | Portion of FSM real GDP by State (FY 2010), inclusive of National Government for Pohnpei State**

*(Source: U.S. Graduate School Pacific Islands Training Initiative, 2011)*

Economic growth, as measured by the real gross domestic product (GDP) (an inflation-adjusted measure that reflects the value of all goods and services produced in a given year, expressed in base-year prices), has been negative or very low over recent years (Figure 7), and has also experienced high volatility over years as well as between States. The economy is dominated by: (i) a large public sector along with a dependent private sector that provides non-traded goods and services to Government and its employees; and (ii) a significant subsistence production for home consumption (Figure 8). Economic activity is largely driven by the rate of disbursement of Compact funds. The Government contribution to GDP has declined significantly, by 11.8%, since the beginning of the first Compact (FSM, 2011). Compact funding for the infrastructure sector has increased from US$17.1 million in 2004 to US$24.2 million in 2010 (U.S. Graduate School, 2011).

**FIGURE 7 | The institutional structure of the FSM economy (%)**

*(Source: U.S. Graduate School Pacific Islands Training Initiative, 2011)*

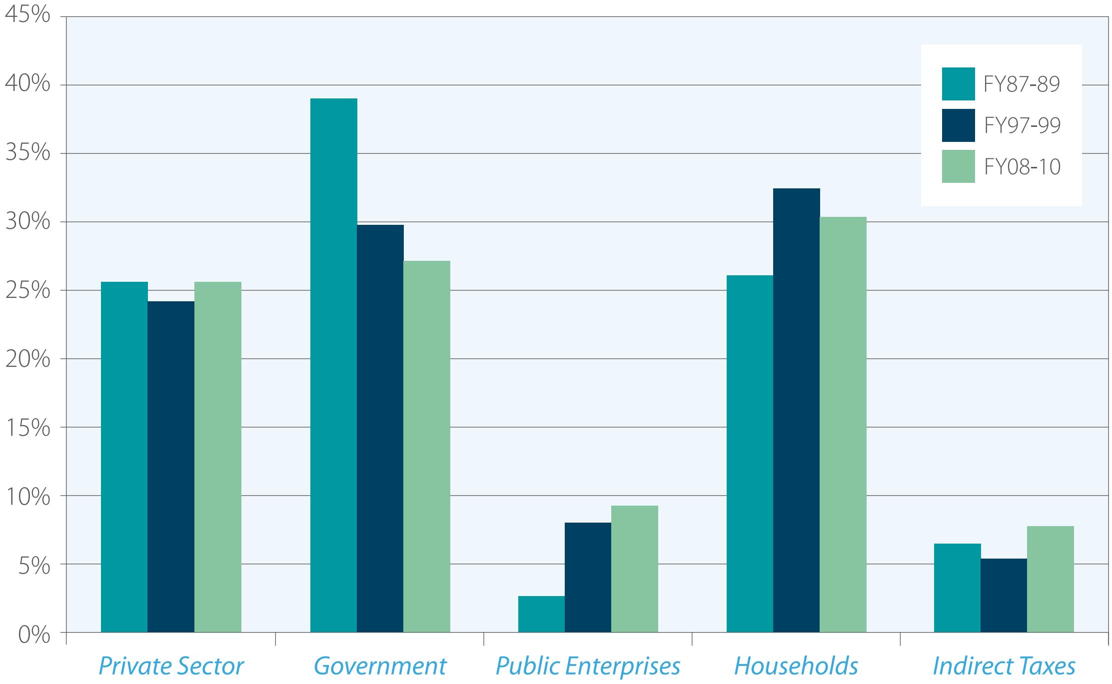
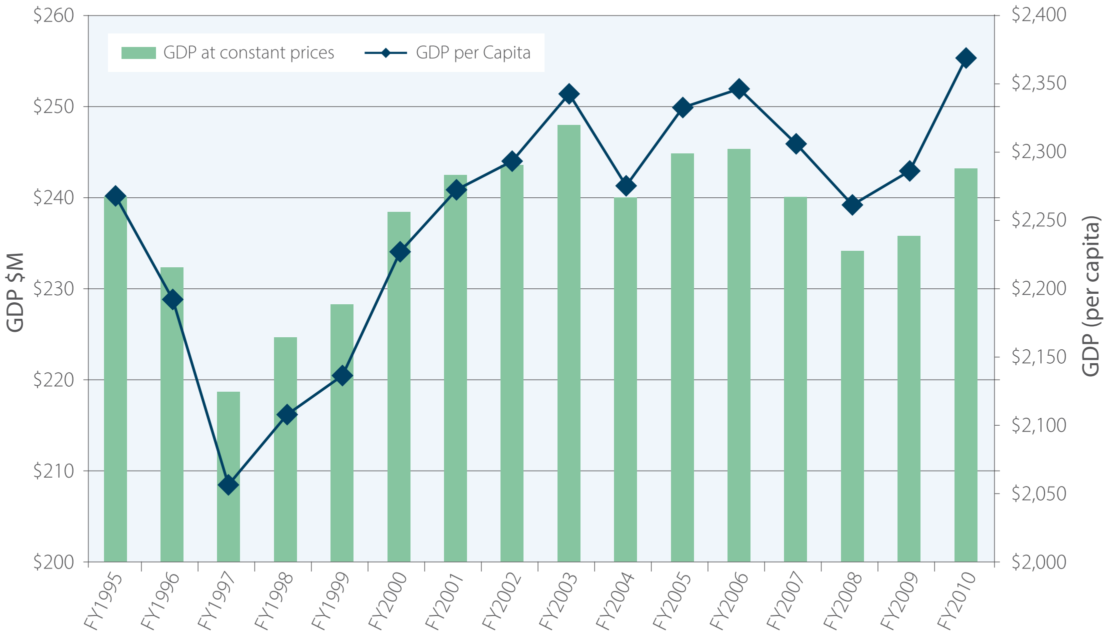



**FIGURE 8 | Real GDP and real GDP per capita**

*(Source, U.S. Graduate School Pacific Islands Training Initiative, 2011)*




The commercial sector is dominated by small business operations, with a few large public companies. Most of the small businesses are family-based focused on the wholesale and retail sectors or small service enterprises like restaurants, taxis and car maintenance. The industrial sector is under developed, with a heavy reliance on imported products.

The reduction in resources since the first Compact, capacity constraints in fulfilling the new fiscal procedure – especially with respect to infrastructure grant implementation – and the need to transition from the use of the capacity-building sector grant for general Government operations, have generated a harsh economic climate. Real per-capita incomes have risen only slightly, from US$2,343 to US$2,368. This represents an improvement of just 1.1%. The fall in economic activity has been accompanied by a reduction in employment – by 370 jobs, or 2.2% of those employed. As incomes have fallen, the economy has failed to provide productive opportunities for the population. As a result outward migration has averaged 1.9% per annum, and the population has declined by 0.4% per annum (FSM, 2011). Even in Pohnpei, where real incomes were stagnant but job opportunities improved, outmigration was strong.

Figure 9 shows the current structure of the FSM economy, as well as changes over time. Most noteworthy is the very small role currently played by the traded goods sectors - commercial agriculture (1%), fisheries (2%), and tourism (2%). In-country agricultural activities provide over 60% of the food consumed, and employ almost 50% of the labor force on a full-time or seasonal basis. While FSM's climate is well suited for year-round agriculture, farmland is in short supply because of the mountainous terrain on FSM's larger islands. In addition, tenure systems generally limit large-scale commercial farming for export. Farmstead livestock production is important throughout the FSM, particularly for subsistence and cultural use.

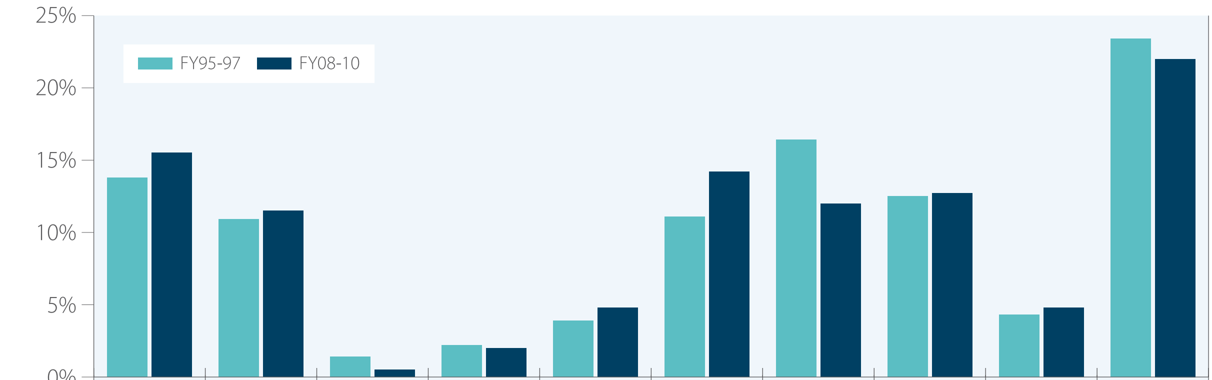
The share of agriculture has grown by 2.3% since the mid 1990s, largely reflecting an increase in household subsistence production. Similarly, the fisheries sector has increased its share of GDP, reflecting the mid-90s financial consolidation and the move to private sector management. The local fishery industry's average annual catches are worth around US$50 million (Table 6). FSM also issues licenses to foreign fishing interests. These licensed foreign fishing vessels consist of mainly purse-seine and long-line tuna boats and earn around US$150 million per annum from fishing in FSM waters.

The share of the manufacturing sector has fallen by 1.1%, largely reflecting the closure of garment factories in Yap. The share of tourism has also fallen, albeit marginally. The early 2000's saw tourist numbers to FSM grow by 10%. But the contribution to GDP has declined by an annual average of 2.1% since 1995, and 3.9% during the second Compact. While tourism infrastructure within FSM is limited, there is considerable potential for boutique-style tourism to cater for the scuba diving, surfing and sailing communities.

The ocean is arguably the FSM's most significant resource. Living marine resources are of great importance since they are a major source of subsistence, recreation, and commerce. The Micronesian culture is heavily influenced by the marine environment and resources.  FSM's EEZ covers the world's major equatorial tuna migratory paths. This makes offshore tuna a primary fishery resource. Inshore reef resources are largely consumed locally and are an essential source of nutrition in the traditional Micronesian diet.

## FIGURE 9 | Sectoral contributions to the FSM economy

*Source: U.S. Graduate School Pacific Islands Training Initiative, 2011*




| | Agriculture | Fisheries | Manufacturing | Tourism | Construction | Distribution | Government | Education | Health | Other Services |
|---|---|---|---|---|---|---|---|---|---|---|
| FY95-97 | 13.8% | 10.9% | 1.4% | 2.2% | 3.9% | 11.1% | 16.4% | 12.5% | 4.3% | 23.4% |
| FY08-10 | 15.5% | 11.5% | 0.5% | 2.0% | 4.8% | 14.2% | 12.0% | 12.7% | 4.8% | 22.0% |

### TABLE 6 | Annual Average Catch Amount and Value (2004-2008) for Oceanic and Coastal Fisheries in FSM

*(Source: Bell et al., 2011)*

| Fisheries Types | | Catch (Tonnes) | US$ Value (millions) |
|---|---|---|---|
| Ocean Fisheries | Tuna-Purse Seine | 19,554 | 23.1 |
| | Tuna-Long Line | 938 | 4.9 |
| | Other Oceanic Fish | 136 | 0.1 |
| | **Total** | **20,618** | **28.1** |
| Coastal Fisheries | Dermersal Fish | 6,290 | 11.7 |
| | Nearshore Pelagic Fish | 3,560 | 6.1 |
| | Invertebrates | 2,750 | 5.5 |
| | **Total** | **12,600** | **23.3** |

Thus agriculture, fisheries and tourism are recognized as providing the long-run growth potential and comparative advantage of the FSM, with the fisheries and tourism sectors likely to offer the most potential for near- term income generation. Agriculture has some potential, particularly for intra-FSM trade, but the small land area limits large-scale farming for export. All three sectors are highly dependent on the continued vitality and quality of the environment and natural resources (ADB, 2005).

As noted above, the informal sector plays an important and often unacknowledged role in the FSM economy. The majority of the FSM population lives in rural areas, including the outer islands, and engages in subsistence and mixed subsistence production for their livelihood. A household and economic survey conducted in 2005 revealed that, nationwide, around 18% of FSM household income is generated from subsistence activities, but this varies across the four States. Yap (29.7%) and Chuuk (26.3%) rely more heavily on subsistence than Kosrae (8.5%) and Pohnpei (8.4%) (FSM Division of Statistics, 2007). The same survey showed that some 40% of FSM total household expenditure was on food and that 46% of this food was home produced, with around 22.4% of this being farm products (Table 7).

### TABLE 7 | Distribution of Total Food Expenditure by Transaction Type and State in 2005

(Values in percent, except where stated)

*(Source: adapted from FSM Division of Statistics, 2007)*

| Transaction type | Total | Yap | Chuuk | Pohnpei | Kosrae |
|---|---|---|---|---|---|
| Food (in millions) | $83.1 | $15.3 | $37.8 | $24.6 | 5.4 |
| Percent | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Purchased | 53.9 | 39.5 | 46.7 | 69 | 75.8 |
| Cereal & Bakery Products | 17.1 | 9.9 | 16.3 | 21.9 | 20.8 |
| Meat & Poultry | 11.1 | 905 | 8.5 | 14.1 | 19.5 |
| Fish & Seafood | 8.7 | 4.8 | 9.1 | 10.5 | 9.6 |
| Fruits, Vegetables & tubers | 2.1 | 1.8 | 1.6 | 2.8 | 3.8 |
| Dairy & Eggs Produced | 2.4 | 1.9 | 1.3 | 3.7 | 5.1 |
| Non-alcoholic beverages | 4.8 | 5.6 | 4.1 | 5.2 | 5.9 |
| Miscellaneous Food | 5.8 | 4.7 | 4.6 | 7.4 | 10.2 |
| Meals away from Home | 1.9 | 1.5 | 1.2 | 3.1 | 1 |

| Transaction type | Total | Yap | Chuuk | Pohnpei | Kosrae |
|---|---|---|---|---|---|
| Home Produced | 46.1 | 60.5 | 53.3 | 31 | 24.2 |
| Cereal & Bakery Products | 0.1 | 0.1 | 0.1 | 0.1 | 0.5 |
| Meat & Poultry | 3.8 | 3.3 | 2.6 | 6.1 | 2.8 |
| Fish & Seafood | 18.9 | 24 | 22.6 | 11.8 | 10.8 |
| Fruits, Vegetables & Tubers | 18.5 | 27.2 | 20.1 | 12.5 | 9.7 |
| Dairy & Eggs Produced | 0.1 | 0.1 | 0 | 0.2 | 0.3 |
| Non-alcoholic beverages | 1 | 5.5 | 0.1 | 0 | - |
| Miscellaneous Food | 3.6 | 0.2 | 7.7 | 0.2 | 0.1 |

An increasing shift back to subsistence farming in some States reflects the rise in global food prices and the loss of employment in FSM's public sector. The agriculture sector continues to employ a significant number of people in self-sufficiency endeavors and small commercial activities (Table 8).

A growing concern is that local foods are more expensive than imported food. This is contributing to a diet shift in FSM. Local foods are not only expensive, but Micronesians have also come to prefer the convenience of imported processed food because of the taste, ease of cooking and its availability in shops. However, because of the low income and high number of members of a household, families are forced to purchase processed foods that are cheap, but of low quality. This is placing a huge burden on the health of Micronesians.

**Table 8 | Percent of Households Engaging in Home Production Activities**
*(Source: FSM Division of Statistics, 2012)*

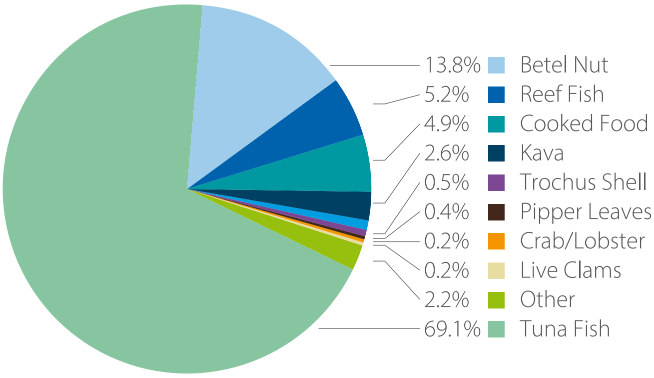
| | Activity | Percent of Households |
|---|---|---|
| **Agricultural** | | **94.6** |
| | Home Use Only | 84.7 |
| | Selling Only | 1.1 |
| | Home Use and Selling | 8.8 |
| **Livestock Raising** | | **81.8** |
| | Home Use Only | 65.3 |
| | Selling Only | 1.4 |
| | Home Use and Selling | 10.9 |
| | Pet | 4.3 |
| **Fishing** | | **70.7** |
| | Home Use Only | 59.2 |
| | Selling Only | 1.1 |
| | Home Use and Selling | 10.4 |

Formerly copra was a ubiquitous cash crop throughout the FSM, but production has now ceased almost completely due to inefficiency and volatile prices for copra, coupled with increasing senility of the coconut palms and transportation issues. The Government-run Coconut Development Authority still processes relatively small amounts of copra into virgin oil and other edible products. Rehabilitation of the coconuts industry is considered a priority, including replanting to replace predominantly senile palms.

In 2010 FSM's exports represented about 12% of GDP. Fisheries and agriculture products dominated the small export volumes (Figure 10). In 2010 FSM's imports were valued at US$ 297.5 million (approximately 57% of GDP). Prepared foodstuffs and beverages, and mineral products, dominated the imports (Figure 11).

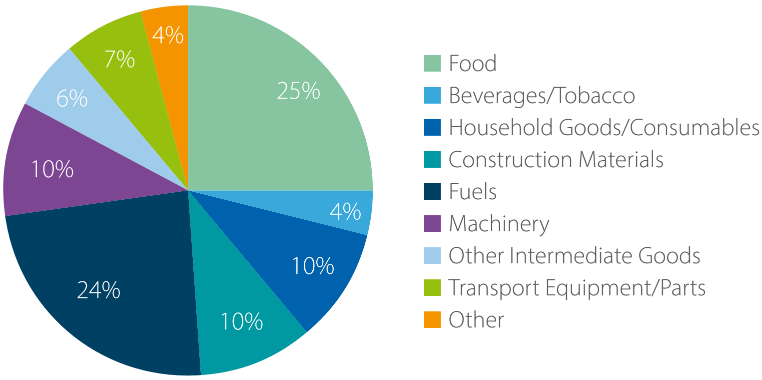
## FIGURE 10 | Percentage share of major exports in 2007

*Source: FSM Department of Resources and Development, 2011*




## FIGURE 11 | Percentage share of major imports in 2010

*Source: U.S. Graduate School Pacific Islands Training Initiative, 2011*




The trade account of the balance of payments runs a significant deficit reflecting the excess of imports over exports. Fuel imports have increased from US$15.7 million in 2000 to US$40.9 million in 2010 (U.S. Graduate School, 2011).

Total food imports have shown a steep increase from around US$17 million in 2000 to US$43.1 million in 2010. Convenience starch foods, including rice, ramen, noodles, flour and bread are the major food items being imported. This group of imports has shown a steep rise over the last 10 years, reflecting a change in diets away from traditional staples. The soaring global prices for food and oil mean the costs of imports will continue to rise. Food expenditures now dominate household expenditures, particularly for poorer families, with up to half of total household expenditures on food. Nationally, around 70% of households have income below US$15,000. These households incur annual dis-savings, resulting in increased hardship (FSM Department of Resources and Development, 2011).

## CHAPTER THREE

# ASSESSING AND MANAGING FSM'S CLIMATE RISKS

3

## 3.1 INTRODUCTION

In the past 10 years or so, since submission of FSM's Initial National Communication to the UNFCCC, considerable progress has been made in documenting the climate-related risks faced by the nation. Substantial advances have also been made in developing relevant policies and plans and establishing and strengthening National and State institutions with mandates for managing climate and related risks, including disaster risk management.

## 3.2 OBSERVED CLIMATE, INCLUDING VARIABILITY, EXTREMES AND TRENDS

There are 23 operational observation meteorological stations in FSM (Australian Bureau of Meteorology and CSIRO, 2011). Multiple observations within a 24-hour period are taken at five stations in Chuuk State, five in Pohnpei State, one in Kosrae State and three in Yap State. In addition, there are two single-observation-a-day climate stations in Pohnpei and seven single-observation-a-day rainfall stations in Yap. Rainfall data for Pohnpei are available from 1949 and for Yap from 1951. Air temperature data are available from 1950 for Pohnpei and 1951 for Yap. The records are homogeneous and more than 95% complete.

There are several sea-level data sets relevant for FSM, including Guam (1948–present), Yap (1969–2005), Chuuk (Moen Island, 1947–1995), Kapingamarangi (1978– 2008), Pohnpei-B (1974–2004) and Pohnpei-C (2002–present). A global positioning system instrument to estimate vertical land motion was deployed at Pohnpei in 2003.

A recently concluded study has resulted in greater understanding of FSM's past and current climate, as well as providing projections for the future climate (Australian Bureau of Meteorology and CSIRO, 2011; Federated States of Micronesia National Weather Service Office, et al., 2011). It is a result of a collaborative effort between the National Weather Service Offices of FSM and the Pacific Climate Change Science Program, a component of the Australian Government's International Climate Change Adaptation Initiative. The findings build on the 2007 IPCC Fourth Assessment Report (IPCC, 2007).

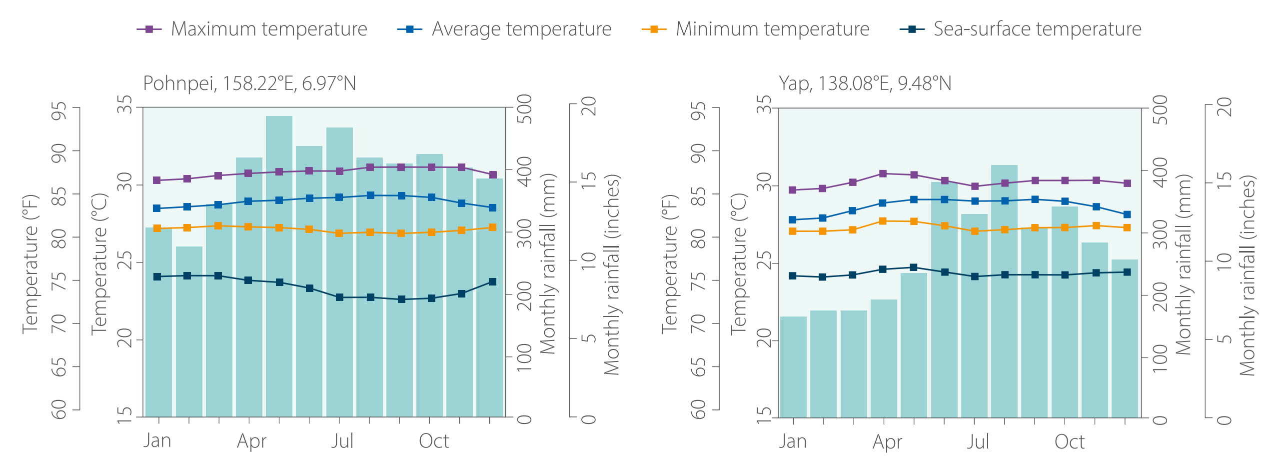
### ***Temperature***

Figure 12 shows monthly average maximum air temperature, mean air temperature, minimum air temperature, sea-surface temperature and average monthly rainfall for Pohnpei and Yap. Sea-surface temperatures around FSM influence the seasonal variations in air temperature, such that there is little seasonal variation in monthly mean maximum and minimum air temperatures, with less than 3$^{o}$F (1.5$^{o}$C) between the average hottest and coolest months.

Sea surface temperatures also influence the trends in air temperature. Historical changes in sea surface temperatures around FSM are consistent with the broad-scale sea-surface temperature trends for the wider Pacific region (Australian Bureau of Meteorology and CSIRO, 2011). Warming was relatively weak from the 1950s to the late 1980s. This was followed by a period of more rapid warming (approximately 0.20ºF (0.11°C) per decade and approximately 0.14ºF (0.08°C) per decade from 1970 to 2009, in the eastern and western regions respectively). At these regional scales, natural variability plays a large role in determining the sea surface temperature, making it difficult to identify long-term trends.

**FIGURE 12 | Mean annual rainfall (grey bars) and daily maximum, minimum and mean air temperatures at Pohnpei (left) and Yap (right), and local sea-surface temperatures**

*Source: Australian Bureau of Meteorology and CSIRO, 2011*



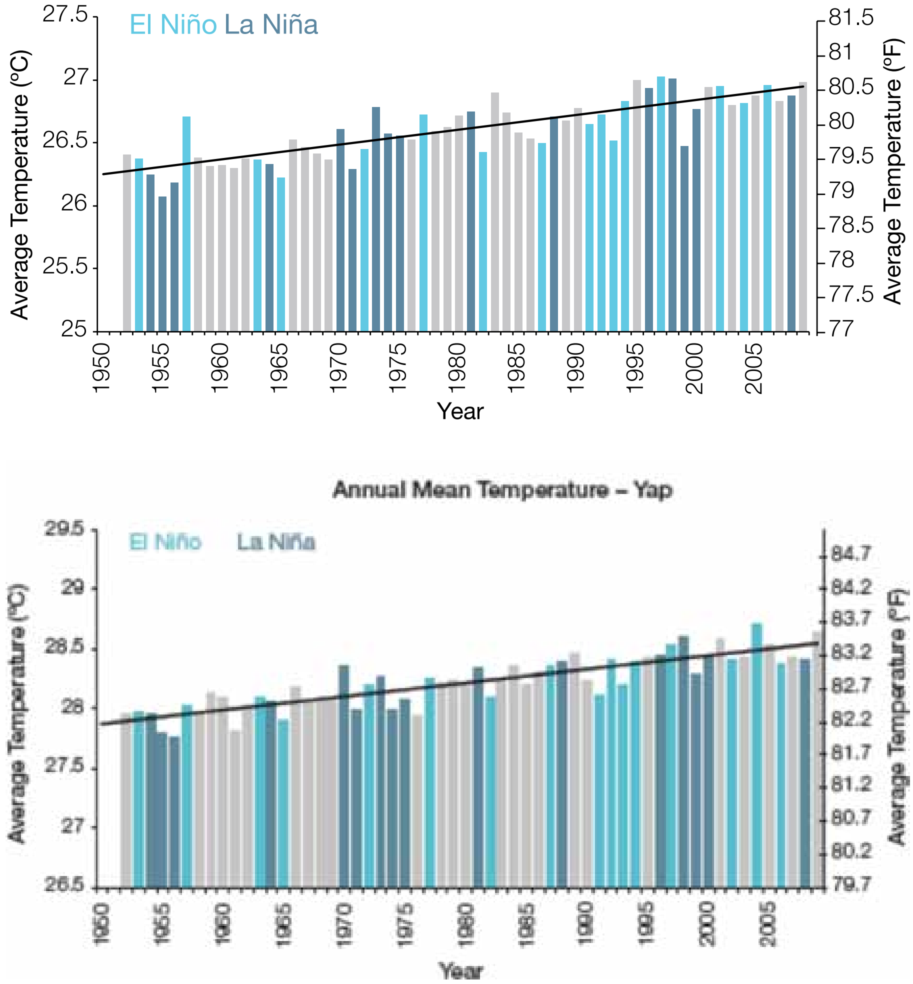

Trends for seasonal and annual mean air temperatures at both Pohnpei (1950–2009) and Yap (1951–2009) are positive (Figure 13). The strongest trend occurs for Pohnpei in the wet season (May-October), with a mean air temperature change of (+0.43°F (0.24°C) per decade). For Pohnpei, annual and seasonal trends in minimum air temperature are greater than those observed in maximum air temperature. However, for Yap, the trends in maximum air temperature for the annual and dry season (November-April) are much greater than those observed for the minimum air temperatures (Australian Bureau of Meteorology and CSIRO, 2011).

Trends in annual maximum air temperatures for Pohnpei, Yap and Chuuk are shown in Figure 14. All three locations have experienced increases of the annual maximum air temperatures of between 0.18 and 0.25°F (0.10 and 0.14°C) per decade.

The return periods for extreme high temperatures have been estimated for Pohnpei. These are based on observed data and projections of future return periods using the output of global climate models, for given emission scenarios and model sensitivity (Hay and Takesy, 2005) (Table 9).

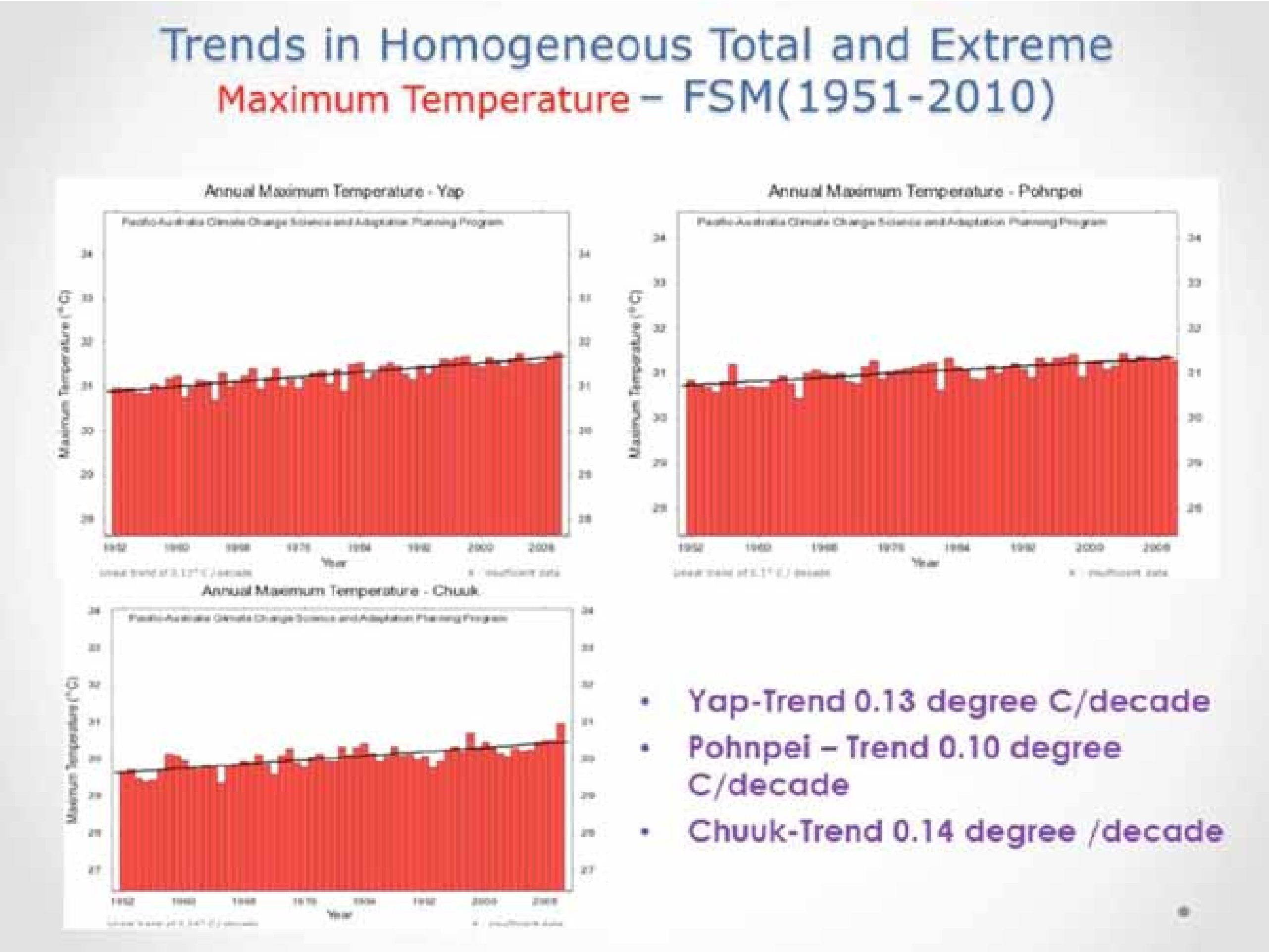
**FIGURE 13 | Annual mean air temperature in Pohnpei (top) and Yap (bottom). Light blue, dark blue and grey bars denote El Niño, La Niña and neutral years, respectively**

*Source: Australian Bureau of Meteorology and CSIRO, 2011*



## FIGURE 14 | Trends in annual maximum air temperatures for Yap, Pohnpei and Chuuk

*Source: National Weather Service, Pohnpei*




## TABLE 9 | Return Periods (yr) for Daily Maximum Temperature, Pohnpei

*(Source: Hay and Takesy, 2005)*

| Maximum Temperature (C) | Observed (1953-2001) | Projected | | |
|---|---|---|---|---|
| | | 2025 | 2050 | 2100 |
| 32 | 1 | 1 | 1 | 1 |
| 33 | 1 | 1 | 1 | 1 |
| 34 | 4 | 2 | 2 | 1 |
| 35 | 24 | 11 | 6 | 2 |
| 36 | 197 | 80 | 39 | 10 |
| 37 | 2617 | 1103 | 507 | 101 |

## *Rainfall and Droughts*

On the large scale, there is an east-west zone of maximum annual rainfall from 4-8°N across Micronesia. The amounts drop off steadily as one progresses northward, where the dry season becomes more prolonged, due to the mid-Pacific subtropical high pressure area and its accompanying trade winds (Figure 15).

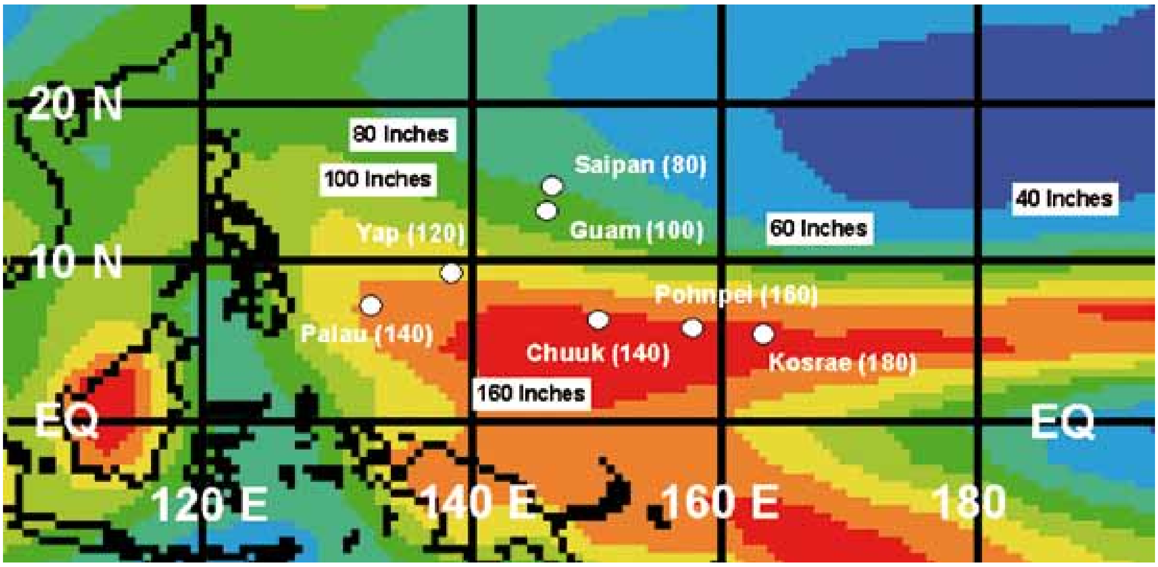
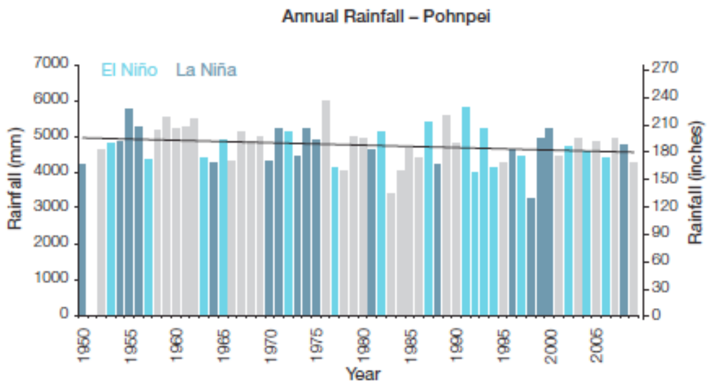
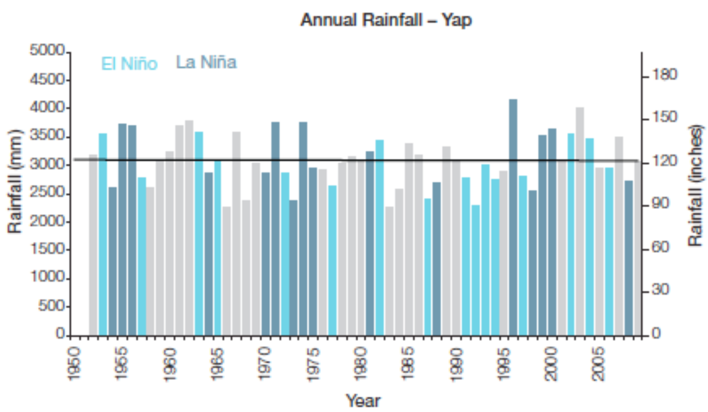



**Figure 15 | Mean annual over-water rainfall in Micronesia. Red = 160 inches per year, orange = 140, yellow = 120, light green = 100, dark green = 80, teal = 60, light blue = 40 inches of annual rainfall)**

*Source: Lander and Khosrowpanah, 2004*

The wet season occurs from May to September when the Intertropical Convergence Zone is strongest and furthest north. The West Pacific Monsoon affects rainfall in western FSM, bringing additional rain during the wet season (Australian Bureau of Meteorology and CSIRO, 2011).



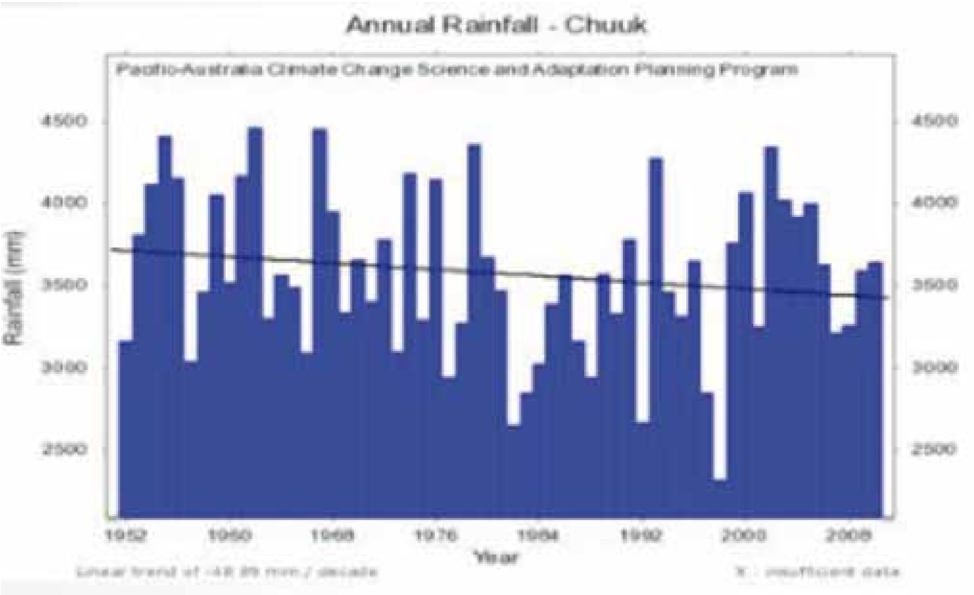

Annual and seasonal rainfall trends for Pohnpei for the period 1950–2009 and Yap for the period 1951–2009 (Figure 16) are not statistically significant (Australian Bureau of Meteorology and CSIRO, 2011). Trends in annual rainfall have also been calculated by the National Weather Service in Pohnpei. Values were -0.31in (7.9mm) per decade for Yap, -3.46in (88mm) per decade for Pohnpei and -1.93in (-48.9mm) per decade for Chuuk. The graph for Chuuk is shown in Figure 17.

**FIGURE 16 | Annual rainfall in Pohnpei (top) and Yap (bottom). Light blue, dark blue and grey bars denote El Niño, La Niña and neutral years respectively**

*Source: Australian Bureau of Meteorology and CSIRO, 2011*

**FIGURE 17 | Annual rainfall in Chuuk, showing the trend of -1.93in (-48.9mm) per decade**

*Source: National Weather Service, Pohnpei*




A chart of rainfall intensity-duration-frequency has been constructed for Pohnpei (Figure 18). For comparison, the rainfall intensity-duration-frequency values measured during Typhoon Pongsona on Guam (red dots connected by red dotted line) are shown. Also, the highest rainfall intensity-duration-frequency values measured over nine months by the WERI/CSP rain gauge network on Pohnpei have been plotted (green dots connected by green dotted line). The Pohnpei event was a fairly typical afternoon thunderstorm (Lander and Khosrowpanah, 2004).

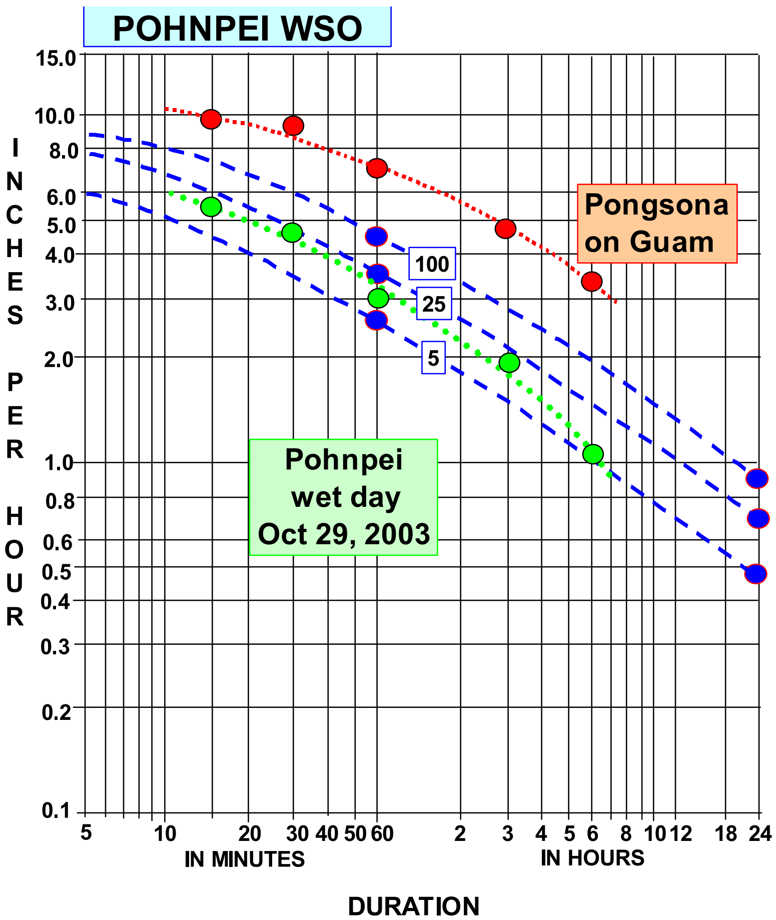



**FIGURE 18 | Intensity-duration-frequency chart of selected return periods at the Pohnpei Weather Service Office (blue dots connected by blue dashed lines)**

*Source: Lander and Khosrowpanah, 2004*

The return periods for extreme daily and hourly rainfall events have been estimated for Pohnpei and Kosrae. These are based on observed data and projections of future return periods using the output of global climate models, for given emission scenarios and model sensitivity (Hay and Takesy, 2005) (Table 10).

### TABLE 10 | Return Periods (yr) for Daily and Hourly Rainfall, Pohnpei and Kosrae

*(Source: Hay and Takesy, 2005)*

a) Daily Rainfall

| Rainfall (mm) | Observed Data | 2025 | 2050 | 2100 |
|---|---|---|---|---|
| **Pohnpei** | | | | |
| 100 | 1 | 1 | 1 | 1 |
| 150 | 2 | 1 | 1 | 1 |
| 200 | 5 | 2 | 1 | 1 |
| 250 | 10 | 5 | 2 | 1 |
| 300 | 21 | 9 | 4 | 2 |
| 350 | 40 | 17 | 8 | 2 |
| 400 | 71 | 28 | 13 | 3 |
| 450 | 118 | 45 | 20 | 5 |
| 500 | 188 | 68 | 30 | 7 |
| **Kosrae** | | | | |
| 100 | 1 | 1 | 1 | 1 |
| 150 | 3 | 2 | 1 | 1 |
| 200 | 6 | 4 | 2 | 2 |
| 250 | 16 | 9 | 5 | 2 |
| 300 | 38 | 21 | 12 | 4 |
| 350 | 83 | 50 | 31 | 9 |
| 400 | 174 | 119 | 83 | 22 |
| 450 | 344 | 278 | 237 | 64 |
| 500 | 652 | 632 | 410 | 230 |

b) Hourly Rainfall

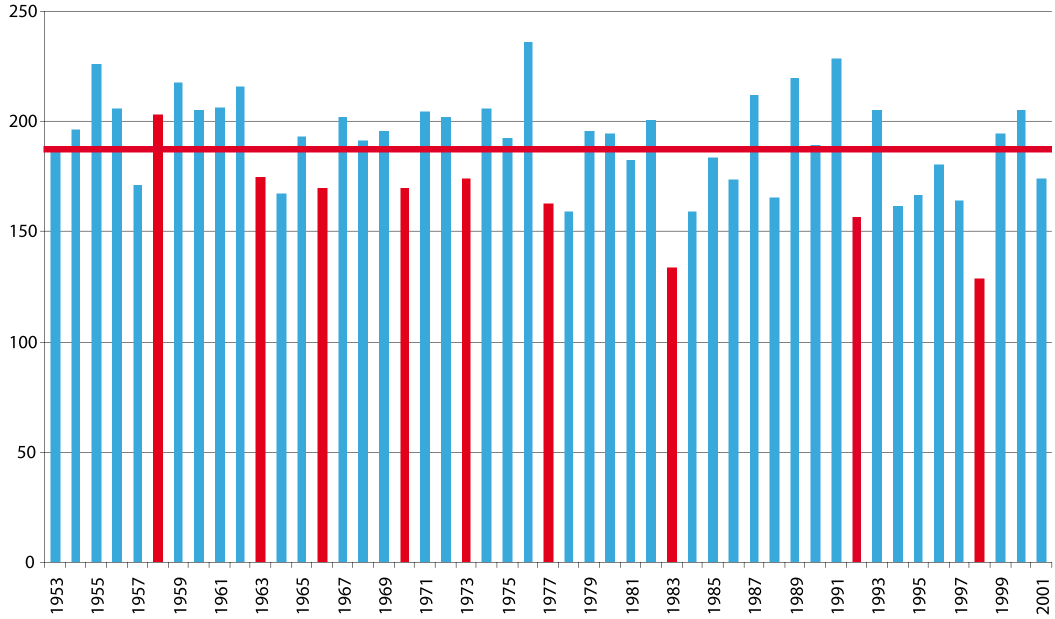
| Rainfall (mm) | Observed Data | 2025 | 2050 | 2100 |
|---|---|---|---|---|
| **Pohnpei** | | | | |
| 50 | 2 | 1 | 1 | 1 |
| 100 | 6 | 3 | 2 | 1 |
| 150 | 14 | 7 | 4 | 2 |
| 200 | 23 | 12 | 7 | 4 |
| 250 | 34 | 18 | 11 | 5 |
| 300 | 47 | 25 | 15 | 8 |
| 350 | 61 | 32 | 20 | 10 |
| 400 | 77 | 40 | 26 | 13 |
| **Kosrae** | | | | |
| 50 | 2 | 2 | 1 | 1 |
| 100 | 8 | 6 | 5 | 3 |
| 150 | 16 | 13 | 10 | 6 |
| 200 | 28 | 21 | 16 | 11 |
| 250 | 41 | 31 | 24 | 16 |
| 300 | 56 | 42 | 33 | 22 |
| 350 | 73 | 55 | 43 | 29 |
| 400 | 91 | 68 | 54 | 37 |

FSM's climate and sea level are both strongly modulated by the ENSO. Under El Niño conditions the country typically experiences drought. Severe drought events have resulted in water and food shortages as well as the occurrence of fires. Effects of El Niño on the FSM involve the persistence of a high-pressure weather zone over the Western Tropical Pacific for many months, blocking low-pressure, rain-bearing air masses. Nearly all extremely dry years on Pohnpei occur during the year following an El Niño event (Figure 19). In some years, drought conditions have continued through the wet season.

The driest year on record in Pohnpei and throughout most of Micronesia occurred in 1998, following the major El Niño of 1997. Some El Niño years are very wet depending upon the behavior of typhoons and the monsoon trough. Most La Niña and neutral years have precipitation that is near normal to slightly above normal, unless it is a year following an El Niño, when rainfall is below normal. Deleterious effects include desiccation of grasslands and forests, draw-down of streamflow and well-heads, and wildfires.

**FIGURE 19 | Time series of annual rainfall at the Pohnpei Weather Service Observatory (WSO). Most post-El Niño years (red bars) are dry**

*Source: Lander and Khosrowpanah, 2004*




The droughts of 1982-1983 and 1997-1998 were especially severe on terrestrial habitats, increasing localized threats to biodiversity. Groundwater sources were taxed, agricultural systems damaged and problems associated with wildfires and invasive species were greatly aggravated. Insufficient rainfall caused water and food shortages, including staples such as taro, coconut, breadfruit, banana, yam, sweet potato, citrus, and sugar cane. Communities in the atolls survived because bottled water, food supplies, and reverse osmosis pumps were imported. Water rationing for only two hours a day in Pohnpei was necessary. High near-surface lagoon and ocean water temperatures, especially associated with low water spring tides, caused coral bleaching and damage to inshore marine ecosystems (Falanruw, 2001). Poor potable water quality resulted in cases of typhoid and cholera. There was also a decrease in fish catch, possibly due to the variations in water temperature that occur during El Nino events.

## *Ocean Acidification*

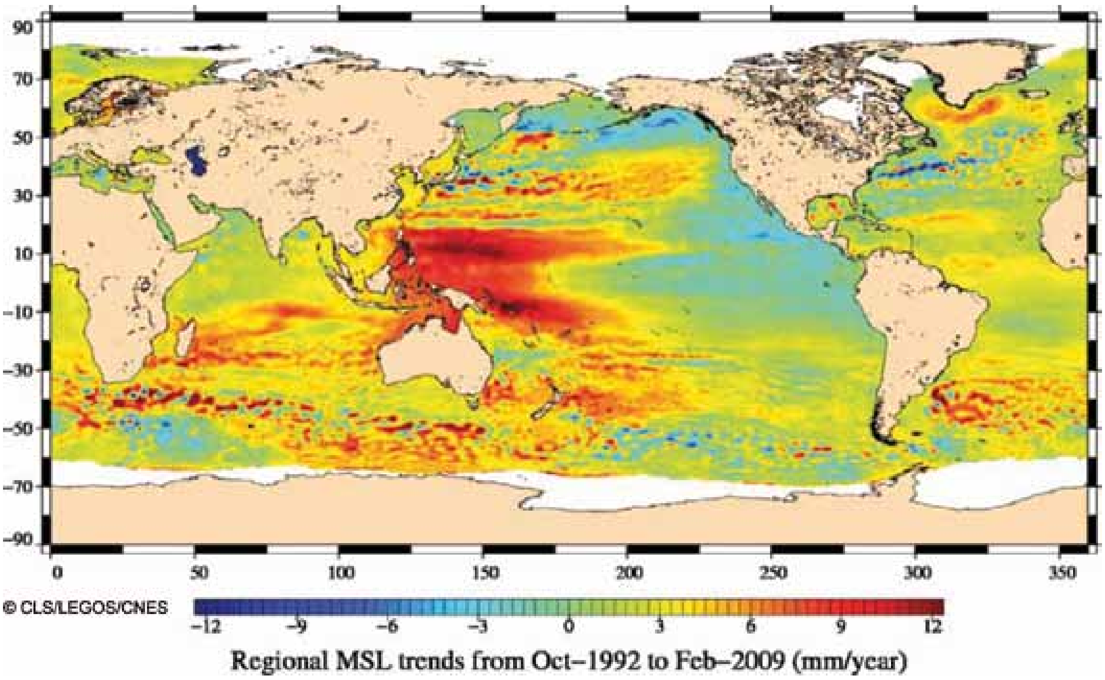
The aragonite saturation state (a common measure of ocean acidification) in the FSM region has declined from about 4.5 in the late 18th century to an observed value of about 3.9 ± 0.1 by 2000 (Australian Bureau of Meteorology and CSIRO, 2011). Based on the large-scale distribution of coral reefs across the Pacific and seawater chemistry, Guinotte et al. (2003) suggested that aragonite saturation states above 4 are optimal for coral growth and for the development of healthy reef ecosystems, with values from 3.5 to four adequate for coral growth, and values between three and 3.5 being marginal. Coral reef ecosystems were not found at seawater aragonite saturation states below three, with these conditions being classified as extremely marginal for supporting coral growth.

## *Sea Level and Extreme High Tides*

FSM is located in part of the global ocean that has experienced some of the highest rates of sea-level rise (Figure 20). Data from the Topex/Poseidon and Jason-1 satellites makes it possible to determine rates of sea-level change between 1992 and 2009. The complex surface reflects the influence of warm and cool bodies of water, currents and winds.

### FIGURE 20 | Rate of sea-level change, 1992 – 2009

*Source: Fletcher and Richmond, 2010*




Monthly averages of the historical tide gauge, satellite (since 1993) and gridded sea-level (since 1950) data agree well after 1993. These data indicate an interannual variability in sea level around FSM of about 10 in (26 cm) (estimated 5–95% range), after removal of the seasonal cycle (Figure 21).

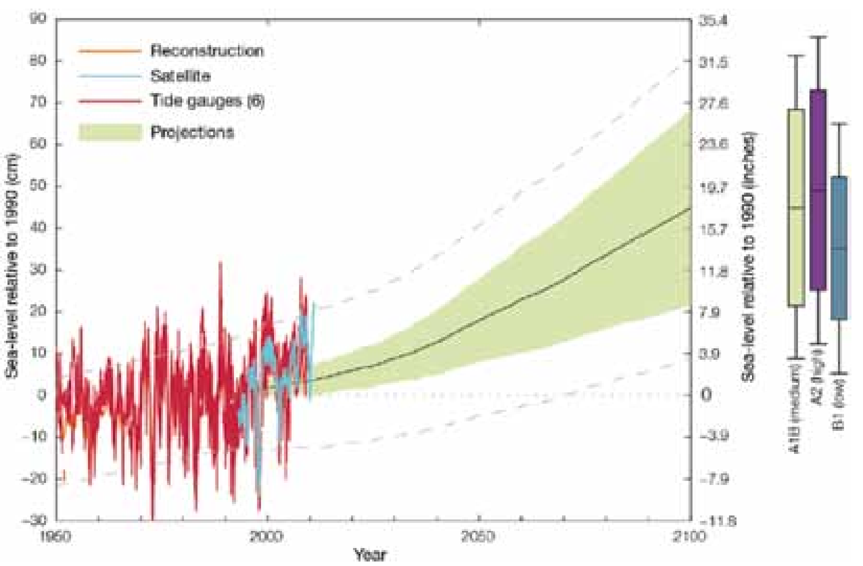



**FIGURE 21 | Observed and projected relative sea-level change near FSM.** The average of the observed in situ relative sea-level records is indicated in red, with the satellite record (since 1993) in light blue. The gridded sea-level data at FSM since 1950, from Church and White (in press), is shown in orange. The projections for the A1B (medium) emissions scenario (5–95% uncertainty range) are shown by the green shaded region from 1990–2100. The range of projections for the B1 (low), A1B (medium) and A2 (high) emissions scenarios by 2100 are also shown by the bars on the right. The dashed lines are an estimate of interannual variability in sea level (5–95% range about the long-term trends). These indicate that individual monthly averages of sea level can be above or below longer-term averages. *Source: Australian Bureau of Meteorology and CSIRO, 2011.*

Since 1993 sea level in the tropical western Pacific has been rising an average of 0.2-0.4in (5-10 mm) per year. For FSM specifically the value is over 0.39 in (10 mm) per year (Figure 22). This is well above the global mean of about 0.12 in (3 mm) per year over the same period. The rise is partly linked to a pattern related to climate variability from year to year and from decade to decade (Australian Bureau of Meteorology and CSIRO, 2011). The extent to which these increases are tied directly to global warming, or to a combination of warming and natural oscillations in the earth-atmosphere system, or some other process, is currently the focus of a substantial research effort.

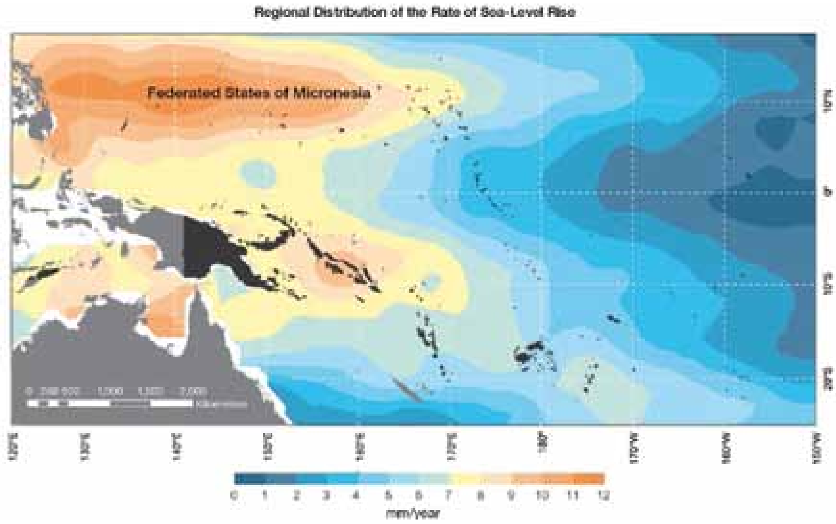



**FIGURE 22 | The regional distribution of the rate of sea-level rise measured by satellite altimeters from January 1993 to December 2010, with the location of the Federated States of Micronesia indicated**

*Source: Australian Bureau of Meteorology and CSIRO, 2011*

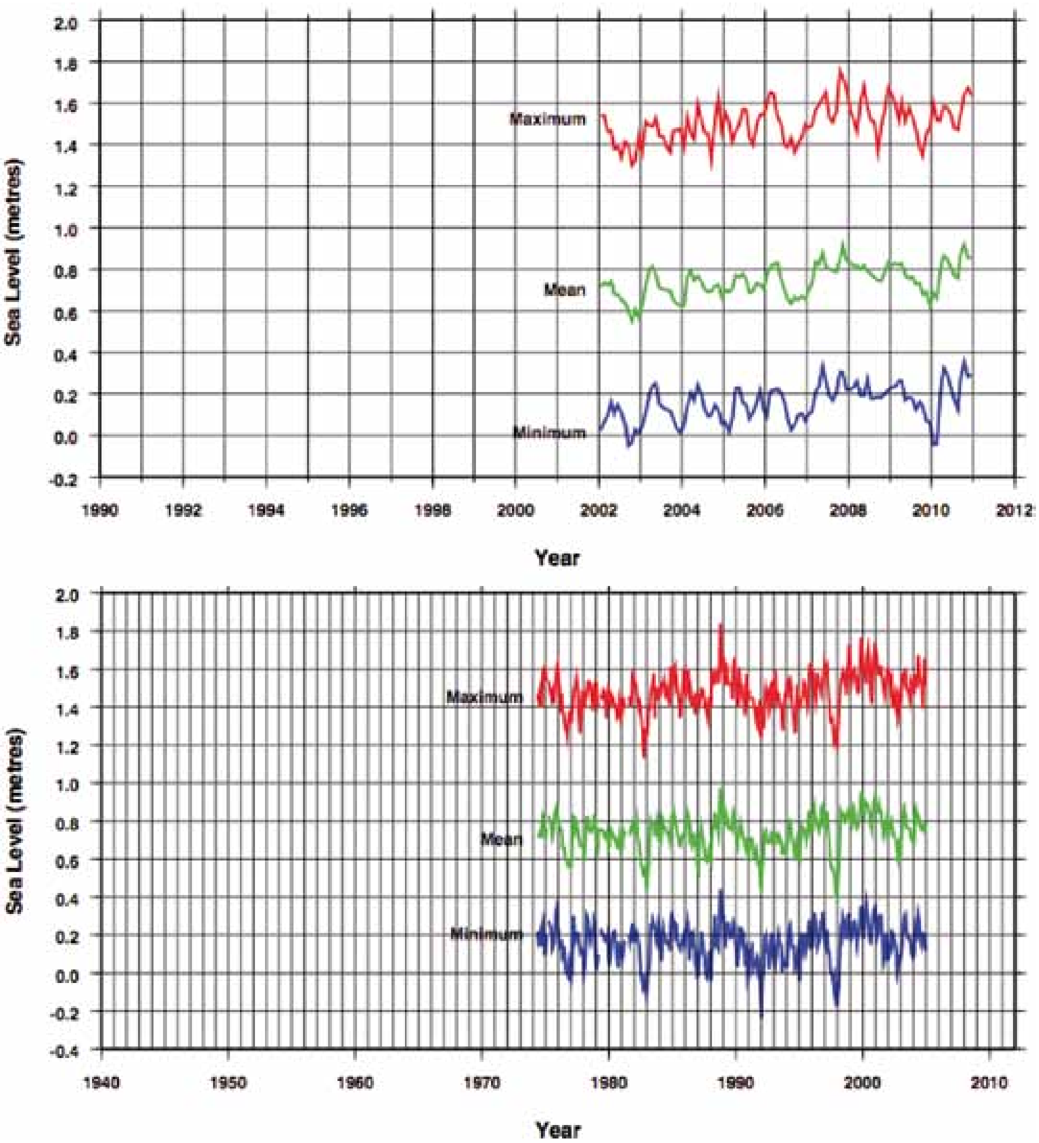
As noted above, FSM's climate and sea level are both strongly modulated by the ENSO. These variations are important as drought, floods and marine inundation due to high sea levels may damage soil and degrade food resources and drinking water. During an El Niño year, the mean sea level drops across most of Micronesia. During La Niña, the sea level is elevated above its normal value. These changes in sea level are highly coherent across the region from Yap to Guam, Chuuk, Pohnpei, and Kosrae.

Typically, the sea level in the region of Pohnpei falls to its lowest value in December of the El Niño year, then quickly recovers by the spring of the year following El Niño (Figure 23). For the SEAFRAME data set, and accounting for the inverted barometric pressure effect and vertical movements in the observing platform, the sea-level trend from 2002 to 2010 is +0.67in (16.9mm) per year. By comparison, in its Fourth Assessment Report the Intergovernmental Panel on Climate Change (IPCC) estimated that global average sea-level rise over the last hundred years was of the order of 1 to 2 mm/yr (IPCC, 2007). For the unadjusted Pohnpei-B Joint Archive the sea-level trend from 1974 – 2006 was 0.07in (1.8mm) per year.

Pohnpei typically experiences its highest monthly mean sea levels around March and its lowest around November and December. The mean sea level over the duration of the SEAFRAME record is 2.44ft (0.745 meters), with a maximum of 5.77ft (1.758 meters on 27 October 2007, and a minimum of -0.16ft (-0.050 meters) on 7 September 2002. Low sea levels were recorded at the end of the El Niño years (1987,1991, 1997, and 2002), while high sea levels were observed in the summers of La Niña years (1988, 1994, 1996, and 1998-2001).

**FIGURE 23 | The record of monthly mean, minimum and maximum sea level at Pohnpei for SEAFRAME gauge, 2002 – 2010 (upper) and Pohnpei-B Joint Archive for Sea Level Data, 1974 - 2006 (lower)**

*Source: Australian Bureau of Meteorology, 2010*




During the major El Niño of 1997 the sea level fell approximately one feet (0.30m) below its long-term average, and during the La Niña years that followed (1998-2001), the sea level rose to levels nearly 1ft (0.30m) above its long-term average. Thus the net difference of the sea level between the El Niño minimum in December 1997 and the La Niña high stands of the sea level during the summers of 1999, 2000, and 2001 was approximately two feet (0.61m). This is substantial, considering that the normal range between the daily high and low astronomical tide is on the order of four feet (1.22m). The long-term rise of sea level due to global warming is estimated to be on the order of four or five inches (100 or 127mm) per century. This is small compared to the ENSO-induced changes in sea level of two feet (0.61m) over the course of a year or two, (Lander and Khosrowpanah, 2004).

The annual climatology of the highest daily sea levels has been evaluated from hourly measurements of tide gauges at Pohnpei and Chuuk (Australian Bureau of Meteorology and CSIRO, 2011). Highest tides at both locations tend to occur around the solstices, particularly at Chuuk, where there is a pronounced June maximum. These periods of highest tides lead to the maximum likelihood of high water levels at both locations in mid-April to mid-July and November to January.

In addition, seasonal sea levels are significantly lower during El Niño conditions and significantly higher in La Niña conditions during October-February. This combination of high solsticial tides with seasonally high water levels during October to February in La Niña years is supported by observations of the highest ten recorded water levels at both sites, of which seven of ten occurred during La Niña conditions, and eight occurred between late October and January at Pohnpei. None of highest ten water levels at either location occurred during El Niño conditions.

Chuuk, with its higher June tidal maximum, has a greater likelihood of extreme water levels during this month than does Pohnpei. The tide gauge information indicates that most occurrences of extreme sea-level events at both Pohnpei and Chuuk are primarily due to a combination of extreme tides and La Niña conditions, with a long term trend induced by sea-level rise.

Since 2000 FSM has been occasionally experiencing a periodic rise of sea level in the low lying coastal areas of both high and low islands. These "king tides" cause marine inundation that damages groundwater resources, taro beds, soil, and agro-forestry resources in coastal settings, especially on low atoll islets. On high islands, coastal communities that experience both intensifying storm runoff and rising ocean waters are experiencing increased flooding and other drainage problems (Fletcher and Richmond, 2010).

Protracted La Niña-like conditions during the first decade of the 21st century caused marine inundation that required provision of emergency food and water supplies to some FSM communities. In 2007, and again in 2008, many FSM communities were flooded by a combination of large swell and spring high tides that eroded beaches, undercut and damaged roads, intruded aquifers and wetlands, and inundated communities. Food and drinking water were in short supply. Seawater flowed into coastal wetlands and surged up through the water table, killing taro, breadfruit, and other foods. Fresh water ponds and wetlands turned brackish and have not yet recovered fully. On approximately 60% of inhabited atoll islets cropping sites in use for generations were physically and chemically damaged, or destroyed. A nationwide state of emergency was announced on December 30, 2008, with food security being declared the top priority for the nation (Johnston, 2012; Shigetani et al., 2009).

The return periods for such extreme high sea level events have been estimated for Pohnpei (Table 11). These are based on observed data and projections of future return periods using the output of global climate models, for given emission scenarios and model sensitivity (Hay and Takesy, 2005).

**TABLE 11 | Return Periods (yr) for Extreme High Sea Level, Pohnpei**

*(Source: Hay and Takesy, 2005)*

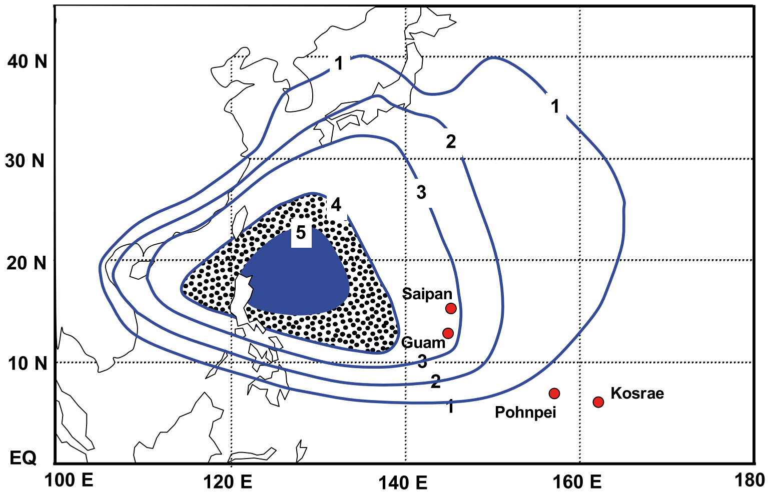
| Sea Level (cm) | Observed Data | 2025 | 2050 | 2100 |
|---|---|---|---|---|
| 80 | 1 | 1 | 1 | 1 |
| 90 | 1 | 1 | 1 | 1 |
| 100 | 4 | 2 | 1 | 1 |
| 110 | 14 | 5 | 2 | 1 |
| 120 | 61 | 21 | 5 | 1 |
| 130 | 262 | 93 | 20 | 1 |
| 140 | 1149 | 403 | 86 | 2 |

### *Tropical Cyclones and Extreme Winds*

The western North Pacific is the most active tropical cyclone basin in the world. Typically the tropical cyclones are spawned in central and eastern Micronesia and track north-westward towards Guam. On average, 28 tropical storms and typhoons occur annually, compared to about ten for the North Atlantic Basin. Of the 28 tropical cyclones, 18 become typhoons, and four become super typhoons. Another distinguishing feature of the western North Pacific basin is that tropical cyclones, although most common in late summer and autumn, can occur at any time of the year, whereas for other basins, off-season occurrences are rare (Lander and Khosrowpanah, 2004).

The main tropical cyclone season for the western North Pacific extends from mid-May through mid-December. For the basin as a whole, tropical cyclones are least likely during the month of February. The highest frequency of occurrence of typhoons in the western North Pacific is in an area just to the northeast of Luzon in the Philippine Sea

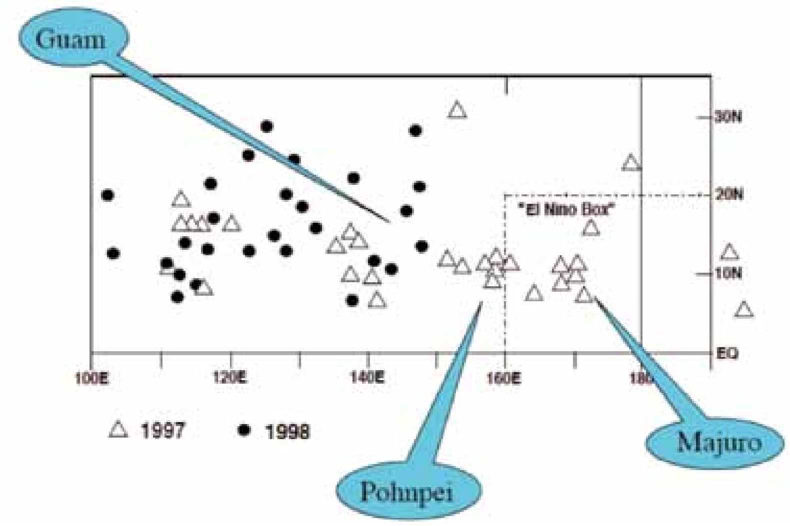
(Figure 24). In the Pohnpei region the frequency of tropical cyclones of tropical storm intensity or higher is less than one per 5-degree latitude-longitude square per year. The frequency of tropical cyclones passing Pohnpei is less than one every three years within 75 n mi, with a sharp gradient that features almost no tropical storms south of 5° N to over three tropical storms or typhoons passing within 75 n mi of Yap each year, on average (Lander and Khosrowpanah, 2004).




## FIGURE 24 | Mean annual number of tropical storms and typhoons traversing 5-degreee latitude by 5-degree longitude squares

*Source: (Lander and Khosrowpanah, 2004).*

The ENSO cycle has a profound effect on the distribution of tropical cyclones in the western North Pacific basin. During La Niña events, above average numbers of tropical storms occur in the FSM region (Australian Bureau of Meteorology and CSIRO, 2011). But the total number of tropical cyclones in the basin is not so much affected as is the formation region of the tropical cyclones. During El Niño, the formation region of tropical cyclones extends eastward into the eastern Caroline Islands and the Marshall Islands (see Figure 25). During the year following an El Niño year, the formation region of tropical cyclones retracts to the west. This results in an increased risk of a typhoon for Pohnpei during El Niño years, and a decreased risk during the year following El Niño and during La Niña years (Lander and Khosrowpanah, 2004).




## FIGURE 25 | The formation locations for all western Pacific basin tropical cyclones during the El Niño year of 1997 (black dots) and the El Niño follow-on year of 1998 (gray triangles)

Note the enormous difference in the formation region (especially in the area designated as the, El Niño box )

*Source: Lander and Khosrowpanah, 2004.*

On Pohnpei, the risk of having typhoon force winds of 65 kt (33.4ms-1) or greater is one year in 10 for El Niño years, and approximately one year in 50 for non-El Niño years. Pohnpei has not experienced a typhoon (wind speed of at least 65 kt (33.4ms-1)) since Typhoon Lola in 1986, an El Niño year. Every several years or so, on average, a mildly damaging tropical storm or depression will affect Pohnpei island (Lander and Khosrowpanah, 2004). The return periods for extreme wind gusts have been estimated for Pohnpei (Table 12). These are based on observed data and projections of future return periods using the output of global climate models, for given emission scenarios and model sensitivity (Hay and Takesy, 2005).

## TABLE 12 | Return Periods (yr) for Extreme Wind Gusts, Pohnpei

*(Source: Hay and Takesy, 2005)*

| Wind Speed (m $s^{-1}$) | Hourly | Daily | | |
|---|---|---|---|---|
| | 1974-2003 | 1961-1990 | 1991-2020 | 2021-2050 |
| 20 | 2 | 2 | 2 | 2 |
| 25 | 8 | 10 | 10 | 9 |
| 28 | 20 | 47 | 40 | 20 |

## 3.3 CLIMATE SCENARIOS AND PROJECTIONS FOR FSM

As part of the Pacific Climate Change Science Program (Australian Bureau of Meteorology and CSIRO, 2011), climate projections were derived from up to 18 global climate models, for up to three emissions scenarios (B1 (low), A1B (medium), A2 (high)) and three 20 year periods (centered on 2030, 2055 and 2090, relative to 1990). The models were selected for their ability to reproduce important features of the current climate, ensuring projections arising from each of the models are a plausible representation of the future climate. As a result, there is not one single projected climate future for FSM, but rather a range of possible futures.

Moreover, the projections do not represent a value specific to any actual location, such as a town or village in FSM. Rather, they refer to an average change over the broad geographic region encompassing the islands and adjacent oceanic areas of FSM.

The following projections are based on the findings of the Pacific Climate Change Science Program (Australian Bureau of Meteorology and CSIRO, 2011).

### *Air and Sea Surface Temperatures*

Surface air temperature and sea-surface temperature are projected to continue to increase over the course of the 21st century. There is very high confidence in this direction of change. The majority of models simulate a slight increase (<1.8°F; <1°C) in annual and seasonal mean surface air temperature by 2030. However, by 2090, under the A2 (high) emissions scenario, temperature increases of greater than 4.5°F (2.5°C) are simulated by almost all models (Tables 13 and 14). A similar (or slightly reduced) rate of warming is projected for the surface ocean (Figure 26).

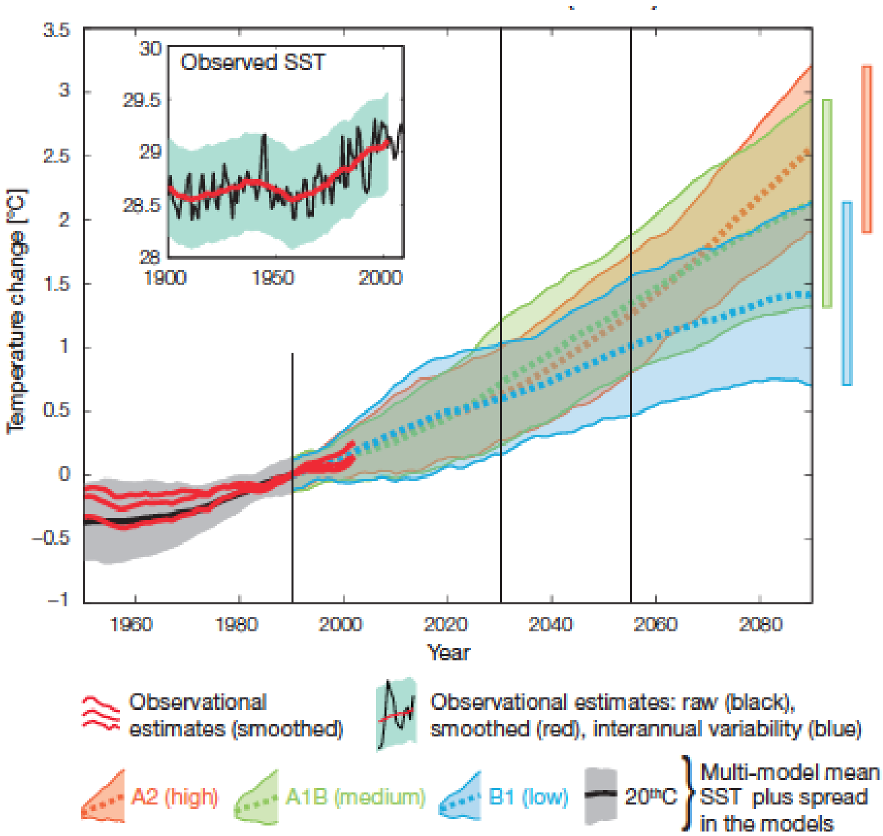



**FIGURE 26 | Historical climate (from 1950 onwards) and simulated historical and future climate for annual mean sea-surface temperature (SST) in the region surrounding the eastern FSM for the CMIP3 models.** Shading represents approximately 95% of the range of model projections (twice the inter-model standard deviation), while the solid lines represent the smoothed (20-year running average) multi-model mean temperature. Projections are calculated relative to the 1980–1999 period (which is why there is a decline in the inter-model standard deviation around 1990). Observational estimates are represented by red lines. Annual average (black) and 20-year running average (red) data is also shown in the inset. Projections for the western Federated States of Micronesia closely resemble those for the east and are therefore not shown.

*Source: Australian Bureau of Meteorology and CSIRO, 2011.*

## TABLE 13 | Projected change in the annual and seasonal mean climate for eastern Federated States of Micronesia[2]

*(Source: Australian Bureau of Meteorology and CSIRO, 2011)*

| Variable | Season | 2030 | 2055 | 2090 | Confidence |
|---|---|---|---|---|---|
| Surface air temperature (°F) | Annual | +1.1 ± 0.7<br>+1.4 ± 0.8<br>+1.3 ± 0.5 | +1.9 ± 0.9<br>+2.7 ± 1.0<br>+2.5 ± 0.8 | +2.7 ± 1.3<br>+4.2 ± 1.6<br>+5.0 ± 1.2 | High |
| Surface air temperature (°C) | Annual | +0.6 ± 0.4<br>+0.8 ± 0.4<br>+0.7 ± 0.3 | +1.0 ± 0.5<br>+1.5 ± 0.6<br>+1.4 ± 0.4 | +1.5 ± 0.7<br>+2.3 ± 0.9<br>+2.8 ± 0.7 | High |
| Maximum temperature (°F) | 1-in-20-year event | N/A | +1.8 ± 0.7<br>+2.5 ± 0.9<br>+2.7 ± 1.1 | +2.3 ± 1.3<br>+4.0 ± 1.8<br>+4.9 ± 2.3 | Low |
| Maximum temperature (°C) | 1-in-20-year event | N/A | +1.0 ± 0.4<br>+1.4 ± 0.5<br>+1.5 ± 0.6 | +1.3 ± 0.7<br>+2.2 ± 1.0<br>+2.7 ± 1.3 | Low |
| Minimum temperature (°F) | 1-in-20-year event | N/A | +2.3 ± 2.9<br>+2.9 ± 3.4<br>+2.5 ± 2.9 | +3.1 ± 2.9<br>+4.1 ± 3.4<br>+4.7 ± 3.6 | Low |
| Minimum temperature (°C) | 1-in-20-year event | N/A | +1.3 ± 1.6<br>+1.6 ± 1.9<br>+1.4 ± 1.6 | +1.7 ± 1.6<br>+2.3 ± 1.9<br>+2.6 ± 2.0 | Low |
| Total rainfall (%)* | Annual | 0 ± 8<br>+1 ± 7<br>+2 ± 7 | +3 ± 8<br>+5 ± 15<br>+4 ± 9 | +4 ± 6<br>+9 ± 15<br>+8 ± 11 | Moderate |
| Dry season rainfall (%)* | November- April | 0 ± 9<br>+1 ± 9<br>+2 ± 10 | +3 ± 9<br>+6 ± 21<br>+5 ± 17 | +4 ± 7<br>+9 ± 20<br>+7 ± 15 | Moderate |
| Wet season rainfall (%)* | May - October | +1 ± 8<br>+1 ± 7<br>+2 ± 8 | +3 ± 8<br>+5 ± 11<br>+4 ± 7 | +5 ± 9<br>+9 ± 14<br>+9 ± 11 | Moderate |
| Sea-surface temperature (°F) | Annual | +1.1 ± 0.9<br>+1.3 ± 0.9<br>+1.3 ± 0.7 | +2.0 ± 1.1<br>+2.5 ± 1.1<br>+2.3 ± 0.9 | +2.7 ± 1.4<br>+4.0 ± 1.6<br>+4.7 ± 1.3 | High |
| Sea-surface temperature (°C) | Annual | +0.6 ± 0.5<br>+0.7 ± 0.5<br>+0.7 ± 0.4 | +1.1 ± 0.6<br>+1.4 ± 0.6<br>+1.3 ± 0.5 | +1.5 ± 0.8<br>+2.2 ± 0.9<br>+2.6 ± 0.7 | High |
| Aragonite saturation state (Ωar) | Annual maximum | +3.4 ± 0.2<br>+3.3 ± 0.1<br>+3.3 ± 0.2 | +3.1 ± 0.1<br>+3.0 ± 0.2<br>+3.0 ± 0.1 | +3.0 ± 0.2<br>+2.6 ± 0.2<br>+2.5 ± 0.2 | Moderate |
| Mean sea level (inches) | Annual | +3.5 (1.2–5.5)<br>+3.5 (1.2–5.9)<br>+3.5 (1.2–5.9) | +6.7 (3.5–10.2)<br>+7.9 (3.5–12.6)<br>+7.9 (3.9–11.8) | +12.2 (6.3–18.1)<br>+15.4 (7.5–23.6)<br>+16.1 (8.3–24.4) | Moderate |
| Mean sea level (cm) | Annual | +9 (3–14)<br>+9 (3–15)<br>+9 (3–15) | +17 (9–26)<br>+20 (9–32)<br>+20 (10–30) | +31 (16–46)<br>+39 (19–60)<br>+41 (21–62) | Moderate |

[2] Projections are for the B1 (low; blue), medium A1B (medium; green) and A2 (high; purple) emissions scenarios. Projections are given for three 20-year periods centred on 2030 (2020–2039), 2055 (2046–2065) and 2090 (2080–2099), relative to 1990 (1980–1999). Values represent the multi-model mean change ± twice the inter-model standard deviation (representing approximately 95% of the range of model projections), except for sea level where the estimated mean change and the 5–95% range are given. The confidence associated with the range and distribution of the projections is also given (indicated by the standard deviation and multi-model mean, respectively).

## TABLE 14 | Projected change in the annual and seasonal mean climate for western Federated States of Micronesia[3]

*(Source: Australian Bureau of Meteorology and CSIRO, 2011)*

| Variable | Season | 2030 | 2055 | 2090 | Confidence |
|---|---|---|---|---|---|
| Surface air temperature (°F) | Annual | +1.2 ± 0.8<br>+1.4 ± 0.9<br>+1.3 ± 0.6 | +2.0 ± 0.9<br>+2.7 ± 1.1<br>+2.6 ± 0.8 | +2.8 ± 1.3<br>+4.3 ± 1.6<br>+5.1 ± 1.2 | High |
| Surface air temperature (°C) | Annual | +0.7 ± 0.4<br>+0.8 ± 0.5<br>+0.7 ± 0.3 | +1.1 ± 0.5<br>+1.5 ± 0.6<br>+1.4 ± 0.4 | +1.6 ± 0.7<br>+2.4 ± 0.9<br>+2.8 ± 0.7 | High |
| Maximum temperature (°F) | 1-in-20-year event | N/A | +1.8 ± 0.9<br>+2.5 ± 1.1<br>+2.7 ± 0.9 | +2.3 ± 1.1<br>+3.8 ± 1.8<br>+4.7 ± 2.3 | Low |
| Maximum temperature (°C) | 1-in-20-year event | N/A | +1.0 ± 0.5<br>+1.4 ± 0.6<br>+1.5 ± 0.5 | +1.3 ± 0.6<br>+2.1 ± 1.0<br>+2.6 ± 1.3 | Low |
| Minimum temperature (°F) | 1-in-20-year event | N/A | +2.2 ± 2.5<br>+2.7 ± 2.7<br>+2.5 ± 2.7 | +2.7 ± 2.7<br>+3.8 ± 3.2<br>+4.3 ± 3.2 | Low |
| Minimum temperature (°C) | 1-in-20-year event | N/A | +1.2 ± 1.4<br>+1.5 ± 1.5<br>+1.4 ± 1.5 | +1.5 ± 1.5<br>+2.1 ± 1.8<br>+2.4 ± 1.8 | Low |
| Total rainfall (%)* | Annual | +1 ± 8<br>+2 ± 9<br>+4 ± 11 | +7 ± 8<br>+7 ± 14<br>+7 ± 11 | +7 ± 11<br>+13 ± 16<br>+12 ± 15 | Moderate |
| Dry season rainfall (%)* | November- April | +1 ± 15<br>+2 ± 16<br>+4 ± 14 | +7 ± 9<br>+7 ± 22<br>+8 ± 18 | +7 ± 12<br>+13 ± 24<br>+10 ± 19 | Moderate |
| Wet season rainfall (%)* | May - October | +2 ± 10<br>+2 ± 8<br>+4 ± 12 | +7 ± 12<br>+8 ± 11<br>+7 ± 13 | +8 ± 14<br>+13 ± 18<br>+14 ± 21 | Moderate |
| Sea-surface temperature (°F) | Annual | +1.1 ± 0.7<br>+1.3 ± 0.9<br>+1.1 ± 0.7 | +1.8 ± 0.9<br>+2.3 ± 0.9<br>+2.3 ± 0.9 | +2.5 ± 1.3<br>+3.8 ± 1.4<br>+4.7 ± 1.3 | High |
| Sea-surface temperature (°C) | Annual | +0.6 ± 0.4<br>+0.7 ± 0.5<br>+0.6 ± 0.4 | +1.0 ± 0.5<br>+1.3 ± 0.5<br>+1.3 ± 0.5 | +1.4 ± 0.7<br>+2.1 ± 0.8<br>+2.6 ± 0.7 | High |
| Aragonite saturation state (Ωar) | Annual maximum | +3.4 ± 0.1<br>+3.3 ± 0.2<br>+3.4 ± 0.2 | +3.2 ± 0.1<br>+3.0 ± 0.2<br>+3.0 ± 0.2 | +3.0 ± 0.1<br>+2.6 ± 0.2<br>+2.4 ± 0.2 | Moderate |
| Mean sea level (inches) | Annual | +3.5 (1.2–5.5)<br>+3.5 (1.2–5.9)<br>+3.5 (1.2–5.9) | +6.7 (3.5–10.2)<br>+7.9 (3.5–12.6)<br>+7.9 (3.9–11.8) | +12.2 (6.3–18.1)<br>+15.4 (7.5–23.6)<br>+16.1 (8.3–24.4) | Moderate |
| Mean sea level (cm) | Annual | +9 (3–14)<br>+9 (3–15)<br>+9 (3–15) | +17 (9–26)<br>+20 (9–32)<br>+20 (10–30) | +31 (16–46)<br>+39 (19–60)<br>+41 (21–62 ) | Moderate |

3 Projections are for the B1 (low; blue), medium A1B (medium; green) and A2 (high; purple) emissions scenarios. Projections are given for three 20-year periods centred on 2030 (2020–2039), 2055 (2046–2065) and 2090 (2080–2099), relative to 1990 (1980–1999). Values represent the multi-model mean change ± twice the inter-model standard deviation (representing approximately 95% of the range of model projections), except for sea level where the estimated mean change and the 5–95% range are given. The confidence associated with the range and distribution of the projections is also given (indicated by the standard deviation and multi-model mean, respectively).

High resolution (5 mi; 8 km) models did not resolve any spatial variability in the changes to surface air temperature. This result is partially a consequence of FSM still being poorly resolved even at eight km resolution. As noted above, current interannual variability in sea-surface temperature and surface air temperature over FSM is strongly influenced by ENSO. As there is no consistency in projections of future ENSO activity, it is not possible to determine whether interannual variability in temperature will change in the future. However, ENSO is expected to continue to be an important source of variability for FSM and the wider region.

## ***Rainfall***

For FSM, wet season (May-October), dry season (November-April) and annual average rainfall amounts are projected to increase over the course of the 21st century. There is high confidence in this direction of change. The majority of models used in the study indicate little change (-5% to 5%) in rainfall by 2030. However, by 2090 the majority simulate an increase (>5%) in wet season, dry season and annual rainfall, with up to a third simulating a large increase (>15%) for eastern FSM under the A2 (high) emissions scenario (Tables 13 and 14). There is moderate confidence in this range and distribution of possible futures.

There is an inconsistency between the projected increases in rainfall described above and the recent declining (Pohnpei) or relatively steady (Yap) trends observed at individual meteorological stations. This may be related to local factors not captured by the models (e.g. topography), or the fact that the above projections represent an average over a relatively large geographic region.

Models do not agree on future ENSO conditions and therefore on the effect of ENSO on future rainfall patterns. However, models do agree that as a global average, tropical settings are likely to see increased rainfall and rainstorm intensity.

## ***Sea Level***

Mean sea level is projected to continue to rise over the course of the 21st century. There is very high confidence in this direction of change. The models simulate a rise of between approximately 2–6 inches (5–15 cm) by 2030, with increases of 8–24 inches (20–60 cm) indicated by 2090 under the higher emissions scenarios (i.e. A1B (medium) and A2 (high)) (Figure 27 and Tables 13 and 14). There is moderate confidence in this range and distribution of possible futures.

Interannual variability of sea level will lead to periods of lower and higher regional sea levels. In the past, this interannual variability has been about 10 inches (26 cm) (5–95% range, after removal of the seasonal signal (see dashed lines in Figure 21). It is likely that a similar range will continue through the 21st century.

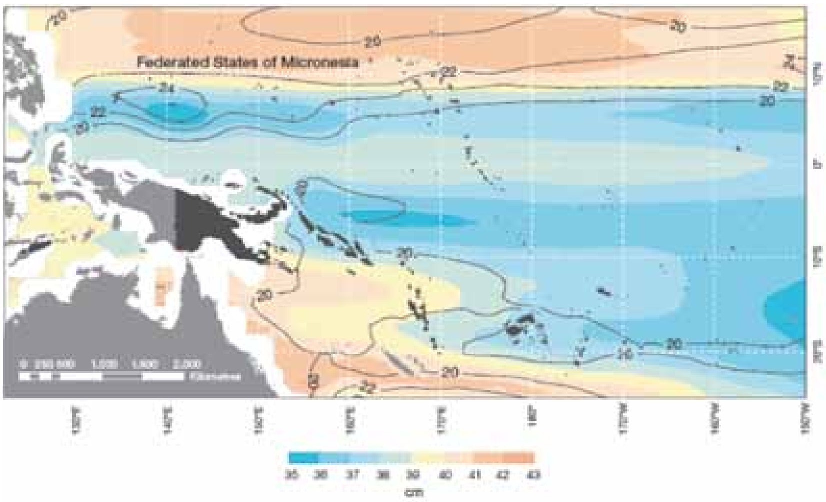



**FIGURE 27 | Projections (in cm) of sea-level rise for the A1B (medium) emissions scenario in the Federated States of Micronesia region for the average over 2081–2100, relative to 1981–2000**
The estimated uncertainty in the projections (in cm) is indicated by the black lines

*Source: Australian Bureau of Meteorology and CSIRO, 2011*

Importantly, winds and waves associated with weather phenomena will continue to lead to extreme sea-level events. In addition to the regional variations in sea level associated with ocean and mass changes, there are ongoing changes in relative sea level associated with changes in surface loading over the last glacial cycle (glacial isostatic adjustment) and local tectonic motions. The glacial isostatic motions are relatively small for the FSM region.

## Ocean Acidification

Acidification of the ocean is projected to continue over the course of the 21st century. There is very high confidence in this projection as the rate of ocean acidification is driven primarily by the increasing oceanic uptake of carbon dioxide, in response to rising atmospheric carbon dioxide concentrations. Projections from all models used to simulate ocean acidification indicate that the annual maximum aragonite saturation state in the FSM region will fall to values below 3.5 by about 2030 and continue to decline thereafter (Tables 13 and 14). There is moderate confidence in this range and distribution of possible futures. The impact of acidification change on the health of reef ecosystems is likely to be compounded by other stressors, including coral bleaching, storm damage and fishing pressure.

## Extreme Events

As indicated in Tables 9, 13 and 14, the intensity and frequency of days of extreme heat are projected to increase over the course of the 21st century. There is very high confidence in this direction of change. For both eastern and western FSM, the majority of models simulate an increase of approximately 1.8°F (1°C) in the temperature experienced on the 1-in-20-year hot day by 2055 under the B1 (low) emissions scenario, with an increase of over 4.5°F (2.5°C) simulated by the majority of models by 2090 under the A2 (high) emissions scenario (Tables 13 and 14). There is low confidence in this range and distribution of possible futures.

There is high confidence that the intensity and frequency of days of extreme rainfall will increase over the course of the 21st century. For both eastern and western FSM the majority of models simulate an increase of at least 0.4 inches (10 mm) in the amount of rain received on the 1-in-20-year wet day by 2055 under a B1 (low) emissions scenario, with an increase of at least 0.8 inches (20 mm) simulated by all models by 2090 under the A2 (high) emissions scenario. The majority of models project that the current 1-in-20-year extreme rainfall event will occur, on average, two to three times every year by 2055 under the B1 (low) emissions scenario and five to six times every year by 2090 under the (A2) high emissions scenario. However, there is low confidence in this range and distribution of possible futures.

The incidence of drought in FSM is projected to decrease over the course of the 21st century. There is moderate confidence in this direction of change. For both eastern and western FSM the majority of models project that mild drought will occur approximately eight to nine times every 20 years in 2030. This frequency is projected to decrease to seven to eight times every 20 years by 2090 under the B1 (low) emissions scenario, and six to seven times under the A1B (medium) and A2 (high) scenarios. The frequency of moderate drought is projected to decrease from once to twice every 20 years in 2030, to once every 20 years in 2090 for all emissions scenarios, while the majority of models project that severe droughts will occur approximately once every 20 years across all time periods and scenarios. There is low confidence in this range and distribution of possible futures.

Tropical cyclone numbers are projected to decline in the tropical North Pacific Ocean basin (0–15ºS, 130ºE–180ºE) over the course of the 21st century. There is moderate confidence in this direction of change. Consistent with this projected reduction in total cyclone numbers, five of six higher resolution simulations also show a decrease in the proportion of the most severe storms (those stronger than the current climate 90th percentile storm maximum wind speed). Most simulations project an increase in the proportion of storms occurring in the weaker categories. Associated with this is a reduction in cyclonic wind hazard.

## 3.4 CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

FSM is fully committed to the notion of sustainability. In 2002 it adopted the following five guiding principles for sustainable development: (i) the people of the FSM hold the sovereign rights over their natural resources; (ii) the National and State Governments actively promote sustainable development through appropriate levels of transparency; (iii) the community is the basic management unit for sustainable development within the FSM; they have the right and responsibility to manage and sustainably develop their resources for their benefit and that of future generations; (iv) improve and encourage at all levels of Government, with the private sector, NGOs, and civil society to be actively responsible for sustainable development; and (v) build on and use the rich ancestral traditional knowledge and experience to devise and implement strategies for sustainable development.

FSM's SDP has four main objectives: (i) stability and security - to maintain economic assistance at levels that support macroeconomic stability; achievement of this objective requires levels of funding close to prevailing levels, to avoid the large periodic step downs in funding that were a characteristic of the first 14-year Compact funding package; (ii) improved the enabling environment for economic growth - to be achieved through the FSM commitment to economic reform and the provision of an enabling environment to support open, outward-oriented and private sector led development; (iii) improved education and health status – use of the annual Compact grant to support the provision of basic services in education and health; and (iv) assured self-reliance and sustainability - to be achieved through establishment of a Trust Fund that would, after a period of time, replace the annually appropriated transfers from the USA.

The ability to feed the country's growing young population on a self sufficient basis remains a challenge. The demands of the current lifestyles, societal attitudes, strong preference for imported goods, and pressure of the rising cost of fuel, contribute to a range of economic challenges. The impact of climate change and increasing population pressures on resources challenge the ability of FSM to develop sustainably (Namakin, 2008).

Due to rapid growth in their populations, many formerly sustainable atoll communities now rely on imported food and water during times of stress. This is exacerbated as a result of drought and sea-level rise being amplified by ENSO conditions. Some scientists have proposed that atoll islets, because they are composed of reef-derived sand and gravel, might continue to accrete during sea-level rise as sediment is added by storm and overwash processes. However, before the fate of the island land mass is determined by overwash, it is likely to have become uninhabitable due to saltwater intrusion into aquifers, wetlands, and soils that will contaminate food and water resources (Fletcher and Richmond, 2010).

Incompatible management of coastal development and natural resources exacerbates these problems. For instance, forest thinning and canopy loss tends to dry the soil and reduce the capture of precipitation. Mining beaches, reefs, and lagoons for construction materials can lead to erosion and habitat loss. Continued building along the shoreline with no set-back exposes the community to coastal hazards. Use of submersible pumps in wells can encourage over-pumping and salinization. Waste disposal without regard to groundwater resources threatens contamination of water supplies (Fletcher and Richmond, 2010).

An overall lack of data on sustainability parameters underlies many of these issues. An absence of master planning tends to promote ad hoc decision-making, which is further acerbated by the need for rapid decision-making in the wake a natural disaster or other crisis. Arable land is scarce and a strongly traditional land use system involving complex land tenure relationships and a high number of invested stakeholders make it difficult to enact changes in policy (Fletcher and Richmond, 2010).

The SDP and the Infrastructure Development Plan (IDP) have provided a strong foundation for developing the Socio-Framework, Ocean and Coastal Framework, Land Framework, Environmental Framework, and Infrastructure Framework. These frameworks make it possible to establish a program of proactive mitigation and adaptation measures designed to alleviate the impacts of climate change (Namakin, 2008).

Economic growth and changing cultural practices, combined with population growth and demographic shifts continue to pose threats to sustainable resource management in FSM. Forests and coral reefs are being lost or degraded. Clearance of the original forest cover for many areas, particularly in the lowlands, and as in Pohnpei and to a lesser degree Chuuk and Kosrae, the uplands, has typically started the process of land degradation in the FSM.

An aerial survey of Pohnpei Island conducted in 2000 by The Nature Conservancy (TNC) found two-thirds of the native forest to have been lost in the past twenty years due to cultivation of sakau as a commercial crop, and to developments such as roads and homesteading in the watershed. Deforestation, unplanned development, and unsustainable agricultural practices, and extreme weather patterns were the main issues identified in the FSMs "First National Report to UNCCD" (FSM Department of Resources and Development, 2011).

Climate and weather related events such as droughts, forest fires, typhoons, storm surges and sea level rise pose further stresses on the already vulnerable ecosystems in FSM. These natural phenomena become more pronounced in the face of land degradation caused by human activities. The high islands of Pohnpei, Kosrae, and Chuuk suffer from landslides and soil erosion, while the lower islands and atolls lose valuable shoreline every year, and have agricultural crops destroyed from sea water intrusion.

The challenges to achieving sustainable development are especially apparent when energy supply and consumption is considered. The SDP for FSM provides a road map for social and economic development for the 20 years, 2004 - 2023. The energy required to achieve the goals of economic and social self-reliance must be affordable, reliable and above all, clean. Thus FSM is focused on broadening its energy base and reducing its dependence on external sources of energy.

FSM is on track to achieve four of its eight Millennium Development Goals (MDGs) by 2015 (Table 15). The goals are:

Goal 1 - Eradicate extreme poverty and hunger
Goal 2 - Achieve universal primary education
Goal 3 - Promote gender equality and empower women
Goal 4 - Reduce child mortality
Goal 5 - Improve maternal health
Goal 6 - Combat HIV/AIDS, malaria and other diseases
Goal 7 - Ensure environment sustainability
Goal 8 - Develop a global partnership for development

Staying on track, as well as eventually achieving the other four MDGs, is being made increasingly difficult due to the changes in climate already being experienced (World Bank, 2012).

### TABLE 15 | FSM's MDG Status at a Glance

*(Source: FSM, 2010)*

| MDG | Current Status | Ability to achieve by 2015 |
|---|---|---|
| Poverty | Off-track | Less challenging local goal achievable |
| Education | On-track | Care needed to prevent regression |
| Gender | Education achieved | Education achieved |
| | Economy off-track | Economy – progress expected |
| | Politics off-track | Politics – progress uncertain |
| Infant and child health | Slightly off-track | Achievable |
| Maternal health | Off-track but data weak | Achievable |
| HIV-AIDS and other diseases | General on-track | HIV & TB achievable; can progress toward localized NCD goal |
| Environment | On-track | Achievable |
| Global partnerships | General on-track | Achievable |

## 3.5 CHALLENGES FACING CLIMATE RISK MANAGEMENT, INCLUDING DISASTER RISK MANAGEMENT

The geographical location of the FSM means that the country is highly vulnerable to natural disasters. Examples of recent such events are provided in Table 16.

### TABLE 16 | Example of Recent Weather-related Disasters in FSM

| Event | Date | Description |
|---|---|---|
| Typhoon and storm surge | 1905 | |
| Typhoon and storm surge | 1907 | |
| Typhoon and storm surge | 1958 | |
| Typhoon Amy | 1971 | |
| Severe Drought | 1982/3 | |
| Typhoon Lola | 1986 | Most recent typhoon to affect Pohnpei |
| Typhoon Nina | 1987 | |
| Typhoon Owen | 1990 | |
| Typhoon Axel | 1992 | |
| Typhoon Isa | 1997 | Caused 19 deaths in Pohnpei |
| Landslides | 1997 | |
| Severe drought | 1997/8 | |
| Tropical Storm Chata'an | 2002 | Caused 43 deaths in Chuuk |
| Typhoon Mitag | 2002 | Caused severe damage in Yap |
| Storm | 2003 | Storm surge destroyed several homes in the municipality of Utwe; all homes were relocated |
| Typhoon Sudal | 2004 | Damage in Chuuk estimated at US$7 million |
| Typhoon Lupit | 2009 | Storm surge flooded taro patches, homes, water catchments, and deep wells in Kosrae, Pohnpei, Chuuk and Yap |

On 2 July 2002, Tropical Storm Chataan struck the islands of Chuuk, resulting in 20 inches (~500 mm) of rainfall in a 24-hour period. Of the 265 landslides attributed to the storm, at least 62 massive landslides occurred on 2 July, resulting in 43 deaths and hundreds of injuries on six islands (Australian Bureau of Meteorology and CSIRO, 2011). Landslides caused the destruction or damage of 231 structures, including homes, schools, community centers, and medical dispensaries. Landslides also buried roads, crops, and water supplies (Harp et al., 2004).

A landslide-inventory map produced after the storm showed that the island of Tonoas had the largest area affected by landslides, although eight other islands also had significant landslides. Based on observations since the storm, Harp et al. concluded that the continuing hazard from landslides triggered by Chata'an was relatively low. However, tropical storms and typhoons similar to Chata'an frequently develop in Micronesia and are likely to affect islands such as Chuuk in the future. To assess the landslide hazard from future tropical storms, Harp et al. produced a hazard map that identifies landslide-source areas of high, moderate, and low hazard (Figure 28). Maps such as these can be used to identify relatively safe areas for relocating structures or establishing areas where people could gather for shelter in relative safety during future typhoons or tropical storms similar to Chata'an.

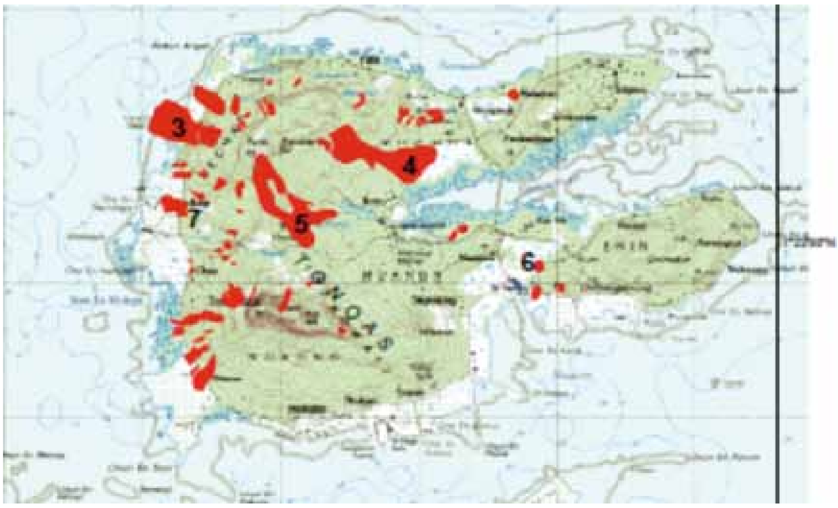



**FIGURE 28 | Map of Tonoas, Chuuk State, showing landslides caused by Typhoon Chata'an**

*Source: Harp et al., 2004.*

In April 1997, Typhoon Isa struck Pohnpei, causing numerous landslides, damage to land and infrastructure, and 19 deaths. In 2002 Typhoon Mitag caused a storm surge that inundated up to 1,640 feet inland destroyed nearly all the food crops in low-lying areas in the north, northeast, and southern parts of Yap Proper. The surge brought many low-lying areas, including parts of Colonia (the main town), under water for several hours. Approximately 150–200 people lost their homes. The coastline, retaining walls, and food crops on Rumung Island, in the north of Yap Proper, were also extensively damaged by the storm surge that went as far as 3,900 feet inland in those areas. In 2009 the damage from the storm surge caused by Typhoon Lupit included contamination of potable water sources, destruction of food crops in all low-lying areas in the outlying islands of Yap, and damage to most of the public utilities and commercial properties.

On average, in any one year FSM is expected to incur US$8 million in losses due to tropical cyclones and earthquakes. The relative contribution from earthquakes is small as most islands of FSM are situated in a relatively quiet seismic area. The exception is Yap Island, which is situated close to the Pacific "ring of fire". While significantly damaging earthquakes have not been experienced in recent times, FSM is subject to large tsunamis, as is evident by large tsunami runups on three occasions in the 1800s. These caused deaths and destruction in the Caroline Islands.

In the coming 50 years FSM has a 50% chance of experiencing natural disaster losses exceeding US$105 million and casualties larger than 220 people. There is a 10% chance of experiencing a loss exceeding US$470 million and casualties larger than 600 people (Pacific Catastrophe and Risk Financing Initiative, 2011).

Natural disasters are thus of special concern given FSM's fragmented composition of smaller islands and dependence on subsistence agriculture and on tourism. Effects of disasters on the natural environment and communities tend to be long-lasting, with high rehabilitation and recovery costs. The islands of the FSM are spread throughout 1,600 miles (2,575 km) of ocean. Within Yap State the closest outer island is 75 miles (121 km) away, with the eastern outlying atolls and coral islands over 560 miles (900 km) away from the main island. Only one hospital exists in each State, and in each case the hospital is located on the main island. Such circumstances make evacuation to or from the main islands of each State difficult and dangerous, and severely limits access to food, water, and medical care and supplies after a typhoon (Permanent Mission of the Federated States of Micronesia to the UN, 2009).

Furthermore, many of the outlying islands are low-lying atolls, a factor that makes them much more susceptible to damage from high winds and the storm surge associated with typhoons. Sea salt deposition can occur throughout the FSM. This hazard is caused by tropical cyclones and results from two processes. The first process involves ocean spray that is carried upward by the surface winds of a tropical cyclone to mix with rain. The concentration of salt in rain in the FSM is unknown but is detectable. The second process comes when ocean spray from large waves crashing along the coastal cliffs is blown inland by severe winds. Under this process, the stronger the winds, the further inland the sea salt is deposited (Permanent Mission of the Federated States of Micronesia to the UN, 2009).

Sea salt deposition can devastate agriculture and other plants and cause heavy corrosion. Some of the effects associated with salt spray, such as the devastation of agriculture and plants and power outages from shorts in electrical facilities, can be observed almost immediately, but corrosion occurs over a long period, has a cumulative effect on the surface it is affecting, and is difficult to observe immediately after a tropical cyclone (WERI, 1999).

But in addition to such disastrous events, chronic climate-related problems are present in FSM. There is persistent coastal erosion that threatens roadways, agro-forestry production, habitable dwellings, and shallow coastal aquifers. Mangrove and coastal strand forests have been lost, exposing the shoreline to environmental damage. Dredging and use of coastal sand and gravel for construction has caused coastal erosion, beach loss, and led to shoreline hardening. These practices have also lead to the slow salinization of wetlands and lakes, salt diffusion into soils adjacent to brackish water bodies, and salinization of well water. Interviews with atoll residents on several islands have revealed that freshwater wetlands and lakes that have been historically important for food production have turned brackish over the past two decades (Fletcher and Richmond, 2010).

The spread of alien plant and insect species throughout FSM watersheds is also decreasing ecosystem diversity and resilience and is threatening food sources. With many border entry points to FSM and increasing passenger and cargo traffic the threat from invasive species and trans-boundary pests and diseases continues to escalate. Such incursions, if and when they occur, pose a significant threat to local ecosystems, agricultural production, human and animal health and food security. Furthermore, the nature and prevalence of agricultural pests and diseases is a critical factor in gaining market access for potential export products (FSM Department of Resources and Development, 2011).

Expert advice on coastal management is urgently needed to guide activities in the FSM. Incompatible management of coastal development and natural resources exacerbate these problems. For instance, forest thinning and canopy loss tends to dry the soil and reduce the capture of precipitation. Mining beaches, reefs, and lagoons for construction materials can lead to erosion and habitat loss. Continued building along the shoreline with no set-back exposes the community to coastal hazards. The use of submersible pumps in wells can encourage over-pumping and salinization. Waste disposal without regard to groundwater resources threatens contamination.

Climate change events, chronic problems, data gaps, lack of master planning, and entrenched land uses decrease the sustainability of FSM communities in the face of changing climate conditions. Challenges include: (i) vulnerability to natural hazards and difficulty recovering from natural hazards; (ii) culture as traditional practice is replaced by imported resources; (iii) increased vulnerability to global warming; (iv) growing pressures on National and State resources; and (v) problem solving by crisis management.

Managing the climate and disaster risks facing FSM is extremely challenging given traditional land use and tenure, unstable slopes in the high islands, complexities in groundwater availability, conflicting plans for watershed use by owners and various groups, low motivation and appreciation of climate risk, data gaps, and a lack of adequate financing. Approached carelessly, the situation could lead to displaced communities lacking real economic underpinning and low social standing. Moving and upgrading basic infrastructure will be expensive. There is little public land, and land ownership is a complex and traditional foundation of political power in the FSM. The above problems converge to place FSM, especially communities on atoll islets and in other coastal settings, at the forefront of risk from climate change. Hence, the most positive outcome will result when authorities assess the feasibility of various climate risk management strategies in a realistic light (Fletcher and Richmond, 2010).

Significant challenges to the eventual success of climate adaptation efforts are posed by traditional and restrictive patterns of land use, decision-making and land tenure; lack of funding and planning; the remote nature of the population and geography; and a lack of abundant resources. Climate risk management focused on community-based adaptation, and implemented through effective land use policies, can improve food and water security, environmental conservation, and sustainability.

Effective climate risk management will be expensive, requiring external sources of funding and partnerships with other nations. These partners are going to be most amenable to providing resources to the FSM when they see that internal programs and policies are being upgraded and improved. Such improvements will raise the overall probability of successfully meeting the climate challenge and increase the likelihood that external investment success will be compounded and consistent with domestic climate risk management.

Internally derived study findings indicate that successful management of climate risk in FSM will be facilitated by strategies that encourage adapting to climate change as well as continued attendance at international gatherings where FSM representatives may share their experiences and the resulting learning.

## 3.6 ADDRESSING CLIMATE CHANGE THROUGH ADAPTATION, DISASTER RISK REDUCTION AND MITIGATION OF GREENHOUSE GAS EMISSIONS

Climate change remains an important policy priority for the FSM. In his statement presented before the thematic plenary in New York, President Emanuel Mori identified an urgent need to addressing climate change.

In the 2004-2023 SDP, Strategic Goal 1 in the Environment Section recognized the need to mainstream climate change into National planning as well as in all economic development activities. In December 2009 the President of the FSM issued an Executive Order directing all relevant sectors to update existing plans and complete them in order to bolster responses towards mitigating and adapting to climate change. The sectors included agriculture (and food security), energy, water, infrastructure, transport, finance, health, and gender.

More specifically, the SDP lays out a strategy for addressing climate change by: (i) raising awareness of climate change among the general population; (ii) developing coastal management plans in all four States; and (iii) developing ways to "climate proof" facilities and structure that support social and other services. In 2009 a five-year Environment Sector Plan was prepared. The amended Compact provides targeted grants for this and other environmental initiatives and $12.3 million has already been awarded for this purpose over the five years 2004-2009.

As a result, FSM has already made considerable progress in implementing this Executive Order. Details of many of the current initiatives are provided in Appendix 3.

*"Micronesia is already experiencing the earliest impacts of climate change. I say with sadness that much subsistence agriculture and fishing, endemic marine and terrestrial species, including coral reefs, are increasingly damaged, if not lost by environmental stresses, associated with global warming. Extreme weather events, droughts, higher tides, and wave surges (not associated with typhoons) have destroyed crops, contaminated water wells, eroded beaches, and threatened the existence of coastal communities."*

Statement by
President Emanuel Mori

*Affected taro patch fadrai atoll Chuuk by Henry Susaia*

## 3.7 ASSESSMENT OF FSM'S CAPACITY TO ADDRESS CLIMATE CHANGE

As part of the FSM National Capacity Self Assessment on implementing the UNFCCC (FSM Office of Environment and Emergency Management, 2009), the thematic assessment identified the root causes of capacity constraints (Table 17). Efforts to address these root causes will be described in Chapter 7.

### TABLE 17 | Root Causes of Capacity Constraints to Implement the UNFCCC in FSM

*(Source: after FSM Office of Environment and Emergency Management, 2009)*

| Focal Areas | Root Causes of Capacity Constraints |
|---|---|
| Adaptation | ▪ Lack of adequate information to support vulnerability and adaptation assessments<br>▪ Lack of adequate baseline information to measure changes and assess impacts<br>▪ Insufficient information on patterns of marine and terrestrial ecosystems and research on critical climate-ecosystem interactions<br>▪ Insufficient information on changing environmental, demographic, economic patterns and trends<br>▪ Limited number of scientific, technical and professional staff<br>▪ Limited understanding/awareness of the importance of adaptation skills, human and technical resources<br>▪ Limited funding to operate adaptation measures and<br>▪ Mainstream into governmental institutional structure<br>▪ Inadequate cooperation and coordination of climate change projects among Government agencies, NGOs and weather service bureaus<br>▪ information at the State and community levels that is collected by State agencies, NGOs and community members is not being utilized during development of adaptation strategies, plans and projects<br>▪ Provision of funding and other initiatives related to adaptation being undertaken by NGOs are not being given adequate recognition |
| Greenhouse Gas Inventory | ▪ Lack of adequate scientific data to complete an accurate Greenhouse Gas Inventory such as fuel consumption from end-us activities, HFC, PFC, and SF consumption, and Carbon dioxide removals<br>▪ Inadequate uptake capacity of its coral reefs, coastal, and upland forest<br>▪ Lack of sustainable Community-based coral protection program<br>▪ Lack of funding |
| Mitigation | ▪ Limited access to new technology and enhanced qualifications in the use of those technology<br>▪ Limited Financial and human resource costs for acquisition and maintenance costs of new technological equipments<br>▪ Limited knowledge of mitigation options –renewable energy projects on solar and hydro<br>▪ Lack of viable incentives towards the promotion of mitigation activities |
| Education, Public Awareness and Training | ▪ Prioritization of local conservation issues in school systems is low<br>▪ Limited environmental education materials for school<br>▪ Limited funds for education and awareness programs<br>▪ Limited promotional campaigns<br>▪ Lack of supplementary materials for community education outreach purposes<br>▪ Fire danger and water conservation awareness and coping methods to high islands and atoll residents is limited<br>▪ Lack of environment education programs in curriculum |
| Research and Systematic Observation | ▪ Inadequate number of scientific, technical, and professional staff to conduct research and systematic observation<br>▪ Inadequate number of trainees in the field of environmental research and systematic observation in regards to climate change<br>▪ Absence of climatologists in the FSM<br>▪ Inadequate meteorology capability<br>▪ Limited funds to promote research and systematic observation in all areas of climate change activities<br>▪ Lack of affordable and user friendly observation and application systems for local communities<br>▪ Lack of documentation on traditional Micronesian knowledge of environmental management systems<br>▪ Lack of completed needs assessment studies prior to any mitigation or adaptation measures |
| Technology Transfer | ▪ Insufficient information on technology transfer<br>▪ Lack of qualified staff in transferring technology<br>▪ Limited Funding for mitigation and transfer<br>▪ Limited Network with major agencies and organizations on appropriating technology use for climate change adaptation and measures |

Deema (2012) notes that current immigration and refugee laws do not adequately address human displacement associated with climate change. This is a matter of particular concern for small islands states such as FSM, as excessively high, and rising, sea levels pose a threat to the long-term habitability of many islands.

FSM, and the two other Freely Associated States (FAS) of Marshall Islands and Palau, are sovereign nations that have negotiated Compacts of Free Association with the USA. These allow many of their citizens to enter, work, and live in the USA with limited restrictions. Voluntary migration from the FAS to the USA under the Compacts has the potential to strengthen the adaptive capacity of the FAS as the effects of high sea levels stress the resources and economies of these states.

However, the current immigration provisions of the Compacts will be insufficient on their own to address large-scale or permanent, forced migration from the FAS connected with sea-level rise. Deema highlights that neither the USA nor the Governments of the FAS appear to provide direct financial support or other types of assistance to support migration to the USA.

Therefore, unless the USA or the Governments of the FAS begin to offer such assistance, only those FAS citizens who possess the financial and social resources necessary to migrate will be able to exercise the immigration rights contained in the Compacts. Deema concludes that voluntary migration from the FAS to the United States of America under the Compacts has the potential to increase the capacity of the FAS to adapt to the effects of climate change, but it should be only one component of a strategy that prioritizes the rights of the citizens of the FAS to remain in the FAS under safe and sustainable conditions.

## 3.8 OVERVIEW OF PROGRESS IN ADDRESSING CLIMATE CHANGE AT NATIONAL AND SUB-NATIONAL LEVELS

The FSM Government signed the UNFCCC on June 12, 1992 and Congress ratified it on November 18, 1993. On December 24, 1994, the Convention entered into force. The Kyoto Protocol was signed by FSM on March 17, 1998 and ratified by Congress on June 21, 1999. As a party to the UNFCCC and the Kyoto Protocol, FSM is dedicated to promote effective strategies to combat Climate Change. Under the UNFCCC Framework, the FSM aims to maintain greenhouse-gas concentrations at an appropriate level so that ecosystems can adapt to climate change, and allow the economy to develop in a sustainable manner.

In his testimony to the House of Representatives committee on foreign affairs subcommittee on Asia, the Pacific, and the Global Environment, FSM Ambassador to the United Nations, Masao Nakayama, expressed concern over the idea of "fast start mitigation strategies to give us time to get mid and long term strategies working effectively". He noted that FSM also needs fast start strategies for adaptation as the impacts of climate change are already being felt.

Overall, activities and projects undertaken by FSM in response to UNFCCC requirements include:

- Participating in climate proofing case studies;
- Compiling a GHG Inventory for FSM;
- Establishing a Climate Change Country Team;
- Preparing and submitting an Initial National Communication;
- Implementing climate change enabling activities;
- Addressing FSM's climate change status at regional and international meetings;
- Working in climate change-related aspects of the Montreal Protocol;
- Participating in the Pacific Adaptation to Climate Change (PACC) project;
- Undertaking studies related to preparation of the Second National Communication;
- Developing a Climate Change Policy;
- Integrating environmental conservation work concepts into educational programs;
- Implementing the Productive Utilization of Micronesian Indigenous Energy Resources project to define, formulate, and finalize medium sized project brief for promotion of renewable energy; and
- Seeking to acquire fiber-optic cable network to improve communications efforts on health, education, and the private sector development.

In 2007, the FSM became the first party to the Montreal Protocol, under which a proposal was submitted to strengthen the treaty in order to address climate change through the acceleration of the phase out of hydro chlorofluorocarbons (HCFC's). Recently, a Climate Protection Award was bestowed on FSM for its contributions to climate protection under the Treaty. This clearly demonstrates FSM's determination to seek ways to address climate change. In addition, public awareness programs aimed to educate and involve the community in addressing the impacts of climate change have been initiated by local conservation groups and the National Government. At the State level, community programs on adaptation and mitigation of climate change have been introduced.

Climate proofing case studies were conducted during the early 2000s as part of enhancing FSM's adaptive capacity and resilience to climate change and variability, including extreme events (ADB, 2006). At both National and State levels climate proofing is one of the major ways to mainstream adaptation. The case studies had several conclusions, especially on the importance that new and upgraded projects be climate proofed at the design stage, including through application of enhanced of environmental impact assessment procedures.

The FSM has taken many important steps to develop specific strategies and program activities to address the issue of climate change by: (i) promoting FSM's pristine island environment (Tourism Framework); (ii) promoting environmentally sustainable production, mitigation, and establishing preventive measures to address global climate changes and terrestrial pollution (Land Framework); (iii) maintaining the health of its ocean and coastal ecosystem for the future and ensuring the sustainable development of offshore marine resources and preservation and conservation of the marine environment (Coastal and Ocean Framework); and (iv) integrate environmental considerations in economic development and improving environmental awareness and education (Environmental Framework). In order to combat the effects of climate change, climate variability and sea level rise FSM is also promoting sustainable economic growth, balancing resource conservation and management and ensuring and improving the quality of life of all inhabitants.

Currently, FSM is one of 13 Pacific island countries to participate in a climate change adaptation initiative, the Pacific Adaptation to Climate Change (PACC) project, funded by GEF with the UNDP and SPREP as implementing agency and partner. FSM's participation in this project reflects its commitment to sustainably manage the environment. In FSM the PACC project is designed to promote climate change adaptation as a key pre-requisite to sustainable development, particularly as it relates to coastal zone management and development. The PACC project objective therefore is to enhance the capacity of the FSM Governments and communities to adapt to climate change, including climate variability, in the selected key development sectors of health and the environment, and particularly as it relates to climate proofing infrastructure projects, policies and communities. The project focuses on supporting capacity building and mainstreaming of climate change adaptation at the National level, primarily through FSM's SDP. It also focuses on providing tools and guidelines, supplemented by practical demonstration of adaptation as both a process and on the ground activity; and through supporting local, National and regional approaches. Demonstration activities focus on Sapwohn community in Pohnpei, and on the Tafunsak section of circumferential road in Kosrae.

## 3.9 FSM'S CLIMATE CHANGE POLICIES AND PLANS

The Nationwide Climate Change Policy (NCCP, 2009), the National Energy Policy and State Action Plans (NEP, 2010), and the National Action Plan to Combat Land Degradation (NAP, 2011) are but a few of the National and State-level plans and policies that the FSM is attempting to implement in order to address major threats to the sustainability and economic and social viability of the country. The SDP and IDP provide a strong foundation for all these initiatives.

The Nationwide Climate Change Policy was adopted by FSM in 2009. The focus is to mitigate climate change (especially at the international level) and adaptation (at the National, State and community levels) to reduce FSM's vulnerability to the adverse impacts of climate change. The Policy outlines the integration of climate change into the SDP and IDP, as well as into other policies, strategies and action plans, including disaster preparedness and mitigation, as necessary.

The main goals of the Policy are listed in Table 18.

### TABLE 18 | Goals of the Nationwide Climate Change Policy (2009)

| Focal Area | Goals |
|---|---|
| Adaptation | ▪ All development agencies in FSM to take into account projected climate change in the design and implementation as stipulated in the FSM SDP/IDP;<br>▪ Use ecosystem-based approaches where applicable;<br>▪ Encourage and strengthen the application of traditional knowledge on conservation practices and other relevant areas;<br>▪ Develop and implement appropriate strategies to improve food production and other relevant sectors. |
| Mitigation | ▪ To advocate a post Kyoto carbon dioxide emission reduction that will keep temperature rise to less than 1.5C by 2020 and beyond;<br>▪ To maintain and enhance FSM as a negative carbon country through effective management of its natural sinks, bio-sequestration (biochar), promotion of renewable energy and energy efficiency, and other appropriate means;<br>▪ To prioritize actions that address both mitigation and adaptation, such as water development using renewable energy (solar water desalination) and other relevant actions;<br>▪ To encourage and strengthen the application of traditional knowledge on transportation practices and other areas. |
| Technology Transfer | ▪ To optimize the use of local technologies, where available;<br>▪ To identify technologies that are locally appropriate;<br>▪ To enhance easy access to, and sustainable use of, new technologies. |
| Finance | ▪ To maximize the use of local resources through establishment of a sustainable financing mechanism to support adaptation, mitigation and resource management initiatives;<br>▪ To increase local financial support from Government, private sector and non-government organizations to enhance capacities to respond to climate change challenges;<br>▪ To insist that developed country Parties responsible for climate change, based on the polluters-pay principle (moral and equity), provide sufficient and sustainable financial and other appropriate resources, to support adaptation, mitigation and other climate-related measures, now and in the future;<br>▪ To negotiate that such assistance described above shall be in addition to existing and future Overseas Development Assistance (ODA) |
| Capacity Building and Training | ▪ To promote, facilitate and develop training programs focused on climate change for scientific, technical and managerial personnel;<br>▪ To provide opportunities to access technical skills and knowledge to address and respond to climate change and its impacts. |
| Education | ▪ To develop and disseminate education materials on climate change and its effects;<br>▪ To develop and integrate climate change and its effects into intermediate, primary and secondary education curricula. |
| Public Awareness | ▪ To promote, facilitate and implement public awareness programs on climate change and its effects, at National, State and community levels, by using relevant means (e.g. radio, newspapers, workshops);<br>▪ To provide public access to information on climate change and its effects;<br>▪ To promote public participation in addressing climate change and its effects by facilitating feedback, debate, partnership activities and linking with other environment-related events (e.g. National Environment Day, World Clean Up Day, National Women's Day) |

Specific priorities include:

- developing a National climate education program implemented through State, non-governmental organizations and community groups;
- installing and maintaining climate-monitoring stations throughout FSM;
- prepare maps of inundation risk and vulnerability and develop an inundation timeline that can inform State and National plans;
- creating a National climate risk management plan and road map for managing climate risk, supported by individual State plans that emphasize community-based adaptation; and
- building food and water resiliency (Johnston, 2012).

FSM already has a Multi-State Hazard Mitigation Plan (MHMP) (2005). This was developed after an extensive process of consultation, led by the OEEM and involving stakeholders across all States, both within and outside Government. The MHMP was due for review in 2008 but this was not undertaken. Rather, given the recent efforts by the OEEM and other Government stakeholders in relation to climate change, and specifically FSM's SNC, it was considered prudent for the Government to identify both climate change and disaster risk management actions - the former through National vulnerability and adaptation assessments and the latter through a review of the 2005 MHMP. The findings would be captured in a single strategic action plan.

This was endorsed by the Presidential Disaster Task Force, which decided that, in the first instance, FSM should consider developing a national climate change adaptation (CCA) and disaster risk management (DRM) policy to provide overall policy guidance. The policy would then be supported by a Joint National Action Plan for CCA and DRM. Through further consultations, OEEM confirmed the need for the development and implementation of a DRM and CCA Joint National Action Plan in order to maximize the benefits of investing its limited financial and human resources to address issues of vulnerability and risk caused by a range of hazards. The intention is for the plan to combine existing and future DRM and CCA efforts that should be integrated given the similarity in focus that each presents. The JNAP will essentially be an aggregation of the DRM/CCA priorities developed by the States, through their respective joint DRM and CCA State Action Plans (JSAPs) (UNISDR and UNDP, 2011). The resulting work program is illustrated diagrammatically in Figure 29.

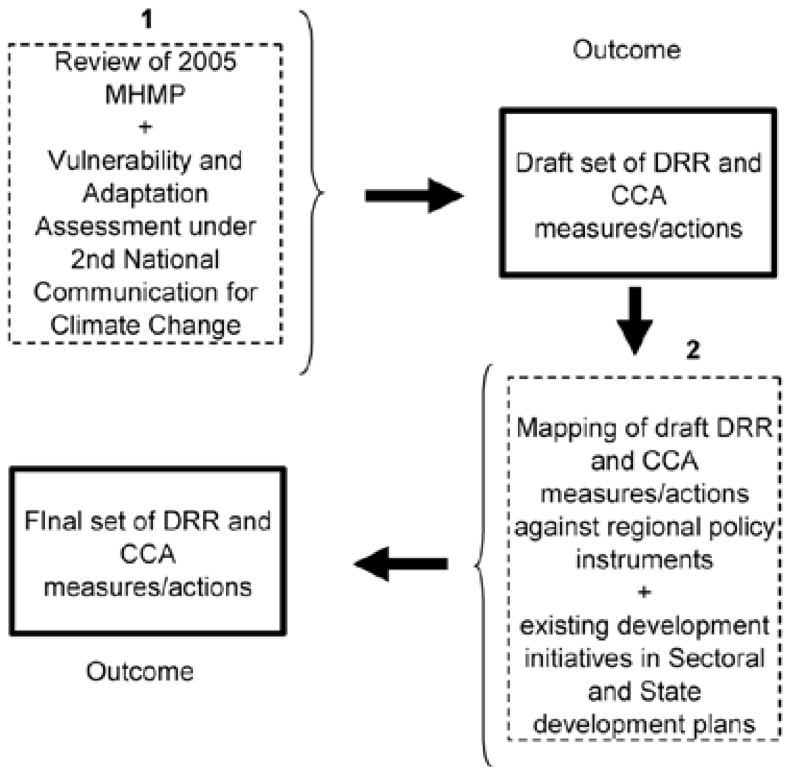



**FIGURE 29 | Diagrammatic illustration of the work flow pursued by FSM to prepare a NAP that addressed climate change adaptation and disaster risk management in an integrated manner**

*Source: SOPAC, 2012.*

Examples of relevant National- and State-level policies and plans are provided in Table 19. It demonstrates the considerable progress that has been made in the last 15 years or so.

## TABLE 19 | Examples of National- and State-level

## Policies and Plans Related to Addressing Climate Change

| Policy/Plan | Brief Description |
|---|---|
| A. National | |
| Nationwide Climate Change Policy | Focus is to mitigate climate change and adapt to its effects in order to reduce FSM's vulnerability to its adverse impacts |
| Energy Sector Policy and State Action Plans | Primary goal is for FSM to be less dependent on imported fossil fuels by implementing energy efficiency and conservation measurements and including more environmentally sound renewable energy sources that are locally available; promote the sustainable socio-economic development through the provision and utilization of cost-effective, safe, reliable and sustainable energy services |
| National Action Plan to Combat Land Degradation | Addresses the role of sustainable land management practices, and identifies actions that need to be implemented to manage land more sustainably |
| National Biodiversity Strategy and Action Plan | Outlines the state of the FSM's biological resources and the current biological and anthropogenic threats that are affecting their continued existence; describes a series of actions to address these concerns |
| National Climate Change and Health Action Plan | Summarizes the key climate-sensitive health concerns for FSM and provides a framework for implementation of adaptation strategies to prevent the most serious impacts of climate change on the health of individuals and communities within FSM |
| Multi-State Multi-Hazard Mitigation Plan | Presents National or "over-arching" hazard mitigation goals, objectives, and actions; more specific actions requiring State- or municipality-level implementation are included in the State-level plans |
| National Plan of Action for Nutrition | Sets out a clear strategic framework to help address nutrition-related health priority problems, and advocates incorporating nutrition goals and components into National development policies and sector plans, programs and projects, particularly in the areas of food and agriculture, fisheries, forestry, health, education, and environment |
| Agriculture Policy | Provides the basis for action by both public and private sectors to invigorate sustainable agriculture growth in FSM; recognizes the major role played by traditional farming systems and the impact of socio-cultural realities; local production needs to remain the core of the food system; the capacity of FSM farmers to trade their produce locally, regionally and internationally needs to be supported and extended |
| FSM Statewide Assessment and Resource Strategies (FSM SWARS) | The SWARS is a five year forestry action plan. It provides a comprehensive spatial analysis of FSM's forestry important forestry resources and Strategies for these priority forest resource areas. The SWARS is also an important tool for resource allocation. |
| Food Security Policy | Provides the framework and strategies to attain and maintain food security and sustainable livelihoods throughout the country; calls for all people in the FSM to have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences |
| Forest Action Plan | Based on State-wide assessments leading to resource strategies which address the highest priorities for forest resource management for priority forest landscape areas; identifies the work needed to address National, regional, and State forest management priorities |

| Policy/Plan | Brief Description |
|---|---|
| **B. State** | |
| Kosrae Shoreline Management Plan | Aims to provide a framework for coastal defense policies and to set objectives for future development and resource management, over the next 20 or so years, within the context of coastal erosion and coastal hazard management |
| Kosrae State Land Use Plan | Represents the direction of land use desired by the people of Kosrae. The intent of the Plan is not to prohibit private landowners from traditional and household uses of their land, but rather to prevent negative impacts from development projects and the use of technologies that affect commonly used resources, such as rivers, mangroves and reef areas |
| Pohnpei State Environmental Impact Assessment Regulations | Designed to help the general public, and Government officials, make decisions with the understanding of the environmental consequences of the proposed action, and take actions consistent with the goal of protecting, restoring and enhancing the environment |
| Kosrae State Disaster Management Plan | Defines the measures to be taken by the State Government to ensure that effective disaster preparedness, response, relief and recovery are carried out |
| Pohnpei Disaster Management Plan | Seeks to mitigate the effects of hazards, to prepare for measures to be taken which will preserve live and minimize damage, to respond during emergencies and provide necessary assistance, and to establish a recovery system to return the community to its normal state of affairs |

The major goal of the Energy Sector Policy is to become less dependent on imported sources of energy by having an increased share of renewable energy sources and having cross-sectoral energy conservation and efficiency standards in place. The aim is that, by 2020, the share of renewable energy sources will be at least 30% of total energy production, while energy efficiency will increase by 50%. Energy efficiency as used here also means reduction of energy losses. In addition, the following broad goals relate to energy services in the FSM: (i) provision of affordable and safe electricity to all the households in the main island centers by 2015; (ii) electrification of 80% of rural public facilities by 2015; (iii) electrification of 90% of rural households by 2020; and (iv) enhance the supply side energy efficiency of the FSM utilities by 20% by 2015.

The National Government has prepared its own energy action plan. In combination with the action plans prepared by the four States, this will delineate a road map that will assist the Nation in achieving its energy goals and objectives. The National Energy Action Plan has four major components: (i) energy efficient appliances; energy conservation (including renewable energy sources); energy awareness campaign; and nationwide energy programs. The last component covers training and capacity building, energy related studies, development of a centralized energy database, donor and development support and coordination and grid connected PV systems for the airport building in Kosrae.

## 3.10 CLIMATE CHANGE LEGISLATION

As noted above, in June, 2012, the FSM Environmental Protection Act became Public Law. It formalizes the current functions and responsibilities of the National Government in the area of environmental management and protection and provides OEEM with the authority to implement, via regulation, the multilateral environmental agreements that FSM had already ratified, including the UNFCCC.

Other than this, the only legislation on climate change to be passed at either National or State levels is the 2011 Act of the State of Kosrae to amend the Kosrae State Code to add new definitions and requirements relating to climate change and climate change adaptation measures. The Act recognizes and defines climate change and climate change adaptation measures, and requires the design and implementation of public infrastructure, such as roads and buildings, to incorporate climate change adaptation measures consistent with the requirements of FSM's Nationwide Climate Change Policy, with the Asian Development Bank "Climate Proofing: A Risk Based Approach to Adaptation (ADB, 2006) and "Climate Change Adaptation in the Pacific (2005), and as reflected through the continuing proceedings of the UNFCCC (1992 et seq).

However, State rules, regulations and codes on environmental protection, building construction and land use planning play an important role in minimizing the threats of climate change to the environment, structures, infrastructure and natural resources. Although there is still much to be done, most of the States have made initial efforts to guide sustainable development through the creation of land use plans, coastal zone plans and appropriate legislation and regulations. The challenge is to implement these plans and enforcing regulations in the face of increasing pressure on land use for economic development.

As an example, Pohnpei State Law 3L-26-92 forms the basis of environmental regulations in the State. It allows the State Environmental Protection Agency to establish rules and regulations related to: (a) earth moving, (b) environmental impact assessment, (c) water supply systems, (d) pesticides, (e) sewage, (f) solid wastes, (g) marine and fresh water quality, (h) air pollution and (i) groundwater. Section 14 declares criminal acts and penalties in violation of these rules and regulations.

Land degradation issues affecting the FSM States today include solid waste, coastal erosion, unsustainable agriculture, deforestation, dredging, soil moving, land filling, sea level rise, watershed land damage, land zoning, wildfires, and the forests. The primary issue is deforestation. Although strategies have been identified and developed to manage land degradation conditions, there is an urgent need to address these issues through effective enforcement so that the land can be utilized accordingly.

Master Land Use Plans are used in the management of land degradation issues. Such Plans provide guidelines for management of land degradation issues, and clarification of their own enforcement. But Land Use Plans in some States have not been adopted. In cases where the Land Use Plan is not utilized, laws are created to regulate. Thus each State has handled and managed its land degradation issues somewhat differently. In Kosrae State, appropriate officials and employees manage their land degradation issues through the Kosrae State Land Use Plan. In Pohnpei State, the Community's partnership with NGO's and other environmental agencies has led to community-based strategies to effectively manage land degradation problems, In Chuuk and Yap States the State Environmental Protection Agency (EPA) executes the implementation of land degradation projects.

## 3.11 INSTITUTIONAL ARRANGEMENTS AND COORDINATION

The FSM Environmental Protection Act designates OEEM as the focal point for all Government climate change activities. As a result, it is the coordinating agency for all climate change projects and activities. Importantly, through the common institutional platform of OEEM, FSM is pursuing an integrated approach to climate change and DRM. OEEM provides technical assistance for the implementation of activities relating to climate change and DRM, and provides scientific, technical and policy oversight.

The National Climate Change Policy identifies the following sectors and, in some cases, the agency responsible for implementing climate change adaptation actions:

- Agriculture/forestry including food security: Department of Resources and Development;
- Disaster management;
- Education: Department of Education;
- Environment: Office of Environment and Emergency Management;
- Gender;
- Health: Department of Health and Social Affairs;
- Infrastructure: Department of Transportation, Communication and Infrastructure;
- Marine/Coastal Resources and Pelagic Fisheries: Department of Resources and Development (DRD) and National Oceanic and Resource Management Authority;
- Tourism;
- Transportation;
- Water resources;
- Weather service; and
- Office of the President

To address climate change matters affecting environmental management and sustainable development in FSM, the Government established a Sustainable Development Council in the 1990s. Over the years FSM has worked closely with SPREP's Pacific Islands Climate Assistance Program, the Secretariat of the Pacific Community (SPC), including the former Pacific Islands Applied Geoscience Commission, and the United States Environmental Protection Agency's Country Studies. This included developing appropriate National strategies for addressing climate change at various levels.

Environmental agencies, both Government and NGOs, are active in addressing climate change by undertaking initiatives to protect the health and natural resources as an effective way to adapt. Government environmental agencies, especially, execute environmental laws and regulations of the US obligated under Compact II and those initiated by the FSM at the National, State, and local levels (Namakin, 2008). As noted above, responsibility for environmental issues is shared between the FSM National Government and the four State Governments. The States take the lead role in ensuring that development avoids vulnerable areas and that critical natural systems are protected.

The FSM National Water Task Force provides direction and strategic guidance to the National Water Policy Officer and to the Department of Resources and Development in relation to the development and implementation of a Comprehensive National Water and Sanitation Policy. It also guides mainstreaming of Integrated Water Resource Management and Water-Use Efficiency principles, and "Ridge to Reef' and "Community to Congress" management approaches, into National and State Government service delivery for water resource management and sanitation. In addition, the Task Force facilitates stakeholder involvement in water resource and wastewater management and takes action where necessary to ensure engagement involving appropriate levels of Government, traditional rights and customs, environmental NGOs, Church and Women's groups, and the private sector. It reviews community awareness of the need for improved water resource management throughout FSM and guides the National Water Policy Officer in planning and implemented water conservation awareness campaigns. An important role is to ensure compatibility between the activities of National demonstration projects and other National, State and community-based activities for Integrated Water Resource Management and Water Use Efficiency.

To achieve the goals of the Energy Sector Plan the Government has established a National Energy Workgroup (NEW). This body is chaired by the Energy Division, which works closely together with the energy sectors in each of the four FSM States. The aim of NEW is to improve coordination between National and State levels in the energy sector. It has responsibility for overseeing and coordinating activities in the country as a whole, as well as in the respective States. Its main task is to oversee and coordinate activities in the energy sector, especially in relation to implementation of the National energy policy. Since NEW consists of the main stakeholders involved in the energy sector, it provides a forum to discuss development in the energy sectors, especially as it pertains to renewable energy, and to help steer these development priorities in the direction as identified in energy policies and plans.

NEW interacts with various stakeholders at the National and State level including the Governments, the utilities, the private sector and NGOs. Its members are from the key departments in the National Government (Energy Division, Department of Resources and Development; OEEM; Office of SBOC; Department of Transportation, Communication and Infrastructure), State Representatives from each State Energy Workgroup, a Representative from the Association of Micronesian Utilities (AMU), a Representative from the College of Micronesia and the Government Energy Advisor(s) (Figure 30).

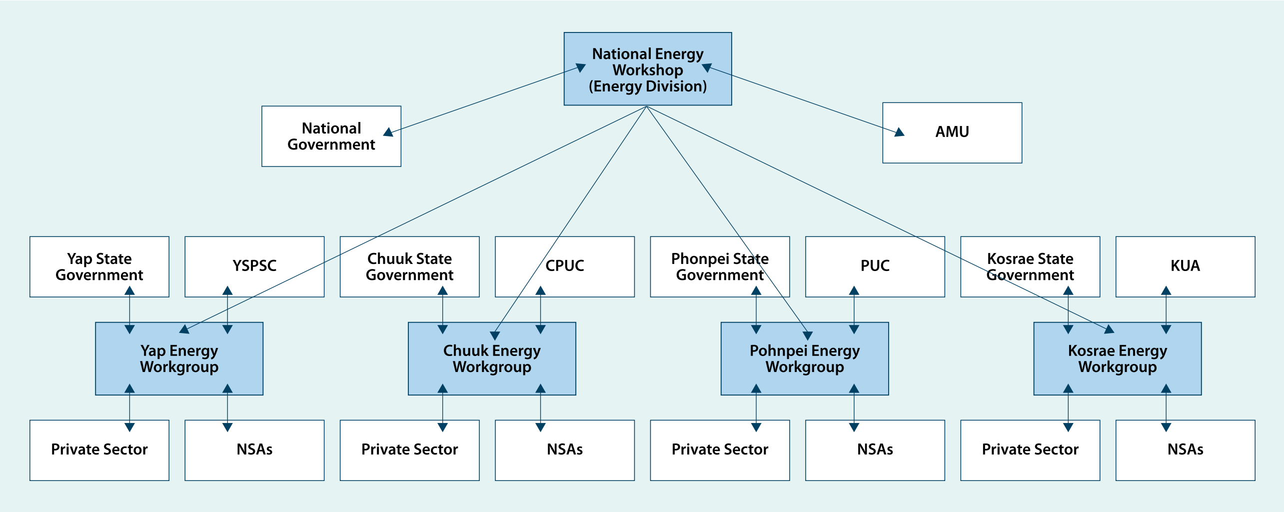
NEW is strongly connected to the four State Energy Workgroups (SEWs). These consist of three or four people: one from the State Government, one representative from the utility company, the State energy officer (currently this position only exists in Pohnpei) or an energy expert and a private sector or NGO representative. The SEWs are responsible for developing and updating the State energy action plans, which are in line with the National energy policy, and putting forward specific objectives and implementable actions at the State level. In addition, the main task of the SEWs is overseeing, coordinating and implementing activities in the energy sector of the State.

Sound management of environmental health and sanitation is vitally important to public health. Responsibility is divided between each State's EPA, or its equivalent, and the State Health Department. Although there should be no conflict in responsibility between the two, in several States the EPA has taken their mandate to include home water and sanitation issues. Consequently, water and sanitation have often been inadequately managed by both agencies. Promotion of clean water, good hygiene and sanitation at the village and home level is an important aspect of public health. Health Departments need to refocus their attention on this issue as an essential part of public health services.

The Health Department in each State has health education staff and programs. From time to time these touch on water quality and water handling issues, but there are no National level public education policies with respect to water supply and sanitation issues. This gap becomes particularly important during epidemics and with cases of water contamination, especially given that the World Health Organization estimates 80% of all diseases are in some way linked with contaminated water.

**FIGURE 30 | Institutional arrangement for the energy sector.**

*Source: FSM Energy Division, 2011.*




FSM's DRD is the lead agency in monitoring the implementation of the FSM Food Security Policy. All relevant sectors (agriculture, fisheries, trade, health, environment, education, transportation and private) are required to collaborate in evaluating the implementation of the Policy, with an evaluation undertaken every two years. The Policy is also to be updated every two years, as necessary.

## 3.12 CLIMATE CHANGE FINANCING

As shown in Table 18, the Nationwide Climate Change Policy provides a framework for climate change financing. Priorities include establishing a sustainable financing mechanism, using local financial sources to strengthen the capacity to respond to climate change, using the polluter-pays principle as a rationale for development partners to support adaptation, mitigation and other climate-related measures on an ongoing basis and in addition to existing and future ODA.

FSM currently relies on development partners to supplement its National budget. Alongside foreign earnings, development aid from foreign governments and international financial institutions plays a key role in the social and economic development of FSM. International and regional development partners provide approximately 60% of annual Government budget expenditure, equivalent to more than one-third of GDP. Of major importance is the financial grant arrangement between the governments of the USA and FSM, under the Compact of Free Association.

Of the approximately US$100 million available annually, 30% is required to contribute towards socio-economic development in the form of infrastructure improvements through to the year 2024. The allocation by sectors is detailed in Table 20.

**TABLE 20 | Compact Funding By Sector**

| Sector | Amount (US$ millions) |
|---|---|
| Water supply and wastewater | 141.9 |
| Education | 135.4 |
| Roads and pedestrian facilities | 120.9 |
| Maritime transportation | 88.5 |
| Air Transportation | 68.4 |
| Solid waste management | 40.8 |
| Health | 32.5 |
| Government buildings | 27.3 |
| Program Management | 10.7 |
| **TOTAL** | **747.5** |

Consistent with the Climate Change Policy, FSM leaders have expressed at both international and regional levels the need for additional resources to assist in identifying, prioritizing and implementing their adaptation actions and strategies for climate change. Representatives of the FSM have attended international climate change meetings to learn more about adaptation and to seek assistance for implementing FSM's adaptation policies and plans.

## 3.13 ENGAGEMENT IN REGIONAL AND INTERNATIONAL PROCESSES

FSM's position on climate change is unchanged from that reported to the World Summit on Sustainable Development in 2002. As an active member of Alliance of Small Island States, the FSM Government remains highly committed to fulfill its obligation to the United Nations Conference on the Environment and Development, the UNFCCC, and Sustainable Development of Small Island Developing States.

Because FSM realizes that climate change is a highly important issue that challenges the future of the country, the FSM Government ratified the UNFCCC in 1993 and the Kyoto Protocol in 1998, in order to ensure and protect the future of the people of FSM. FSM engages with a range of multilateral and bilateral development partners, including: (i) several United Nations agencies, such as the United Nations Children's Fund, UNDP and the United Nations Population Fund; (ii) agencies making up the Council of Regional Organizations in the Pacific, including SPC as well as the Forum Fisheries Agency; and other regional commissions, such as the Western and Central Pacific Fisheries Commission. Key bilateral development partners include Australia, the European Union, Japan, New Zealand, China and the USA. Other development partners include the Asian Development Bank, the International Monetary Fund and the World Bank. A Donor Forum was held in November 2012. Climate change will be on the agenda.

Since submission of FSM's INC, climate change representatives of the FSM Government have been actively involved in various climate change activities to address FSM's need to gain additional resources for mitigation and adaptation. Through on-going projects and program initiatives for each UN Convention, the FSM continues to work towards sustainability, despite its lack of adequate machinery, funding, and manpower resources. Such initiatives are geared to encourage society and the private sector to actively participate in sustainable development efforts for a better environment. Finally, FSM continues to enhance partnership ties with various international countries through environmental initiatives.

FSM joined with Palau, the Marshall Islands, the Commonwealth of the Northern Mariana Islands, and Guam as signatories to the Micronesian Challenge. As a result, FSM is committed to effectively conserve by 2020 at least 30% of the near-shore marine resources and 20% of the terrestrial resources across Micronesia. The Micronesian Challenge is seen as a giant step by leaders of the Micronesian countries to build the resilience of their communities to the impacts of climate change. Since 2002 more than five upland forests have been placed under protection, more than 15 new marine protected areas have been established, and the designation of two UNESCO Biosphere Reserves has occurred, all with NGOs and communities central to the process (FSM, 2010).

# 4

## CHAPTER FOUR
# VULNERABILITY AND ADAPTATION

## 4.1 INTRODUCTION

Climate change is perhaps the most serious threat facing the people and ecosystems of Micronesia, now and in the future. It will likely cause major adverse environmental, social, cultural, and economic repercussions and, in some cases, already is having detrimental consequences. All the islands of the FSM are vulnerable to the threat posed by these repercussions. Throughout the nation, the immediate coastal areas are typically the most heavily developed, providing homes, infrastructure, and economic opportunities for the majority of the population. On high islands, options for abandoning coastal areas affected by inundation or flooding and moving landward are quite limited due to steep slopes inland, and complex land tenure systems. On atolls, saltwater intrusion is already destroying taro and other crops, and damaging groundwater supplies even before potential large-scale inundation necessitates the migration of islet inhabitants. And, across the FSM, major historical and cultural sites located along shorelines could soon be lost forever.

As a consequence of these and other threats related to climate change, FSM is actively engaged in assessing the vulnerability to climate change, and to identifying and implementing adaptation measures. This represents significant progress from the situation when the INC was submitted. At that time, as no formal vulnerability assessments had been completed, the INC called for such studies to be undertaken. The INC did identify potential adaptation measures, but these were of a generic nature rather than being based on a formal assessment of their ability to reduce climate-related risks.

This chapter shows that considerable effort has been put into undertaking vulnerability and adaptation assessments in FSM, at a variety of spatial scales and for various sectors. There is a focus on food security as a priority theme for FSM's responses to climate change. However, there are still shortcomings, including:

- no comprehensive understanding of vulnerability to climate change at National, State, island or community levels;
- assessments are not being informed by the results of formal analyses of current let alone future risks; and
- identification of appropriate adaptation measures remains at a very generic level.

## 4.2 FOURTEEN ATOLL ASSESSMENT OF FOOD SECURITY

In 2010 the Government conducted vulnerability and adaptation assessments on 14 atoll islands in the States of Pohnpei, Chuuk and Yap, as part of the preparations for completing this SNC. The study was the first comprehensive ecosystem approach to assessing food security in the outer islands of FSM. Assessments were undertaken by seven working groups, covering the following thematic areas: Socio-economic Enumeration; Water Security and Coastline; Soils; Forest and Vegetation; Pests/Invasive Species; Marine Rapid Ecological Assessment; and Disaster and Risk Management.

The objectives of the assessment were to:

- establish the social baseline situation of the atolls;
- to assess the likely impacts of climate change and non-climate change factors on food security on the atolls;
- to assess the vulnerability of food security on atolls to climate change and non-climate change factors; and
- to design a monitoring and evaluation framework for the continuous assessment of impacts of climate change on food security and the effectiveness of adaptation measures implemented in order to reduce the impacts of climate change.

***Methods***

The islands covered in the assessment were: (a) Pohnpei Atolls: Nukuoro, Sapwuahfik; (b) Chuuk Atolls: Kuttu, Namoluk, Losap, Nomwin, Pisarach, Pollap; and (c) Yap Atolls: Satawal, Elato, Lamotrek, Gaferut, Falalop (Woleai), and Fadrai (Ulithi). The selection of islands was undertaken in consultation with the affected States, as well as the National Government Departments of Transportation Communications and Infrastructure, Resources and Development, and OEEM. The major criteria for selection were island attributes being: (i) representative of other islands as well as representing some unique characteristics; (ii) islands that can capture the various attributes that fill out the baseline data; (iii) islands that are considered most vulnerable; (iv) geographic location so that travel distance and time were minimized; and (v) overall cost and duration of the study.

Table 21 shows the household vulnerability matrix that was used to establish baseline, current and future vulnerabilities of food security on the 14 atolls.

The Pest and Disease Team was tasked to survey the major staple crops and other food crops of the atolls for pest and diseases including invasive species on plants and vertebrates. The specific objective of the survey was to determine pest and disease problems on giant taro and breadfruit which are the major crops and main food source on atolls. The survey was also extended to cover other food crops (e.g. bananas) and invasive species (Englberger et al., 2010).

Since agroforests serve as food production areas, sources of fiber and medicines, while providing the ecosystem services of forests, vegetation surveys were included in the assessment, consistent with the Forest Action Plan (see Table 19). SPC Land Resources Division, through the Forests and Trees Team along with FSM State Forest Resource Managers, undertook a vegetation survey that included the design of survey/monitoring plots, co-ordination and the actual field survey of the 14 atoll islands. The recently developed design for Monitoring, Assessment, Reporting of Sustainable Forest Management for atoll islands in the Pacific was used for the survey. With the absence of reliable maps and satellite images, four strips of 100m x 10m were established and assessed on all the atolls surveyed. Strips were evenly distributed along the islands, but ran across the islands. The four strips make up a plot. A total of 13 plots, one in each of the islands surveyed, were established and assessed (see Figure 31). Each plot consisted of 20 units of 20m x 10m, that is five units per strip and it covers a total sampling area of 4000m2 (Mateboto, 2010).

## TABLE 21 | Household Vulnerability Matrix for the Food Security Assessment

*(Source: Halavatau, 2010)*

| Risk of an Event | Ability to Cope | | | |
|---|---|---|---|---|
| Shocks/Trends | Household characteristics | Access to resources | Production/income opportunities | Support structures |
| BASELINE VULNERABILITY<br>Crop production<br>Droughts<br>Soil conditions<br>Pests and diseases<br>Market risks<br>Price fluctuations<br>Food shortages<br>Access to employment | Composition<br>(age dependency ratio)<br>Education<br>Health status<br>Outmigration | Access to land<br>Access to labour<br>Liquid assets<br>Productive assets<br>Credit<br>Common property<br>(for wild foodstuff and other products)<br>Food stores | Crop/livestock production<br>Other income sources<br>Seasonal migration | Community support mechanisms (claims)<br>NGOs<br>Govt policies<br>Access to social services |
| CURRENT VULNERABILITY<br>Crop production and livestock risks<br>Droughts<br>Soil conditions<br>Pests and diseases<br>Market risks<br>Price fluctuations<br>Food shortages<br>Access to employment | Composition<br>(age dependency ratio)<br>Education<br>Health status<br>Outmigration | Access to land<br>Access to labour<br>Liquid assets<br>Productive assets<br>Credit<br>Common property<br>(for wild foodstuff and other products)<br>Food stores | Crop/livestock production<br>Other income sources<br>Seasonal migration | Community support mechanisms (claims)<br>NGOs<br>Govt policies<br>Access to social services |
| FUTURE VULNERABILITY<br>Climate change<br>Environmental degradation<br>Land pressures<br>Outmigration | Demographic changes | Land tenure changes | Employment trends | Support structure changes |

## FIGURE 31 | Plot layout and strip design

*Source: Mateboto, 2010.*


The vulnerability and adaptation assessment undertaken by the marine survey team was designed to determine the marine stock which adds value to the management of and atolls' food security and resiliency. Atoll communities and reef owners provided guidance on the reef areas being impacted by climate change, including coral bleaching, crown of thorns and starfish abundance. Local marine experts selected sites for detailed studies, based on the ecological features of the lagoon/fringing reefs in targeted islands. These included the windward and leeward side of the inner/outer reef slope/wall of the lagoon/fringing reefs. Survey methods included use of coral photoquads to determine coral diversity and develop coral resiliency indicator. Fish density counts and belt transects were used to determine fish diversity. Herbivore fish count was used as a resilience indicator. Macro-invertebrate density counts and belt transects were used to determine species diversity. Benthic health observations were undertaken at every other two meter on the belt transects. Observation time swims (50 meters x 10 minutes x 5 sets) were used to survey reef morphology (Takesy, no date).

The results provided by these surveys were used in a climate change and food security vulnerability analysis for the 14 atolls, based on the understanding vulnerability equates to the product of exposure to risk and inability to manage the risk. Three types of indicators were used: food security status indicators, indicators of the degree of exposure to risks and indicators of the ability to manage the risks at different levels (Halavatau, 2010).

### *Findings*

**Pests and Diseases.** The survey of the major staple crops and other food crops of the atolls for pest and diseases, including invasive species on plants and vertebrates identified major variations in the presence of invasive plants species amongst the islands. There were 12 invasive plant species identified competing mainly with giant swamp taro, and therefore affecting productivity. At the time of the survey most insects were present in low numbers. However, mealybugs were present on most islands and on the islands of Pisarach, Pollap and Satawal they were present in high numbers affecting taro, breadfruit, coconut, banana and other crops (Englberger et al., 2010).

From 47 ant samples, 24 different species have been identified. Three species are amongst the top 10 invasive ant species in the world. From the 38 giant swamp taro samples, most of them were infested either as adults, eggs or juvenile nematodes. All nematodes found on giant swamp taro were *Radopholus sililis*. From the seven banana samples, five samples were infested with the nematodes *Pratylenchus sp.*, one had Radopholus similis and two out of the five samples had both species.

The mango fruit fly, known to be present throughout the FSM, was the only species found on most islands. The islands of Nomwin and Elato were free from fruit flies. On breadfruit trees, longhorn beetle larvae were found to tunnel inside branches, causing parts of the branches to die. For those introduced plant species that are not widespread eradication is recommended.

Black leaf steak disease on banana was prevalent on most islands. Citrus canker was present on Nukuoro, Pisarach and Pollap; a parasitic mushroom was found on banana, causing significant damage on some of the islands.

In many cases it was observed that bananas stems were breaking before bunches were ready for harvest. This is mainly caused by poor management, overcrowding of bananas and absence of best agricultural practices, e.g. mulching, de-leaving of old leaves and leaving sufficient space between plants. Other major damage included leaf burning on giant swamp taro *(Cyrtosperma)*. This is caused by stressed plants due to the prolonged drought and, in most cases by sea water damage (flood) and salt water intrusion. Rats were reported to be a problem on all islands. For the island of Gaferut which is a breeding area for birds, rat eradication is recommended.

It is likely that a change in climate could trigger an outbreak of certain pests, e.g. mealybugs, scale insects, whiteflies. For most of the diseases sanitation is one of the recommendations. For the control of mealybugs, biological control is recommended.

**Agroforesty.** Forests and planted trees can help local communities adapt to climate change through livelihood diversification and provision of ecosystems services. Sustainable management of forest and tree resources increases the resilience of people and eco-systems to cope with extreme weather patterns, and therefore safeguarding food security. Mateboto (2010) found that the main drivers of forest and tree clearing in the atolls were clearing for agriculture, clearing for infrastructure development, clearing for village expansion due to high population, burning, unsustainable harvesting and unnecessary clearing, and the lack of appreciation or knowledge of the values of forest and trees. He recommended that it is important to maintain and build a resilient landscape for food and water security, protection of soil, coastal erosion, biodiversity and adverse weather conditions, and recommended the mitigation and adaptation measures shown in Table 22[4]. He also recommended that a reassessment should be undertaken every three to five years, to monitor the status of the forest and tree resources.

[4] In small island countries there are often strong synergies between adaptation and mitigation interventions, resulting in significant co-benefits – locally and globally. Table 22 provides some tangible examples

## TABLE 22 | Adaptation and Mitigation Measures for Forest and Tree Resources

*(Source: Mateboto, 2010)*

| Critical Vulnerable Sectors/ Systems | Impacts | Adaptation/ Mitigation Option I | Adaptation/ Mitigation Option II | Adaptation/ Mitigation Option III |
|---|---|---|---|---|
| Forest & Tree Resources | ▪ Change in Species composition<br>▪ Coastal erosion, salt spray<br>▪ Salt water intrusion, salination<br>▪ Food insecurity<br>▪ Loss of Biodiversity, genetic resources<br>▪ Forest & tree health and Invasive species<br>▪ Carbon Emissions<br>▪ Extreme weather patterns | **Sustainable Management of Forest & Tree resources:**<br><br>*Fire Management*<br>▪ Reduce/Stop burning of trees<br><br>*Forest & tree Conservation*<br>▪ Stop unnecessary cutting of trees<br>▪ Replant breadfruit and coconut trees | **Forest restoration and rehabilitation:**<br><br>Restoration of Mangrove forest<br><br>Rehabilitation of coastal forest & trees, e.g. planting of *Calophyllum inophyllum, Casuarina equisetifolia* | **Sustainable agriculture systems:**<br><br>Agro – Forestry<br><br>Raising of planting areas by de-composting and mulching<br><br>Introduce other variety of breadfruits that may fruit at different times as the local variety.<br><br>Introduce climate change resilient crops (CePaCT) |

In order for the FSM to be able to carry out these recommended adaptation and mitigation measures, Mateboto (2010) identified the following needs:

- Reliable information on forest resources;
- Sound forestry policies and programmes for climate change mitigation and adaptation consistent with forestry and sustainable development objectives;
- Capacity and resources for implementing sustainable forest management;
- Ability to address inter-sectoral issues; and
- Education and awareness.

**Food Security.** Vulnerability of food security was assessed using the four determinants of food security – food availability; food access, food utilization and stability (Halavatau, 2010). With regard to food availability, most households on the atolls grow their own food. The main staple crops were used to assess vulnerability of domestic production to climate change and non-climate change factors. The PlantGro computer model was used to assess the impacts of climate change on the most important staples as well as introduced crops that can be grown to improve the supply of locally grown food.

Swamp taro does well where precipitation exceeds evapotranspiration on an annual basis. It can tolerate temperatures as high as 100°F (38°C). It is a hydrophyte (water loving plant) adapted to fresh to brackish water conditions. pH tolerance of swamp taro has not been studied much, but has been found to grow on acid sulphate soils to soils with subsoil pH of more than eight. At salinity of three to six ds/m, swamp taro will fail to grow.

Tolerance of atoll breadfruits is relatively high. It can still yield even if rainfall is reduced to around 40 in (1000 mm). A drought of a few months can be tolerated, but fruits will prematurely drop. It can still survive if temperatures are increased to around 104°F (40°C). On atolls breadfruit can grow in quite high salinity soils - of more than 6ds/m. Some varieties should be able to tolerate 12ds/m.

Pandanus grows well in areas with rainfall 1500 to 4000mm. However, it can withstand droughts of up to 6 months or more. It also grows well where temperatures are 75°F to 82°F (24 to 28°C), but can survive where temperatures are up to 97°F (36°C). It can withstand salt spray and is commonly found on coastal soils, sandy and rocky beaches. It can grow on free drained soils to impeded drainage. It will grow well in saline, sodic and nutrient poor soils as well as peat swamps. It will survive salinity of 6ds/m.

Banana plants adapted to atoll conditions can withstand temperature and rainfall changes, but at a salinity of 6ds/m or more the yield decreases significantly. Coconut can withstand temperature changes, rainfall and salinity up to 12ds/m.

The preceding results show that increasing soil salinity is the greatest threat to crop productivity on the atolls of FSM. Increasing soil salinity of atoll soils to 6ds/cm kills crops like cassava, pawpaw, and yams. And when soil salinity is increased to 12ds/cm (a condition caused by sea water inundation), only coconut and the dryland giant taro (sawahn Hawaii, tannia, *Xanthosoma sagittifolium*) can survive.

In addition to crop production being vulnerable to the impact of climate change, there are also non-climate change factors affecting crop production. These include poor soils on atolls, pests and diseases, deforestation, loss of biodiversity, limited choice of livestock, erosion of traditional knowledge, and limited trading. Effective adaptation initiatives should integrate both climate change and non-climate change factors.

On average all atolls are food secure from the point of view of food availability since all islands have more kcal/capita/day than the FAO/WHO minimum of 2100 kcal/capita/day. But the contribution of imported foods (especially cereals) to the diet is quite significant, ranging from 17 to 43%. With limited transportation services the observed trend of increasing dependency on imported food is a major concern.

The preceding analysis of food availability undertaken by Halavatau (2010) indicates some vulnerability on the atolls. Clearly the staple crops are vulnerable to climate change, especially impacts of sea-level rise in terms of increasing salinity. This will compound the already traditional (non-climate change) factors such as soil infertility, pests and diseases. There is a need for an on-going evaluation for adaptable varieties of traditional crops as well as introduced root crops like taro, cassava, and sweet potato. A detailed analysis of food balance sheets (Table 23) shows there are vulnerabilities in terms of availability of foods. The availability of local meat is low and, if not addressed, can result in increased reliance on imported meat and tinned meat. The increasing contribution of imported foods to the diet is a very big concern as it will have adverse effects on promotion of growing and consumption of local foods.

The best adaptation will be the promotion of growing of local foods and developing legislative framework to guide importation of processed and other food products.

With regard to household food access, a household can access food either by producing its own foods or by procuring food. Indicators to measure household access include access to land, household food production, and household incomes. At least 70% of households in the atolls own land, with sizes ranging from 0.2 acres to over 10 acres (0.1 to four hectares). A majority of the land is of average to good quality. Most of the households who own land produce their own food. Most households produce enough food crops and catch enough marine foods, but local meat production is not enough for all atolls.

Average incomes per household for the atolls range from US$35 to US$628/week and more than 50% of households of most atolls stated that their incomes were not sufficient. For most atolls the expenses that had most impact on their incomes were food security expenses. Analysis of the indicators of household food access suggests that household production is vulnerable to climate change. This is further discussed under food availability. Access to land is also vulnerable to sea-level rise and its impacts on increasing salinity and rendering land quality poor. Households are also vulnerable to events of global economic crisis and high prices of imported food items.

## TABLE 23 | Food balance sheets for the individual atolls surveyed

*(Source: Halavatau, 2010)*

| Atoll | Quantity/ person/day | Local starch | Wild harvest | Local fish | Local meat | Coconut | Sugar | Cereal | Imported Meat | Imported Fish | Milk | TOTAL | % Import |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kuttu | Kg | 0.47 | 0.26 | 0.84 | 0.03 | 0.44 | 0.01 | 0.28 | 0.02 | 0.01 | 0.006 | 2.367 | |
| | Kcal | 426.6 | 292.5 | 588 | 72.6 | 813 | 38.7 | 948.8 | 28 | 19.7 | 3.7 | 3231.6 | 31.9 |
| Nomuwin | Kg | 0.78 | 0.17 | 0.85 | 0.04 | 0.34 | 0.02 | 0.39 | 0.036 | 0.005 | 0.006 | 2.637 | |
| | Kcal | 700 | 248.9 | 595 | 85.3 | 636.6 | 77.4 | 1345.2 | 43.9 | 8.65 | 3.7 | 3744.65 | 39.5 |
| Nomulok | kg | 0.41 | 0.14 | 0.59 | 0.03 | 0.23 | 0.02 | 0.32 | 0.023 | 0.011 | 0.006 | 1.777 | |
| | kcal | 594 | 155.2 | 406 | 72.6 | 423.2 | 77.4 | 1138 | 28 | 19.7 | 3.7 | 2917 | 43.2 |
| Losop | kg | 0.98 | 0.37 | 1.22 | 0.04 | 0.32 | 0.02 | 0.46 | 0.06 | 0.02 | 0.006 | 3.506 | |
| | kcal | 1029 | 414.2 | 681 | 176 | 588.8 | 77.4 | 1575 | 72 | 37 | 3.7 | 4654.1 | 37.9 |
| Piherarh | kg | 1.62 | 0.49 | 0.38 | 0.04 | 0.35 | 0.02 | 0.35 | 0.01 | 0.008 | 0.006 | 3.706 | |
| | kcal | 1418.9 | 673.35 | 448.73 | 71.1 | 645 | 77.4 | 1223.5 | 23.3 | 13.8 | 3.7 | 4598.78 | 28.6 |
| Pollap | kg | 0.82 | 0.35 | 0.58 | 0.04 | 0.25 | 0.01 | 0.35 | 0.01 | 0.01 | 0.006 | 2.426 | |
| | kcal | 870.6 | 579.1 | 717 | 78.8 | 460 | 38.7 | 1231.6 | 21.2 | 17.3 | 3.7 | 4018 | 32.7 |
| Elato | kg | 0.94 | 0.23 | 0.44 | 0.03 | 0.29 | 0.02 | 0.28 | 0.05 | 0.02 | 0.006 | 2.306 | |
| | kcal | 983.1 | 80.55 | 523.65 | 66.24 | 533.6 | 77.4 | 948.8 | 93.5 | 34.6 | 3.7 | 3345.14 | 34.6 |
| Lamotrek | kg | 0.91 | 0.2 | 0.36 | 0.05 | 0.28 | 0.02 | 0.24 | 0.01 | 0.005 | 0.006 | 2.081 | |
| | kcal | 913 | 85.7 | 443.21 | 123.7 | 515.2 | 77.4 | 838.2 | 23.3 | 8.65 | 3.7 | 3032.06 | 31.4 |
| Fadarai | kg | 0.71 | 0.37 | 0.75 | 0.05 | 0.43 | 0.02 | 0.33 | 0.02 | 0.01 | 0.006 | 2.696 | |
| | kcal | 666.8 | 201.4 | 839.5 | 101.9 | 800 | 77.4 | 1163.6 | 27 | 18.5 | 3.7 | 3898.8 | 33.1 |
| Woleai | kg | 0.58 | 0.24 | 0.38 | 0.08 | 0.24 | 0.02 | 0.31 | 0.01 | 0.03 | 0.003 | 1.893 | |
| | kcal | 592 | 110.3 | 475.8 | 176.2 | 441.6 | 77.4 | 1072 | 21.2 | 47.1 | 1.85 | 3014.95 | 40.45 |
| Satawal | kg | 0.7 | 0.33 | 0.31 | 0.06 | 0.22 | 0.01 | 0.31 | 0.1 | 0.01 | 0.006 | 2.056 | |
| | kcal | 690.2 | 277.5 | 385 | 112.4 | 404.8 | 38.7 | 1050 | 144.2 | 17.3 | 3.7 | 3123.8 | 40.1 |
| Nukuoro | kg | 0.89 | 0.4 | 0.46 | 0.07 | 0.37 | 0.03 | 0.17 | 0.09 | 0.02 | 0.006 | 2.506 | |
| | kcal | 720.4 | 509.5 | 585.9 | 134.1 | 675 | 116 | 218.7 | 160.6 | 34.6 | 3.7 | 3158.5 | 17.01 |

Adaptation measures include addressing food production issues, as discussed under food availability. Each atoll should also develop income opportunities to improve the purchasing power of households.

With regard to food utilization, indicators such as dietary diversity, perception of food sufficiency and security, and number of meals per day can be used. However, the study used meal frequency. This revealed a risk of moving into reliance on imported foods. Atoll populations also face increased occurrence of NCDs in a substantial percentage of the households.

It is recommended that each State in FSM consider developing a regulatory framework to guide importation of food to counter increasing NCDs and vitamin and mineral deficiencies.

Analyses showed that stability of food supply in the atolls is affected by transport (shipment) of food to the islands, and by natural disasters such as cyclones and droughts. If the potential impacts of climate change are not addressed, food supply will also be affected.

Overall Halavatau (2010) highlighted the need to consider the impacts of climate change on food security. The study established a methodology for developing baseline data that can be used to develop baseline situation for food security and to assess the vulnerability of food security to climate change.

The atolls of FSM are vulnerable to climate change impacts on food security in the following ways:

- Food availability is vulnerable to climate change especially increasing salinity due to sea level rise affecting food production – crops, fisheries, and animals. There are also traditional factors such as poor soils, pests and diseases, etc which should be taken into consideration in the equation in a holistic manner;
- Household food access is also vulnerable because incomes are low and there is increasing reliance on imported foods which means cheap poor foods will be purchased; and
- Food consumption is vulnerable to changing diet – there is a trend of moving to imported foods and there is also a trend of NCDs on the atolls related to overeating and maybe changing dietary patterns to imported low quality foods.

Overall, the adaptation potential for the food security sector was identified to be:

**Public Awareness.** It is important to train and educate farming communities and the public in climatic change and its potential impacts on life. Improved training and general education of populations dependent on agriculture should also be conducted. Agronomic experts can provide guidance on possible strategies and technologies that may be effective. Farmers must evaluate and compare these options to find those appropriate to their needs and the circumstances of their farm.

Technological Potential to Adapt. Technological options with promise for adapting to climate change are:

- Introduction of salt tolerant species: Increased soil salinity will be the most important agricultural problem in the vulnerable areas; salt tolerant varieties of current crops (swamp taro, breadfruit and banana) should be sourced; otherwise new salt tolerant crops should be introduced;
- Introduction of heat tolerant crops: The current sources of vegetables for FSM are mostly European cool vegetables such as cabbages, tomatoes, potatoes, etc; with the expected temperature increases as part of climate change, there is a need to introduce heat tolerant vegetable crops both for domestic consumption and for potential export;
- Improved Pest and Disease Management: Climate change will create a new pest and disease regime, and therefore the need to develop improved pest and disease management programs;
- Crop Research: There is a need also to invest in agricultural research aiming at developing crop management strategies for the future climate conditions;
- Restoration of Degraded Lands: Sea-level rise will result in land degradation; this implies the need for a degraded land restoration policy to restore lands for such purposes as agriculture;
- Farm Relocation: Sea level rise will result in flooding and inundation of some farmlands; these farms should be relocated to locations still fit for farming;

- Agricultural Diversification: Government should be prepared by having an agricultural diversification plan for vulnerable areas; this should include potential non-agricultural developments better fitted to the anticipated conditions in the vulnerable areas;
- Promotion of Agroforestry: Many of the current farming systems problems are related to roles of trees; it is therefore essential to revert farming systems to traditional agroforestry systems; but with modifications addressing the environmental shortcomings of such systems.

## 4.3 STATEWIDE ASSESSMENTS AND RESOURCE STRATEGIES

State-Wide Assessments and Resource Strategies (SWARS) are five year forestry action plans. They are a tool for islands to identify their highest priorities for forest resource management and seek implementation of their strategies, with on-island partners and with assistance from the US Department of Agriculture (USDA) Forest Service (FS) and other donors. The SWARS includes two components in the assessment and planning to identify priority forest landscape areas and highlight work needed to address National, regional, and State forest management priorities, namely: (i) State-wide Assessment of Forest Resources which provides a spatial analysis of forest conditions and trends in each State and delineates priority rural and urban forest landscape areas; and (ii) State-wide Forest Resource Strategy—provides long-term strategies for investing State, federal, and other resources to manage priority landscapes identified in the assessment, focusing where federal investment can most effectively stimulate or leverage desired action and engage multiple partners (FSM Department of Forestry, 2010).

***Methods***

Preparation of FSM's SWARS was been a collaborative effort and iterative consultation process coordinated by FSM's DRD, with assistance from The Nature Conservancy and the USFS, in cooperation with the Chuuk, Kosrae, Pohnpei and Yap State Forestry agencies to identify priorities in line with their three National themes. Through coordination by FSM DRD with the FSM States, several consultation processes and trainings were undertaken to develop the assessment component of the SWARS using GIS data for the spatial analysis. Several agencies and other key partners, including conservation NGOs, communities, and natural resource related entities were involved in the SWARS process (FSM Department of Forestry, 2010).

***Findings***

The SWARS focuses on program-by-program planning and emphasizes program integration to meet island priorities, which are in turn tied to one or more broad National themes and objectives (Table 24).

*Landslide chuuk by US FEMA*

## TABLE 24 | National Themes and Objectives

*(Source: FSM Department of Forestry, 2010)*

| | National Themes | | FSM Issues | Relevant FSM SDP Sector Goals |
|---|---|---|---|---|
| 1. | Conserve Working Forest Landscapes | 1. | Food security (agroforest) in response to climate change impacts. | Agriculture Sector Strategic Goal 1: A well resourced and properly focused agriculture sector operating within a stable and consistent policy framework. |
| 1.1 | Identify and conserve high priority forest ecosystems and landscapes. | 2. | Coastal stabilization (strand forest and mangrove forest) in response to climate change impacts. | Agriculture Sector Strategic Goal 2: Increase production of traditional farming systems for home nutritional and transitional needs and cash incomes. |
| 1.2 | Actively and sustainably manage forests. | 3. | Biodiversity conservation (relates to Forest Legacy, invasive species control, protected areas management, gap analysis, etc. | Agriculture Sector Strategic Goal 3: Increased volumes of saleable surpluses to be marketed by the private sector into local and regional markets. |
| 2. | Protect Forest from Harm | 4. | Watersheds (high islands). | Agriculture Sector Strategic Goal 4: Promote environmentally sound and sustainable production. |
| 2.1 | Restore fire-adapted lands and reduce risk of wildfire impacts. | 5. | Productive and sustainable harvesting of forests. | Environment Sector Strategic Goal 1: Mainstream environmental considerations, including climate change, into national policy and planning as well as in all economic development activities. |
| 2.2 | Identify, manage and reduce threats to forest and ecosystem health. | 6. | Urban and community forestry (utilities cooperators, hazard tress, arboriculture). | Environment Sector Strategic Goal 3: Reduce energy use and convert to renewable energy sources/Minimize emission of greenhouse gases. |
| 3. | Enhance Public Benefits from Trees and Forests | 7. | Capacity-building – overall (recruiting new generation of natural resource managers). | Environment Sector Strategic Goal 4: Enhance the benefits of sustainable use of the FSM's genetic resources and ensure benefits derived are fairly shared amongst shareholders. |
| 3.1 | Protect and enhance water quality and quantity. | | | Environment Sector Strategic Goal 5: Manage and protect the nation's natural environment, protect, conserve and sustainably manage a full and functional representation of the FMS's marine, freshwater and terrestrial ecosystems. |
| 3.2 | Improve air quality and conserve energy. | | | Environment Sector Strategic Goal 6: Improve environmental awareness and education and increase involvement of the citizenry of the FSM in conserving their country's natural resources. |
| 3.3 | Assist communities in planning for and reducing forest health and wildfire risks. | | | Environment Sector Strategic Goal 1: Establish effective biosecurity (border control, quarantine and eradication) programs to effectively protect the FSM's biodiversity from impacts of alien invasive species. |
| 3.4 | Maintain and enhance the economic benefits and values of trees and forests. | | | |
| 3.5 | Protect, conserve, and enhance wildlife and fish habitat. | | | |
| 3.6 | Connect people to trees and forests, and engage them in environmental stewardship activities. | | | |
| 3.7 | Manage and restore trees and forests to mitigate and adapt to global climate change. | | | |

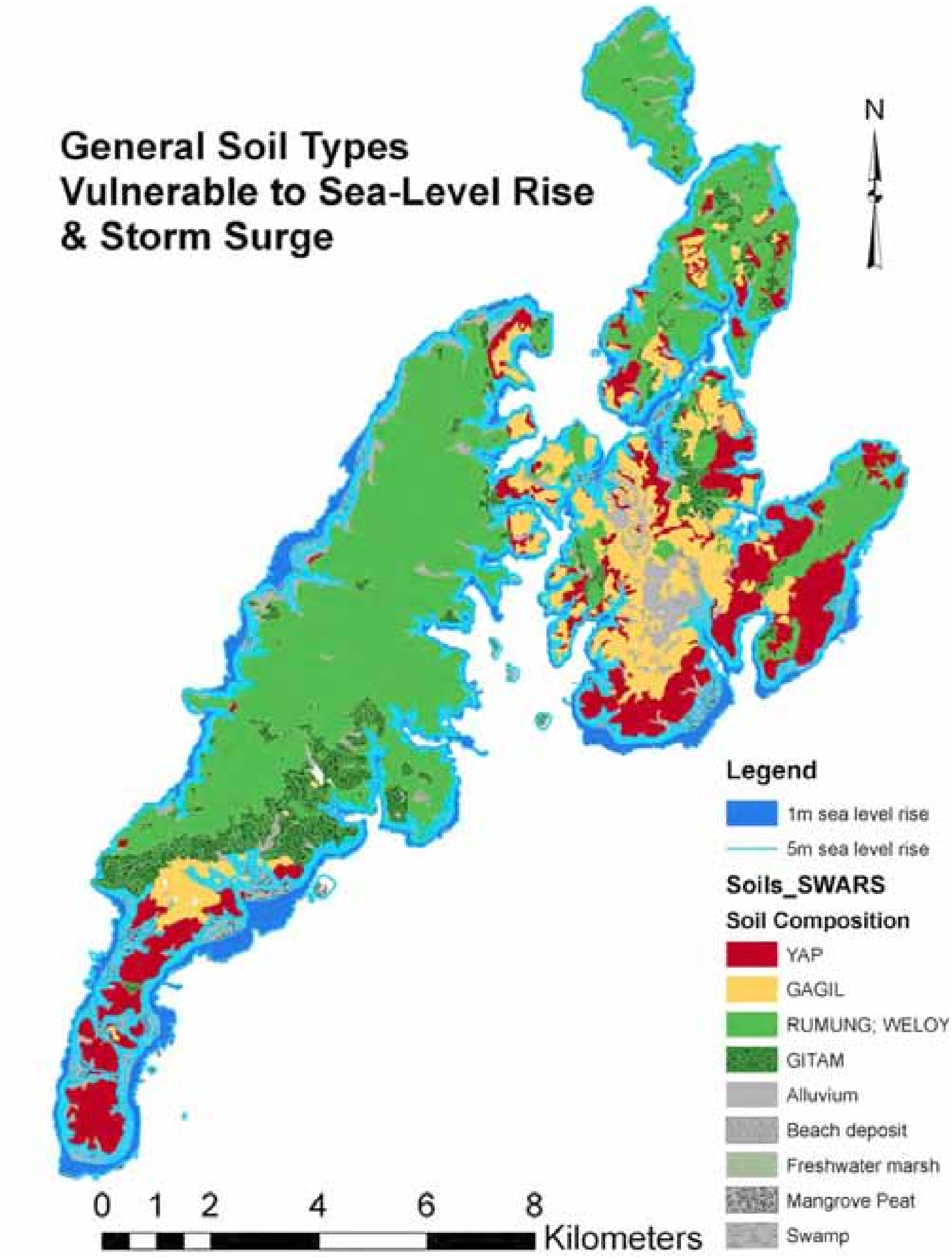
A number of shared major issues emerged during the assessment process.

**Food Security.** This is a major concern of all four States, especially with respect to climate change and sea-level rise (FSM Department of Forestry, 2010).. For example, the Yap State map showing that the islands most fertile alluvial soils are all vulnerable to salt water inundation (Figure 32) indicates the magnitude of this challenge. In urban areas on the high islands, most of the agricultural areas are located around coastal areas and vulnerable to rising ocean waters and are already enduring increased flooding and drainage problems (FSM Department of Forestry, 2010).

**FIGURE 32 | General soil types, along with a blue overlay indicating the zone of 1 meter sea level rise (in dark blue), and the areas vulnerable to a 5 meter storm surge (in light blue)**

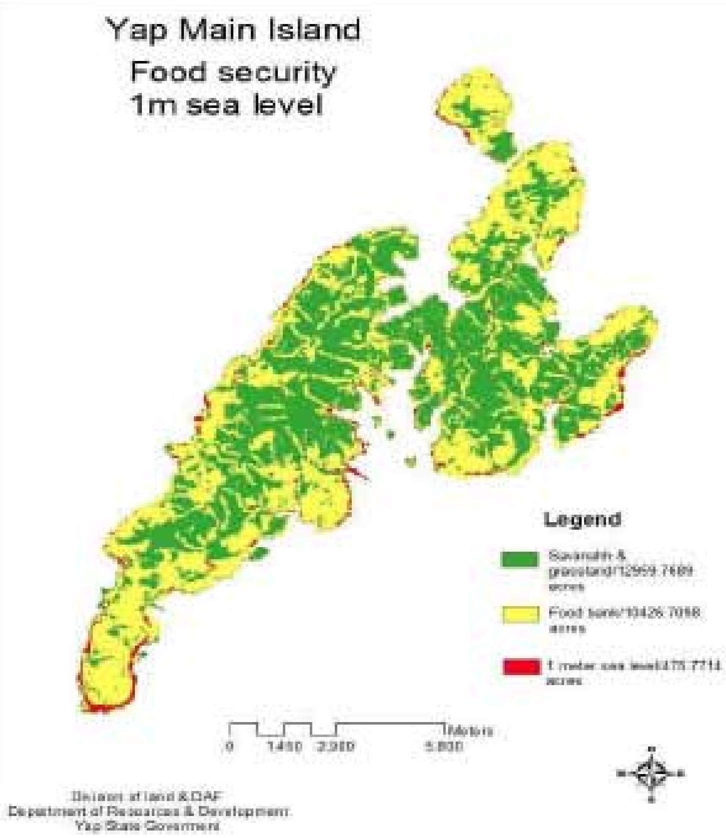
The map indicates that most of Yap's most fertile (alluvial) soils are vulnerable to storm surge

*Source: FSM Department of Forestry, 2010.*



The high islands of the FSM will need to begin now to prepare for rapid population increase in the form of climate change refugees from low-lying islands, while at the same time, enhancing and adapting their own food production systems. Most agricultural areas on the high islands are also located near coastal areas which are susceptible to sea-level rise and storm run-off during intensive rainfalls. Figure 33 shows a spatial analysis of the impact of a one-meter rise in sea level on areas in Yap that are more suitable for food production. GIS analysis showed the impact of potential storm surge areas currently used for food crops cultivation. While GIS maps are yet to be produced for the other three FSM States, it should be noted that the main islands (volcanic islands) are vulnerable to sea surge as most of the communities and agricultural production is located within the coastal zones (FSM Department of Forestry, 2010).

**FIGURE 33 | Impact of 5-meter storm surge on areas suitable for food production on mainland Yap**
All of Yap's Outer Islands (with the exception of Fais) are mostly within the 2-meter zone of sea level rise, and within the area of potential storm surge




*Source: FSM Department of Forestry, 2010.*

Biodiversity conservation includes maintaining ecosystem integrity, conserving native species and the major biosecurity issues of invasive species and wildfires. All States have identified areas of special biodiversity significance, and keystone habitats (such as mangroves and sea turtle and seabird rookeries), and keystone species such as fruit bats (flying foxes). The conservation of these areas involves addressing forest health "biosecurity" issues of invasive species and wildfires as well as establishment of protected and wisely managed areas.

**Watersheds.** All States recognized the importance of, and requested assistance for managing watersheds on a landscape basis. The States with the highest mountains, Pohnpei and Kosrae, are already working on central watershed reserves. The States of Chuuk and Yap have more scattered, smaller watersheds and will be developing proposals for grants to evaluate and begin working in high priority watersheds. On low-lying atoll islets, the issue is not watersheds, but the thinning of fresh water lenses.

**Production and Sustainable Harvesting.** All four States face problems of unsustainable harvest of forest resources. The unsustainable harvesting of mangroves for firewood is greatest in Kosrae and Chuuk. Ironically, the most unsustainable exploitation of upland trees for lumber is in Yap which has the least amount of forest with big trees. Yap is already experiencing an unsustainable number of sawmills, and a foreign owned sawmill has recently been set up in Kosrae. All States are requesting an assessment of the level of timber that could be sustainably supported (or the lack of such potential). Such information is urgently needed in Yap and Kosrae, and it is important that other States have information from such an assessment up front, before timber extraction projects are proposed or just initiated.

There is also a need to plant more trees to provide a sustainable supply of timber, tree crops and forest habitat, and to protect the best tree planters, namely fruit bats and birds (FSM Department of Forestry, 2010).

**Coastal Stabilization.** Coastal stabilization is a great concern of all States, especially on low-lying islands where the existence of a whole culture of Rematau, "people of the deep sea" adapted to life on small islets and to traditional seafaring is threatened. On high islands it is essential to protect mangroves as a hedge against storm winds and surge. Mangroves sequester more than their share of atmospheric carbon and store it in deep mud, adding prospects of revenue from carbon credits to the ecosystem service value of these marine forests. Mangroves are under great threat throughout the FSM. Most States have developed or are working on, or planning to develop mangrove management plans. Negotiations for carbon credits will help increase incentives to preserve mangroves. We are already seeing how some efforts to protect coastlines serve to telescope the problem to adjacent areas. Expert advice on coastal management is urgently needed to guide activities in the FSM.

**Urban Forestry.** There is a need to turn forestry from a small Government agency into a community concern. Forestry agencies can assist communities in developing and implementing quality projects.

**Capacity Building.** There are three needs for capacity building in Forestry. With the advent of the Micronesia Challenge and other expectations, Forestry staff currently find it difficult to both carry out work under performance-based budgets as well as to accommodate such additional programs and visitors. A second need in capacity development is for training relevant to work at hand. Forestry agencies are interested in opportunities for scholarships to develop forestry professionals, internships and relevant training resulting in certification in needed skills. The third need in capacity development is to assist communities in understanding environmental issues and in developing and implementing quality projects (FSM Department of Forestry, 2010).

## 4.4 FOOD SECURITY ASSESSMENT

Subsequent to the 14 island assessment, another study assessed food security in the FSM (Susumu and Kostka, 2011). The specific aims were to: (i) describe the food security situation in FSM with respect to the four dimensions of food security (availability, accessibility, nutrition and stability); (ii) analyze food security and its underlying vulnerabilities; and (iii) identify strategies and actions to food insecurity in the FSM.

### *Methods*

The study was undertaken using secondary data and National reports. Qualitative interviews and participatory analysis were also conducted with public and private sectors responsible for food for the FSM people. A food security problem analysis was undertaken to guide the development of a FSM food security logframe (Appendix 4). The logframe also took into consideration the priority actions identified during the FSM Food Summit (March 2010). This also involved stakeholder analysis and problem analysis on Food Security problems in FSM.

### *Findings*

Susumu and Kostka (2011) document several important findings. Low local food production and consumption habits favor imported food items. As a result, cash income is a major factor in accessing food. Unemployment is a serious problem not only in the urbanized centers of FSM States but also in rural areas. A high unemployment rate, compounded by large household sizes, is resulting in growing poverty and hardship in FSM. The situation in Chuuk is particularly serious, with every employed person supporting, on average, 12 others.

High migration rates are also eroding labor in the rural areas. Another growing problem is the nutritional value of food consumed due to favoring imported food. Studies indicated that consumption of imported poor quality food is high for the youths. Rice and other poor nutrition imported foods are becoming the main staple food for Micronesians. Dependency on food imports is causing loss of agricultural/crop diversity and taste of local foods, resulting in high incidence of non-communicable diseases. This dependency on imported foods also makes FSM vulnerable to the economic shocks given the rising food/oil prices and limited transportation between FSM islands. As already noted, although there is a belief that all Micronesians have access to land, landless people is already apparent in Pohnpei.

Another challenge the rural areas face is accessing arable or cultivable land to grow food. This is especially serious in the atoll communities with high population density. The other problem faced by atoll communities is the nature of the islands, vulnerable to sea-level rise and other impacts of climate change. Evidence shows that most taro patches are already affected by salt-water inundation. There is little effort to address food processing of seasonal food crops like breadfruit, which is abundant and wasted during the fruiting season.

## *Recommendations*

Susumu and Kostka (2011) formulated several recommendations. The wide array of problems facing food production and supply systems in FSM indicate the need for effective agriculture research and development strategies to address food insecurity. Since FSM has limited scope for export-orientated agriculture and industrial development to enhance its ability to purchase food imports, research and development initiatives should focus on improving subsistence agriculture.

Following are the recommended strategic options for food security in FSM (Susumu and Kostka, 2011).

**Ensure food availability.** Increase/enhance production and productivity of agricultural systems. This includes formalization /strengthen farmers associations to enable consistency in food supply. To do this, farmers need to access credit and capacity building and provisioning of input supplies such as planting materials (crops suitable for different local conditions including salt/drought tolerant varieties, focusing on nutritious crops) and formation of livestock supplemental feeding program etc. There is also a need to develop gene banks at the State levels to ensure continuous access of planting materials. Awareness raising for consumption of local produce and benefits of local food should be strengthened through policy and regulation.

Engage youth in Agriculture programs which should include creating sustainable economic activities to attract the young to remain in communities and promote of aquaculture to help minimize overfishing. There should be standards on imports/exports

**Food Access.** Improved access to income generating opportunities as well as improved access to basic services was a common priority identified by men, women, and youth. Emphasis was placed on access to scholarships and skills training to improve chances to find employment or other income opportunities, especially for those who have left school without earning a high school diploma.

Also, improved market access for people from the rural and outer islands was identified as a priority in order to enhance trading of local produce and value adding products should be promoted. Food processing and preservation techniques should be enhanced, by establishing food processing facilities and/or introduction of simple food processing techniques. FSM also has export potential of tradable produce with the neighboring islands. Hence export of surpluses should be promoted.

Increase access to skills and recreation centers to cater to youth drop-outs and women who did not complete their education and have no means of accessing skills to find a job. Improving craftwork or starting a small business were priorities particularly shared by women and youth, in order to improve their economic opportunities. It is also important to improve basic services and infrastructure delivery especially, transport to connect outer islands to State and overseas capitals to improve access to markets (e.g., to sell local produce, fish catch, and handicrafts). Higher education, health, power supply, and water were also common priorities. Improving/expanding small loan schemes should occur, with the purpose of developing farm land. Other recommendations are:

- Implement a policy towards making agricultural production mandatory on farm land- Encourage landowners to start production; Promote land leasing of unfarmed land;
- Improve roads in the rural areas and open new roads to rural areas that are currently inaccessible Make use of State allocated funds for infrastructure development Improve transportation of food and agricultural products from outer islands to markets in urban centers; and
- Strengthen income generating opportunities in agriculture especially for farmers to generate more interest for youths to pursue farming as a career.

**Utilization.** Recommendations are to:

- Improve food safety in FSM through policies, standards, trainings, awareness, surveillance etc;
- Increase awareness of the need to include primarily local foods at all functions, starting with Government functions. National/State proclamations, policies, media announcements etc;
- Increase awareness of the need to minimize consumption of unhealthy foods and drinks;
- Continue promoting healthy local foods and healthy life styles; translation of let's go local materials into vernaculars and explore ways to minimize the price of local foods; the private sector, including restaurants, should be partnered to promote serving local foods; and
- Enhancing of importation, exportation, processing and ensuring interstate commerce is safe and with the best quality for human consumption.

**Stability of Food Supply.** The study resulted in the following recommendations:

- There is a need to diversify production through agroforestry practices and providing enabling environment for income generation both in the urban and rural areas; States should focus on establishing gene banks and promotion of healthy crops.; formalizing interisland supply of food and seedlings during disasters instead of food relief programs;
- Traditional food preservations techniques should be strengthened by reviving them through sharing the skills in the communities, schools; promote at home etc;
- Improve access to information, particularly on food security needs to be strengthened;
- Strengthen research on climate proof varieties and distribution to vulnerable communities;
- review literature on atoll agriculture and undertake baseline surveys of atoll agriculture farming systems;
- Establish and atoll crop germ plasm collection;
- Undertake preliminary varietal screening trials under coastal and atoll conditions; and
- Strengthen food security information and outreach programs.

## 4.5 US FOREST SERVICE ASSESSMENT OF MANGROVE LOSS IN YAP

An unexplained decline in the mangrove forests has been observed at several locations in Yap. A study was undertaken to map the geographic extent and distribution of the mangrove forest decline, and provide rough estimates on the amount of loss (Liu, 2011).

### *Methods*

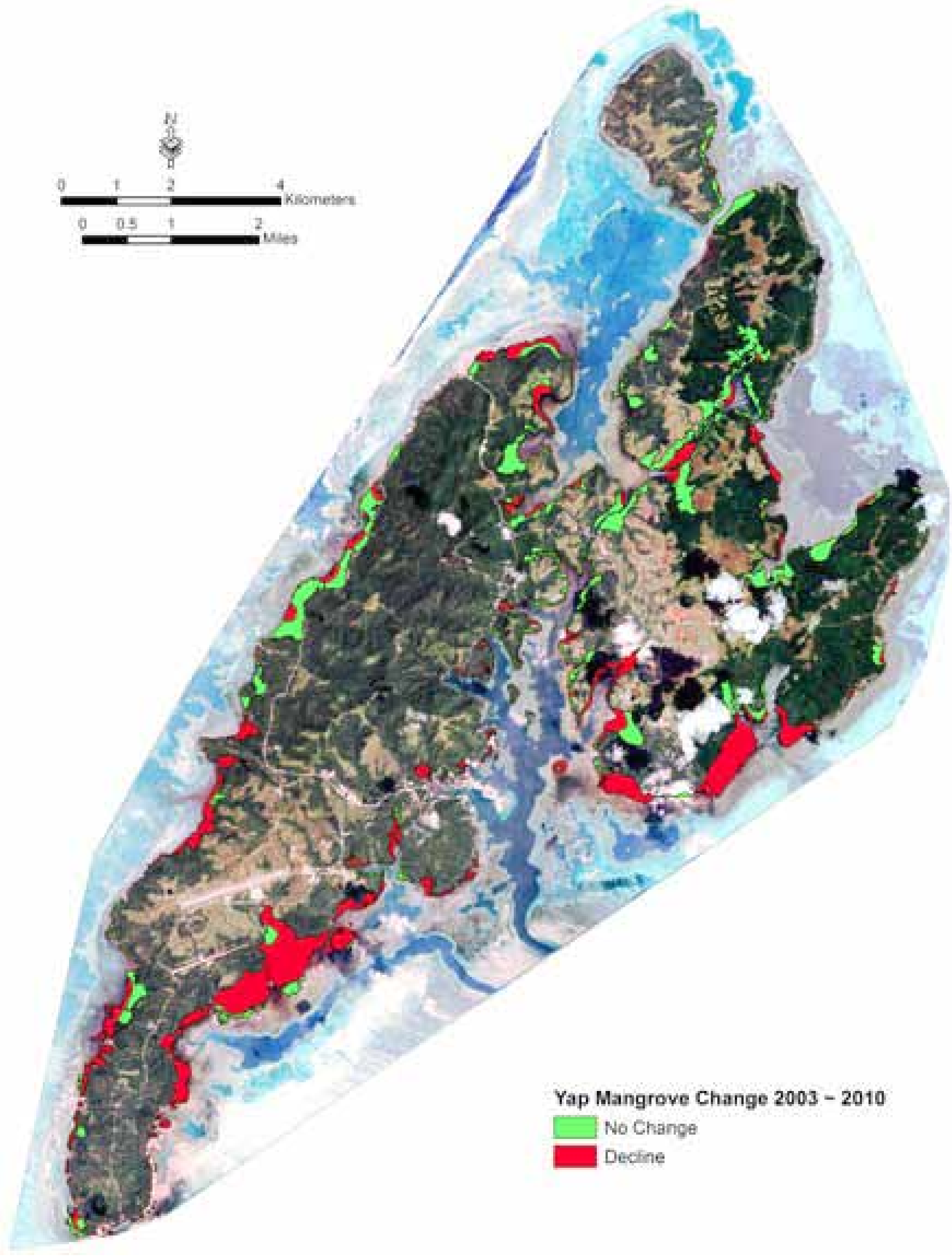
Visual interpretation was undertaken for quick change detection by comparing the natural color WorldView-2 satellite imagery of the Yap islands from 2010 to a set of QuickBird-2 data collected in 2003.

### *Findings*

Visual results are shown in Figure 34. Of the 2,742 acres of mangrove forests mapped, 1,447 acres or about 53% were identified as being already lost or in the process of declining.

**FIGURE 34 | Results of quick change detection of mangrove change in Yap, by comparing the natural color WorldView-2 satellite imagery of the Yap islands from 2010 to a set of QuickBird-2 data collected in 2003**

*Source: Liu, 2011.*



## 4.6 THREE ISLAND VULNERABILITY AND ADAPTATION STUDY, POHNPEI STATE

In March, 2008, an impact assessment was undertaken in three of the southern islands (Sapwahfik, Nukuoro and Sapwahfik islands) of Pohnpei State. The objective of the impact assessment was to identify areas severely affected in terms of agriculture crops, coastal erosion, and possible destruction of living habitats as a result of past occurrences of unusual high tides and strong waves (Susaia, 2009).

### *Findings*

Table 25 is an example of the assessment results, in this case for Sapwuahfik Island, population 1,120.

### *Recommendations*

Based on the assessment findings the following actions are proposed to address the impacts resulting from natural and man-made processes on the southern islands included in the study.

A) Immediate Actions:

Provide food, water and water storage tanks immediately.

B) Long Term Actions:

Agriculture Crops

- Taro Patches need to be rehabilitated
- Isolation of stagnant salt water and rain water from taro patch to safeguard the fertility of the soil.
- Relocation of Taro Patch to another suitable area
- Replanting of alternate crops
- Establish taro patches on Pohnpei proper for future assistance to the affected outer islands.

Coastal Erosion Management

- Re-vegetate the coastlines with mangroves, pandanus, etc.
- Buildings should be set back from the shoreline
- Man made activities such as extraction of beach sand should be designated and controlled
- Sea walls and groins structures should be climate-proofed design so that it could uphold future storm surges and high tides.

*Coastal erosion on Polap atoll Chuuk by Henry Susaia*

## 4.7 RISK-BASED ADAPTATION FOR SAPWOHN, A COASTAL COMMUNITY ON SOKEHS ISLAND, POHNPEI STATE

When the study was undertaken in the early 2000s, Sapwohn Village on Sokehs Island (Figures 35 and 36) had a population of 1234, living in 259 dwellings. The community was established after Pingelap, an outer island of Pohnpei, was devastated by a typhoon in 1905. The "environmental refugees" were eventually relocated to Sokehs Island and allocated land that became vacant after the 1907 uprising. Most of the houses, commercial buildings (small stores) and community structures (church and nahs – meeting places) are built on a narrow strip of relatively flat land that runs between the shore and the steep slopes of Sokehs Mountain (ADB, 2006).

### TABLE 25 | Damage Assessment Results for Sapwuahfik Island, Pohnpei State

*(Source: Susaia, 2009)*

| SPECIFIC AREA | CROPS DAMAGED % | | | | LIVESTOCKS | DAMAGED % | HOUSES | DAMAGED % |
|---|---|---|---|---|---|---|---|---|
| | TARO | BREADFRIUT | BANANA | COCONUT | NONE | | NONE | |
| Weteluhk | Nil | Nil | Nil | .05% | | Nil | | Nil |
| Pikinmetkow | Nil | Nil | Nil | Nil | | Nil | | Nil |
| Wahd | Nil | Nil | Nil | Nil | | Nil | | Nil |
| Dekehn Men | Nil | Nil | Nil | Nil | | Nil | | Nil |
| Pikepe | Nil | Nil | Nil | Nil | | Nil | | Nil |
| Pikin Keleng | Nil | Nil | Nil | Nil | | Nil | | Nil |
| Sirop | Nil | Nil | Nil | Nil | | Nil | | Nil |
| Pikin Karkar | Nil | Nil | Nil | Nil | | Nil | | Nil |
| Paina | Nil | Nil | Nil | Nil | | Nil | | Nil |
| Ngatik | 80% affected | Nil | 80% affected | Nil | | Nil | | Nil |

REMARK: Weteluhk Atoll- Approximately 0.05% of coconut trees on the shoreline is affected by erosion.

### FIGURE 35 | Sokehs Island, Pohnpei State

*Source: ADB, 2006.*

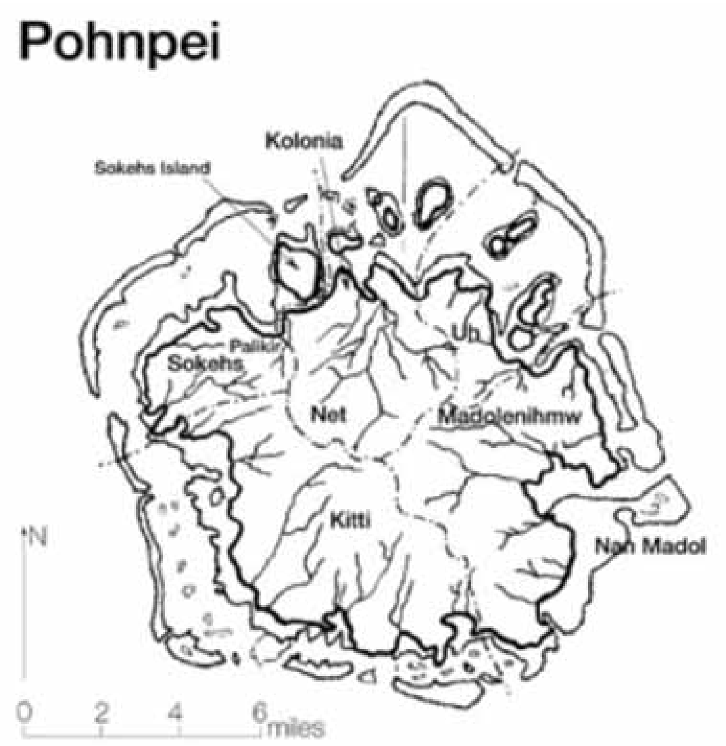


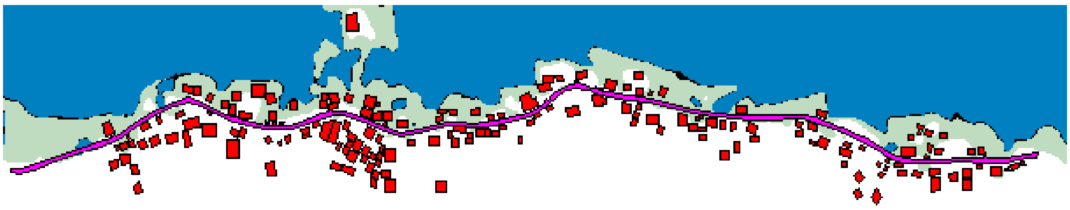
**FIGURE 36 | Sokehs Village is located close to the shoreline, below the steep slopes of Sokehs Mountain.**

*Source: John E. Hay.*

The case study covered the area shown in Figure 37. The resident population of 776 occupied 144 dwellings. In addition there were 15 unoccupied dwellings, seven commercial buildings (two unoccupied), four combined residential and commercial buildings, four community buildings and four nahs (meeting places). There were no Government buildings in the study area. Collectively all structures had an estimated replacement value of US$15,063,000. Many structures were being flooded regularly, as a result of either heavy rainfall events and/or high sea levels (ADB, 2006).

**FIGURE 37 | The study area in Sapwohn Village, showing the location of all structures**

*Source: ADB, 2006.*



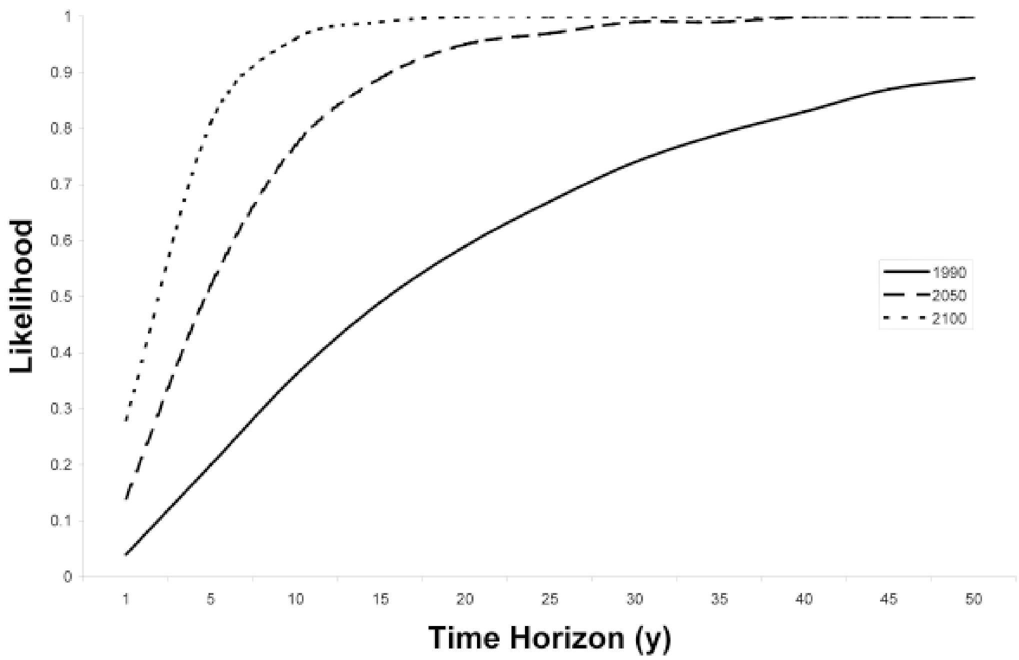
## *Methods*

Climate change scenarios were used to develop projections of how the likelihoods of extreme rainfall events might change in the future. Projections were based on the Hadley Centre (United Kingdom) Global Climate Model (GCM) with best judgement of model sensitivity as this gave results intermediate between those provided by three other GCMs, namely those developed by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), Japan's National Institute for Environmental Science and the Canadian Climate Centre. Similarly, the SRES A1B greenhouse gas emission scenario was used when preparing the rainfall projections as this scenario is close to the middle of the envelope of projected emissions and greenhouse gas concentrations. For sea level the Canadian GCM was used to develop projections. In all cases best judgement was used for model sensitivity (ADB, 2006).

Figure 38 shows the likelihood of a hourly rainfall of 7.9 in (200 mm) occurring within a given time horizon. The likelihood of such an event will increase markedly as a result of global warming. While some of the flooding associated with such heavy rainfall events is due to overtopping of small channels that drain the slopes of Sokehs Mountain, most is due to overland flow originating from the hill slopes above the community.

**FIGURE 38 | Likelihood (0 = Zero Chance; 1 = Statistical Certainty) of an Hourly Rainfall of 200 mm (7.9 in) Occurring Within the Indicated Time Horizon (Years) in Pohnpei**

*Source: ADB (2006).*




Based on the topography of the study area, and given the lack of strong channelisation of flow, an assumption was made that sheet flow occurs down the full length of the slope. The study area was divided into five sub catchments based around two 'gullies'. The sub catchments with gullies were allocated a greater catchment area as a reflection of the channelisation which occurs with these gullies. A simple Excel-based 'conceptual model' was developed, using first principles (including the Rational Method) to estimate flood depths for different segments of the study area.

The estimates were based on one hour rainfall intensities for given return periods. The model was validated using observed flooding depths associated with a storm in October 2003.

The simple model used in the case study was based on limited information inputs and has undergone very limited ground truthing of possible hydrodynamics within the flood area. The model was developed to assist in understanding how climate change (i.e. changing rainfall patterns) may alter flood risks, and how adaptation measures may reduce unacceptable risks. More detailed modelling using appropriate hydraulic and hydrodynamic models would need to be used for location specific flood risk estimates.

### *Findings*

The spatial distributions of flooding for individual and ensemble rainfall events were estimated for the current climate and for scenarios of future climate. Consultations with stakeholders identified one option to reduce flood depths, namely through constructing a diversion channel above the flood area. The costs and benefits of this potential adaptation measure have been determined, and are described in detail below. The effectiveness of both regulatory and voluntary adaptation measures have also been assessed

Figure 39 presents estimated depths of flooding in the case study area associated with an hourly rainfall with a return period of 25 y, for current conditions and for 2050. Under current conditions the 25 y hourly rainfall (210 mm) results in flooding up to a depth of between 0.4 and 0.6 m for most of the area. A small area is flooded to less than 0.2 m. By 2050 the 25 y hourly rainfall is projected to increase to 393 mm. This results in a substantial increase in flood risk. Maximum flood depths will be over 1 m, with all areas being flooded to at least 0.2 m.

However, the full consequences of the increased likelihood of more frequent and intense rainstorms can be seen when the impacts of all the changes in the precipitation regime are integrated over, say, the next 50 years (Table 26).

**TABLE 26 | Projected Costs (US$ million) of Flooding for Sapwohn as a Consequence of Heavy Rainfall**

*(Source: ADB, 2006)*

| | No Climate Change | | With Climate Change | |
|---|---|---|---|---|
| | Discount Rate | | Discount Rate | |
| | 0% | 3% | 0% | 3% |
| To 2050 | 18.21 | 9.99 | 30.84 | 15.59 |
| To 2100 | 37.59 | 12.55 | 90.47 | 23.01 |

While the study area was already experiencing high damage costs as a result of extreme rainfall events, it is apparent that these will be exacerbated dramatically by climate change, even in the next few decades. Measures to reduce the flood risks need to be considered, and especially their effectiveness at reducing the risks in a financially sound manner. Consultations with stakeholders, most notably community leaders and residents of the study area, resulted in a number of adaptation measures being identified as potential ways to reduce the flood risk to acceptable levels. Their preference was for "no regrets" options.

The flood modeling confirmed that runoff from the steep slopes above the community is a major contributor to flood risk. Accordingly, the effectiveness of drainage works that would divert this runoff away from the built up areas was explored. The effectiveness of changes to the building practices, and to land use planning and environmental impact assessment regulations, was also investigated. This included provisions such that when new buildings are constructed, or existing buildings are substantially renovated, there is a requirement for these works reduce the flood risk.

In addition to the flood diversion option, several realistic regulatory and voluntary measures were identified and their cost effectiveness assessed. The measures included:

- requiring that the minimum floor height of new and renovated buildings is sufficient to avoid flooding for a rainfall event of a given return period;
- encouraging building in areas where flood depth will be less than a given amount for a rainfall event of a given return period;
- requiring that all buildings have a specified minimum floor elevation; and
- homeowners adapt when the perceived risk is greater than 10%.

**FIGURE 39 | Flooded Areas and Depths for a Two Hour Rain Storm with a Return Period of 25 years, for Present Day (Left) and for 2050 (Right)**

Color Coding for Calculated Flood Depths is: < 0.2 m Yellow, 0.2 to 0.4 m Green, 0.4 to 0.6 m Orange, 0.6 to 0.8 m Light Brown, 0.8 to 1.0 m Dark Brown and > 1.0 m Red.

*Source: ADB, 2006.*

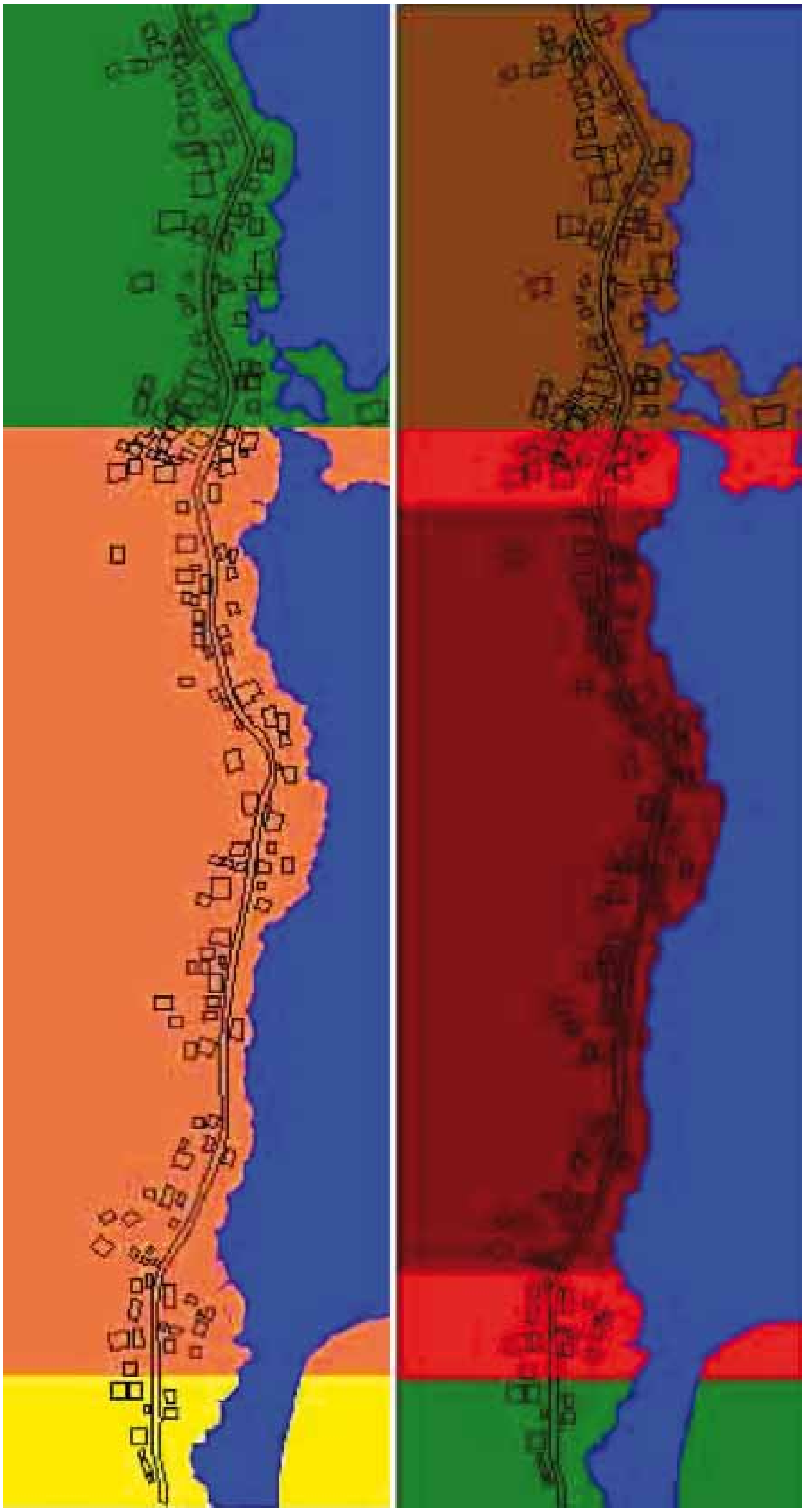


Table 27 illustrates how damage costs will be reduced over a 50 year for examples of the application of the above measures.

### TABLE 27 | Cost and Consequential Change in Damage Costs for Selected Regulatory and Voluntary Measures, over next Fifty Years

*(Source: ADB, 2006)*

| Measure | Change in Damage Costs | | | | Direct Cost of Intervention (US$ million) | |
|---|---|---|---|---|---|---|
| | No Climate Change | | With Climate Change | | | |
| | US$ million | % | US$ million | % | No CC | With CC |
| Divert 50% of runoff from a 25 y storm at US$10 per cubic meter | -4.08 | -41 | -8.34 | -53 | 0.87 | 1.62 |
| Minimum floor height such that no flooding in 25 year storm | -1.64 | -16 | -3.92 | -25 | 0.44 | 0.94 |
| Encourage building where flood depth <0.5 m in 25 year storm | -1.02 | 10 | 4.1 | -25 | Nil | Nil |
| All buildings have minimum floor elevation of 1 m | -2.23 | -22 | -0.89 | -7 | | |
| Homeowners relocate when flood risk is greater than 10% | 8.62 | 86 | 21.58 | 172 | 8.62 | 21.58 |

Discount rate = 3%
[1] Adaptation cost based on US$100 per $m^2$ of floor area per m raised;
only for aging properties with longevity of 50 years
No CC = without climate change
With CC = with climate change

For the selected scenarios both the diversion works and the regulatory measures qualify as "no regrets" interventions, including being cost effective. It is instructive to consider the incremental costs of the adaptation measures. Table 28 highlights these, and compares them to the incremental benefits of undertaking adaptation.

### TABLE 28 | Incremental Costs and Benefits of Selected Adaptation Measures (US$ million)

*(Source: ADB, 2006)*

| | Incremental Benefit | Incremental Cost |
|---|---|---|
| Divert 50% of runoff from a 25 y storm at US$10 per cubic meter | 4.52 | 0.75 |
| Minimum floor height such that no flooding in 25 year storm[1] | 2.28 | 0.50 |

Discount rate = 3%
[1] Adaptation cost based on US$100 per m2 of floor area per m raised;
only for aging properties with longevity of 50 years

In both cases climate change will impose significant incremental costs on the community, but the incremental benefits of addressing the increased risks attributable to climate change are larger, by at least a factor of four.

The study area is also subject to coastal flooding resulting from high tides. Rarely do these relate to the consequences of a tropical cyclone (typhoon). Rather the high ocean water levels are usually associated with king tides, strong onshore winds and with the La Niña phase of ENSO.

Similar analyses to those for rainfall induced flooding were undertaken in order to assess both the damage costs associated with high sea levels and the nature of interventions that would reduce the risk to an acceptable level. Figure 40 shows the area and depth of flooding if a 25 year event occurred today or in 2050. The damage costs arising within the area modelled as a result of the ensemble of high sea level events projected to occur over a future time period can also be calculated. The method used is analogous to that used to determine the damage costs from flooding associated with heavy rainfall events occurring over a specified time period into the future. Table 29 summarizes the key results of these calculations.

**FIGURE 40 | Spatial Extent of Flooding (Shown in Red) from High Sea Level with a Recurrence Interval of 25 yr, for Current Conditions (left) (Maximum Depth 2.3 m) and in 2050 (right) (Maximum Depth 2.6 m)**

*Source: ADB, 2006.*

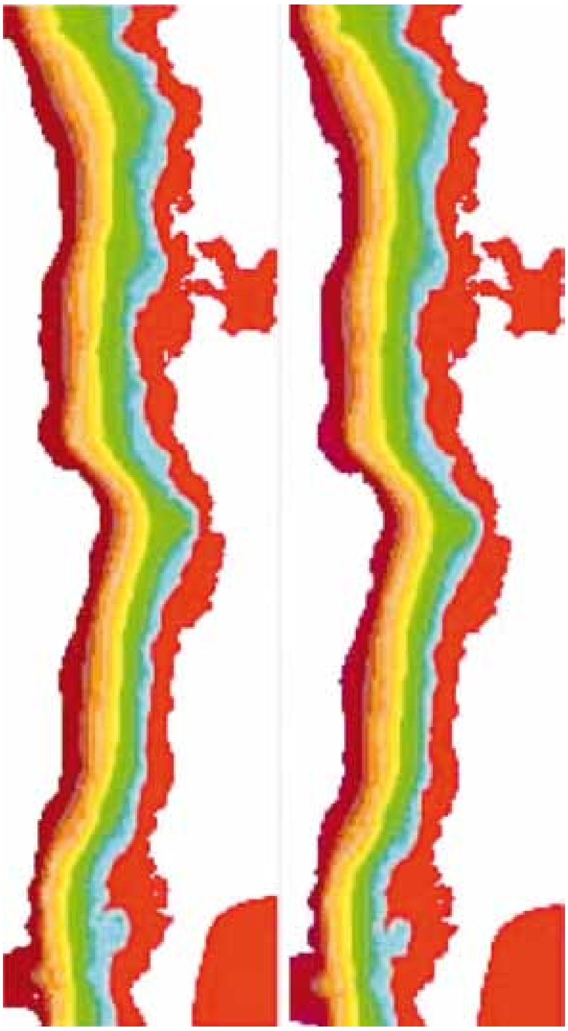


**TABLE 29 | Projected Costs (US$ million) of Flooding of Sapwohn Village as a Result of High Sea Levels**

*(Source: ADB, 2006)*

| | No Climate Change | | With Climate Change | |
|---|---|---|---|---|
| | Discount Rate | | Discount Rate | |
| | 0% | 3% | 0% | 3% |
| To 2050 | 10.04 | 5.51 | 10.54 | 5.72 |
| To 2100 | 20.72 | 6.92 | 23.34 | 7.38 |

It is apparent that high sea levels (including high tides) present a significant risk to structures, infrastructure and other assets in the study area, and of course also to the people who reside and/or work there. Several realistic regulatory and voluntary measures were again identified and their cost effectiveness assessed. The measures included:

- requiring that the minimum floor height of new and renovated buildings is sufficient to avoid flooding for a storm surge event of a given return period;
- encouraging building in areas where flood depth will be less than a given amount for a storm surge event of a given return period;
- requiring that all buildings have a specified minimum floor elevation; and
- homeowners adapt when the perceived risk is greater than 10%.

Residents of Sapwohn Village are already implementing some of these measures on a voluntary basis.

Table 30 illustrates how damage costs will be reduced over a 50 year for examples of the application of the above measures.

For the selected scenarios all measures qualify as "no regrets" adaptation initiatives, including being cost effective.

## 4.8 COASTAL RISK AND ADAPTATION FOR KOSRAE STATE

Since 1905, there has been no typhoons to directly affect Kosrae and few significant storms. One consequence is an insufficient supply of beach sands and cobbles to maintain the seaward position of the shoreline, resulting in a general naturally occurring, landward retreat over the last 50 or so years to a more stable position. Another consequence is a reduced the level of protection provided by the coral rubble banks on the outer parts of the reef as these rubble banks have been gradually broken down.

Virtually everyone on Kosrae lives on land that is less than 12 ft (4 m) above mean sea level. All of this land is at risk from the impacts of a typhoon or tsunami, with there being potential for significant loss of life and destruction of a high percentage of residential property from the effects of wind, high tides and waves (Figure 40). The five main villages on Kosrae are all at significant risk. All of Kosrae's infrastructure (roads, utilities) are located on low land close to the coastline. There will be significant damage to the road and loss of power and telecommunication infrastructure if a typhoon were to directly affect Kosrae. None of the existing coastal defenses around the island will protect the coastline, or the land behind, from the effects of high water levels and waves caused by a typhoon or tsunami.

**TABLE 30 | Cost and Consequential Reduction in Damage Costs for Selected Regulatory and Voluntary Measures, for New/Renovated Buildings Only, Over the Next 50 Years**

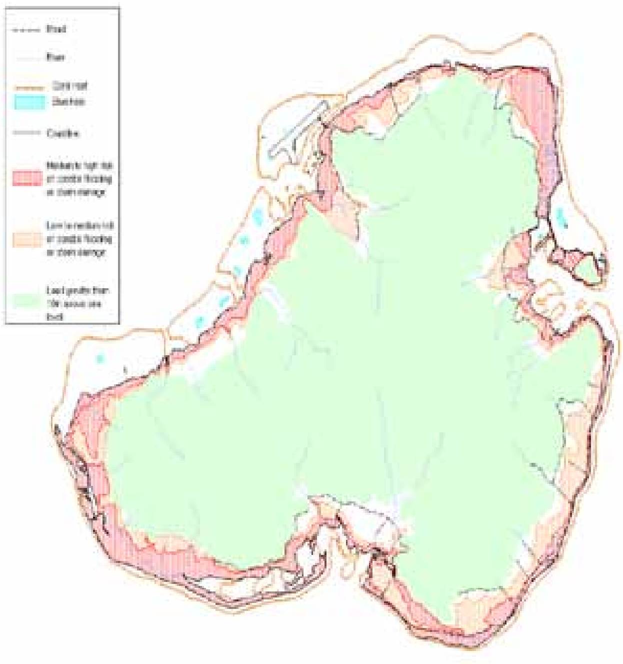
*(Source: ADB, 2006)*

| Measure | Reduction in Damage Costs | | | | Direct Cost of Intervention (US$ million) | |
|---|---|---|---|---|---|---|
| | No Climate Change | | With Climate Change | | | |
| | US$ million | % | US$ million | % | No CC | With CC |
| Minimum floor height such that no flooding in 25 year storm | 1.79 | 34 | 1.88 | 35 | 0.02 | 0.02 |
| Encourage new (relocate) building (only from aging) where flood depth <0.5 m in 25 year storm | 0.58 | 11 | 0.63 | 12 | Nil | Nil |
| New buildings (only from aging) have minimum floor elevation of 1 m | 1.79 | 34 | 1.88 | 35 | Nil | Nil |
| Homeowners relocate when flood risk is greater than 50% (and not from aging) | 0.58 | 11 | 0.63 | 12 | Nil | Nil |

Discount rate = 3%
No CC = without climate change
With CC = with climate change
[1] Adaptation cost based on US$100 per m2 of floor area per m raised; only for aging properties with longevity of 50 years

### FIGURE 40 | Areas of high to medium and medium to low risk of coastal flooding and storm damage on Kosrae

*Source: Kosrae Development Review Commission, 2000).*



A typhoon or severe storm would also destroy much of the mature mangrove areas such as those at Okat and Yela and have a short term impact (10 to 20 years) on the coral reef. However, typhoon events are a vital process in limiting long term coastal erosion by re-supplying sand, cobbles and coral rubble to the reef flat and coastline from the coral reef.

Mangrove areas on Kosrae provide direct coastal protection for about 22% of the coastline (Table 31). Mangroves are also an important component of the overall natural coastal defenses between Utwe and Walung, Kuplu and Mutunnenea. Mangroves only provide coastal protection along relatively sheltered coastlines, i.e. those that experience low wave energy.

### TABLE 31 | Locations where Mangroves provide Direct Coastal Protection to the Coastline

*(Source: Kosrae Development Review Commission, 2000)*

| Location | Approximate length of coastline KM (miles) |
|---|---|
| Lelu Habor | 4.5 (2.8) |
| Malsu, Tafunsak | 0.1 (0.06) |
| Kemuen, Tafunsak to Mvot | 10.0 (6.2) |
| Utwe Habor | 3.1 (1.9) |
| Tenwak | 0.4 (0.25) |
| **TOTAL** | **18.1 (11.2)** |

A common response to the threats of coastal erosion and coastal hazards is to build sea walls or other forms of "hard" coastal defenses. On Kosrae this approach has failed to resolve many of the erosion problems and in a number of places made the problem worse. Economic constraints have resulted in many inadequate sea walls (such as around Lelu island). These provide a very low standard of protection to the land behind against coastal hazards. More effective but more expensive coastal protection is not economically justifiable other than at a small number of locations around the island. Effective coastal defenses generally cost between US$500 and US$1,500 per linear foot. For example, the Tafunsak sea wall cost $1,300 per foot of coastline.

The consequences of climate change, such as sea level rise and changes in weather patterns will not cause new problems and risks on Kosrae. It will simply gradually increase or exacerbate the frequency and magnitude of the risks and problems caused by existing coastal hazards. Reducing the present risks to the people and infrastructure of Kosrae posed by existing natural climate variability will be the most effective way in reducing the coastal hazard risks posed by future climate changes (Kosrae Development Review Commission, 2000).

Most of the sea walls around Lelu Island require frequent maintenance and would not be sufficient to protect the land during periods of large waves. Building sea walls and other coastal defenses does not stop coastal erosion. Coastal defenses can only reduce the risk of loss of land immediately behind the defenses in the short term (tens of years). No coastal defense on Kosrae will protect the land behind it from the effects of an extreme event such as a typhoon or significant tsunami. Even with coastal defenses, people or infrastructure will still be at considerable risk from storm damage and flooding on Kosrae.

## 4.9 POST DISASTER ASSESSMENTS IN THE OUTER ISLANDS OF FSM

In December 2008 all four of the FSM States declared a state of emergency as a result of damage caused by the tidal surges in December 2008, depriving the staple food and livelihood of the communities in the outer-islands. On December 30, 2008, President Mori signed a Presidential Emergency Declaration and officially declared a National State of Disaster for FSM (Susumu et al., 2009).

In response, three joint post disaster assessment (PDA) teams, representing the FSM Government, State Governments and the US Federal Emergency Management Agency (FEMA), were dispatched in early January, 2009. They went to all outer islands of FSM, to assess and determine the severity of the damage to subsistence crops and ground water drinking water systems and infrastructures (Susumu et al, 2009).

### *Methods*

Upon arrival on each island, the PDA team met the members of the community for orientation and briefing on the purpose of the assessment. Ground assessments included determining the impact to taro swamps, breadfruits, coconuts, water quality and quantity on the impacted islands and determining the prolonged effect of the salt intrusion and salt spray on staple crops of the islands. Assessment procedures were based on the following (Susumu et al., 2009):

**A. Cause of failure from the tidal surge:**

- Tidal flooding of taro patches;
- Extreme high tide causing salt water intrusion into subsurface water lens of taro farms;
- Salt spray from wind and wave action; and
- Persistent high levels of standing salt water in taro farms over a long period.

**B. Assessment sampling:**

- Random sampling of taro plants by extraction;
- Inspecting taro corms for rotting;
- Salinity measures of standing water in taro farms; and
- Visual inspection of crops (breadfruit, banana, and papaya).

**C. Assessment data:**

- Agricultural assessment data was categorized by the projected impact it would have to staple crops. Thresholds for damage assessments were as follows: Destroyed (100-90%), Severe (90-70%) Moderate (70-20%), and Negligible (20-0%)

## *Findings*

Table 32 shows the effect of the tidal surge on the staple crops for the islands of Chuuk State. Similar information is available for the outer islands in the other three States.

## *Recommendations*

In order to restore the staple crops for food security and to improve the diet of these islanders, the following recommendations should be adopted (Susumu et al., 2009):

**Rehabilitation and Crop Diversification.** Rehabilitation of agricultural crops on these islands is essential in order to restore and improve the diet of the outer island people. Therefore, assistance should support strategies of increasing diversity of crops for food security, increase food quantity and quality to improve the nutrition and health of the people while protecting the environment. Crop diversification can also create income earning opportunities for the limited land in these islands. There is potential for integrating other crops such as pumpkin and other vegetables that can grow in the atoll. Crop diversification and introduction of new crops will certainly contribute in improving the nutritional status and food security for the people of these islands. This can also create greater self-reliance and increase income opportunities from common food crops.

**Salt Tolerant Varieties.** Improving agricultural production by developing food crops that can adapt to environmental changes and improve the growing food demands and as well as constantly increasing population of these islands is a priority. SPC is committed to providing salt tolerant varieties to assist in this risk reduction program.

**Composting should be Practiced to Increase Productivity.** People need to be provided with agricultural extension services to conduct basic agricultural techniques such as composting, mulching and nursery techniques. This will result in improve productivity of subsistence agriculture and at the same time better land management techniques.

### TABLE 32 | Effect of Tidal Surge on Staple Crops in the Islands of Chuuk

*(Source: Susumu et al., 2009)*

| | | | Crops Damaged | | | |
|---|---|---|---|---|---|---|
| **Island** | **Distance** | **Population** | **Taro** | **Breadfruit** | **Banana** | **Coconut** |
| ***Mortlocks*** | | | | | | |
| Satawan | 341 | 955 | Destroyed | Severe | Severe | Negligible |
| Ta | 329 | 339 | Severe | Severe | Severe | Negligible |
| Kuttu | 330 | 873 | Severe | Severe | Severe | Negligible |
| Moch | 312 | 854 | Severe | Severe | Severe | Negligible |
| Ettal | 291 | 267 | Destroyed | Severe | Severe | Negligible |
| Eneop | 285 | 505 | Moderate | Negligible | Negligible | Negligible |
| Lekinioch | 289 | 927 | Destroyed | Severe | Severe | Negligible |
| Namoluk | 300 | 407 | Severe | Severe | Severe | Negligible |
| Losap | 301 | 448 | Destroyed | Severe | Severe | Negligible |
| Piis | 295 | 427 | Severe | Severe | Severe | Negligible |
| Nama | 297 | 995 | Severe | Severe | Severe | Negligible |
| Murillo | 212 | 607 | Destroy | Severe | Moderate | Negligible |
| Reo | 200 | 245 | Destroy | Moderate | Moderate | Negligible |
| Fananu | 180 | 355 | Destroy | Moderate | Moderate | Negligible |
| Nomwin | 180 | 711 | Severe | Moderate | Negligible | Negligible |
| Onari | 130 | 178 | Destroy | Moderate | Negligible | Negligible |
| Ono | 115 | 182 | Destroy | Moderate | Negligible | Negligible |
| Makur | 120 | 156 | Destroy | Moderate | Negligible | Negligible |
| Piserach | | 469 | Destroy | Moderate | Moderate | Negligible |
| Pollap | 111 | 905 | Severe | Moderate | Moderate | Negligible |
| Ulul-Onoun | 35 | 580 | Severe | Moderate | Moderate | Negligible |
| Houk | 27 | 451 | Severe | Moderate | Moderate | Negligible |

| Island | Distance | Population | Crops Damaged | | | |
|---|---|---|---|---|---|---|
| | | | Taro | Breadfruit | Banana | Coconut |
| *Mortlocks* | | | | | | |
| Polowat | 27 | 1015 | Destroy | Moderate | Moderate | Negligible |
| Tamatam | | 365 | Severe | Moderate | Moderate | Negligible |
| Nidw | | 711 | Severe | Moderate | Moderate | Negligible |
| Udot | | | Severe | Moderate | Moderate | Negligible |
| Siis | | | Destroy | Moderate | Moderate | Negligible |

**Appropriate Spacing to Benefit Companion Crops.** Introduction of rationale planting patterns is essential in the atolls. This requires capacity building through extension services specifically on agroforestry production techniques to strengthen local Government capacity in planning and execution of island based agroforestry development.

**Coastal Erosion Prevention.** Tree planting on coastal areas and proper planting pattern with reduce coastal erosion which will maintain land productivity for agriculture in these islands (Susumu et al., 2009).

## 4.10 AGRICULTURAL IMPACT ASSESSMENT AND RESPONSE, KAPINGAMARANGI ATOLL, POHNPEI STATE

In late 1999 a joint USDA/US Peace Corps/Kapingamarangi Municipal Government project was undertaken on the atoll of Kapingamarangi. It is located slightly over 400 miles (650 km) southwest of Pohnpei and comprises roughly 0.52 square miles (approximately 330 acres). In a normal year the island usually has sufficient rain to support large amounts of natural vegetative growth. There were over 400 adults on the atoll, distributed over three islands in over 125 households (Johnson, 2000).

The Kapingamarangi Atoll was hard hit by two droughts in 1997 and 1998, due to El Niño/La Niña influences in those years, resulting in a severe reduction in local food crops, especially the three main food sources of the atoll: breadfruit, coconut, and taro. The aim of the study was to assess the state of agricultural resources in the wake of El Niño/La Niña induced drought, offer advice and information resources to local farmers, and introduce several new species of plants for food and soil improvement (Johnson, 2000).

### *Findings*

A survey undertaken in April 1999 revealed 75% of the breadfruit trees and 68% of the coconut trees were either severely stressed and/or dying. Meanwhile, taro, the primary source of starch on the atoll, was estimated to be at 25% of its pre-drought levels, with importation from other islands needed to make up the deficit (Johnson, 2000).

### *Response*

As a result of the survey findings a Conservation Plan for the atoll was prepared, with an emphasis on replanting of traditional crops, introduction of new crops, incorporation of basic organic farming methods, and agricultural education. A Peace Corps volunteer began implementing the conservation plan, performed an informal survey of the state of agriculture on the island, and suggested improvements to the current plan (Johnson, 2000).

The Conservation Plan involved multi-year strategies and multiple goals, but a decision was made to aim for limited but productive targets by preparing a plan for the short term goals for the first project period. It included adding fruit trees and to the atoll resources. Seeds for eggplant, pepper, Chinese cabbage, watermelon, cucumber, and cantaloupe were brought to the atoll, along with saplings of soursop, Pohnpeian lemon, a few breadfruits and cuttings of gliricidia, a nitrogen-fixing tree that could be used for soil improvement. Maintenance and improvement of the taro plantings was also seen to be of importance. As a result, most of the gliricidia cuttings were planted around the taro patches on the islands of the atoll, placed in a way that they would act to reduce sunscald and evaporation, and causing the nitrogen rich leaves to fall into the growing area. In combination with the gliricidia trees, the local population were encouraged to incorporate dead material (leaves, broken up tree parts, etc.) into the soil and as top dressing and mulch with an emphasis on its use in taro planting.

The fruit tree saplings were planted on various islands, with the majority being planted on the two main residential islands of Welou and Touhou. Of especial interest to the people of Kapingamarangi were the lime trees, and these were planted in the most hospitable places, around wells wherever possible, in order to maximize the survival rate. Members of the municipal council and others were given guidance on transplanting seedlings from grow bags, as well as using the seedlings for general agricultural instruction such as watering, shade/sun requirements, etc. The vegetable seeds and grow bags were also used for demonstration at the local school, culminating in distribution of three Chinese cabbage seeds and a grow bag to each of the participating students.

***Recommendations for Future Action***

The following recommendations were made in the light of the need for planning for future droughts to start immediately (Johnson, 2000). The essential problem in the agricultural future of the atoll is the periodic nature of the droughts. Although 1997 and 1998 drought period was of a greater than average length and severity, drought is a problem to be expected in the future, and that all planning should be based around this eventuality. One of the best ways to minimize the agricultural problems of a drought would be to encourage and support the development of non-native vegetable crops that can be grown around the family houses using waste water for irrigation. Further inputs of seeds, grow bags, hand tools, and associated supplies will be necessary to achieve this.

A permanent agricultural advisor position has been proposed in the past. Such a position would provide much needed support for all agricultural activities. The development of this position would help produce greater yields in the introduced and native crops, and could serve as a source for information on pest control and growing conditions. Periodic visits or a permanent posting of outside specialists to the atoll would provide additional resources in support of the advisor and help introduce new practices and plants.

An insect and plant pathogen control program is required. Optimization of the local taro plants through breeding and propagation for drought resistance and improved yield, or the introduction of new species of taro. As the coconut and breadfruit are impossible to save as a group, the taro presents the best source of carbohydrates potentially available to the atoll in a time when other food sources are diminished. Instituting a test crop area, and experimenting with yields of different types and sizes of taro to maximize production, would help achieve this result (Johnson, 2000).

## 4.11 AN ASSESSMENT OF FSM'S FRESHWATER SUPPLIES

The range of size, geomorphology, hydrology, and climates of FSM's 74 inhabited islands have resulted in an extremely diverse range of freshwater systems. Even though each of the States is centered around main high islands, and include numerous outlying coral atolls, the freshwater resource differs greatly between States, in terms of rainfall, storage capacities, and water supply infrastructure (Johnston, 2012).

While atolls generally receive considerably less rainfall than the high islands, but the issue lies in their lack of storage capacity. This problem is intensified by the unpredictable seasonal variations in rainfall in relation to ENSO, associated with droughts and also damage caused by large storm events. The preparedness of the States to manage the impacts from these disaster events is generally seen as low, with the impacts set to intensify with human induced climate change, the communities will be at an even greater risk.

The traditional culture and lives of the island communities are centered around freshwater, and the wealth of knowledge and beliefs of the fragile systems is being seriously threatened by the polluting and overuse of these water resources. Knowledge of the system built up over many generations becomes vital in knowing the limits of a system. Modern management needs to utilize this knowledge in order to supply a safe and dependable water supply. Developing industries, including food production, fisheries and the emerging tourism sector, continue to use greater amounts of water. Good governance of water is essential for public health standards to be maintained and for the unique biodiversity and environments of FSM to be protected.

The water management issues that are common across FSM include the contamination by human and livestock waste that is discharged into water bodies, issues with land access making enforcement difficult, the complexity of a three tier Government, the great geographic spread of the populated islands in FSM, as well as the limited capacity and technical expertise of the water sector in FSM (Johnston, 2012).

Approximately 60% of water resources in FSM exist as surface water in the form of small, intermittent streams that drain catchments areas of limited aerial extent. The streams are low for about 20% of the year. The development of surface water is therefore inherently expensive, since it requires the construction of dams to impound the surface runoff for use during dry periods.

The topography in the stream basins is not conducive to the construction of economical dams. Furthermore, surface water requires extensive and costly treatment, largely to reduce high turbidity, undesirable taste and odours, and to remove all micro-organisms. The remaining 40% of the islands' water resources exist as groundwater in small, dispersed zones of sedimentary deposits, weathered volcanics and weathered schist. These formations are not conducive to the development of high yielding wells as drilling through such sediments is expensive.

However, the hydrogeology is suitable for multiple, low- to medium-yielding wells in the range of 20-150 gallons per minute. The quality of the ground water is mostly excellent, but many health hazards in the FSM are related to poor water quality and limited water quantity. In the FSM's raised coralline islands, the freshwater lens is tapped through shallow, hand-dug wells to supplement the rainwater catchments and storage tanks which are widely used and commonly the main source of drinking water in the outer islands. The small low lying coral islands face severe constraints in terms of both the quality and quantity of freshwater due to limited groundwater resources and protected by a thin permeable water lens (Johnston, 2012).

The atoll aquifers consist of a layer of freshwater floating on saltwater. Recharge from rainfall typically forms a thin lens of freshwater that is buoyantly supported by denser, underlying saltwater, and mixing forms a zone of transitional salinity. The thickness of this mixing zone is determined by the rate of recharge, tidal dynamics, and hydraulic properties of the aquifer. The freshwater zone of atoll islets is formed largely within unconsolidated sand and gravel, with some coral and a few cemented layers of sandstone and conglomerate.

The freshwater portion of the aquifer typically follows the long axis and elongated shape of the islets. The maximum elevation of the water table is near or slightly above mean sea level. The thickest part of the freshwater lens, which may reach several tens of meters, may be located near the center of the islets in areas where there is a greater abundance of fine-grained and less-permeable sediment; or on the lagoon side if that location is characterized by finer-grained sediment. Fine sediment has reduced permeability and thus retains water. The center of islets is also typically the lowest point; hence wetlands and open pools of water fed by the aquifer are not uncommon.

Roof catchments exist in all four islands. In many of the islands, there are no appropriate actions or policy to protect and safeguard watershed and groundwater resources, which poses a threat due to the rapid population growth on the main islands. On the outer islands, there are no piped water systems and the residents rely exclusively on individual rainwater catchments and dug wells. The standard of construction and maintenance of these facilities varies considerably from island to island (Johnston, 2012).

## 4.12 RAPID ECOLOGICAL ASSESSMENT OF BIODIVERSITY AND STATUS OF REEF-BUILDING CORALS, AND CORAL COMMUNITIES OF POHNPEI

Rapid Ecological Assessments (REAs) have been undertaken in all four States. The following describes the REA undertaken in Pohnpei State (Turak and DeVantier, 2005). Surveys of biodiversity and status of coral communities of Pohnpei, And and Pakin Atolls were undertaken in June and July, 2005. The surveys formed part of a Rapid Ecological Assessment sponsored by the Conservation Society of Pohnpei, with support from The Nature Conservancy and various Government agencies (Turak and DeVantier, 2005).

The project had five main objectives:

- Conduct a survey of species diversity by identifying hard and soft corals and other benthic marine organisms and by compiling a detailed list of species for each site and for the survey region in general;
- Assess coral community types, their current status and health, and the extent of impacts on these reefs from disturbances such as coral bleaching, Crown-of-thorns starfish outbreaks, destructive fishing practices, and terrestrial runoff;
- Collect samples of hard corals and other benthic organisms which are difficult to identify in the field for further identification;
- Analyze and interpret the data in relation to the broad and specific aims of the marine assessment, as defined in the proposal "Rapid Ecological Assessment of Pohnpei Lagoon and And Atoll"; and
- Map and rank the coral reefs visited for biodiversity conservation value.

### *Methods*

Field surveys conducted using SCUBA at 36 stations around Pohnpei, And and Pakin Atolls. The stations were selected to provide a broad range of reef habitat types, as developed in relation to different environmental conditions (e.g. distance from shore, water clarity, wave energy and exposure, slope angle, depth). At most stations (survey areas of ca. 1 ha), deep and shallow sites were surveyed concurrently, representing the deeper reef slope (usually > 10 m depth) and the shallow slope, reef crest and flat (< 10 m depth) respectively.

Two types of information were recorded during the approximately one and a half hour SCUBA survey swims at each station: an inventory of species, genera and families of sessile benthic taxa; and an assessment of the percent cover of the substrate by the major benthic groups and status of various ecological - environmental parameters.

### *Findings*

With respect to coral bleaching, no evidence was found of major recent bleaching was found. Some reef areas of Pohnpei lagoon were reported to have bleached in 1998 and 2002, triggered by extreme freshwater runoff events rather than high sea temperatures. There assessment showed there had been strong recovery, at least of coral cover. Potential species-specific effects on community composition / structure were unknown.

The shallow nearshore lagoon communities are dominated in many locations by poritids, growing in local environmental conditions that include regular immersion in near-fresh water to a depth of tens of centimeters, following intense rainfall and run-off, and high sea temperatures in the semi-enclosed areas. These corals are likely to have a degree of local acclimation, providing resistance and / or resilience to these impacts. Nevertheless, extreme and/or prolonged events beyond this local acclimation regime could disturb these communities. Outside the lagoon, water movement from wave action and current flow and the deep drop-offs, with depths > 1,000 m close to the outer barrier reef edges, may help to maximize mixing and minimize impacts from high sea temperatures on the outer reef slopes.

## 4.13 CLIMATE CHANGE AND HUMAN HEALTH VULNERABILITY ASSESSMENT

The purpose of the assessment was to define and describe the health impacts of climate change that pertain to the Federated States of Micronesia and, through a process of statistical analysis and stakeholder consultation, to consider the relative risk that each of these issues pose to communities throughout the four States (FSM Department of Health and Social Affairs, 2011).

***Background***

The communities most vulnerable to the health effects of climate change in FSM include: populations at risk of being (or that have already been) displaced, for example residents of low-lying atolls or those living close to coasts, rivers and hillsides; women; those at the extremes of age (children and the elderly); those with pre-existing health problems (co-morbid conditions, the disabled); certain occupations (fishermen, farmers, outdoor workers); the poor and socially disadvantaged; and those that lack access to public information broadcasts and communications (e.g. radio) (FSM Department of Health and Social Affairs, 2011).

The most prominent vector-borne diseases in FSM are flaviviruses transmitted by mosquitoes. Dengue fever occurs in epidemics in FSM. Investigation of an outbreak in Yap State in 1995 included an entomological survey and correlation with daily rainfall data. The survey identified several species of virus-transmitting mosquito of the Aedes and Culex genii, in particular A. hensilli in Yap. No statistically significant correlation with rainfall was found. An outbreak of Zika virus in 2007, also in Yap, affected close to 1000 residents and demonstrated once again the susceptibility of isolated island communities to exotic imported infections.

Both of these outbreak investigations confirmed that pooled water sources, including those around households, were prime mosquito-breeding sites. In late November 2011 Yap experienced another dengue outbreak, with almost 700 cases reported, over 140 admissions to Yap State Hospital and two possible dengue-related deaths. A State of Emergency was declared due to the outbreak.

Diarrheal illness is a major cause of morbidity in FSM, resulting in thousands of hospital admissions each year, and a recent outbreak of Hepatitis A (transmitted primarily via water) caused significant morbidity in Pohnpei. A study of the relationship between climate variables and admissions of patients with diarrhea to Pohnpei Hospital (ADB, 2006) found that outbreaks of gastroenteritis were partly associated with prolonged periods of low rainfall followed by a heavy rainfall event.

Cholera occurs in epidemics in FSM, with at least one outbreak occurring in both Chuuk and Pohnpei over the last decade. An investigation of an outbreak in Chuuk in the 1980's concluded that transmission occurred primarily via foods contaminated by food-handlers inside homes, and noted that the traditional practice of allowing food to sit at warm room temperatures for extended periods allowed rapid multiplication of the organism.

The most serious common infection transmitted from animals to humans in FSM is leptospirosis, which has caused several hundred hospitalisations over the last decade, mostly in Pohnpei. The main animal reservoirs are thought to include rodents and domesticated pigs, dogs and livestock.

The study undertaken by ADB (ADB, 2006) also found that influenza outbreaks in Pohnpei were partly associated with rapidly-increasing mean daily temperature ranges (the difference between the mean daily maximum and minimum temperatures). Respiratory infections tend to follow seasonal patterns; in the tropics the peaks tend to occur just prior to and during the wet season. One hypothesis for why this occurs is that rainfall increases the risk of transmission by bringing people into closer proximity indoors. The greatest burden of disease due to respiratory infections occurs in children and is exacerbated by malnutrition, particularly in developing countries. Obstructive airways diseases (such as asthma) may also be exacerbated by increased ozone production due to higher air temperatures – this phenomenon is known to cause increased airway irritability and may result in a greater number of deaths due to respiratory problems.

In addition to the direct health effects of events such as typhoons (such as traumatic injuries and deaths), a study following Typhoon Sudal in Yap in 2004 documented dozens of patient presentations to the emergency clinic during the clean-up effort. Complaints were thought to be at least partially attributable to the impact of the disaster ranging from minor (upper respiratory tract infections, minor trauma, gastrointestinal illnesses) to major (serious medical problems and trauma). It is predicted that, via a range of effects, climate change may increase the number of patients suffering from a variety of mental health problems including depression, anxiety, substance abuse and post-traumatic stress disorder. It important to recognize the risk of violence, including sexual violence, is often higher in the aftermath of natural disasters. This disproportionately affects women and children.

The potential pathways by which climate change may affect NCDs such as cardiovascular disease, chronic airways disease, kidney disease and metabolic diseases including diabetes are complex and relatively poorly understood. The relationship between heatwaves and increased cardiovascular and respiratory mortality has been well-described. Diabetes and other chronic diseases (including cancer and cognitive impairment) are also thought to increase the susceptibility of individuals to heat stress. There is also a genuine and frequently-expressed concern among Pacific islanders that climate change will further force food choices away from nutritious, locally-grown sources towards processed and/or imported items.

The rates of obesity and diabetes may increase with climate change acting as a "multiplier" via its effects on, among other things, agriculture, fisheries, the economy and human activity. The rates of adult obesity and diabetes in Pohnpei are an alarming 43% and 32%, respectively.

While ciguatera is not thought to be as much of a problem in FSM as it is elsewhere in the Pacific, there are two reasons why ciguatera should be considered here. The first is that the disease (caused by the ingestion of toxic algae consumed by carnivorous reef fish) may be sensitive to warming seas and/or ENSO) patterns, though there is a lack of consensus regarding the effects of these variables on accumulation of the harmful dinoflagellate organism in the marine food chain. The second reason is that a study of ciguatera in Yap State in 2001 revealed not only a probable high-risk fish species (Plectropomus leopardus, or Variola louti, known locally as "lap-lap"), but also a potential antidote to the toxin. Residents of Ulithi atoll have apparently been using the extract from a local plant (Messerschmidia argentea, known to the locals as "lippi") as an effective treatment for fish poisoning. Further study of this local remedy should be an international research priority, with some work already having been undertaken by researchers in New Caledonia) (FSM Department of Health and Social Affairs, 2011).

## Methods

The data from the four State hospital records (inpatient and outpatient) between 2000 and 2010 were collected from the Health Information Department. Hospital records include sex, age and diagnosis coded by the International Classification of Diseases, version 10 (ICD-10). Weather data was collected from the Weather Service Office.

Individual patient data were converted to daily number of all-cause and cause-specific patients and combined with daily weather data. Time series distribution of daily number of inpatients and outpatients in each State were plotted along with weather data. Time series of three key climate-sensitive diseases were performed [dengue fever (ICD-10: A90-A91), diarrhoeal illness (ICD-10: A00-A09) and leptospirosis (ICD-10: A27)] in addition to several broader categories of diseases [(circulatory (ICD-10: I00-I99), respiratory (ICD-10: J00-J99) and infectious diseases (ICD-10: A00-B99)]. Association with ENSO) was also examined for each disease category. The strength of the ENSO was measured by sea-surface temperature (SST) anomalies in the Niño 3 region (NINO3) in the Pacific Ocean, which were derived from NOAA Climate Prediction Center data.

Generalised linear Poisson regression models allowing for overdispersion were used to examine the relationship between weather (temperature and rainfall) and NINO3 variability and the number of all-cause and cause-specific inpatients in different lag months (zero, one, two and three months earlier). Because there was no clear seasonality observed in disease incidence, seasonality was not controlled in the model. Potential mutual confounding between temperature and rainfall was also not controlled in the model. All statistical analyses were carried out using Stata 10.0.

## *Findings*

Figures 41 and 42 show some suggestive evidence of an increase in cases of respiratory disease and diarrhoeal illness in Pohnpei at a monthly maximum temperature threshold of ≥32-33°C; the peak effect appears to be at a lag of approximately one month (i.e. the health outcomes manifest several weeks following the environmental condition in question, in this case monthly maximum temperature). No such associations were observed in the other States. There was little evidence for the association between NINO3 and the number of all-cause outpatients, circulatory, respiratory and diarrhoeal diseases in Pohnpei, Yap and Chuuk. However, significant associations were observed in each disease in Kosrae. The directions of the associations were dependent on the type of the disease and lag period.

In these figures RR represents the relative risk of respiratory disease and diarrheal disease respectively (scaled against the mean monthly number of cases). The centre line in each graph shows the estimated spline curve (natural cubic spline with three degrees of freedom), and the upper and lower lines represent the 95 percent confidence limits.

**FIGURE 41 | Relationship between temperature and respiratory outpatients in Pohnpei**

*Source: FSM Department of Health and Social Affairs, 2011.*

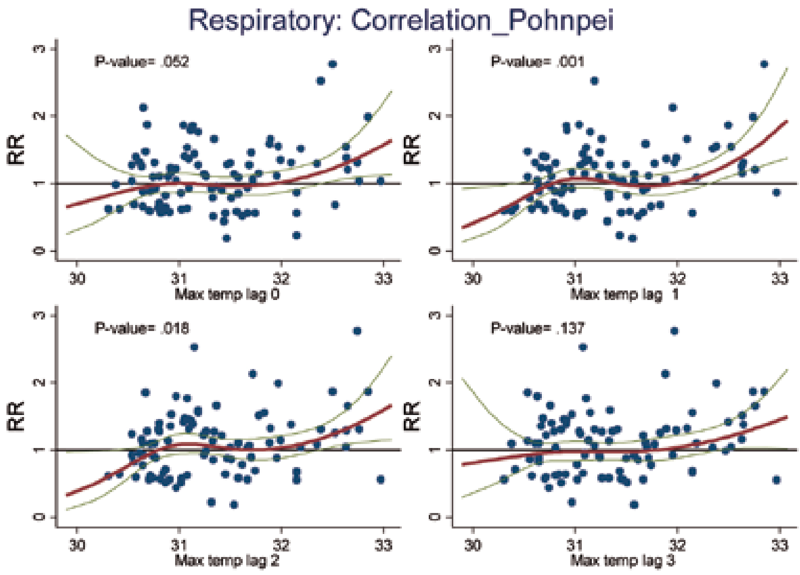
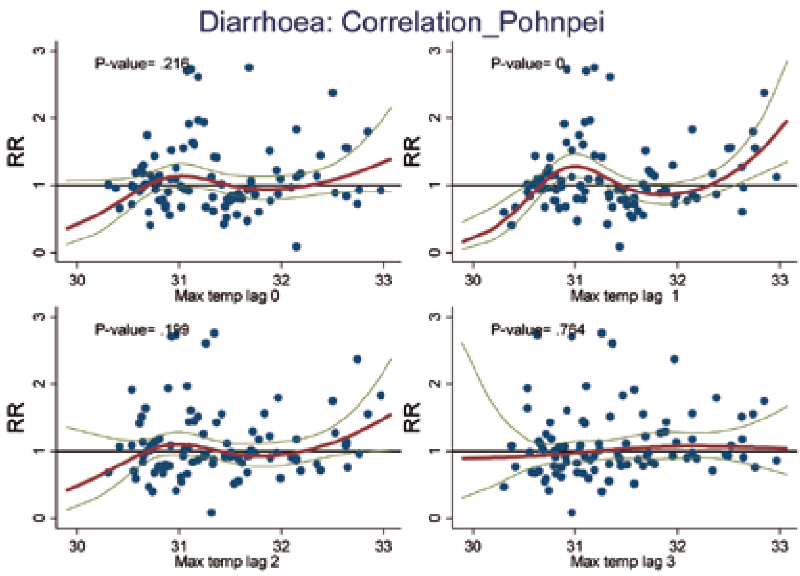



**FIGURE 42 | Relationship between temperature and diarrhoea outpatients in Pohnpei**

*Source: FSM Department of Health and Social Affairs, 2011.*



## *Climate Change and Health: Needs and Adaptation Strategies for FSM*

Findings on the likely effect of climate change, levels of risk posed by climate-sensitive disease in FSM, and needs and gaps are summarized in Appendix 5, as are the potential adaptation strategies to deal with climate-sensitive health risks in FSM. The needs and gaps are also further discussed in Section 7.7.

In summary, the key needs and adaptation strategies are (FSM Department of Health and Social Affairs, 2011):

- Vector-borne and water-borne diseases and malnutrition represent the most serious climate-sensitive health risks to FSM;
- There is a lack of recent, high-quality, peer-reviewed public and environmental health research in FSM and the Micronesian region, including research into the health impacts of climate change;
- Available health data are incomplete;
- The process of data recording, collection and analysis needs significant improvement in FSM;
- Human resources in health information systems, biostatistics, epidemiology and public health need to be increased
- This requires recruitment of new staff, training and up-skilling of current staff;
- Effective project management and implementation of climate change and health projects will require high-level buy-in, cross-sectoral cooperation and inter-agency support;
- Although analysis of available health and climate data in FSM undertaken in the assessment did not show many clear, strong associations between climate variability and specific disease outcomes, there is suggestive evidence of a maximum temperature threshold effect in relation to respiratory disease and diarrheal illness in Pohnpei (at ≥32-33°C with a lag of lag of zero, one and two months).

## *Recommendations*

The assessment resulted in the following recommendations, among others (FSM Department of Health and Social Affairs, 2011):

- Review, discuss and consider implementation of the adaptation strategies listed in Appendix 5;
- Emphasize the importance of community engagement and involvement with adaptation activities;
- An initial focus should be on diseases considered to be "high risk" with respect to climate change in FSM (vector-borne and water-borne illnesses and malnutrition/food security);
- The FSM EpiNET team should mainstream climate change and health issues into their program activities, with the Environmental Health Coordinator acting as the key contact for climate change and health, with input from representatives from OEEM, DRD, the Weather Service Office and other National agencies and Offices as needed;
- Public education, health promotion and effective health communication are high priorities for future public health planning and resourcing in anticipation of climate change;
- Health professionals should be provided with education and training related to climate change and health;
- Improve the health information/data collection system;
- Improve current biostatistics reporting system;
- Ensure ongoing quality control;
- Recruit and/or train health personnel in biostatistics and epidemiological analysis;
- Note that the Syndromic Surveillance Officer for the World Health Organization's Syndromic Surveillance System in FSM may be able to support training of other health information staff in this field, or even, in the short term at least, take on some extra responsibilities within the health statistics section of the Department of Health and Social Affairs;
- Work closely with other agencies, sectors and NGO's on existing and future climate change policies, frameworks and projects in FSM;
- Encourage the active participation of other sectors in climate change-related projects;
- The health sector, particularly public health, should be acknowledged as a key stakeholder in climate change adaptation activities in FSM;
- Consideration should be given to reducing the carbon emissions of the health sector as part of a broader climate change mitigation strategy for FSM;

- Acknowledgement should be made of the health co-benefits inherent in a variety of climate change adaptation and mitigation strategies such as reducing air pollution, consumption of locally-grown, nutritious foods, increasing personal energy expenditure (e.g. walking, cycling), reducing energy consumption and fuel-dependent transport, and increasing the use of renewable energy sources, which includes both long-term cost savings and benefits to health; and
- Increase training, recruitment and retention of health professionals (doctors, nurses and allied health) should continue to be of the highest priority for FSM as a general health system strengthening measure, as well as in anticipation of the health impacts of climate change.

*Adaptation consultation Mwoakilloa Atoll Pohnpei by OEEM*

## 4.14 ASSESSMENT OF A "SENTINEL EVENT" FOR CLIMATE CHANGE IN CHUUK, FSM

On March 5, 2007, an acute-onset, a high sea-level event occurred in two coral atoll islands of Micronesia (Lukunoch and Oneop), resulting in coastal erosion, shoreline inundation, and saltwater intrusion. A study was undertaken to describe the impact of this acute-onset sea-level-rise disaster on the coral atoll populations and to generate hypotheses for further investigation of the association between climate change and public health (Keim, 2010).

### *Methods*

Households of Lukunoch and Oneop islands, Micronesia, were assessed for demographics, asset damage, food availability, water quantity and quality, hygiene and sanitation, and health status. Every fourth household on Lukunoch was randomly selected (n=40). All Oneop households were surveyed (n=72). : A total of 112 total households were respondents, representing 974 inhabitants. Heads of each household were interviewed in the local language using a standard survey tool. Prevalence data were analyzed, and 95% confidence intervals were calculated (Keim, 2010).

### *Findings*

The results are summarized in Table 33. On Lukunoch, roughly half of all households surveyed reported at least a partial loss of their primary dietary staple and source of calories (taro and breadfruit). Six (15%) of 40 Lukunoch households surveyed reported a complete loss of taro and four (10%) of the 40 households reported a complete loss of breadfruit. On Oneop, nearly all households reported at least a partial loss of these same food staples. Twenty four (31%) of all 76 Oneop households reported a complete loss of taro and another 24 (31%) households reported a complete loss of breadfruit. One third of all households surveyed reported a complete loss. On Lukunoch 11(28%) of 40 households reported damage from salination, but none were damaged to the point of a complete loss. Forty-nine (64%) of 76 Oneop households reported salination and five (6%) reported complete loss of their well. These findings are consistent with events that have been predicted to occur as a result of climate change.

**TABLE 33 | Agricultural Losses as Reported by Heads of Households**

*(Source: Keim, 2010)*

| **Agricultural Losses as Reported by Lukunoch Islands Heads of Households*** | | | |
|---|---|---|---|
| **Food Source** | **No Damage/Loss** | **Partial Damage/Loss** | **Complete Loss** |
| Taro | 22/40 (55; 39-71) | 12/40 (29; 15-44) | 6/40 (16; 6-30) |
| Breadfruit | 18/40 (45; 29-62) | 18/40 (45; 29-62) | 10/40 (10; 3-24) |
| Coconut | 24/40 (60; 43-75) | 13/40 (32; 19-49) | 3/40 (8; 2-20) |
| Garden | 25/40 (62; 45-77) | 14/40 (35; 21-52) | 1/40 (3; 0.1-13) |
| Livestock | 30/40 (75; 59-87) | 10/40 (25; 11-39) | 0 (0) |

* Data are given as number (percentage; 95% confidence interval, in percentages).

| **Agricultural Losses as Reported by Oneop Islands Heads of Households*** | | | |
|---|---|---|---|
| **Food Source** | **No Damage/Loss** | **Partial Damage/Loss** | **Complete Loss** |
| Taro | 9 (13) | 43 (59) | 24 (31) |
| Breadfruit | 16 (22) | 36 (47) | 24 (31) |
| Fish | 30 (39) | 44 (58) | 2 (3) |
| Coconut | 23 (30) | 40 (53) | 13 (17) |
| Garden | 6 (8) | 38 (50) | 32 (42) |
| Livestock | 11 (14) | 38 (50) | 27 (36) |

* Data are given as number (percentage).

These findings suggest that highly vulnerable populations of both islands experienced disastrous losses in crop productivity and freshwater sources. The findings reveal the need for effective public health research and sustainable interventions that will monitor and shape the health of small island populations predicted to be at high risk of adverse health effects due to climate change.

### *Recommendations*

Effectively addressing the health risks of climate variability and change will require wide-ranging responses from National and State agencies and departments (Keim, 2010). Costs would need to be determined by the individual agencies, but would likely exceed $100 million annually. A comprehensive surveillance and monitoring system to address the health risks of climate change is necessary to provide the information needed to implement timely and appropriate programs and activities to reduce the health risks of climate change. Key public health research categories that address these essential services include surveillance and monitoring; field, laboratory, and epidemiologic research; model development; development of decision support tools; and education and capacity building of the public and public health and health care professionals.14 The findings of the current study suggest that the need for this research has become even more urgent.

Information on climate-sensitive disease risks and needs in FSM and on potential adaptation strategies to deal with climate-sensitive health risks in FSM is presented in Appendix 5. The information is based on consultations with health and climate stakeholders in all four States (FSM Department of Health and Social Affairs, 2011).

## 4.15 RISK ASSESSMENT AND MANAGEMENT FOR INFRASTRUCTURE

The infrastructure development plan for Kosrae includes completion of the circumferential road. The existing coastal road currently covers about two-thirds of the circumference of the island, but currently there is a 10 mi (16 km) gap, designated RS4. The proposed alignment of the road skirts the mangrove, hugging the coastline at the foot of the steeper slopes. Most of the proposed road is 7 to 10 m above mean sea level, with the lowest point about 4 m above mean sea level. On the inland, steeper side of the road, small drainages require that provision be made for handling peak runoff flows so as to prevent damage to the road and associated infrastructure. The primary purpose of the road is to complete the road around the island of Kosrae and provide all-weather land access to remote Walung in the southwest. It is the only community without reliable links to the other Municipalities.

Completion of this link will also allow easier access to the presently undeveloped interior of the island along the western coast, providing scope for agriculture and new settlement in the area. Currently the timing and extent of future development along the western coast due to the new road is extremely uncertain. Development is unlikely to be significant along the road segment under study, but there are plans to construct power lines to join Walung to the existing electricity distribution system from two directions along the new route. This will convert the present 'radial' configuration of the power distribution system in Kosrae to a more reliable ring-main, with benefits for the whole island.

There are three major issues concerned with the climate-related risks to completion and maintenance of the circumferential road in Kosrae:

- The hydraulic design features for the road up to, and beyond, the Yela Valley crossing;
- Making a choice amongst the options for routing across the Yela Valley, of which there are currently five; and
- The hydraulic design features for each of the above options.

Stakeholder consultations resulted in the decision to focus on the first of the above three issues, The assessment related only to the (6.1 mi) (9.8 km) portion of RS4 that lies north of the Yela Valley. The portion yet to be built is 4.1 mi (6.6 km) in length. The remainder (2.0 mi or 3.2 km) had already been constructed, with drainage works designed for an hourly rainfall of seven in (178 mm) (ADB, 2006).

### *Methods*

Climate change scenarios were used to develop projections of how the likelihoods of extreme rainfall events might change in the future. Projections used the Hadley Centre (United Kingdom) GCM, with best judgment of model sensitivity as this gave results intermediate between those provided by three other GCMs, namely those developed by the Australian CSIRO, Japan's National Institute for Environmental Science and the Canadian Climate Centre.

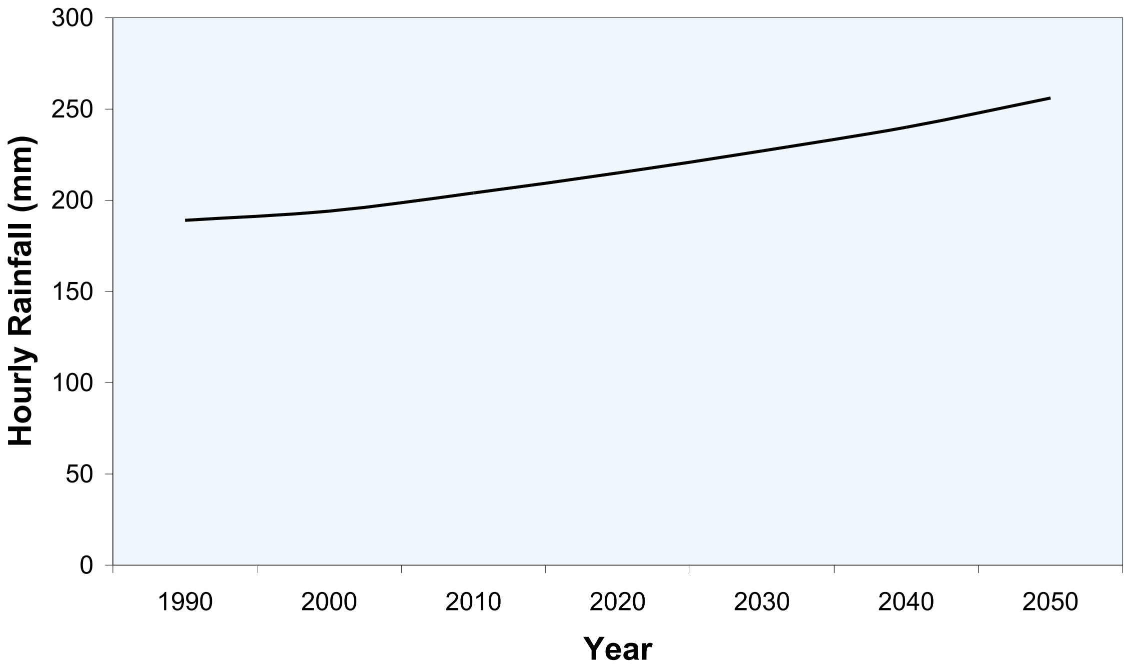
Similarly, the SRES A1B greenhouse gas emission scenario was used when preparing the rainfall projections as this scenario is close to the middle of the envelope of projected emissions and greenhouse gas concentrations.

As noted above, the drainage works for the original road design (both built and yet to be built sections) were based on an hourly rainfall of seven in (178 mm). This value was thought to have a recurrence interval of 25 years, but was derived using hourly rainfall data for Washington, DC, USA, since no hourly rainfall data exist for Kosrae. The observed data were adjusted subjectively to approximate Kosrae conditions.

The current case study used hourly rainfall data for Pohnpei, adjusted by the ratio of the mean annual rainfalls for Kosrae and Pohnpei. Based on these data an hourly rainfall of 178 mm has a recurrence interval of 23 years. The design rainfall was intended to be the hourly rainfall with a return period of 25 years. For present conditions this is 190 mm, but Figure 43 reveals that by 2050 the hourly rainfall with a 25 year return period will have increased to 10 in (254 mm).

**FIGURE 43 | Hourly Rainfall (mm) with a Return Period of 25 years.|**

*Source: ADB, 2006.*




## *Results*

A recommendation was made to the Government of the State of Kosrae that the design of the road be modified so the drainage works could accommodate an hourly rainfall of 254mm. This recommendation was accepted, and a "climate proofed" design was prepared and costed. The results shown in Table 34 indicate that the incremental cost of "climate proofing" the road design and construction for the yet to be built section is in the vicinity of US$500,000.

## TABLE 34 | Construction Costs for the Yet to be Built 6.6 km (4.1 mi) Section of RS 4 (2004 US$)

*(Source: ADB, 2006)*

| | Original Design | "Climate Proofed" Design |
|---|---|---|
| Road Surface | 1,254,000 | 1,254,000 |
| Drainage Works | 640,000 | 1,151,000 |
| **TOTAL** | **1,895,000** | **2,406,000** |
| Incremental Cost | | 511,000 |

A cost benefit analysis of "climate proofing" the road took into account the following when determining the net present values and internal rate of return (Table 35):

- Construction costs (with and without "climate proofing");
- Maintenance costs over 50 years (with and without "climate proofing"); and
- A discount rate of 3%, to allow for differing importance attached to current and future investments.

## TABLE 35 | Total Construction, Maintenance and Repair Costs for the Yet to be Built Section of RS4

*(Source: ADB, 2006)*

| | Original Design | "Climate Proofed" Design | Net Benefit of "Climate Proofing" |
|---|---|---|---|
| No climate change | 4,475,000 | | |
| With climate change | 7,803,000 | 4,986,000 | 2,817,000 |
| Internal Rate of Return | | | 11% |

Net present values (US$) over 50 years, with discount rate of 3%

Figure 44 illustrates the above results. While the capital cost of the "climate proofed" road would be higher than if the road was constructed to the original design, the accumulated costs, including repairs and maintenance, would be lower after only 15 years, approximately. This is due to lower repair and maintenance costs for the "climate proofed" road.

As noted above, a two mi (3.2 km) portion of RS4 has already been constructed, including the drainage works. The design for these was based on an hourly rainfall of seven in (178 mm) for a 25 year recurrence interval. It is informative to consider the cost of retroactively "climate proofing" this section of road (i.e. using a design rainfall of 10 in (254 mm)). The results are presented in Table 36.

*High tide Kosrae main road by KIRMA*

**Figure 44 | Accumulated Costs (Construction, Repairs and Maintenance) for the Yet to be Built Section of RS 4, for the Original (Red Line) and "Climate Proofed" (Green Line) Designs.**

*Source: ADB, 2006).*


**TABLE 36 | Construction Costs for the Built 2 mi (3.2 km) Section of RS 4 (2004 US$)**

*(Source: ADB, 2006)*

| | As Built | "Climate Proofed" Design |
|---|---|---|
| Road Surface | 518,000 | |
| Drainage Works | 406,000 | 776,000 |
| **TOTAL** | **924,000** | |
| Incremental Cost | | 776,000 |

The information presented in Tables 35 and 37 show that it is more costly to "climate proof" retroactively - US$776,184 for a 3.2 km section of existing road (US$243,000 per km) as opposed to US$511,00 to "climate proof" 6.6 km of new road (US$77,00 per km). But a cost benefit analysis (Table 37) reveals that the retroactive "climate proofing" is still a cost effective investment, with an internal rate of return of 13%.

**TABLE 37 | Total Construction, Maintenance and Repair Costs of Built Section of RS4**

*(Source: ADB, 2006)*

| | Original Design | "Climate Proofed" Design | Net Benefit of "Climate Proofing" |
|---|---|---|---|
| No climate change | 3,504,000 | | |
| With climate change | 6,833,000 | 3,875,000 | 2,958,000 |
| Internal Rate of Return | | | 13% |

Net present values (US$) over 50 years, with discount rate of 3%

The Government of FSM and the Government of the State of Kosrae were informed of these findings as well as possible funding options for "climate proofing" the section of road that has yet to be built. The options included:

- not "climate proofing" the road, since:
  - more important investments may have to be made (e.g. in health)
  - the climate may not change in the way that is projected; and
  - an extreme even (e.g. hourly rainfall of10 in) can happen at any time – it is only possible to consider average recurrence intervals.
- using internal funds – i.e. from State budget;
- using National funds
- using Compact II funds on the basis that the true ("most likely") costs of the project have increased
- seeking additional funding from international donor agencies such as:
  - the Global Environment Facility (GEF);
  - multilateral financial institutions (e.g. ADB);
  - bilateral donors (e.g. Government of Canada); and
  - public-private partnerships, possibly including a road toll.

The last option is a possibility since the high ecological value of the Yela Valley might encourage a philanthropic organization to fund the additional construction costs required to ensure the road is "climate proofed" and in addition is not going to place valuable ecosystems at risk. Based on the information available to it, the Government of the State of Kosrae decided it would not proceed with construction of the section of RS4 north of the Yela Valley until additional funds are available to complete the "climate proofing".

***Follow Up***

The FSM component of the PACC Project has been undertaking road improvements for RS-3 and RS 4 in Kosrae, based on the findings of the ADB study. Hydrologic analysis has been performed on the watershed areas above RS-3 and RS-4 for a 25-year return period and a maximum rainfall of 12 in (305 mm) per hour. New 36" diameter pipe culverts will be added to the existing cross-drainage structures while some of the 24" diameter pipe culverts will be retained together with all the existing reinforced box culverts. In Road Section 4, new box culverts will be constructed.

The Department of Resources and Economic Affairs has completed all survey work for RS-3 and RS 4. Stake (markers) quantity estimates and road cross sectioning by station was completed for RS-3, covering 2.43 miles. Plotting of survey data, road design and quantity estimates were since completed for RS 4.

## 4.16 PILOT STUDY ON HERITAGE AND CLIMATE CHANGE IN MOCH ISLAND, CHUUK

The pilot study was conducted in order to establish research processes and protocols for the investigation of the impact of climate variability and change on cultural heritage in the coral atoll islands of Micronesia. The study was undertaken with the support of a small grant from the School of Arts and social Sciences, James Cook University, Australia, and in-kind support from the Historic Preservation Office, Chuuk, Federated States of Micronesia (Henry et al., 2008). According to Rubenstein (2002:75), 'Micronesian island communities accommodated to climate extremes and natural disasters through the development of social and political linkages between the more vulnerable coral atolls and the neighboring high islands'.

***Methods***

The research team spent four days on Moch Island in the Mortlocks, conducting formal interviews and participating in informal discussions with people about their experiences of climatic events and the changes they had observed on the island in relation to such events. The geographical location and stories associated with the culturally important places identified by people as being affected by climatic events were recorded and a preliminary map was produced.

## Findings

Research participants expressed concern that their way of life, history and place-based knowledge of Moch would be lost in the event of evacuation and requested that the research team record and preserve oral history, narratives, genealogies and other aspects of cultural heritage for future generations. Mochese and other peoples of the Mortlock Islands are actively engaged in making sense of and interpreting what they have heard regarding scientific predictions of climate change. While not actually living in fear, many people are concerned about the possibility of future evacuation as a result of sea-level rise and related food insecurity. Yet evacuation was considered a last resort and a number of research participants said that they would only leave the island if the whole population was forced to move en masse;

All the research participants referred to kinship networks across the region and engaged in practices of exchange within these networks. These networks provide an essential means of social and economic support. People are actively and continuously building and maintaining sea walls and they clearly considered these to be a necessary and effective response to high tide and sea level rise. They called upon financial and other support to build stronger and higher seawalls in the face of impending sea level rise related to climate change. One research participant expressed doubt about the effectiveness of sea walls and recalled that after people began building sea walls, the beaches that he had played on as a child, began to disappear.

The researchers mapped one location where mangroves seedlings had been planted as an alternative means of future protection of the shoreline. They also documented taro patches that were healthy, but were also shown patches that had been destroyed by salt water inundation. The researchers were informed that the common taro patch on the adjacent uninhabited island was no longer productive due to salt water inundation.

Overall, the mapping exercise revealed Moch to be a cultural web of places constituting a land/seascape steeped in heritage significance. Analysis of interviews with key research participants demonstrated that people are deeply concerned about the potential loss of their home islands, significant places and place-based knowledge due to climate change. The research team was urged to return to Moch to document, record and safely store cultural knowledge for the sake of future generations. It was concluded that there was a need for a longer term study on Moch. In addition, comparative studies on heritage values in other parts of the State, which are more immediately affected by sea-level rise, are recommended as urgently required.

## Recommendations

The following recommendations arose out of the pilot study (Henry et al., 2008):

- That outer islander knowledge and concerns about climate change be recognised and incorporated into National and regional responses;
- That heritage values are taken into account when documenting the social impact of climate events;
- That existing social strengths and adaptive cultural practices inform the development of policy and response planning associated with climate change;
- That social support networks are mapped across the region so as to document social capital and assess resilience of communities in the face of climatic events;
- That further research is conducted on oral histories, narratives, place-based knowledge, social practices and cultural heritage values that people fear will be lost due to climate change factors;
- That comparative studies of other islands and island groups are conducted to assess different local understandings of and responses to climate change; and
- That comparative studies of other islands and island groups are conducted to assess local level vulnerabilities and resilience to climatic factors.

## 4.17 GENERAL COMMENTS ON ADAPTATION IN THE FSM

Fletcher and Richmond (2010) have concluded that successfully achieving climate adaptation within the FSM may be facilitated by two steps: (i) forming international partnerships to aid adaptation efforts; and (ii) continuing the development of internal policies focused on building resilient and sustainable communities.

This may be facilitated with the following:

- Public education on climate risks in FSM including education of Government workers and other decision makers, of community members, and of landowners in particular;
- Community-based adaptation offers an opportunity to effectively institute adaptation measures with immediate benefit;
- Working within traditional land use policies to implement climate risk management as this will engender more domestic partnerships;
- Defining best management practices and aligning Government programs and policies with these practices;
- Strategic redevelopment of coastal communities vulnerable to flooding now and in coming decades;
- Conserving and promoting island and oceanic ecosystem services;
- Preserving and promoting traditional culture to facilitate adaptation strategies and community accord;
- Improving food and water security with a focus on domestic production as a core strategy in the National economy; and
- Master planning of communities focused on sustainability with enhanced Government services such as health, sanitation, water and power, emergency services, and others (Fletcher and Richmond, 2010).

CHAPTER FIVE

# NATIONAL GREENHOUSE GAS EMISSIONS INVENTORY

5

## 5.1 INTRODUCTION

The information in this section is extracted from a report prepared by Furow and Konno-Anisin (2010). That report, the second inventory report for FSM, used data from a 2000 survey, with 1994 data used as the baseline.

## 5.2 METHODOLOGY

The *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventory* was used as the primary workbook for all greenhouse gas calculations and analysis. All four States in the FSM were covered by the inventory. However, in areas where data were lacking or questionable, an estimated value was used instead as raw data to calculate emissions. Data used in the study allowed emissions to be calculated for several sectors and gases that have been identified by the IPCC as known sources of human-related greenhouse gas emissions (Table 38). The detailed methods used are described in Appendix 6.

**TABLE 38 | List of Sectors and Gases Included in the Inventory**

*(Source: Foruw and Konno-Anisin, 2010)*

| | Gases Assessed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sectors Covered** | **CO2** | **CH4** | **N2O** | **NOX** | **CO** | **NMVOCS** | **SO2** | **HFCs** | **PFCs** | **SF6** |
| Energy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | | | |
| Industrial Processes | Yes | No | No | No | No | Yes | No | Yes | No | No |
| Agriculture | No | Yes | Yes | Yes | Yes | No | No | | | |
| Forestry and Other Land Use | Yes | Yes | Yes | Yes | Yes | No | No | | | |
| Waste | Yes | Yes | Yes | Yes | No | No | No | | | |

Due to the fact that the FSM has a small population and limited land area, the activities outlined under most of these sectors do not have much practical relevance for the country. The only exception is the energy sector, which has been identified as being the principal source of greenhouse gas emissions in the country as well as in other small Pacific Island Countries. The rest of the sectors, regardless of the priority listings, were covered depending on the availability and quality of data.

The primary greenhouse gases covered by the inventory were carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$). In addition, greenhouse gases such as carbon monoxide (CO), oxides of nitrogen (e.g., NO and $NO_2$), were included whenever data was available.

## *Energy Sector*

Because data from source categories are not readily available in the FSM, non-$CO_2$ gases from fossil fuel combustion were not included in the inventory. However, these were estimated for biomass fuels as supporting data on this category is available from the 1994 FSM Census.

Although several methods are available for estimating carbon dioxide emissions, only the "reference approach" was used to determine carbon dioxide emissions from the energy sector. This method estimates total $CO_2$ emissions based on the amount of fuels supplied to the economy for National consumption and therefore does not depend on detail information regarding fuel type, technology, and operating conditions. In this respect, the reference method may be termed a "top down" approach, as opposed to the "bottom-up" approach" which is calculated at a detail activity/technology level.

## *Land Use Change and Forestry*

The methodology proposed by the IPCC for land-use change and forestry is based on two premises: i) the flux of carbon dioxide to or from the atmosphere is assumed to be equal to changes in carbon stocks in existing biomass and soils; and ii) the rates of changes in land-use and the practices used to bring about the change (e.g., burning, and clear-cutting) are used to derive assumptions that determine their impacts on carbon stocks and the biological responses to a given land-use. Given these assumptions, there are large uncertainties associated with the IPCC methods for estimating fluxes of $CO_2$ from land-use change and forestry. The IPCC, therefore, recommends and encourages countries preparing an inventory to make simple assumptions about the effects of land-use change on carbon stocks and the subsequent biological responses to the land use changes.

## *Agriculture*

The emissions from this sector are primarily based on domestic livestock and burning of savanna. These are the primary sources of greenhouse gases identified from agriculture in the FSM.

## *Waste*

A default value of 0.4 for the methane correction factor was used in the calculation of methane emissions from solid waste disposal sites. This is based on the assumption that all municipal solid waste (MSW) is disposed of in unmanaged SWDS which are shallow, with a depth or 5 meters or less. This type of waste disposal practice tends to enhance aerobic decomposition, generating extremely low methane emissions.

Methane emissions from wastewater handling were estimated for only domestic or municipal wastewater handling operations. Nitrous oxide emissions from human sewage were calculated using India's per capita protein consumption of 55 grams of protein/person/day, or 20.75 kilograms protein/person/yr.

## 5.3 NATIONAL EMISSIONS AND SINKS

National emissions are documented for the following sectors: energy, land use changes and forestry, agriculture, waste and industrial processes.

### ***Energy Sector***

Similar to most small Pacific island countries, energy use in the FSM, relates mainly to the use of secondary liquid fossil fuels. These are processed liquid fuels such as gasoline, diesel, jet fuel, etc. Biomass fuels, solar, and wind power are also used to supplement the energy needs of certain areas in the country. For instance, biomass fuels are used largely for traditional cooking purposes but not for other energy generation activities (e.g., crude oil, orimulsion, or natural gas liquids). Solid fossil fuels (e.g., coal, oil shale, peat) are not used in the FSM. As a whole, FSM has no indigenous supplies of fossil fuels and relies on outside imports to meet its fuel needs for energy.

The total amount of $CO_2$ emitted in the FSM as a result of fossil fuel combustion is estimated at 151.91 gigagrams, or 151,910 metric ton. Thus $CO_2$ emissions have decreased by 7.7% since 1994 when the amount of $CO_2$ emitted in the FSM was estimate to be 164.51 gigagrams[5]. This is largely a result of changes in the economy and efforts to move to a lower carbon economy (e.g. increased use of renewable energy). Significantly, FSM's contribution on a global scale is a mere 0.003% of global $CO_2$ emissions.

Carbon dioxide released from biomass fuel consumption is excluded from the preceding total as the net emission from this source is assumed to be offset by reforestation of woody plants and coconut trees. Separately, $CO_2$ emissions from biomass fuel consumption in the FSM are estimated to be 28.87 gigagrams, or 28,870 metric tons. This compares to 26.86 gigagrams in 1994.

Emissions of non-$CO_2$ gases (such as $CH_4$, $N_2O$, $NO_x$, and CO) were not calculated due to lack of information.

### ***Land Use Changes and Forestry***

The IPCC documentation identifies the following three processes as the main source as the main source or sink of $CO_2$ related to land use changes and forestry: changes in carbon stored in soil due to changes in land-use practices (source or sink); organic soil conversion to agriculture or plantation forestry (source); and liming of agricultural soil (source). Land-use practices affect carbon stored in soil by modifying carbon inputs to soil as well as the decomposition rate of soil organic matter. Extensive clearing of native vegetation (e.g., forest, savanna, grassland, and wetlands) leads to a reduction of soil carbon because of decreased carbon inputs and enhanced decomposition from the disturbed land. However, after the land is abandoned, natural re-vegetation (follow) tends to follow, thus, increasing the level of carbon in the soil. An exception is where the land never fully recovers in which case carbon stocks in the soil may decline further. Organic soil converted to agricultural purposes or plantation forestry also release carbon dioxide due to the rapid oxidation or organic matter in the soil.

Land-use changes and forestry in FSM are typical of any island country where people utilize these resources mainly at the subsistence level. Generally, the major disturbance on the land that are relevant to this sector comes from limited clear-cutting and burning to plant crops such as taro, yams, breadfruit, bananas, coconuts, and cassava. Even more limited are lands set aside for pasture since the local population raises animals for the most part close to their residence primarily for personal consumption. These kinds of land-use practices, therefore, do not require extensive use of the land as found in developed countries. Woody biomass and other forest-type trees are usually left standing on the cleared land to control erosion, provide shading, and in certain cases replace soil nutrients used up by the crops. These kinds of practices are very helpful (sequestration) for carbon dioxide. In addition, imports of food materials which supplement locally grown crops have lessen land disturbances that would otherwise be much higher given the recent increase in population.

[5] The original estimate of 235.95 gigagrams was subsequenty revised downwards to 164.51 gigagrams.

Forest and other woody biomass stocks are also not harvested in commercial timber operations. In fact, commercial timber operations are virtually non-existent in the FSM. However, the local population relies on these sources of timber materials for building local houses. Nevertheless, the amount harvested each year is extremely small given the imported building materials are also available on the islands. Today, many residences are building using cement, tin roofs, lumber and other imported materials. This lessens the impact on forest and other woody biomass stocks in the country. Agricultural programs involving tree planting, although done intermittently over the years, are also contributing to sustainable use of forest and woody biomass stocks. These stocks also provide an important source of firewood for some residents, although electric and kerosene stoves have become popular in recent years. Liquid propane gas stoves are also used in some homes. All these alternatives contribute to the overall reduction of fuel wood consumption in the FSM. This helps preserve existing forest and woody biomass stocks.

Carbon dioxide emissions, or removal by soil, is not a significant category in the FSM as land-use and agricultural practices do not involve extensive disturbances on the land. For instance, intensive use of organic soil and liming of agricultural soils are virtually not practiced in the country for increasing crop production and managing forestry. Consequently, carbon dioxide emissions from such practices are much lower, and for the purpose of this study, will be considered insignificant.

Human activities that affect land-use change and forestry are quite limited. Also, most data relevant to calculating emissions or uptake or $CO_2$ are simply not available in the FSM. As a result, it was assumed that emissions, if any, from this sector are usually offset by uptake from existing forests and other plants and vegetation in the Eastern Caroline (i.e., Chuuk, Pohnpei, and Kosrae). In effect, there is considered to be a net uptake of $CO_2$ for land-use changes and forestry in the FSM.

Table 38 shows the change in FSM's forest cover between 1983 and 2006. The latter data were derived from a forest inventory conducted in 2005 on Kosrae, and 2006 in Yap, Chuuk, and Pohnpei. The inventories were undertaken by a multinational crew that included foresters from the FSM, American Samoa, and the U.S. Department of Agriculture, Forest Service (FAO, 2010). This indicates that over the 23 years forest cover on all forest land has increased by 627 ha, or by 27.3 ha per year. Forests are composed of medium- to large-diameter trees of several tropical species, interspersed with agroforesty in more populated areas.

The information in Table 39 was not available for the 2000 GHG inventory, but is expected to inform the next inventory.

### TABLE 39 | Extent of Forest and Other Land in FSM

*(Source: FAO, 2010)*

| | FAO Calibrated Data 1983 (ha) | FAO Calibrated Data 2006 (ha) | Total change in 23 years | Area Δ per year |
|---|---|---|---|---|
| All forest land | 63,393 | 64,020 | 627 | 27.25 |
| Other land | 6,478 | 5,851 | -449 | -19.52 |
| Inland water | 129 | 129 | 0 | 0 |
| **TOTAL** | **70,000** | **70,000** | | |

Table 40 shows the GHG emissions and sinks as a result of land use changes and forestry.

### TABLE 40 | Greenhouse Gas Emissions and Sinks as a Result of Land Use Changes and Forestry

*(Source: Foruw and Konno-Anisin, 2010)*

| Greenhouse gas source and sink categories | $CO_2$ emissions (Gg) | $CO_2$ removals (Gg) | $CH_2$ (Gg) | $N_2O$ (Gg) | $NO_x$ (Gg) | CO (Gg) |
|---|---|---|---|---|---|---|
| Land-use change and forestry | 24.94459 | -568.40867 | 0.00022 | 0.00000 | 0.00005 | 0.00190 |
| A. Changes in forest and other woody biomass stocks | 0.00000 | -506.94954 | | | | |
| B. Forest and grassland conversion | 0.82536 | 0.00000 | 0.00022 | 0.00000 | 0.00005 | 0.00190 |
| C. Abandonment of managed lands | | -86.40372 | | | | |
| D. $CO_2$ emissions and removals from soils | 24.11933 | 0.00000 | | | | |
| E. Other (please specify) | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |

## *Agriculture*

Greenhouse gas emissions from agriculture activities are largely from the following sources:

- Methane ($CH_4$) and nitrous oxide ($N_2O$) from domestic livestock
- Methane ($CH_4$) emissions from flooded rice fields
- Non-$CO_2$ emission from burning of savannas
- non-$CO_2$ emission from burning of agricultural residues
- direct emission of nitrous oxide ($N_2O$) from agricultural soils
- direct emission of nitrous oxide ($N_2O$) from animal production and
- indirect nitrous oxide ($N_2O$) emission from the use of fertilizer in agriculture.

As noted previously, agriculture in the FSM is basically carried out at the subsistence level. Crops and domestic livestock are raised primarily for personal consumption. "Large" scale farming operations are not prolific in the country and much of their production is aimed at local consumption. Even then, their production level for both crops and domestic livestock is extremely low compared to similar commercial operations in larger countries.

Following is a description of agricultural practices in the FSM that are identified under the IPCC guideline as being potential sources of greenhouse gas emission. Other potential sources not applicable to the FSM are disregarded for obvious reasons. Indeed, among the potential sources listed earlier, only methane emission from domestic livestock and non-$CO_2$ emissions from savanna burning have any significance in the FSM.

Nitrous oxide emissions from manure management system are not covered since virtually no commercial livestock operations utilize manure in this manner. Manure, however, is used periodically as fertilizer and no definite method of storage has been identified in the FSM. This study also disregards rice cultivation as a source of methane since rice is not grown in the country. The same as also true for non-$CO_2$ emission from the burning of agricultural residues and nitrous oxide ($N_2O$) emission from agricultural soils. The type of crops and extent of cultivation in the FSM do not require extensive burning or agricultural residues. Finally, agricultural soil is often farmed using pre-existing organic materials on the land. The amount of nitrogen-based fertilizer used in the FSM is extremely low and is not a significant source of direct and indirect nitrous oxide emission. This is also probably true for nitrous oxide ($N_2O$) emission from animal manure.

Domestic livestock consist mainly of pigs, goats, and chickens and are usually raised on the same plot of land that the family resides. While some pigs, goats, and chickens are kept in pens or coops, most are left to roam the yard and sometimes adjacent land area. Of these animals, only pigs and chickens are raised in commercial operations. The goat population, which has increase dramatically in recent years, is mainly confined to Pohnpei and basically ranges freely.

The burning of Savanna is routinely experienced in the FSM especially during long periods of droughts. Yap, for instance, has a more pronounced dry season compared to the other States, thus, making it prone to numerous fires on an annual basis. During El Nino years, the frequency and extent of the fires is greatly exacerbated. In any case, the grassland usually recovers very fast when the rainy season arrives. Nearby vegetation may also invade some of the burnt area and takes over formerly grassland areas.

As noted in Table 41, FSM's methane emissions from agriculture are estimated to be around 0.028 gigagrams, or 28 metric tons in 2000.

### TABLE 41 | Emissions from the Agriculture Sector

*(Source: Foruw and Konno-Anisin, 2010)*

| Greenhouse gas source and sink categories | $CO_2$ emissions (Gg) | $CO_2$ removals (Gg) | $CH_4$ (Gg) | $N_2O$ (Gg) | $NO_x$ (Gg) | CO (Gg) | NMVOCs (Gg) | $SO_x$ (Gg) |
|---|---|---|---|---|---|---|---|---|
| Agriculture | | | 0.02750 | 0.00001 | 0.00029 | 0.01723 | 0.00000 | 0.00000 |
| A. Enteric fermentation | | | 0.02684 | | | | | |
| B. Manure management | | | 0.00000 | 0.00000 | | | 0.00000 | |
| C. Rice cultivation | | | 0.00000 | | | | 0.00000 | |
| D. Agriculture soils | | | | 0.00000 | | | 0.00000 | |
| E. Prescribed burning of savannahs | | | 0.00066 | 0.00001 | 0.00029 | 0.01723 | 0.00000 | |
| F. Field burning of agriculture residues | | | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | |

### *Waste*

Methane ($CH_4$) emission from solid waste disposal sites was estimated at 0.034 gigagrams, or 34 metric tons (Table 42). In 2000 FSM's methane emissions from wastewater handling were 0.027 gigagrams, or 27 metric tons (Table 39). Commercial and industrial wastewater handling operations were not included in the calculations because data on these types of operations were simply not available. More importantly, emissions from these sources are believed to be minimal given that the nation has a very limited industrial/commercial base. In fact, only the fishing industry may have some relevancy in this section, but due to very limited fish processing operations, the actual amount of methane emitted may be quite low. Sludge handling systems, can produce a considerable amount of methane under anaerobic conditions, and is also excluded from the calculations since apparently no such operations existed in the country. Sludge operations of these types is used for recovering methane and therefore should be distinguished from aerated sludge in dry beds, which is available at some of the wastewater treatment plant in the FSM (Chuuk State).

### TABLE 42 | Emissions from the Waste Sector

*(Source: Foruw and Konno-Anisin, 2010)*

| Greenhouse gas source and sink categories | $CO_2$ emissions (Gg) | $CO_2$ removals (Gg) | $CH_4$ (Gg) | $N_2O$ (Gg) |
|---|---|---|---|---|
| Waste | | | 0.06157 | 0.04823 |
| A. Solid waste disposal on land | | | 0.03433 | |
| B. Waste-water handling | | | 0.02724 | 0.04823 |

The amount of nitrous oxide emitted from human sewage in 2000 was found to be 0.048 gigagrams, or 48 metric tons.

## *Industrial Processes*

GHGs such as $CO_2$, $CH_4$, $N_2O$, CO, NMVOCs, $SO_2$, HFCs, PFCs, and $SF_6$ are emitted from a wide variety of industrial processes, which physically or chemically transform raw materials into final products for usage and consumption. Emissions from energy-related processes are not included in this section as these are already covered under the Energy Sector.

Because the FSM lacks such a highly development industries base and does not manufacture raw materials or intermediate products in large quantities suitable for worldwide exports, only the following industrial processes were found to have relevance to the FSM GHG emissions inventory:

- Carbon dioxide ($CO_2$) emissions from lime production
- NMVOCs emissions from road paving with asphalt
- NMVOCs emissions from bread-making and other food production processes (e.g., meat, fish, etc.)
- Products containing HFCs and PFCs.

Carbon dioxide ($CO_2$) is emitted from lime production in a series of steps starting from quarrying the raw material (e.g., limestone), and then crushing, sizing and heating the material to an extremely high temperature (approximately 1100° C). This process of producing lime is called calcining or calcination. It includes hydrating the lime to calcium hydroxide. In addition, $CO_2$ is also released from transferring, storing, and handling the final product.

NMVOCs are emitted from the asphalt used in paving operations where the asphalt acts as a binder for aggregates. As such, the NMVOCs can be emitted at the plant during manufacturing, the actual road paving operations, and the subsequent road surface itself.

NMVOCs are also emitted from breadmaking and other food production process (e.g., meat, fish, etc). In breadmaking, NMVOCs are released through fermentation in the bread, the actual baking process, and the drying of the final product. Similarly, other food production processes (e.g., meat and fish process) also release NMVOCs in a considerable quantity.

Finally, products containing HFCs and PFCs such as a fire extinguisher or refrigerator may leak these chemicals into the atmosphere slowly over a period of time. This is especially true for the halocarbons that are enclosed in a unit that form an integral part of the overall product.

The FSM has no heavy industries nor does it export products out of the country in large quantities during that time, the same is for 2000. The only exemption may be the clothing industry, which had one or two companies operating in the country at the time of the inventory, and the fishing industry. Both are small compared to similar operation in more developed countries. In any case, the clothing industry is not listed above as a possible source of greenhouse gas from the industrial sector. Several small-scale bakeries, coconut product manufactures (e.g., soap, oil, etc), lime producers, were also in operation at the time but their production levels were quite low since their products were aimed mainly for local consumption. Product contains HFCs and PFCs are also imported into the FSM. This includes fire extinguisher, refrigerator, and other products which may leak these extremely damaging gases into the atmosphere over a long period of time.

Table 43 shows the emissions related to industrial processes that were calculated for 2000. Emissions from the use of mineral products were 0.071 gigagrams, or 71 metric tons for carbon dioxide and 23.97 gigagrams, or 239.7 metric tons for NMVOC emissions.

## TABLE 43 | Emissions from Industrial Processes

*(Source: Foruw and Konno-Anisin, 2010)*

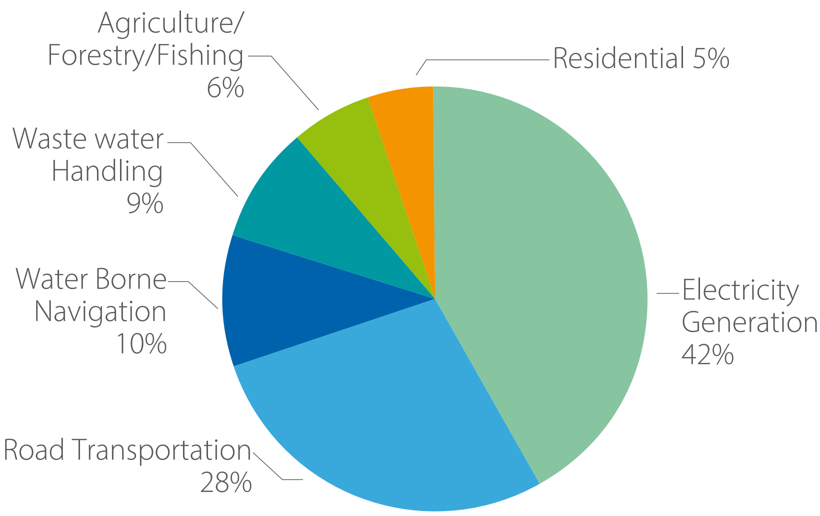
| Greenhouse gas source and sink categories | $CO_2$ emissions (Gg) | NMVOCs (Gg) |
|---|---|---|
| Industrial processes | 0.07125 | 24.02669 |
| A. Mineral products | 0.07125 | 23.97105 |
| B. Chemical industry | 0.00000 | 0.00000 |
| C. Metal production | 0.00000 | 0.00000 |
| D. Other production | 0.00000 | 0.05564 |

### *Overall Emissions*

Figure 45 shows the key source activities that contributed most to FSM's GHG emissions in 2000, while Figures 46 and 47 and Table 44 show the sectoral breakdown of FSM's total GHG emissions in 2000. The dominance of the energy sector and electricity generation are readily apparent. Figure 47 shows the contribution of specific GHGs to the total $CO_2$-eq emissions in the FSM in 2000.

## FIGURE 45 | Key source activities that contributed most to FSM's GHG emissions in 2000.

*Source: Foruw and Konno-Anisin, 2010.*




*Forest clearing Pohnpei by CSP*

**FIGURE 46 | Sectoral breakdown of FSM's total GHG emissions in 2000.**

*Source: Foruw and Konno-Anisin, 2010.*

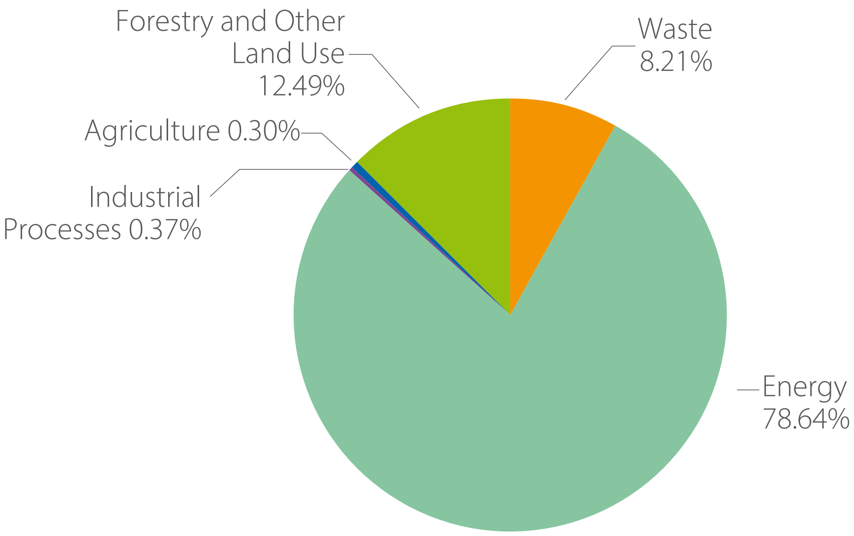
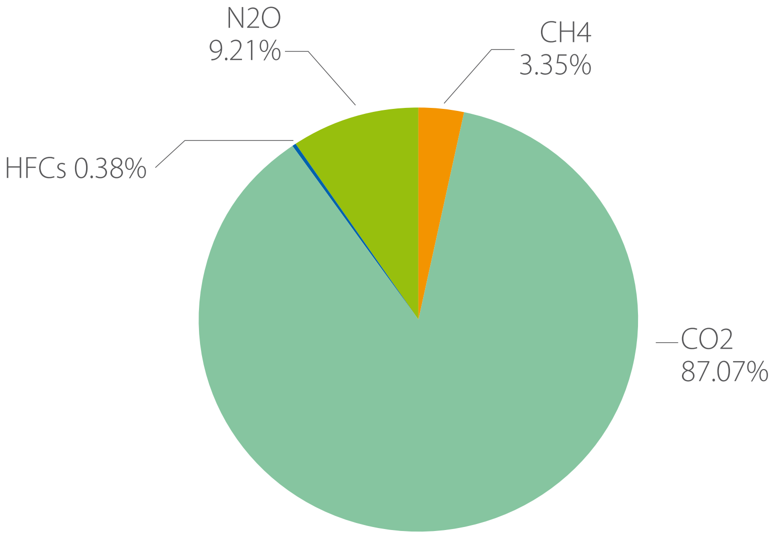



**FIGURE 47 | Contribution of specific GHGs to the total $CO_2$-eq emissions in the FSM in 2000.**

*Source: Foruw and Konno-Anisin, 2010.*




*Sea inundation taro patch by Henry Susaia*

## TABLE 44 | Sectoral Breakdown of FSM's Total GHG Emissions in 2000.

*(Source: Foruw and Konno-Anisin, 2010)*

| Greenhouse gas source and sink categories | $CO_2$ Emissions | $CO_2$ Removals | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOCs | $SO_2$ | HFCs | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | P | A |
| **Total National Emissions and Removals** | **151.98626** | **-568.40867** | **0.27864** | **0.05191** | **1.25537** | **7.31946** | **25.06748** | **0.30726** | **0.00051** | **0.00000** |
| **1. Energy** Reference Approach [1] | 151.91501 | | | | | | | | | |
| Sectoral Approach [1] | 151.91501 | | 0.18935 | 0.00367 | 1.25502 | 7.30033 | 1.04079 | 0.30726 | | |
| A. Fuel Combustion | 151.91501 | | 0.18935 | 0.00367 | 1.25502 | 7.30033 | 1.04079 | | | |
| B. Fugitive Emissions from Fuels | 0.00000 | | 0.00000 | | 0.00000 | 0.00000 | 0.00000 | 0.00000 | | |
| **2. Industrial Processes** | 0.07125 | | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 24.02669 | 0.00000 | 0.00051 | 0.00000 |
| **3. Solvent and Other Product Use** | 0.00000 | | | 0.00000 | | | 0.00000 | | | |
| **4. Agriculture** | | | 0.02750 | 0.00001 | 0.00029 | 0.01723 | | | | |
| **5. Land-Use Change and Forestry** | (2) 0.00000 | (2) -568.40867 | 0.00022 | 0.00000 | 0.00005 | 0.00190 | | | | |
| **6. Waste** | | | 0.06157 | 0.04823 | | | | | | |
| **7. Other (please specify)** | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | | |
| **Memo Items:** | | | | | | | | | | |
| **International Bunkers** | 28.85714 | | 0.00072 | 0.00066 | 0.25979 | 0.14340 | 0.03762 | 0.00002 | | |
| Aviation | 21.08681 | | 0.00015 | 0.00060 | 0.08937 | 0.02979 | 0.01489 | 0.00001 | | |
| Maritime | 7.77033 | | 0.00057 | 0.00007 | 0.17042 | 0.11361 | 0.02272 | 0.00001 | | |
| **$CO_2$ Emissions from Biomass** | 28.44480 | | | | | | | | | |

P = Potential emissions based on Tier 1 Approach.

A = Actual emissions based on Tier 2 Approach

A comparison of 1994 and 2000 total emissions, by gas, is presented in Table 45. It shows an 8% reduction on $CO_2$ emissions between 1994 and 2000. Over the same period $CO_2$ removals increased by almost 20%. There were negligible changes for other categories of emissions.

### TABLE 45 | Total Greenhouse Gas Emissions for 1994 and 2000, by Gas

*(Source: Foruw and Konno-Anisin, 2010)*

| Greenhouse gas source and sink categories | $CO_2$ emissions (Gg) | $CO_2$ removals (Gg) | $CH_4$ (Gg) | $N_2O$ (Gg) | $NO_x$ (Gg) | CO (Gg) | NMVOCs (Gg) | $SO_x$ (Gg) |
|---|---|---|---|---|---|---|---|---|
| Total national emissions and removals (1994) | 164.53460 | -474.11537 | 0.23374 | 0.05115 | 1.41058 | 6.56199 | 24.98618 | 0.36476 |
| Total national emissions and removals (2000) | 151.98626 | -568.40867 | 0.27864 | 0.05191 | 1.25537 | 7.31946 | 25.06748 | 0.30726 |

## 5.4 EMISSIONS RELATED TO INTERNATIONAL BUNKERS

Table 46 shows the emissions related to international bunkers. These are not considered to be part of National emissions by FSM.

### TABLE 46 | Emissions from International Bunkers

*(Source: Foruw and Konno-Anisin, 2010)*

| Greenhouse gas source and sink categories | $CO_2$ emissions (Gg) | $CH_4$ (Gg) | $N_2O$ (Gg) | $NO_x$ (Gg) | CO (Gg) | NMVOCs (Gg) | $SO_x$ (Gg) |
|---|---|---|---|---|---|---|---|
| **International bunkers** | **28.85714** | **0.00072** | **0.00066** | **0.25979** | **0.14340** | **0.03762** | **0.00002** |
| Aviation | 21.08681 | 0.00015 | 0.00060 | 0.08937 | 0.02979 | 0.01489 | 0.00001 |
| Marine | 7.77033 | 0.00057 | 0.00007 | 0.17042 | 0.11361 | 0.02272 | 0.00001 |

## 5.5 STRENGTHENING THE EMISSIONS INVENTORY

### *Energy Sector*

In general, the quality of data from the energy sector is reasonably good, for fossil fuel imports. The primary reason is that Mobil Oil was the only importer of fossil fuel into the FSM in 2000. Data for the whole FSM were compiled regionally at the company's main office in Guam, making it easier for researching and cross-checking figures as opposed to having many sources of fossil fuel imports. Nevertheless, there is always room for improvements as shown by the recommendations outlined below:

1. Conduct survey to gather data on fuel combustion from sub-categories or "end use activities" within the energy sector so that non-$CO_2$ emissions can be calculated much more accurately during the next round of National inventory. Sub-categories or "end use activities" within the energy sector include electrical production, transportation, manufacturing industries, forestry. Information derived using this approach can also be used in calculation of $CO_2$ emissions, thus providing a means to verify the results using the Reference Approach.

2. Per capita annual biomass fuel consumption (Kt dm/1000 persons) must be determined for the FSM. This must be done for each of the four States and the specific types of biomass fuel used, including fuelwood, coconut husk and coconut shells. Any other types of biomass fuel not included in the current inventory, but are used to a large extent in the FSM, should be covered by this analysis.

3. International bunkering fuel data needs to be sourced and analyzed to obtain a much more accurate picture of fuel consumption for both aviation and marine transports in the FSM. Currently only rough estimates are used.

These recommendations, especially from this sector, should be given top priority in advance of another inventory being undertaken. This is because, as mentioned earlier, the majority of greenhouse gas emissions in the FSM are from the energy sector. Furthermore, the country's aim toward economic self-sufficiency means that an increase in energy usage is foreseeable in the future.

## *Land Use Changes and Forestry*

One of the greatest obstacles encountered in completing this part of the inventory was the lack of the data needed to perform the necessary calculations. Data needed for these calculations require further studies/survey in this area and include the following:

### $CO_2$ Emission/ Removal from Changes in Forests and Other woody Biomass Stocks

1. Amount and type of biomass (and hence carbon) contained in different ecosystems.
2. Annual growth rate by type of forest (default values are available but could result in highly uncertain National totals).
3. Total biomass consumption from stocks.

### CO2 Emission from Forest and Grassland Conversion

1. Area converted annually (default values are available but could result in highly uncertain National totals)
2. Amount of biomass before and after conversion (default values are available but could result in highly uncertain National totals).
3. Fraction of biomass burned on-site and off-site.
4. Average area converted over 10 years for each forest/grassland type.
5. Fraction of biomass left to decay (10 years average).

### On-Site Burning of Forest: Emissions of Non-CO2 trace Gases

1. Area converted annually (default values are available but could result in highly uncertain National totals).
2. Amount of biomass before and after conversion (default values are available but could result in highly uncertain National totals).
3. Fraction of biomass burned on-site.

### Net CO2 Removal From Abandonment of Managed Lands

1. Total land are abandoned and re-growing for the last 20 years (no default values).
2. Annual rate of aboveground biomass growth by vegetation type (default values are available but could result in highly uncertain National totals).
3. Total land are abandoned and re-growing for more than 20 years (no default values).

### CO2 Emissions/Uptake by Soil from Land-Use Change and management

1. Land area for soul type for each land-use/management system (current inventory year).
2. Land area by soil type for each land-use/management system (20 years prior to the current inventory year).
3. Amount of soil carbon.

It should be stressed that, although relevant data are missing in this sector, there is a growing consensus that $CO_2$ emissions are virtually insignificant in the FSM. FSM should use its limited funding reserve to support other studies that clearly show an abundant emission level of GHGs. If and when these other studies are completed, and funding is available, then research in this area is recommended.

***Waste***

Based on the inventory findings, the waste category is not a major source of GHG emissions in the FSM. Consequently, it is recommended that future inventories use estimates and default data provided by the IPCC guideline to calculate greenhouse gas emissions from this sector. This approach eliminates the need to fund unnecessary studies of a minor sector that is an insignificant contributor to the global greenhouse gas emission.

## 5.6 CONCLUSIONS

The GHG emissions inventory endeavored to quantify FSM's contribution to global GHG emissions. Six sectors are identified by the IPCC guidelines as potential sources of GHG emissions. However, similar to many small Pacific island countries, in the FSM, the energy sector is the primary source of GHG emissions. This inventory, therefore, focused primarily on the energy sector although emissions from other sectors were also calculated whenever the required data were available.

A comparison of 1994 and 2000 emissions showed an 8% reduction on $CO_2$ emissions between 1994 and 2000. Over the same period $CO_2$ removals increased by almost 20%. There were negligible changes for other categories of emissions.

# CHAPTER SIX
# PROGRAMS AND MEASURES TO MITIGATE EMISSIONS

## 6.1 INTRODUCTION

As will be shown below, since the INC was submitted, FSM has made considerable progress in identifying, assessing and implementing measures to reduce GHG emissions. However, much remains to be done in achieving the National goals of increasing National energy security and achieving National energy self-sufficiency, including increasing the use of renewable energy.

As has been shown in the previous chapter, FSM is highly dependent on imported petroleum fuels to sustain its economy. Petroleum fuels are used for both electricity generation and transportation, with the former being the major user. In 2008, the FSM Petroleum Corporation (PetroCorp) was established, in a combined effort to achieve greater economies of scale. It currently serves all four FSM States, and is a wholly Government-owned enterprise.

Electricity is regulated at the State level. Consequently, there are four electricity utilities, each with its own tariff structures, generation and distribution networks. Of the four utilities, only the one in Pohnpei has hydroelectric generating capacity; the others all rely solely on diesel generators. The Yap utility is the only one that has diesel minigrids on some of its outer islands; the other utilities operate only on the main islands.

Energy is an integral component of the SDP as it is referenced in all four of its objectives. A key objective is to provide ample sources of renewable and other forms of low carbon energy. Experience with renewable energy has in the past been with solar home systems for outer islands, solar fridges, solar systems for telecommunication, solar freezer systems and solar pumps, limited wind energy use for water pumping, and small scale hydroelectricity generation (2 MW on Pohnpei). The wind resource has not been properly assessed, but the hydrological potential of FSM (mainly Pohnpei) has been found to be 6.9 MW. The solar resource, depending on the island, is good to very good (5.5 kWh/m2/day as a yearly average).

Biomass in the form of wood and coconut husk products is used for local cooking. In most outer island communities biomass is the primary energy source. Renewable energy sources are being introduced in the outer islands and in the State centers. Photovoltaic solar energy is being increasingly accepted as a sustainable and economically viable source of energy nationwide, while Pohnpei has additional potential for hydro energy. In initiatives that would broaden the nations' energy mix, Kosrae is considering exploiting wave energy, Yap wind power and Chuuk bio-fuels.

Achievement of economic stability and security requires a vibrant energy sector. The necessary energy infrastructure to promote economic and social development in both the State centers and out-lying Islands is a high priority. Equally, delivery of education and health services is contingent on the quality of energy infrastructure and services available.

The impacts of the high fuel prices of 2008 have resulted in the rise in the costs of goods and services in FSM. In 2010 FSM spent US$40.9 million dollars on imported fuel (US Graduate School Pacific Islands Training Initiative, 2011). This amount represents more than 50% of the aggregate sectoral grants that FSM receives from the US Government under the Compact, and nearly 20% of nominal GDP for the country. This shows why energy self-sufficiency is a priority need.

To diversify away from nearly total dependence on diesel fuel for power generation requires the development of available renewable energy resources, Access to affordable and reliable renewable energy is key to increasing energy self sufficiency and to enhancing sustainable livelihoods (Kosrae Utilities Authority, 2012). Kosrae Utilities Authority (KUA), a State agency, was one of the first Pacific island utilities to recognize and confront the challenges and set a road map to a self-sufficient and sustainable energy future. In 2005 KUA adopted a comprehensive strategic plan to reduce, and ultimately eliminate, the State's dependence on fossil fuels, to improve the quality, minimize the cost and expand the use of electricity in the State, to achieve equal access for affordable and sustainable renewable energy sources in an environmentally responsible and commercially viable manner.

## 6.2 OVERVIEW OF MITIGATION OPTIONS FOR THE FSM

IT Power (2006) estimated the potential of renewable energy and energy efficiency to reduce GHG emissions in several Pacific Island countries (Table 47). The reductions and savings were calculated using a "business as usual" (BAU) growth in emissions over ten years, from 2000.

**TABLE 47 | GHG Emissions Reduction and Potential Savings**

*(Source: IT Power, 2006)*

| Country | Project baseline Emissions in 10 years, BAU | | Potential Annual GHG Savings | | | Relative Savings from Renewable Energy and Energy Efficiency | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (Gg) | Year | Gross (Gg) | Adjusted (Gg) | Adjusted as % of baseline | RE (Gg) | % of Total | EE (Gg) | % of Total |
| FSM | ~ 168 | 2012 | 23.9 | 23.9 | 14% | 16.8 | 70% | 7.1 | 30% |
| Kiribati | 72.2 | 2013 | 26.5 | 26.5 | 37% | 24.5 | 92% | 2.0 | 8% |
| RMI | 400 | 2013 | 22.3 | 22.3 | 6% | 8.0 | 36% | 14.3 | 64% |
| Palau | 441 | 2013 | 49 | 49 | 11% | 12 | 24% | 37 | 76% |

Estimates of the total GHG emission are derived from corresponding estimates of reductions of fossil fuels in all sectors of the economy, including power generation, transport and household use. The Table shows that in FSM by the year 2012, it was consider possible, in principle, to reduce projected fossil fuel use only by 14%, with about 70% of the saving coming from renewable energy and 30% from energy efficiency measures. Energy efficiency is an important part of the energy sector, particularly in supply side management for power utilities. The Pacific Power Association started an energy efficiency assistance program in 2009 for the utilities, but to date no large-scale measures have been undertaken.

However, the average estimated electricity consumption in electrified households has decreased over the last four years, revealing that demand-side management initiatives may be starting to have an effect. High electricity cost and the introduction of cash power meters (pre-paid meters] have encouraged energy saving behaviors at consumer level. Energy efficiency and demand-side management can have a significant impact if implemented at a large scale, and that outreach programs need to be implemented to create more awareness amongst consumers.

Some utilities have started to advise the public on demand-side management and discussions are being held to start programs such as changing to low energy light bulbs and using energy efficient appliances. In addition, regulatory frameworks and incentive programs at State level can help spur private sector investment and reduce consumption by that sector.

## 6.3 ENERGY EFFICIENCY

The Government is encouraging developers to adopt a set of energy standards well above those prescribed by law within the code of building regulations. Building codes and energy standards are currently unavailable in the FSM. They follow USA building codes. More recently, codes have been developed and implemented in Hawaii and Guam. These codes could be used as example and adapted to conditions in the FSM.

Some recent and newly constructed buildings have included energy efficiency measures; however, by putting forth a building code standard model, developers will have an easier guide to follow. Standardization of new construction, or retro-fit projects, will prepare the market for the revision of the building regulations currently in use, and create movement towards a requirement of 40% improvement in the energy performance of new houses and other buildings, compared to the current standard. It is also important to have a program that offers support to developers to build both residential and commercial buildings with an energy performance standard of at least 60% above that required in the currently used building regulations. This action will demonstrate the opportunities for a strong shift towards low carbon output and energy efficient housing and other structures in FSM.

## 6.4 RENEWABLE ENERGY SOURCES

### *Solar Energy*

These are several existing and potential sources of renewable energy in the FSM. The potential use is particularly high for solar energy and hydropower (Pohnpei State), but also the potential of wind energy, bio-fuel, methane gas and tidal and wave energy also need to be evaluated.

High solar radiation levels throughout the FSM create a rich resource of solar energy, although the available energy varies from place to place because of local cloud cover. This is especially the case on the islands with mountains, such as the main islands of Pohnpei and Kosrae and the Lagoon Islands of Chuuk.

As for other Pacific Island countries, solar energy provides a particularly good source of energy for outer islands that are further away from the State centers and often have low population sizes. Stand-alone systems can provide a solution for the energy needs in such places. There remain many opportunities both to expand the use of off-grid installations on the outer islands and for grid-connected systems on the main islands where electricity networks are available.

In the State of Pohnpei, 400 solar home systems (SHS) were installed on several islands in the early 1990s. For quite some time this program formed the largest outer island PV system program of the North Pacific (DoI, 2006). In addition, 300 SHS were installed in various outer islands in Yap and in 402 households in Chuuk. These initiatives were undertaken after the 1982 cholera outbreak, to allow solar powered pumps to provide flush water for toilets. This aimed at reducing the use of water from shallow wells, contributing to the spread of cholera.

More recently, under the European Development Fund (EDF-9 REPS program), a major PV electrification initiative was implemented in the outer islands of Pohnpei, Chuuk and Yap (Table 48). Off-grid PV systems with a total capacity of 120.88 kWp were installed in 11 outer islands. In Kosrae five grid-connected PV systems with a total capacity of 52.5 kWp were installed. The PV systems in Kosrae are being monitored by the utility. A detailed analysis of the performance of these grid-connected systems has now been completed (IT Power, 2010; Pacific Islands Forum Secretariat, 2011).

## TABLE 48 | Photovoltaic Systems Installed in the FSM under the EDF-9 REPS Program

*(Source: FSM Energy Division, 2011)*

| State | Island | Site | System size |
|---|---|---|---|
| **Yap** | Asor | PV-mini grid | 19.5 kWp |
| | Fadrai | PV-mini grid | 28.08 kWp |
| **Chuuk** | Satawan | High school | 6.6 kWp |
| | Moch | Public facilities - PV-mini grid | 6.7 kWp |
| | Udot | High school | 3.4 kWp |
| | Onoun | Public facilities - PV-mini grid | 10.5 kWp |
| **Pohnpei** | Kapingamarangi | School | 5.8 kWp |
| | | Dispensary and municipal office | 4 kWp |
| | Nukuoro | Dispensary | 3 kWp |
| | | School | 4.6 kWp |
| | Sapwaufik | School and municipal office | 8.4 kWp |
| | | Dispensary | 3 kWp |
| | Mwoakilloa | Dispensary | 2.5 kWp |
| | | School | 6.1 kWp |
| | Pingelap | School | 6.2 kWp |
| | | Dispensary | 2.5 kWp |

The Support to the Energy Sector in Five ACP Pacific Island Countries (REP-5) program is a 9th European Development Fund (9th EDF) multi-country initiative which funds renewable energy and energy efficiency projects in five Pacific Island Countries. REP-5 had the overall mandate of "Poverty Reduction through improved access to electricity". Although REP-5 ostensibly covered five countries, each of the four FSM States took a different approach to activities funded under REP-5. The range of activities undertaken under REP-5 is diverse, but falls into two basic categories. These are: (i) provision of solar power to outer islands - this covers a variety of installations ranging from SHS, micro- and mini-grid systems through PV systems for schools, dispensaries, and in some cases, administrative buildings; and (ii) strengthening of National provision of electricity either directly through grid-connected PV systems or through activities to conserve electricity consumption (energy planning and policy and energy efficiency and savings).

Technical and socio-economic investigative tools were adopted which were sufficiently flexible to accommodate the different circumstances. These used quantitative techniques when looking at the energy systems (e.g. solar energy produced, impacts on over electricity production and energy savings) and qualitative techniques associated with rapid rural appraisals (i.e. interviews with key individuals, unstructured group and individual discussions) for the socio-economics inputs.

REP-5 has addressed poverty alleviation on outer islands at a number of levels and there has been a significant improvement in the quality of life for many islanders (Pacific Island Forum Secretariat, 2011). REP-5 has financed a range of initiative covering SHS and mini-grid home solar energy and school and dispensary electrification. Home electrification has resulted in significant increases in the earning capacity of women, while richer residents have been able to purchase consumer durables. The individual purchase of home freezers, or the provision of freezers for community use by local authorities on some islands, has increase food security through allowing the storage of fish for sale or later consumption.

The impacts of school electrification vary. Some schools have extended scholastic activities into the evening, widened the curriculum and provided a focus for community activities; while other schools have not reacted to the opportunities provided by electrification other than to switch on lights on overcast days. It has proven difficult to gauge the long-term impact of school electrification and subsequent increased scholastic activity on educational achievement because there are no targeted monitoring systems in place.

REP-5 energy awareness and conservation activities have also been successful and have provided useful synergy with other activities. In some cases, the energy awareness campaign achieved wide coverage and served not only to change consumer habits, but also stimulated demand for pre-paid meters, thereby further saving energy. However, in FSM REP-5 was not able to trigger the start of any sizeable independent private sector business activities in the fields of solar energy, energy efficiency and energy saving.

Despite some limitations, solar energy has a large potential in the FSM. There remain many outer islands where solar energy can provide affordable energy to people that would otherwise have to live without. On islands in the State centers where electricity systems are available, PV systems can provide energy to the grid in order to significantly reduce the need for fossil fuel. This will help create a more sustainable energy mix, as well as reduce overall costs to both utilities and families.

The bulk of the REP-5 funding was allocated mainly to the installation of solar PV systems in all four States. In Yap, Chuuk, and Pohnpei the focus was rural electrification of outer islands, whereas on the single island State of Kosrae the PV systems installed have been connected to the main utility grid. REP-5 funding for Yap State has resulted in installation of a PV-powered minigrid on Asor and Fadrai islets in Ulithi Atoll. The system on Asor has a PV capacity of 19.3 kWp, a battery capacity of 1850 Ah at 48V, and will provide electricity to all 18 houses and all public buildings. The system on Fadrai is larger, at 28.1 kWp of PV capacity and 2880 Ah of battery capacity at 48V. This system will provide electricity to all 31 houses and all public buildings. The voltage system used is 230V/60 Hz, in order to discourage users from buying appliances on the main island of Yap and overusing the minigrid (Yap uses the US voltage system, 120V/60Hz). For The systems were installed in March 2009, at a cost of €700,000.

REP-5 provided four outer islands of Chuuk (Onoun, Moch, Satawan and Udot with standalone PV systems for schools and dispensaries. The PV systems range in size from 3.4 to 10.5kWp, for a total of 27 kWp across all four islands. The voltage used for powering appliances is 120V/60Hz. The PV systems were installed in January and February 2009, at a cost of €350,000.

In Pohnpei State, the five outer islands Mwoakilloa, Pingelap, Kapingamarangi, Sapwuafik and Nukuoro received standalone PV systems for schools and dispensaries. The PV systems range in size from 3.0 to 13.6 kWp, for a total of 48.3 kWp. Onoun has a minigrid connecting all public buildings, the doctor's house and the school dormitories The voltage used for powering appliances is 120V/60Hz. The PV systems were installed in January and February 2009, at a cost of €700,000.

Kosrae State received a total of five grid-connected PV systems for its airport, legislature, governor's office, hospital, and power plant. All systems were roof mounted, except the one at the power station that was mounted on a car park shading structure. The systems vary in size from 4.9 to 16.4 kWp, for a total capacity of 52.5 kWp. The PV systems were installed in September 2008, at a cost of €375,000.

*Solar powered school in Onoun Chuuk State by REAM*

Table 49 shows the overall impact of grid-connected systems installed under REP5, while Table 50 shows Outer Island Population Gaining Access to Electricity under REP-5

### TABLE 49 | Overall Impact of Grid-Connected Systems

*(Source: Pacific Islands Forum Secretariat, 2011)*

| REP-5 States | Units | FSM | | |
|---|---|---|---|---|
| | | Kosrae | | |
| | | 2009 | 2010 | Total |
| Total installed capacity of diesel generation | MW | | 3,390 | |
| Total consumption of diesel for electricity generation | Litres | 1,556,435 | 1,696,154 | 3,252,592 |
| Total electricity production from diesel | MWh | 5,870 | 6,405 | 12,275 |
| Specific diesel consumption if electricity generators | Litres/kWh | 0.2652 | 0.2648 | 0.2650 |
| Total installed capacity of solar | kWp | | 45.25 | |
| Total solar electricity production | MWh | 145.026 | 56.277 | 301.303 |
| Total electricity production – total electricity demand | MWh | 6,015 | 6.462 | 12,476 |
| % of solar electricity production on total electricity production | % | 2.41% | 0.37% | 1.61% |
| Electricity savings due to energy savings measures (estimates) | MWh | n.a | n.a | n.a |
| Electricity savings due to LPG cook stove | MWh | - | - | - |
| Total savings of diesel electricity due to [PV system + EE + LPG] | MWh | 145.026 | 56.277 | 201.303 |
| Total savings of diesel electricity due to [PV system + EE + LPG] | % | 2.41% | 0.37% | 16.61% |
| Total saving of diesel due to [PV system + EE + LPG] | Litres | 38,456 | 14,902 | 53,341 |
| COs equivalent reduction (Coef. xx $tCO_2$/MWh) | t $CO_2$ Equiv. | 39 | 15 | 54 |

### TABLE 50 | Outer Island Population Gaining Access to Electricity under REP 5

*(Source: Pacific Islands Forum Secretariat, 2011)*

| REP-5 States | Islands | Population Gaining Access to Electricity | Population Gaining Access to Electricity as % of Outer Island Population |
|---|---|---|---|
| Yap | Asor | 18 households, approx. 126 people | 3 |
| | Fadrai | 36 households, approx. 252 people | 6 |
| | **TOTAL** | **378 persons** | **9** |
| Chuuk | Satawan | Approx. 944 people | 2 |
| | Moch | 277 students and approx. 844 people | 2 |
| | Udot | Approx. 1,750 people | 4.5 |
| | Onoun | Approx. 590 people | 1.5 |
| | **TOTAL** | **4128 persons** | **10** |
| Pohnpei | Kapingamarangi | Approx. 480 people | 22 |
| | Nukuoro | Approx. 365 people | 17 |
| | Sapwaufik | Approx. 645 people | 30 |
| | Mwoakilloa | Approx. 180 people | 8.5 |
| | Pingelap | 98 students, 3 teachers and 2 dispensary staff and approx. 440 people | 21 |
| | **TOTAL** | **2210 persons** | **98.5** |

Solar lanterns will be provided to outer-island homes in Chuuk and Pohnpei States. This will help households reduce their expenses on kerosene for lighting, and will also reduce the risk of injury or fire caused by kerosene lamps. A total of 3,000 lamps will be distributed; 2,000 will have amorphous PV panels and 1,000 will have polycrystalline panels so that their performance can be compared in a Pacific environment.

A proposed Yap Renewable Energy Development Project will support development of the power system in State in order to reduce dependency on imported diesel. This will be achieved through expansion of renewable power generation and improving the supply side efficiencies of power delivery. Power generation is supplied by Yap State Public Service Commission which is a 100% State owned corporatized utility. There is a single power grid on Yap Proper, with an installed capacity of 8.3MW (peak load 2.4MW) and about 1,500 residential customers. On Yap Proper access to electricity is high, at an estimated 97%. The power supply in Yap is relatively stable, with adequate capacity, however oversized diesel generators have resulted in low generation efficiencies.

Due to remoteness and high diesel transportation costs, power tariffs are high and the Yap economy is highly vulnerable to fuel price shocks. In Yap, about half of all imported fuel is used for power generation. In 2005 and 2006, the value of diesel imported to Yap for power generation exceeded the total value of exports. In 2008, diesel imported for power generation represented 17.6% of all imports by value to Yap. In 2010 average power tariff was $0.45/kWh (generation cost $0.32/kWh). However, this is anticipated to rise in 2011 due to escalating diesel prices. Power tariffs allow for full cost recovery for utility, but tariff reform is required to ensure utilitycan continue to operate on a sustainable basis.

While household consumption is low due to predominance of traditional buildings, power usage by Government offices is relatively high . Through improved supply side energy efficiency and conversion to renewable energy under the Project, it is estimated that Yap can convert 28% of power generation to renewable energy and reduce diesel consumption for power generation by 32%.

The project is proposing to support (i) development of grid-connected wind power generation (about 1.5MW) on Yap Proper, (ii) development of grid-connected solar power (about 0.3MW) on Yap Proper, (iii) improved generation efficiencies of the existing diesel generation through a smaller diesel generator to be operated during low demand periods, and (iv) capacity building within the power utility, through targeted training and development of required systems, tentatively to include procurement, financial management, fiduciary controls, asset management and system operation management.

### ***Hydropower***

Yap and Chuuk have no hydro sites. The greatest renewable energy opportunity for fuel saving in the FSM is offered by small hydro development, especially for Pohnpei, and possibly for Kosrae. A thorough review of the hydro potential is needed. The following is a preliminary qualitative assessment.

Hydro sites on Kosrae have limited potential and are unlikely to be cost effective for development. However further study could show that Kosrae might have a potential of pico hydro installations that can act as standalone systems and power some homes located that are close to rivers. On Pohnpei there is a hydro power installation on the Nanpil River. Surveys indicate that there are other developable sites in Pohnpei, though at the time it was not economic to develop these sites. The survey findings should be reviewed in light of fuel prices now being higher. Sites which are now economically viable should be seriously considered for hydro development.

Rainfall amounts on both Pohnpei and Kosrae are high, with rainfall amounts in the interior can exceed 400 inches (1,016 cm) annually (see Section 2.2). Such amounts offer opportunities for hydro development on numerous streams. But stream flows vary considerably due to the rapid runoff and small catchments. As a result, the streams are generally not practical for base load hydropower without using expensive and environmentally problematic storage ponds. Despite this, hydropower has an acceptable tradeoff between reliability of power delivery and cost of installation. In some cases, drinking water reservoirs have been used as storage ponds to secure more constant water supply.

The downside of the small catchments and the variable stream flows is offset by the fact that the environment impact of systems that make use of existing streams (so-called run-of-the-river development) is small, and the systems are relatively cheap. Thus during their extensive operational life such systems can provide substantial fuel savings.

### *Wind Energy*

The resource for wind energy is not very well known in the FSM, but the economic feasibility of energy production from wind is considered borderline. Meteorological measurements as well as the low latitude location indicate moderate resource availability. Furthermore, typhoons are a risk for wind power systems. However, due to the mountainous nature of some of the islands, there may be locally beneficial conditions for wind energy.

The main recommendation to come out of earlier studies of potential renewable energy use in the FSM is to carry out a feasibility study on the use of wind energy throughout the country. After broadly defining locations where wind energy could potentially be implemented, detailed wind assessments and wind maps should be created to more precisely identify the main wind energy sites.

### *Biofuel*

An important source of biofuel is coconut oil. The outer islands of FSM have a large and underutilized resource that could be further developed. Using coconut trees for this purpose is not new to the country. There was an active industry for copra, the dry meat of coconuts, after the Second World War until the 1970s (Johnston, 2004). Although the price of copra remained stable after this period, the cost of living increased, along with labor costs. This reduced the incentive to commercially exploit copra. As a result, there were few new coconut plantings to replace an increasing proportion of senile trees (Department of Interior, 2006).

There is an opportunity for FSM to develop coconut production on outer islands and thereby increase income for those living there. At current prices and production levels, coconut oil could be shipped to the State centers where large diesel fuel users, especially the utility companies and businesses with back-up generators, could use coconut oil to create a fuel mix, and in this way reduce their use of diesel fuel. This would boost the coconut oil industry and prepare it for production on a larger scale when diesel prices increase further. Income for rural communities, and reduction in costs to the private sector in the centers, would bring macroeconomic benefits for the country. However, limited transport to the State centers is a significant barrier.

Until recently, there was an operational coconut factory on the main island of Pohnpei. This produced biofuel from coconuts. The company could produce 150 gallons of coconut oil (over 550 liters) in an eight hour day. Besides using this for their own vehicles, the company sold coconut oil to individual and corporate customers on the island. With little effort, an engine can be adjusted to run on a mix of diesel and biofuel. The owners of the coconut factory were planning to increase production and to start selling fuel for boats. However, in July 2008 a fire destroyed the entire factory. The owners had no insurance and there were no readily available funds to rebuild the factory.

In 2001 a copra warehouse in Yap was devastated by a fire (Department of Interior, 2006), and in Chuuk a copra oil production facility was also destroyed by a fire. Neither has been rebuilt. This impacted the total amount of copra produced and exported nationally.

Biofuel from coconut oil remains a socially and economically viable source of renewable energy and efforts should be strongly pursued to once again integrate it into the overall energy mix. In order to deliver on this potential Kosrae has a target to plant 200,000 coconuts in 2012.

### *Biomass*

In the FSM biomass continues to be the largest source of energy for cooking. For the mountainous islands of the State centers of Pohnpei, Kosrae and Chuuk, and some of the outer islands, biomass in the form of wood is available on a sustainable basis. Also in low-lying atolls biomass is used for cooking, but in different forms, such as coconut shells, fronds and husks, mangrove wood or plants.

As in other Pacific island countries, commercial use of biomass for electricity production by means of combustion or gasification is limited to facilities that process agricultural or forest products. There are no industries in the FSM that process such products since agricultural processing tends to be done in small scale, often family-owned, decentralized facilities. There is currently no industry that produces biomass waste. If producing biofuel from coconut oil did become a large-scale industry, enough biomass waste could be generated to justify commercial biomass combustion or gasification to produce heat or electricity (Department of Interior, 2006). Should this occur, a feasibility study should be undertaken to assess the feasibility of such an operation.

Waste to energy is another development that is being carefully followed by the FSM Government. Plans are being formulated to start a (solid) waste composition study in 2010. There are some animal farms in the FSM that produce enough waste to generate biogas in an economically viable way. In such a process, animal waste Is disposed in an environmentally friendly way, with biogas as a byproduct. In 2008 some small pilot biogas installations were installed in Pohnpei, with the assistance of the Chinese Government. These are being monitored by the Pohnpei State Government.

There is also and independent biogas producer on the main island of Pohnpei that aims at creating a closed, environmentally sustainable cycle in household energy use. Animal waste produced by a pig serves as input for the biogas digestion tank, which provides gas for daily cooking. There is some interest from the Kosrae State Government to replicate such low-scale household digestive systems. Currently no sewer or landfill waste is used to generate biogas. When such facilities are to be upgraded, a feasibility study should be carried out to investigate the economic and environmental sustainability of an add-on facility to extract biogas.

### *Ocean Energy*

Although FSM includes a vast area of ocean, there is currently no sufficiently mature ocean energy technology that can be used in the FSM. Tidal energy is a potential source for the FSM. The tidal range is not very large, but through certain reef passages and some man-made causeways and bridges, high speeds and high volumes of water flows are observed locally. The FSM energy sector is following the development in ocean and tidal technologies. Pre-studies are planned to be undertaken early in the 2010s.

In 2011 KUA, together with Ocean Energy Industries Inc., formed Ocean Energy Kosrae, an independent power producer in Kosrae State. The company's goal is to build a 1.5 MW power generating wave power farm. The peak load in Kosrae is currently about 1.2 MW. When fully operational the wave power farm will eliminate annual GHG emissions of at least 7000 tons (Kosrae Utilities Authority, 2011).

## 6.5 BARRIERS AND OPPORTUNITIES

The Nationwide Climate Change Policy (2009) includes ambitious mitigation goals including maintaining and enhancing FSM as a negative carbon country through effective management of its natural sinks, bio-sequestration (biochar), promotion of renewable energy and energy efficiency, and other appropriate means. Table 17 identified some of the capacity constraints related to achieving such mitigation outcomes. If FSM is to achieve the full potential for mitigating its GHG emissions, significant capacity building needs must be addressed (see Section 7.3)

CHAPTER SEVEN

# OTHER INFORMATION

7

## 7.1 INTRODUCTION

This section provides information in the role of non-governmental organizations, capacity building, climate change information, technology transfer, education, training and public awareness, and constraints, gaps, needs and priorities.

## 7.2 ROLE OF NON-GOVERNMENTAL ORGANIZATIONS

The true locus of authority in island communities is the community itself. Climate risk management, such as changes in land use policy can be facilitated with the participation of community stakeholders and landowners. Community based adaptation to climate change must involve all stakeholders in defining adaptation steps. Thus NGOs can be valuable partners in managing climate risk in the FSM.

For example, TNC, Rare (an organization that uses social marketing for biodiversity conservation), the Micronesia Conservation Trust (MCT) and other local partners are working together to implement climate awareness and adaptation activities through the Rare Pride Campaigns. MCT, TNC, Pacific Resources for Education and Learning, and other partners have developed a climate change adaptation tool. This is being used to train trainers and community leaders across Micronesia to educate them about climate change and to help them begin taking steps to adapt to climate. MCT is also working with Public Broadcasting Station to make the tool more interactive and to have it available online.

In Kosrae, local environmental NGOs and educational institutions in Kosrae that also support natural resource management and conservation efforts include the Kosrae Conservation and Safety Organization, the Yela Environmental Landowners Authority, and the College of Micronesia-FSM/ Kosrae Campus Land Grant Program. At the municipal level, Resource Management Committees have been established in each of the five main communities on the island. These Committees are legitimately recognized by municipal charters, and play a participatory role in both local and State natural resource management needs and issues. The Committees are comprised of volunteers from the local communities that assist in the conservation and sustainable use of island resources. State-level resource management and conservation efforts have become favorably transitioned down to the community-based and community-driven conservation initiatives that are managed by local community groups and/or private landowners.

## 7.3 CAPACITY BUILDING NEEDS FOR ASSESSMENT AND MANAGING CLIMATE RISKS IN FSM

In an assessment of FSM's capacity to address climate change, Namakin (2008) identified the following capacity needs actions for the most prioritized climate change issues in the FSM. The following capacity building needs were identified for the thematic responses to climate change:

## Adaptation

**Systemic level:**

- a policy framework should be in place by all different sectors to consider to deal with adaptation.

**Institutional level:**

- all institutions should recognize and implement their roles, responsibility and mandates to related to adaptation; and
- institutions should be specialized in dealing with the impacts of climate change on all sectors, including health, economy, and biodiversity.

**Individual level:**

- training and education opportunities should be provided for individuals to improve their knowledge and skills on adaptation project design and implementation, and more in approaching vulnerability and adaptation assessments;
- awareness programs should be considered for heads of the village, decision makers, youth groups, church leaders to incorporate adaptation; and
- individuals with expertise should be recognized and utilized to build on what they have and able to train others.

## GHG Emissions

**Systemic level:**

- there should be in place both short and long term policy framework and legal framework that would address greenhouse gas emissions at all inter-related sectors;
- policy on clean energy should be legislated to help support addressing emission reduction; and
- there is a need to put more needs on transferring technology in terms of emission reduction.

**Institutional level:**

- implement legal framework or strengthen enforcement of existing frameworks;
- develop an institutional framework that provides guidance on GHG actions;
- establish an institution with well trained staff in project design, guiding the policy making to actions and data and information management and networking.

**Individual level:**

- individuals should be provided training on how to conduct greenhouse gas inventory, including both data collection and data analysis, and the management of the data.

## Mitigation

**Systemic level:**

- though FSM makes only a small contribution to global GHG emissions, high levels in Government should support mitigation;
- clean energy should be legislated to guide all sectors to apply mitigation; and
- awareness of needs on funding for technology transfer to deal with mitigation should be implemented.

**Institutional level:**

- develop institutional plans to encourage Government leaders to implement a strong energy policy;
- seek funding and improvement of existing small renewable energy projects, such as coconut oil in place of diesel, solar power, etc.;

- undertake training on the implementation of renewable energy and energy efficiency projects;
- establish a system in place to monitor GHG saving from mitigation projects; and
- provide and update stakeholders and local communities of mitigation information to be a learning tool.

**Individual level:**

- individuals should be provided with education and training to learn or improve their knowledge and skills in renewable energy to addressing climate change.

The following are recommendations arising from the National Capacity Self Assessment relating to implementing the UNFCCC in FSM (Office of Environmental and Emergency Management, 2009):

- Obtain new technology;
- Increase the number of technical experts in climate change and its related fields;
- Training in Vulnerability and adaptation techniques is crucial;
- Develop Research and Systematic observation;
- Training in storm surges modeling and mapping is needed;
- A GHG database must be created;
- An archive of baseline data needs to be in place;
- Hazard maps must be updated;
- Institute a Clearing House Mechanism;
- Create bus service system to reduce fuel costs and GHG emissions;
- Enhance public awareness programs for all levels of society; and
- Develop specialist capacity for environmental management.

Currently the four FSM States have their own environmental laws and regulations. Such laws and regulations are intended to regulate and enforce environmental protection practices on water supply systems, sewage, solid wastes, pesticides, marine and freshwater quality, air pollution, and groundwater. Other regulations formulated under the environmental protection agencies at the State levels contribute to the preventive measures to mitigate climate change in the region. Laws should be uniform throughout the four FSM States.

Public awareness on the impacts of climate change in the FSM needs to be enhanced. In terms of training, FSM currently lacks climatologists. As climate change continue to pose a threat to the islands, it is necessary for FSM as a nation to be equipped with the appropriate resources. Climate change experts are needed in the FSM to effectively meet the increasing threats of climate change to FSM. The proposed positions in are as follows: Air Quality Specialist, Climate Change Specialist for Carbon, Bio-Fuels Life Cycle Analyst, Carbon Specialist, Climate Change Scientist, Research Analyst, Climate Change Specialist for Adaptation, Renewable Energy Specialist, and Water Resources Specialist. Furthermore, continued training in meteorology should be expected as the FSM island States are inevitably vulnerable to natural disasters. Essentially, the need to upgrade a forecasting system at the National Weather Service Office is evident, based on its limited capacity to analyze weather data.

The SWARS (FSM Department of Forestry, 2010) recognized the need for up to date aerial photography and LIDAR data. The basis for most data for forest assessments in the SWARS was vegetation maps based on aerial photography from 1976. Only for Pohnpei have more recent vegetation maps been made based on more recent aerial photography. These maps indicate a serious decline in upland native forest.

There are only limited data on overall forest trends for the rest of the FSM (see Table 39). All States have requested assistance to obtain current aerial imagery in their respective chapters. The availability of such imagery, combined with increasing GIS capacity, would enable even local foresters to develop updated vegetation maps to compare with earlier vegetation maps to determine trends, and to serve as baselines from which to measure progress in forest stewardship.

In addition to updated aerial photography, LIDAR imagery is greatly needed in order to more accurately assess vulnerability to sea level rise and storm surge throughout Micronesia. This is especially important for low-lying outer islands that are close to sea level.

With regard to forest management in FSM three needs for capacity building have been identified. The first is in the number of staff, as current staff levels are low. With the advent of the Micronesia Challenge and other initiatives, Forestry staff currently find it difficult to both carry out work under performance-based budgets as well as to accommodate these additional programs and visitors. It is anticipated that some of the US$12 million pledged by TNC and Conservation International will help increase the number of persons working in Forestry.

The second need in capacity development is for training relevant to work at hand. Forestry agencies are interested in opportunities for scholarships to develop Forestry professionals, internships and relevant training resulting in certification in needed skills. Yap has identified a potential training and internship program with mainland U.S. firefighters. The third need in capacity development is to assist communities in understanding environmental issues and in developing and implementing quality projects.

The FSM National Plan of Action for Nutrition recognized the following capacities and needs:

- Weak data on primary economic sectors limiting the basis for planning;
- Lack of a clear strategic framework for agriculture and food security across the four States;
- Soaring food and oil prices and a deep trade balance deficit;
- Increasing levels of food and nutrition related non communicable diseases, which impact negatively on health system, families and National economy;
- Lack of food quality and safety standards and legislative framework;
- Limited market opportunities and lack of competitiveness of agricultural products;
- The coconut remains an important potential cash crop for people in the outer islands, but extensive replanting is needed to replace senile stands; and
- The potential for aquaculture development remains unrealized.

## 7.4 EDUCATION, PUBLIC AWARENESS AND TRAINING

The FSM acknowledges the development of human resources is the key to sustainable development, including addressing climate-related risks. In the past FSM placed greater emphasis on capital economic development projects than on human resource development. Recently this trend has changed and programs to develop local resource capacity and institutional strengthening have been undertaken, including programs for gender equality and improvements for the nations women and children. Further improvements in all formal educational services are required to provide the training and skills required to sustainably develop the nation. International and local NGO communities operating within the FSM have contributed considerably to this, especially in the areas of environmental management and community empowerment.

Although considerable effort and advancements have been made, communication and coordination among National and State Government agencies with the private sector, NGO community, local municipalities and citizens need to be further improved, with special emphasis on awareness of environment and sustainable resource utilization and management. This is especially important for cumulative and long-term impacts. The further development of community-based services will greatly assist in this endeavor.

The Pacific Islands Climate Education Partnership (PCEP) is funded by the US National Science Foundation and serves the United States-affiliated Pacific Island region that includes FSM. Students and citizens within the region are helped to gain the knowledge and skills to advance understanding of climate change, mitigate the extent of climate change, and adapt to its impacts. As an example, the PCEP Climate Education Framework for Grades 3-5 guides the PCEP climate education curriculum in participating elementary schools between Grades 3 and 5. It describes the desirable levels of climate science knowledge and skills that the students should have by the end of the fifth grade. The Framework draws extensively from current US initiatives in science education and climate education, but is contextualized for the tropical Pacific islands.

As part of a larger project to develop guidance materials to support community-based adaptation to climate change in Micronesia, a workshop was held in September, 2010, in Pohnpei, to gather input from various stakeholders. Lessons learned were identified by workshop participants. These will be reflected in follow up education and training initiatives. They included:

- Climate change work in Micronesia has to be incorporated into existing planning processes;
- Adaptation strategies are mostly about doing more and better management of target resources;
- Community leaders should be a target audience for spreading this work in the region;
- It is important to link communities together to support one another through social networking;
- Natural resource managers cannot do this alone but need a multi-sectoral approach in working with communities on climate change adaptation;
- Climate vulnerability and adaptation planning at the community level most likely needs support from outside facilitators from local resource agencies/organizations;
- Don't overlook the small things – adaptation strategies can be simple and make a huge difference (e.g. fixing water leaks);
- Effective catchment of water, storage and distribution can be effective solution to the lack of fresh water in many of Micronesia sites;
- Climate change and adaptation to climate change are not new. Pacific Islanders have been adapting to climate and social change for centuries. Adaptation is culturally relevant and a skill of island communities; and
- Some communities in the Pacific are already active in developing and implementing adaptation strategies and can be a source of both inspiration and experience to support other communities to pursue similar efforts.

FSM's new National Emergency Operations Center that houses OEEM was built in Palikir, Pohnpei in February 2013. The estimated costs of the building was around US$260,000. Funding for the new building has been made available through the European Union Disaster Risk Reduction project (B-Envelope) implemented by the SOPAC Division of SPC. The project will also furnish the building with basic office furniture and install early warning communication equipment, to strengthen the capacity of OEEM in their work. The B-Envelope project has completed renovation of all State Emergency Operation Centers and will also install early warning communication equipment to some outer islands in the Federated States of Micronesia. A total of Euro 1.4 million was allocated to upgrade infrastructure and strengthen early warning systems in the Federated States of Micronesia.

The National Communications Strategy for the FSM component of the PACC project aims to give direction to how the project should communicate externally and internally at the municipal, State, National, regional and international level, as one of the means to achieve the objective of the NCCP.

More specifically, the strategy aims to streamline communication within the FSM and provide a coordinated approach to developing messages that should be going out to not only local communities (since they will be directly affected) but also the international community on what PACC is doing to enhance resilience to climate change. Ultimately, the strategy will also progressively reflect on the FSM as a case study for adaptation, and show why, and demonstrate how, reducing climate-related risks is an integral part of sustainable development.

The Kosrae Youth Environmental Expedition is a collaborative youth environmental outreach program in which through participation in a week-long camp out, school children are provided the opportunity to be exposed to the natural environment, explore nature, discover what factors affect the health and condition of their surrounding environment, identify and apply simple solutions that will either help enhance the health and condition of the natural environment or help abate problems identified. School children are also able to learn about things in nature and establish a sense of stewardship towards their environment and resources. For a full-on learning experience, interactive presentations, dialogue, and activities are facilitated by project staff.

The expedition is carried out every third quarter of each school year. It was first initiated in 2008 through a collaborative effort of the Government and NGOs, including the Department of Education.

The Kosrae Youth Environmental Speech Contest was first initiated in 2011 and was intended to be an annual event. The contest sought to provide the opportunity for Kosrae's youth population to present their opinions and ideas on how to deal with a wide range of environmental issues, including climate change. The topic for 2011 Contest was, "Your Potentials Against the Potential Threats of Climate Change". The general public, school children, parents, local leaders, and conservation practitioners attended the event as observers. In addition, the entire event was broadcast on radio and televised on the local cable TV.

## 7.5 CLIMATE CHANGE INFORMATION, INCLUDING RESEARCH AND SYSTEMATIC OBSERVATIONS

As noted above, a cross-cutting information issue in the FSM is the need for up to date aerial photography and LIDAR data. This is highlighted by the fact that the basis for most of the forest assessments in the SWARS was vegetation maps based on aerial photography from 1976 (FSM Department of Forestry, 2010). Only for Pohnpei have more recent vegetation maps been made, based on more recent aerial photography. These maps indicate a serious decline in upland native forest. There are no data on overall forest trends for the rest of the FSM, except that given in Table 38. A Federal Aviation Administration certified airline experienced in the precision flying needed for such aerial photography is based on Yap, and the U.S. Forest service or other agencies have the cameras and professional staff for such work.

In addition to current aerial photography, LIDAR imagery is greatly needed in order to more accurately assess vulnerability to sea level rise and storm surge throughout Micronesia. This is especially important for low-lying outer islands that are close to sea level.

Land elevation information is a major data gap that could be resolved with airborne LiDAR surveys available from several sources. Mapping topography and bathymetry in the coastal zone, matched with geospatial information on community parameters (infrastructure, roads, development, etc.) would allow for a risk and vulnerability analysis (RVA). RVA is an important step in developing a plan to manage climate risk and to design adaptation strategies. There are other data gaps as well: soil and agro-forestry geospatial layers, wave and sea-level monitoring instrumentation are lacking, geospatial information on climate and ocean processes (for instance, lagoon circulation is poorly understood), and others. Data on soil fertility and treatments or amendments to improve the fertility of soils is needed as are programs for producing food on atolls experiencing salt-water intrusion.

As part of nationwide energy sector initiatives, a centralized energy database is being established and managed by the Energy Division of the Department of Resources and Development. In order to monitor the development of the energy sector, and to improve joint efforts that will bring FSM closer to achieving the goals set in its Energy Policy, it is crucial to set up and maintain such a centralized energy database. It will help in monitoring the current situation and its evolution over time. The database will integrate with the sub-regional and regional energy databases and serve as a source of information for the energy sector.

In FSM significant information data gaps hamper comprehensive planning. For example, water management suffers from a lack of adequate hydraulic modeling and calculations of sustainable yield. Atoll aquifer systems are poorly understood and there is little knowledge of what sustainable groundwater withdrawal rates are appropriate from one island to the next, as well as among the main islands. Rates of coastal erosion are not measured and thus development on eroding shores does not take this hazard into account. As a result shoreline hardening is widespread and beach loss is common. This interferes with FSM's plans for the development of tourism.

Arguably the most crucial data gap is the lack of site specific climate data to constrain down-scaled global circulation projections. Although this is a problem globally, the need for regional and local-scale climate modeling in the FSM is critical. Projecting future rain, storm, wind, evapotranspiration, surface temperature, ENSO patterns, and other fundamental parameters, needs to be the target of focused modeling research so that climate risk management activities can be planned.

An improved understanding of the variability in tides and sea-levels around Kosrae is required to adequately account for sea-level considerations within the PACC demonstration project and for subsequent completion of the circumferential road. Initiatives include installation of one permanent sea level station at Lelu wharf which will collect 10 minute tide data and barometric pressure. Three temporary sea level stations will be used to determine variations in sea level around the island. These short-term (>262 days) deployments of a gauge at other locations (initially at Okat, then, Walung and Utwe) will allow a better understanding of Kosrae's tides overall. All sea level stations have been tied into the global WGS84 height datum the local survey system to enable accurate assessment of tide changes over time. A permanent rainfall and solar radiation station has been installed at the airport. It will collect rainfall amounts at ten minute intervals automatically to determine peak intensities. The solar radiation sensor will provide continuous readings of available solar energy on the island.

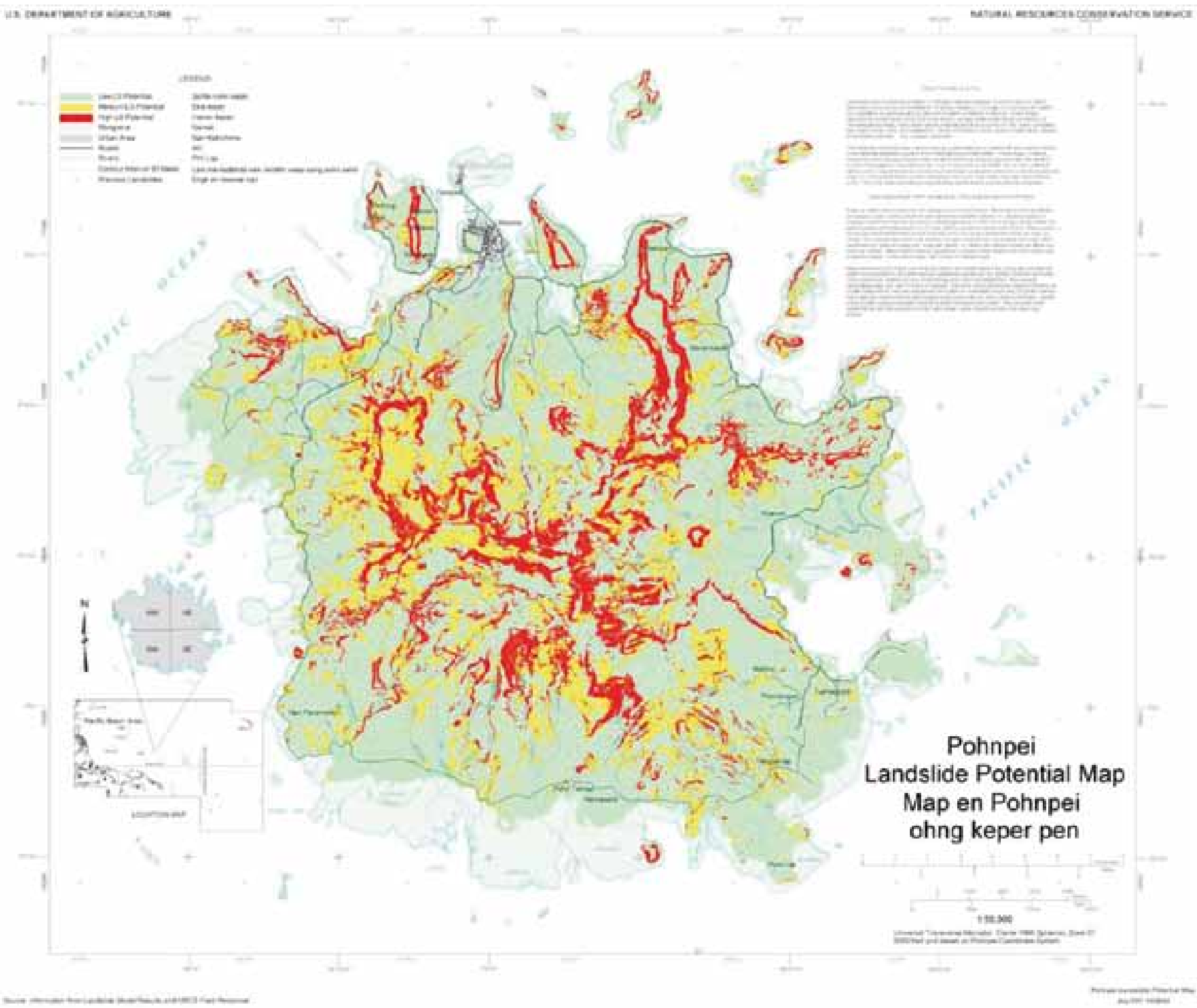
The purpose of these monitoring initiatives is to provide adequate baseline monitoring on Kosrae. This will help ensure fit-for-purpose climate-related information is available to inform future climate sensitive decision-making and planning.

In April 1997, two major storms struck Pohnpei Island in rapid succession. This triggered more than 30 landslides, caused serious property damage and took the lives of 19 people. The U.S. Department of Agriculture-Natural Resources Conservation Service was requested to prepare a landslide potential map showing where landslides initiate (Figure 48). This information is useful in assisting local officials and decision-makers in developing landslide hazard maps that will delineate areas like hospitals, typhoon/disaster shelters, school, roads and public utilities within potential hazard areas down slope of the landslide potential areas indicated in this report.

Thus the landslide hazard zone maps provide a critical planning tool needed by various Pohnpei State Agencies to aid in disaster preparedness planning and response activities; as well as support zoning officials, civil engineers, and landowners in providing indicates of sites requiring detailed engineering investigations or plans.

**FIGURE 48 | Pohnpei Landslide Potential Map 1:50,000 scale**

*Source: USDA-NRCS Pacific Basin Area, 2001.*



## 7.6 TECHNOLOGY TRANSFER

In FSM's Nationwide Climate Change Policy the priorities for technology transfer are identified as optimizing the use of local technologies, where available, identifying technologies that are locally appropriate, and enhancing easy access to, and sustainable use of, new technologies. The thematic assessment undertaken as part of FSM's National Capacity Self Assessment on implementing the UNFCCC identified the root causes of capacity constraints to technology transfer. These were as insufficient information on technology transfer, the lack of qualified staff in transferring technology, limited funding for mitigation and transfer, and limited networking of major agencies and organizations on appropriating technology use for climate change adaptation and mitigation measures (FSM Office of Emergency and Environmental Management, 2009).

In the National Capacity Self Assessment the need to build capacity for technology transfer was elaborated at several levels, namely:

**Systemic level:**

- develop a legal framework that will coordinate technology transfer – both on adaptation and mitigation measures; and
- develop an information system for FSM that will facilitate access to other successful technologies and transfer to meet local needs that are similar to other areas in the region.

**Institutional level:**

- promote the assessment and transfer of appropriate technologies that avoid adverse impacts on local environments and traditional cultures and society.

**Individual level:**

- training for individuals so they can conduct technology needs assessment and other related activities with respect to adaptation and mitigation technologies.

## 7.7 CONSTRAINTS, GAPS, NEEDS AND PRIORITIES

Table 17 lists the goals of the Nationwide Climate Change Policy (2009). Climate change events, chronic problems, data gaps, lack of master planning, and entrenched land uses decrease the sustainability of FSM communities in the face of changing climate conditions. As a result, there is a vulnerability to natural hazards with a difficulty recovering from the hazards, a loss of culture as traditional practice is replaced by imported resources and a further strain on National and State resources with the focus on crisis management rather than problem solving.

An absence of master planning tends to promote ad hoc decision-making, further influenced by the need for rapid decision-making in the wake of a recent crisis. Arable land is scarce. A strong traditional land use system involving complex land tenure relationships, along with a high number of invested stakeholders, make it difficult to enact changes in policy. There are also data gaps that hamper comprehensive planning.

There is a need to work with lending institutions such as the FSM Development Bank, the Rural Development, and the Pacific Islands Development Bank, as well as commercial banks, to encourage them to give more consideration to climate change when providing loans for building and other development initiatives. Incentives, such as offering lower interest rates for loans climate risks are addressed, are one initiative that banks might consider. Development partners should also be encouraged to ensure that climate-related risks and opportunities are given due consideration.

In FSM rates of coastal erosion are not measured and thus development on eroding shores does not take this hazard into account. As a result shoreline hardening is widespread and beach loss is common. This interferes with FSM plans for the development of tourism. Land elevation is a major data gap that could be resolved with airborne surveys. Adequate Geographical Information Systems would allow for a risk and vulnerability analysis, important step in developing a plan to manage climate risk and to design adaptation strategies.

There are other data gaps as well with soil and agro-forestry mapping, wave and sea-level monitoring, and geospatial information on climate and ocean processes that are poorly understood. FSM actually has 10 climate recording stations, with 11 more for rainfall only, but with little expertise and inconsistent monitoring procedures the data are seldom put to beneficial use. Projecting future climate parameters such as rain, storm, wind, evapotranspiration, surface temperature, ENSO patterns, and other fundamental parameters needs to be the target of focused modeling research so that climate risk management activities can be planned.

The overall lack of data on climate change, and on sustainability parameters, underlies many of the difficulties in managing climate-related risks in the FSM. Water management suffers from a lack of adequate hydraulic modeling and calculations of sustainable yield. Atoll aquifer systems are poorly understood and there is little knowledge of what sustainable groundwater withdrawal rates are appropriate from one island to the next, as well as among the main islands.

The vulnerability of food and farming systems to the new fundamentals of climate change and scarcer, costlier oil is not well considered in current policy. To date there has been insufficient consideration placed on adaptation and resilience within food and farming systems, especially in terms of biodiversity, sufficient skilled labor and supporting infrastructure that a low–carbon, more resourced constrained future necessitates.

Wildland fires can be common in the FSM during the dry season, when rainfall amounts are low, humidity is relatively low, and the trade winds consistently blow across the islands. It is likely that the FSM experiences many more wildland fires than has been reported in readily available information. Several uncontrollable fires were reported throughout the FSM during the drought of 1998. However, no location data are readily available for the fires. Location data on historical fires in the FSM are only readily available for the State of Yap, from 2001–2003.

Several key issues related to health information systems, biostatistics and epidemiology in FSM have been identified. The following list includes some of the issues which need to be addressed (FSM Department of Health and Social Affairs, 2011):

- changes to both the health information software (eg. the switch from WinPAS to HIS - Microsoft Access-based system - in the mid-1990's) and disease codes (from ICD-9 to ICD-10) have resulted in a loss of institutional knowledge; some States may be still trying to "catch up" following these changes;
- medical records coding is currently performed by a very small number of people;
- there are delays in health data transfer and processing;
- there are problems with filing, transfer and updating of medical records (eg. from neonatal records to patient files);
- the health information system requires more managerial support and understanding as well as technical support; and
- disease surveillance capacity (apart from the WHO syndromic surveillance system) is currently inadequate; this is partly due to the multiple responsibilities of key individuals, and may also be due to a lack of understanding of others regarding the process and importance of disease surveillance.

# 8

## CHAPTER EIGHT
# REFERENCES

## REFERENCES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# GLOSSARY
## (SOURCE: ADAPTED FROM IPCC, 2007)

**Adaptation** - Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities; various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

**Adaptation assessment** - The practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility.

**Adaptive capacity** - In relation to climate change impacts, the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

**Anthropogenic** - Resulting from or produced by human beings.

**Aragonite** – A calcium carbonate (limestone) mineral, used by shell- or skeleton- forming, calcifying organisms such as corals (warm- and coldwater corals), some macroalgae, pteropods (marine snails) and non-pteropod molluscs such as bivalves (e.g., clams, oysters), cephalopods (e.g., squids, octopuses).Aragonite is more sensitive to ocean acidification than calcite, also used by many marine organisms.

**Baseline** - The baseline is the state against which change is measured. It might be a 'current baseline', in which case it represents observable, present-day conditions. It might also be a 'future baseline', which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines.

**Biofuel** - A fuel produced from organic matter or combustible oils produced by plants. Examples of biofuel include alcohol, black liquor from the paper-manufacturing process, wood, and soybean oil.

**Biomass** - The total mass of living organisms in a given area or volume; recently dead plant material is often included as dead biomass. The quantity of biomass is expressed as a dry weight or as the energy, carbon or nitrogen content.

**Capacity building** - In the context of climate change, capacity building is developing the technical skills and institutional capabilities in developing countries and economies in transition to enable their participation in all aspects of adaptation to, mitigation of, and research on climate change, and in the implementation of the UNFCCC and Kyoto Mechanisms, etc.

**Carbon sequestration** -The process of increasing the carbon content of a reservoir/pool other than the atmosphere.

**Climate** - Climate in a narrow sense is usually defined as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. The classical period of time is 30 years, as defined by the World Meteorological Organization.

**Climate change** - Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines 'climate change' as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

**Climate prediction** - A climate prediction or climate forecast is the result of an attempt to produce an estimate of the actual evolution of the climate in the future, e.g., at seasonal, interannual or long-term time scales.

**Climate projection** - The calculated response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often based on simulations by climate models. Climate projections are distinguished from climate predictions, in that the former critically depend on the emissions/concentration/radiative forcing scenario used, and therefore on highly uncertain assumptions of future socio-economic and technological development.

**Climate (change) scenario** – A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships and assumptions of radiative forcing, typically constructed for explicit use as input to climate change impact models. A'climate change scenario' is the difference between a climate scenario and the current climate.

**Climate variability** - Climate variability refers to variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

**Coral bleaching** - The paling in color which results if a coral loses its symbiotic, energy-providing, organisms.

**Discount rate** - The degree to which consumption now is preferred to consumption one year hence, with prices held constant, but average incomes rising in line with GDP per capita.

**Downscaling** - A method that derives local- to regional-scale (10 to 100 km) information from larger-scale models or data analyses.

**Drought** - The situation that exists when precipitation is significantly below normal recorded levels, causing serious hydrological imbalances that often adversely affect land resources and production systems.

**El Niño-Southern Oscillation (ENSO)** - El Niño, in its original sense, is a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. This oceanic event is associated with a fluctuation of the inter-tropical surface pressure pattern and circulation in the Indian and Pacific Oceans, called the SouthernOscillation. This coupled atmosphere-ocean phenomenon is collectively known as El Niño-Southern Oscillation. During an El Niño event, the prevailing tradewinds weaken and the equatorial countercurrent strengthens, causing warm surface waters in the Indonesian area to flow eastward to overlie the cold waters of the Peru current. This event has great impact on the wind, sea surface temperature, and precipitation patterns in the tropical Pacific and coastlines of Peru and Ecuador. It has climatic effects throughout the Pacific region and in many other parts of the world. The opposite of an El Niño event is called La Niña.

**Emissions scenario** - A plausible representation of the future development of emissions of substances that are potentially radiatively active (e.g., greenhouse gases, aerosols), based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socio-economic development, technological change) and their key relationships. In the IPCC Special Report on Emissions Scenarios (SRES), new emissions scenarios – the so-called SRES scenarios – were published.

**Food security** - A situation that exists when people have secure access to sufficient amounts of safe and nutritious food for normal growth, development and an active and healthy life. Food insecurity may be caused by the unavailability of food, insufficient purchasing power, inappropriate distribution, or inadequate use of food at the household level.

**Greenhouse effect** - The process in which the absorption of infrared radiation by the atmosphere warms the Earth. In common parlance, the term 'greenhouse effect' may be used to refer either to the natural greenhouse effect, due to naturally occurring greenhouse gases, or to the enhanced (anthropogenic) greenhouse effect, which results from gases emitted as a result of human activities.

**Greenhouse gas** - Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. This property causes the greenhouse effect. Water vapor (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) and ozone (O3) are the primary greenhouse gases in the Earth's atmosphere. As well as CO2, N2O, and CH4, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

**Gross Domestic Product** - Gross Domestic Product (GDP) is the monetary value of all goods and services produced within a nation.

**Impact assessment** – In the context of climate change - the practice of identifying and evaluating, in monetary and/or non-monetary terms, the effects of climate change on natural and human systems.

**Impacts** – In the context of climate change, the effects of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts. Potential impacts are all impacts that may occur given a projected change in climate, without considering adaptation. Residual impacts are the impacts of climate change that would occur after adaptation.

**Infrastructure** - The basic equipment, utilities, productive enterprises, installations and services essential for the development, operation and growth of an organisation, city or nation.

**Kyoto Protocol** - The Kyoto Protocol was adopted at the Third Session of the Conference of the Parties (COP) to the UN Framework Convention on Climate Change (UNFCCC) in 1997 in Kyoto, Japan. It contains legally binding commitments, in addition to those included in the UNFCCC. Countries included in Annex B of the Protocol (most member countries of the Organisation for Economic Cooperation and Development (OECD) and those with economies in transition) agreed to reduce their anthropogenic greenhouse gas emissions (CO2, CH4, N2O, HFCs, PFCs, and SF6) by at least 5% below 1990 levels in the commitment period 2008 to 2012. The Kyoto Protocol entered into force on 16 February 2005.

**Likelihood** - The likelihood of an occurrence, an outcome or a result, where this can be estimated probabilistically.

**Millennium Development Goals (MDGs)** - A list of ten goals, including eradicating extreme poverty and hunger, improving maternal health, and ensuring environmental sustainability, adopted in 2000 by the UN General Assembly, i.e., 191 States, to be reached by 2015. The MDGs commit the international community to an expanded vision of development, and have been commonly accepted as a framework for measuring development progress.

**Mitigation** - Human intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

**No regrets** - A policy, plan or action that would generate net social and/or economic benefits irrespective of whether or not anthropogenic climate change occurs.

**Ocean acidification** - Increased concentrations of $CO_2$ in sea water causing a measurable increase in acidity (i.e., a reduction in ocean pH). This may lead to reduced calcification rates of calcifying organisms such as corals, molluscs, algae and crustacea.

**Projection** - The potential evolution of a quality or set of quantities, often computed with the aid of a model. Projections are distinguished from predictions in order to emphasize that projections involve assumptions – concerning, for example, future socio-economic and technological developments, that may or may not be realized – and are therefore subject to substantial uncertainty.

**Resilience** - The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

**Salinization** - The accumulation of salts in soils.

**Salt-water intrusion / encroachment** - Displacement of fresh surface water or groundwater by the advance of salt water due to its greater density. This usually occurs in coastal and estuarine areas due to reducing land-based influence (e.g., either from reduced runoff and associated groundwater recharge, or from excessive water withdrawals from aquifers) or increasing marine influence (e.g., relative sea-level rise).

**Scenario** - A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections, but are often based on additional information from other sources, sometimes combined with a 'narrative storyline'.

**Sea-level rise** - An increase in the mean level of the ocean. Eustatic sea-level rise is a change in global average sea level brought about by an increase in the volume of the world ocean. Relative sea-level rise occurs where there is a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence. In areas subject to rapid land-level uplift, relative sea level can fall.

**Sustainable development** - Development that meets the cultural, social, political and economic needs of the present generation without compromising the ability of future generations to meet their own needs.

**Uncertainty** - An expression of the degree to which a value (e.g., the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain projections of human behavior. Uncertainty can therefore be represented by quantitative measures (e.g., a range of values calculated by various models) or by qualitative statements (e.g., reflecting the judgement of a team of experts).

**United Nations Framework Convention on Climate Change (UNFCCC)** - The Convention was adopted on 9 May 1992, in New York, and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community. Its ultimate objective is the 'stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. It contains commitments for all Parties. Under the Convention, Parties included in Annex I aim to return greenhouse gas emissions not controlled by the Montreal Protocol to 1990 levels by the year 2000. The Convention entered in force in March 1994.

**Vulnerability** - Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

# APPENDIX

## APPENDIX 1

### Stakeholders and Consultations

Several consultations were held to plan for, formulate, review and finalize the FSM Second National Communication. Because consultation meetings in FSM can be very costly, especially when involving all four FSM States, the Project piggy-backed on many existing meetings that could provide critical input to the SNC Report. Some of the meetings and key stakeholders are outlined below:

**1. Climate Change Country Team**

The Climate Change Country Team was the overall advisory group to the project. Members of the team include representatives from the FSM Department of Foreign Affairs, FSM Department of Resources & Development, FSM Department of Health & Social Affairs, FSM Department of Justice, FSM Office of SBOC and the FSM Office of Environment & Emergency Management. Each of the four States are represented on the Team and represented by Yap State Office of Planning & Budget, Chuuk State Environment Protection Agency, Pohnpei Environment Protection Agency and the Kosrae Island Resource Management Authority. The Country Team initiated the Project and held several meetings throughout the SNC project. Although the group doesn't regularly meet specifically on the SNC, they provided constant input to the process and inputs on submissions from the different working groups or teams.

**2. 3rd FSM Environment Conference**

FSM holds its' National Environment Conference every two years to focus on different environmental issues. Participants of the Environment Conferences include Government and non-government representatives from sectors such as environment, resource management, environment health, energy, weather services, and etc. from National level as well as State level. At the 3rd Environment Conference, a stock-take of Climate Change activities in the FSM was undertaken and involved all the participants of the National Environment Conference.

**3. NPFE**

The SNC report was also reviewed by the stakeholders brought together to prioritize on the GEF Star allocation for GEF5. Participants included those from all relevant sectors such as environment, resource management, health, education, disaster management, etc.

**4. 3rd EPA Directors Meeting**

The heads of environment agencies meet annually to discuss priorities and share lessons. At their third Meeting, the 5 directors from National and State Governments met and included on their agenda, a review of the SNC report, particularly the assessments and had input to the progress and outline of the draft.

**5. SNC Review Meeting**

A draft report was initially reviewed by key stakeholders by email but then a Meeting was held specifically to do a detailed review of the draft report with inputs during the meeting and afterwards to provide consultant with final inputs to provide a final draft.

**6. FSM In-country Preparatory Meeting for SIDS Conference**

Stakeholders from across several sectors met to review a draft of the FSM Report to the SIDS Conference planned for 2014. FSM took the opportunity to also have participants this meeting also review the final draft of the SNC with inputs provided to the climate change country team and Government to finalize the draft. Participants included those from Government and non-government stakeholders from various sectors related to sustainable development.

# APPENDIX 2


## Acknowledgements

Acknowledgement is given most especially to the communities and individuals whose lands and peoples were visited and consulted to develop the Second National Communication Report. To access these land and communities, the Municipal Governments were relied on heavily to make those connections and facilitate the critical consultations at the community level.

The Departments and Offices at the State level provided immense information and data for the Report. At the National level, many individuals from national Government departments and offices provided many hours in helping with consultations and review of the different parts of the Report. The technical staff and vast data and information also obtained from local NGO partners provided valuable up-to-date information to the Report.

Acknowledgement is given to all those who contributed to the technical inputs to the report which was quite considerable involving many experts from different fields. The contribution of technical teams that undertook the assessments through the extensive visit to many of the outlying islands are acknowledged. Appreciation goes to Professor John Hay, the principal author of the report, and other consultants whose expertise and skills enabled the skillful authoring of this report and focused reports that supported this national communication

Finally, the financial and technical contributions of UNDP and GEF are acknowledged here.

# APPENDIX 3

## Ongoing Climate Change Adaptation Activities

*(Source: SPC, 2012)*

| Title and Timeframe | Description, country focus and agencies responsible |
|---|---|
| Micronesia Challenge (MC)<br><br>*2006–ongoing* | Sub-regional conservation initiative, which enhances community resiliency by using traditional knowledge and ecosystem strategies to conserve vulnerable coastal land resources by 2020; goals are to effectively conserve at least 30% of nearshore resources and 20% of terrestrial resources.<br><br>The MC includes: Micronesians in Island Conservation Network; Pacific Islands Managed and Protected Area Community; Locally Managed Marine Area Network – Micronesia Node; Micronesia Challenge Young Champions<br><br>**Agencies responsible:** Micronesia Chief Executives (Guam, Mariana Islands, FSM, Palau and RMI); The Nature Conservancy; National Oceanic and Atmospheric Administration, Micronesia Conservation Trust, FSM Department of Resources & Development (R&D) |
| Micronesia Conservation Trust (MCT)<br><br>*2002–ongoing* | MCT was formally established by The Nature Conservancy in 2002 as a charitable and irrevocable corporation organised to manage and provide funds for the accomplishment of the following mission: 'to support biodiversity conservation and related sustainable development for the people of Micronesia by providing long term sustained funding'.<br><br>In 2006, MCT was selected as the financial mechanism for the Micronesia Challenge and has since fully regionalised its board and organisational structure and services.<br><br>MCT is administered under FSM law, has a board of trustees. |
| Pacific Adaptation to Climate Change Project (PACC)<br><br>*2009–2013* | The PACC Project is designed to promote climate change adaptation as a key pre-requisite to sustainable development in Pacific Island countries. Its objective is to enhance the capacity of the participating countries to adapt to climate change and climate variability, in key development sectors. Mainstreaming, demonstration and communications are implemented at the community and country levels.<br><br>Kosrae was chosen as the pilot State, focusing on coastal infrastructure, e.g. roads that are already experiencing erosion from sea-level rise and flooding.<br><br>**Agencies responsible:** UNDP (implementing agency); Global Environment Facility (GEF), AusAID (funding agencies); Secretariat of the Pacific Regional Environment Programme (SPREP) (implementing partner). FSM Kosrae Island Resource Management Authority (KIRMA) |
| Pacific - Australia Climate Change Science and Adaptation Planning Program (PACCSAP)<br><br>*2011–2013* | PACCSAP: supporting the Government of FSM develop improved climate change projections and adaptation planning activities. 2012–2013. FSM and 14 other Pacific countries are part of this AUD 32 million project, which builds on the foundation of the Pacific Climate Change Science Programme and the Pacific Adaptation Strategy Assistance Programme.<br><br>**Agencies responsible:** AusAID; Australian Department of Climate Change and Energy Efficiency; Australian Bureau of Meteorology, Commonwealth Scientific and Industrial Research Organisation. FSM OEEM |
| Implementing Sustainable Water Resources and Wastewater Management in Pacific Island Countries (Pacific IWRM) | Pacific IWRM is developing 'Ridge to Reef – Community to Catchment' integrated water resource management activities in the 14 participating Pacific Island countries.<br><br>**Agencies responsible:** Global Environment Facility; SPC Applied Geosciences and Technology Division FSM R&D |
| $MAPCO_2$ Project<br><br>*2011 – ongoing* | A $MAPCO_2$ was deployed within the Chuuk Lagoon in November 2011. The goal of this joint effort is to establish a long term monitoring station in Micronesia as part of global ocean monitoring network system for coral reef areas.<br><br>**Agencies responsible:** National Oceanic and Atmospheric Administration Carbon Group; Korea Ocean Research and Development Institute. FSM R&D |

| Title and Timeframe | Description, country focus and agencies responsible |
|---|---|
| Global Climate Change Alliance: Pacific Small Island States (GCCA:PSIS)<br><br>*2011–2014* | The overall objective of the GCCA: PSIS is to support the Governments of nine small Pacific Island States, including FSM, in their efforts to tackle the adverse effects of climate change. Overall available funding is €11 m.<br><br>**Agencies responsible:** European Union (EU); SPC (Implementation); SPREP. FSM OEEM |
| University of the South Pacific USP-EU GCCA Project<br><br>*2011–2014* | The USP-EU GCCA project addresses the challenges of climate change impacts in the 15 Pacific ACP countries, including FSM, through capacity building, community engagement, and applied research. The objective of this project is to develop and strengthen the Pacific ACP countries' capacity to adapt to the impacts of climate change. Overall available funding is € 8 m.<br><br>**Agencies responsible:** European Union; University of the South Pacific.FSM- MFA? |
| North Pacific ACP Renewable Energy and Energy Efficiency Project (North-REP)<br><br>*2010–2014* | The overall objective of North-REP is to improve the quality of life on the outer islands by increasing access to basic electricity and reducing dependency on fossil fuels through energy efficiency and increased penetration of matured renewable energy technologies in the North-REP countries (FSM, RMI and Palau).<br><br>Overall available funding for FSM is US$ 10 m.<br><br>**Agencies responsible:** European Union; SPC (implementing agency); FSM R&D. |
| Coping with Climate Change in the Pacific Island Region (CCCPIR)<br><br>*2009–2015* | CCCPIR covers 12 Pacific Island countries and six components ranging from regional and National mainstreaming of climate change, implementation of adaptation activities on the ground, and climate change related to tourism, energy and education.<br><br>Overall available funding is € 17 m. The share for FSM amounts to US$ 440,000.<br><br>**Agencies responsible:** German Ministry for Economic Cooperation and Development (BMZ, funding); German International Cooperation (GIZ, implementing agency); SPC (regional partner), FSM OEEM, R&D |
| Unite for Climate | Children's vulnerability to climate change and disaster impacts in East Asia and the Pacific.<br><br>**Agency responsible:** UNICEF, FSM Department of Health and Social Affairs, Red Cross |
| ADAPT Asia – Pacific Annual USAID Forum on Adaptation<br><br>*2012 onwards* | Designed to help Asia-Pacific country Governments understand the technical and scientific demands required to apply for climate finance<br><br>**Agency responsible:** USAID, FSM OEEM |
| National Climate Change and Health Action Plan | Regional framework for action to protect human health from effects of climate change in the South East Asia and Pacific region.<br><br>**Agencies responsible:** World Health Organization, FSM – Department of Health and Social Affairs, State Environment Protection Agencies, OEEM, |
| Technical Assistance(TA) to the Federated States of Micronesia for Strengthening Infrastructure Planning and Implementation<br><br>*2011–2013* | TA will support State utilities within FSM in executing infrastructure projects more effectively by having an agreed upon approach to systems and procedures for project planning, design, and management across the country; and build capacity in the Department of Transportation, Communications and Infrastructure to plan, design, and oversee project execution.<br><br>The Government of FSM has requested ADB to finance US$ 700,000 equivalent.<br><br>**Agencies responsible:** ADB, Japan Fund for Poverty Reduction, FSM TC&I |
| Pacific Islands Climate Education Partnership (PCEP)<br><br>*2011–ongoing* | Educates students and citizens across the Pacific about the urgency of climate change impacts in ways that exemplify modern science and honour indigenous cultures and environmental knowledge. This project, funded by the National Science Foundation (NSF), serves the United States-affiliated Pacific Islands.<br><br>**Agencies responsible:** US National Science Foundation (NSF); WestEd. FSM OEEM, National and State Departments of Education |

| Title and Timeframe | Description, country focus and agencies responsible |
|---|---|
| Climate Adaptation, Disaster Risk Reduction and Education (CADRE)<br><br>*2011 -2014* | Aims to build resilience of vulnerable communities to natural hazards particularly those that are climate induced. Will target approximately 10,000 school aged students at up to 50 schools with climate adaptation, disaster risk reduction and education program.<br><br>Track 1 educational component, including capacity building of students, teachers, administrators and the local community; technical assessments of climate change impact and disaster risk on schools grounds, and the surrounding community.<br><br>Track 2 roll out of adaptation measures stemming from the recommendations contained within the change impact assessments and exercising of the climate adaptation and disaster risk management plans<br><br>**Agencies responsible:** AusAID, IOM, FSM OEEM, National and State Departments of Education |

# APPENDIX 4

## Food Security Logframe for FSM

*(Source: Susumu and Kostka, 2011)*

| | Intervention Logic | Objectively Verifiable Indicators | Sources (Means) of Verification | Assumptions and Risks |
|---|---|---|---|---|
| **Overall Objective (Goal)** | To ensure food security and a healthy livelihood for FSM People | ▪ % improved health of vulnerable groups by 2015<br>▪ % increase in income by 2015 | HIES, DOH report, Quarterly Report | ▪ Continue to depend on imported food |
| **Project Purpose** | To increase food production through enhancing crop, livestock and aquaculture production systems | ▪ % increased in crop production<br>▪ % increased in livestock production<br>▪ % increased in fish production | Agriculture office reports, COM-FSM CRE reports, Field Surveys<br>State fisheries report<br>HIES | ▪ Socio-economic of FSM remain unchanged<br>▪ Strong collaboration between stakeholders and partners |
| **Results (Outputs)** | 1.0 Crop production increased | ▪ % increase in crop area (acreage) and production by 2015<br>▪ % increased in production and productivity<br>▪ No. of genebanks/nurseries established<br>▪ % increased in no. of farmers | Field Surveys | ▪ Problems and productions opportunities remain unchanged<br>▪ Strong participation of women/youth groups |
| | 2.0 Livestock production and productivity increased | ▪ % increase livestock numbers and production by 2015<br>▪ # of new livestock species introduced and distributed by 2015 | Quarterly reports | ▪ Problems and productions opportunities remain unchanged<br>▪ Socio-economic remain unchanged |
| | 3.0 Increased market access provided | ▪ No. of market facilities established<br>▪ Volume of sales increased (Tonnage)<br>▪ # of high value commodities exported by 2015<br>▪ % increase of commodities supplied to the domestic markets by 2015<br>▪ % increased income from agricultural sales by 2015. | Agriculture reports<br>Market surveys<br>Quarterly reports | ▪ Favourable Government support<br>▪ Farmers Associations remain active |
| | 4.0 Aquaculture is promoted throughout the four States | ▪ No. of aquaculture projects established in FSM<br>▪ No. of MPAs established and enforced | Quarterly reports | Favourable Government support<br><br>Strong partnership and collaboration between partners |
| | 5.0 Increase consumption of local food | ▪ # of awareness programs carried out<br>▪ % increased consuming local food on a daily basis by 2015. | DOH reports<br>HIES<br>Market survey | Consumption patterns remain unchanged |

| Activities | | Inputs | Costs | Timeframe | Responsibility |
|---|---|---|---|---|---|
| **Result 1.0** | | **1.0 Increased crop production** | | | |
| 1.1 | Baseline information on agricultural production collected; farmers production problems identified | Travel<br>Supplies<br>Personnel<br>Meetings/workshops | 5,000 | Ongoing | NPC, COM-FSM CRE-AES, NRCS, NGO's, R&D, SPC, State Agriculture, FAO |
| 1.2 | Identify community/farmers needs | Meetings | 1,000 | April | COM-FSM CRE-AES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, PASAP, FAO |
| 1.3 | Conduct research and production field trials for selected vegetables | Seeds<br>Fertilizer<br>Meetings | 1,000 | April - June, 2011 | COM-FSM CRE-AES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, PASAP, FAO |
| 1.4 | Identify potential sites for nursery establishment in all four States | Meetings<br>Personnel<br>Travel | 2,000 | May-June, 2011 | NPC, State Agriculture Office, Farmers Associations, FAO |
| 1.5 | Establishment of nurseries for convenient access by farmers/communities | Nursery materials<br>Seeds/planting materials | 20,000 | July 2011 | NPC, State Agriculture Office, Farmers Associations, FAO |
| 1.6 | Procurement, Propagation, distribution of seeds/seedlings | Seeds/ Planting Materials | 50,000 | July - Ongoing | COM-FSM CRE-AES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, FAO |
| 1.7 | Engage youth/women's groups through provisioning of input supplies and tools | Seeds/ Planting Materials<br>Personnel<br>Meetings/workshops | 50,000 | Ongoing | NPC, State Agriculture Office, Farmers Associations, FAO |
| 1.8 | Establish on-farm demonstrations of recommended crop husbandry practices | Pilot Farms<br>Target farmers and communities<br>Seeds/ Planting Materials<br>Personnel | 10,000 | Ongoing | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, FAO |
| 1.9 | Conduct trainings on control of pests and diseases and integrated pest management | Personnel<br>Training materials<br>Farmers<br>Travel | 20,000 | August, 2011 | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, FAO |
| 1.10 | Facilitate trainings on traditional agro-forestry agricultural farming systems | Personnel<br>Training materials<br>Farmers | 50,000 | September 2011 | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, FAO |
| 1.11 | Facilitate the establishment of genebanks in selected communities | Personal<br>Training materials<br>Nursery equipment and materials | 20,000 | November 2011 | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, FAO |

| | | | | | |
|---|---|---|---|---|---|
| 1.12 | Strengthen Biosecurity and pest control | Personal<br>Training<br>Travel<br>Supplies/equipment | 20,000 | December 2011 | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, FAO |
| 1.13 | Promotion of Organic fertilizers | Personal<br>Travel<br>Workshops | 10,000 | January 2012 | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, FAO |
| 1.14 | Strengthen research climate tolerant varieties and distribution of climate tolerant species | Planting materials<br>Personal | 10,000 | February 2012 | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, FAO, PASAP |
| 1.15 | Rehabilitation of damaged taro patches in atoll communities and diversification of crop species | Contractual services<br>Construction materials<br>(blocks, cement, etc.) | 100,000 | March - September, 2012 | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, FAO |
| 1.16 | Integrated home gardening | Planting materials<br>Planting pots | 10,000 | Ongoing | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, FAO |
| **2.0 Results** | | **2.0 Increased livestock production** | | | |
| 2.1 | Facilitate the introduction and distribution of improved breeds | Personnel<br>Training materials<br>Farmers | 15,000 | December 2011 | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture |
| 2.2 | Promote production of Local breeds | Local breeds<br>Farmers | 1000 | December 2011 | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture |
| 2.3 | Facilitate trainings on livestock waste management | Personnel<br>Training materials<br>Farmers<br>Travel | 2000 | Ongoing | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture |
| 2.4 | Conduct research on local feed supplements | Chinese Technicians<br>Pilot Farm<br>Local Feeds<br>Personnel | 10,000 | Ongoing | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture |
| 2.5 | Identify and introduce adaptable new species of livestock | Livestock | 20,000 | Ongoing | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture |
| 2.6 | Facilitate establishment of small scale butchery | Construction equipment<br>Contract | 20,000 | June 2012 | COM-FSM CRE-AES, CES, NRCS, NGO's, NPC, R&D, SPC, State Agriculture, FAO |
| **Result 3.0** | | **3.0 Increased market opportunities provided** | | | |
| 3.1 | Identify 5 high value potential crops or commodities for export market | Personal<br>Meetings<br>Net working<br>Workshops<br>Travel | 15,000 | October 2012 | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, FAO |
| 3.2 | Establishment of processing facilities | Contractual services | 50,000 | December 2012 | NPC, R&D, SPC, FAO-TCP, FAO |

| | | | | | |
|---|---|---|---|---|---|
| 3.3 | Establishment  of quality standards | Personal<br>Workshops<br>Travel | 8000 | December 2012 - Ongoing | R&D, SPC, FAO-TCP, NPC, FAO |
| 3.3 | Facilitate the establishment of the supply chain from farms to markets | Personnel<br>Workshop materials | 10,000 | March 2012 | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, FAO |
| 3.4 | Facilitate trainings on farm management and post harvest handling | Personnel<br>Training materials<br>Farmers<br>Workshop | 10, 000 | March 2012 | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, FAO |
| 3.5 | Conduct market survey for export and domestic commodities | Personnel<br>Market Vendors<br>Survey Materials | Travel<br>Personnel | 5000 | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, FAO |
| 3.6 | Conduct farmers' survey on farming practices used, crops grown, produced and harvested | Personnel<br>Market Vendors<br>Survey Materials | | April 2012 | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, FAO |
| 3.7 | Development of markets in each State | Contractual services<br>Workshops | 100,000 | September 2012 – April 2013 | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, FAO |
| 3.8 | Establish quarantine treatment facility (HFTA) | Personnel<br>Contract | 500,000 | June  - September 2013 | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, FAO |
| **Result 4.0** | | **Improved awareness program on agriculture** | | | |
| 4.1 | Develop awareness programs for young people to pursue careers in agriculture | Personnel<br>Awareness Materials/<br>Programs<br>Youth Organizations<br>Schools | 500 | Ongoing | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, IFCP, FAO, DOE |
| 4.2 | Promotion of local food | Transportation (Travel)<br>Personal<br>Meetings/Workshops<br>Networking<br>Publications<br>Agricultural input supplies | 100,00 | Ongoing | NPC, IFCP, State Agriculture, Farmers Associations, IFCP, COM-CRE, R&D, SPC, NGOs, DOE |
| 4.3 | Create awareness on agricultural recommendations via radio broadcasts and newspapers, TV | Personnel<br>Awareness Materials/<br>Programs<br>Media (Kaselehlie Press, Radio broadcasts, local TV) | 500 | Ongoing | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, IFCP, FAO |
| 4.4 | Translation of awareness materials into vernacular languages | Personnel<br>Awareness Materials/<br>Programs<br>Media (Kaselehlie Press, Radio broadcasts, local TV et.) | 2,000 | Ongoing | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, IFCP, FAO |

| | | | | | |
|---|---|---|---|---|---|
| 4.5 | Create awareness on CHEEF benefits to communities and schools | Personnel<br>Awareness Materials/<br>Programs<br>Media (Kaselehlie Press,<br>Radio broadcasts, local TV) | 10,000 | Ongoing | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, IFCP, FAO |
| **Result 5.0** | | **Aquaculture is promoted throughout the four States** | | | |
| 5.1 | Identify potential aquaculture projects for communities | Personnel | 5000 | January 2014 | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, FAO |
| 5.2 | Promotion/and training provided on aquaculture | Personnel<br>Training materials | 10,000 | June 2014 | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, FAO |
| 5.3 | Procurement of project supplies and equipment | Project supplies/materials | 50,000 | November 2014 | NPC, COM-FSM CRE AES, R&D, SPC, NGO's, FAO |

# APPENDIX 5

## Climate-sensitive Disease Risks and Needs in FSM*

*(Source: FSM Department of Health and Social Affairs, 2011)*

| Health issue | Likely effect of climate change | Risk (ie. likelihood x impact) posed by climate-sensitive disease in FSM (high, medium, low) | Needs/gaps |
|---|---|---|---|
| Vector-borne diseases (eg. arboviral infections – dengue, Zika) | Altered geographic range of mosquito vectors; possible increased incidence of disease due to effects on vector population, viral replication, human behaviour etc | High | Integrated vector management; training for local environmental health officers in mosquito surveillance; lack of knowledge/ understanding on the part of public on vector-borne disease; human resources for vector-borne disease control |
| Water-borne diarrhoeal pathogens | Likely increased incidence of diarrhoeal disease due to effects of increased temperature, altered rainfall patterns | High | Lack of access to clean drinking water for some members of community (eg. outside large towns); lack of public understanding re: risks of transmission; improved water infrastructure, safety monitoring; review laboratory diagnostic facilities for water-borne infections; strengthen outbreak response capacity |
| Malnutrition (under-nutrition) | Possibly increased due to failure of crops, fisheries; greatest impact likely on children and other highly vulnerable groups (eg. pregnant women) | High | Micronutrient deficiencies of particular concern in children; antenatal care (including nutrition) needs improvement<br><br>Consider link between childhood malnutrition and worm infestations, anaemia etc<br><br>(NB. food security bigger issue on outer islands) |
| Zoonotic infections [mainly leptospirosis; also avian influenza] | Possible increased incidence due to effects on rainfall (particularly flooding), temperature, human activity<br><br>NB. lack of in-depth knowledge regarding relationship between leptospirosis and climate | Medium-High | Up-to-date survey of domesticated animals (review previous work in this area, eg. Uni of Hawaii, SPC, Fiji School of Medicine); lack of sufficient accurate diagnostics (case definitions & laboratory confirmation); training of health professionals, animal/agriculture workers; lack of public awareness of disease transmission/risks |
| Food-borne disease | Possibly increased due to increased ambient temperature, humidity (eg. Salmonella, E. coli, Staph. aureus etc) | Medium-High | Lack of specific data on food-borne diseases; improve diagnostic capacity, surveillance and response; lack of public understanding re: routes, risks of transmission; lack of adequate training of food handlers |
| Obesity, circulatory disease, diabetes and related NCD's | Possibly increased due to altered dietary patterns (move from fresh to processed foods); population displacement; compromised food security; altered human activity levels | Medium | Lack of adequate consumption of healthy, nutritious, local foods; lack of food choices (due to imported foods, processed foods and cost considerations) and compromised food security leading to obesity, Type 2 diabetes, vascular disease and associated complications thereof<br><br>NB. obesity is increasing among FSM children |

| | | | |
|---|---|---|---|
| Mental health | Possible increased rates of depression, post-traumatic stress disorder, ?substance abuse due to loss of land, livelihoods, population displacement etc | Medium | Lack of trained counsellors (for crisis, drug, depression etc); lack of other skilled mental health professionals (NB. only one part-time psychiatrist for FSM)<br><br>NB. suicide rate in FSM appears to be increasing again after a period of decline |
| Respiratory disease (including asthma, influenza, TB) | Possible increase due to effects of temperature, rainfall; increased population density, overcrowding, migration patterns (potential for spread across countries)<br><br>NB. increased ozone exposure with higher temperatures may increase rates/risk of obstructive airways disease | Medium | Currently in early stages of syndromic surveillance program (for influenza-like illness); need to improve sample collection for accurate and early diagnosis |
| Skin disease (bacterial & fungal infections, infestations eg. scabies); skin cancers; ?psoriasis | Possible increase with increased humidity, ?more frequent/ severe droughts in some areas; possible increased UV exposure | Medium | Lack of early recognition/understanding risks/consequences; possible transmission via contaminated water |
| Poverty, socio-economic disadvantage | Acknowledge that poverty and socioeconomic disadvantage may be both risk factor and effect with respect to climate-related health impact | Medium | Need to consult with Division of Social Affairs |
| Traumatic injuries and deaths | Possible increase due to increased frequency and severity of extreme weather events (eg. typhoons, storm surges)<br>NB. State of Emergency declared in three consecutive years in 2007-2009 in Chuuk State due to impact of storm surges | Low-Medium | Lack of early warning systems (for extreme weather events eg. tsunamis, typhoons etc); lack of community preparedness; lack of response capacity within health system (eg. for mass casualty event)<br><br>Lack of current understanding re: likelihood of future extreme weather events in FSM |
| Typhoid | Possible increased cases/risk of transmission following heavy rains/storms | Low-Medium | Lack of accurate diagnostic capacity (case definitions, lab confirmation) |
| Ciguatera (fish poisoning, harmful algal blooms); ?turtle poisoning; ?scombroid | Possible increased incidence due to increased sea temperature, altered ENSO patterns, ?coral bleaching | Low-Medium | Lack of knowledge about risk burden in FSM and specific risk factors; ?surveillance programs; lack of diagnostic capabilities |
| Eye disease (eg. conjunctivitis, cataracts, ?pterygia) | Probable link with prolonged dry periods, droughts etc; possible increased UV exposure | Low-Medium | Lack of public understanding re: risks of transmission; occasional shortfalls in medication supply during outbreaks |
| Malaria | Possible intrusion into FSM | Low | Surveillance for malaria vectors as part of routine entomological/environmental health activities |
| Filariasis | Uncertain; possibly increased risk of transmission due to effects on insect vector range | Low | Baseline survey - confirm endemicity in different States; high school survey; difficulty in making accurate diagnoses |

**Note that other health issues discussed during State consultations that have plausible or postulated links with the effects of climate change include the effects of radiation (both UV and nuclear fallout) and reproductive health and fertility.*

## Potential Adaptation Strategies to Address Climate-sensitive Health Risks in FSM

*(Source: FSM Department of Health and Social Affairs, 2011)*

| Health issue | Adaptation strategies/activities | Responsible agencies | Resources |
|---|---|---|---|
| Vector-borne diseases (eg. arboviral infections – dengue, Zika) | - Distribution of mosquito nets;<br>- updated survey of mosquito populations; consider parallel or combined survey of rats and ants (linked to transmission of zoonotic infections and impact on food security); focus on high-risk breeding sites (eg. ports)<br>- community awareness campaign (eg. about pooled water around the home) + environmental clean-ups;<br>- train local EHO's in mosquito surveillance, developing vector control techniques | DH&SA, EPA (and State agencies including KIRMA) | National/State budgets; consider assistance from SPC, WHO, donors, SPREP, FAO, CROP agencies (eg. USP, Forum Secretariat), UNDP, EU, JICA, GTZ etc |
| Water-borne diarrheal pathogens | - Disinfection/treatment kits for communities;<br>- community awareness program;<br>- expand existing programs to outer islands;<br>- chlorination/treatment of community/household water systems (NB. link in with Safe Household Water Treatment & Storage program – multi-agency incl WHO/UNDP);<br>- improve water sources, water quality and water safety planning (WSP – Urban & Rural); NB. differences in supply between States (State vs municipal);<br>- consider use of household testkits ($H_2S$);<br>- research into link between WBD and *sakau* (kava drinking);<br>- link with Water Policy;<br>- ongoing certification of laboratory and water/sanitation technicians;<br>- review each State's Rural Sanitation Program; consider expanding beyond sanitation/sewerage (used in response to cholera outbreaks from 1980's through to 2000) (explore opportunities for incorporation of successful strategies of this program into current and future water safety programs) | DH&SA, EPA/KIRMA | As above |
| Malnutrition (under-nutrition) | - Increased domestic production; decrease dependence while increasing quality of imported food products<br>- support trials of drought- and salt-resistant crops, recognising the importance of local knowledge and traditional practices with respect to healthy, local, nutritious foods that may be particularly resilient to climate change (eg. pandanus);<br>- consider importing proven resistant crops to vulnerable areas;<br>- prepare emergency relief funds (for crop failures);<br>- support research/development into aquaculture;<br>- link with Food Security Policy, PASAP projects;<br>NB. projects in Chuuk State including managing artificial taro patches | OEEM; Dep of Agriculture NB. DoA is considering aquaculture trials (eg. Yap); DH&SA; "Go Local" EPA/ Chuuk Women Council food program; NGO's | As above, including NGO's budgets |

| | | | |
|---|---|---|---|
| Zoonotic infections [eg. leptospirosis, avian influenza] | - Survey of domesticated animals (eg. pigs);<br>- strengthen laws/policies regarding hog-raising (ie. consider regulations/standards)<br>- health promotion campaign (hygiene & sanitation, safe swimming, personal protective equipment) (NB. previous community awareness campaign performed – could use same/updated materials);<br>- training of health professionals on accurate and timely diagnosis (?improve case definition, laboratory diagnostic capacity);<br>- consider value of mass vaccination of animals<br>NB. EPA/Environmental Health initiative (2007) in Chuuk clearing trees around houses (to reduce rats), testing water and moving pigs away from household water sources in an effort to reduce water contamination, diarrhoeal illness and leptospirosis;<br>- need to enforce legislation/regulations regarding domestic animals (eg. preventing pigs from contaminating water supplies)<br>- support EPA plans to test waste disposal systems for pigpens | DH&SA, EPA/KIRMA, R&D | As above |
| Food-borne disease | - Setting official standards for food safety/handling (commercial, household);<br>- consider cultural practices/traditional food preparation techniques, feasting etc (eg. *kamadipw*) – need for community education campaign (possibly targeting community leaders) about safe practice (NB. Pohnpei cholera outbreak in 2000 linked to kamadipw);<br>- consider training in food handling, prevention guidelines etc;<br>- improve diagnostic capacity to differentiate pathogens;<br>- improve public health capacity regarding epidemic surveillance and response | EPA (has food safety regulations, particularly for businesses), KIRMA; DH&SA | As above |
| Obesity, circulatory disease, diabetes and related NCD's | - Link with current and future NCD programs;<br>- increase awareness of the link between climate change and NCD's | DH&SA | As above |
| Mental health | - Offer training in crisis counselling (use existing networks eg. churches);<br>- prioritise recruitment and training of new counsellors and mental health professionals<br>- improve telephone/online support (eg. Hotline ?link with Quitline, women's crisis hotline) – *discuss with Mental Health office and link with current/future programs eg. Mental Health Catastrophe Plan?*;<br>- possibly online diagnostic psychiatric support (eg. GPPsychSupport in Australia) | DH&SA | As above |
| Respiratory diseases (including asthma, influenza, TB) | - Strengthening existing syndromic surveillance system;<br>- training of health professionals in sample collection;<br>- liaise with TB program – have they considered impacts of CC *(overcrowding etc)*? *Mass Drug Administration/DOTS program;*<br>- re-emphasise public education/health promotion (hygiene, reducing transmission);<br>- ensure appropriate immunisation coverage (eg. influenza) | DH&SA | As above (NB. link with WHO for syndromic surveillance program) |
| Skin disease (bacterial & fungal infections, infestations eg. scabies); skin cancer; ?psoriasis | - Education of public and health professionals;<br>- health promotion (eg. differentiation between benign and serious skin conditions such as Hansen's disease);<br>- UV protection | DH&SA, Dep Education, EPA/OEEM/KIRMA | As above |
| Poverty, socio-economic disadvantage | - Research exploring the relationship between poverty, disadvantaged populations and climate-sensitive health risks (eg. survey of young women in Chuuk State)<br>- support existing and future poverty-reduction strategies | | |

| | | | |
|---|---|---|---|
| Traumatic injuries and deaths | - Establish effective extreme weather early warning systems;<br>- community emergency preparedness training;<br>- link/strategise with Public Health and Hospital Emergency Preparedness Program activities, National Disaster Coordination Office, FEMA, USAID;<br>- review and strengthen response/relief capabilities;<br>- review reports from previous severe events to identify key gaps/weaknesses in preparedness, planning and response | OEEM, Weather Service Office, DH&SA | As above |
| Typhoid | See above for water-borne disease – community education, safe drinking water use, *sakau* practice | DH&SA | As above |
| Ciguatera (fish poisoning, harmful algal blooms); ?turtle poisoning; ?scombroid | - Community education<br>- research into specific fish carriers in FSM and appropriate treatment strategies; (eg. ?possible antidote on Yap – consider potential intellectual property rights involved in this research, ?role of mannitol in severe cases) *(NB. extensive study done in Fiji ?discuss with OEEM re: same species)* and environmental conditions which induce HAB's;<br>- research and record traditional knowledge re: safe seafood eating practices; | DH&SA | As above |
| Eye disease (eg. conjunctivitis) | Educate community re: transmission; ensure secure medication supply; UV protection | | |
| Malaria | Link in with mosquito population survey mentioned above (see Dengue) – ensure adequate surveillance for Anopheles | DH&SA, EPA/KIRMA | As above |
| Filariasis | Aim to eliminate from FSM (?as per National plan/ PacELF program); strengthen diagnostic capacity | DH&SA, Dep of Education | As above (NB. links with WHO) |

# APPENDIX 6

## Methods used in the Greenhouse Gas Inventory

*(Source: Furow and Konno-Anisin, 2010)*

The 1996 IPCC guidelines list six sectors as the primary basis for which all data are drawn to compile a country's National inventories. These six sectors comprise the following:

- Energy
- Industrial Processes
- Solvent and Other Product Use
- Agriculture
- Land-Use change and Forestry, and
- Waste

Solvent and other product use, however, are exempted from the National inventories since its calculation method for estimating greenhouse gas emissions has not been formulated by the IPCC. The rest of the sectors, depending on the availability and quality of data, are included in this study and are prioritized in terms of their contribution to the overall greenhouse gas emissions in the FSM.

### *Energy Sector*

With the exception of liquid propane gas (LPG), Mobil Oil of Micronesia imports all liquid fossil fuels into the FSM. This company has branches in all four States and is the primary source of all fossil fuel data used in this study. Data on these fuels are quite reliable as the information was compiled from company records at Mobile Oil's main office in Guam.

LPG is distributed by various companies in each State, for local consumption. The nature of these operations made it necessary to estimate the amount of LPG used in FSM. The amount may be very small because most households use electricity or traditional methods.

Biomass data are derived through estimation of local household usage. It excludes power generation since in FSM it is not used in producing electricity. Biomass data are compiled from estimates based on the 1994 FSM Population Census and an estimated average per capita annual consumption of relevant biomass fuels such as coconut husks, coconut shells, and wood.

The reference approach formula for calculating National fuel consumption is expressed by the following relationship:

*National Fuel Consumption (Mt) = Production + Imports-Export-International Bunkers-Stock Change*

Where:

Production = fuel produced in-country. Except for biomass fuel, this factor will not be covered as here is no fossil fuel production in FSM.
Import = fuel brought in the country from the outside. Import is the greatest source of fuel into the country and will be the primary factor considered for calculation.
International Bunkers = fuels used in international marine and aviation transportation.

Only international aviation bunkering will be covered here and is based on a premise that 95% of kerosene imported into the country is used for this purpose. International marine bunkering will not be covered in this study. A fishing company (Ting Hong) used bunkering fuel extensively but operated mainly within FSM waters. Other categories of ocean-going vessels such as commercial, cargo, and yachts may also be negligible because these rarely buy their fuel in the FSM. The larger ships use cheaper crude grade oil, not available locally

Stocking change is the net increase or decrease in fuel stocks. There is no available data on stock change in the FSM in 1994. For the purpose of this study, stock change will be assumed insignificant.

Once the National fuel consumption in metric tons are calculated for each gas, a secondary formula is applied to obtain the actual CO2 emission in gigagrams. This secondary formula is outlined by the following expression.

Actual CO2 Emission (Gg)=National Fuel Consumption (Mt) x Net Calorific Value (Tj/103)x Carbon Emission Factor (t C/103Tj) – Stored Carbon (Gg C) x fraction of Carbon oxidized x 44/12.

Where:

National Fuel Consumption = the total amount (Mt) of each fuel consumption in-country and is derived from the first equation.

Net Calorific Value = measurement for a particular fuel value for heating purposes. Default values for each fuel type were used.

Carbon Emission Factor = ……

Stored Carbon = carbon retained for long periods of time within non-fuel products manufactured from fuels. Stored carbon is calculated separately for fuels used in non-energy purposes. For the purpose of this study, only lubricant and other insignificant fuel product will be covered. LPG, gasoline, and diesel oil, which can also be used for non-energy purposes, are assumed here to be used mainly for energy, thus, having no carbons stored.

Fraction of Carbon Oxidized = fraction of carbon burnt up when a certain fuel type is combusted. In most cases, this value is in the 98-99 percentile range. (Note: Default values for each fuel type are used in this study.)

44/12 = molecular weight ration of CO2 to C. this ratio is used for converting elemental carbon to the carbon dioxide compound.

In this study, a separate set of calculations was performed to derive an estimate of the amount of biomass consumed. This initial set of calculations, although optional for countries with relevant data, relies on the 1994 FSM Census to determine FSM's population and the households engaged in using open fires as their main cooking facilities. In addition, the average household consumption for each specific type of fuel wood was estimated on a daily basis to correspond to the following:

- Fuelwood consumption = 4.5 kg/house/day
- Coconut husk = 1.35 kg/house/day
- Coconut shell = .90 kg/house/ day

This information provided the basis for calculating the National total of biomass consumed. Based on the amount of biomass consumed, non-CO2 emissions were calculated using the formulas outlined above.

### ***Land Use Changes and Forestry***

The IPCC guideline outlines the following formulas for calculating both CO2 and non-CO2 greenhouse gases as applied to the activities outlined earlier in this section:

## CO2 Emission/Removal from Changes in Forest and Other Woody Biomass Stocks

Step 1) Estimating total carbon content in annual growth of logged and plated forest

*Total Carbon Content = Area Of Forest/Biomass Stocks (Kha) x Annual Growth Rate (t dm/ha) x Carbon Fraction of Dry Matter.*

Step 2) Estimating the amount of biomass harvested

*Total biomass Consumption from stocks = [Commercial Harvest (if applicable) x Biomass Conversion/Expansion Ration (if applicable) + Total traditional Fuelwood Consumed + Total Other Wood Use] – Wood Removed From Forest Clearing*

Step 3) Converting wood harvested to carbon removed

*Annual Carbon Released = Total Biomass Consumption from Stocks x Carbon Fraction*

Step 4) Estimating net annual carbon dioxide uptake or release

*CO2 Annual Emission/Release = Total Carbon Content – Annual Carbon Release x (44/12)*

## CO2 Emissions from Forest and Grassland Conversions

Step 1) Estimating biomass cleared

*Annual loss of biomass (Kt dm) = [Biomass Before Conversion (t dm/ha) – Biomass After Conversion (t dm/ha) x Area Converted Annually (Kha)*

Step 2) Estimating Carbon Released by Burning Aboveground Biomass On-Site

*Qty. of Carbon Released from Biomass Burned Off-Site (Kt C) = Annual Loss of Biomass (Kt dm) x Fraction of Biomass Burned on site x Fraction of Biomass oxidized on Site x Carbon Fraction of Above-ground Biomass*

Step 3) Estimating Carbon Released by Burning Aboveground Biomass off-site

*Qty. of Carbon Released from Biomass Burned Off-Site (Kt C) = Annual Loss of Biomass (Kt dm) x Fraction of Biomass Burned off-site x Fraction of Biomass oxidized off-Site x Carbon Fraction of Above-ground Biomass*

Step 4) Estimating Total Carbon Released by Burning Aboveground Biomass on-and Off-site

*Total Immediate Carbon Released (Kt C) = Qty. of Carbon Released from Biomass Burned On Site (Kt C) + Qty. of Carbon released from Biomass Burned Off-Site (Kt C)*

Step 5) Estimating CO2 Released by Decay of Aboveground Biomass.

*Carbon Released from Decay of Aboveground Biomass ( Kt C) = Biomass Before Conversion (t dm/ha) – Biomass Before Conversion (t dm/ha) x Average Area Converted (Over a 10 year period) x Fraction left to \Decay of Aboveground Biomass*

Step 6) Estimating Total CO2 Emissions from Forest and Grassland Conversions

*Total Annual CO2 Released (Gg CO2) = Total Immediate Carbon Released (Kt C) + Carbon Released from Decay of Aboveground Biomass (Kt C) x (44/12)*

## On-Site Burning of Forests: Emissions of Non-CO2 Trace Gases

Step 1) Estimating Nitrogen Released

**Total Nitrogen (N) released (Kt N) = Qty. of Carbon Released from Biomass Burned On Site (Kt C) x Nitrogen-Carbon ratio**

Step 2) Estimating CH4 Emissions

*Total CH4 Emission from On-Site Burning = Qty. of Carbon Released from Biomass Burned On Site (Kt C) x CH4 Emissions ration x (16/12)*

Step 3) Estimating CO Emissions

*Total CO Emissions from On-Site Burning = Qty. of Carbon Released from Biomass Burned On Site (Kt C) x CO Emissions ratio x (28/12)*

Step 4) Estimating N2O Emissions

*Total N2O Emissions from On-Site Burning = Total Nitrogen (N) Released (Kt N) x N20 Emission Ratio x (44/14)*

Step 5) Estimating NOx Emissions

*Total NOx Emissions from On-Site Burning = Total Nitrogen (N) Released (Kt N) x N0x Emission Ratio x (46/14)*

## Net CO2 Removal from Abandonment of managed Lands

Step 1) Calculating Annual Carbon Uptake in Aboveground Biomass (Land Abandoned in the last 20 years)

*Annual Carbon Uptake from Lands Abandoned in the Last 20 yrs (Kt C) = Total Area Abandoned and Re-Growing (Last 20 yrs) x Annual rate of Aboveground Biomass Growth (t dm/ha) x Carbon Fraction of Aboveground Biomass*

Step 2) Calculate Annual Carbon Uptake in Aboveground Biomass (Land Abandoned>20 yrs)

*Annual Carbon Uptake from Lands Abandoned in the Last 20 yrs (Kt C) = Total Area Abandoned and Re-Growing (>20 yrs) x Annual rate of Aboveground Biomass Growth (t dm/ha) x Carbon Fraction of Aboveground Biomass*

Step 3) Calculate Total CO2 Uptake from Abandoned Lands

*Total CO2 Uptake from Abandoned lands (Gg CO2) = Annual Carbon Uptake from Lands Abandoned in the Last 20 Yrs (Kt C) + Annual Carbon Uptake from Lands Abandoned for more than 20 Yrs (Kt C) x 44/12*

## CO2 Emissions or Uptake by soil from Land-Use Change and Management

Step 1) Calculating Net Annual Emissions from Mineral Soil

*Total Net Changes in Soil in Mineral Soils (Tg) = Soil Carbon for Current Inventory year (Mg C/ha) x (Land Area of current Inventory year (Mha)- (Soil Carbon for 20 years prior to the Current Inventory Year Mg/C/ha) x (Land Area of current Inventory year (Mha))*

Step 2) Calculating net Annual from Organic Soil

*Net Carbon Loss from Organic Soil (Mg/yr) = Land Area of Organic Soil (ha) x Annual Loss Rate (Mg C/ha/yr)*

This step will be omitted from the FSM calculation as organic soils are not used intensively for crop production or plantation forestry.

Step 3) Calculating Annual Emissions from Liming of Agricultural Soils

*Carbon Emissions from Liming (Mg C) = Total Annual of Lime (Mg) x Carbon Conversion Factor*

This step will be omitted from the FSM calculation as organic soils are not used intensively for crop production or plantation forestry.

Step 4) Estimating Total Net Emissions form Soil

*Total Annual CO2 Emission (Gg/yr) = (Total net Changes in Soil Carbon in Mineral Soils (Tg) x (Conversion Factor x 44/12) + (Net Carbon Loss from Organic Soil (mg/yr x Conversion Factor x 44/12) + (Carbon Emission from Liming (Mg C) x Conversion Factor x 44/12)*

The methodology proposed by the IPCC for land-use change and forestry is based on two prmises:1) the flux of carbon dioxide to or from the atmosphere is assumed to be equal to changes in carbon stocks in existing biomass and soils, and 2)the rates of changes in land-use and the practices used to bring about the change (e.g., burning, and clear-cutting) are used to come up with assumptions that determined their impacts on carbon stocks and the biological responses to a given land-use. Given this assumptions, there are large uncertainties associated with the IPCC methods for estimating fluxes of CO2 from land-use change and forestry. The IPCC, therefore, recommended and encourage countries doing the inventory to make simple assumptions about the effects of land-use change on carbon stocks and the subsequent biological response to the land-us change.

The IPCC guideline outlines the following formulas for calculating both CO2 and non-CO2 greenhouse gases as applied to the activities outlined earlier in this section:

## ***CO2 Emission/Removal from Changes in Forest and Other Woody Biomass Stocks***

Step 1) Estimating total carbon content in annual growth of logged and plated forest

*Total Carbon Content = Area Of Forest/Biomass Stocks (Kha) x Annual Growth Rate (t dm/ha) x Carbon Fraction of Dry Matter.*

Step 2) Estimating the amount of biomass harvested

*Total biomass Consumption from stocks = [Commercial Harvest (if applicable) x Biomass Conversion/Expansion Ration (if applicable) + Total traditional Fuelwood Consumed + Total Other Wood Use] – Wood Removed From Forest Clearing*

Step 3) Converting wood harvested to carbon removed

*Annual Carbon Released = Total Biomass Consumption from Stocks x Carbon Fraction*

Step 4) Estimating net annual carbon dioxide uptake or release

*CO2 Annual Emission/Release = Total Carbon Content – Annual Carbon Release x (44/12)*

## ***Emissions from Forest and Grassland Conversions***

Step 1) Estimating biomass cleared

*Annual loss of biomass (Kt dm) = [Biomass Before Conversion (t dm/ha) – Biomass After Conversion (t dm/ha) x Area Converted Annually (Kha)*

Step 2) Estimating Carbon Released by Burning Aboveground Biomass On-Site

*Qty. of Carbon Released from Biomass Burned Off-Site (Kt C) = Annual Loss of Biomass (Kt dm) x Fraction of Biomass Burned on site x Fraction of Biomass oxidized on Site x Carbon Fraction of Above-ground Biomass*

Step 3) Estimating Carbon Released by Burning Aboveground Biomass off-site

*Qty. of Carbon Released from Biomass Burned Off-Site (Kt C) = Annual Loss of Biomass (Kt dm) x Fraction of Biomass Burned off-site x Fraction of Biomass oxidized off-Site x Carbon Fraction of Above-ground Biomass*

Step 4) Estimating Total Carbon Released by Burning Aboveground Biomass on-and Off-site

*Total Immediate Carbon Released (Kt C) = Qty. of Carbon Released from Biomass Burned On Site (Kt C) + Qty. of Carbon released from Biomass Burned Off-Site (Kt C)*

Step 5) Estimating CO2 Released by Decay of Aboveground Biomass.

*Carbon Released from Decay of Aboveground Biomass ( Kt C) = Biomass Before Conversion (t dm/ha) – Biomass Before Conversion (t dm/ha) x Average Area Converted (Over a 10 year period) x Fraction left to \Decay of Aboveground Biomass*

Step 6) Estimating Total CO2 Emissions from Forest and Grassland Conversions

*Total Annual CO2 Released (Gg CO2) = Total Immediate Carbon Released (Kt C) + Carbon Released from Decay of Aboveground Biomass (Kt C) x (44/12)*

## On-Site Burning of Forests: Emissions of Non-CO2 Trace Gases

Step 1) Estimating Nitrogen Released

*Total Nitrogen (N) released (Kt N) = Qty. of Carbon Released from Biomass Burned On Site (Kt C) x Nitrogen-Carbon ratio*

Step 2) Estimating CH4 Emissions

**Total CH4 Emission from On-Site Burning = Qty. of Carbon Released from Biomass Burned On Site (Kt C) x CH4 Emissions ration x (16/12)**

Step 3) Estimating CO Emissions

*Total CO Emissions from On-Site Burning = Qty. of Carbon Released from Biomass Burned On Site (Kt C) x CO Emissions ratio x (28/12)*

Step 4) Estimating N2O Emissions

*Total N2O Emissions from On-Site Burning = Total Nitrogen (N) Released (Kt N) x N20 Emission Ratio x (44/14)*

Step 5) Estimating NOx Emissions

*Total NOx Emissions from On-Site Burning = Total Nitrogen (N) Released (Kt N) x N0x Emission Ratio x (46/14)*

## Net CO2 Removal from Abandonment of Managed Lands

Step 1) Calculating Annual Carbon Uptake in Aboveground Biomass (Land Abandoned in the last 20 years)

*Annual Carbon Uptake from Lands Abandoned in the Last 20 yrs (Kt C) = Total Area Abandoned and Re-Growing (Last 20 yrs) x Annual rate of Aboveground Biomass Growth (t dm/ha) x Carbon Fraction of Aboveground Biomass*

Step 2) Calculate Annual Carbon Uptake in Aboveground Biomass (Land Abandoned>20 yrs)

*Annual Carbon Uptake from Lands Abandoned in the Last 20 yrs (Kt C) = Total Area Abandoned and Re-Growing (>20 yrs) x Annual rate of Aboveground Biomass Growth (t dm/ha) x Carbon Fraction of Aboveground Biomass*

Step 3) Calculate Total $CO_2$ Uptake from Abandoned Lands

*Total $CO_2$ Uptake from Abandoned lands (Gg $CO_2$) = Annual Carbon Uptake from Lands Abandoned in the Last 20 Yrs (Kt C) + Annual Carbon Uptake from Lands Abandoned for more than 20 Yrs (Kt C) x 44/12*

## ***$CO_2$ Emissions or Uptake by soil from Land-Use Change and Management***

Step 1) Calculating Net Annual Emissions from Mineral Soil

*Total Net Changes in Soil in Mineral Soils (Tg) = Soil Carbon for Current Inventory year (Mg C/ha) x (Land Area of current Inventory year (Mha)- (Soil Carbon for 20 years prior to the Current Inventory Year Mg/C/ha) x (Land Area of current Inventory year (Mha))*

Step 2) Calculating net Annual from Organic Soil

*Net Carbon Loss from Organic Soil (Mg/yr) = Land Area of Organic Soil (ha) x Annual Loss Rate (Mg C/ha/yr)*

This step will be omitted from the FSM calculation as organic soils are not used intensively for crop production or plantation forestry.

Step 3) Calculating Annual Emissions from Liming of Agricultural Soils

*Carbon Emissions from Liming (Mg C) = Total Annual of Lime (Mg) x Carbon Conversion Factor*

This step will be omitted from the FSM calculation as organic soils are not used intensively for crop production or plantation forestry.

Step 4) Estimating Total Net Emissions form Soil

*Total Annual $CO_2$ Emission (Gg/yr) = (Total net Changes in Soil Carbon in Mineral Soils (Tg) x (Conversion Factor x 44/12) + (Net Carbon Loss from Organic Soil (mg/yr x Conversion Factor x 44/12) + (Carbon Emission from Liming (Mg C) x Conversion Factor x 44/12)*

## ***Agriculture***

The formulas outlined below are specified in the IPCC guideline and are used in calculating methane and nitrous oxide emissions from domestic livestock and savanna burning.

$CH_4$ Emission form Domestic Livestock Enteric Fermentation and Manure Management.

Step 1) Estimating Methane Emission from Enteric Fermentation

*Emission from Enteric Fermentation (t/yr) = number of Animals x Emission Factor for Manure Management (kg/head/year)*

Step 3) Estimating Total methane Emission from Enteric Fermentation and Manure Management.

*Total Annual Emission from Domestic Livestock = (Emission from Enteric Fermentation + Emission from Manure Management) 1000*

To perform the calculations outlined above, data on the number of livestock in the country needs to be determined. Unfortunately, the country does not have any current method of agricultural survey, which is conducted on a regular basis. This study, therefore, relies on estimates to come up with the required data on the number of livestock in the country. For instance, each State based on experience is assumed to have between 1 and 3 commercial pig operations with each site averaging between 20 and 100 pigs. In addition, each household in the country is also assumed to have an average of 1 to 3 pigs. The same problem with lack of data is also seen from commercial chicken operations, which were also in operation in 1994.

This study, therefore, assumes that each State at the time had between 1 and 10 commercial operations; each having 100 to 400 chickens. Family-raised chickens are assumed to range between 10 to 30 individuals. Given these simple assumptions, the number of pigs and chicken in commercial operation can calculate. The estimated numbers of family-raised pigs and chickens can be extrapolated from the number of households, which is currently available from the 1994 FSM Census of Population & Housing. As for the goat population, it is projected based on the 1990 figures so that in 1994, Pohnpei had 2,331 heads; Chuuk had 280 heads; Kosrae had 91 heads. Yap still had no goat population in 1994.

The projection method used her assumes that the annual growth rate of goat population on Pohnpei, Chuuk, and Kosrae is as follows:

- 333 goats/year in Pohnpei
- 40 goats/year in Chuuk
- 13 goats/ear in Kosrae

The total goat population in the FSM based on this projection is 2,702. Still, it is important to note the goat population figures may be quite different from the actual numbers. Nevertheless, because of the lack of data, this study will use these figures to estimate greenhouse gas emissions for the goat population. Greenhouse gas emissions from cattle and water buffalo, because their numbers were extremely low during the previous inventory, are covered in this inventory. Methane produced from enteric fermentation among these animals is therefore assumed to be insignificant. Furthermore, manure management system is apparently not utilized with regard to these two types of animals. Manure from these two types of animals is usually left in the open and does not decomposed anaerobically. This translates into minimal methane and nitrous oxide emissions from this particular source.

### Non-CO2 Emission from Savanna Burning

Step 1) Estimating Total Biomass that Actually Burns

*Quantity of Biomass Actually Burned (Gg dm) = Area Burned by Category (k ha) x Biomass Density of Savanna (t dm/ha) x Fraction of Actually Burned*

Step 2) Estimating the Proportion of Living Biomass Burned

*Quantity of Biomass Actually Burned (Gg dm) = Quantity of Biomass Actually Burned (Gg dm) x Fraction of Living Biomass Burned*

Step 3) Estimating the proportions of Dead Biomass Burned

*Quantity of Dead Biomass Burned (Gg dm) = Quantity of Biomass Actually Burned (Gg dm) - quantity of Living Biomass Burned (Gg dm)*

Step 4) Estimating the Total Carbon released from Living Biomass

*Total Carbon released (Gg C) = Quantity of Living Biomass Burned (Gg dm) x Carbon Fraction of Living Biomass*

Step 4) Estimating the Total Carbon released from Dead Biomass

*Total Carbon released (Gg C) = Quantity of Dead Biomass Burned (Gg dm) x Carbon Fraction of Dead Biomass*

Step 5) Estimating Non-CO2 Trace Gas Emissions from Savanna Burning

*Total methane (CH4) Emission (Gg) = Total Carbon Released (Gg C) x Emission Ratio x 28/12*

*Total Carbon Monoxide (CO) Emission (Gg) = Total Carbon Released (Gg C) x Emission Ratio x 16/12*

*Total Nitrous oxide (N2O) Emission = Total Carbon Released (Gg C) x Nitrogen-Carbon Ratio x 44/28*

*Total oxide of Nitrogen (NOx) Emission = Total Carbon Released (Gg C) x Nitrogen-Carbon Ratio x Emission Ratio x 46/14*

### *Waste*

A default value of 0.4 for the methane correction factor was used in the calculation of methane emissions from solid waste disposal sites since it was assumed that all municipal solid waste (MSW) go to unmanaged SWDS which are shallow with a possible depth or 5 meters or less. This type of waste disposal practice tends to enhance aerobic decomposition, generating extremely low methane emissions.

Methane emissions from wastewater handling was estimated for only domestic or municipal wastewater handling operations. Nitrous oxide emissions from human sewage was calculated using India's per capita protein consumption of 55 grams of protein/person/day or 20.75 kilograms protein/person/yr.

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