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Analysis of Integrating Disaster Risk Reduction and Climate Change Adaptation in the US Pacific Islands and Freely Associated States

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Summary of Findings

The project to support the Climate Adaptation Partnership in the Pacific: Pacific RISA Phase 2 in the US Pacific Islands and Freely Associated States (US-FAS) proposed to use the hazard mitigation planning processes and disaster risk reduction planning efforts to ensure that essential information on climate-related hazard risks were being integrated into the risk and vulnerability assessments in ways that would ultimately support climate adaptation planning. The US Pacific Islands are already engaging in disaster risk reduction and climate adaptation strategies that provide unique learning opportunities.

In the context of examining climate-related hazard risks and risk reduction efforts in the US Pacific Islands, it became clear that the opportunities and capacities to engage in risk reduction vary greatly among the island jurisdictions. Resources available for the project in this initial phase included document review, electronic surveys and phone interviews, and informal discussions and occasional meetings with disaster managers in the region that provided opportunities to discuss the ability to integrate climate risk information into disaster risk reduction and climate change adaptation efforts.

The framework for looking at the plans and programs was to use the disaster risk reduction lens, implemented through hazard risk and vulnerability assessment, which mimics the process for climate adaptation planning. The summary of recommendations identified from looking at the integration of disaster risk reduction and climate adaptation planning inclues:

1) Learn from the historical evolution of disaster risk reduction and climate change adaptation frameworks, which provide lessons for developing synergistic activities and for implementing considerations that minimize poor outcomes and mal-adaptation in addressing risk.

2) Develop plans that will be participatory and consultative, and plan to maintain engagement with stakeholders for the long-term.

3) Engage in integrated socioeconomic assessments to understand systemic effects of risk reduction actions and evaluate the potential consequences of risk reduction actions before implementation.

4) Engage in joint risk reduction efforts to leverage scarce resources since many of the proposed adaptation actions are similar to hazard mitigation and disaster risk reduction actions.

5) Develop and maintain better historical records to improve models and scenarios used in planning.

6) Use economic valuation methods and socioeconomic assessments to develop loss estimates for important assets that do not have a clear economic value, such as water resources, cultural resources, and ecosystem services. This will also benefit arguments for funding and aid in the prioritization risk reduction actions.

7) Develop and implement integrated climate and disaster risk assessments that take into account social, cultural, biological, physical, economic, governance, and other approaches.

8) Focus on developing ethnographic studies and gender analyses to aid in understanding deeper implication for loss of resources and implications of management actions, specifically targeting sectors where certain populations may be at heightened risk from the impacts of disasters and climate change.

9) Target the implementation of formal and information education and awareness building to build sustainability, intergenerational knowledge transfer, and resilient communities and people.

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1.0 Introduction

The Pacific Islands are among the places worldwide currently experiencing the first impacts of climate change. These impacts have visibly appeared through extreme climate events and localized disasters. Although the islands have experience adapting to long-term changes and their socioeconomic systems have enabled survival in remote locations for centuries, rapid change challenges these systems to adapt and to cope with increased risks. Given that island ecosystems and communities are on the "climate frontlines," the Pacific Islands are serving as a "climate testbed" to provide critical, global lessons for adaptation. The United States has the unique opportunity to learn from island systems politically associated with the US, including the State of Hawaii, the Territories of Guam and American Samoa, the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia, the Republic of the Marshall Islands, and the Republic of Palau.

Recent climate-related disasters, such as coastal inundation, drought, floods, wildfires, and tropical cyclones, have underscored the precarious relationships of people and their island environments. There are limited resources to address risks in multiple sectors and environments, and the available resources should be maximized to enable adaptation. The shared political histories and institutional development since World War II provide impetus for developing synergies in risk reduction programs. Although the past development of disaster management regimes in the region evolved separately from the climate change community globally, the realization that climate-related extremes are among the most costly for the Pacific Islands has moved these communities closer together, and there are increasing collaborations in dealing with climate change issues through disaster risk reduction methods, especially in the Pacific.

The frameworks that have evolved in climate and disaster risk reduction communities focus efforts on identifying and reducing vulnerability and on building resilience.[1] Key elements in these approaches emphasize understanding concepts of exposure to risk, sensitivity to risk, and capacity to address risk.[2] Even with fewer fiscal resources to address expected changes in

[1] 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* (Baede 2007). Resilience is 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 (Baede 2007). Disaster Risk Reduction (DRR) is a systematic approach to identifying, assessing and reducing the risks of disaster. It aims to reduce socio-economic vulnerabilities to disaster as well as dealing with the environmental and other hazards that trigger them: here it has been strongly influenced by the mass of research on vulnerability that has appeared in print since the mid-1970s (Wisner et al. 2004).

[2] Exposure refers to People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses(UNISDR 2009, 15). Sensitivity is the degree to which a system is affected, either adversely or beneficially, by *climate variability* or *climate change*. The effect may be *direct* (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or *indirect* (e.g., damages caused by an increase in the frequency of coastal flooding due to *sea level rise*) (Baede 2007). Capacity building is a conceptual approach to development that focuses on understanding the obstacles that inhibit people,

climate, island governments and non-governmental organizations have begun to work on ecosystem-based adaptation and actions that can be undertaken with existing resources, including local, indigenous, and gendered knowledge. These knowledge systems are foundational for determining social, political, and cultural processes for decision-making that guide risk reduction and adaptation efforts.

The intent of this paper is to explore synergies in integrating disaster risk reduction and climate change adaptation in the US Pacific Islands (states, territories, and freely associated states). The risk reduction and adaptation lessons learned in communities in Micronesia, Hawaiʻi, and other Pacific Islands demonstrate the importance of localized efforts in implementing actions to reduce risk. It highlights best practices from the integration of climate risk reduction and adaptation projects in the Pacific Islands. The Pacific Island experiences provide lessons to the global community about integrating socio-cultural assessment and integrated management in climate adaptation policies and programs.

2.0 Background of US Pacific Islands in Disaster Risk Reduction

The islands have a long history of dealing with climate-related disaster threats that relied on use of traditional knowledge and skills. The evolution of the current disaster management system and approaches reveals the history of colonization and neglect of traditional knowledge as the political, economic, and social systems adapted western management practices. Based on local geographies and cultures, islanders developed unique and diverse practices to deal with localized risks and impacts. Although the US Pacific Islands deal with many similar disaster threats, such as tropical cyclones, drought, and flooding, the magnitude and intensity of these threats has resulted in different localized experiences with disaster. (See Appendix A for an overview of climatology in each jurisdiction to understand the variation in the region.)

Although recent risk reduction efforts call for integration of indigenous knowledge for disaster risk reduction and climate adaptation, many of the practices were subverted during the establishment of the US Pacific Island government and management systems. Understanding this history of social, cultural, political, and economic change and how these evolved the current disaster management system in the US Pacific Islands is important in considering the ways to reduce risks and adapt to climate change.

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governments, international organizations and non-governmental organizations from realizing their developmental goals while enhancing the abilities that will allow them to achieve measurable and sustainable results. Adaptive capacity is the whole of capabilities, resources and institutions of a country or *region* to implement effective *adaptation* measures (Baede 2007). Resilience: “The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure This is determined by the degree to which the social system is capable of organising itself to increase this capacity for learning from past disasters for better future protection and to improve risk reduction measures” (UNISDR 2005, 4).

2.1 Traditional Ways to Manage Risks in Island Ecosystems

The diversity among the islands in the Pacific means that there are a variety of Pacific cultures and that traditional knowledge has evolved in different ways in different parts of the region. Of the US Pacific Islands, only American Samoa lies in the southern hemisphere but the longitudinal difference from Hawai'i is relatively small, resulting in an hour difference in time zones. Both Hawai'i and American Samoa are characterized as Polynesian, while the other US Pacific Islands are Micronesian cultures. The Micronesian Islands span thousands of miles just north of the equator, and result in four time zones across the International Date Line. The vast distances in the region and in the island cultures advanced separate and unique ways to deal with risks.

Across the Pacific the many traditional ways of understanding and interpreting local weather signs, based on women's and men's knowledge of their environment, have helped communities prepare for disasters. In many countries, for example, an unusually large and early harvest of mangoes at the beginning of a wet season is a sign of impending cyclone activity. Wasps building nests in low-lying positions is a sign of impending cyclone activity and, in some parts of the Northern Pacific, frigate birds flying low over the reef a sign of impending storm activity. Pacific Island communities have used traditional coping mechanisms for survival. Food preservation, rotation of planning sites, and crop diversity contributed to food security (Campbell 2006).

Traditional housing structures and building methods responded to weather elements, such as wind, salt spray, and inundation. Many communities on higher islands lived inland and at higher elevations away from the sea and potential impacts from coastal inundation. Men and women often had specific roles in these communities defined by their gender that influenced the knowledge they held (Anderson 2008). Men were often primary builders and women were often responsible for securing food and water for their communities. In recovery periods from disaster, many of the islanders would use their knowledge in traditional sailing to relocate to other islands until recovery occurred (Hezel 1975, 1983; Lessa 1968). Systems developed in Wa'ab (Yap) in the Federated States of Micronesia known as *sawei,* in which the atoll islanders provided special goods, hibiscus and banana fiber woven cloths, and other tributes to the municipality of Gagil, and in exchange received bamboo, goods, and protection from "magic" that caused great storms and destruction of the islands (Hezel 1975, 1983). As this system evolved, the atoll islands of Yap have been provided land on the high island to relocate communities dealing with disaster threats and impacts.

In the areas of disaster risk reduction, emphasis for survival, recovery, and preparedness focuses on food security, cooperation, housing and settlements, and environmental knowledge. For food security, several elements contribute to developing community resilience including: surplus production, agricultural diversity, planting resilient crops, food storage and preservation, "famine" foods as alternative sources, and land fragmentation that enables plant survival in some areas to prevent total crop losses (Campbell 2006; Falanruw 1990). Many of these long-used traditional techniques help strengthen communities and enable them to deal with changes.

As the settlements became more permanent and imported materials have been used in the development of urban areas, there has been loss in beneficial practices and knowledge systems that promote sustainable ecosystems. Since goods and materials are not locally available, the islands become increasingly reliant on donor nations for sustainability of the urbanized developments and infrastructure. The lifestyle changes inherent in the organization and participation in westernized governance further limits traditional knowledge of land management, agriculture, diet, and health, resulting in dependencies on external actors and finance systems.

2.2 FEMA in the US Pacific Islands

With the development of western governance in the Pacific Islands, disaster management became integrated in these institutions and systems. During the Trust Territory period for Micronesia following World War II, the naval administration helped to relocate people following a disaster. With heavy influence of the military in all of the US Pacific Islands, the disaster management practices developed in strong correlation with military practice, especially at the local levels whereby disaster management is coordinated by Civil Defense and national defense organizations in Hawaiʻi and Guam. In the United States, the national funding and resources for disaster management shifted in the late 1970s to the Federal Emergency Management Agency (FEMA), and this was extended to US affiliations and implemented through their local emergency management organizations.

FEMA provided several disaster relief programs beyond the feeding assistance to which the islanders had become accustomed. These additional programs included Individual Assistance, Public Assistance, Temporary Housing, the Individual and Family Grant Program, and later the Hazard Mitigation Grant Program. The US Flag Islands (Hawaiʻi, Guam, Mariana Islands, and American Samoa) were eligible for the Pre-Disaster Mitigation Grant Program after the first grant was issued in 2003. Hawaiʻi State became the only island to receive funding for the Project Impact programs that lasted from 1997-2001.

FEMA implemented several programs for emergency relief and recovery assistance, including Individual Assistance, Public Assistance, and emergency temporary shelter and feeding assistance programs surrounding a disaster.[3] These programs are developed and standardized at the federal level, and have been incorporated into law. The relief programs do not consider culture, context, geography, or place. These programs become implemented as a part of a disaster declaration in which the local government does not have the resources to recover and requests assistance. Even though these programs were standardized to promote fairness in implementation, the lack of consideration of special needs, populations, and contexts results in differentiated outcomes that do not realize the intent of the programs.

[3] Individual Assistance provides individuals affected by a disaster with "funds to facilitate recovery," which can be in the form of low interest loans, cash grants, housing assistance, etc. Public Assistance is provided to the governments for emergency measures and debris removal, as well as reconstruction of public facilities and infrastructure (See www.fema.gov).

The assistance programs encountered difficulties in implementation across the Pacific, with fewer problems in places like Hawaiʻi where development patterns had aligned more similarly with those in the contiguous US. After Typhoon Orchid in 1987, the Temporary Housing Program had implementation problems because the officials administering the program were unable to determine the number of facilities to rebuild because family living arrangements differed from single-family homes in the United States. The officials further encountered misinformation about resource availability, and thus designed the temporary houses similarly to army barracks using imported plywood with assistance from SEABEE team (Navy Civil Engineers) to construct these shelters. It took months to import the materials and construct shelters that were only supposed to be "temporary." In these islands that had until this point constructed local houses with coconut woven mats for walls, coral rock floors, and thatched roofing, these houses from outside were mistaken for permanent structures. Raised plywood floors rotted quickly and needed replacement within two years in these environments, but the materials to replace these houses were still unavailable in the islands. These types of misunderstandings have plagued implementation of relief programs, which do not quite "fit" the needs of the islands. Since local housing designs, even with modified improvements for wind-strength, could not be certified by US engineers, local structures became ineligible as replacement structures. The temporary housing programs literally changed the landscape of the islands, and it was easy to see which islands had been impacted by typhoons or hurricanes.

As the Compacts of Free Association were negotiated for Palau and renegotiated for the FSM and the Marshall Islands, FEMA requested that their requirements to assist in emergencies be removed from the agreement. FEMA's frustration in working with the islands was often matched by the irritation of the islanders because the cultural and traditional requests for assistance were misunderstood by FEMA. Chuuk officials expressed their aggravation with "the arrogant and authoritarian leadership of the few who were in supervisory positions of the FEMA team in the field" (Gouland 1991). Complaints were often voiced that FEMA sent people who did not have any experience with islands, even if they knew agriculture in the continental US, their knowledge of taro fields were limited. Alternatively, FEMA representatives complained of ill treatment over cultural misunderstandings and of poor accounting practices in all the islands.

Because of these variations in implementing relief assistance and mitigation plans, FEMA developed new programs and has separated eligibility for these programs in the US Pacific Islands. Currently, American Samoa, CNMI, Guam, and Hawaiʻi are required by the Stafford Act[4] to develop standard state hazard mitigation plans and update these plans every three years to maintain access to post-disaster recovery and hazard mitigation funding programs.

[4] The federal laws governing mitigation planning include the *Robert T. Stafford Disaster Relief and Emergency Assistance Act* (Stafford Act), as amended by Section 322 of the *Disaster Mitigation Act of 2000* (P.L. 106-390), which details the requirement for hazard mitigation planning, the *National Flood Insurance Act of 1968,* as amended by the *National Flood Insurance Reform Act of 2004* (P.L. 108-264) and *44 Code of Federal Regulations (CFR) Part 201 – Mitigation Planning.* The Stafford Act details the requirement for hazard mitigation planning. Code of Federal Regulation, Title 44: Emergency Management and Assistance, Part 201 - Mitigation Planning, http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;rgn=div5;view=text;node=44%3A1.0.1.4.53;idno=44;sid=19795d6f3faca1242474afea5c680d9c;cc=ecfr.

The Republic of Palau, the Federated States of Micronesia (FSM) and the Republic of the Marshall Islands (RMI) now fall under relief programs administered by the US Agency for International Development (USAID) Office of Foreign Disaster Assistance (OFDA). For relief assistance in the FSM and RMI, FEMA has entered into memorandums of agreement with USAID to aid in logistical coordination of response and relief programs. The primary resources for reducing risk through implementation of hazard mitigation actions, therefore, are only available to American Samoa, CNMI, Guam, and Hawaiʻi.

2.3 International Disaster Risk Reduction Programs in the US Pacific Islands

Disaster risk reduction efforts are guided by the Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters, to which the world's Governments agreed in Hyogo, Kobe, Japan, in 2005. The Hyogo Framework for Action (HFA) aims for "the substantial reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and countries." The HFA lays out a detailed set of priorities to achieve by 2015.

An important feature of the HFA is its legally non-binding character, which allows it to set out a well-grounded set of technical and organizational requirements for reducing disaster risks, while leaving the details of its implementation to the decision of governments and relevant organizations, according to their needs and capacities. The HFA emphasizes that disaster risk reduction is a central issue for development policies, in addition to being of interest in various scientific, humanitarian, and environmental fields.

The document "Words Into Action" (2007) serves as a guide for implementing the HFA. The United Nations International Strategy for Disaster Reduction (UNISDR) secretariat provides technical assistance and coordinates the implementation of the HFA. UNISDR specifically works with countries to aid in the integration and mainstreaming of disaster risk reduction in national policies. Since the HFA development in 2005, the UNISDR has coordinated the Global Platforms on Disaster Risk Reduction in 2007 and 2009 to ensure that countries move forward in risk reduction with exposure to new and emerging issues, such as specific impacts from climate change.

The Republic of Palau, the Federated States of Micronesia, and the Republic of the Marshall Islands participate in the international meetings directly and with additional representation from regional organizations that aid governments in developing disaster risk reduction programs and policies. The UNISDR works with national governments and regional organizations to provide technical assistance and funding for program implementation. In addition, international donors can fund projects directly in the RMI, FSM, and Palau. They can also fund projects through regional organizations, such as the Asian Development Bank, the Secretariat of the Pacific Community Pacific Islands Applied Geoscience Commission (SPC/SOPAC) and the Secretariat of the Pacific Regional Environment Program (SPREP). The other US Pacific Islands are represented by the United States in international meetings, and cannot individually request or apply for funding through the UN system.

The HFA and supporting planning approaches advise consideration for approaches consistent with development goals and integration cross-cutting issues in these plans. The framework supports concepts of sustainable development and poverty reduction, with emphasis on actions that support Millennium Development Goals (MDG).[5] Cross-cutting issues include integration of multi-hazard approaches, gender perspective and cultural diversity, community and volunteer participation, and capacity building and technology transfer. By integrating these cross-cutting issues into planning approaches and risk reduction actions, there are opportunities to leverage resources reduce risks in areas not previously engaged in disaster management.

2.4 Global Disaster Trends and Climate Risk

The Center for Research on the Epidemiology of Disasters (CRED)[6] defines disaster as "a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction, and human suffering" (Scheuren 2008, 3). CRED developed a database of global disasters, which are characterized by the following criteria: 1) 10 or more people reported killed; 2) 100 people reported affected; 3) declaration of a state of emergency; and 4) call for international assistance.[7]

Review of the data demonstrates an upward trend in occurrence of natural disasters worldwide. "The upward trend is mainly driven by the increase in the number of hydro-meteorological disasters" (Scheuren et al. 2008, 16). "Globally, more hydrological disasters were reported in 2010. However, as meteorological disaster occurrence was lower, it evened

[5] The Millennium Development Goals (MDGs) are eight international development goals that all 193 United Nations member states and at least 23 international organizations have agreed to achieve by the year 2015. These include: 1) eradicate extreme poverty and hunger; 2) achieve universal primary education; 3) promote gender equality and empower women; 4) reduce child mortality rates; 5) improve maternal health; 6) combat HIV/AIDS, malaria and other diseases; 7) ensure environmental sustainability; and 8) develop a global partnership for development (UN 2012).

[6] The Center for Research on the Epidemiology of Disasters (CRED) is located in the Université Catholique de Louvain, Ecole de Sante Publique in Brussels, Belgium. CRED has developed a database of worldwide disasters or emergency events database (EM-DAT) used by the Office of Foreign Disaster Assistance, US Agency for International Development (USAID), the International Strategy for Disaster Reduction (ISDR), and other organizations, such as the World Health Organization, the International Federation of Red Cross and Red Crescent Societies (IFRC), and the European Union Humanitarian Office (ECHO). CRED's website is located at: http://www.emdat.be/Database/terms.html.

[7] CRED recognized that "though often caused by nature, disasters can have human origins. Wars and civil disturbances that destroy homelands and displace people are included among the causes of disaster. Other causes can be: building collapse, blizzard, drought, epidemic, earthquake, explosion, fire, flood, hazardous material or transportation incident (such as a chemical spill), hurricane, nuclear incident, tornado, or volcano" (CRED website, Glossary, 2008). CRED and Munich Re worked to develop a common categorization system for databases on natural hazards: 1) biological; 2) geophysical; 3) climatological (drought, extreme temperatures, wildfires); 4) hydrological (floods, wet mass movements); and 5) meteorological (storms) (Scheuren 2008, 4). The last three hazards have been called hydro-meteorological hazards, which are the natural hazards influenced by climate change.

out an increase in disaster occurrence in 2010. Similar to the average over the last decade, hydrological disasters were by far the most abundant disasters in 2010. These disasters represented 56.1% of the total disaster occurrence in 2010, and together with meteorological disasters - the second-most frequent disasters - accounted for 79.0% of total occurrence" (Guha-Sapir et al 2011, 1). Similar trends existed for the past decade with losses averaging more than USD $80 billion per year each year.

The years with highest recorded incidents of hydro-meteorological disaster correspond with climate extremes in the El Niño-Southern Oscillation climate cycle. Hydro-meteorological disasters will be even more prevalent with anticipated changes in climate where scientists project increased occurrence of extreme climate events (IPCC 2007, 107). This indicates that the future will see constant increases in the numbers of disasters. In October 2006, Sir Nicholas Stern, former Chief Economist and Senior Vice President of the World Bank, predicted that, by the middle of this century, climate change will account for a loss of at least 5% in global growth (USD $ 2,200 billion) each year (Stern 2006). If we also take its impact on environment and health and subsequent and secondary effects into account, it could be as much as 20% of annual global GDP (around USD $ 9,000 billion). The cost of actions to reduce risks were estimated to account for 1% of global growth (USD $445 billion) per year (Stern 2006).

These types of loss estimates are not particular to the Pacific Islands. Given the challenges facing the islands from climate change, in the long term there may be total losses of ecosystems, islands, and livelihoods. Increased dependence on the global community and donor organizations for funding and resources further necessitate planning action to reduce risks.

3.0 Process for Integrating Disaster Risk Reduction and Climate Change Adaptation

As mentioned in the introduction, disaster risk reduction (DRR) and climate change adaptation (CCA) approaches emphasize the reduction of vulnerability and the increase of capacity building to focus on creating and sustaining resilient communities that are capable of dealing with disaster and climate change impacts. These approaches are essential for a region that depends on environmental resources such that every sector becomes climate-sensitive and at risk from climate-related impacts.

While the theoretical underpinnings and practice of both DRR and CCA have emerged along different trajectories at the global level, which has ultimately led to parallel institutional frameworks informing the work of practitioners in these fields, there has more recently been a call at the highest policy levels to explore synergies and opportunities for collaboration between DRR and CCA practitioners. This is evidenced by the growing body of literature on Climate Risk Management and the establishment of bodies such as the Inter Agency Taskforce (IATF) Working Group on Climate Change and Disaster Risk Reduction as part of the UN International Strategy for Disaster Risk Reduction under the Hyogo Framework for Action (UNISDR 2005).

It is well acknowledged that because the economies and small communities of Pacific Island Countries are highly dependent on natural resources, they are more vulnerable to the impacts of climate change and natural hazards. While distinctions are often made between strategies provided by the disaster risk management community to address the current risk of hazards and climate variability and the strategies adopted by the climate change community in adapting to the future risk of climate change the reality is that the nature of risk and its root causes are converging rapidly. In the Pacific where resources are limited and communities are unlikely to differentiate between current risk and future risk, there is much impetus for adopting a "no regrets" multi-hazard approach to risk reduction that involves collaboration of the risk management and climate change communities.

In addition, there is increasing evidence that successful adaptation and coping capacity relies upon measures that address the livelihood activities of poor and vulnerable communities. This not only requires an understanding of how livelihoods are conducted and sustained island governments and communities, it requires a strong appreciation of how climate change will impact upon available natural resources and the differentiated roles of women, men, the elderly, youth, non-governmental organizations, communities, and government will play in managing these natural resources. Capacity assessments can help us to understand the ways that knowledge systems and roles in society can be employed to reduce risk and build resiliency.

The Pacific Island countries are situated precariously in the midst of political needs for attention based on characterizations of vulnerability, scientific needs for improved data collection and monitoring systems, financial and socioeconomic needs to manage risks, and localized needs to build resilient communities through increased food security and energy self-sufficiency---concepts that may directly conflict in achieving sustainability for island systems in the face of climate change. With recognition that islands are experiencing first impacts of climate change, research agendas have set out to develop vulnerability assessments that provide evidence for climate adaptation, and resultant funding for these efforts. This becomes a double-edged sword in that research agendas set out to demonstrate vulnerability, using scientific methods that can be argued convincingly in global climate negotiations. To meet the degree of scientific proof, more attention is focused on funding global data systems and technologies. Most of these technologies do not exist locally, and these approaches do not encourage capacity development in the islands but rather attract donor funding for external contractors. The processes for determining and verifying vulnerability tend to focus on problems and deficiencies defined by the external consultants, and therefore may miss the most pressing issues perceived by local communities and island governments. Furthermore, the emphasis on vulnerability all but negates attention to knowledge, skills, and adaptive capacity.

To better understand the entry points for potential inclusion of climate adaptation into the disaster risk reduction approaches, it is important to understand the exposure and sensitivity of assets to climate-related hazards (such as tropical cyclones, drought, flooding) and the degree to which climate change could exacerbate the impacts of all hazards and may increase vulnerability of the environment to deal with these impacts. The capacity to deal with the exposure and sensitivity through governance, policies, programs, regulations, human intellectual capital, knowledge systems, financial capital, labor and human resources must be assessed to know the degree to which the islands can deal with the threats that they are facing from climate change. Recommended actions should take this information into consideration.

3.1 Integrating Assessments

Since "the starting point for reducing disaster risk and promoting a culture of disaster resilience lies in the knowledge of the hazards and the physical, social, economic and environmental vulnerabilities to disasters that most societies face" (UNISDR 2006, iii), it is essential to develop a multi-disciplinary framework to build resilience from disasters and adapt to climate change. In addition to the fields of natural resource management, geology, oceanography, and coastal hazards research, plans and policy must carefully measure and develop the socioeconomic, or social, cultural, livelihood, and other related factors, alongside the communities affected. Disasters exacerbate current socioeconomic vulnerabilities, and climate change will magnify the problem further by causing increased frequency of potential disasters from combined ENSO variability, extreme events, wave overtopping, and sea level rise, with little or no time between events for recovery.

Reducing vulnerability depends on understanding sustainable livelihoods and the capacities, assets, and activities that lead to sustainability (Adger 2006). The consideration, promotion, and development of such assets of a community are critical to fostering sustainable development and disaster resilience. The community-based disaster risk and resilience framework constitutes the basis of the study approach that includes identification of hazards, risk and vulnerability, and capacity to address risks (Bollin and Hidajat 2006). Several methods listed in this paper, such as community surveys, mapping (GIS), and planning workshops, have been used to gain a broad and multi-disciplinary perspective of current community vulnerabilities to climate change as indicators of critical gaps in hazard resilience (Wood 2007, 5, 6).

Furthermore, methods for understanding community vulnerability to hazards examine exposure (number of facilities/people in hazard area) and sensitivity (percentage of facilities/people in hazard area) to gauge the severity of risk and determine where reduction measures may be effective in increasing capacity and resilience (Wood 2007). The findings from the research team will be integrated into this framework to demonstrate the links among climate, physical, environmental, and socioeconomic dimensions. Crucial information regarding socioeconomic vulnerabilities and opportunities related to climate change at each of the local sites and will help understand how to enhance local adaptive capacities and resilience to the impacts of climate variability and change. To strategize alternatives for adaptation, a better understanding of the capacities of communities to adapt and the limits to adaptation are needed (Adger et al. 2008).

Research demonstrates that characteristics of vulnerability emerge from using integrative approaches that consider the range of external systems, infrastructure, globalization, and socioeconomic and cultural factors may drive risk by increasing susceptibility for disaster (Adger 2006; Wisner et al 2004). Understanding the socioeconomic factors that relate to livelihoods and livelihood alternatives for the local population, and how these factors are integrally related to ecosystems and resources, are critical for reducing risks and vulnerabilities.

3.2 Reducing Vulnerability

The seven US Pacific Island jurisdictions have made assessments of their climate-related hazards and risks. The US Pacific Island states and territories must follow guidance specified in hazard mitigation planning to identify vulnerability to climate-related hazards. The other three freely associated states have begun to develop joint disaster risk reduction and climate change adaptation plans, based on information from previous disaster plans and climate national communications on the status of climate impacts prepared for the United Nations Framework Convention on Climate Change (UNFCCC). In addition, all seven jurisdictions have been including in the US National Climate Assessments.

The climate-related hazards identified in the plans are specific to occurrence and experiences of each island jurisdiction, and includes: tropical cyclones, hurricanes, and typhoons; climate change; climate variability; coastal erosion; coastal inundation, storm surge; drought; extreme heat; flooding; landslides, debris flow, mud flow (associated with heavy rainfall); lightening; sea level rise and variation; strong winds; and, wildland fire. In some of the plans, subsequent threats from climate change are discussed for health-related hazards and dam failures resulting from technological problems during heavy rainfall. Not only do the hazards need to be identified, but assets at risk must also be recognized.

The extent and quality of the data and information varies by jurisdiction, although information exists to make informed, thoughtful decisions on ways to reduce risks in each location. For the Pacific Islands, the hazard risk data has been primarily developed from historical records of occurrence and loss data. Climate extremes have resulted in changes that exceed expectations and challenge the ability to adapt rapidly, and historical records may not be good enough. The ability to consider the risks related to assets that need to be protected in consultation with decision-makers, technical experts, community leaders, and cultural practitioners expands the likelihood that the assessments will be useful and that those who need to respond to threats will be better informed.

3.2.1 Understanding exposure and sensitivity

Understanding the exposure and sensitivity of systems to impacts of climate depends on the available data used to assess vulnerability. The climate hazards with the best data for understanding and modeling impacts are tropical cyclones and floods. For the Pacific islands, analyses have been developed using historical records and impact mapping using geographic information systems (GIS).

The assets (social, cultural, built environment, ecosystem services) have been considered in the context of the plans for reducing risk. The primary assets that are documented include the buildings and infrastructure for each jurisdiction. Advances in satellite technology and mapping tools make it easier to see images of building footprints and locations of critical infrastructure. Other key factors in assessing sensitivity include the age of buildings and infrastructure, the types of materials used, the degree to which may have been identified and mitigated in initial building phases (such as raising facilities above the base flood elevation levels). For other resources that enhance social and ecosystem services, there may not be a direct way to visualize the risk through mapping, and this may limit the inclusion of important assets under consideration in these plans. The disaster risk reduction and hazard mitigation plans tend to focus on the built environment and urban corridors. Best environmental practices in watershed management and conservation activities are essential to reducing risk, but may not be included directly as disaster risk reduction activities.

There are further challenges in risk assessment approaches that tend to focus on the economic and financial losses from the climate-related disasters. Difficulty in placing value on non-economic activities has proved challenging in making arguments for protection and preservation of culturally important assets and identifying the intangible benefits of resources. In addition, perspectives from cultural practitioners and resource users that would be essential in valuation of social, sacred, environmental, and cultural resources have not been incorporated effectively in the risk reduction process. The current national plans and processes that inform disaster risk reduction and climate change adaptation have not integrated gender analysis, traditional ecological knowledge, cultural resource management, ecosystem-based adaptation, and community participation; yet, there are pilot projects in climate adaption and disaster risk reduction that are exploring these approaches and there will be better understanding of localized vulnerability when these projects have been completed.

3.3 Enhancing Capacity

In the documents to integrate disaster risk reduction and climate adaptation, there are references to understanding capacity. The FEMA hazard mitigation plans require an assessment of the capabilities to implement the plans and reduce overall risks, including reference to: government policies, legislation, and regulations; governmental agencies mandated to address risks; governmental and non-governmental plans and programs; human capital: knowledgeable people, technical expertise, number of laborers; financial resources to pay for staff, purchase equipment, and maintain plans and programs; available and accessible technology; integration of knowledge systems, including indigenous, cultural, community, and gender perspectives; and, legal mechanisms and frameworks. Although the list is not exhaustive, it demonstrates the difficulty in integrating DRR and CCA since there are many types of knowledge and expertise at multiple scales---from global to island community---that should be integrated to reduce risks.

In the existing plans and frameworks developed for DRR and CCA in the US Pacific Islands, there tends to be more recognition of the governmental aspects, technologies, staffing and labor, and financial resources. Areas that have not been considered much, if at all, include the integration of knowledge systems. Not only are there opportunities to enhance capacity in other areas, but to gain new perspectives and potential ways to reduce risk with alternative practices and methods that have not yet been fully explore in relation to risk reduction. These have also not been considered with sectors that will be largely impacted from climate change, including agriculture and food security, communications systems, economy and finance, education, energy, environment, government, health, society and culture, transportation, waste, and water. There will likely be important applications for reducing risk by sector when considered through the lens of different knowledge systems.

In addition, education is widely recognized as a key capacity requirement for risk reduction and poverty alleviation. This may be a critical capacity area that should be developed as an adaptation strategy. Not only is it important to develop awareness and knowledge of climate change and disaster risks, but to develop the capacity to manage the data, develop plans, make informed and relevant decisions, and apply risk reduction measures. The island governments rely heavily on external knowledge and expertise. Part of becoming a more resilient population will be to reduce the dependency on external consultants in favor of local knowledge and expertise.

3.3.1 Improving Information Gaps and Technical Capacity

The review of the disaster risk reduction, hazard mitigation, and climate adaptation planning documents revealed that several of the hazards have well-developed information and monitoring mechanisms, but quite a few extreme events, such as drought and sea level rise, require better methods to assess impacts, losses, and projected loss.

The technical capacity is lacking in the availability of quality-controlled datasets that can be used in models and mapping efforts. Information on losses appears only where statistics have been kept, as well. Drought is one of the hazards that proves challenging to assess loss and is a key hazard area for climate-related impacts. In the assessment of drought risk, the losses are calculated in the US based on programs providing relief assistance. These are primarily in the agriculture sector. Only those with adequate access to land and financial capital are able to tap into the relief assistance programs in the agriculture sector. In addition, the future losses from crops that cannot recover or cannot be planted on the regular harvest cycle and the problems in reproductive cycles of plants and animals result in extended losses beyond the timeframe of the drought. In addition, the impacts to livelihoods and quality of life have not been adequately assessed, and cannot be characterized by economic loss.

Additional hazards that prove challenging to assess are wildfire impacts. Better forecasting improvements aid in the ability to prevent threats from occurring. When these threats do occur, unless the fire has occurred at an urban interface where there are identified losses to buildings and infrastructure with an economic value, it is difficult to assess the loss of an old-growth forest that is essential in bringing water throughout the ecosystem or the loss of top-soil that prevents erosion, siltation, and mudflows from occurring.

To improve the capacity to adequately assess these losses and to promote the importance of risk reduction from climate change and other hazards that are challenging to assess, it is important to convene knowledgeable individuals to advance alternative methods for assessment. Economic valuation may provide some lessons, but there need to be better methods for assessing the impacts using qualitative assessments integrated with loss estimation tools.

The levels of perceived costs and losses help to prioritize risk reduction actions based on limited resources. To reduce risks, the methods of demonstrating and calculating losses have to be better assessed. In addition, there need to be improved tools for communicating the losses. The lack of technical capacity is lacking globally, not just in the Pacific Islands.

3.3.2 Improving Integration of Knowledge Systems

The lack of use of alternative perspectives and knowledge systems in planning results in the implementation of plans and actions that may not adequately address risks in an equitable and just way. Plans programs and policies informed solely by decision-makers and people in the disaster management or climate change communities will miss areas where information may be inaccessible. Communities, people, and livelihoods that may be severely impacted by disasters and climate change may not have been involved in the implementation of risk reduction measures. There have been numerous interventions in the Pacific that have resulted in unintended consequences because those with the knowledge to address risks were never consulted.

3.3.2.1 Indigenous Knowledge

While there has been international advocacy for including traditional knowledge and validating observations of long term change recorded in oral histories as science, it is still not yet become a widespread methodology in climate policies and in disaster risk reduction activities. Acknowledging traditional ecological knowledge as science, the gathering and translating of these oral histories will enable assessments to ascertain ways that the community has adapted in a place-based context to local environmental changes (Watson 2009). In island systems, the climate is always changing and the islanders learned to adapt and adjust their practices to cope with these observed changes. Increased studies and review of records that hold indigenous knowledge are important to understanding ways that particular ecosystems and environments may be able to adapt. Using culturally appropriate methods for engaging indigenous scientists and cultural practitioners is essential for building capacity to address climate risks.

In addition, it is important to understand critical assets for perpetuating cultural practice that may be affected by climate change. The ability to identify key cultural resources enables local practitioners to identify strategies for dealing with loss of cultural resources, whether the options are to document and archive the location and let the change happen, to transplant planting materials for migration to more suitable environments, or to implement structural hardening and retrofits to preserve sites. These choices will vary by resource and by community, depending on their understanding and knowledge of the climate risks. This emphasizes the reason that it is important to engage community and cultural practitioners in risk reduction efforts.

Discussions with the five Micronesia jurisdictions revealed that the exploration of traditional ecological knowledge and practice is central to current efforts in climate change adaptation.

Many of these efforts do not require an influx of financial resources, but can be developed by consulting elders and implementing actions before knowledge is lost. A pilot project in the Marshall Islands uses traditional replanting methods to rebuild coastline with native plants that are also used as a food resource. Younger generations are implementing the replanting with advice from elders. This is a less costly alternative to developing a seawall that would require importing materials for construction and external consultants. By using local knowledge, the community is building capacity and enhancing local knowledge and education for younger generations (Anderson and Wongbusarakum 2010).

Indigenous knowledge systems are also gendered, primarily through community roles and divisions of labor, and it is important to differentiate the knowledge. In this way, the adaptation planning frameworks and analyses will have a better characterization of vulnerability and adaptive capacity based on demographic (age, ethnicity, gender, special needs, etc) and socio-cultural characteristics (livelihoods, class status, social positionality, etc.) (Anderson 2009). Understanding the social profile of risks may change the assumptions about the community at risk. For example, there may be more Hawaiian women in rural communities that live below the poverty line, but the elderly women may have more disaster risk adaptation knowledge and may practice alternative land use practices that contribute to resilience.

3.3.2.1 Gender Analysis

The gender analysis of disaster risk reduction efforts are done by looking at the development of the planning process, the meetings, the determination of mitigation actions, and the identification of key people who will be implementing the plans to see who was involved in the analysis. In addition, it is important to understand the gender divisions of labor and cultural rules to ensure that disaster risk reduction actions will address key changes in climate. Gender analysis applied to disaster risk management reveals other social issues related to race, ethnicity, class, and poverty that can often determine social vulnerability to disasters. Gender analysis can also be used to examine social issues related to environmental management, conflict, complex emergencies, health crises, and climate change.

Gender operates at multiple scales: international, national, and local. The local arena is where we experience the disaster or climate impact, while the national and international arenas set the stage for policies, planning, and programs at all phases of the disaster cycle (hazard mitigation, preparedness, impact, response, recovery and rehabilitation)---but these scales intersect and overlap and do not provide neat categories for analysis. Local cultures and communities in which people live have developed expectations for how men and women express their identity. These expectations often appear through stereotypes, but these can change over time and in different generations. Just as culture is dynamic, so are these gender roles in society. Although expressed in roles of masculinity and femininity in society, gender roles vary by context and place. In the US Pacific Islands, the freely associated states of Palau, Marshall Islands, and the Federated States of Micronesia have matrilineal systems that are still in effect for land tenure and leadership. The Polynesian Islands have long-established roles of matriarchs and leadership by women. The process of colonization extinguished many of these roles, and western government systems tend to have a disproportionate number of leadership positions filled by men. The fields of disaster management and climate change still reflect an imbalance in management, but this is slowly changing.

Factors contributing to poverty and inequity change the design of the disaster by increasing government responsibility for safety costs of disasters and by expanding the magnitude and reach of disaster impacts. The lack of attention and the exclusion of segments of the local population *increase* vulnerability to risks because inappropriate management networks have been overlaid on different geographic landscapes. The increased vulnerabilities to hazard risk align with inequities that exist in everyday life.

> There are systematic disparities in the freedoms that men and women enjoy in different societies, and these disparities are often not reducible to differences in income or resources. While differential wages…constitute an important part of gender inequality in most societies, there are many other spheres of differential benefits, e.g. in the division of labor within the household, in the extent of care or education received, in liberties that different members are permitted to enjoy (Sen 1992:122).

The lack of gender equity in formal disaster organizations has resulted in recommendations in gender and disaster workshops to increase the numbers of women in these organizations (Anderson 2005; Anderson and Enarson 2004). The number of women working in this field and the number of women with leadership positions are drastically lower than the number of men (Anderson 2005). The numbers of women impacted by disasters, however, are typically higher, if the information is recorded, as in the 2004 tsunami where almost three quarters of the deaths were women (Oxfam 2005). A recent statistical study about the effect of natural disasters on the life expectancy of men and women in 141 countries demonstrated that more women die than men as the direct and indirect result of disasters, with strongest effects in countries with low social and economic rights for women (Neumayer and Plümper 2007). The study showed that in addition to greater numbers of women killed, the females were killed at earlier ages than men, and natural disasters resulted in narrowing the gender gap in life expectancy (Neumayer and Plümper 2007, 1). Although this study represents the first statistical analysis to understand implications of gender in disaster risk reduction, there are place-based, localized considerations that indicate that similar impacts may not be true in Pacific communities.

Women visibly participate in organizations representing the “informal” sector of disaster management. [8] In many community-based and non-profit organizations, women have attained leadership roles. A brief review of 161 environmental, health, social welfare, and educational non-profit organizations in Hawai‘i reveals that about 80% of these organizations have women as executive directors or top-level staff (Anderson 2005, 203). By comparison with the public

[8] Informal is used here in contrast to the formal disaster management organizations, such as Emergency Management Agencies, Civil Defense, National Guard, military, emergency response, meteorologists, seismologists, etc, and these organizations have mandates and functions that exist in addition to reducing risks as these organizations, such as improving the environment or health of civil society.

sector, a review of women's positions in the United States' National Weather Service, which provides information to the public on a range of hazards, showed women represented only 7% of middle to upper management (Anderson and Enarson 2004).

The positions of women in the "informal" sector mean that they may not access information or have access into the discussions and processes that influence decision-making. The non-profit, civil society, and community organizations may not be aware that their activities and efforts assist in risk management. Formal disaster risk managers may not be aware, and therefore, do not think it important to include these organizations in planning processes and public awareness programs. Even with women in positions of power in urban and rural organizations that minimize impacts of disasters through their daily actions and operations, women do not often appear in disaster risk management planning processes. Many of these planning processes now try to be inclusive and require multi-disciplinary, multi-sectoral approaches. There remains, however, some disconnection between the formal and informal sectors. The separation of these areas of risk management may undermine the goals of risk reduction through ignorance of potential benefits from engaging in broad, participatory processes.

There have been attempts to "mainstream gender" through localized cases at the project level and through increased numbers of women in disaster organizations. In the Pacific, women have been placed as Meteorologist in Charge in two weather service offices and several other women were hired as climate focal points. It is difficult to declare causality, but these places with women in the climate sector have extended their reach into communities, prioritized education and outreach efforts, and increased networking about weather, climate, and disaster information among governmental and civil society organizations (Anderson 2007). In addition, the Marshall Islands Office of Environmental Planning and Policy Coordination has a woman in a key leadership role that participates in international negotiations for the pasts seven years and Palau had a woman in the highest position for five years.

In the Marshall Islands and the Federated States of Micronesia, where there are matrilineal systems that establish women's leadership roles in society, there have been increased women's organizations participating in programs and planning involving climate change. There has been increased advocacy for supporting sustainable agriculture and food security programs that are predominantly the responsibility of women. Informal requests for information on the ways that climate-related health risks, especially from the loss of potable water, can be integrated into planning and outreach efforts to deal with climate change. The participation of women in disaster risk reduction and climate change adaptation planning has shifted the focus of risk reduction from primarily infrastructure projects to those related to societal benefits.

4.0 Lessons Learned and Recommendations for Reducing Risk in the US Pacific Islands

A review of disaster risk reduction and climate change adaptation in the US Pacific Islands reveals that efforts are underway to reduce risks and address issues from climate change. Each of the islands have developed risk reduction plans that can be improved with better information and data, but which currently provide capacity in addressing climate-related hazard risks and impacts from climate change. As models and knowledge improve, there will be increased places for integrating information into risk reduction planning efforts.

The planning process provides opportunities for looking at risks throughout the vulnerability and capacity assessment process and for identifying focal areas for risk reduction actions. Lessons learned from considering the disaster risk reduction and climate adaptation efforts in the Pacific Islands to date reveal areas of missing information and knowledge gaps that can be targeted in updated planning, and in the development of proposals and implementation of risk reduction actions. The following lessons and recommendations are highlighted for further consideration.

Lesson learned from historical implementation of programs in the US Pacific Islands:

- Risk reduction programs need to be island-relevant and integrate local knowledge and management to be effective. Approaches must be collaborative. Therefore, climate adaptation planning will require early and continuous consultation at the local levels in development of these plans. *Recommendation:* Develop plans that will be participatory and consultative.

- Attention to planning is important in order to look at the costs and consequences from implementing actions in the Pacific Islands region, where there are additional disasters created when implementing interventions to managed disasters. Due to the precarious nature of island ecosystems from climate change impacts, it is essential that plan and actions are evaluated to prevent “mal-adaptation” from occurring. *Recommendation:* Engage in integrated socioeconomic assessments to understand systemic effects of risk reduction actions and evaluate the potential consequences of risk reduction actions before implementation.

Lessons learned from Disaster Risk Reduction Trends

- The data and occurrence of hazard impacts in the Pacific Islands has been consistent with increases in climate-related risks. As programs focus on risk reduction, there has been a convergence on climate-related disaster risks. At the same time, there have been increased efforts to reduce threats from climate change. Many of the proposed adaptation actions are similar to hazard mitigation and disaster risk reduction actions, and therefore, there is opportunity to merge efforts and maximize limited resources and capacity to address risks. *Recommendation:* Engage in joint risk reduction efforts to leverage scarce resources.

Lessons learned from Risk Reduction Planning

- Climate change adaptation and disaster risk reduction planning involve similar processes, sensitive sectors, and actions to reduce risks; therefore, joint planning efforts will maximize limited resources and improve opportunities for leveraging scarce resources to achieve similar results. *Recommendation:* Engage in joint disaster risk reduction and climate adaptation efforts.

Lessons learned from Vulnerability and Capacity Assessments

- Technical capacity relies on access to information, equipment and tools, and personnel to analyze and use the technologies. Many hazards do not have accurate historical records to use in modeling and some hazards have less spatial component and are not as effective in mapping. *Recommendation*: Develop better historical records to improve models and scenarios used in planning.
- The ability to assess current losses and project future losses from climate-related hazards and from climate change impacts lack the quality-controlled data to produce effective projections of loss. Loss is further limited to economic impact data and damage assessments. *Recommendation*: Use economic valuation methods and socioeconomic assessments to develop loss estimates for important assets that do not have a clear economic value, such as water resources, cultural resources, and ecosystem services. This will also benefit arguments for funding and aid in the prioritization risk reduction actions.
- Many risk and vulnerability assessments have not integrated thorough socioeconomic assessments, and this challenges the ability to identify threats and risk reduction actions. Therefore, assessments must take into account social, cultural, biological, physical, economic, governance, and other approaches. *Recommendation:* Develop and implement integrated assessments.
- Cross-cutting issues of gender and culture offer great opportunities for developing a deeper understanding of the effects of climate-related hazards and climate change impacts. Rather than focusing solely on vulnerability, the approaches emphasize understanding the ways that resources are used and managed, and offer opportunities to develop programs that take capacities into account and target resources more effectively. *Recommendation:* Focus on developing ethnographic studies and gender analyses to aid in understanding deeper implication for loss of resources and implications of management actions, specifically targeting sectors where certain populations may be at heightened risk from the impacts of disasters and climate change.
- Education, both formally and informally, is an important tool in building and sustaining resilient communities. Education will build capacity and it will aid in risk reduction efforts. *Recommendation:* Target the implementation of formal and information education and awareness building to build sustainability, intergenerational knowledge transfer, and resilient communities and people.

Since the US Pacific Islands lie in the heart of the Earth's climate system, they offer a unique opportunity to learn lessons about what it means to be resilient in the face of disasters and climate change. The variation in island systems and geographies offers consideration of different aspects of risk reduction. The Pacific Islands are already learning lessons from their histories about the ways that risk reduction efforts and interventions should occur. The international community should seize this moment to test and learn from approaches implemented in the Pacific Islands.

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APPENDIX A: Climate Synopsis for the US Pacific Islands

Sources: taken primarily from the Pacific Regional Integrated Science and Assessment Program (Pacific RISA) website: www.pacificrisa.org

American Samoa

American Samoa's climate is tropical with a relatively dry season, June through August, and a wet season, January through March. The annual rainfall in 2007 was 145 inches (3,683 mm) or 26 inches (660 mm) more than the 30-year average between 1971 and 2000 [6]. The amount of rainfall can vary greatly depending on the location and from year to year [8]. For example, the rainfall averages about 125 inches a year at the airport, but Pago Pago, less than 4 miles from the airport at the head of a harbor open to the prevailing wind, receives nearly 200 inches a year [7]. The average temperature in 2007 was 83.3°F (28.5°C) compared to 80.9°F (27.2°C) from the 30-year average [6]. Relative humidity is high during most of the year, ranging from 70-90% during the wet season and 60-70% during the dry season. Trade winds blow almost continually [8].

During ENSO events, there are likely to be drier than normal periods. Rainfall has generally been associated with tropical storms that may be more likely to generate in the region during ENSO. The strength of the El Niño event has some effect on the precipitation, and some ENSO signals have been wetter than normal. With a few exceptions, American Samoa did not show any significant variations in sea level during the strong and moderate El Niño years. In contrast, La Niña years showed two distinct scenarios. During strong La Niña years, sea level was lower than average. During moderate La Niña years, sea level was higher than average. The deviations were most pronounced from February to July during both strong and moderate La Niña years [1].

Heavy showers and long rainy periods can occur in any month while typhoons are common from December to March [2]. Tropical cyclones impact the island chain with tropical storm-force winds once every three years, on average [9]. In 2003, heavy rainfalls resulted in severe landslides and flooding, for which a Presidential Disaster Declaration was made [2]. Tropical Cyclone Heta in 2004 and Tropical Cyclone Olaf in 2005 resulted in disaster declarations with flooding, high surf, and high winds [3]. The prevailing winds throughout the year are easterly trades, interrupted more often in summer than winter, and sometimes associated with tropical cyclones, convergence bands, and upper level disturbances.

American Samoa has several climate sensitive sectors that provide livelihood for the people, including the tuna canneries that are the primary economic resource and marine and coastal ecosystems. American Samoa developed a climate change working group within the Coral Reef Advisory Group to monitor impacts of changes on coral reef ecosystems. During the Stakeholder Workshop, the Government described a commitment to developing a climate change adaptation strategy that would support community-based adaptation measures in the villages (See Page Stakeholder Dialogue, American Samoa Summary Report, 2006). Understanding that the natural environment contributes to their livelihood, the American Samoa Government has formed many environmental task forces and initiatives to promote sustainable development of resources for long-term survival of their people.

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Commonwealth of the Northern Mariana Islands (CNMI)

The Northern Mariana Islands are considered the sunniest islands in Micronesia [3]. The islands have a tropical marine climate moderated by seasonal northeast trade winds from November to March and easterly winds from May to October. Average year-round temperature is 84° F (28.9°C) with an average humidity of 79%. The ocean temperature averages 82° F (27.8°C). There is little seasonal temperature variation. Temperature, however, is affected by elevation; hence, the islands of Saipan and Rota show considerably greater temperature variations between the coastal and mountainous areas [5]. The dry season runs from December to June, and the rainy season from July to November [4]. Average yearly rainfall is 50 inches (130 cm) per year [6].

The west coast of Saipan, the most populated area in CNMI, is protected by a fringing barrier reef, while the relative absence of reefs on the east make that side of the island subject to strong waves fed by the tradewinds, particularly during Saipan's winter (November to April). The Commonwealth is situated some 600 miles (965.61 km) east of an area in the western Pacific which is the breeding area of cyclonic disturbances. As a result the Commonwealth is in what is known as weather condition four at all times which means that 40 mile (64.37 km) an hour winds are possible within 72 hours [5]. These cyclonic disturbances can quickly and sometimes unexpectedly develop into typhoon force winds of 120 miles (193 km) per hour or greater. Typhoon season runs from July to January, and the islands of the CNMI are usually subject to at least one typhoon each year [5]. Flooding and wind damaged vegetation are a common result of frequent storms with winds above 60 mph (96.56 kph)[6].

Sometimes the islands experience droughts from low rainfall during the period from December through June [5], and have experienced drought during strong ENSO events, although not as severely as many other islands in Micronesia. During the 1997-1998 ENSO event, the island implemented water conservation measures. Since tourism is a large driver of the local economy, the hotels used desalination units to ensure that guests had enough water and acted as a backup resource for critical facilities, such as the hospital. Alternatively, there has been frequent flooding in low-lying coastal areas and roadways of Saipan during heavy rainfall, which required drainage improvements and flood mitigation planning. The Northern Mariana Islands recognized the need to include climate-related hazards in the update of their hazard mitigation plan. (See Stakeholder Dialogue, CNMI Summary Report, 2006).

Large-scale tourism drives the economy, and many of the tourist visit to see the natural beauty of the Northern Mariana Islands, which is highly dependent on climate. Small increases in temperatures could result in large impacts to coral reefs, and subsequent impacts to the marine and coastal environment. Landfills to support the increase population on the island have resulted in groundwater contamination on Saipan, which might contribute to disease [4], and has conflicted with environmental conservation and endangered species protection [1]. There is recognition that environmental degradation and stressors will exacerbate the impacts from variations and changes in climate.

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Territory of Guam

Guam's climate is almost uniformly warm and humid throughout the year. The mean annual temperature is 81.9 °F (27.7°C) in 2007 [4]. Generally, the range is from the low 70s to the middle 80s. The coolest and least humid months, marked by prevailing westerly tradewinds, are in December through February. Although the warmest months are from March through August, the trade winds blow steadily from the east or northeast. There are two seasons, the dry and the rainy. The dry season typically begins in December and extends through June. The rainy season falls within the remaining months [5].

The annual rainfall totals 80-110 inches (2,032-2,794 mm) [5], with the total precipitation of 88 inches (2,235 mm) in 2007 [4]. Three-quarters of the rain falls between June and December, averaging about 85 inches (215 cm) a year on the lowland coast around Apra Harbor and 110 inches (280 cm) in the highest mountain locations of the southern half of the island [7]. During the rainy season there is a breakdown of the trades, and on some days the weather may be dominated by westerly moving storm systems that bring heavy showers, or steady and sometimes torrential rain [6]. Guam lies within the typhoon belt and is periodically struck by tropical storms and typhoons [7]. Guam has experienced numerous typhoons, which are most frequent from June through December. An average of three tropical storms and one typhoon pass within 180 nautical miles (330 km) of Guam each year. Since 1962, ten of thirteen major disaster declarations resulted from typhoons, and two of the other disasters were associated with climate [2]. The most intense typhoon to pass over Guam recently was Super Typhoon Pongsona, with sustained winds of 125 miles per hour on December 8, 2002, leaving massive destruction as the oil tanks in Apra Harbor caught fire [1, 2]. The loss of harbor operations made response to the disaster more difficult [2].

As a higher island, Guam has greater freshwater resources, which means that there were fewer problems with water supply during the 1997-1998 ENSO event. Super Typhoon Paka hit Guam in

December 2007, which was the last rainfall for the next few months and the island was recovering from the storm when the results of the strong ENSO came. Water conservation measures were enacted to ensure water for drinking, household use, and agriculture, while also fighting wildfires. The worst problems during the drought were the severe wildfires, which contributed to loss of vegetation and destabilized hillsides and stream banks, resulting in erosion and sedimentation. The coral reefs, which provide habitat, food, and protection for the islands, as well as attraction for its main tourism industry, could experience increased pressure from extreme events that result in bleaching or sedimentation that covers and kills the reefs. During disasters throughout Micronesia, people from atoll islands historically migrate to Guam because it usually has more food and water resources available. With increased migration from the impacts of climate change, Guam's resources may exceed their carrying capacity.

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State of Hawaiʻi, USA

Hawaiʻi has a tropical climate with constant trade winds blowing from the east. Hawaiʻi has two seasons: Summer from May to October, and winter from October to April. Summer highs are usually in the upper 80s°F, (around 31°C) during the day and mid 70s, (around 24 °C) at night. Winter temperatures during the day are usually in the low to mid 80s, (around 28 °C) and (at low elevation) seldom going below the mid 60s (18 °C) at night [7]. In 2007, the mean temperature is 78 °F (25.6 °C) in Honolulu and 74.2°F (23.4 °C) in Hilo [4]. While Hawaiʻi's climate is equable, the mountainous topography makes it one of the most spatially diverse on earth. Hawaiʻi has various ecosystems ranging from deserts to tropical rain forest and even frozen alpine tundra, all in close proximity [4]. Snow, although not usually associated with tropics, falls at the higher elevations of Mauna Kea (13,796 feet/ 4,205 meters) and Mauna Loa on the Island of Hawaiʻi in some winter months [8].

The average rainfall of Hawaiʻi's island ranges from 10 inches (250 mm) to 445 inches (11,300 mm) [4]. Local climates vary considerably on each island, generally divisible into windward and leeward areas based upon location relative to the higher mountains. Windward sides face the Northeast Trades and receive much more rainfall; leeward sides are drier and sunnier, with less rain and less cloud cover [8]. Variations in rainfall on the Hawaiian islands are dramatic. At one extreme (for example, the west side of Hawaiʻi Island), the annual rainfall averages 20 inches. At the other extreme, the annual average exceeds 300 inches (7,620mm) along the lower windward slopes of the high mountains in Haleakala (Maui), and at the summit of the lower mountains of Kauai, Oʻahu, and western Maui [2]. Mount Waiʻaleʻale on Kauai, is notable for rainfall, as it has the second highest average annual rainfall on Earth, about 460 inches (38 ft. 4 in., or 11.7 m) [8].

Hawaiʻi has experienced rapid warming, especially since the mid-1970s. Its air temperature trend has diverged from the Pacific Decadal Oscillation (PDO) and local sea surface temperature trends, perhaps signaling increasing influence of global warming [1]. Drought, although it rarely affects an entire island at one time, may occur when there are either no winter storms or no trade winds. If there are no winter storms, the normally dry leeward areas are most impacted. A dry winter, followed by a normally dry summer and another dry winter, can have serious effects. The absence of trade winds affects mostly the windward and upland regions, which receive a smaller proportion of their rain from winter storms [4]. Hawaiʻi's climate is likely to continue to become drier as warming continues. Reduced precipitation in combination with a possible increase in potential evapotranspiration due to increased temperature would result in significant reductions in ground-water recharge and stream discharge, and would severely impact vulnerable high-elevation ecosystems [1].

Coastal erosion and beach loss are chronic and widespread problems in the Hawaiian Islands. Shorelines are already affected as a result of island subsidence processes. Loading of the Pacific tectonic plate by the growth of Hawaiʻi's volcanoes, lithostatic flexure (down-bowing) of the plate, as well as compaction of the volcanic products, cause the islands to sink at a measurable rate. Typical erosion rates in Hawaiʻi are in the range of 15-30 cm/yr or 0.5-1 ft/yr, with some areas reaching annual average erosion rates of up to 5-6 ft /yr (Hwang, 1981; Sea Engineering, Inc., 1988; Makai Engineering, Inc. and Sea Engineering, Inc., 1991) [7]. A sustained sea level rise associated with global climate change will add more threat to the coastal built environment and significantly increase loss of beaches and coastal ecosystems [7]. This is a severe threat to tourism, the largest industry in Hawaiʻi, contributing 21.5% of the Gross State Product (GSP) in 2001 [3].

Although hurricanes and tsunami are a rare occurrence in Hawaiʻi, all main islands have been affected. Tsunamis have accounted for more lost lives than the total of other local disasters [6]. High winds and associated marine flooding from storm events such as Kona Storms and hurricanes, sea level rise, seasonal high surf, stream flooding on coastal plains, all increase the risk exposure along developed coastal lands of Hawaiʻi [7].

Hawaiʻi State has a multi-hazard mitigation plan that addresses climate-related hazard risks, as well as considers some of the impacts from future climate change, such as sea level rise and more frequent extremes, especially in the hydrological cycle where Hawaiʻi has a history of flood and drought hazards occurring in the same year, such as 2007. Most major disaster declarations for Hawaiʻi are based on climate related hazards that total billions of dollars in damages [7]. Even the earthquake disaster in 2006 damaged irrigation infrastructure and reservoirs that created extensive drought-related problems during the ENSO event that followed in 2007 [7]. Each of the four counties has its own mitigation plan that address localized risks. The plan recommends hazard mitigation actions, similar to climate change adaptation strategies, to build resilience [7].

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Federated States of Micronesia

The Federated States of Micronesia extends 1,700 miles (2,736 km) from the east to west forming the Western Carolinian Islands [2]. The four states in the nation include: Pohnpei (with the FSM's capital city in Palikir), Kosrae, Chuuk, and Yap. With the wide variation in location and geology, the islands have a wide range of climates and experience different impacts across the country.

Kosrae

Kosrae's climate is tropical oceanic. Located only 5° north of the equator, Kosrae experiences periods of heavy rainfall associated with the Intertropical Convergence Zone (ITCZ). In 2007, the average annual temperature is 81°F (27.2 °C) with only 0.5 °F departing from the 30-year mean temperature recorded between 1970 and 2000 [5]. Rainfall is relatively high, slightly over 200 inches (5,080 mm) in 2007, nearly 30 inches (762 mm) more than the 30-year average [5]. The precipitation is normally higher in the highlands. The state has experienced three severe droughts in recent times, in 1982-83, 1992-93 and 1997-98. All three were a result of El Niño. Kosrae is located to the south and east of the typhoon track and very rarely experiences a direct strike from a typhoon. However, Pacific typhoons often go through the development stage in the area causing severe local winds. During the rainy season of November through March frequent severe rainstorms are sometimes accompanied by damaging winds, which can damage transmission and distribution facilities [9]

Pohnpei

Pohnpei's close proximity to the equator, right in the middle of the intertropical convergence zone (ITCZ), substantially reduces seasonal weather change [9]. Average annual temperature since 1970 has been around 81° F (27 °C) [5]. The island's highest point, at 2,540 feet (798 m), is the summit of Mount Nahnalaud, thought to be one of the wettest spots in the world, with an average annual rainfall exceeding 400 inches (10,160 mm) [8]. While it has been estimated that within Pohnpei's high mountainous interior it can rain as much as 330 inches (8,384 mm) a year, the weather service in Kolonia Town measured total precipitation of 194 inches (4,928 mm) in 2007, approximately 9 inches (229 mm) more than the 30-year average [5]. Runoff from the rains feed numerous streams and rivers that originate in the interior highlands. Typically, Pohnpei's interior is almost completely cloud covered, and the island's residents can expect most days to be partly cloudy, with periods of sunshine, then overcast and rain [9].

Pohnpei is generally south and east of the typhoon belt, but periodically experiences short, severe tropical storms [9]. The northern part of Pohnpei is where tropical disturbances often form, though most develop into typhoons north and west of the state. The southernmost atoll in the state is

Kapingamarangi, located 2° north of the equator, and subject to droughts, particularly during La Niña events [8]

Chuuk

From about November to June, the climate of Chuuk is influenced chiefly by northeasterly tradewinds with average monthly speeds of 8-12 mph (13-19 km/h). By about April, however, the trades begin to weaken, and by July give way to the lighter and more variable winds of the doldrums. Between July and November, the island is frequently under the influence of the ITCZ. This is also the season when moist southerly winds and tropical disturbances, many associated with the ITCZ, are most frequent, and when humidities often are oppressively high. Temperature in Chuuk is remarkably uniform; with the highs generally in the middle 80s, and lows in the middle 70s. In 2007 the average temperatures was 82.2 °F (27.9 °C) [5] The northern atolls receive about 80 inches of rainfall a year while the annual rainfall in Southern atolls is normally higher, about 160 inches (4,060 mm). Monthly rainfall ranges from 6 to almost 16 inches (152-406 mm). The least amount of monthly rainfall (6 to 9 inches/152-228 mm) occurs during the months of January through March as stronger northeasterly trade winds approach the state of Chuuk [9]. The total precipitation of Chuuk in 2007 was measured at 127 inches (3,226 mm) [5].

Although the major typhoon tracks of the western Pacific lie to the north and west of Chuuk, several of the storms have passed close enough to the island to cause widespread damage. Tropical storms generally occur between the months of July and November [9]. Severe typhoons with winds in excess of 100 mph (161 km/h) strike portions of Chuuk, including Supertyphoon Nina in November 1987 [7] and Typhoon Chata'an in July 2002. Chata'an brought heavy rainfall causing extensive flooding, mudslides, and landslides that resulted in deaths and required more than $10.6 million in federal assistance [2]. According to the 2007 PEAC staff visit with the Chuuk Weather Service Office (WSO), sea level rise, drought, and inundation are biggest threats to Chuuk. Most infrastructure is located close to the coastline, as the interior of the islands are mountainous. Taro patches in Chuuk State suffered great losses from an inundation event in March 2007 [4].

Yap

The ITCZ lies near Yap during the northern summer, particularly as it moves northward in July and southward again in October. At such times, showers and light, variable winds predominate, interspersed with heavier showers or thunderstorms, occasionally accompanied by strong and shifting winds. In 2007 the average annual temperature in 2007 is 80.5 °F (26.9 °C), and annual rainfall is 138 inches (3493 mm) [5]. Since the twenty-first century began, Yap has experienced two major typhoon disaster declarations, Typhoon Lupit in 2003 and Typhoon Sudal in 2004 [2].

Despite plentiful rainfall (Pohnpei is one of the wettest places on Earth), during extreme ENSO events, drought conditions do occur periodically throughout FSM, especially when the El Niño condition moves into the Western Pacific. At these times, groundwater supplies have dwindled to emergency proportions, with a major drought disaster declaration in 1998 and emergency declarations in 2007[2]. The states of Pohnpei and Chuuk declared drought emergencies in several islands in these states due to food and water shortages from climate variability [6, 7]. In addition, the FSM faces wildfires, extreme tides, sea level variation, and erosion. Tropical typhoons (June to December) constitute an annual threat, particularly to the low-lying atolls [1, 3]. Fisheries, a primary economic sector in the FSM, have high correlations of fish catch with sea surface temperatures (SST) and ENSO events. As pelagic fish leave the region, the FSM experiences severe economic setbacks.

With the current stresses on the environment, infrastructure, and economy in the FSM, more frequent extreme events and climate change could pose severe problems for the resilience of the island communities. To address these issues, several non-profit organizations working with the government have begun to identify marine protected areas and conservation areas to protect resources for food security. In addition, some of the low-lying atolls have made arrangements to secure tracts of land on higher islands for possible relocation.

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The Republic of the Marshall Islands (RMI)

The weather in the Marshall Islands is tropical - hot and humid, but tempered by trade-winds which prevail throughout the year. The trades are frequently interrupted during the summer months by the movement of the Intertropical Convergence Zone (ITCZ) across the area [4]. The recorded annual temperature averages since 1948 show hardly any fluctuation with 82.6 °F (28.1 °C) at Kwajalein Weather Station in 2007 [3].

Pacific typhoons generally develop to the east of the Marshall Islands area but the RMI is only occasionally subjected to the full brunt of a Pacific typhoon. The northern atolls are more subject to typhoons than are the southern atolls. The storms (sustained winds of 40-74 mph/64-119 km/h) impact the atoll about once every four to seven years on average, corresponding to El Niño-Southern Oscillation events that warm the ocean waters and provide conditions for the genesis of cyclones. An analysis of the historic record of typhoons in the Marshall Islands has identified a significant association between the occurrence of ENSO and the occurrence of typhoons in the Marshall Islands [6]. While typhoons normally occur further to the west, the warming of the ocean waters around the Marshall Islands, as part of the ENSO phenomenon, spawns typhoons further to the east. The results of the statistical analysis suggest that typhoons are 2.6 times more likely to occur during ENSO years, with a 71% chance of a typhoon or severe tropical storm striking during an ENSO year, and only a 26% chance of one happening during a non-ENSO year [5, 6]. Much more common are minor storms of the easterly wave type, especially from March to April and October to November [1].

Due to the long distance from north to south, rainfall varies greatly throughout the Marshall Islands. In the wet, southern atolls, rainfall is heavy and can average as much as 160 inches (1,524 mm) per year, while the dry, northern atolls may only average 20 inches (508 mm). There is also a wet and dry season, with the wettest months being between May and November [1]. In 2007, the total rainfall at the Majuro Weather Station was 119 inches (3,014 mm), 13 inches (330 mm) less than the normal annual amount measured between 1970 and 2000. In Kwajalein, it was 89 inches (2,261 mm), also 11 inches (279 mm) less than normal [3].

The Marshall Islands are historically referred to in folklore as "jolet jen Anij" (gifts from God). A God-given sanctuary away from the harshness of other areas is therefore part of the socio-cultural identity of the people. However, they are now often referred to as a "front line state" with regard to the climate change issue. The country has suffered inadequate supplies of potable water as a result of ENSO related events. Moreover, the Marshall Islands lie in open ocean and the average height above sea level of its 1,225 islets in 29 atolls is only 7 feet (2 meters). Fragile coral reefs fringe the atolls, and serve as the only line of defense against the ocean surge. The clearance over the reef in the sections that are covered by water is usually no more than a couple of feet. Given the physics of wave formation and the increasing frequency and severity of storms, the Marshall Islands will likely be at even greater risk. It is likely that evacuation would have to be effected long before inundation is total. The Marshallese would become among the first of many environmental refugees [1].

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Republic of Palau

Palau has a tropical climate with an annual mean temperature of 83.0 °F (28.3 °C) [3] and average humidity of 82%. Rainfall can occur throughout the year, and more frequently between July and October (heavily during December and January [4], averaging a total of 128 inches (3,251 mm) in 2007, which is nearly 21 inches (533 mm) less than the normal amount measured in 30 years from 1971 through 2000 [3]. Normal monthly precipitation exceeds 10 inches (254 mm), and in some years each month has received at least 15 inches (381mm). February, March, and April are the driest months of the year [4]. Winds are generally light to moderate, and the northeast trades prevail from December through March. During April, the frequency of tradewinds decreases, and there is an increase in the frequency of east winds. In May, the winds are predominantly from southeast to northeast [4]. Palau is outside the typhoon belt and is therefore less likely to experience typhoons compared to other places in Micronesia [2]; however, typhoons can happen from June to December.

There are several areas of general environmental concern, including illegal fishing and overharvesting, inadequate facilities for disposal of solid waste in Koror, along with the handling of toxic waste from fertilizers and biocides, and extensive sand and coral dredging in the Palau lagoon [1, 5]. In the last decade, major environmental problems and threats related to climate change has drastically increased. As a result of warming sea surface temperature in 1997 and 1998, mass coral bleaching event occurred. Approximately one-third of Palau's corals died, with coral mortality as high as 90% in some areas [2]. This had severe, adverse impacts on its important marine tourism industry. Sea level rise of low-lying areas is a threat to coastal vegetation, agriculture, and the purity of the nation's water supply. Palau already has a problem with inadequate water supply and limited agricultural areas to support the size of the population. The nation is also vulnerable to earthquakes and volcanic activities [5].

Recognizing its dependence on climate sensitive sectors, Palau has participated in climate assessments and developed adaptation strategies to address risks that have been used in national communications and international negotiations. In addition, Palau has taken proactive conservation measures to protect coastal and marine resources, including implementing permit fees and visitor limits for frequented areas, placing a moratorium on mangrove clearing to protect coastal habitat, and developing marine protected areas to preserve fisheries habitat and resources.

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