Hazards, Climate, and Environment Program
Social Science Research Institute
University of Hawai`i at Mānoa

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Overview of Climate Risk Reduction in the US Pacific Islands Hazard Mitigation Planning Efforts

Prepared by: Cheryl L. Anderson, PhD
Director, Hazards, Climate, & Environment Program

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2424 Maile Way Saunders 719 Honolulu HI 96822
tel 1.808.956.3908 fax 1.808.956.2884 www.hazards-climate-environment.org

Summary of Findings

1) The US Pacific Island states and territories are required by FEMA to develop hazard mitigation plans to receive funds for post-disaster recovery. Hazard mitigation actions and climate change adaptation actions are similar, if not the same, but previously the communities developing hazard mitigation plans are not working with people developing climate adaptation plans. Given the similarities in hazard mitigation and climate adaptation actions, there is an opportunity to improve risk reduction by increasing the consideration of climate risks throughout the hazard mitigation planning process in the US Pacific Islands.

2) The hazard mitigation planning process details entry points for including climate risk reduction and adaptation measures at each phase in the process. The hazard mitigation planning process is explicitly defined in the Stafford Act and states/territories must adhere to hazard mitigation planning requirements, which include: 1) plan approval and adoption; 2) participatory planning process; 3) hazard risk identification and profiling; 4) vulnerability assessment; 5) hazard mitigation strategy and action determination; 6) capability assessment; and 6) plan maintenance and update every three years.

3) Hawai'i and American Samoa identify hazard threats from climate change, although Hawai'i is the only US Pacific Island to attempt to identify potential losses and projected impacts from climate change. Hawai'i's hazard mitigation plan is also the only plan to propose hazard mitigation actions to address climate change.

4) Climate change will exacerbate hazard impacts and necessitate changing the calibration of models for projected impacts. The methods for projecting impacts currently rely on historical records, and the types of impacts will be different from these records. Furthermore, most hazard assessments do not factor in cumulative and secondary climate-related impacts such as those that occur during an El Niño or La Niña cycle.

5) Methods for projecting losses rely heavily on historic damage and economic losses. These records are not consistent for the climate-related hazards. Magnitude of loss based on economic data does not help to prioritize actions, because the losses are not comparable. Qualitative values of impacts and projected socio-cultural losses need to be improved and used in hazard mitigation and climate adaptation planning.

6) Hazard mitigation actions are often similar to climate adaptation actions, although climate adaptation requires a look at longer timescales for addressing impacts and reducing risks. Key areas for climate adaptation include: structural mitigation measures for buildings, including hardening and retrofit, and improved design; 2) building codes, permitting for structures, and enforcement; 3) coastal zone management; 4) conservation and natural resource management; 5) infrastructure and critical lifelines design improvements and hardening; 6) insurance; 7) land use designation and zoning;

8) public health interventions and planning; 9) public education, awareness, and training; and, 10) water resource, floodplain and watershed management.

7) There are several key sectors that need to be considered in hazard mitigation and climate adaptation planning in order to minimize impacts and develop resilience throughout society. These sectors include: agriculture and food security, communications, economy and finance, education, energy, environment, health, society and culture, transportation, waste, and water. Within these sectors, hazard mitigation actions could be improved in agriculture and food security, economy and finance, health, waste, and water.

8) Concentration on capacity building offers a key area to improve education and outreach information and increase local expertise in addressing risks. Capacity building is essential to risk reduction and to developing resilient governments and communities that can adapt to climate impacts.

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Introduction

Hazard mitigation means taking action to reduce or eliminate long-term risk from hazards and their effects. Typically, hazard mitigation actions fall into classifications of structural mitigation (i.e. building codes and retrofits, dam and levee design, drainage systems) and non-structural mitigation (i.e. public awareness and education, permitting and enforcement, laws and regulations, land use designations) and are exercised through land use, floodplain management, coastal management, water resources management, and integrated planning. As the costs of disasters continued to rise through the 1980s and 1990s, the Federal Emergency Management Agency (FEMA) shifted their focus from response to support hazard mitigation that would provide funding *prior* to the impact of a hazard, and therefore, hopefully prevent disaster occurrence. The United States developed a series of hazard mitigation programs administered by FEMA and further revised the *Stafford Disaster Relief and Emergency Assistance Act* to direct US states and territories to conduct hazard mitigation planning. [1]

As the United States emphasized risk reduction through hazard mitigation planning, the focus in the global disaster community supported disaster risk reduction through poverty alleviation and sustainable development, where hazard mitigation becomes a part of the overall framework for addressing risks to impacts from natural hazards. The World Conference on Disaster Reduction "Hyogo Framework for Action 2005-2015" defines disaster resilience in the following declaration: "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 2005, 7). Reducing vulnerability depends on understanding sustainable livelihoods and the capacities, assets, and activities that lead to sustainability (Adger 2006; Chambers and Conway 1992). The consideration, promotion, and development of such assets of a community are critical to fostering sustainable development and disaster resilience (Birkmann 2006; Cannon 2008).[2]

Given the increased awareness of climate change threats to island ecosystems and the ways that climate change is revealed through disasters, it is important to ascertain the degree to which the hazard mitigation plans take climate risks into account. The intent of this report is to review the current hazard mitigation planning documents for the U.S. Pacific Islands, which are guided by requirements from the Federal Emergency Management Agency (FEMA) to determine the ways that climate information has been incorporated into these plans. These include:

- ***American Samoa Revision and Update of the Territory Hazard Mitigation Plan***, 2008.
- ***Commonwealth of the Northern Mariana Islands Standard State Mitigation Plan,*** 2010.

[1] Code of Federal Regulation, Title 44: Emergency Management and Assistance, Part 201 - Mitigation Planning, access November 2011, 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

[2] 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).

- ***2008 Guam Hazard Mitigation Plan***, 2008.
- ***State of Hawai'i Multi-Hazard Mitigation Plan, 2010 Update***, 2010.
    - ***County of Hawaii Multi-Hazard Mitigation Plan***. 2010.
    - ***Kaua'i County Multi-Hazard Mitigation Plan, 2009 update***, 2009.
    - ***Multi-Hazard Pre-Disaster Mitigation Plan for the City & County of Honolulu***, Volumes I and II, 2010.
    - ***Maui County Multi-Hazard Mitigation Plan, 2010***. Volumes I and II, 2010.

Each government preparing the plan determines the list of hazards considered during the planning process, although FEMA provides some suggestions in their guidance documents, which currently do not explicitly mention climate change. It is noteworthy, therefore, that two of the four primary jurisdictions covered in this review explicitly specify climate change in the list of hazards (Hawai'i and American Samoa), and three of the plans discuss climate variability in the hazard identification phase of mitigation planning as part of discussions of extreme climate events, such as drought (Hawaii, CNMI, and American Samoa). The State of Hawai'i is the only mitigation plan that attempts to estimate potential costs from climate change: increased temperatures, loss of water, ecosystem impacts, health impacts, and sea level rise in addition to costs for exacerbating climate-related hazards. The State of Hawai'i also identifies local entities and capacities that are focused on climate risk reduction and proposes some hazard mitigation actions to reduce risks from climate change.

In the United States, development of hazard mitigation plans is compulsory for states and territories; however, there is currently no requirement for developing climate adaptation plans, although there is support from the federal and many state governments for reducing risks from climate variability and change. The hazard mitigation plans currently include severe weather and extreme climate events, such as tropical cyclones, floods, drought, and wildfire. The review of these areas can be strengthened by consideration of the ways that climate variability and change will exacerbate projected impacts. Furthermore, the hazard mitigation plans provide an opportunity to consider additional threats such as coastal erosion, sea level rise, and health-related disasters, and to specifically address climate change in a mandated planning framework. The proposed hazard mitigation actions for climate-related hazards are often the very same actions proposed for climate adaptation. The hazard mitigation plans further offer an opportunity to receive funding for implementation, which means that inclusion and strengthening of climate risk reduction in these plans supports climate adaptation planning, even though direct funding for climate adaptation planning may not be available or may be limited by financial constraints. The importance of strengthening climate risk reduction in the hazard mitigation planning process is the opportunity to leverage resources for achieving similar outcomes in reducing risks to populations, property, resources, economies, and livelihoods.

This report highlights ways in which federal, state, territorial, and local governments may improve their inclusion of climate risk reduction in the hazard mitigation planning process, which will in turn inform climate adaptation planning and increase resiliency in overall disaster risk reduction.

2.0 Background on FEMA Requirements and Disaster Risk Reduction

This report is limited to an overview of the required hazard mitigation plans. The significance of these plans is that their development is established legislatively. 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.[3]

As a result of continued increases in disaster response and recovery costs into the 1990s, the Federal Emergency Management Agency (FEMA) and the United States Congress provided funds to communities, counties, and states to reduce impacts from natural hazards through hazard mitigation *prior to* the occurrence of the hazard. Changes in federal laws, with amendments to the Stafford Act, resulted in pre-disaster mitigation project funding and detailed mitigation planning requirements. Each state and county must have a mitigation plan that identifies steps to reduce impacts from hazards. If the State, Territories, and Counties do not have approved plans in place and a disaster occurs, they will not be entitled to public assistance and other FEMA funding. Access to disaster recovery funding remains the primary incentive for governments to adhere to mitigation planning requirements.

2.1 U.S. Pacific Islands Participation in Hazard Mitigation Planning

Among the U.S. Pacific Islands, there are four places that are eligible for funding and resources from FEMA. These include: American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), Guam, and Hawai'i. These jurisdictions are required to develop standard state mitigation plans, which must be updated every three years. In Hawai'i, the four counties (City & County of Honolulu, Hawai'i, Kaua'i, and Maui) are required to prepare local mitigation plans in order to be eligible for hazard mitigation grant funding, which must be updated every five years.

In the past, FEMA provided funding to the Federated States of Micronesia, the Republic of the Marshall Islands, and the Republic of Palau, but responsibilities changed with renegotiation of the Compacts of Free Association that establishes the relationship with the United States for access to funding, technical assistance, and other specified resources.[4] Since the Freely

[3] 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

[4] An associated state is the minor partner in a formal, free relationship between a political territory with a degree of statehood and a (usually larger) nation, for which no other specific term, such as protectorate, is adopted. The details of such free association are contained in United Nations General Assembly resolution 1541 (XV) Principle VI, a Compact of Free Association, and are specific to the countries involved. Under the Compact Agreements, the Freely Associated States are entitled to US postal services and subsidies in postal mailing rates, establishment of the local Weather Service Offices supported by the US NOAA National Weather Service Pacific Regional Headquarters, the USDA Natural Resources Conservation Service technical assistance, Capital Improvements grant

Associated States (FAS) are not eligible for the same levels of planning assistance, they are not required to adhere to the hazard mitigation planning process as the state and territorial governments. For this reason, these three will not be considered in this report because the policies and support for disaster risk reduction have been developed through separate, regional and international arrangements. The FAS have begun to integrate disaster risk reduction and climate change adaptation in their national action plans through regional assistance programs, and these programs guide eligibility for funding to implement risk reduction actions. Given the similarities of the FAS in development of disaster risk reduction plans, and the similarities of the US territories and states in risk reduction support, the FAS will not be considered in this report that focuses on FEMA-required hazard mitigation plans and the opportunities in these planning processes to integrate climate risk management approaches.

2.2 Plan Approval and Implementation Significance

Each of the plans requires extensive review and approval by FEMA to enable access to funding assistance and to remain in compliance with the hazard mitigation provisions of the Stafford Act. At a federal level, the oversight ensures adherence to a standardized process for developing and updating the plans. FEMA approval legitimizes the hazard mitigation plan and the actions identified as part of the risk reduction strategy, such that proposed programs, policies, projects, and other mitigation actions become eligible for funding and support.

The Standard State Hazard Mitigation Plan requirements ensure that the state or territorial governments adopt the mitigation plan at the highest level of government to ensure implementation and enforcement of the plan. The multi-hazard mitigation plans for American Samoa, CNMI, Guam, and Hawaiʻi have been adopted by the Governors through Executive Orders. The process requires the establishment of multi-sector disaster management committees with key officials or agency leads, which ensures integration of needs from many sectors in the recommendations for projects and hazard mitigation actions.

The inclusion of climate risk reduction in the hazard mitigation plans would strengthen the plans and would provide support for implementation of climate risk reduction actions. Funding may become available through annual competitive processes or post-disaster funding programs to address identified mitigation actions. Federal agencies besides FEMA can work with local jurisdictions to leverage funding since there has been vetting of the mitigation actions through established, approved processes. This means that the inclusion of climate risk management and climate change adaptation within the plan have government support, and it is possible to access funding to address identified risks.

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funding, and Federal Aviation Administration (FAA) assistance. Until 2008, the Federated States of Micronesia and the Republic of the Marshall Islands received disaster assistance through FEMA. The renegotiated compacts shifted disaster assistance responsibilities for these two places to the US Agency for International Development (USAID) Office of Foreign Disaster Assistance (OFDA), which already administered aid to the Republic of Palau in emergencies.

3.0 Plan Requirements and Organization

To better understand the entry points for potential inclusion of climate adaptation into the disaster risk reduction efforts in the US Pacific Islands, it is important to understand the requirements of the hazard mitigation plans. There are two approaches used in the plans to consider climate. First, each of the climate-related hazards (such as tropical cyclones, drought, and flooding) individually identified by the government in the plan will undergo consideration in the planning process steps of hazard identification, risk and vulnerability assessment, mitigation actions, and implementation. The eight plans reviewed in this paper (for American Samoa, Guam, CNMI, State of Hawaiʻi, County of Maui, City & County of Honolulu, County of Hawaiʻi, and County of Kauaʻi) assess climate related hazards in each of the required steps.

In the second approach for discussing climate in the hazard mitigation plans, climate variability and change may be discussed separately as a hazard, with discussions of climate-related effects as hazards, including sea level rise, increasing temperatures, and changes in extreme weather events. In the hazard identification process, the State of Hawaiʻi, the County of Kauaʻi, and American Samoa directly specify climate change in the list of hazards. Guam and CNMI also highlight climate variability as it exacerbates impacts of climate-related disasters in the first approach. The State of Hawaiʻi Multi-Hazard Mitigation Plan specifies risk and vulnerability related to climate change, extreme climate events, and sea level rise, and attempts to provide loss projections and increased risks of health-related disasters and technological disasters as climate change exacerbates the impacts of these hazards.

These two approaches used for addressing climate risks will be discussed in the next section, which details the required planning process and the places where climate risks have been included in the plan. The ways that each jurisdiction currently addresses climate is highlighted with each requirement. The next section further summarizes the points of entry where climate risks and their impacts can be inserted using the directed process.

In order to understand the legal requirements in each of the phases---planning process, risk and vulnerability assessment, mitigation strategy and actions, capability assessment, and maintenance and plan update---the Stafford Act pertaining each phase has been included in the boxes throughout Section 3. The information in the boxes is important because it follows the strict guidance used to evaluate the hazard mitigation plans and attain approval. Within each of these elements, it is possible to identify entry points for the ways in which climate risks can be addressed in the context of disaster risk reduction.

3.1 Planning Process

> PLANNING PROCESS: *§201.4(b): An effective planning process is essential in developing and maintaining a good plan.*
> Documentation of the Planning Process
> ***Requirement §201.4(c)(1):*** *[The State plan **must** include a] description of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated.*

Coordination Among Agencies

Requirement §201.4(b): The [State] mitigation planning process ***should*** *include coordination with other State agencies, appropriate Federal agencies, interested groups, and…*

Program Integration

Requirement §201.4(b): [The State mitigation planning process ***should****] be integrated to the extent possible with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives*

Source: Code of Federal Regulation, Title 44: Emergency Management and Assistance, Part 201 - Mitigation Planning

In designing an appropriate planning process, each of the island jurisdictions established an advisory committee. The role of the committees was to: 1) identify the hazards that would be included in the plan; 2) provide technical information in support of the risk and vulnerability assessment; 3) identify hazard mitigation goals and mitigation actions; 4) review the strategy; 5) identify an implementation plan and review maintenance and updates to the plan; and, 6) approve the plan and recommend adoption to the Governors. The State of Hawaiʻi advisory body, the Hawaiʻi State Hazard Mitigation Forum, has adopted a formal set of by-laws establishing rules for membership, meeting attendance, roles and responsibilities, and voting requirements. Other jurisdictions have established these advisory bodies through the plan development process and the executive order that adopts the plan.

The membership of these multi-hazard advisory groups generally includes: state disaster managers and hazard mitigation officers; state resource managers (water, coastal zone, shoreline, forestry, wildfire, solid waste, floodplain, land management); state planners (including land use, statistics, and GIS); health and environmental protection managers; public works and building managers; structural engineers; civil engineers; meteorologists; geologists; university researchers; utilities managers; public outreach coordinators; and, civil society organizations (Red Cross). Many of these organizations have federal ex-officio or non-voting members from FEMA, Homeland Security, the military, the National Weather Service, US Geological Survey, and the Army Corps of Engineers.

3.1.1 Climate Change Integration in the Planning Process

The inclusion of climate change considerations in the hazard mitigation planning processes may be guided by the expertise of the advisory committees and planning teams that coordinate and facilitate the development of the documents. During the development of the plan and the update process, the advisory committee is consulted about the list of identified hazards. In the State of Hawaiʻi, several advisory committee members and decision makers in disaster management specified inclusion of climate change, climate extremes, and sea level rise.

The required planning process requires extensive consultations with stakeholders in disaster risk reduction. These include leaders, decision makers, and resource managers in both the public and private sectors related to disaster risk reduction. This further specifies involvement of communities and local jurisdictions impacted by hazards. One component of the consultation process is the opportunity to educate decision makers, communities, and the general public about disaster risks and specifically about climate impacts. In addition, the participatory meetings have enabled the planning teams to ground-truth the results of the risk and vulnerability assessments and verify that mitigation actions will have positive consequences for communities. In some community meetings, the consultation process helped to discover localized impacts, such as effects on cultural and sacred sites or areas where poor drainage systems or building designs has resulted in disaster.

By increasing participation in risk reduction efforts, more capacity is built in organizations, institutions, and communities to deal with disaster risks and to identify coping mechanisms that will help to build resilience to disaster impacts. Since the exact degree of the impacts from climate change may not be certain, the public awareness aspects of the planning process aid in increasing knowledge about the risks and empower people to make decisions about the ways that they will address these risks at all levels---household, community, island, county, and state/territory levels.

3.2 Risk and Vulnerability Assessment

> RISK ASSESSMENT: *§201.4(c)(2): [The State plan must include a risk assessment] that provides the factual basis for activities proposed in the strategy portion of the mitigation plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview. This overview will allow the State to compare potential losses throughout the State and to determine their priorities for implementing mitigation measures under the strategy, and to prioritize jurisdictions for receiving technical and financial support in developing more detailed local risk and vulnerability assessments*
> Identifying Hazards
> *Requirement §201.4(c)(2)(i): [The State risk assessment **shall** include an] overview of the type … of all natural hazards that can affect the State*
> Profiling Hazards
> *Requirement §201.4(c)(2)(i): [The State risk assessment **shall** include an overview of the] location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate*

Source: Code of Federal Regulation, Title 44: Emergency Management and Assistance, Part 201 - Mitigation Planning

The risk assessment aspect of the planning process requires identification and profiling of the natural hazards that affect the jurisdictions. Historical data on the magnitude and frequency of hazards is used to characterize most hazards. Databases of hazards with occurrence, degree of impact, and costs associated with the hazard have been developed in each jurisdiction during the development of the first hazard mitigation plans required in 2002 to 2004. Appendix A lists the hazards identified in each mitigation plan and highlights the climate-related hazards.

The climate-related hazards identified in the plans include: 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. Two of the hazards have been shaded in lighter color in Appendix A, because climate change could heighten impacts, but were not directly responsible for these kinds of disasters, especially as they were considered by the teams preparing the plans. Climate change and extremes were not identified as the cause of dam and levee failure or of health-related disasters in the hazard mitigation plans specifically; however, extreme weather exacerbated the conditions for dam failure in 2006 in Kauai, but the cause was due to lack of maintenance of the dam system. Although climate variability and climate has direct impacts on heat stroke, dengue fever, malaria, and water-borne disease, other epidemics and diseases considered in the hazard mitigation plans, such as AIDS, HIV, and gonorrhea, do not have a clear link with climate change. Other hazards listed in the plans and Appendix A do not have a clear climate component and have not been highlighted; however, it is, important to use a multi-hazard framework for risk reduction because the incidence of cascading and multiple hazard impacts during recovery can overwhelm communities and governments. For example, the 2006 earthquake in Hawaiʻi caused significant damage to irrigation systems just prior to the onset of an ENSO drought, which resulted in severe impacts to the Hamakua agricultural community even though the initial problem stemmed from a seismic-related hazard.

The hazard profile requires the statement of probability of future hazard events. Each jurisdiction is required to provide data on the number of occurrences of the hazard and frequency of occurrence using historical records. Of the climate-related hazards, there is good long-term data on hurricanes and floods, but often the data availability for other hazards is scant and the risk models are poor, if they even exist.

Geographic Information Systems (GIS) have been developed in the four jurisdictions and is used in profiling hazards. Many of the slow onset hazards do not have an easily identifiable spatial footprint, such as a flood event, which makes identification of the exposure and sensitivity to the hazard risk difficult. Because of this difficulty, the hazard mitigation plans must use the standard of ***best available data***. This means that there are many unknown aspects of disasters that have not been factored into the assessments. The requirements for updates to the hazard mitigation plans enable newer data and better studies to be incorporated in the assessment.

To get better assessments of probabilities, hazard scenarios have been developed and modeled to understand future risks, but the models require use of good, consistent records. For extreme rainfall and wind events, NOAA National Weather Service has good historical datasets. Events, such as drought and landslides, have multiple definitions and the data may be held by different organizations or long-term records may not be available. Even before factoring in the added impacts from climate change, it is difficult to assess the probability of future occurrence based on available data.

3.2.1 Climate Change in the Risk Assessment

Not all of the US Pacific Island hazard mitigation plans consider the extent of climate-related risks in the hazard identification and profiles. The plans have varying degrees of information for severe weather and extreme climate events. Hawai'i is the only jurisdiction to include assessments of sea level rise, even though all islands will have risks from sea level rise and sea level rise further increases the risks from coastal inundation threats during tropical storms. The degree to which drought and wildland fire risks have been included varies by perception of the risk, such that Guam has not developed assessments on these risks in great detail because they do not suffer from drought as much as the atoll islands throughout Micronesia. Should the hazard mitigation plans include climate variability, climate change, and sea level rise in addition to the climate-related hazards and extremes in the hazard identification phase, the jurisdictions strengthen opportunities for support to better understand these risks. Since climate change will likely exacerbate impacts from the extreme climate events identified in the plans, the inclusion in the risk assessment will lead to improved knowledge of risks.

Climate change further complicates the requirements to identify the degree of risk and probability of future events. Models and assessment tools provide information for some of the natural hazards: hurricanes/typhoons, earthquakes, flooding, tsunami inundation, coastal inundation from storm surge, and erosion rates. The standard is to use the best available data, but many datasets have not been maintained long enough to understand trends and probabilities of occurrence. The added impacts to severe weather events, such as increase in frequency and magnitude, are still argued among climate scientists, although most conclude that the cumulative impacts of sea level rise combined with severe storms and coastal inundation could devastate islands. These factors have not been adequately included in the risk assessments of the Pacific Islands in the hazard mitigation phase. Even the jurisdictions that discuss climate change impacts do not have good probabilistic data on future event occurrence and frequency.

Rapid changes in climate have altered the calibration and the skill in predictability of many models. An increase in sea level rise will alter the degree of coastal storm inundation, but questions remain as to the degree of change. Climate change complicates analysis of risks and predictability of occurrence. Since factoring climate change into the assessments complicates the analysis of hazard risks and since much of the data to conduct analyses are lacking, there remains significant opportunity to substantially improve hazard analyses through modeling hazard events and probabilities. Furthermore, most hazard assessments do not factor in cumulative and secondary climate-related impacts such as those that occur during an El Niño or La Niña cycle.

3.2.2 Climate Change in the Vulnerability Assessment

> Assessing Vulnerability ...[by Jurisdiction] and [of State Facilities]
> *Requirement §201.4(c)(2)(ii): [The State risk assessment* **shall** *include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State* **shall** *describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State owned critical or operated facilities located in the identified hazard areas shall also be addressed*
> *Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development*
>
> Estimating Potential Losses
> *Requirement §201.4(c)(2)(iii): [The State risk assessment* **shall** *include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State* **shall** *estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas*
> *Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development*

Source: Code of Federal Regulation, Title 44: Emergency Management and Assistance, Part 201 - Mitigation Planning

Understanding the monetary costs associated with disasters are important for targeting risk reduction efforts and for justifying funding allocations for hazard mitigation actions. Climate-related hazards represent the greatest number of recorded disasters, but there are missing data in terms of the disaster impact. Records are inconsistent even within the same hazard. The best data comes from disaster declarations that received FEMA assistance. For the Pacific Islands, the data from tropical cyclones—hurricanes and typhoons---appear to be the best available, yet, there are cyclones where damage statistics are missing. Although the records of storm occurrence date back into the 1800s, the records of costs and damages do not date back further than 1950 for any of the jurisdictions.

Even though the information in Table 1 shows that climate-related disasters have resulted in significant costs to Pacific Islands, the missing data and inconsistent records indicates that the actual impact costs are greatly underestimated. The data does not provide a cost for intangible or ineligible items in damage assessments and does not include values for the loss of life or livelihoods. The lack of damage records highlights the need for consistency and quality of disaster data. The dates of timelines and the inflation rates associated with the estimates are not consistently reported. There are few means of comparing disasters reported each year since the rates may be reported in the year of impact or may be recalculated with inflation calculators during the year that the hazard mitigation plans were updated. The estimated damages for climate-related hazards reported in the U.S. Pacific Islands' mitigation plans are roughly as follows:

Table 3-1. Recorded and Reported Historical Damages from Climate-Related Hazards.

	Climate-Related Disasters with Recorded Losses	Recorded Losses from Disaster Events	Total Recorded Climate-Related Hazard Loss
American Samoa	Tropical Cyclone/Hurricane	$ 188,023,000	
	Heavy Rainfall/Flood	$ 9,525,000	
	High Surf (Not recorded separately from losses in tropical cyclones/hurricanes.)	-	
	Landslide (Not recorded separately from losses in heavy rainfall event.)	-	
	Total American Samoa	**$ 197,548,000**	**$ 197,548,000**
CNMI	Tropical Cyclone/Typhoon	$ 75,626,757	
	Total CNMI	**$ 75,626,757**	**$ 75,626,757**
Guam	Tropical Cyclone/Typhoon (since 1962)	$ 2,017,611,796	
	Hazardous Surf (associated w/Cyclone)	$ 4,000,000	
	Drought (losses not recorded)	-	
	Wildland Fire (losses not recorded)	-	
	Total Guam	**$ 2,021,611,796**	**$ 2,021,611,796**
Hawaiʻi	Tropical Cyclone/Hurricane (since 1980)	$ 3.499,000,000	
	Flooding/ Heavy Rainfall	$ 256,700,000	
	High Surf	$ 12,900,000	
	Drought (since 2000)	$ 19,502,790	
	Wildland Fire (since 2007)	$ 2,905,762	
	Total Hawaiʻi	**$ 3,791,008,552**	**$ 3,791,008,552**
TOTAL			**$ 6,085,795,105**

Source: Figures extracted from eight hazard mitigation plans—American Samoa, CNMI, Guam, Hawaiʻi, and Hawaiʻi Counties of Hawaii, Maui, Kauai, and Honolulu---listed in the references section of this document.

Table 1 shows the estimates for climate-related hazard losses in the Pacific Islands at well over $6 billion; yet, these estimates do not include hazard losses that may be chronic, such as flooding and coastal erosion, and that do not have presidential disaster declarations. Although hazard occurrence records date back to 1800s for heavy rainfall and some hurricanes, the records of loss statistics may not date back further than the 1960s, and records are inconsistent by jurisdiction, by hazard, and by event occurrence. The lack of loss data is significant because the costs are used to generate political support for risk reduction activities, and without good information, it is difficult to weigh the severity of the potential disaster and garner the support to reduce risks.

Data on climate-related losses are under-reported. Many of the climate-related hazards investigated in the hazard mitigation plans (see Appendix A) do not have data on historical losses. The recorded loss amounts are based on the total damages paid by FEMA and the US Department of Agriculture to those eligible to claim losses. The loss estimates are missing records on damages in every hazard, but the loss data is worse for every hazard besides tropical cyclones (hurricanes/typhoons) and floods. There are no reported loss data in the hazard mitigation plans for: coastal erosion, coastal inundation/storm surge (although this may be aggregated with storm loss disaster declarations), extreme heat, landslides/mud flows/debris flows (unless aggregated with flood loss disaster declarations), lightening, strong winds (unless part of a disaster declaration), and wildland fires (unless losses were paid as part of a disaster declaration).

Because of eligibility criteria, some people who are impacted by disaster, specifically drought, are ineligible for assistance programs (based on size of farms or ranches, ownership of land, long-term leases, etc.). The impacts to employment and the economy from drought and climate-related disasters are, therefore, well underestimated when referencing historical loss data. Furthermore, reported losses are only from disasters large enough to have declarations,[5] which means that chronic losses from increased flooding events may not warrant relief assistance but may result in severe individual losses and increased localized vulnerability to flooding.

Identifying the costs associated with potential losses is complicated. There are numerous methods, and these methods are dependent on the quality of the data, requiring well maintained, long-term data sets to provide robust analysis on risks. In many of the island jurisdictions, long-term loss records have not been kept consistently or were lost during severe storms. Federal agencies may have data on losses related to payments for their particular programs and technical assistance provided following a disaster, but often these were not accumulated in a single record. Several agencies and organizations working on different recovery aspects of one disaster event will keep separate records. The information is often inaccessible at the jurisdictional level, and this complicates the development of the hazard mitigation plans since the plans demand use of the best available data and the hazard mitigation planner may not have access or knowledge of all the costs associated with previous disaster response and recovery operations and scientific modeling efforts.

The types of loss models accessible and useful to each jurisdiction are not consistent. The table in Appendix B provides a list of estimated loss projections for future hazards with the methods used for assessment. The requirement is that each of the hazards identified and profiled in the plan should include estimate future loss projections based on ***best available data***. Most of the island jurisdictions rely on community vulnerability analyses using quantitative and qualitative data, where available, but are primarily based on historical loss records with some trends analysis and extrapolation for future losses. The disasters that have a distinct spatial footprint, such as tsunami inundation or flood zones, can be integrated with asset layer data (such as critical facilities, houses, and infrastructure) to determine the types of loss from impact. As

[5] Disaster declarations require the State or Territory to verify that the amount of loss to public facilities, infrastructure, and residences exceeds the ability of the State or Territory to cover the costs of the damages. A Presidential declaration must be made in order to receive federal funding assistance through the Federal Emergency Management Agency. FEMA covered disasters in the Pacific region include: tropical cyclones (hurricanes, typhoons), flooding (heavy rainfall and coastal inundation), flood associated with dam and levee failure, earthquake, tsunami, and landslides. Special programs in FEMA cover wildfire disasters and assistance for water and food delivery have been provided in severe droughts. Drought declarations are made by the state and the US Department of Agriculture (USDA). The USDA Farm Service Agency (FSA) administers relief assistance to the agriculture sector, which usually experiences the largest impacts from drought. Eligibility requires land ownership or long-term leases (10-years or more) to secure funding assistance, which means that farmers on short-term leases cannot access many relief assistance programs.

more sophisticated modeling for a particular hazard is developed, the spatial footprint of the disaster improves and provides better data for projecting impacts from single events. One of the more sophisticated loss models, HAZUS-MH, has been developed for earthquakes, hurricanes, and flooding, but only the State of Hawaiʻi has had success in using this FEMA-developed tool. When the model has been reviewed in light of recent disasters to see how well the model predictions reflected actual disaster impacts, the results varied. Earthquake models tested well; hurricane/typhoon events could be calibrated effectively but required modifications to account for topographic effects on wind risks; and flood results did not align with costs associated from flooding disasters.

The HAZUS-MH can depict average annualized losses (AAL) for disasters that try to provide a picture of how costly each disaster will be on an annual basis, and is used to calculate insurance coverage. The AAL for hurricanes and flooding result in millions annually to cover loss of structures and content. For other hazards where spatial analysis and location are relevant to exposure and sensitivity, the use of Geographic Information Systems (GIS) showing hazard extent related to buildings, infrastructure, utilities and critical lifelines, environmental features, and natural resources can be used to look at the features affected during scenarios depicting different levels of severity.

The current estimates do not provide the full impacts of disasters. The AAL costs from the model are estimate of replacement costs and most of them do not contain cost dues to disruptions on economy nor do they contain estimated values of probable human casualty. The FEMA Benefit-Cost Analysis (BCA) method allows for including such factors as disruption of functionality and loss of life to justify mitigation actions. If all such costs of disasters are aggregated, then a true cost would be higher than the current estimates.

To get better accuracy on the types of impacts expected from the hazard, models demand baseline data on the assets and features that will be impacted, such land use, infrastructure, structures, development plans, and social and environmental factors. There need to be improved methods to record losses and socioeconomic impacts to begin to understand the magnitude of climate-related disaster impacts. Since climate change may increase the frequency or intensity of climate extremes, planning efforts should consider future costs of these impacts. Improved record keeping and economic analyses will be important to justify funding that supports climate risk mitigation and climate adaptation planning.

3.3 Mitigation Strategy and Actions

> MITIGATION STRATEGY: *§201.4(c)(3) [To be effective the plan must include a] Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment*
> Hazard Mitigation Goals
> *Requirement §201.4(c)(3)(i): [The State mitigation strategy* ***shall*** *include a] description of State goals to guide the selection of activities to mitigate and reduce potential losses*
>
> *Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities*

Mitigation Actions

Requirement §201.4(c)(3)(iii): [State plans **shall** *include an] identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section* **should** *be linked to local plans, where specific local actions and projects are identified*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities

Source: Code of Federal Regulation, Title 44: Emergency Management and Assistance, Part 201 - Mitigation Planning

Hazard mitigation actions underway through agency or organization mandate or regulations en force or proposed to reduce risk in the US Pacific Island hazard mitigation plans typically fall into the following categories: 1) structural mitigation measures for buildings, including hardening and retrofit, and improved design; 2) building codes, permitting for structures, and enforcement; 3) coastal zone management; 4) conservation and natural resource management; 5) infrastructure and critical lifelines design improvements and hardening; 6) insurance; 7) land use designation and zoning; 8) public health interventions and planning; 9) public education, awareness, and training; and, 10) water resource, floodplain and watershed management. In Table 3-2, the primary areas of hazard mitigation are further clarified through the types of actions that fall in these areas and the multidisciplinary types of expertise and capacity recommended in implementing these actions.

Table 3-2. Types of Hazard Mitigation Actions and Recommended Expertise

Key Hazard Mitigation Areas	Types of Actions	Recommended Expertise
Building and Facilities - Hardening structures and relocation of critical facilities	Install metal hurricane straps or clips to secure roof; Secure facility and building openings, such as installing shutters; Construct safe rooms to use for sheltering in place; Install steel posts and groundings; Install fire-proof roofing shingles and materials; Secure openings and vents from wildfire smoke and embers; Raise elevation of floors and electrical systems above base-flood elevation; Remove debris and loose items from surroundings; Use waterproof paints and caulking; Assess structural risks of critical and essential facilities; Provide and maintain emergency generation; Store solar power and secure solar panels; Relocate facilities out of inundation pathways; Identify mitigation options as conditions in building permit provisions	Structural engineers, electrical engineers and contractors, architects, building contractors, planning and permitting officials, plumbers, modelers, geospatial planners and technicians
Building Codes	Develop, implement, and enforce International Building Codes (IBC) with amendments addressing localized hazard risks; Train engineers and contractors on new codes for implementation; Enforce codes through regulations, inspections,	Structural engineers, civil engineers, architects, public works officials, planning and permitting officials, inspection agents, hazards researchers

	and penalties	
Coastal zone management	Develop setback rules from the shoreline for development; Model and map coastal inundation and flood risks; Ensure access to resources; Regulate use and minimize risks through Special Management Use permits	Coastal geologists, coastal resource managers, environment managers, lawyers, geospatial planners and technicians
Conservation and natural resource management	Develop fire risk maps and assessments of resources for fighting fires; Identify historical and natural preservation sites; Map and inventory natural and cultural resources; Regulate use and enforce restrictions in sensitive areas	Ecologists, botanists, agriculture extension agents and land management specialists, landscape architects; indigenous scientists; archaeologists
Critical Lifelines and Infrastructure Improvement	Place utility lines underground (electrical, telecommunications); Raise roadways; Relocate roads inland; Develop bypass roads; Harden bridges	Transportation engineers and planners, bridge engineers and planners, civil engineers, local planning and permitting officials, telecommunications officials and companies; power utilities companies and commissions
Insurance	Develop insurance for public, private, and residential use; Ensure accessibility to those needing hazard insurance in terms of pricing and type of hazard; Disclose risks in property purchases; Develop risk maps and risk zones for identifying risk, development, and recovery funding; Build public awareness on insurance availability; Set aside contingency funds to support under-insured populations; Provide incentives for residential rate reductions	Insurance commissioners, insurance agents, claims adjusters, re-insurance agencies, economists, financiers, real estate agent, property developers, hazard scientists and modelers, hazard risk researchers
Land Use and Management	Designate land use (conservation, agriculture, urban); Zone use (residential, commercial, commercial agriculture); Identify and secure conservation buffers around streams and coastal areas; Secure defensible space between vegetation and wildlands, especially in urban interface; Regulate development and special use	Land use planners, surveyors, land use attorneys, land use commissioners/decision makers, conservation and environmental engineers, resource managers, cultural practitioners, indigenous scientists, archeologists, agronomists, landscape architects, geospatial planners and technicians
Public health interventions	Develop protocols for assessing health risks and minimizing spread of disease; Inventory and stock medical supplies and medications; Pre-position supplies at key distribution and mass sheltering centers; Develop a plan for securing medical expertise in crisis for trauma, emergency, pregnancy, and psychological health; Ensure environmental health through clean water, working drainage systems, and sewerage system maintenance	Public health officials, medical doctors specializing in trauma, obstetrics, and psychiatry, disease pathologists, medical geographers and anthropologists, first aid and CPR certified responders and community members, dispensary workers, water inspectors, environmental health specialists, water engineers, public works officials,
Public education,	Integrate hazards science in formal	Educators and curriculum

awareness, and training	education; Develop culturally appropriate informal education on hazards through workshops, informational booths at public venues and fairs, media programs (radio, television), and collaboration with non-governmental organizations	development specialists; Public relations and public affairs specialists in public agencies; outreach specialists in non-profit organizations; cultural practitioners
Water resource, floodplain, and watershed management	Develop and enhance storage and distribution systems; Minimize system leakage and maintain pipes; Map flood risks and conduct vulnerability assessments; Engage insurance industry to cover flood losses; Restrict building permits to include heights above base flood elevation; Design coastal structures with breakaway walls and areas for water flow; Design ponds and settlement basins; Integrate water use from streams into irrigation schemes; Inspect and maintain dams and levees; Provide tools for the general public to assess the flood risk of residential properties; Plant fire-resistant vegetation; Install irrigation in high-risk locations; Restrict water use; Implement conservation programs	Hydrologists, meteorologists, forestry, conservation, and resource managers, dam engineers, water engineers, indigenous resource managers, drought managers, architects and land developers, flood risk modelers, geospatial planners and technicians, public works officials, cultural practitioners, indigenous scientists, agriculture extension agents and land management specialists, landscape architects

Sources: State of Hawaiʻi, 2010; American Samoa 2008; Commonwealth of the Northern Mariana Islands 2010; Guam 2008; Federal Emergency Management Agency 2003; Insurance Institute for Business and Home Safety 2012; Natural Resource Conservation Service 2012; Brnich and Mallett (US Department of Health and Human Services, Centers for Disease Control and Prevention, and the National Institute for Health and Occupational Safety) 2003; University of Hawaiʻi School of Ocean, Earth Science and Technology (SOEST), Department of Meteorology, and the Social Science Research Institute (SSRI) 2003.

The hazard mitigation actions provide tools to deal with hazard risks. These tools can be implemented by government agencies, non-governmental organizations, private businesses, homeowners, or geographically-defined communities. Many actions defined as hazard mitigation actions may be the same as those that are considered climate adaptation actions. These are actions that have been determined in response to results from risk and vulnerability assessments. Often, the difference in the approaches to determining actions is based on temporal scale, where many climate adaptation actions will be in response to perceived future risk of ten to fifty years, and hazard mitigation actions are often determined based on lessons learned from a previous hazard, using historical occurrence to identify the action. Nonetheless, many hazard mitigation actions involve construction and types of activities that are implemented as a long-term solution. Facilities, infrastructure, and water storage systems will be designed for 30-50 year timeframes. Given that the hazard mitigation actions will have an expected longer-term project life, it is important to assess the added vulnerability that climate change will have on the disaster.

Since the impacts from climate variability and change vary greatly by hazard and across sectors, it may be difficult to ascertain the hazard projections to use in climate adaptation planning;

however, the consideration of a range of possible threats can be factored into the design and implementation of the actions. For island jurisdictions, the threat of sea level rise is clear, but the degree of variation is less certain. When considering shoreline development and hardening critical facilities and infrastructure, it will be important to consider the range of projected sea level rise through the life of the project, and determine actions that have consideration of the impacts from increased levels of storm surge and coastal inundation even though the sea level rise will be incremental. Rainfall variation from extremes of drought to flooding have already impacted island ecosystems, and studies are determining some of the future projections for rainfall, which can be factored into proposed flood and drought mitigation actions. Extreme temperatures may have a great impact on flora and fauna that help maintain healthy ecosystems and watersheds, and threats to particular species will likely increase the vulnerability of the ecosystem to respond to climate extremes. These considerations are important to include in the development of hazard mitigation actions.

In Table 3-3, the type of hazard mitigation actions that have been proposed in the hazard mitigation are described by sector relevance. The third column considers the way that the actions can be conceived in order to also contribute to climate adaptation, such that the hazard mitigation plans will become more robust in considering ways to address current identified risks as well as projected risks from climate change.

Table 3-3. Hazard Mitigation and Climate Adaptation Actions by Sector

Sector of Impact	Hazard Mitigation Action	Climate Adaptation Action
Agriculture & Food Security: food growth and production	Ensure availability of water resources; Plant drought-resistant crops; Enhance food preservation techniques; Develop drought mitigation and contingency plans at the community and farm-scale levels; Preserve seeds and grow young plants and clippings in a nursery for use in recovery planting	Same actions in context of increased extremes and need for food; Identify rainfall trends and use to inform water resource enhancement; Factor population trends for food requirements; Preserve land for agricultural use; Maximize alternative space for growing food (i.e., rooftop gardens, urban gardens, indoor/ window spaces, hanging gardens)
Agriculture & Food Security: distribution, infrastructure	Identify and secure storage facilities for use in post-disaster response and recovery; Harden storage facilities, especially those sited near designated shelters and mass recovery operations centers; Ensure energy for freezing & food preservation; Provide staging areas or containers for food at population centers; Engage in agreements with stores and distribution centers to ensure food availability in disasters	Same actions with longer timeline for availability of food and water in crises; Provide incentives and ensure transportation mechanisms to "buy local" foods; Develop mechanisms to transport goods among local communities to sustain local economies post-disaster
Communications: information distribution	Develop informational materials for climate-related hazards in multiple languages (for non-native speakers, visitors); Develop a warning system and clear messaging of system use for multiple hazards	Same actions for communicating risk from extreme climate events; Deliver consistent, clear messages on added impacts from climate change
Communications: infrastructure & systems operations	Enhance system redundancy; Install underground lines and/or high wind-rated poles for utility lines.	Same actions for hardening system and developing redundancy; Develop energy efficient/ renewable energy in operations; Site lines &systems in 'climate-proofed' facilities
Economy and Finance	Hardening financial institutions; Hardening facilities for key economic industry/drivers; Business	Develop 'climate-proofed' institutions; Harden connections to enhance electronic monetary

	contingency plans to ensure functionality post-disaster; Ensure protection of labor, staff, and human resources; Ensure operations continuity and hardening of electronic monetary system	and transfer system
Education: formal and informal education, public awareness, training, capacity building	Develop hazards science for K-12, college curricula; Develop and implement training for engineers, government, first responders, educators, communities	Develop additional climate science curricula; develop outreach materials for communities to use in location-specific climate adaptation projects
Education: systems, campuses, facilities, infrastructure	Harden facilities; Designate shelter spaces and storage for emergency response and post-disaster needs; Develop contingency plans to ensure system functionality	Climate-proof facilities; Harden and relocate infrastructure
Energy: infrastructure, distribution	Harden key facilities; Harden power poles or place wires underground; Ensure fuel storage availability for transport for recovery;	Climate-proof infrastructure; Relocate critical infrastructure underground or inland
Energy: supply and use	Develop renewable energy sources; Encourage conservation programs; Provide incentives for 'Energy Star' appliance use; Ensure widespread access to resources; Increase native and endemic vegetation near buildings for natural cooling effects	Use renewable energy sources; Ensure social justice and access to energy resources
Environment: forests, terrestrial ecosystems	Develop fire breaks; Develop water dip tanks for fire suppression; Maintain groundwater recharge areas; Stabilize stream banks; Engage in watershed management to protect water resources; Reduce invasive species; Promote conservation and biodiversity	Conduct same actions in context of longer timelines and expected extremes of impacts; Prioritization of funding allocation and resources to save impacted environments; Promote conservation and enhance carbon sequestration methods
Environment: coastal zone, wetlands, sand dunes, anchialine ponds	Ensure setback laws from ocean & streams; Stabilize shoreline; Limit development along shoreline; Determine evacuation routes	Same actions with longer timeline that factors in sea level rise for shoreline development, permitting, and setback rules.
Environment: marine ecosystems, coral reefs, fishponds, mangroves	Set up marine protected areas; prohibit destructive fishing practices; Install anchor mooring buoys; Prevent removal of mangroves (indigenous); Implement coral reef restoration; Promote conservation; Eliminate invasive species	Same actions with longer timelines that factor in sea level rise; Develop prioritization and protocols for protecting and restoring habitat from increased temperatures
Government	Based on risk and vulnerability assessments, harden or relocate essential government facilities to ensure critical and essential government functions continue in disaster, response, and recovery; Develop continuity and contingency plans	Same actions with respect to extreme climate events; Ensure that critical and essential government facilities are located
Health: environmental quality	Protect and test water quality; Ensure adequate wastewater system for coping with storm waters	Same actions with consideration for relocation of water quality and wastewater facilities in coastal inundation zones
Health: hospitals, clinics, dialysis centers, infrastructure	Harden facilities; Ensure functionality during and post-disaster; Ensure access and medical evacuation plans; Enact operations continuity plans	Same actions, Develop 'climate-proofed' facilities and infrastructure required to access health needs
Health: disease, pandemic flu outbreaks	Organize protocols for treating patients and minimizing spread (i.e. social distancing, public facility closures); Inventory and secure medicines and vaccine prior to disaster; Pre-position medicines at community center locations	Same actions with planning for increased extreme events and wider exposure to risks; Engage in planning and protocols for identifying and containing emerging health risks.
Society & Culture: sacred sites, churches, *heiau*, community centers, crisis centers	Determine/inventory sacred sites and ensure protection; Map sites to consider in permitting land use and development; Harden community centers and churches to use as shelters	Same actions with consideration of climate impacts to sites; Develop cultural resource management strategies to preserve sites, knowledge, and culture; Develop "climate-

		proofed' methods for important social centers and facilities.
Transportation: ports of entry, harbors, airports, facilities/hubs	Harden facilities in ports of entry; Develop redundant power systems to maintain operations; Identify and develop contingent ports of entry (i.e. operational airstrip or harbor on neighboring island); Harden fuel & other hazardous materials storage; Maintain and harden/secure baseyards with heavy equipment for disaster response & recovery	Same actions; Develop 'climate-proofed' ports of entry and facilities; Use alternative fuels to prevent oil spills, contamination, fires, and secondary impacts in critical ports of entry
Transportation: infrastructure, roadways, railways, landing strips	Identify critical transport routes, potential fail points, and debris clearance procedures; Harden bridges and critical coastal segments; Relocate coastal roadways inland where possible; Identify bypass areas and alternative routes;	Same actions; Develop 'climate-proofed' transportation infrastructure and access way
Waste: solid waste management, debris management	Harden treatment facilities; Identify and monitor potential exposures and threats from hazardous materials; Ensure landfill sites will not be exposed during storms and coastal inundation	Same actions with consideration for relocation in areas of high environmental impact; Develop 'climate-proofed' treatment facilities and disposal sites
Water: resource management	Identify and protect resources; Engage in conservation programs, watershed management, and integrated water resource management (IWRM); Develop water sources accessible to firefighters; Harden water reclamation facilities; Monitor quality; Conservation; Minimize pavement and impervious surfaces for groundwater recharge	Same actions with consideration of water availability trends and projections; Protect watershed areas for long-term preservation; Use gray water for non-potable uses; Ensure groundwater recharge considerations in development permitting
Water: system, distribution, infrastructure	Harden and maintain storage tanks and systems, levees, and dams; Determine alternative energy sources for distribution during power failures, especially to critical and essential facilities; Maintain pipes and distribution system	Same actions; Develop 'climate-proofed' infrastructure and systems; Ensure equitable public access to water

3.3.1 Climate Change in the Mitigation Strategy

In the 2007 update of the Multi-Hazard Mitigation Plan, the State of Hawai'i included a goal to consider climate impacts in disaster risk reduction. It is the only plan to specifically address climate change in the goals and objectives. Two other plans, however, specifically address climate variability and change as hazards, which mean that the plans must include a climate risk and vulnerability assessment and develop mitigation actions to specifically address these climate change and climate-related risks.

The hazard mitigation plans require identification and listing of mitigation actions that should be included in the plan to become eligible for FEMA hazard mitigation funding.[6] Many of the functions within government agencies and administrative rules contribute to disaster risk reduction, and these proposed actions do not require additional funding. These actions are highlighted by agency and by hazard in the mitigation plans. In addition, programs, policies, and projects that contribute to hazard mitigation are included in all of the plans. To address

[6] FEMA's hazard mitigation funding sources include the Hazard Mitigation Grant Program (HMGP) and the Pre-Disaster Mitigation Grant Program (PDM). HMGP becomes available after a disaster has occurred and is determined as a percentage of the overall damage estimates that will be made to reduce future risks. PDM is a nationally competitive grant program, and funding levels shift annually depending on allocations from US Congress.

perceivable risk reduction gaps demonstrated by the risk and vulnerability assessment, the plans must propose additional mitigation actions. The multi-hazard mitigation actions at all levels are intended to build resilience and are consistent with actions to adapt to impacts of climate change.

The proposed mitigation actions can be updated on a regular basis, especially if a new crisis emerges that targets funding for particular problems (such as the 2009 tsunami in American Samoa that has brought disaster-specific training and programs). The categorization of proposed mitigation actions that target climate-related hazards and climate change impacts have been included in Table 3-4, sorted by sector of impact, type of hazard, and jurisdiction. Most of these proposed actions target protection of people, enhancement of critical facilities, and improvement of critical lifelines through structural mitigation, improved data collection and analyses, and education, and actions that were identified in the previous section, Table 3-3.

Table 3-4. Proposed Hazard Mitigation Actions that Contribute to Climate Adaptation by Sector

	Number of Proposed Mitigation Actions by Hazard for Each Jurisdiction			
Sector of Impact	Am Samoa	CNMI	Guam	Hawaiʻi
Agriculture & Food Security	-	-	-	2H, 3D, 1W, 1CC, 1CV, 1SLR
Communications	5H	1H, 2F	-	1H, 1LD
Economy and Finance	2CI, 3F	-	-	1H, 1CC, 1CV, 1SLR
Education	-	1MH, 2H, 1F, 1D, 1W, 1CE, 1LD	1MH, 1H	1MH, 1H, 1F, 1D, 1W, 1CC, 1CV, 1SLR
Energy	4H, 2CI	1H, 2F, 1W	2H	1MH, 1H, 1LD
Environment	2H	1H, 1W	3H, 1W	1H, 2D, 3W, 2CC, 2CV, 2SLR, 1CE
Government	1F, 1SLR	2H, 1F, 1D	4MH. 2H, 1F	3MH, 4H, 3F, 4D, 1W, 3CC, 2CV, 3SLR, 2CE
Health	-	2CI	1H	1H, 1CC, 1CV, 1SLR
Society & Culture	1H, 1F	2H, 1F	1H, 1F, 1W	2H, 1F, 2CC, 2CV, 2SLR, 2LD
Transportation	1H, 4CI, 2LD	1F	2CI, 1F	1H, 1F, 2W, 1CE, 2LD
Waste	-	1CI	1MH	1H, 1F
Water	-	1CI, 2F, 2D	2MH, 3CI, 1F, 1D	1H, 3F, 3D, 2CC, 1CV, 1SLR, 1LD

Climate-related Hazard Key: MH=multi-hazard; CV=climate variability; CC=climate change; CE=coastal erosion; CI=coastal inundation, storm surge; D=drought; EH=extreme heat; F=flooding; H=hurricanes, tropical cyclones and storms, high winds; LD=landslides, mudflow, debris flow (from heavy rainfall); L=lightning; SLR=sea level rise; W=wildfire

A review of Table 3-4 reveals that there are several sectors in the US Pacific Islands in which where there are few hazard mitigation and climate adaptation actions proposed to address perceived impacts in these areas. While the information contained in the table may highlight areas of neglect that can be addressed in future plan updates, which occur every three years, it may also be the case that those involved in developing the plan did not consider the full range of options for all sectors and hazards. In the hazard mitigation plans, American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), and Guam do not propose mitigation actions for the agriculture sector. American Samoa is the only jurisdiction that does not propose public education, outreach, and training to ensure that the population is aware of hazards; however, in September 2009, American Samoa initiated a month-long public education and awareness project that utilized media. Guam does not have any proposed projects in the communications sector, and both Guam and CNMI do not have any projects in economy and finance. American Samoa does not have any projects in health, waste, and water sectors.

In terms of climate-related hazards, none of the jurisdictions propose actions for lightning and extreme heat. Projects addressing hurricane risks have been proposed in all sectors. Hawai‘i has projects to address climate variability and change, including sea level rise, and American Samoa has a project to address sea level rise. Hawaii includes drought mitigation proposals in several sectors, whereas the other jurisdictions may have one drought project, and it would seem that drought has impacted the islands more severely than information reflected in plans and documents.

3.4 Capability Assessment

State Capability Assessment

*Requirement §201.4(c)(3)(ii): [The State mitigation strategy **shall** include a] discussion of the State's pre- and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas [and] a discussion of State funding capabilities for hazard mitigation projects*

Local Capability Assessment

*Requirement §201.4(c)(3)(ii): [The State mitigation strategy **shall** include] a general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities*

Funding Sources

*Requirement §201.4(c)(3)(iv): [The State mitigation strategy **shall** include an] identification of current and potential sources of Federal, State, local, or private funding to implement mitigation activities*

Local Funding and Technical Assistance

*Requirement §201.4(c)(4)(i): [The section on the Coordination of Local Mitigation Planning **must** include a] description of the State process to support, through funding and technical assistance, the development of local mitigation plans*

Local Plan Integration

*Requirement §201.4(c)(4)(ii): [The section on the Coordination of Local Mitigation Planning **must** include a] description of the State process and timeframe by which the local plans will be reviewed, coordinated, and linked to the State Mitigation Plan*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities

Prioritizing Local Assistance

Requirement §201.4(c)(4)(iii): [The section on the Coordination of Local Mitigation Planning must include] criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs, which should include consideration for communities with the highest risks, repetitive loss properties, and most intense development pressures

Further, that for non-planning grants, a principal criterion for prioritizing grants **shall** *be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities

Source: Code of Federal Regulation, Title 44: Emergency Management and Assistance, Part 201 - Mitigation Planning.

3.4.1 Climate Change in the Capability Assessment

The hazard mitigation planning requirements specify that the capability to implement the hazard mitigation plans should be assessed. The plan assesses capabilities in terms of: 1) organizational or agency responsibilities to address key sectors of mitigation; 2) key personnel and staff designated to working on key issues of risk reduction; 3) policies, laws, and regulations that support disaster risk reduction; and 4) funding available for implementation. Each of the island jurisdictions meets the capability criteria, but there are challenges involved in each of the assessment areas that may serve as opportunities to integrate climate risk analyses into the reduction frameworks.

The capability assessment provides an opportunity to consider the effectiveness of current mitigation actions. These include identification of policies that reduce disaster risk through land use, building code implementation, environmental protection, insurance, and other actions. The capability assessment will highlight areas for improved policy development for risk reduction support. The assessment further considers the types of funding sources available to implement mitigation actions. The challenge is that there is never enough available funding to provide materials and support staff time on identified projects.

The capability assessment is a beginning, but it does not clarify the capacity of the organization and government to implement the plans. There needs to be a deeper evaluation of the available knowledge and skill to: engineer mitigation in buildings or infrastructure; use traditional ecological knowledge or indigenous science to address risks; communicate effectively at the local level; understand and apply modeled risk reduction results; use GIS to manage land, water, and resource use; to manage large-scale projects; and, implement the mitigation strategies. Since climate risk assessment involves the use of new and changing concepts, technologies, policies, and actions, it will be important to know the ways that capacity can be developed and supported to reduce risks.

3.5 Maintenance and Plan Update

PLAN MAINTENANCE PROCESS
Monitoring, Evaluating, and Updating the Plan *Requirement §201.4(c)(5)(i): [The Standard State Plan Maintenance Process* **must** *include an] established method and schedule for monitoring, evaluating, and updating the plan*
Monitoring Progress of Mitigation Activities *Requirement §201.4(c)(5)(ii): [The Standard State Plan Maintenance Process* **must** *include a] system for monitoring implementation of mitigation measures and project closeouts. Requirement §201.4(c)(5)(iii): [The Standard State Plan Maintenance Process* **must**

> *include a] system for reviewing progress on achieving goals as well as activities and projects in the Mitigation Strategy*

Source: Code of Federal Regulation, Title 44: Emergency Management and Assistance, Part 201 - Mitigation Planning.

3.5.1 Climate Change in the Implementation, Maintenance, and Update of the Plan

Since the standard state hazard mitigation plans must be updated every three years, the planning cycle is ongoing. Opportunities for plan updates are an important point of entry for integrating climate risk management into the hazard mitigation planning process.

The plans are required to outline the planning framework for the next three-year cycle. An evaluation of the effectiveness and use of the plan should be undertaken, although it will always be a challenge to prove that a disaster was mitigated by direct actions. The evaluation process offers an additional opportunity to build public awareness around hazard mitigation and improve communication in the risk reduction community.

The plan update should address recommendations from the evaluation process and design ways to overcome obstacles in implementing risk reduction actions. With limited funding available, it is important to consider the ways to leverage resources among organizations. Since many hazard mitigation actions promote disaster resilience, there is an opportunity to develop climate adaptation strategies within an existing planning framework that must be adopted by high levels of local government and approved by the federal government.

4.0 Hazard Mitigation and Climate Adaptation Gaps

A review of the hazard mitigation plans reveals several gaps in data, models, and information about many hazard risks and about the ways that climate change will ultimately exacerbate impacts. The identification and discussion of these gap areas reveals areas to target efforts in risk reduction. This section identifies key areas that need attention in the hazard profile and analysis, the areas requiring attention in the risk and vulnerability assessment to understand and evaluate expected impacts and losses, and areas for capacity building to improve the local jurisdiction's ability to conduct vulnerability assessments and develop risk reduction and adaptation plans.

4.1 Hazard Profile Data Gaps

A review of the data available on hazard profiles shows that most of the records are based on documentation from historical records. These records vary greatly by hazard type. The length of time that the records and quality control of data further varies greatly. Because of the disparate datasets, it becomes challenging to model and make decisions based on available data, and requires additional technical expertise. Understanding the added pressures and extremes from climate change the island jurisdictions becomes even more difficult without quality managed data.

In most cases, the most reliable datasets have been recorded and stored regionally with federal assistance. The National Weather Service rainfall records are among the best datasets available in the Pacific Islands. Data on the occurrence of tropical cyclones (hurricanes, typhoons), high winds, and lightning strikes have been well recorded and stored. In several instances, stream gauges and staff for monitoring natural effects lost funding, and the records that can be used in developing model projections may be lost for particular locations.

In Appendix C, the gaps in climate-related hazard profiles appear to be largely in the integration of data into hazard risk models to ascertain the extent of change. The table in the appendix displays the climate-related hazard and the list of data that exists and information that will improve the hazard mitigation plans for each jurisdiction. As attention comes to improving hazard records and data quality, the risk analyses can be improved and gain better accuracy in projecting the extent and magnitude of the hazards. The hazard risks data is critical for determining the extent for implementing hazard mitigation options. Since many of these options will be expensive, it will be important to consider the life of the project and the extent to which actions will provide protection.

4.2 Risk and Vulnerability Assessment Gaps

As previously discussed in section three, there are significant gaps in the development of the risk and vulnerability assessment. To identify the vulnerabilities (exposure and sensitivity) to the hazard requires consideration of the assets in relation to the hazard risk. In addition, it is important to understand the type of the vulnerability:

- *Will the drought impact the communities' ability to grow taro and have enough for poi?* (where vulnerabilities are social, cultural, agricultural/food security, and economic);
- *Will a Category-4 hurricane result in the loss of roofing and sheltering for more than half of the population on Oahu?* (where vulnerabilities are economic, social, security, and psychological)
- *Will sea level rise require me to raise the base-flood elevation of buildings or relocate facilities?* (where vulnerabilities are economic, social, governmental, and political)

Understanding the type of vulnerability in relation to the hazard becomes essential information to determine the ways to address the risks. The information used in the hazard mitigation plans often does not have the level of detail required to ascertain information on multiple aspects of the vulnerability. The assets identified and mapped in the plans include: transportation infrastructure, energy utilities, critical facilities (such as hospitals), emergency operations (police, fire, disaster), disaster shelters, residences, key environmental features, schools, historic places, open spaces, water sources, communications infrastructure, economic and finance facilities, and government buildings. Assets that are not mapped are often socially important facilities that aid in societal recovery after the disaster, but are not deemed critical in the midst of an emergency, such as domestic violence and rape crisis centers, mental health facilities, and dialysis centers. For the US Pacific Islands, most of these assets have been included in the geographic information system (GIS) layers and can be considered with each of the spatial hazard risks.

The types of losses estimated in the hazard mitigation plans are primarily economic losses, because it is typically easier to determine the cost of a facility than the value of a life or use of the coastal ponds for sustaining fishing activities. The data regarding other qualitative impacts for climate-related hazards is still poor. In Appendix D, the climate-related hazard vulnerability is considered for each jurisdiction. The primary gap is related to the lack of knowledge to determine projected losses from each hazard. The historical loss data is currently the best available data from many of the hazards, with some projected losses from either increased population or expanded development. The loss data is important to argue for resources to develop hazard mitigation actions that will reduce overall risk. In addition to the economic loss data, however, more information is needed on the economic valuation of natural resources and socio-cultural features. In reviewing the range of methods used to assess losses and risks, it became apparent that there is a need to standardize methods for evaluating loss.

4.3 Capacity Assessment Gaps

The capacity to assess risks and determine actions is a key feature of building resiliency in hazard mitigation and climate adaptation. Even though the hazard mitigation plans outline the capability of the jurisdictions to reduce their risks, there are a number of issues that arise that become barriers to implementation of plans and hazard mitigation actions. These will continue to result in challenges to climate adaptation unless these are addressed.

Gaps in capacity to implement hazard mitigation and climate adaptation include:

- **Finance:** The financial resources to identify and implement a risk reduction solution often present the greatest challenge to the US Pacific Islands. Many of the hazard mitigation actions were identified in the first iteration of the development of the plans, and while the states or territories continue to prioritize the activities, they are unable to find the financial resources to support the implementation of the actions.
- **Technology:** Each of the four jurisdictions has developed GIS layers that are maintained by the government, with some collaborative user groups to share data layers. The data needs to be maintained, secured, and updated. This requires equipment and software upgrades, access to tools (ie LiDAR), and training to use the latest tools.
- **Staff and Personnel:** Even when there are knowledgeable and trained personnel, the island jurisdictions often cannot compete with salaries from other places. People with advanced training are often in high demand, and the government cannot compete with the private sector for salaries and benefits. The islands experience a high degree of turnover in staffing and personnel, which may inhibit implementation of hazard mitigation actions.
- **Knowledge:** There are many types of knowledge that are required for developing hazard mitigation and climate adaptation actions. Table 3-2 identifies many of the types of knowledge and expertise required. In addition, key socio-cultural knowledge characterized by age, gender, and ethnicity may be essential to building resilient communities. Historically, the island jurisdictions have evolved and adapted to change by integrating expertise in different areas of risk reduction and resource management.
- **Planning:** Most of the island jurisdictions subcontract large agencies and organizations from the U.S. continent to conduct the hazard mitigation planning and integrated planning.

- **Legal:** Legal support for implementation of hazard mitigation plans is often critical. Concepts such as relocating residences and businesses to safer areas may be considered a legal “taking” and involve complex legal arrangements to prevent a property owner from developing in particular areas, especially in island communities where land is limited and expensive. The legal system is also important for ensuring environmental and social justice in implementing risk reduction actions.
- **Policy, Legislation, and Regulation:** Supportive governmental policies, legislation, and regulations are essential for ensuring implementation of hazard mitigation and climate adaptation actions. Rules and regulations need to be enforced to ensure their effectiveness.

5.0 Options for Improving Climate Risk Management and Adaptation through Hazard Mitigation Planning

The hazard mitigation planning process as required by FEMA for Hawaiʻi, American Samoa, Commonwealth of the Northern Mariana Islands, and Guam offers an important opportunity to engage in climate adaptation. The planning process can be used increase awareness about climate-related hazards and the expected impacts from climate change. The process identifies and prioritizes projects for funding, and identifies funding streams to implement proposed actions. The hazard mitigation planning process has been established by law and has detailed requirements for compliance. The plans receive high-level government approval and attention that can be highlighted for support in implementing the mitigation actions.

The hazard mitigation planning process is synergistic with climate adaptation frameworks and involves many similar elements in approach. Many of the actions included in the plans address climate adaptation. For example, the drought portions of the plan have been used to focus on developing and conserving water resources, which support adaptation efforts. Many tropical cyclone mitigation actions target risk reduction in the built environment or in support of the energy sector. These mitigation actions provide unique opportunities to include considerations of climate change in the design of the projects, such as considering potential longer-term climate impacts in the analyses to improve the longevity of the project or to consider integrating the use of renewable energy to support energy needs during disasters. As downscaled and localized climate information becomes available, the information can be incorporated into GIS to improve the quality of the risk and vulnerability assessments. There are numerous opportunities to build effective climate adaptation actions within the scope of the hazard mitigation plans.

The hazard profile and risk identification process enables better data to be developed and incorporated into risk reduction for climate-related hazards. Even though all of the plans identify hurricanes, typhoons, and strong winds, flooding, drought, and wildfire, they have varying degrees of information for each of these hazards. Most of the climate-related hazards have historical data for event occurrence. Some of these have geospatial data on the location of occurrence. Although models to project future impacts have been developed for hurricanes and high winds and flooding, the other extreme climate impacts do not have information on the extent of change, the magnitude of risk, and the probability of future occurrence. Records for impacts and losses of drought and wildfire need to be improved to better value social, cultural, agricultural, and economic magnitude of impact from these extreme events, and these need to be detailed in the planning processes to argue for increased funding and attention to reduce risks.

The area that would benefit the most from increased effort will be on enhancing and supporting capacity development to engage in risk reduction activities. Many of the hazard assessments and plans are conducted by external consultants, who will not help to build local capacity to implement actions. With expected risks from climate change, integrating specialized, local knowledge in the planning efforts will ensure that it is possible to adapt to climate change. Improving local capacity further ensures that impacted communities and governments have the intellectual capital and knowledge to recover and be resilient.

Bringing the disaster risk reduction aspects into climate change adaptation will enable a more targeted focus in reducing the impacts from climate-related risks. Throughout the hazard mitigation planning process required for Hawaii, American Samoa, the Commonwealth of the Northern Mariana Islands, and Guam, there are key entry points that will facilitate climate-related hazard risk reduction. Hazard mitigation activities become essential tools for climate adaptation and improve risk reduction in key sectors. Since the hazard mitigation planning must be conducted and updated every three years, synergies exist for implementing climate adaptation activities with fewer additional resources. The governments should seize the opportunity to use the hazard mitigation planning processes to engage in risk reduction and climate change adaptation.

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APPENDIX A: Hazards included in US Pacific Island Region Multi-Hazard Mitigation Plans

HAZARDS	AS	CNMI	GU	HI	C&C Honolulu	Hawai'i	Kaua'i	Maui
Climate Change	X			X			X	
Climate Variability	x	x		X			X	
Coastal Erosion			X	X	X	X	X	X
Coastal Inundation/ Storm Surge	x	x	x	x	x	x	x	x
Dam or Levee Failure			X	X	X	X	X	X
Drought	X	X	X	X	X	X	X	X
Earthquake	X	X	X	X	X	X	X	X
Extreme Heat			X	x				
Flooding	X	X	X	X	X	X	X	X
Hazardous Materials	X		X	X	X	X	X	X
Hazardous Surf/ Rip Current			X	x	X	X	x	X
Health-Related Hazard / Disease			X	X			X	
Hurricane, Typhoon, Tropical Cyclones	X	X	X	X	X	X	X	X
Landslide, Mudflow, Debris Flow (Heavy Rainfall Events)	X		X	X	X	X	X	X
Landslide (Seismic)			X	X	X	X	X	X
Lightning			X					
Sea Level Rise	X			X			X	
Strong Winds				x	X	X	x	X
Terrorism			X	X			X	
Transportation Accident (Aviation, Port)			X	X				
Tsunami	X	X	X	X	X	X	X	X
Volcanic Eruptions (Lava flow, Gases/Vog)		X	X	X	X	X	X	X
Wildfire	X	X	X	X	X	X	X	X

AS: American Samoa; CNMI: Commonwealth of the Northern Mariana Islands; GU: Guam; HI: State of Hawai'i; C&C Honolulu: City & County of Honolulu on Oahu Island; Hawaii: County of Hawaii: Kauai: County of Kauai; Maui: County of Maui. Note: '**X**' is used where hazards have been explicitly identified as "hazards" for the State or Territory in the hazard mitigation plan, and '**x**' is used where this is mentioned as a secondary impact or threat with another hazard.

	Explicit Climate Risks: Hazards directly caused by climate variability and change or reflect extreme climate events.
italics	Risks exacerbated by climate change, but are primarily result of other causes, such as technology failure, aging infrastructure, poor sanitation, and lack of household and water system maintenance.
	Not directly impacted by climate change. Effects of seismic hazards on critical infrastructure may further exacerbate risk during climate extremes, such as drought and flooding.

APPENDIX B: Projected Losses from Hazards and Methods for Calculating Projected Losses

HAZARDS	AS	Projection Method	CNMI	Projection Method	GU	Projection Method	HI	Projection Method
Climate Change	lack of data and methods for projections		NC		NC		$428.2 M	quantitative analyses, extrapolations from AAL (hurricanes, erosion, flood, wildfire, drought)
Climate Variability	lack of data and methods for projections		lack of data and methods for projections		NC		X	quantitative analyses, extrapolations incl. in CC
Coastal Erosion	NC		NC		lack of data and methods for projections		$11 M	quantitative analyses, shoreline change studies
Coastal Inundation/ Storm Surge	lack of data and methods for projections		lack of data and methods for projections		$559.2 M	quantitative analyses, reported as flooding hazard during storm	x	quantitive analyses, modeling event scenarios
Dam or Levee Failure	NC		NC		lack of data		$2.2 B	quantitative analyses
Drought	lack of data and methods for projections		lack of data and methods for projections		lack of data	historical losses not recorded/ reported	$8 M	quatitative analyses, historical record worst event
Earthquake	$251.6 M	quatitative analyses	$1,027 M	CVA	fault proximity: $1,222 M; liquefaction: $279.3M	quantitative analyses, basesd on potential exposure, overestimation of actual impact, fails to account for mitigation	$99.4 M	HAZUS-MH average annualized losss
Extreme Heat	NC		NC		lack of data		lack of data and methods	risk considered but lack of models for projecting costs
Flooding	$125.6 M	quatitative analyses	$109.6 M	CVA	w/tropical cyclone: $559.2 M	quantitative analyses	$15.2 M	HAZUS-MH average annualized losss
Hazardous Materials	lack of data and methods for projections		NC		$1,448.4 M	quantitative analyses, basesd on potential exposure	lack of data and methods	quantitative analyses, historical records

Community Vulnerability Assessment (CVA): uses building loss estimates, supplemented by FEMA Benefit Costs Analysis.
HAZUS-MH Average Annualized Loss (AAL): Loss calculations of hazards (AAL = ∑ Li x Pi) shows the average loss expected each year. This calculation is used by the insurance industry to set rates based on loss over time. This does not then reflect the impacts from a single event.
HAZUS-MH Probabilistic Scenario: The modeled results of the impact to structures and facilities from a hazard event.
Mass Management Tool (MMT): tool adapted to islands as part of FEMA and US Army Corps of Engineers HURREVAC model
NC: no consideration in the plan development and no discussion in the plan
Quantitative analyses: includes hazard location, probability/magnitude, asset values, asset location, asset characteristics, uses GIS. Database characteristics for the CVA loss estimates include: type of foundation, construction of exterior wall, roof material, topography, location in flood zone, and construction date.
AS= American Samoa; CNMI=Commonwealth of the Northern Mariana Islands; GU=Guam; HI=Hawai`i

HAZARDS	AS	Projection Method	CNMI	Projection Method	GU	Projection Method	HI	Projection Method
Hazardous Surf/ Rip Current	lack of data and methods for projections		NC		$559.2 M	estimates are based on association with tropical cyclones	lack of data and methods	
Health-Related Hazard / Disease	NC		NC		lack of data		lack of data and methods	
Hurricane, Typhoon, Tropical Cyclones	$150 M	lack of methods for probabistic modeling; estimated facilities replacement values	$327 M	CVA; Mass Management Tool (MMT)	severe wind, extreme: $3,891.7 M severe wind, very high: $3,710.5M	quantitative analyses	1) $390 M 2) $845 M	1) HAZUS-MH average annualized losss 2)HAZUS-MH probabilistic hurricane scenario
Landslide, Mudflow, Debris Flow (associated with heavy rainfall)	$80.3 M	quatitative analyses	NC		lack of data	analyses are based on association with seismic risk, but not precipated by heavy rainfall	$6.5 M	quantitative analyses
Landslide/Rockfall (Seismic)	lack of data and methods for projections	historical data accounts primarily for risks associated with heavy rainfall	lack of data and methods for projections		$170.5M	quantitative analyses	lack of data and methods	most landslides occur during heavy rainfall
Lightning	NC		NC		lack of data		NC	
Sea Level Rise	lack of data and methods for projections		NC		NC		$331.6 M	quantitative analyses, historical records, extrapolations
Strong Winds	NC		NC		NC		x	included in hurricane studies, no separate loss data available
Terrorism	NC		NC		lack of data		lack of data and methods	

Community Vulnerability Assessment (CVA): uses building loss estimates, supplemented by FEMA Benefit Costs Analysis.
HAZUS-MH Average Annualized Loss (AAL): Loss calculations of hazards (AAL = ∑ Li x Pi) shows the average loss expected each year. This calculation is used by the insurance industry to set rates based on loss over time. This does not then reflect the impacts from a single event.
HAZUS-MH Probabilistic Scenario: The modeled results of the impact to structures and facilities from a hazard event.
Mass Management Tool (MMT): tool adapted to islands as part of FEMA and US Army Corps of Engineers HURREVAC model
NC: no consideration in the plan development and no discussion in the plan
Quantitative analyses: includes hazard location, probability/magnitude, asset values, asset location, asset characteristics, uses GIS. Database characteristics for the CVA loss estimates include: type of foundation, construction of exterior wall, roof material, topography, location in flood zone, and construction date.
AS= American Samoa; CNMI=Commonwealth of the Northern Mariana Islands; GU=Guam; HI=Hawai`i

HAZARDS	AS	Projection Method	CNMI	Projection Method	GU	Projection Method	HI	Projection Method
Transportation Accident (Aviation, Port)	NC		NC		lack of data		lack of data and methods	
Tsunami	lack of data	Based on 2009 tsunami, there will be data and loss estimates for the plan updates	$157.5 M	CVA	$ 1,013 M	quantitative analyses	$185.05 M	average annualized losses; quantitative analyses
Volcanic Eruptions (Lava flow, Gases/Vog)	NC	No volcanic threat	lack of data and methods for projections		lack of data	Note: no volcanoes in Guam, but gases from the Northern Mariana Islands could potentially have impact, but this is not studied	$9.2 M	quantitative analyses
Wildfire	lack of data and methods for projections		$37.2 M	CVA	very high: $1,137.3 M high: $2,288.4 M	quantitative analyses	$3 M	historical losses for extreme event

Community Vulnerability Assessment (CVA): uses building loss estimates, supplemented by FEMA Benefit Costs Analysis.
HAZUS-MH Average Annualized Loss (AAL): Loss calculations of hazards (AAL = ∑ Li x Pi) shows the average loss expected each year. This calculation is used by the insurance industry to set rates based on loss over time. This does not then reflect the impacts from a single event.
HAZUS-MH Probabilistic Scenario: The modeled results of the impact to structures and facilities from a hazard event.
Mass Management Tool (MMT): tool adapted to islands as part of FEMA and US Army Corps of Engineers HURREVAC model
NC: no consideration in the plan development and no discussion in the plan
Quantitative analyses: includes hazard location, probability/magnitude, asset values, asset location, asset characteristics, uses GIS. Database characteristics for the CVA loss estimates include: type of foundation, construction of exterior wall, roof material, topography, location in flood zone, and construction date.
AS= American Samoa; CNMI=Commonwealth of the Northern Mariana Islands; GU=Guam; HI=Hawai`i

APPENDIX C: Climate-Related Hazard Data Gaps by Island Jurisdiction

Hazard	Gaps to be Addressed
climate variability	**AS:** ENSO and extreme climate events are discussed, but the plan lacks historical record of impacts and modeled future impacts. Loss data is not modeled except for some extreme climate events that occur during ENSO have loss records.
	CNMI: Historical records of ENSO occurrence are available, but not modeled impacts. Loss data is not modeled or calculated. Loss data is not modeled except for some extreme climate events that occur during ENSO have loss records.
	GU: ENSO and extreme climate events are discussed, but the plan lacks historical record of impacts and modeled future impacts. Loss data is not modeled except for some extreme climate events that occur during ENSO have loss records.
	HI: Historical records of ENSO and related rainfall trends are available, and the profile could be improved as advances in modeling occur. Attempts are made to calculate and model losses.
climate change	**AS:** The profile on climate change includes potential impacts from flooding and sea level rise. The degree and magnitude of the impacts are not modeled.
	CNMI: Plan currently does not mention CC.
	GU: Plan currently does not mention CC.
	HI: Preliminary data exists from looking at extreme climate events, sea level variation, and temperature change. Data on ocean acidification and potential impacts and models of greater impact from climate change are being conducted but have not been available for hazard mitigation plans. Projected losses are aggregated from the data on extreme climate events, but does not accurately account for losses, and extrapolations and models for projected losses need to be improved considerably.
coastal erosion	**AS:** Coastal erosion and shoreline studies have been conducted for Tutuila, but not for other islands. There is information on historical occurrence. Current and projected loss data is not available.
	CNMI: Historical occurrence of coastal erosion exists but the data has not been mapped and included in hazard mitigation plans. Current and projected loss data is not available.
	GU: Historical occurrence records and locations of impact records exist. Trends and models of future impacts have not been conducted. Current and projected loss data is not available.
	HI: Historical occurrence records and locations of impact records exist. Shoreline trends and future projections have been studied and modeled for Kauai, Maui, and Oahu, with some site-specific studies on the shorelines of Hawaii Island. Some analyses have been integrated with sea level change studies for the islands of Oahu and Maui. Current and projected loss data is not available.
coastal inundation, storm surge	**AS:** Historical records of coastal inundation associated with a tropical cyclone are available. Inundation rates change with the characteristics of each hurricane, and scenarios for different hurricanes would improve planning for inundation. Models do not include integration of sea level rise projections. Current and projected loss data is not available.
	CNMI: Historical records of coastal inundation associated with a tropical cyclone are available. Models and future projections of inundation have not been conducted. Current and projected loss data is not available.
	GU: Historical event and location data exist. Models and future projections of inundation have not been conducted. Current and projected loss data is not available.
	HI: Historical event records and locations of impact are available. Models have been developed for the island of Oahu during catastrophic events and worst case scenarios. Some projected loss data has been included in the catastrophic plans.
drought	**AS:** Historical event records are available. Current and projected loss data is not available.
	CNMI: Historical event records are available. Current and projected loss data is not available.

	GU: Historical records associated with ENSO cycle. Models and projections of future drought have not been conducted. Current and projected loss data is not available.
	HI: Historical event records and locations of impact exist. Areas of severe risk for the agriculture industry have been mapped. Current losses do not reflect extent of actual loss, and projected loss data is not available.
extreme heat	**AS:** Records for temperature are available at limited locations, but not modeled for hazard impacts. Current and projected loss data is not available.
	CNMI: Records for temperature are available at limited locations, but not modeled for hazard impacts. Current and projected loss data is not available.
	GU: Records for temperature are available at limited locations, but not modeled for hazard impacts. Current losses are considered negligible, and projected loss data is not available.
	HI: Records for temperature are available at limited locations, but not modeled for hazard and climate change impacts. Current and projected loss data is not available.
flooding	**AS:** Historical event records and Flood Insurance Rate Maps that designate flood zones on probability of occurrence are available. Current and repetitive loss data is available and projected losses have been modeled based on flood risk zone, which does not account for climate change.
	CNMI: Historical event records and Flood Insurance Rate Maps that designate flood zones on probability of occurrence are available. Current and repetitive loss data is available and projected losses have been modeled based on flood risk zone, which does not account for climate change.
	GU: Historical event records and Flood Insurance Rate Maps that designate flood zones on probability of occurrence are available. Current and repetitive loss data is available and projected losses have been modeled based on flood risk zone, which does not account for climate change.
	HI: Historical event records and Flood Insurance Rate Maps that designate flood zones on probability of occurrence are available. Current and repetitive loss data is available and projected losses have been modeled based on flood risk zone, which does not account for climate change.
hurricanes, tropical cyclones and storms, high winds	**AS:** Historical event records are available and have been used to look at scenarios for high wind risk and coastal inundation. Current loss data is available and projected losses have been modeled based on historical events, which does not account for climate change.
	CNMI: Historical event records are available and have been used to look at scenarios for high wind risk and coastal inundation. Current loss data is available and projected losses have been modeled based on historical events, which does not account for climate change
	GU: Historical event records are available and have been used to look at scenarios for high wind risk and coastal inundation. Current loss data is available and projected losses have been modeled based on historical events, which does not account for climate change
	HI: Historical event records are available and have been used to look at scenarios for high wind risk and coastal inundation. Catastrophic events have been modeled. Current loss data is available and projected losses have been modeled based on historical events, which does not account for climate change but does include losses based on different scenarios.
landslides, mudflow, debris flow (from heavy rainfall)	**AS:** Historical event records exist. Soil maps and landslide risk maps have been developed for Tutuila. Current loss data is limited and projected loss data is not available.
	CNMI: Historical event records are not available. Current loss data is limited and projected loss data is not available.
	GU: Historical event records and locations of impact from mud and debris flow exists. Current loss data is limited and projected loss data is not available.
	HI: Historical events exist and locations, especially near transportation corridors, have been mapped. Current loss data is limited to extrapolations from transportation losses and projected loss data is not available.
lightning	**AS:** Historical event data available from the National Weather Service (NWS), but not included

	in plans and models. Loss data is not available.
	CNMI: Historical event data available from NWS, but not included in plans and models. Loss data is not available.
	GU: Historical event and location data exist. Loss data is not available.
	HI: Historical event data available from NWS, but not included in plans and models. Loss data is not available.
sea level rise	**AS:** Records of historical change and projected changes exist, and should be used with additional modeling for sea level rise impacts and scenarios with coastal inundation models. Loss data is not yet available.
	CNMI: Studies on the extent of sea level rise have not been conducted. Loss data is not available.
	GU: Sea level rise studies have not been conducted and integrated into the hazard mitigation plans. Loss data is not available.
	HI: Historical trends data and future projections have been used in hazard mitigation plans. The sea level rise analyses need to be integrated into models for wave heights, coastal inundation, and other effects. Some loss data has been extrapolated from degree of impact to key economic sectors, such as tourism.
wildfire	**AS:** Historical occurrence and scenarios of wildfire risk have been developed and used in the hazard mitigation plans. Loss data is limited and not reflective of the loss to key species and habitat.
	CNMI: Historical occurrence and location data is available. Loss data is limited and not reflective of the loss to key species and habitat.
	GU: Historical occurrence data and locations impacted exist and have been mapped. Modeled risk projections have not been conducted. Loss data is limited to infrastructure and facility impacts in historical records, and not reflective of the loss to key species and habitat.
	HI: Historical occurrence data and locations impacted by wildfire records exist. Loss data is limited to infrastructure and facility impacts in historical records, and not reflective of the loss to key species and habitat.

AS=American Samoa; CNMI=Commonwealth of the Northern Mariana Islands; GU=Guam; HI=Hawaii