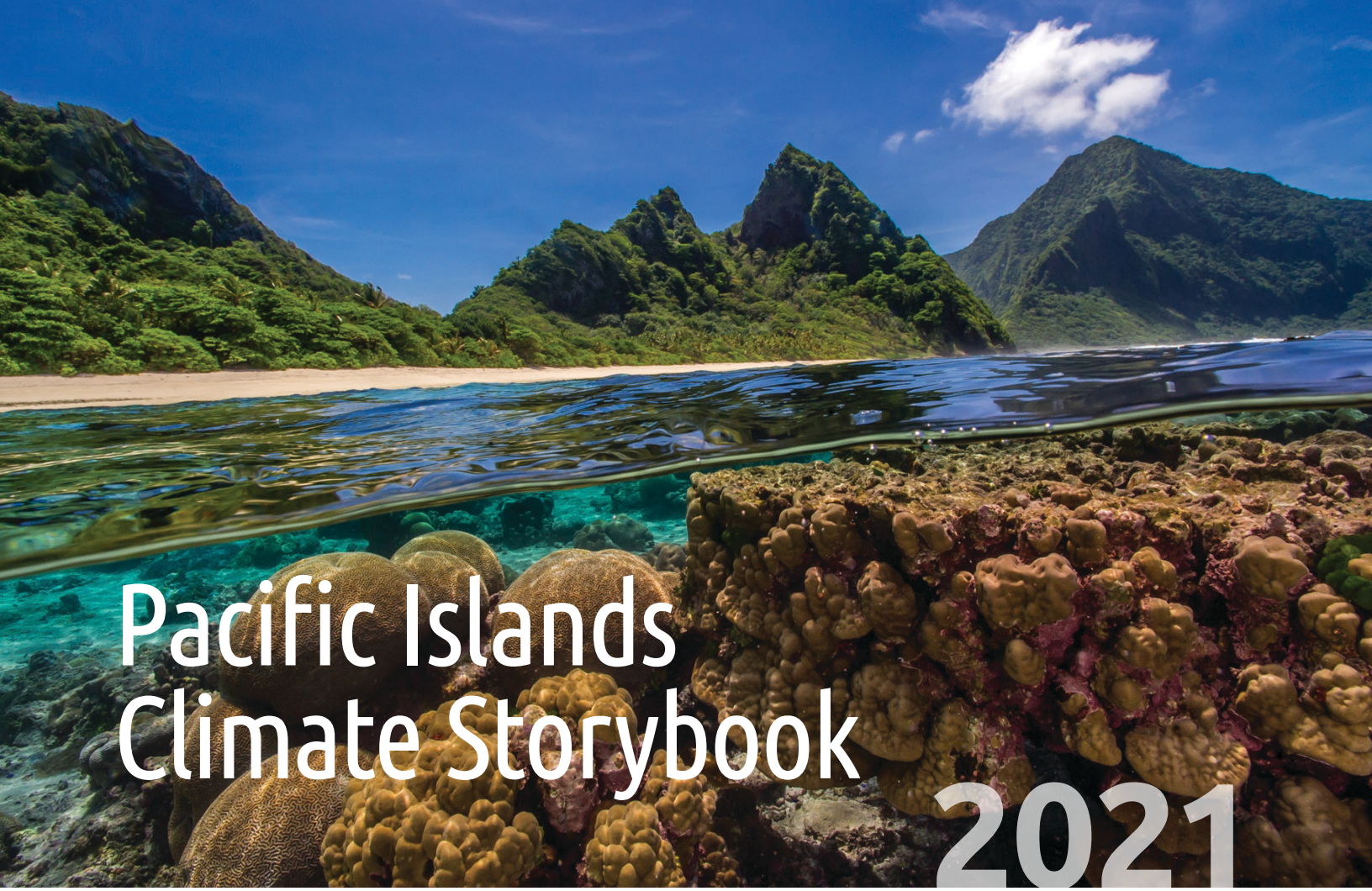
Pacific Islands Climate Storybook

Cover Image: Ofu Lagoon, American Sāmoa. Source: The Ocean Agency (photo by Shaun Wolfe)



Pacific Islands Climate Storybook 2021

Prepared by the National Oceanic and Atmospheric Administration with support from the United States Agency for International Development and the Pacific Regional Integrated Sciences and Assessments Program

Recommended Citation:
Marra, J., C. Courtney, and L. Brewington, 2021: *The Pacific Islands Climate Storybook*. Honolulu, HI: The Pacific Regional Integrated Sciences and Assessments Program.
www.pacificrisa.org/pacific-islands-climate-storybook/

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

Pacific RISA
a NOAA RISA team

EAST-WEST CENTER

USAID
FROM THE AMERICAN PEOPLE

Acknowledgments

The Pacific Islands Climate Storybook was made possible through the extraordinary efforts of numerous government agencies and non-government organizations throughout the Pacific Islands region. The entities listed below were instrumental in providing technical expertise and administrative and logistical support in the planning and implementation of Climate Services Dialogs and developing the Climate Stories that are captured in this document. We also thank the many other groups that participated in the Climate Services Dialogs who shared their knowledge and expertise. Tetra Tech, Inc. provided technical and facilitation support to the US National Oceanic and Atmospheric Administration (NOAA) under Contract No. WC133F-11-CQ-0003; Task Order No. 0001. The Pacific Regional Integrated Sciences and Assessments (RISA) program supported the 2021 update to this document and additional case studies under NOAA grant number 2018-2005445.

	American Sāmoa, Environmental Protection Agency
American Samoa Power Authority	American Sāmoa Power Authority
Australian Government Bureau of Meteorology	Australian Government, Bureau of Meteorology
Australian Aid	Australian Agency for International Development
CSIRO	Australian Commonwealth Scientific and Industrial Research Organization
	College of the Marshall Islands
Cook Islands Meteorological Service	Cook Islands Meteorological Service
CORAL REEF ADVISORY GROUP CRAG	Coral Reef Advisory Group
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Deutsche Gesellschaft für Internationale Zusammenarbeit
EAST-WEST CENTER	The East-West Center

	Government of Sāmoa, Meteorological Services
	Government of Vanuatu
	Government of Vanuatu, National Advisory Board on Climate Change and Disaster Risk Reduction
	Government of Vanuatu, Meteorology and Geo-hazards Department
	Guam, Office of the Governor
	Hatohobei Organization for People and Environment
	Micronesia Challenge
	Micronesia Conservation Trust
	The Nature Conservancy
	New Zealand National Institute of Water and Atmospheric Research
	The Pacific Islands Climate Change Cooperative
	Pacific Climate Information System
	Pacific Islands Climate Adaptation Science Center
	Pacific Regional Integrated Sciences and Assessments Program
	Pacific Islands Marine Protected Areas Community

	Palau International Coral Reef Center
	Republic of the Marshall Islands Ministry of Health and Human Services
	Republic of the Marshall Islands Office of Environmental Planning and Policy Coordination
	Secretariat of the Pacific Community
	Secretariat of the Pacific Regional Environment Programme
	The University of Hawai'i Sea Level Center
	The University of the South Pacific
	US Department of Agriculture
	US Geological Survey
	Water and Environmental Research Institute of the Western Pacific, University of Guam
	World Health Organization

The 2021 Pacific Islands Climate Storybook can be found at www.pacificrisa.org/pacific-islands-climate-storybook/
The original 2015 Storybook can be found at www.pacificislandsclimate.org/csstories/

Table of Contents

Acknowledgments ..... **B**

Table of Contents ..... **E**

Introduction **1**

Overview of the Climate Services Dialog Process **3**

Climate Story Development Process 7

Climate Story Template 7

Illustrative Climate Story Template 8

Key Messages to Guide Climate Services Development and Delivery **9**

Pre-Dialog Technical Exchange and Planning **12**

Good Practices in Developing Learning Objectives 13

Learning Outcomes and Illustrative Verbs to Specify Learning Objectives 14

Pre-Dialog Activity: Describe Existing Climate Early Warning System 15

Using the READY-SET-GO Framework 16

Session 1: Share Climate Knowledge **17**

Activity #1: Share Climate Knowledge 18

Session 2: Diagnose Climate Services **19**

Activity #2: Diagnose Existing Early Warning System for a Climate-Related Event 20

Using the READY-SET-GO Framework 20

Available Climate Services Products and Tools 21

Climate Information 21

El Niño-Southern Oscillation 22

Sea Level Rise and Sea Surface Height 23

Storms 24

Drought 24

Sea Surface Temperature and Coral Bleaching 25

Activity #3: Develop a Climate Early Warning Outline 27

Session 3: Build Climate Stories **28**

Good Practices for Overcoming Climate Change Communication Challenges 29

Climate Communication Activity: Review Questions for Climate Communication Video 30

Activity #4: Reflect on Key Messages and Best Practices 30

Template to Guide Climate Communication Strategy Development 31

Post-Dialog Climate Story Follow-Up **32**

Illustrative Climate Story Interview Questions 32

Pacific Island Climate Stories 33

High and Dry: Learning from the 1997–98 El Niño Impacts on Water Resources in American Sāmoa 35

"The Actual Sea Went All the Way Up": Coastal Flooding on Manus, Papua New Guinea 39

In the Dark of Monday Morning: Coastal Flooding on Majuro 43

"It's Falling from the Sky but Not Hitting the Ground": Drought in the Outer Atolls of the Marshall Islands 47

The Cloud Nasara: The Development and Use of Vanuatu's ENSO Handbook 51

Remembering what a Healthy Reef Looks Like: A Community-Based Reef Restoration and Education Program in Humåtak, Guam 55

Seesawing: Coastal Change in Ngaraard, Palau 59

Symbiosis: Responding to Coral Bleaching in the Two Sāmoas 63

When Drought Brings Sickness, Part I: Water-Borne Disease in the Marshall Islands 67

When Drought Brings Sickness, Part II: Vector-Borne Disease in the Marshall Islands 71

Introduction

Climate services—the development and delivery of actionable information about climate patterns, trends, and their impacts on communities, businesses, and ecosystems—are essential to many aspects of policy, planning, and decision-making in Pacific Islands. Consultation with decision makers is critical to ensuring such information is useful, useable, and utilized. The US National Oceanic and Atmospheric Administration (NOAA), with its globally recognized scientific and technical expertise, is in a unique position to work with the Pacific Island Meteorological Services and other regional organizations to support robust and sustained capacity development consistent with the Global Framework for Climate Services.

NOAA, working through the US Department of State and the US Agency for International Development (USAID), undertook an initial two-year project (2012–14) to support climate change adaptation in the Pacific Islands region. The Pacific Regional Integrated Sciences and Assessments (RISA) program expanded upon this initial project in 2020–21 to incorporate new partners and sectors. These efforts involved conducting a series of activities to enhance scientific and technical capacity and provide climate services. With an emphasis on engagement and consultation between service providers and users, activities have included building regional networks; packaging and disseminating existing climate-related products and services; development of new or enhanced products and services; and advancing sub-regional and in-country training and core capacity-building. The final report of the initial project, *Enhancing Capacity for Adaptation to Climate Change and Variability in the Pacific Small Island Developing States,* summarized the following key accomplishments:

- Climate services users are better informed about the current state of knowledge about climate variability and its impacts, more skilled in understanding, translating, and applying the science behind and consequences of a changing climate, better able to make use of the technical capabilities at their disposal to assess adaptation options and strategies, and, as a result, are able to make better decisions as they set priorities and allocate resources.
- Climate services providers are better informed about what local knowledge, needs, and questions are most relevant, and, as a result, are better able to match products and services to user requirements.

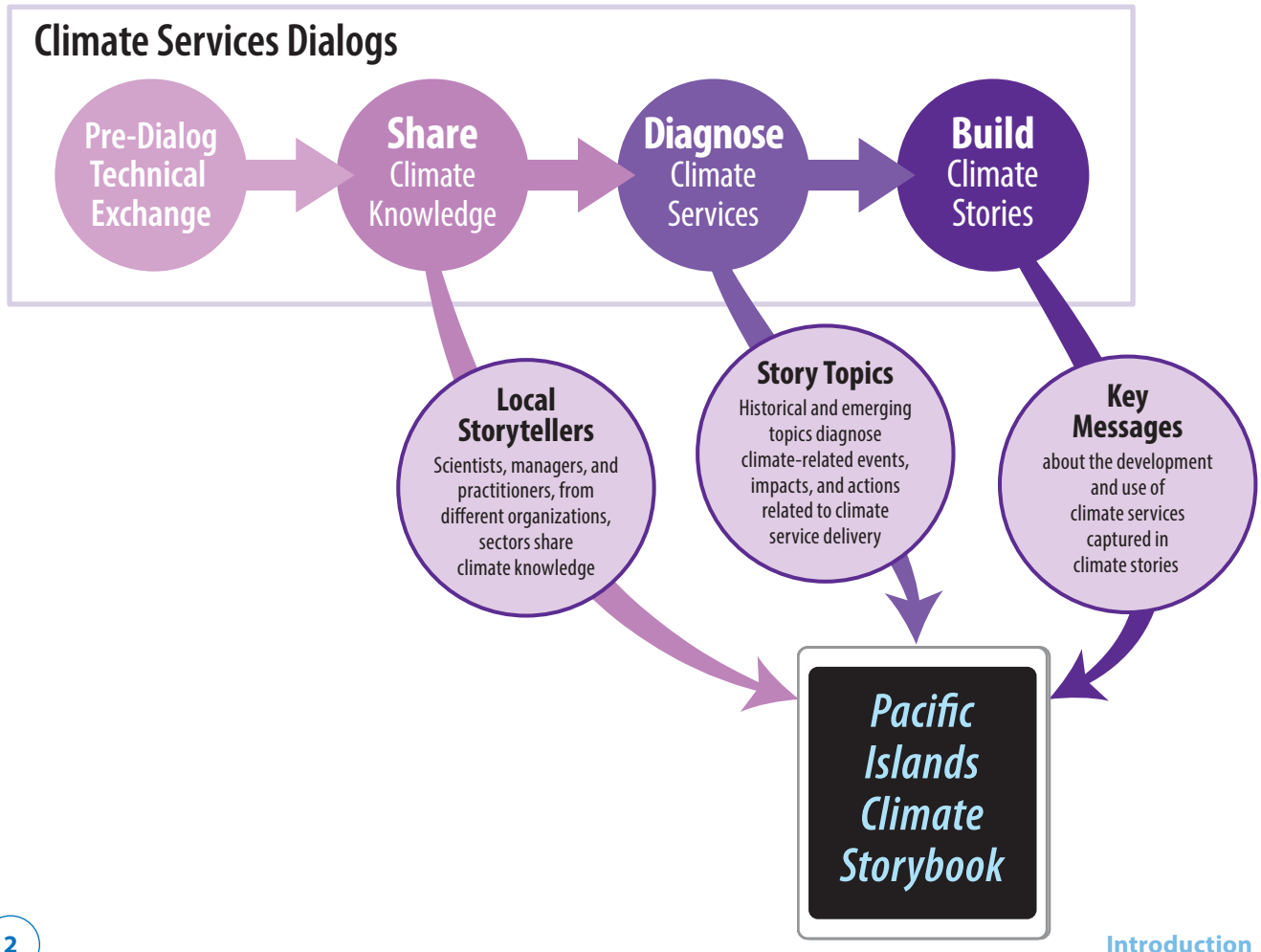
Guiding Principles for Climate Services in the Pacific Islands

- Focus on the transformation of information by placing content in a form that is easily understood and readily accessible, aggregating and customizing it so that is specific to sector and locale, and linking it to local knowledge and terminology.
- Ground product and services development and delivery in the iterative co-production of knowledge at multiple levels to ensure that science and services are appropriately and successfully applied to relevant problems and questions.
- Implement integrated program planning and product development by directing attention to the alignment and coordination of activities needed to minimize gaps and overlaps, and to support robust and sustained capacity development in the region.

From the Pacific Islands Climate Services Forum held in Suva, Fiji January 21–25, 2013

- An increase in the supply of regional practitioners and trainers to support training-of- trainers and sharing of lessons learned.
- A significant increase in regional coordination and collaboration among programs and partnerships across the Pacific, including national governmental counterparts, regional organizations and networks, and stakeholders in multiple sectors.

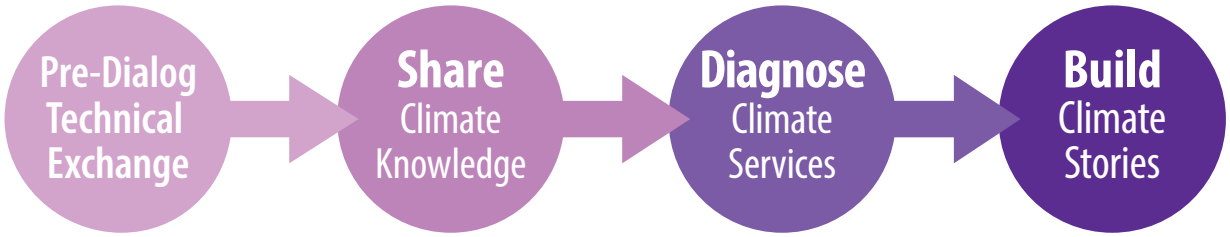
An important component of the capacity-building approach is to develop and conduct Climate Service Dialogs, which are three-day workshops designed to share climate knowledge, diagnose and enhance existing climate services, and build Climate Stories that can be shared across sectors and communities. The Pacific Islands Climate Storybook is a living compilation of technical material, process guides, and activities used to conduct the Climate Services Dialogs and build Climate Stories. Through the Climate Services Dialog process, local storytellers share climate knowledge and diagnose climate services to generate story topics that can be developed into Climate Stories and key messages about the development and delivery of climate services. The materials include a model agenda reflecting process flow, break-out session guidance that contains sample questions, examples of outcomes such as historical timelines, and a Climate Story template. Background and technical guidance for the various modules (e.g., Overview of Climate Services, Climate Change and Variability, and Communicating Climate) are provided in this Storybook. Climate Stories that incorporate experiential knowledge and scientific data are also included. These stories help inform regional and local decision-makers about the impacts of climate change and variability while highlighting key messages and best practices.



Overview of the Climate Services Dialog Process

The dialog process is designed as a three-day workshop to assist government agencies, academic institutions, non-governmental organizations (NGOs), the private sector, and other stakeholders as they work together to analyze and strengthen end-to-end climate services development and delivery. The dialogs described in this Storybook focus on assessing the capacity of existing climate services in Pacific Islands to provide early warning through seasonal outlooks and forecasts for the El Niño-Southern Oscillation (ENSO) and other climate-related events to affected sectors. The process was developed and refined based on a series of workshops conducted between 2014–20 by NOAA and partners in the Marshall Islands, Sāmoa, American Sāmoa, Papua New Guinea, Vanuatu, Palau, the Cook Islands, and Guam.

The dialog is organized into three sessions: 1) Share climate knowledge; 2) Diagnose climate services and identify opportunities to enhance climate service delivery; and 3) Build Climate Stories to share key messages and best practices. Storytelling is an important mode of communication in the Pacific Islands and the way people document history, exchange information, and learn to adapt to change. The Climate Services Dialog process brings together experiential and scientific knowledge as a basis for documenting historic climate-related events and impacts as a means to enhance climate early warning.



Develop climate early warning focus for dialog	**Session 1**	**Session 2**	**Session 3**
Identify sectors and agency participants	Provide overview of climate services	Describe existing climate services	Explore techniques in climate communication
Describe and diagnose existing climate services delivery	Share stories that illustrate key messages and best practices in the delivery of climate services	Assess capacity of climate services to support early warning for a specific event by sector	Build Climate Stories by sector to communicate key messages and best practices
Develop, review, and refine objectives for the Climate Services Dialog	Share experiential and science-based knowledge on climate-related events and impacts	Explore existing products and services that support situational awareness for climate early warning	Refine and share Climate Stories
		Review decision-making processes and identify actions to strengthen products and services that support climate early warning	

The overall objectives of the dialog are to:

- Raise awareness of the state of knowledge about climate science, impacts, and adaptation
- Identify available climate and weather service products and services to support climate adaptation planning, disaster risk management, and sustainable development
- Learn about seasonal climate-related science and information including placing current observations and forecasts into a local context that is more easily accessed and used
- Learn about the effects of climate change on natural resources (e.g., freshwater, coral reefs, shorelines) and best practices to minimize impacts on resources and the sectors that depend on them (e.g., tourism, agriculture, aquaculture, disaster management)

The expected outcomes of the dialog include:

- Improved ability to generate accurate, timely and regionally-relevant forecasts to appropriate sectors
- A user community that is better informed about the current state of knowledge about climate variability and change and its impacts and as a result able to make better decisions as they set priorities and allocate resources
- A provider community that is better informed about what problems and questions are most relevant and, as a result, are better able to match products and services to user requirements
- Climate Stories developed to communicate key messages and best practices

Pre-Dialog Technical Exchange and Planning

Pre-Dialog Technical Exchange

When preparing for the dialog, the managers from the National Meteorological Services and sector agencies (e.g., natural resources, agriculture, disaster management, tourism) should work together to identify the climate early warning focus. The climate early warning focus could be drought, coastal inundation, coral bleaching, or other events of concern along with identification of the sectors impacted. This Pre-Dialog Technical Exchange is intended to help sector agencies describe the status of existing climate services for early warning for a specific climate-related event. This background information is presented during the dialog and serves as the basis for diagnosing the climate services for each sector. Several planning sessions may be needed to enable the agency leads to work together to prepare for the dialog. The output of these sessions is a presentation summarizing the current state of climate services for Session 1 of the dialog.

Participants: National Meteorological Services and representatives of other agencies, institutions, and organizations from key sectors.

Objectives:

- Develop climate early warning focus for dialog
- Identify sectors and agency participants
- Share knowledge of past climate-related events by developing a historical timeline of the events and impacts

- Describe and diagnose existing climate services delivery to provide climate early warning for the focal climate-related event (e.g. drought, coastal inundation, coral bleaching)
- Develop, review, and refine objectives for the dialog

SESSION 1: Share Climate Knowledge

Share Climate Knowledge

Session 1 of the dialog engages participants from relevant sectors in sharing their experiential and scientific knowledge of the history and impacts of climate variability and change. This sharing is accomplished through storytelling and structured activities such as constructing a historical timeline of climate-related events and mapping impacts to "set the scene." The Climate Story Template is introduced early in the session to forecast the expected output of Session 3: Build Climate Stories. For the sharing of climate knowledge, participants are encouraged to identify story topics that they can begin to develop.

Guiding questions for setting the scene include:

- What historic climate related events have impacted the sector or resource of interest?
- What areas were impacted by these events?
- How long did the events last and how often did they occur? What are the patterns and frequency of these events?
- Have these climate-related events occurred at the same time?
- What were the impacts of the climate-related events (e.g., ecological, socioeconomic, infrastructural, or cultural)?
- What priority issues have you had to deal with as a result of these impacts?

An overview of climate variability and change, and the available climate services, is presented to give participants a common understanding of the key concepts and terms. Participants share their stories verbally. If feasible, these stories should be recorded to capture insights and lessons that can be used to develop Climate Stories and communicate to a broader audience after the dialog.

Participants: Participation in the dialog should encompass sectors related to the focal resource or sector and associated assets (e.g., freshwater resources, coral reefs, or shorelines). Participants should be in mixed groups (i.e., not grouped by sector).

Objectives:

- Gain a common understanding of the nature of climate variability and change, and the role of climate services in early warning
- Share climate impacts and adaptation experiences by sector and begin to identify key messages and best practices

SESSION 2: Diagnose Climate Services

Diagnose Climate Services

Session 2 is focused on diagnosing the information flow, decisions, and actions that are needed for climate early warning for each sector and identifying the types of information and tools that can be used to enhance situational awareness and support decision-making. Participants will first examine what works and what needs to be improved upon; then, with additional input they will begin to map out the elements of a climate early warning system for the focal resource or sector and associated assets based on the Ready-Set-Go framework. Participants within each sector will develop a climate early warning outline using the Ready-Set-Go framework and a list of action items to be implemented that will enhance climate services delivery.

The READY-SET-GO Framework for Climate Early Warning

Participants: Create small break-out groups by sector to enable focused work on sector-specific climate services delivery needs and best practices.

Objectives:

- Develop an enhanced climate early warning system outline using the Ready-Set-Go framework

SESSION 3: Build Climate Stories

Build Climate Stories

During Session 3, participants will review key messages and best management practices and consider how to communicate them and desired outcomes. Key concepts in communicating climate change will be presented including setting clear goals, defining the target audience, and framing messages. Participants will observe good examples of climate communications and discuss what works and what doesn't. The final output of this session is a Climate Story for each sector that can be communicated or disseminated to a broader audience. In preparing Climate Stories, participants will draw on previous sessions to:

- Set the scene by describing historical events and impacts
- Diagnose the events by analyzing information flow, decisions, and actions
- Reflect on the event by identifying key messages and lessons learned

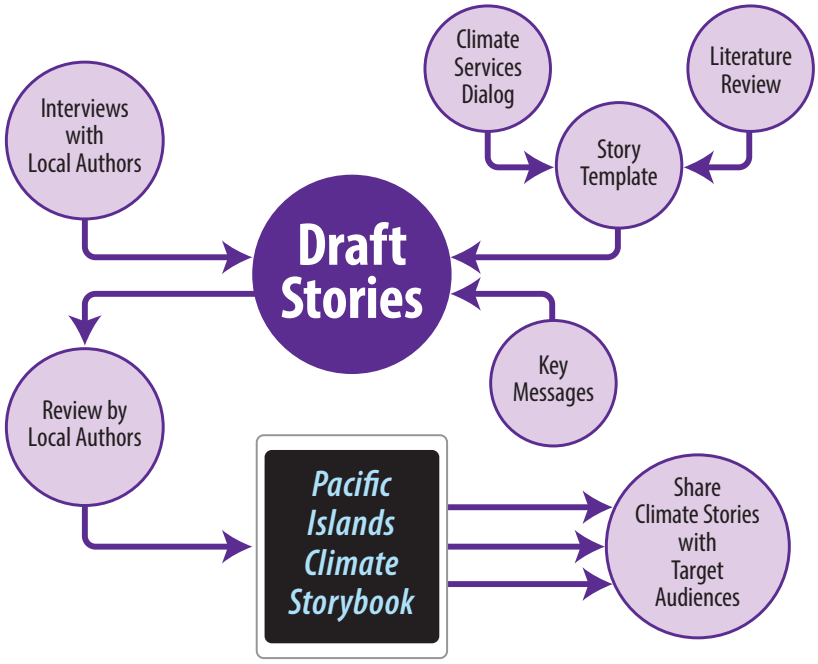
Participants: Participants remain in their break-out groups to develop their Climate Stories.

Objectives:

- Develop a Climate Story with key messages and best practices

Climate Story Development Process

The Climate Story development process is initiated through the dialog (Sessions 1, 2, and 3) using the story template and local scientific and experiential knowledge. Additional work outside the dialog is encouraged to fully develop the Climate Story, such as reviewing literature and interviewing selected stakeholders who then become local authors. These interviews can also help develop and refine the key messages and lessons learned. Key messages represent the "moral of the story." Examples of key messages that emerged from the climate story development process are provided in this Storybook. Finally, participants are encouraged to share their Climate Stories to target audiences as part of an overall climate communication strategy.



Climate Story Template

A Climate Story is like a case study about climate change and variability-related issues, actions, and key messages in narrative form. This approach conveys information in a way that is easy for decision-makers and stakeholders to understand and apply.

Objectives:

- Capture information from communities about historical events, impacts, and lessons learned (both positive and negative) related to measures that can be taken to increase community resilience in light of a changing climate
- Use this information to identify key messages and best practices, and where appropriate specific actions that can be taken to enhance situational awareness and early warning
- Blend technical and experiential knowledge in a format that is most meaningful, useful, and easily distributed

Illustrative Climate Story Template

Story Title

A short descriptive title that draws the reader to the story

The story title should refer to the location, type of climate event, and impacts. A catchy title will draw the reader's interest.

Setting the Scene

A brief description of the location, significance, and key actors in the story

The first paragraphs should start with an engaging scene, action, or quote from a character. The date and location of the story should be mentioned to give the story context. The significance of the climate event should be emphasized to build narrative tension. This can be done by explaining the impacts of the climate event, such as the first signs of high water over-topping a seawall, impacts on a food source, or a quote from about the need for/importance of climate early warning. The following should be included within this section:

- Story date and location
- Impacts of the event from both a technical and experiential perspective—note the significance of impacts for relevant sectors
- Potentially an introduction to the local author or storyteller we are following

Diagnosing the Event

A detailed narrative of the scientific and experiential knowledge used to make decisions and take action

This section provides an overview narrative of the decision-making process—the sources and types of information, the flow of information to and from the various stakeholders, and the types of actions taken and when, as well as measures needed to improve the situation—additional and/or more integrated and targeted information, and better communication among stakeholders. This is where more detailed information about the science of the climate event can be placed, such as the cause of the event and recurrence time. Key messages can be inserted as call-out boxes within the story. They should be referred to in the surrounding paragraphs so they flow with the story rather than interrupt it. The following should be included within this section:

- The chronology of the climate event or development of a climate service
- What climate services were used or needed (include as many details as possible, such as timing, warning content and format, and stakeholders involved)
- Information about that type of event (e.g., How often does it happen and for how long? When did it last happen? What causes the event?)
- Potentially a flashback to a previous event to compare impacts or available services

Telling the Moral of the Story

Reflecting on the event, key messages, and lessons learned

This section tells the end of the story and reflects on the event, fleshing out the key messages and lessons learned. Quotes from the local author or storyteller will be particularly helpful here. If any similar event has happened since this story took place, mention if anything learned from this story was applied. The following should be included within this section:

- What are the key messages, if not already highlighted, and how do they relate to the story?
- Has the event happened again and has anything been learned/improved?
- Have climate services or products been updated since then?

Using Multimedia

Providing visual and audio depth to a story

- Insert as many pictures and illustrations as possible
- Some stories could have an accompanying short audio file and a photograph of the local author telling the story

Key Messages to Guide Climate Services Development and Delivery

During the Climate Services Dialogs conducted across the Pacific Islands, a number of key messages and good practices were captured. These key messages were incorporated and refined as part of climate storytelling.

Engage *with the community and other stakeholders early and often*— building community ownership and participation from the beginning leads to more positive, sustainable outcomes.

- Robust relationships between stakeholders at the national or regional level (e.g., meteorological services, disaster responders, managers and planners in sectors such as water resources, agriculture, fisheries, and tourism), and those at the community-level (e.g., village councils, fishers, farmers, small businesses) must be developed and nurtured. Underrepresented and vulnerable members in a community also need to be involved, including women, elders, and people with disabilities.
- Engagement must be carried out in a culturally appropriate manner, employing trusted messengers and using established pathways. Relationships with champions and other dedicated individuals should be cultivated as they are indispensable when it comes to inspiring governments, communities, and individuals to take action.
- Success depends on developing long-term relationships that build trust and foster an enabling environment, and these can be easily mobilized in times of emergencies.

Know *your physical/environmental setting*—using locally-relevant indicators to understand and predict the impacts of a changing climate will help ensure that products and services are appropriate to time and place.

- Consider the full range of climate parameters.
- Be aware of the difference between climate change and climate variability, and recognize that climate variability (e.g., El Niño and La Niña) may result in different effects being experienced in different places at the same time.

Know *your social/cultural setting*—understanding community values, aspirations, and perspectives, as well as the sensitivity of critical assets and community adaptive capacity, will drive adaptation from the bottom up.

- Recognize that social and ecological vulnerability are linked in resource-dependent communities to avoid maladaptation.
- Recognize that there is considerable value in local/experiential knowledge, that it needs to be linked to and used with scientific/technical knowledge, and that local/experiential knowledge should be gathered and preserved as part of a robust climate services program.

***Tailor** information to the needs of the user*—commitment to an iterative process involving the co-production of knowledge at multiple levels will ensure that products and services are specific to sector and locale, as well as the nature and timing of decision-making.

- Data and information must be transformed (and translated into local languages and dialects) by placing content in a form that is easily understood and readily accessible, aggregating and customizing it so that it is appropriately and successfully applied to relevant problems and questions. Attention also needs to be given to the generation and transmission of data and information (along with transformation) with the ultimate goal of being useable, useful, and utilized.
- Products and services should form an "end to end" suite, from seasonal forecasts that support early warning to decadal projections that support climate adaptation, and they should draw upon and integrate core capabilities including observations and modeling.

***Commit** to robust and sustained monitoring and assessment*—the maintenance and expansion of existing monitoring networks will lead to an improved ability to understand and predict a changing climate and associated impacts over both the short and long term.

- Monitoring needs to be matched to the situation, measuring indicators and impacts relevant to key issues. Identify and establish baselines and thresholds, and verify models and predictions.
- Documenting regional and local impacts (as well as climate parameters) will help inform both scientists and decision-makers.
- Resources must be provided, in the form of funding and expertise, to establish, maintain, and upgrade monitoring networks at multiple scales.

***Be aware** that impacts due to a changing climate exist along with (and often exacerbate) impacts from a myriad of other non-climate stressors*—climate adaptation will be most effective when it is integrated with disaster risk reduction, sustainable development, ecosystem-based management, and other such multi-sectoral approaches to planning and policy development.

- Understanding and addressing non-climate stressors is a foundation for adapting to a changing climate.
- Multi-sectoral approaches increase technical support and reduce financial cost by leveraging resources among multiple stakeholders. The potential for maladaptation is also reduced.

***Direct** attention to the alignment and coordination of activities*—integrated program planning and product development will maximize efficiency and effectiveness (by minimizing gaps and overlaps, and maximizing information consistency and messaging), as well as enrich the potential for local to regional capacity development.

- Donors, program managers, communities, NGOs, and other partners need to leverage existing partnerships, recognizing the disparity between funding cycles and the lack of continuity this creates.
- Capacity building of National Meteorological Services and the enhancement of their distribution networks is essential to ensuring that meaningful information reaches end users.
- Encourage communities of practice among scientists, climate services providers, and managers as a way to share lessons and improve outcomes.
- Cultivate educational and professional mentorships as a means to build capacity over the long term.

Tanguisson Beach, Tamuning, Guam. Source: Philip Davis on Unsplash

Pre-Dialog Technical Exchange

Pre-Dialog Technical Exchange and Planning

Process Agenda

Technical Exchange/Planning Session Objectives	Facilitation Notes
Develop Focus of the Dialog • Identify the climate early warning focus, such as drought, coastal inundation, or coral bleaching, • Identify affected sectors, departments, and communities • Finalize dates, venue for the dialog • Identify speakers for Session 1 • Identify facilitators for group work	**Activity:** The Meteorology Department reaches out to other department/sector representatives to identify a priority climate early warning issue as the focus of the Climate Services Dialog. It could be the most recent climate-related event/condition that resulted in impacts to various sectors or a predicted future event/condition of concern to the community. Facilitators should be identified for group work. **Output:** As a result of this outreach, the focus of the dialog is identified and a core team is developed to participate in the pre-dialog technical exchange and planning sessions.
Share Climate Knowledge • Capture history of climate-related events/conditions and impacts • Identify participants based on affected sectors, departments, and communities • Review/refine objectives, process guide, and activity guides for Session 1	**Activity:** The core team meets to share knowledge of the climate-related event/condition, impacts, and best practices from their sector. The core team should walk through the process agenda and activities for Session 1. The core team should review and refine the sample process guide including objectives and speakers for each session. Good practices for developing learning objectives are described here. A dry-run of Activity 1 by the core team will capture the history of climate-related events/conditions and impacts. **Output:** The output of this meeting is a compilation and common understanding by the core team of the history of climate-related events/conditions and impacts. While participants will be asked to share their knowledge of this information in Session 1, it is helpful to have gone through this exercise beforehand to verify dates, locations, and impacts. Participants may not remember the exact month or year in which an event occurred. In addition, the core team should develop the participant list and finalize the dates for the dialog. Finally, the core team should have refined the objectives, process guide, and activities for Session 1, as well as finalized the list of participants based on the affected sectors, departments, and communities.
Diagnose Climate Services • Develop a common understanding of climate services components and the Ready-Set-Go framework for climate early warning • Describe existing climate services delivery for the focus climate-related event/sectors of the dialog • Review/refine objectives, process guide, and activity guides for Session 2 • Identify speakers for Session 2	**Activity:** The core team should walk through the process agenda and activities for Session 2. The core team should discuss the Ready-Set-Go framework and describe the existing climate early warning system for the focus of the dialog, e.g., drought, coastal inundation, coral bleaching. Guiding questions to support the description of the existing climate early warning system using the Ready-Set-Go framework are provided in the Pre-Dialog Activity. The core team should review and refine the sample process guide, including objectives and speakers for each session. **Output:** The output of this session is a description of the existing climate early warning system for the focal climate event/condition within the context of the Ready-Set-Go framework. This description will be presented to the participants during Session 2. Participants will use this description as the basis for diagnosing strengths and weakness and identifying ways to improve the system.

Good Practices in Developing Learning Objectives

Every training activity should be based on a defined set of instructional objectives. Objectives perform several key functions, such as:

- Inform the participants of what is important and guide them through the material
- Provide a basis upon which the instruction is designed (much like a map)
- Provide a framework upon which to evaluate the success of the learning activity
- Stress the behavioral changes expected rather than attitudes or insights that cannot be measured

"Good" objectives:

- Are clearly stated
- Define or describe an action
- Can be measured, in terms of time, space, amount, and/or frequency

Objectives are often categorized according to the hierarchical level of the skills, behaviors, or tasks identified during the needs analysis. There are two commonly-used levels of objectives:

- **Terminal Learning Objectives (TLO):** TLOs are objectives that correspond to the overall instructional goals of the course. TLOs describe what participants will be able to do at the end of the overall instructional course.
- **Enabling Learning Objective (ELO):** ELOs, also known as subordinate objectives, correspond to the skills that are required to accomplish the TLO. Specifically, they define the skills, knowledge, or behaviors that participants must master to successfully achieve the TLO.

Vague verbs such as "understand", "know", or "learn about" should be replaced with more specific action verbs such as "identify", "state", or "describe." Categories of learning objectives following Bloom's Taxonomy are provided in the table on the next page.

Learning Outcomes and Illustrative Verbs to Specify Learning Objectives

Learning Outcome	Description	Verbs
Knowledge	The recall of previously learned material (facts or theories) in essentially the same form taught.	Acquire, Define, Describe, Detect, Identify, Label, List, Mark, Match, Name, Outline, Recall, Recognize, Reproduce, Select, State
Comprehension	Seeing relationships, concepts, and abstractions beyond simply remembering the material. Typically involves translating, interpreting, and estimating future trends.	Compare, Contrast, Convert, Defend, Distinguish, Estimate, Explain, Extend, Generalize, Give examples, Illustrate, Infer, Interpret, Paraphrase, Predict, Rephrase, Represent, Summarize, Transform, Translate
Application	The ability to use learned material in new and concrete situations, including the application of rules, methods, concepts, principles, laws, and theories.	Administer, Change, Compute, Demonstrate, Develop, Differentiate, Discover, Employ, Identify, Manipulate, Modify, Operate, Predict, Prepare, Produce, Relate, Restructure, Solve, Transfer, Use
Analysis	The ability to break down material into its component parts so the organizational structure may be understood, including identification of the parts, analysis of the relationships between parts, and recognition of the organizational principles involved.	Break down, Categorize, Classify, Deduce, Diagram, Differentiate, Discriminate, Distinguish, Identify, Illustrate, Outline, Plot, Point out, Relate, Select, Separate
Synthesis	The ability to put parts together to form new patterns or structures, such as a unique communication (a theme or speech), a plan of operation (a research proposal), or a set of abstract relations (schemes for classifying information).	Combine, Compile, Compose, Create, Derive, Design, Develop, Devise Explain, Formulate, Generate, Modify, Organize, Produce, Rearrange, Reconstruct, Relate, Rewrite, Tell, Write
Evaluation	The ability to judge the value of material for a given purpose. Learning in this area is the highest in the cognitive hierarchy because it involves elements of all the other categories, plus conscious value judgments based on clearly defined criteria.	Appraise, Assess, Conclude, Criticize, Decide, Describe, Interpret, Judge, Justify, Relate, Summarize, Validate

Source: Armstrong, P. (2010). *Bloom's Taxonomy*. Vanderbilt University Center for Teaching. Retrieved from https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/

PRE-DIALOG ACTIVITY: Describe Existing Climate Early Warning System

As part of the pre-dialog technical exchange, the core team should describe any existing early warning systems for the focal climate-related event/condition using the Ready-Set-Go framework. This means describing the flow of information and timing of decisions and actions related to the event/condition. The information flow, stakeholders involved, and decisions/actions taken are mapped using the Ready-Set-Go framework. A member of the core team should be identified to present the existing system to the participants during Session 2. The participants will use this description as the basis for diagnosing the strengths and weaknesses of the existing climate services and identifying ways to strengthen an early warning system for a specific climate-related event/condition.

An example thought process is provided below:

Scenario

An existing climate early warning system is described based on the [climate-related event/condition; e.g., drought that occurred from month/year to month/year].

I learned about the potential for a [**event/condition**] from [**source(s) of information**]. I monitored the information starting from [**months, weeks, days**] before the onset of the [**event/condition**]. I first communicated information about the potential for a [**climate-related event/condition**] to [**agencies, organizations, communities**] on [**date or days before onset**].

I continued to monitor [**source(s) of information**] for [**duration**]. When the conditions got to [**a particular threshold or trigger**] I decided to inform [**agencies, organizations, communities**] about the need to prepare for the [**climate-related event/condition**]. Information on actions to take to prepare were communicated by [**types of communication methods**] to [**agencies, organizations, communities**]. Preparedness actions included [**types of actions by stakeholder group**].

[**Emergency response/mandatory action; e.g., evacuation, water rationing**] protocols were activated on [**date**]. Instructions to communities were delivered by [**types of communication methods**].

Using the READY-SET-GO Framework

Climate Early Warning System for: [climate-related event/condition; e.g., drought, coastal inundation, coral bleaching]	**Ready** • Begin planning and monitoring of forecasts • Update contingency plans • Sensitize communities • Enable early warning systems	**Set** • Continue monitoring • Adjust plans • Warn communities • Conduct local preparation activities	**Go!** • Activate response • Instruct communities to evacuate, if needed
• How did you find out about the event (sources and types of information)? • How far in advance did you know about the event (months, weeks, days)? • How and when did you communicate to stakeholders that could be affected? • What parameters did you use to track the event? • How did you use the information to make decisions/identify actions? • How did you communicate actions you wanted people to take? • What actions were taken? • What triggered those actions?			

Share Climate Knowledge

SESSION 1: Share Climate Knowledge

Process Agenda

Day 1	Session 1 **Share Climate Knowledge**	**Objectives/Facilitation Notes** **Objectives:** • Conduct opening program and introductions • Provide overview of Climate Services Dialog highlighting overarching themes of building your Climate Story • Provide overview of end-to-end climate services • Share Climate Stories that illustrate key messages and best practices in the delivery of climate services • Share experiential and science-based knowledge on climate-related events/conditions and impacts
45 minutes	Climate services and dialog overview	An overview of each session of the dialog is presented to give participants a roadmap of the daily activities and expected outputs of each session. Basic climate science and impacts (climate change, variability) and components of an end-to-end climate services delivery system are presented to provide an understanding of the nature of these services from a multi-sectoral perspective. The Ready-Set-Go framework is introduced as a tool to support and strengthen climate early warning systems.
45 minutes	Share climate stories	This session sets the scene for sharing experiential knowledge of climate-related events and impacts that will be explored in more detail in Activity #1. Storytellers are identified before the dialog to share their Climate Story. The Illustrative Climate Story Template is presented as a guide toward building their stories. Three to four storytellers give oral presentations highlighting impacts and best practices based on the template provided to them ahead of time. Without using presentations, storytellers sit together facing the participants. Audio and/or video recordings of these stories can support future outreach efforts. Questions are held until after all stories are shared. Participants are encouraged to jot down questions, key messages, and best practices for further discussion. See Pacific Island Climate Stories and Key Messages for examples.
1 hour	Discussion of key messages and best practices	Facilitator calls for questions and asks participants to report back on key messages and best practices that they heard from the storytellers. Facilitator guiding questions: • What are common messages you heard from the stories? • What are some best practices that you could envision adopting in your work? The facilitator should be ready to help start the conversation by identifying a few key messages and best practices based on what was presented or by reviewing key messages handout. Facilitator records key messages and best practices on a flipchart.
1 ½ hours	Experiential knowledge Activity #1—Share climate knowledge	Activity 1 is designed to document historical climate-related events and impacts to provide the broadest range of information that can be used to strengthen climate services. A historical timeline is developed to document the temporal aspects of these events. Maps can be used to document spatial aspects of these events, including specific sites, islands, or groups of islands impacted. Participants will brainstorm impacts of climate-related events on different sectors. Break-out groups should be made up of people from different sectors and individuals should be identified to record group work and report out.

Day 1 (continued)	**Session 1** (continued)	**Objectives/Facilitation Notes**
30 minutes	Report out and synthesis	Participants reconvene to share timelines and discuss the events, identifying similarities or differences. The facilitator synthesizes the report and makes a composite timeline of events and impacts building on inputs from each group. This will be used in Session 2 for sector break-out activities. The workshop team can make a summary impact matrix to present during Session 2.
45 minutes	Technical knowledge Presentation by technical expert on relevant climate variables	A technical expert presents the state-of-knowledge about climate science in the region. As part of this presentation and subsequent discussions, experiential knowledge (Activity 1 results) is related to the technical knowledge presented here. The technical expert needs to provide a summary of relevant essential climate variables.
30 minutes	Synthesis discussion of events and impacts	Record key events and impacts highlighted during the previous sessions on flipcharts.

ACTIVITY #1: Share Climate Knowledge

Objective: • Document historical climate-related events and impacts of climate change on timelines and maps • Brainstorm impacts of climate-related events on focal resources or assets, and identify priority issues **Output:** Historical event timeline, impact map(s), list of impacts and priority issues	• **Participants:** divided into small multi-sector groups • **Materials:** flipcharts, markers, sticky dots (various sizes and colors) • **Facilitator:** guides participants through focus questions • **Recorder:** prepares summary of historical events for the Climate Story outline
Focus Questions: • What is the history of climate-related events that have impacted the focal resources or assets? • What areas were impacted by these events? • How long did these events last and how often did they occur? What were the patterns and frequency of these events? • What were impacts of the climate-related events (ecological, socioeconomic, infrastructural, and cultural)? • What priority issues did you have to deal with as a result of these impacts?	• Use a large sheet of paper to document historical events—sticky notes can be used to write down discrete events and impacts (who, what) to be placed on the historical timeline • Mark affected areas on printed maps of the island/region using stickers and sharpies, create a legend • Break-out group facilitator leads group discussion around each timeline about the events and identifies similarities or differences across groups
Report Out	• Each group highlights the "when" and "where" of historical events • Facilitator prepares a composite historical timeline based on the group reports • The output of this activity will be used in Session 2

Diagnose Climate Services

SESSION 2: Diagnose Climate Services

Process Agenda

Day 2	Session 2 **Diagnose Climate Services Delivery**	**Objectives/Facilitation Notes** **Objectives:** • Recap of events and impacts as a result of sharing stories and developing historical timeline • Participants are divided into sector groups • Describe existing climate services • Diagnose strengths, weaknesses, and opportunities for existing climate services to support climate early warning by sector • Explore existing products and services that support situation awareness • Identify actions to improve the situation and develop a climate early warning outline
30 minutes	What is the current situation?	Review of the Ready-Set-Go framework presented in Session 1. Deliver the Pre-Dialog Technical Exchange and Planning presentation that describes the existing Ready-Set-Go situation for the climate-related event(s)/condition. The guidance for developing this presentation is provided in the Pre-Dialog Activity. Start by focusing on one event/condition that was identified in Session 1. Expand to more than one if there is time. Revisit key messages and rewrite them as questions.
1 hour	Activity #2: Diagnose existing early warning system	Break-out groups will diagnose the current capacity to deliver end-to-end climate services for each sector using a specific climate event. Focus questions include: • What worked? What didn't? (information, communication, effectiveness of actions) • What other parameters/information did you wish you had to take action/make decisions?
30 minutes	Exploring available products, tools, and climate services	Present examples of early warning systems, types of information, and tools that can be used to enhance situational awareness and support decision-making. Participants will examine what works and what needs to be changed, and through this process begin to map out the elements of a climate early warning system.
1 hour	Activity #3: Develop a climate early warning system outline	Break-out groups will outline a climate early warning system that highlights actions needed to strengthen the delivery of climate services for each sector. • What discoveries did you make? • What would you do differently? This is a good time to revisit key messages and best practices and incorporate them into the climate early warning outline.
30 minutes	Report out and synthesis	Break-out groups report on the outline and synthesize results to identify key actions needed to move forward.

ACTIVITY #2: Diagnose Existing Early Warning System for a Climate-Related Event

Objective: The information flow, decisions, and actions made relative to a selected climate-related event/condition will be diagnosed based on the presentation of the existing system. Participants will describe what worked, what did not work, and what needs to be changed for future issues related to climate events. **Output:** Strengths, weaknesses, opportunities of existing system	• **Participants:** divided into small multi-sector groups • **Materials:** flipcharts, markers, sticky dots (various sizes and colors) • **Facilitator:** guides participants through focus questions • **Recorder:** prepares summary of historical events for the Climate Story outline
Focus Questions: • What worked? What didn't? (information, communication, effectiveness of actions) • What other parameters/information did you wish you had to take action or make decisions?	

Using the READY-SET-GO Framework

Climate Early Warning System for: [climate-related event/condition; e.g., drought, coastal inundation, coral bleaching]	**Ready** • Begin planning and monitoring of forecasts • Update contingency plans • Sensitize communities • Enable early warning systems	**Set** • Continue monitoring • Adjust plans • Warn communities • Conduct local preparation activities	**Go!** • Activate response • Instruct communities to evacuate, if needed
• What worked? What didn't? (information, communication, effectiveness of actions) • What other parameters/information did you wish you had to take action/make decisions? • What was missing?			

Available Climate Services Products and Tools

Below is a list of websites and tools for climate information in the Pacific Islands with an emphasis on climate early warning, seasonal outlooks, and ENSO monitoring. They include products and information from a mix of agencies, institutions, and organizations, which are geared toward the transfer of regionally-relevant climate information for the region.

Climate Information

NOAA Climate Portal

With the rapid rise in the development of online technologies and climate services across NOAA, there has been an increasing need for greater collaboration in response to customer requirements, emerging needs for improved decision-making capabilities across all sectors of society facing impacts from climate variability and change, and the importance of leveraging climate data and services to support research and public education. To address these needs, NOAA developed the NOAA Climate Services Portal. The goal is for the Portal to become the "go-to" website for NOAA's climate data, products, and services for all users.

The Pacific Ocean Portal

The aim of the Pacific Ocean Portal is to enhance the capacity of Pacific Islands to manage and mitigate the impacts of climate variability and tidal events. The Portal works with stakeholders in the Pacific Islands to build tools that can forecast and report on climate, tides, and the ocean. It provides a number of products and services generated for tourism, ocean monitoring, coral reefs, sea level, fisheries, and maritime shipping.

NOAA NESDIS National Centers for Environmental Information

NOAA's National Centers for Environmental Information (NCEI) are responsible for hosting and providing access to one of the most significant climate data archives on earth, with comprehensive oceanic, atmospheric, and geophysical data. From the depths of the ocean to the surface of the sun and from million year-old tree rings to near real-time satellite images, NCEI is the leading US authority for environmental information.

US Global Climate Observing System (GCOS) Program

NOAA is an active participant and proponent of the sustained and robust operation of a diverse array of climate observing systems that are part of a global network of climate observing systems under the Global Climate Observing System (GCOS).

Asia-Pacific Data Research Center (APDRC)

The APDRC is building towards a one-stop shop of climate data and products for users. Its mission is to increase understanding of climate variability in the Asia-Pacific region by developing the computational, data management, and networking infrastructure necessary to make data resources readily accessible and usable to researchers and general users, and by undertaking data-intensive research activities that will both advance knowledge and lead to improvements in data preparation and products.

Pacific Climate Change Science Program

Through the Pacific Climate Change Science Program and the Pacific-Asia Climate Change Science Adaptation Planning Program (PACCSAP), the Australian Government provided tools and knowledge to 15 Pacific island countries to enhance their capacity to adapt to a changing climate.

Global Tropics Hazards and Benefits Outlook

The Climate Prediction Center's Global Tropics Hazards and Benefits Outlook page is updated weekly and contains forecast information on temperature, precipitation, tropical cyclones, and ENSO for the global tropics.

APEC Climate Center (APCC)

The APCC provides a variety of climate information products and services based on a multi-model ensemble prediction system.

El Niño-Southern Oscillation

Pacific ENSO Applications Climate Center

The Pacific ENSO Applications Climate (PEAC) Center was established in 1994 as a multi-institutional partnership to conduct research and produce information products on climate variability related to the ENSO climate cycle in the US-Affiliated Pacific Islands. The mission of PEAC is to conduct research and develop information products specific to the region on the ENSO climate cycle, its historical impacts, and long-term forecasts of ENSO conditions.

Hawai'i and US Pacific Islands Climate Impacts and Outlooks Dashboard

This website serves as a digital version of the quarterly "Hawaii and US Pacific Islands Regional Climate Impacts and Outlook." The quarterly outlook draws on the Pacific ENSO Applications Climate Center's "Pacific ENSO Update" quarterly newsletter and other sources to bring together seasonal predictions and projections alongside information on recent impacts of weather and climate events in a concise and accessible format.

NOAA National Weather Service (NWS) Climate Prediction Center ENSO Page

This NOAA program exists to monitor, assess, and predict important oceanic and atmospheric phenomena that affect Pacific weather.

International Research Institute (IRI) ENSO Forecast

The Columbia University International Research Institute (IRI) for Climate and Society provides a monthly summary of the status of ENSO, based on the NINO3.4 index (120-170W, 5S-5N).

NOAA National Center for Environmental Prediction Coupled Forecast System ENSO Forecast

The Coupled Forecast System (CFS) v2 provides a prediction of monthly and seasonal mean sea surface temperature anomalies (degrees C) for the Niño 3.4 region (120–170W, 5S–5N). Observations are shown by the solid black line. Thin lines display forecasts from individual CFSv2 ensemble members, and the dashed line shows the ensemble mean. Seasonal averages of +0.5 degrees C or higher favor El Niño, while seasonal averages of -0.5 degrees C or lower favor La Niña. This product is updated weekly.

Island Climate Update

New Zealand's National Institute of Water and Atmospheric Research Island Climate Update is a monthly summary of the climate in the tropical South Pacific Islands, with an outlook for the coming months. This bulletin is a multi-national project with collaboration from a number of Pacific nations and support from various organizations.

Sea Level Rise and Sea Surface Height

The University of Hawai'i Sea Level Center (UHSLC)

The UHSLC serves multiple roles in supporting real-time oceanographic operations as well as climate and oceanographic research. It collaborates with agencies within host countries in the installation and maintenance of a global network of tide gauge stations. The data are routinely processed, analyzed, and distributed at varying levels of temporal resolution and quality control depending upon the timeliness of release and application.

Pacific Islands Ocean Observing System (PacIOOS)

The Pacific Islands Ocean Observing System at the University of Hawai'i empowers ocean users and stakeholders in the Pacific Islands by providing accurate and reliable coastal and ocean information, tools, and services that are easy to access and use. Information on waves, currents, shoreline impacts, water characteristics, and weather conditions are available for the US-Affiliated Pacific Islands.

Predictive Ocean-Atmosphere Model for Australia (POAMA)

Seasonal forecasts of sea-level anomalies in the Western Pacific are generated using the Australian Bureau of Meteorology's Predictive Ocean-Atmosphere Model for Australia (POAMA). This is a global ocean-atmosphere coupled ensemble seasonal forecast system developed jointly by the Bureau of Meteorology and the CSIRO Division of Marine and Atmospheric Research (CMAR).

Global Forecast System (GFS)-Wave

GFS-Wave is coupled to the Global Forecast System (GFSv16), as part of the Unified Forecast System, and is an updated version of NOAA's WaveWatch III. Forecast wave height (in meters) and vector (speed and direction) of the waves out to 96 hours. Red colors indicate regions of high waves; blue colors indicate smaller waves.

Climate Forecast System Sea Surface Height Forecast

The NWS Climate Forecast System models projected sea surface height for eight-month periods. Blue areas denote lower sea heights; red areas are higher. Forecasts are from initial conditions of the last 30 days, with four runs from each day. Forecast ensembles consist of 40 members from an initial period of 10 days.

Storms

Active Watches, Warnings, and Advisories

The NWS Active Watches, Warnings, and Advisories website contains links to track current hazards, conditions, radar, and forecasts for the US Pacific Islands region.

Cyclostorm: Watching the Hurricane Zone

This page provides access to a wealth of hurricane and tropical cyclone information including coverage of current tropical cyclones, typhoon and hurricane bulletins, and satellite and radar imagery around the world. Subpages exist for the Central, Western, Eastern, and South Pacific.

Global Tropics Hazards and Benefits Outlook

The NWS Climate Prediction Center's Global Tropics Hazards and Benefits Outlook is a forecast for areas with elevated odds for above- or below-median rainfall and regions where tropical cyclogenesis is favorable or unfavorable for the upcoming week-1 and week-2 time periods. The rainfall outlook shows precipitation integrated over a week and targets broad-scale patterns, rather than local conditions that are highly variable.

Drought

US Drought Monitor

The US Drought Monitor provides a map and narrative summary of drought conditions across the US-Affiliated Pacific Islands, and is updated weekly.

Sea Surface Temperature and Coral Bleaching

NOAA OceanWatch—Central Pacific

NOAA's OceanWatch portal acquires and processes satellite information and creates a variety of satellite data products for the Pacific Ocean region, as an updated source of daily regional satellite oceanographic observations. Satellite-based activities include observation, monitoring, analysis, and data distribution. As part of its operational responsibilities, OceanWatch operates a direct readout station for the acquisition of real-time sea surface temperature data from the Advanced Very High Resolution Radiometer (POES AVHRR) sensors onboard the NOAA polar-orbiting satellite constellation.

Daily Optimum Interpolation Sea Surface Temperature (OISST)

The NOAA 1/4 degree resolution daily Optimum Interpolation Sea Surface Temperature (or daily OISST) is an analysis constructed by combining observations from different platforms (satellites, ships, buoys, and Argo floats) on a regular global grid. Starting from April 1, 2020, NCEI released a new version, OISST v2.1, to replace OISST v2.

Sea-Surface Temperature (SST) Anomalies

The NWS Climate Prediction Center produces weekly averages of SST anomalies (degrees C) for the past 12 weeks. Analysis is based on the OISST. This product is updated bi-weekly.

Equatorial Sub-Surface Temperature Anomaly

The NWS Climate Prediction Center's equatorial sub-surface temperature anomaly product shows anomalies at depths to 450-m across the equatorial Pacific for the previous 13 weeks. This product is updated every five days.

NOAA Coral Reef Watch (CRW)

The NOAA Coral Reef Watch Program's satellite data provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. Continuous monitoring of SST at global scales provides researchers and stakeholders with tools to understand and better manage the complex interactions leading to coral bleaching. When bleaching conditions occur, these tools can be used to trigger bleaching response plans and support appropriate management decisions. Operational 5-km daily Coral Bleaching Thermal Stress Monitoring products are available and are summarized below.

Coral Reef Watch Products—Bleaching Alert Areas

The NOAA CRW daily 5-km satellite Bleaching Alert Area product outlines the areas where coral bleaching thermal stress currently reaches various bleaching stress levels, based on satellite SST monitoring.

Coral Reef Watch Products—Coral Bleaching HotSpot

The NOAA CRW daily 5-km Coral Bleaching HotSpot product measures occurrence and magnitude of instantaneous thermal stress, potentially resulting in coral bleaching. The scale ranges from 0 to 5 degrees C. HotSpot values of 1 degree C or more indicate thermal stress leading to coral bleaching and are highlighted. Spatial resolution is 0.05 degrees.

Coral Reef Watch Products—Degree Heating Weeks

The NOAA CRW daily 5-km satellite coral bleaching Degree Heating Week (DHW) product shows accumulated thermal stress, which can lead to coral bleaching and death. The scale ranges from 0 to 16 degrees C-weeks. Spatial resolution is 0.05 degrees. The DHW product accumulates the instantaneous bleaching thermal stress (measured by Coral Bleaching HotSpots) during the most recent 12-week period and is directly related to the timing and intensity of coral bleaching. Significant coral bleaching usually occurs when DHW values reach 4 degrees C-weeks. If DHW values reach 8 degrees C-weeks, widespread bleaching is likely and significant mortality can be expected.

ReefBase Online Geographic Information System (ReefGIS)

ReefBase's Online Geographic Information System (ReefGIS) allows users to display coral reef-related data and information on interactive maps. Users can zoom, search, query, and save datasets on coral reefs.

Reef Resilience Toolkit

The Reef Resilience Toolkit, part of the US Climate Resilience Toolkit, connects coral reef and marine protected area managers and practitioners with information, experts, and resources to innovate, accelerate, and leverage solutions for improved global coral reef health, restoration of reef fisheries, and community-based climate adaptation efforts. Created and updated by global experts in coral reefs, fisheries, and climate change, the Toolkit features 1) Synthesized information on science and management tools and techniques; 2) Easily searchable summaries of journal articles about reef resilience science; and 3) Case studies highlighting successful management strategies.

Reef Resilience Network

The Reef Resilience Network led by The Nature Conservancy builds the capacity of reef managers and practitioners around the world to better address the local impacts of climate change and other stressors on coral reefs. The Network has the following main components: 1) Aggregation, translation, and access to new coral reef science and management strategies for coral reef practitioners; 2) Communication to coral reef managers worldwide on new resources and tools for managing for resilience; 3) Virtual capacity-building; and 4) Case studies in reef management, an online forum, and a community of practice.

ACTIVITY #3: Develop a Climate Early Warning Outline

Objective: Using the input from presentations on climate services products and output from Activity #2, participants will develop a climate early warning system outline **Output:** Strengths, weaknesses, opportunities of existing system	• **Participants:** divided into small multi-sector groups • **Materials:** flipcharts, markers, sticky dots (various sizes and colors) • **Facilitator:** guides participants through focus questions • **Recorder:** prepares summary of historical events for the Climate Story outline
Focus Questions: • What discoveries did you make? What would you do differently? • What is a proposed climate early warning system outline for [climate-related event/condition; e.g., drought, coastal inundation, coral bleaching]	• Participants identify areas for improvement and develop an improved plan for a future similar event

EXERCISE: What should happen? Rewrite how it should be.

Scenario

An existing climate early warning system is described based on the [climate-related event/condition; e.g., drought that occurred from month/year to month/year].

I learned about the potential for a [event/condition] from [source(s) of information]. I monitored the information starting from [months, weeks, days] before the onset of the [event/condition]. I first communicated information about the potential for a [climate-related event/condition] to [agencies, organizations, communities] on [date or days before onset].

I continued to monitor [source(s) of information] for [duration]. When the conditions got to [a particular threshold or trigger] I decided to inform [agencies, organizations, communities] about the need to prepare for the [climate-related event/condition]. Information on actions to take to prepare were communicated by [types of communication methods] to [agencies, organizations, communities]. Preparedness actions included [types of actions by stakeholder group].

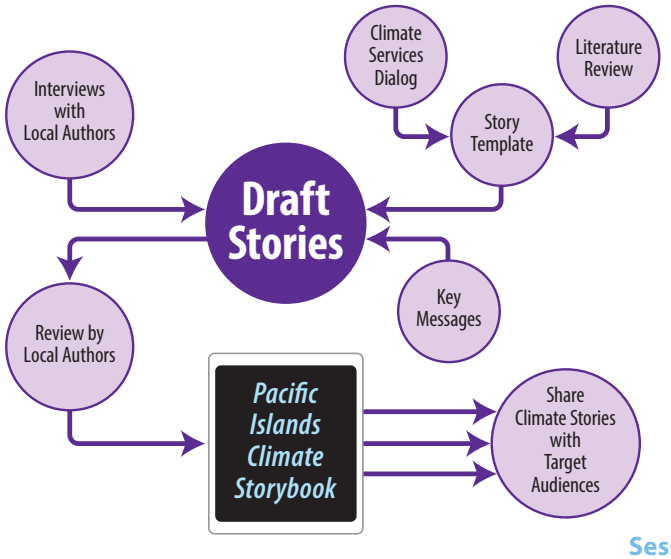
[Emergency response/mandatory action; e.g., evacuation, water rationing] protocols were activated on [date]. Instructions to communities were delivered by [types of communication methods].

Build Climate Stories

SESSION 3: Build Climate Stories

Process Agenda

Day 2	Session 3 **Build Climate Stories**	**Objectives/Facilitation Notes** **Objectives:** • Explore techniques in climate communication • Communicate key messages and best practices through the development of a climate story
1 hour	Presentation of climate communications concepts and best practices Review and discussion of a climate communication piece	This session will begin with a presentation of key concepts and best practices in communicating climate change including setting clear goals, defining the target audience, and framing messages. Participants will watch a short communication piece and discuss it in the context of the key concepts and best practices. Sample supporting materials: 1. Good practices guidance for climate communication challenges handout 2. Pacific Adventures of the Climate Crab video 3. Video review questions Discu ssion: What are key messages that worked well and what are key challenges in climate communication?
1 hour	Activity #4: Reflect on key messages and best practices	Participants will synthesize the various outputs of the dialog into a climate story for each sector building on the key messages and best practices highlighted throughout the dialog. Each sector will develop a 5 minute presentation of their climate story. A randomly assigned "target audience" will be provided for their story (Prime Minister, village leader, etc.). Revisit key messages and integrate them as appropriate in your story.
30 minutes	Share Climate Stories	Each break-out group reports out on their Climate Story tailoring their presentation to the target audience assigned to them as well as appropriate framing of the messages for that audience.



Good Practices for Overcoming Climate Change Communication Challenges

Challenge	Guiding Principles
Beginning climate change communication with communities' lived experience of change is important for contextualization but can risk unassociated problems being blamed on climate change	• Communication should be grounded in community perceptions of climate and change but facilitators must have the capacity to weave scientifically-derived climate change knowledge through dialog. • Include a general discussion of changes and challenges taking place in a community so that various contributing factors (including climate change) can be considered. • The degree of emphasis placed on the concept of climate change should relate to the immediacy of risks faced now; in many cases, an approach that reduces existing vulnerabilities is sufficient in the short to medium term to address the implications of climate change. • Investment in facilitators and mentors must be made to improve the quality of climate change communication.
Dominant discourses of extraordinary vulnerability to climate change in the Pacific can influence how climate communication is packaged, creating a misperception of risk and misplaced anxiety at the community scale	• Doom and gloom impact scenarios must be balanced with positive messaging about Pacific adaptive capacity and real adaptive solutions; fear does not motivate action. • Discussing impacts within the foreseeable future is more motivating at the community scale than dwelling upon long-term, worst-case projected impacts. • Community-based communication requires a significantly different approach to communication for global advocacy or general public awareness; organizations must have the capacity to tailor information to local conditions.
Scientific explanations of climate change causes, consequences, and uncertainties can be confusing and therefore disempowering for communities that are unfamiliar with a Western scientific frame of reference	• There is a need for standardization of climate change science messages; however, these must then be truly tailored to literacy levels of local context using diverse methods and humor where appropriate. • Making complex climate science resonate with local knowledge systems requires great skill and should only be embarked upon cautiously by experienced facilitators; a "less is best" approach may be better for the less experienced. • Anecdotes tailored to things and situations familiar to a community (e.g., "smoke" rather than carbon dioxide) are more effective than explaining abstract concepts such as greenhouse gases. • Emphasis on historical trends and more "certain" aspects of climate change should come before the discussion of future projections. • Limit discussions of future projections to those that are directly relevant to the community. • Ensure discussion of future climate is based upon current climate variability and extremes. • The issue of uncertainty should be presented in an honest fashion—there are still many unknowns about how climate change will manifest at the local scale. This often requires a lengthy, two-way discussion.

CLIMATE COMMUNICATION ACTIVITY:
Review Questions for Climate Communication Video

Review Questions	Notes
1. What are the goals of this communication piece (e.g., knowledge, buy-in, action)?	
2. Who is the target audience (stage of change)?	
3. How are the messages framed (what is the perspective, context)?	
4. How effective are message controls and delivery methods?	
a. Use of terminology	
b. Use of images	
c. Media used	
d. Messenger	

ACTIVITY #4: Reflect on Key Messages and Best Practices

Objective: Participants will review key messages and finalize this document. Participants will assemble a rough draft Climate Story using the template and make a short presentation **Output:** Climate Story for each sector	• **Participants:** divided into small multi-sector groups • **Materials:** flipcharts, markers, sticky dots (various sizes and colors) • **Facilitator:** guides participants through focus questions • **Recorder:** prepares summary of historical events for the Climate Story outline
Report Out Outline: 1. Define a value statement and target audience. What is the importance of this resource? Who will you be communicating your story to? 2. Set the scene. What is our current situation? (Session 1) 3. Diagnose an event. How do we improve the climate early warning system to make informed decisions? (Session 2) 4. Reflect on the event. What are key messages and best practices? (Session 3)	• Participants draw on presentations and build climate story activities to identify key messages and best practices. Facilitator records best practices on a flipchart or participants can develop a presentation • Target Audience—select, community leader, natural resource manager, Minister, Prime Minister/President, etc.

Template to Guide Climate Communication Strategy Development

Part 1: Scope of Communication Message
What would you like to communicate about adaptation in your message?
Who would you like to communicate with?
Part 2: Describe Target Population Characteristics
What is the target population's current stage of change?
What is the perspective(s) of your message (message framing)?
Other considerations:
Part 3: Message Controls and Delivery Methods
Terminology (words to use or stay away from):
Images (graphs, pictures of impacts, etc. What visual aid(s) can help deliver your message?):
Media (in-person meetings, written materials, website, etc.):
Messenger(s):
Part 4: Draft Message

Post-Dialog Climate Story Follow-Up

After the dialog, additional work may be needed to complete the Climate Story. Review the literature to ensure that the scientific information in the story is factually correct and interview a key local author to fact-check the story and provide interesting statements that can be quoted.

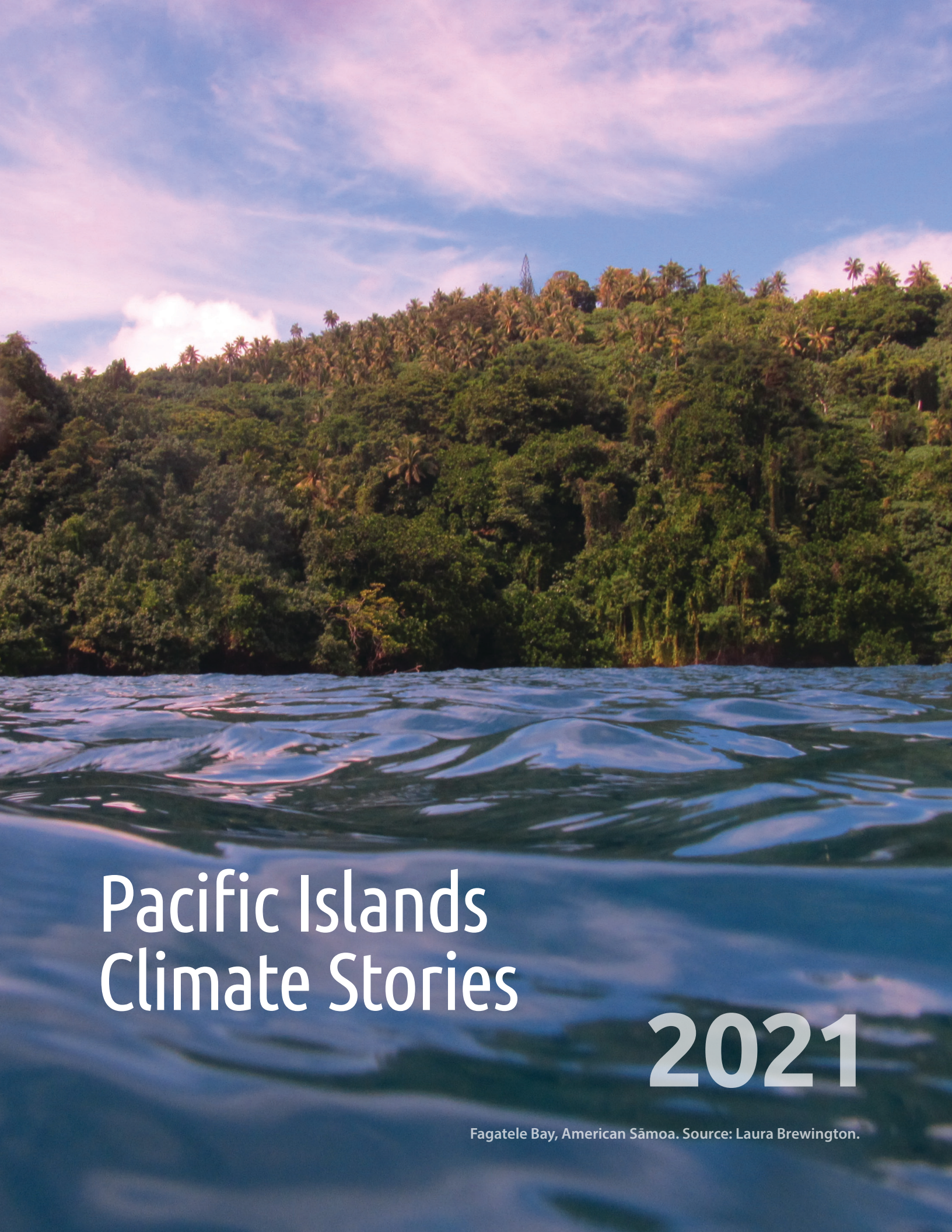
Illustrative interview questions are provided below.

Illustrative Climate Story Interview Questions

This is an example based on an ENSO event in American Sāmoa, but it can be modified to fit a story about any other climate event, climate service, or product. This is just a framework to base the interview on; invariably the interviewee will answer multiple questions all at once or lead the interview along a new tangent, which is most often welcome.

Start by explaining the format of the story and its purpose as a tool to illustrate lessons learned and key messages about the use and delivery of climate services in the Pacific.

- Please state your name, occupation, and location, for the sake of the recording and any other outputs that may be developed from the interview.
- What kinds of impacts does ENSO have on American Sāmoa? Impacts on rainfall patterns, temperature, or marine species?
- How often does ENSO affect American Sāmoa? How long do those events usually last? (For other climate-related events, such as coastal flooding and coral bleaching, ask about past magnitude and frequency of such events)
- When was the most recent El Niño or La Niña event in American Sāmoa?
- What were the impacts to American Sāmoa? **Try to draw out anecdotal information that will enrich the story with questions such as:** What did it look like? How did it impact your or your community's daily life? When did you first observe its impacts?
- How did American Sāmoa first hear of the oncoming event? Was it forecasted, and if so, how far ahead of its onset?
- How did American Sāmoa prepare for and respond to the event? Was there an established plan or set of actions? **If this story is highlighting a specific response plan, such as a drought or coral bleaching plan, ask here:** When was this plan developed? What was the process for developing it? What agencies, organizations or community members were involved?
- What climate services or information were used in preparing and responding to the ENSO event? If the story is highlighting a specific climate service or product, such as a handbook or early warning system, ask here about the development of the service/product: When was it developed? What was the process for developing it? What agencies, organizations, or community members were involved?
- What climate services were needed or lacking for the preparation and response? Have any new climate services been developed since then as a result of this need?
- Are there any other lessons learned from this event that could be applicable elsewhere?



Pacific Islands Climate Stories

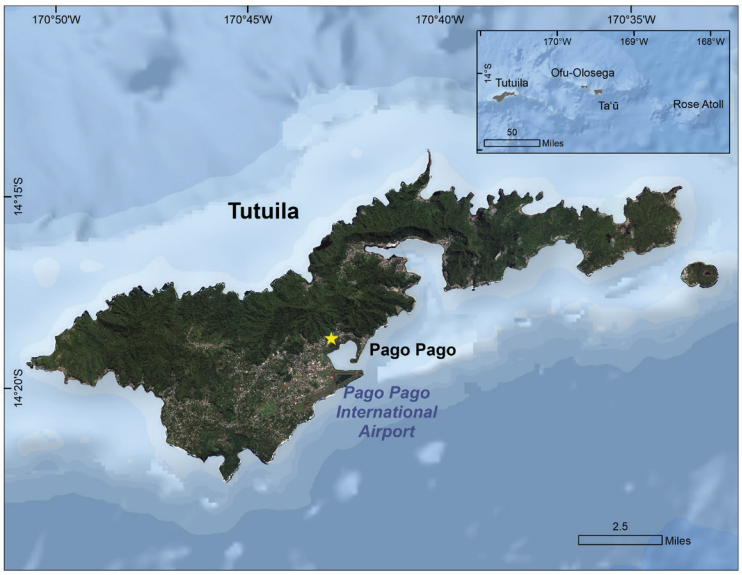
2021

Fagatele Bay, American Sāmoa. Source: Laura Brewington.

From 2014 to 2020, Climate Services Dialogs were carried out in eight Pacific Island countries and territories, including the Marshall Islands, Sāmoa, American Sāmoa, Papua New Guinea, Vanuatu, Palau, the Cook Islands, and Guam. The Climate Stories that follow were produced by regional and local decision-makers during the Dialogs, and highlight key messages and best practices for adapting to the impacts of climate change.

High and Dry: Learning from the 1997–98 El Niño Impacts on Water Resources in American Sāmoa

In January 1997, scientists at the Pacific ENSO Applications Climate (PEAC) Center in Hawai'i began to detect signs of an oncoming El Niño in their climate models. Residents of the island of Tutuila, American Sāmoa, in the South Pacific, had yet to see any changes in weather indicative of an El Niño—and they wouldn't for another six months until a severe drought caused by the El Niño was well upon them. The scientists at PEAC knew they needed to alert residents of Pacific Islands, such as Tutuila, about the expected weather changes quickly before it was too late to prepare.



Tutuila Island in American Sāmoa. Map by Laura Brewington.

Despite high annual rainfall on Tutuila, clean freshwater is already a limited resource under normal weather conditions, so droughts can be devastating. Five high islands and two atolls comprise American Sāmoa, but the majority of the territory's population resides on Tutuila, which is a high volcanic island with a network of jagged ridgelines that join along a crooked spine down the center of the island. The island is intensely green, with the exception of rooftops and rock faces that slope steeply to the ocean. Much of the surface water and some of the groundwater on Tutuila has been contaminated by pig farm waste and development along streams. The majority of Tutuila's piped freshwater is supplied by a single aquifer under Tāfuna Plain, the most densely populated part of the island. In the past, some groundwater wells in this aquifer have been shut down because of contamination or intrusion of brackish water caused by overdrawing.

American Sāmoa's freshwater aquifers are recharged by rainfall largely derived from a dense strip of clouds that hovers over the islands called the South Pacific Convergence Zone (SPCZ). The SPCZ tends to move away from American Sāmoa in a strong El Niño due to altered wind patterns and pressures, leaving Tutuila high and dry. An El Niño is the warm phase of an almost cyclical climate phenomenon called the El Niño-Southern Oscillation (ENSO), which is characterized by changes in the geographic distribution of rainfall, wind, and water temperature in the Pacific. The Pacific experiences El Niños with some regularity—every three to seven years. An El Niño typically lasts between six and 18 months before reverting back to normal or switching to the cold phase, La Niña.

In 1982–83, an El Niño brought crippling drought to American Sāmoa and many other Pacific Islands. During the El Niño, Tutuila received less than three quarters of its average annual rainfall. The PEAC Center had yet to be established so Pacific Island residents were given little to no warning about the El Niño. The drought had caused widespread consequences for American Sāmoa, from limiting water use by residents to halting production at tuna canneries, which account for a quarter of the water consumed in the territory.

"We were told what was going to happen and we just took off with it. We made public announcements; we set up a war room; we let people know about the low rainfall. And then we started to lower the pressure on the system."

The same impacts were feared 15 years later in 1997. "We didn't want the fish canneries to shut down as they did in the years before," said Utu Abe Malae*, Executive Director of the American Sāmoa Power Authority (ASPA). "The fish canneries are the main employers on the island."

The El Niño's effects were delayed in reaching American Sāmoa in 1997, but the severity of the drought far exceeded that of 1982. "The place started to turn brown, which is very unusual for a tropical island. It doesn't look right," described Mr. Malae.

Local author Utu Abe Malae, Executive Director of ASPA. Source: Talanei.

In April, May, and June 1997, Tutuila received only 64% of its typical rainfall. The drought became more extreme in the spring and summer of 1998, reaching lows of 6% and 17% of monthly averages in April and May, respectively. It was the worst drought on record since American Sāmoa began keeping rainfall records in 1966.

"Really dry and dusty. The crops weren't growing so well without moisture. You know, in the islands the topsoil is very thin so it doesn't take much for low rainfall to affect the growth of crops," recalled Mr. Malae.

By measure of rainfall, this drought should have had serious repercussions for American Sāmoa's residents and businesses. Yet Tutuila's residents did not feel the severity of the drought as intensely as in previous droughts because the island was better prepared. Working with representatives from National Weather Service Offices, the PEAC Center had spread the word across the Pacific about the strong El Niño that was on its way by holding government briefings with island-specific predictions.

"We were told what was going to happen and we just took off with it," said Mr. Malae of ASPA's response to the El Niño warning. "We made public announcements; we set up a war room; we let people know about the low rainfall. And then we started to lower the pressure on the system. We hired all the plumbers on the island to go out and help families fix their plumbing—some had leaks—in order to try and keep the water consumption down."

Messages about conserving water, including installing water catchments and preventing forest fires and water-borne diseases, were circulated on the radio and television by ASPA, the Weather Service Office, and the Territorial Emergency Management Coordinating Office.

KEY MESSAGE

Engage with the community and other stakeholders early and often*—building community ownership and participation from the beginning leads to more positive, sustainable outcomes.*

"And then we advised the two canneries, the main economic source of revenue for the island and employment. We had people go in with plumbers and engineers and inspect the usage and try to cut down on the water consumption as much as possible."

With leaks plugged and communities well informed, the government did not have to impose limits on water use or close canneries or schools. Where the drought was more extreme, some communities resorted to drawing unsanitary water from wells and it was necessary to employ filtration and purification equipment to make it potable. Through a US Department of Agriculture loan, ASPA obtained two micro-filtration plants to make use of freshwater from streams. Some other Pacific Islands had to impose limits on freshwater use, such as in the Marshall Islands, where water use was restricted to seven hours every two weeks. For the most part, though, American Sāmoa had enough water to operate as usual.

The 1997–98 El Niño illustrated the value of the PEAC Center's constant monitoring of the regional climate, which enabled early forecasting and warning of the drought in American Sāmoa. Early forecasting alone, however, would not have allowed Tutuila to be so prepared. The chain of communication starting with the localized forecast briefings that the PEAC Center conducted on many islands let governments plan ahead for the impending drought. The government, in turn, engaged the public in water conservation, which was crucial to preventing debilitating water scarcity.

KEY MESSAGE

Commit to robust and sustained monitoring and assessment*—the maintenance and expansion of existing monitoring networks will lead to an improved ability to understand and predict a changing climate and associated impacts over both the short and long term.*

Though the 1997–98 drought was more severe, as measured in rainfall, than the drought of 1982–83, the impacts were less debilitating. The key difference between the two events was the early detection and communication of the oncoming El Niño, which enabled American Sāmoa to engage the public in preventative measures.

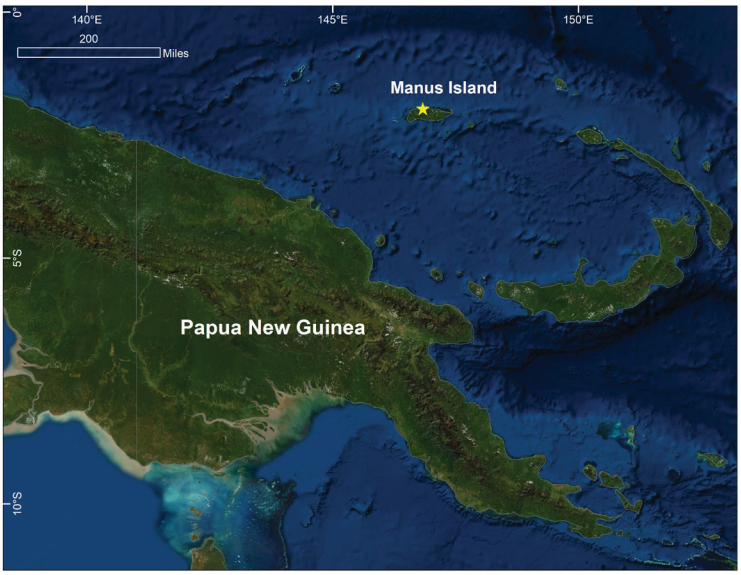
After the rain returned in September and October, ASPA continued to monitor rainfall conditions. They still receive and contribute to the regular PEAC ENSO forecasts and summaries as well as information from other climate services providers in the Pacific Islands. "We also increased the number of sites to take rainfall readings," said Mr. Malae. "We installed rain gauges all over the island ourselves."

Tutuila now has a clear success story of the importance of climate early warning paired with effective community engagement, and even more rainfall monitoring on the island. The next time a drought does hit, Mr. Malae said, "we will definitely be better prepared."

** Prior to the 2021 update to this Storybook, local author and champion Utu Abe Malae passed away in American Sāmoa. He is remembered throughout the Territory and the region for his dedication to improving Pacific Island water resources and his leadership through ASPA.*

"The Actual Sea Went All the Way Up": Coastal Flooding on Manus, Papua New Guinea

"I can remember, vividly," said Dr. Gabriel Kulwaum, The Nature Conservancy and the Climate Change Coordinator for Manus Province, Papua New Guinea (PNG). "The actual sea went all the way up about 5,000 feet inland. It came through under my house and it was about 1 foot, 2 feet high, where I stood and witnessed the ducks and chickens floating." Most of his neighbors had evacuated to higher inland areas by that time, on December 8, 2008. Only a few residents remained by the coast, who later had to be rescued from roofs and the tops of coconut trees.



Papua New Guinea and Manus Island. Map by Laura Brewington.

Manus is the northernmost province of PNG, composed of several low-lying atolls and green and hilly Manus Island—where the provincial capital sits, along with most of the province's population of 60,000. The province is located just below the equator, atop the tectonic "Ring of Fire" responsible for many volcanic eruptions, earthquakes, and associated tsunamis in the region. Waves reaching far inland are not unfamiliar to Manus residents.

Several days before Dr. Kulwaum witnessed the water rising under his house, the PNG Natural Disaster Office began telling coastal communities that huge swells generated by distant storms to the north were forecast to strike the northern coast of Manus Island. The warnings were aired over the radio, keeping people across PNG informed. "PNG Natural Disaster Office was coordinating the disaster that happened across the country. And in Manus, they kept us informed and we were ready to move. And the police and the army, they were organized on standby," said Dr. Kulwaum.

KEY MESSAGE

Engage with the community and other stakeholders early and often*—building community ownership and participation from the beginning leads to more positive, sustainable outcomes.*

On December 8, the unusually large swell reached the northern coasts of islands in Manus Province, along with many other parts of Papua New Guinea, the Solomon Islands, the Marshall Islands, Kiribati, and the Federated States of Micronesia. "I was right there on the beach. I saw the falling trees," Dr. Kulwaum said of the first day of the coastal flooding. "So I decided to move inland and I started up the hill, watching the sea come onshore. The sea went up 10 feet. In fact about 1,500 feet from the shore you could see the swell coming up. Very frightening."

"Most people moved uphill. They moved up with their eating utensils, their bedding, and so on." Manus Island's hilly center, with elevations up to 2,350 feet, offered refuge for coastal residents. "We are looked after by our natural environment. We have land where we can collect firewood. We have gardens inland that were not affected by the rising sea and the fruits were available for that as well. But more importantly, we have family networks, we have very strong family networks, where we depend on each other."

"We have the scientific knowledge and the traditional knowledge. And I must say that our people knew about climate change before the scientists came in and told us that this is climate change."

Tribal chiefs, or *lapan*, helped mobilize the community in family groups during the flooding. In addition to the national and provincial government, the Manus people recognize the *lapan* as a traditional form of tribal governance. "We need to strengthen the tribal governance. I think across the Pacific we have the chiefmanship system. We have the traditional institutions that must be strengthened because we depend on that to mobilize our people to address the natural disaster."

KEY MESSAGE

Know your social/cultural setting—*understanding community values, aspirations, and perspectives, as well as the sensitivity of critical assets and community adaptive capacity will drive adaptation from the bottom up.*

The coastal flooding continued for a week. "People were looked after by their relatives. The churches also were on standby and the government came in after 10 days of disaster. They distributed food, especially to the outlying islands." The low-lying atolls in Manus Province were struck much harder than Manus Island. "The islands were very much overrun by the sea and the actual food crops were destroyed, and soon after this the government in Manus sent a rapid assessment team out with the assistant from the national government to the islands to make the assessment." As a result, food and freshwater, along with other supplies, were sent to the outer islands.

Coastal erosion on the Momote-Lorengau road, Manus Island. Source: Reproduced from Narayan S. et al. 2015. *Protecting against coastal hazards in Manus and New Ireland provinces Papua New Guinea: An assessment of present and future options.* Wildlife Conservation Society Technical Report. DOI: 10.13140/RG.2.1.4607.2729

Coastal flooding events such as this are infrequent in the region. "I am 52 years old now. I live with my mother. I live with my father. And they never tell me the story of this disaster. So in other words, what I am saying is, such a disaster did not happen in their lifetime," said Dr. Kulwaum. Tsunamis, caused by earthquakes along the Ring of Fire, are more common. But the combination of exceptionally large swell and high tide, which caused the extreme flooding in December 2008, happens so rarely

that the people of Manus haven't experienced it in the last 100 years. With accelerated sea level rise and more severe storms caused by climate change, the frequency of flooding events such as these will increase. Subsequently, the demand for early warning—days, weeks, months, and even years ahead of time—about potential coastal flooding will also increase.

Flooding was extensive in villages throughout Manus Province. Source: Green Left.

In response to projected impacts from climate change, Manus Province initiated a project on climate change adaptation a few years after the flooding event. "The point of this project was to build resilience in coastal communities and their ecosystems to the impacts of climate change," said Dr. Kulwaum. "We have community educators, we trained them, we informed them, and they went out into the community to pass on the information about the effects of climate change and how it happened." They spread awareness through many channels including radio, printed materials, and songs and plays by school children.

"There are two kinds of knowledge: we have the scientific knowledge and the traditional knowledge. And I must say that our people knew about climate change before the scientists came in and told us that this is climate change."

"It is acknowledged at the government level that we need to address climate change," said Dr. Kulwaum. "But the question is the actual implementation. How do we translate this policy to the community level?" The impacts of climate change are so overwhelming in Manus—and the government funding equally underwhelming—that Manus communities are taking it on themselves to adapt. "The people took ownership and the people became accountable." They are testing salt-resistant crops, buying water tanks, digging wells, and lifting houses off the ground. "We are getting ready and we are responding to the issue of climate change."

In the Dark of Monday Morning: Coastal Flooding on Majuro

High tide came at 5:30am, allowing the swell to rise higher and move farther inland. Source: EcoWatch.

In the early hours of Monday, March 3, 2014, officers from the local police on the low-lying atoll of Majuro, capital of the Republic of the Marshall Islands, began knocking on doors to alert residents of the large waves that were overtopping sea-walls and flooding their properties.

"I was in bed at home, as most people were, because it was 3am," said Angela Saunders, head of the Majuro regional office of the International Organization for Migration (IOM), which was one of the groups, alongside the Marshall Islands government, active in responding to the coastal flooding. A phone call from a colleague woke Saunders, telling her about the high swells flooding the atoll.

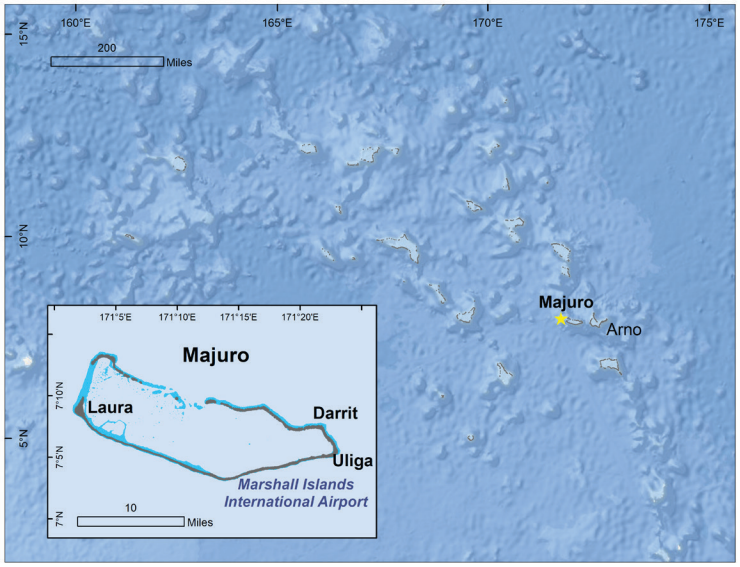
Families were evacuated from their homes in the dark of that morning. High tide, which would exacerbate the already significant flooding from high swells, was a few hours away. The impacts of coastal flooding on atolls can be far reaching. Private property damage can displace residents into temporary shelters that are often ill-equipped. Public infrastructure can be damaged or destroyed, inhibiting transportation and the logistics for emergency response. Saltwater intrusion can diminish the availability and quality of groundwater. Coastal flooding can also ruin crops and threaten public health through water-borne diseases and increased insect infestations. Over the radio, the government warned residents that the high seas could last for the next two days, becoming especially dangerous around high tide.

Later that morning, Saunders left her house, where there was some standing water in the yard, to assess the more stricken areas of the atoll. High tide had come and gone at 5:30am, allowing flooding to subside for the time being. "There was still a fair amount of water on some parts of the road, so we were driving through maybe a foot of water in some places. And lots of people were out and already cleaning up by the time we got there." Debris had been washed onto the roads and the Majuro local government was working to clear it away.

Majuro, like many atolls, is composed of several land segments with elevations less than 10 feet above sea level, connected by a shallow reef encircling a large lagoon. This coastal flooding event was particularly impactful to the atoll because waves entered the lagoon through a northern passage and flooded the land from both the lagoon and ocean sides. Multiple ocean and atmospheric phenomena can cause coastal flooding on atolls, including typhoons, tsunamis, large swells, and king tides—the highest tide of the year, also called the perigean spring tide. Many attributed this event to a king tide but the flooding actually began during a mid-tide—it peaked at a high tide that was

a foot or so lower than the king tide of 2014, which occurred later in the year. The flooding was caused by exceptionally large waves formed by distant storms located north of the Marshall Islands near Japan and exacerbated by high tide. The frequency and magnitude of coastal flooding events on Majuro and other nearby atolls have increased significantly over the last decade, with several taking place in recent years. Accelerated sea level rise due to climate change will likely increase both the frequency and magnitude of these floods.

Most of the residents of Majuro didn't realize the swell was approaching until the waves reached their homes at 3am. "It didn't give people any time to protect their homes, remove or secure their property, or find alternative places to stay."



Majuro, the capital of the Marshall Islands. Map by Laura Brewington.

The Chief Secretary of the Marshall Islands called a meeting of the National Disaster Committee at 8am, which Saunders attended along with representatives from the various departments and organizations that respond during an emergency. "Each of those representatives gave an update of the situation from their perspective," said Victoria Bannon, the Representative to the North Pacific Region for the International Federation of Red Cross and Red Crescent Societies (IFRC) in Majuro.

At the conclusion of the meeting, Bannon and Saunders joined assessment teams that were dispatched to monitor conditions in the shelters and assess needs. Schools had been canceled across Majuro and those schools—along with the College of the Marshall Islands, churches, and other facilities—were used as emergency shelters. Some shelters were officially designated; others were spontaneous. "The classrooms had been cleared out, and people were sleeping on the floors, mostly in bedding that we provided but also with bedding that they brought themselves from their own homes and they were using the shared bathroom facilities," said Bannon. "Families who could afford it booked hotel rooms or stayed with relatives."

Almost 1,000 people relocated to shelters on Majuro, along with around 250 on Arno, Majuro's less populous neighboring atoll. Meals were served in these shelters and bottles were filled with desalinated water in case the flooding further compromised Majuro's freshwater resources. Other supplies, such as bedding, clothing, and personal hygiene materials, were donated through local businesses, the Red Cross, the Salvation Army, and other organizations coordinated through the Ministry of Internal Affairs and the Marshall Islands Red Cross.

As high tide returned early that evening, radio announcements warned residents to stay clear of the shore. The large swells had not completely subsided and they became more dangerous as the rising tide again brought them closer to coastal homes. "People were still relocating to shelters, just to be safe," said Saunders. "The next two sets of high tides weren't as bad."

In anticipation of the evening high tide and others to follow, the local government and the Ministry of Public Works started building berms with bulldozers in an attempt to protect the coastline. The combination of high tides and large swells promptly eroded most of these berms because of the poorly consolidated and fine material, such as sand, used to build them. Some berms made of coarser aggregate material—with mixed grain sizes like sand, gravel, and rock—fared better.

The 2014 flooding in Majuro. Source: US Geological Survey.

"The idea behind berms is that they're migratory. So they're going to move as the island moves over time—whether via natural process or accelerated via climate variability and climate change," said Karl Fellenius, Coastal Management Extension Agent for the University of Hawai'i Sea Grant College Program based in Majuro. Berms are part of the natural topography of atoll islands, but they have been highly modified or removed through development. Coastlines across the world are constantly changing shape under the powerful influence of ocean tides and currents, and atoll islands are particularly soft and easily molded. "So there is a significant rationale for re-building berms using mixed grain-sized materials, compacting and vegetating them, and allowing them move with the island as the island moves. And then when the storms happen, they would provide some protective barrier but they're not intended to stop the island topography from changing."

KEY MESSAGE

Tailor information to the needs of the user—*commitment to an iterative process involving the co-production of knowledge at multiple levels will ensure that products and services are specific to sector and locale, as well as the nature and timing of decision-making.*

Given that the shorelines will, in the end, draw their own contours, berms cannot be the only solution to coastal flooding. "We need to find that good balance between a reasonable level of prevention coupled with a more effective early warning preparedness and response system," said Bannon.

This coastal flooding event particularly illustrated the need for a more robust early warning system. Most of the residents of Majuro didn't realize the swell was approaching until the waves reached their homes at 3am. "It didn't give people any time to protect their homes, remove or secure their property, or find alternative places to stay," Bannon said.

More time could have allowed people in affected areas to take those precautions—but it's not only the timing that must be improved. "It's also the content of the warning. Because if the content doesn't lead people to action, then there's no point," said Bannon. "An early warning, ideally, needs to be issued hand-in-hand with some recommendations for how communities can actually use that information. For people in certain areas—is it recommended for them to protect their property or to sandbag their doors—or evacuate?"

Recognizing the lack of accessible early warning prior to the flooding, IFRC began working with the Marshall Islands Red Cross, the Secretariat of the Pacific Regional Environment Programme (SPREP), and the National Weather Service on a pilot project, supported by the Finland-Pacific (FINPAC) project, an initiative of the Finnish government, to address this need for a comprehensive early warning system. "The project looks into the kinds of weather and climate-related services that already exist, how they could be better used and communicated to the community and then work with the national disaster response framework to set up a community-based early warning system where people are notified and also have a plan in place for responding to different types of hazards," said Bannon. This was only one of several efforts to address early warning, such as the High Sea Level and Inundation Forecast Tools for Majuro developed by Pacific Islands Ocean Observing System (PacIOOS) for which Fellenius was the local liaison, and other work by regional groups such as NOAA, SPREP, the South Pacific Applied Geoscience Commission (SOPAC), the Secretariat of the Pacific Community (SPC), and the Pacific ENSO Applications Climate (PEAC) Center. Building new partnerships and leveraging existing ones within these organizations will be important to maximizing the capacity of the Weather Service Office in Majuro to develop effective early warning systems for coastal flooding and other hazards, from early detection to widespread communication.

KEY MESSAGE

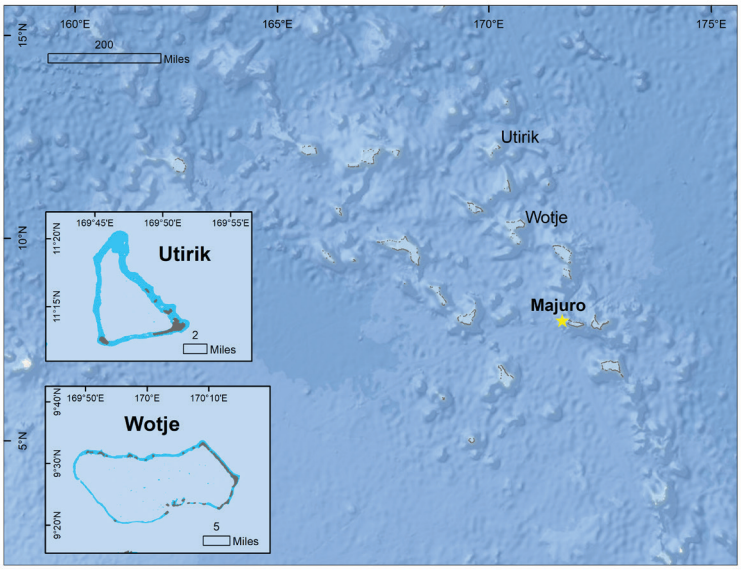
Direct attention to the alignment and coordination of activities—*integrated program planning and product development will maximize efficiency and effectiveness (by minimizing gaps and overlaps, and maximizing information consistency and messaging), as well as enrich the potential for local to regional capacity development.*

Some areas were still flooded the next day, but most of the roads were cleared of debris. Teams were sent out to assess the impact of the past day and more than 100 homes were damaged on Majuro and Arno—many with doors and windows broken and debris washed inside. The foliage on breadfruit trees were turning yellow, distressed by the saltwater saturating the soil. A national state of emergency was announced that night. No coastal flooding was reported after that time, and by Wednesday evening most families had returned to their homes, with the exception of about 200 people who remained in shelters for a week.

"It's Falling from the Sky but Not Hitting the Ground": Drought in the Outer Atolls of the Marshall Islands

"You see that rain out there?" asked meteorologist Chip Guard, looking up at the sky above Majuro in the Marshall Islands. "It's falling from the sky but not hitting the ground. We call that virga. You know where we see virga? In deserts."

The dry season hovers over the low-lying atolls of the from December to April. In late 2012, the months leading up to the dry season were much drier than normal in the northern atolls of the Marshall Islands, known as "the outer islands". Wotje and Utirik Atolls, two of the outer islands, received only 28% and 25%, respectively, of their normal rainfall for September through November.



Wotje and Utirik Atolls in the Marshall Islands. Map by Laura Brewington.

"We were looking at the seasonal outlook for rain and it was saying by January, February, March, it's not looking like it's getting any better," recalled Reggie White of the Weather Service Office in Majuro. The office was receiving rainfall observations and forecasts from the Pacific ENSO Applications Climate (PEAC) Center, the Weather Forecast Office (WFO) in Guam, and multiple weather observation stations in the Marshall Islands. All signs pointed towards a dry spell that was unlikely to let up for several months.

A dense strip of clouds that extends across the Pacific just north of the equator—visible on most satellite images of the earth—called The Intertropical Convergence Zone (ITCZ) supplies precipitation to the Marshall Islands. There is also an area of low atmospheric pressure called the Tropical Upper Troposphere Trough (TUTT), in which clouds often form and showers often follow, which supplies additional rainfall. Changes in the location or size of the TUTT and ITCZ can cause a decline in rainfall, such as the drought that developed in late 2012.

"Drought kind of sneaks up on people. It comes slowly and if you're not preparing yourself for it, you can find yourself in deep trouble because the rain can stop just almost instantaneously."

In the past, droughts have crippled islands in the region, such as the drought of 1983, which caused widespread suffering and some deaths in nearby Micronesia, and the drought of 1998, during which it was necessary to ration water in the Marshall Islands but early warning eliminated much of the potential suffering. The desert-like conditions Guard described are not unfamiliar to the Marshallese people, but are devastating all the same. By the beginning of 2013, precipitation in the outer islands was already at a huge deficit.

"You have to realize that the people from the outer northern islands were calling in and saying, 'We are in need of water,'" said White. That January, 13 local governments in the outer islands requested assistance from the national government in dealing with the drought. The ground was cracking and the leaves were turning; the lower atmosphere became drier and the groundwater saltier.

"Basically drought is sneaky. Drought kind of sneaks up on people. It comes slowly and if you're not preparing yourself for it, you can find yourself in deep trouble because the rain can stop just almost instantaneously," said Guard. The outer island atolls depend on rainwater to refill their tanks and recharge their aquifers, which dwindle quickly when the rain stops.

In situ indicators, such as salty groundwater, indicated drought before it was observed in technical meteorological measurements. The National Weather Service has observation stations on only eight of the 24 atolls that comprise the Marshall Islands, so they must depend on satellite information and experiential observations from other atolls to fill the gaps.

"We could only get scientific measurements from those observation stations but to get a better feel on the neighboring atolls, which don't have equipment and rain gauges, we were asking them, 'So how much water is in your tank?'" said White. "The well water is much more brackish than it was two months ago. It's getting saltier. At the cleaning, they have only now a foot of water in their water tank. So those types of information we were collecting and trying to make sense of it and trying to relate it to actual rainfall in one of the neighboring islands that we had an observation point on."

White and his team in Majuro were communicating with outer islands through a new tool called the Chatty Beetle, which had been incorporated into the operations of the Weather Service Office a couple years earlier. The Chatty Beetle is a text-based alert system that rings loudly until an incoming message is received, and sends a confirmation back to the sender. "That allows us to communicate via satellite with the outer islands using short burst messages so we can pass rainfall information back and forth and also issue warnings and things like that," said Guard.

The outer islands' requests in January, and the subsequent exchanges with the Weather Service Office, illustrated the importance of recognizing experiential knowledge, embedded in the local social and cultural setting, alongside technical knowledge. Later that month, the WFO in Guam began issuing warnings about the severity of the drought in the region and predictions of what was to come.

KEY MESSAGE

Know your social and cultural setting—*understanding community values, aspirations, and perspectives, as well as the sensitivity of critical assets and community adaptive capacity will drive adaptation from the bottom up.*

"On the fifth of February we issued a Drought Information Statement," said Guard. This comprehensive bulletin included a synopsis of the conditions and impacts, including rainfall, temperature, and coral bleaching threats, as well as a five to 10 day forecast of those variables. The government used this drought information statement to develop drought response planning.

Preparing to transport solar-powered reverse osmosis desalination system to Utirik Atoll in 2013. Source: Australian Aid.

The national government declared a state of emergency on April 19. During the first three months of 2013, less than 4 inches of rain fell on many of the outer islands. At the Wotje weather observation station, the driest of the weather stations in the Marshall Islands, less than an inch of rain was recorded from January through March.

On the heels of the emergency declaration, assessment teams were sent to the outer islands, led by the National Disaster Management Office and supported by USAID, the Office of Foreign Disaster Assistance (OFDA) and the IOM. The assessments found that groundwater was too salty and people were suffering associated health problems including gastritis, diarrhea, vomiting, abdominal pain, fever, and hepatitis.

"They're using this groundwater and it's always kind of salty," said Guard. "But you rarely hear the outer islanders complain about water quality, they just drink it. But one day they can drink it and the next day they can't during these severe droughts. The concentration of salt gets too high and, you know, they've got about 48 hours before people start getting very sick and some people can die. So it's very critical that we provide the government enough information, far enough ahead of time, so it can deliver the water resources that are necessary."

Boatloads of bottled water were sent to the outer islands, along with several individual desalination and reverse osmosis units to produce fresh water on the atolls most in need. Transporting supplies and equipment, both Guard and White emphasized, is the most costly part of responding to drought.

KEY MESSAGE

Direct attention to the alignment and coordination of activities—*integrated program planning and product development will maximize efficiency and effectiveness (by minimizing gaps and overlaps, and maximizing information consistency and messaging), as well as enrich the potential for local to regional capacity development.*

"You have to realize that in the Marshall Islands, the biggest challenge is the distance between islands," said White. "All that equipment in totality might only cost a few dollars but the trip you make from here to there is very expensive because you have to pay for fuel and to charter the ship." The earlier and more specific the forecasts can be, the more efficient the response can be. Ensuring that the efforts of response groups—from multiple levels of government, communities, and other organizations—are aligned together and informed by forecasts and the needs of the community make the response all the more effective.

The rain returned to the outer islands in June, though the national state of emergency was extended on June 7 for another 30 days. The atolls still faced significant hurdles ahead. Many of their crops had withered in the drought. "The coconuts have dried up; the breadfruits have dried up; the taro has dried up; the tapioca has dried up," said Guard. "It's going to be eight to 10 months before the food sources can come back." Plants were sent to the outer islands, including sweet potato and dryland taro from Fiji, as people set to replanting their gardens.

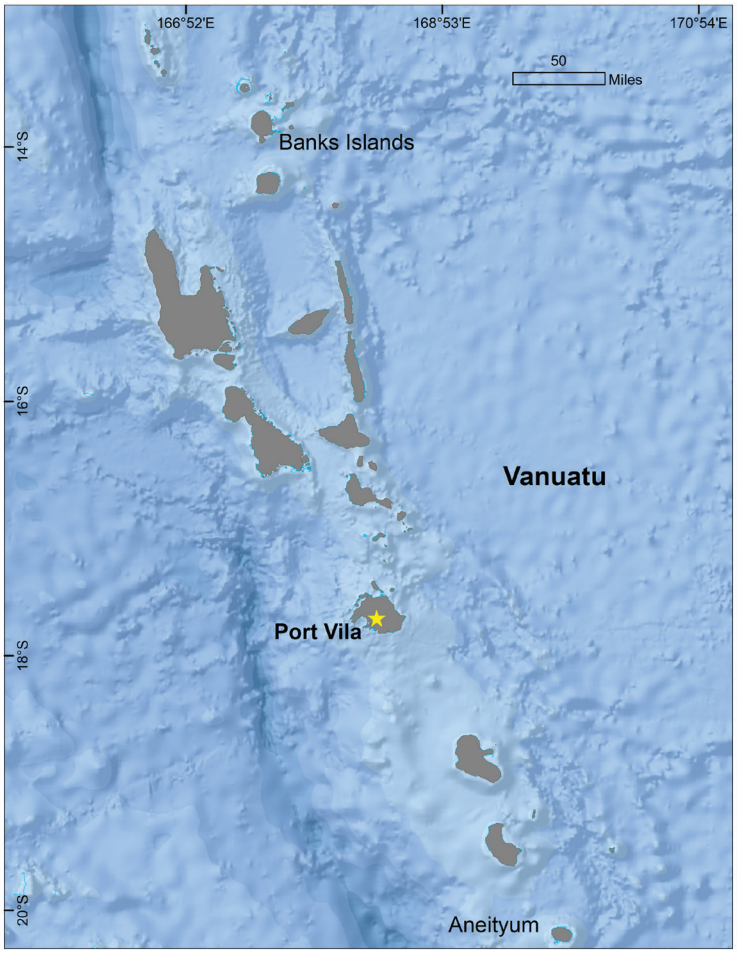
KEY MESSAGE

Commit to robust and sustained monitoring and assessment—*the maintenance and expansion of existing monitoring networks will lead to an improved ability to understand and predict a changing climate and associated impacts over both the short and long term.*

Following the drought, the Marshall Islands continued monitoring climate conditions and training outer island residents in drought recognition and response. More comprehensive monitoring networks for rainfall and other climate variables—all the way from Utirik to Majuro—improve prediction of future droughts. As the observational knowledge of on the ground conditions from the outer islands proved invaluable, the Majuro Weather Service Office and WFO Guam continued training communities on when and how to communicate drought indicators. "That way," White explained, "when the next drought creeps up, the response can be earlier and more effective."

The Cloud *Nasara*: The Development and Use of Vanuatu's ENSO Handbook

The cloud *nasara* determines where it rains in Vanuatu, a nation of about 80 small, high volcanic islands in the Western South Pacific. It determines whether the taro leaves in the Banks Islands in the north grow brown and curl inwards or gather glossy droplets in their center; whether the rainwater catchment tanks on Aneityum to the south are full or drained dry; whether small bridges in the capital of Port Vila are washed out in a flood or the streambeds below them harden into cracked ground. The cloud *nasara*, which roughly means "the meeting area of clouds" in Bislama—one of the national languages of Vanuatu, is a dense strip of clouds that heavily influences where and when it rains in Vanuatu.



Vanuatu and the capital of Port Vila. Map by Laura Brewington.

Prevailing easterly and southeasterly winds in the Western South Pacific converge near Vanuatu, to form the cloud *nasara*, also called the South Pacific Convergence Zone (SPCZ). The location of the cloud *nasara* can be influenced by ENSO, which is characterized by cyclical changes in the geographic distribution of rainfall, wind, and water temperature in the Pacific. During an El Niño event, the warm phase of ENSO that typically occurs every three to seven years, the cloud *nasara* tends to shift away from Vanuatu due to changing wind and atmospheric pressure patterns, leaving Vanuatu and its neighboring countries such as Fiji and the Solomon Islands, in drought. In addition to the dryness, El Niño can also raise air temperatures, accelerating evaporation of what little surface water remains. An El Niño event typically lasts between six and 18 months before reverting back to normal or switching to the cold phase, La Niña. These changes in climate affect many land-based sectors in Vanuatu, including agriculture, livestock, freshwater resources, and human health.

Farmers are perhaps most vulnerable to climate variability in Vanuatu, and therefore need to understand and adapt to these changes. "They have coping strategies traditionally," said Philip Malsale, former Manager of the Climate Division of the Vanuatu Meteorological and Geo-Hazards Department (VMGD), "but in this time and age people tend to rely more on scientific information."

Local author Philip Malsale, now the Climatology Officer for SPREP's Climate and Oceans Support Program in the Pacific (COSPPac). Source: SPREP.

Malsale and the VMGD saw the need for a product that could translate scientific information from climate early warning (CLEW) systems into useable strategies to cope with ENSO. The development of an ENSO handbook to support CLEW systems was initially suggested at the first Agro-Met Summit, a series of workshops that the VMGD hosts to bring together meteorologists and representatives from land-based sectors including agriculture, forestry, and livestock. The handbook, it was suggested, could be an accessible guide to how to respond to ENSO that would bring information on climate variability down to the community level—"a linkage between farmers and the scientific institutions."

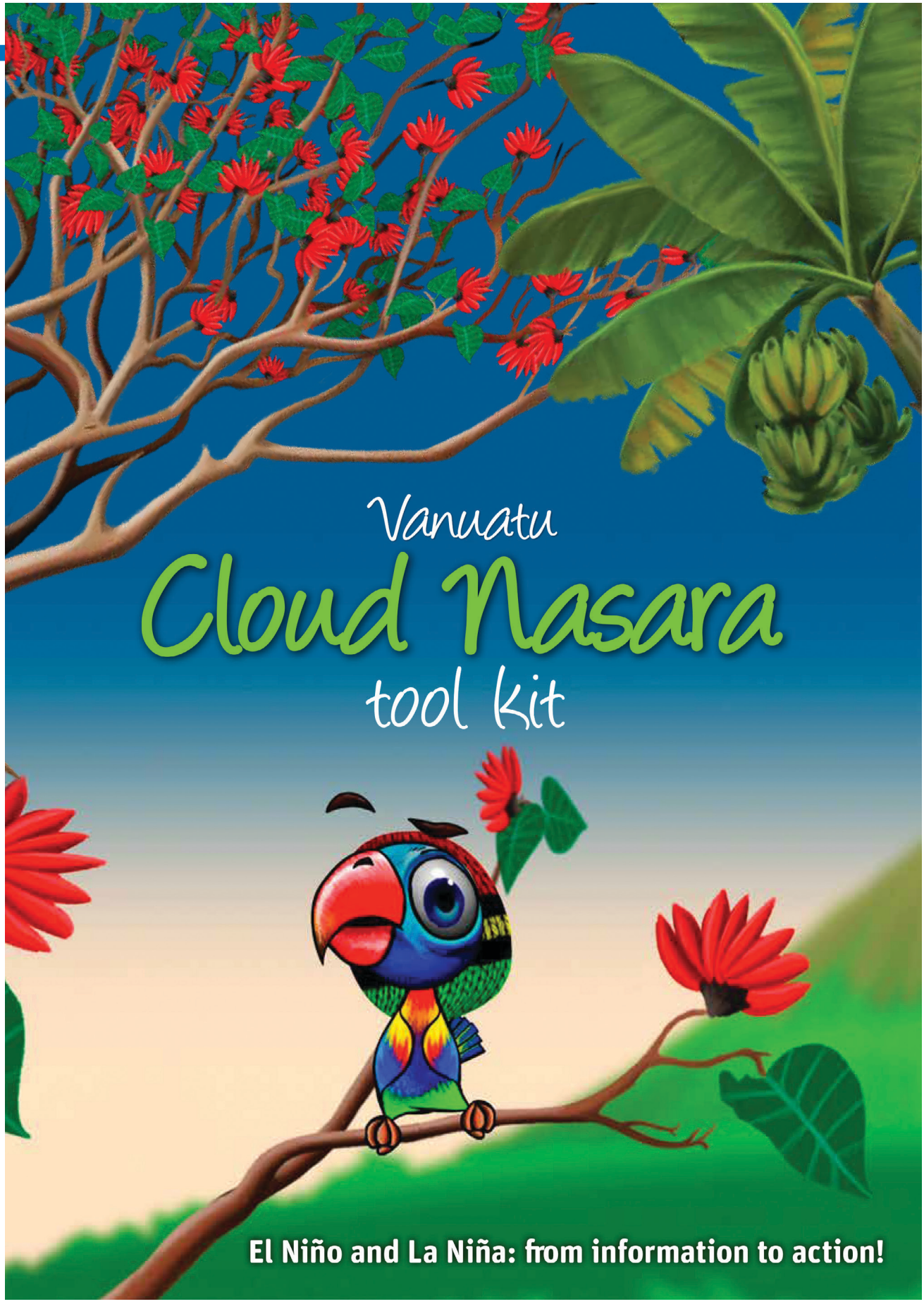
After several iterations of draft and review within the group of meteorologists and land-based sector specialists attending the Agro-Met Summit, the Vanuatu ENSO Handbook was born. Scientists contributed information on ENSO indicators and forecasts while farmers contributed methods to adapting to climate variations. The VMGD engaged both scientists and sector specialists in the handbook's development to ensure that the product would be most helpful to its intended audience. "We'd have to refine that and bring it over to the next Agro-Met workshop summit. We would get comments and then finally, the year before last, we printed it out and submitted to farmers our final copy," said Malsale. The handbook was printed and made available online.

KEY MESSAGE

Engage with the community and other stakeholders early and often—*building community ownership and participation from the beginning leads to more positive, sustainable outcomes.*

The handbook includes coping strategies for growing a variety of crops in drought conditions. For banana trees, for example, the handbook suggests removing all but two of the young shoots from the parent tree and replanting them in a different area to relieve some of the water demands in the soil. When growing taro, farmers should try to plant five to six months before the dry season, the handbook recommends, so they can harvest it before the drought commences. Additionally, the handbook describes how to plant the taro deep in the soil—allowing the roots to reach deeper water reserves—and how to select drought-tolerant varieties of taro like Navia and Fiji taro, which have small leaves that point down away from the sun.

The handbook could be an accessible guide to how to respond to ENSO that would bring information on climate variability down to the community level—a linkage between farmers and the scientific institutions.



The Vanuatu ENSO Handbook. Source: the VGMD.

The handbook is meant to be used with climate updates that the VMGD issues about ENSO. "We handed this out to the farmers during our workshops," said Malsale. "So if we put out the information on any ENSO events, the farmers can look it up on what sector they are involved with—agriculture—and what specific crops they're dealing with, cassava. If they're talking about vegetables, then these are the steps that you need to do."

Since the handbook was published, the VMGD has continued to expand their knowledge of how to cope with ENSO locally. "To be honest, there are many, many ways on how people here can cope with these events using the traditional knowledge that was passed on from generation to generation," explained Malsale. "And currently we are having a traditional knowledge project that is within the climate division that is funded by the Australian government. We are collecting information on traditional indicators, indications of the different climate events."

Despite the engaging and applicable nature of the handbook, VMGD was worried that its messages wouldn't reach all the necessary audiences. "What we have seen in the past in Vanuatu is, if you print out some scientific information, distribute it in posters, fliers, and publications, people don't really read those things," said Malsale.

"So we think that the most effective way of preaching climate science to the Vanuatu community, especially those in the rural areas, is coming up with an animation. The characters inside have to be familiar to those people, and the setting has to be familiar—some local setting. So when people watch they can relate to it very easily and they can understand it."

KEY MESSAGE

Tailor information to the needs of the user—*commitment to an iterative process involving the co-production of knowledge at multiple levels will ensure that products and services are specific to the sector and local, as well as the nature and timing of decision-making.*

In response, the VMGD, along with a number of partners including the Red Cross and the German and Australian governments, developed a six-minute animated movie about the cloud *nasara* and ENSO to accompany the handbook. The animation shows how the cloud *nasara* forms, how El Niño and La Niña can change its location, and how heavy rainfall or drought can ensue. The cast includes dancing clouds, a parrot who likes only reggae music, and a string band he throws fruit at.

"If people see what's really happening in science, then with the ENSO handbook, they can link events," said Malsale. The VMGD distributes this animation, along with the ENSO handbook and a second animation that explains ENSO across the Pacific through the lens of the Climate Crab. These aids provide a more interactive way to teach students about ENSO and climate change.

"Linking what you're doing with those who will use it, I think that's the missing thing that [meteorological] services have in the Pacific or elsewhere in the world," Malsale continued. "You know, linking the products that you have with those that will be affected."

Remembering what a Healthy Reef Looks Like: A Community-Based Reef Restoration and Education Program in Humåtak, Guam

"I remember when I was little, what a healthy reef looked like," said Joseph Quinata, chairman of the Humåtak Community Foundation in the village of Humåtak on the southern coast of Guam. The reef in Humåtak, or Umatac, hasn't looked healthy for a while. The silty skeleton of a once prolific and colorful reef stretches around the bay. "We realized that our reef was in a really bad state," said Quinata. "So we wanted to, as a part of the whole exercise, look at the whole cause so that we can address that."

Guam and the location of Humåtak village. Map by Laura Brewington.

Quinata is referring to the "whole exercise" of establishing the Umatac Coral Reef Ambassadors (URCA) program, a community movement that teaches youth in the village about environmental issues and climate threats their ecosystem faces, from the verdant hills down to the bay. Human-caused and climate-induced soil erosion has led to sediment runoff into the bay and several coral bleaching events in recent years have left patches of the reef dead.

Due to its location in the Pacific, Guam is heavily influenced by the quasi-cyclical climate phenomenon, ENSO, which swings between its two phases, El Niño and La Niña, causing dramatic changes in temperature, rainfall, sea level, and other variables. Humåtak can expect more rain at the onset of an El Niño followed by a period of drought afterwards. Increased rain will wash more sediment into the bay, whereas drought will contribute to the extremity of hillside fires ignited by hunters in the village, further increasing soil erosion.

Climate change will only add to the impacts of climate variability and human activity with accelerated sea level rise, warming sea surface temperatures, and ocean acidification. As the Humåtak community continues to restore their reefs, it will be important for them to monitor and understand how climate variability and climate change impact the bay.

Humåtak Bay in Guam. The Humåtak Community Foundation established a community program to address environmental issues and climate threats facing their ecosystems, from the verdant hills down to the bay. Source: Mayors Council of Guam.

> *"The people we needed to work with initially were the youth. Because they speak to their parents, and they are much more effective in speaking to their parents than perhaps even the media is, or even scientists."*

By educating the youth on these impacts, UCRA empowers them to become advocates for environmental stewardship in their community and implement research and restoration projects on the reef. The Humåtak Community Foundation and UCRA were established in 2011 to fill a gap in their education system.

KEY MESSAGE

Be aware that impacts due to a changing climate exist along with (and often exacerbate) impacts from a myriad of non-climate stressors—*climate adaptation will be most effective when it is integrated with disaster risk reduction, sustainable development, ecosystem-based management, and other such multi-sectoral approaches to planning and policy development.*

"It sort of triggered when they closed our school down at the village. And so we were all thinking that perhaps maybe we need to do things—take things into our own hands—and address these issues ourselves and not depend on the government to do it for us," said Quinata.

"Before we even formed the foundation, we did a household survey in the village and our surveys asked these questions regarding conservation and regarding preservation work, and regarding all the missions that we would like to see." The survey responses illustrated the need for a forum in which the community could discuss conservation and restoration and address the underlying human and climate impacts leading to the environmental degradation their community was observing. Quinata emphasized the importance of engaging with the community before and throughout the development of the foundation to be sure the program was aligned with the desires of the community.

"There are different ways we need to address it," said Quinata of improving the health of the reef. "The first step we needed to do was education. And the people we needed to work with initially were the youth. Because they speak to their parents, and they are much more effective in speaking to their parents than perhaps even the media is, or even scientists."

The youth in the program, ranging from elementary school age to mid-20s, meet in the evenings at their community center. Quinata and other volunteer teachers talk to the youth about impacts to the environment, including the deleterious effects hillside burning has on reefs. Hunters from Humåtak and other nearby towns burn the hillside so that a few weeks later, the new shoots that grow out of the ashes will attract deer and pigs to the now-open field where hunters have a clear shot at their prey. If the fire is lit during dry La Niña conditions, it could spread farther and faster.

The Umatac Coral Reef Ambassadors program teaches youth to be advocates for the health of their reefs. Source: Humåtak Community Foundation.

"The kids are taught that if you burn the hills, the rain comes and erosion happens and it goes down to the river. And the river takes that eroded silt out to the reef, smothers the reef. When the coral spawns, it can't get into a place where it can grow." El Niños, which occur about every three to seven years and persist for about six to 18 months, tend to increase rainfall on the island and amplify runoff.

"We impart the information and help them develop the skills, and once they start to advocate for whatever it is, then that's an indicator that we have accomplished what we wanted to accomplish in the first place," said Quinata. The program hoped that this knowledge would enable the youth to advocate for better environmental practices in the town and they have been seeing the results. "At least for the last two years, we have not seen any hill burning at the village area."

Now that human influences on the reef have diminished, the youth engage in conservation work on the weekends to restore the reef. Part of this restoration work includes experiments in coral growing. "They've collected dead corals. They've tied them up on a rope and they suspend them right before full moon," said Quinata. "And during spawning, they pray and hope that the corals attach to the suspended coral." Tracking climate conditions that are favorable to coral growth will also help to ensure their restoration efforts are more effective. The kids made their own documentary about their coral spawning experiments.

KEY MESSAGE

Engage with the community and other stakeholders early and often—*building community ownership and participation from the beginning leads to more positive, sustainable outcomes.*

The education and restoration efforts of the Humåtak Community Foundation are making their reef more resilient to the impacts of climate change and variability—though the community doesn't talk about it in the same terms. In the survey that Quinata and his co-founders posed to their community, they tried to gauge literacy about climate change and other environmental threats facing their bay. "The community didn't know much about it—at least the jargon that we're talking about, or that the scientists talk about."

"We talked about climate change, and the concept of climate change is not something they see as that important, because to them," Quinata said, "that's the scientist's job." But if you frame an issue such as climate change-induced accelerated sea level rise differently—stripped of the technical jargon—you get a different response. "When we talk about the waters coming up to their property, then it is a great concern to them."

Coral bleaching, similarly is an aspect of climate change that resonates with the community. "We see—and the kids understand about—coral bleaching. And they're able to detect that," said Quinata. The kids have witnessed the white bleached corals that result when the tiny symbiotic algae that inhabit coral tissue and provide coral with nutrients are expelled under stressful conditions, both human- and climate-induced, such as increased temperature, sediment runoff, or pollution. The elders in Humåtak tell the youth that, in their lifetime, they have also seen coral bleaching. Coral bleaching events will become more common as sea surface temperatures rise in a changing climate. Though they don't talk about the connection between climate change and coral bleaching in the same way that Western scientists do, they are addressing the problem all the same. Educating the community about the impacts of climate variability and change on their bay—and available information on the forecasts for those impacts—will further their resilience.

Quinata and his fellow board members at the Foundation want to continue to restore Humåtak Bay to the healthy reef of Quinata's youth by fostering the traditional knowledge and practices from past generations alongside modern science. "The foundation provides that mechanism for us to continue doing what we're supposed to be doing. Like how we were doing 60 years ago, when it was controlled by our clan—our head of clan. But now that generation is gone."

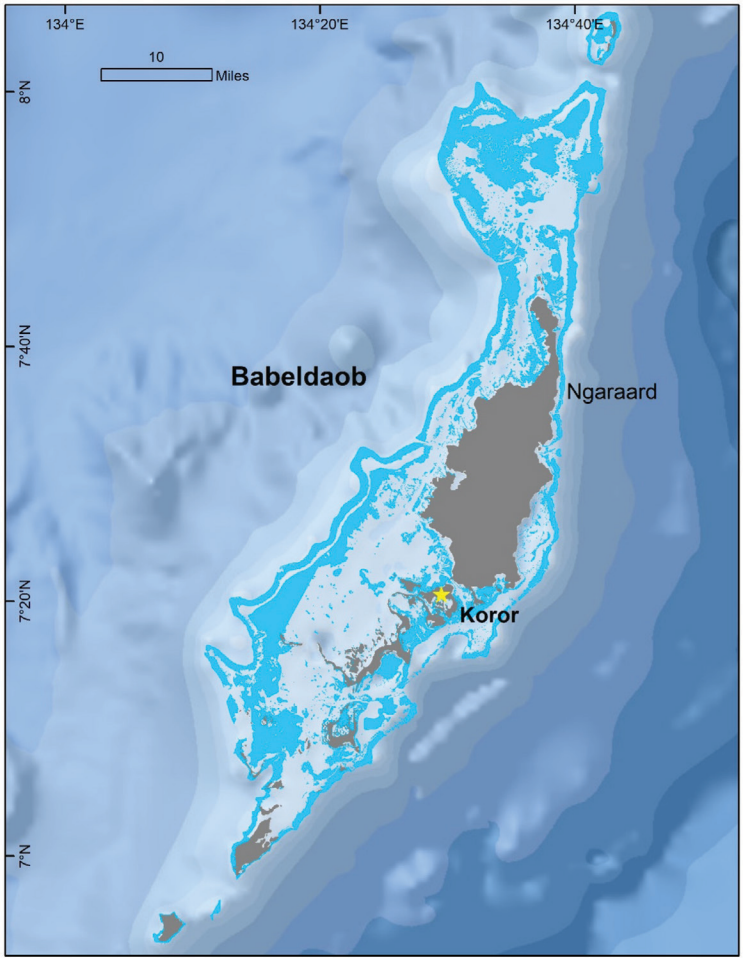
As the UCRA program proves to be continually successful in engaging the whole community in protecting the reef, the foundation hopes to expand the afterschool program into a full K–12 charter school. They aim to design a school where students can learn traditional knowledge from mentors and elders.

By tapping into the traditional knowledge of sustainable practices in their bay and educating the youth about human and climate impacts on their ecosystem, the foundation aims reclaim the abundant, colorful, healthy reefs of Humåtak's past. "And that's what keeps us going, is the vision that we see at the end."

Seesawing: Coastal Change in Ngaraard, Palau

"You cannot really stop the power of the water," said JeRome Temengil, site manager of the Kerradel Conservation Network, the local chapter of the Protected Areas Network (PAN) in Ngaraard State in northern Babeldoab, the Republic of Palau's largest island. "It actually shifted most of the sand away from the coastline. So you see where the sand stops and where the land is. You see the land that has been eroded under, so you see the tree roots on the coastline."

The coastline in Ngaraard has a history of seesawing inland and offshore, which has recently been at odds with coastal infrastructure. Traditionally, the population of Ngaraard—around 2,000 people, Temengil estimates—lived inland in the hilly center of the state. "Years ago, people actually lived in the middle of the land because they were a mountain people. But right after, when we started having administrations—for example, like the Spanish and the Germans—that's when we started moving to live on the coastline because it was closer to the ocean," explained Temengil. When the coastline became the economic and social center on Ngaraard, the seesawing of beach erosion and accretion began to clash with the newly settled population.



Palau's main island of Babeldaob and the coastal state of Ngaraard. Map by Laura Brewington.

A team of scientists assessed the coastline dynamics off a village on the eastern coast of Ngaraard for a case study in a coastal erosion and flooding guide, the Pacific Islands Coastal Change Toolkit. As the scientists walked the beach, talking with residents about what the coastline used to look like, they found that the north end of the beach had eroded while the south end had accreted. They noted evidence such as a line of ironwood trees, which establish themselves right up to the waterline, that now had 150 feet of sand and small vegetation on the water side—implying that the beach had accreted 150 feet in the trees' lifetime. These coastal dynamics are attributed to erosion and accretion by wind-driven currents and punctuated by dramatic storm damage.

Ngaraard's eastern coastline is low and exposed to the easterly tradewinds and currents, as well as infrequent but impactful storms. When storms do strike the coastline, storm surge floods the low-lying areas and washes away sand in some areas while building up sand in others, creating berms. These new berms change the interaction of currents

with the coastline resulting in accretion in new areas over time—until the next storm comes.

Coastal erosion in Palau. Ngaraard's planners and policy makers need to understand the varying influences on the physical environment to anticipate appropriate actions. Source: JeRome Temengil.

Palau is just south of the main tropical cyclone, or typhoon, pathway, making their incidence relatively infrequent in Ngaraard. This made the recent landfall of two typhoons in the last three years all the more surprising. Natural climate variability causes sporadic periods of increased storm activity, which Palau has recently experienced. In December 2012, Typhoon Bopha struck Ngaraard on its northeastern track from the equator to the Philippines.

"It really had a huge impact on intracoastal Ngaraard because the winds were coming from the east—and the east is much lower than the west side—so it destroyed a lot of houses," said Temengil. "It created flooding that came through the villages. And so people had to move away from the east coast. And it took us months and months to recover."

"During the typhoon, most of our taro plants were destroyed by the salt water. And what Palau Community College is doing is they have more than five species of taro and they're trying to figure out which of the taro is more resilient to saltwater."

"And the second typhoon that came through, I think it was 2013, a year after. It also devastated the east coast," he continued, referring to Typhoon Haiyan, the strongest typhoon on record at the time. "Most of the crops—for example taro plants or beetle nut trees, most of the edible fruits—they were all destroyed."

It is important for Ngaraard's planners and policymakers to understand these varying influences on the physical environment in order to anticipate appropriate actions. Climate service that provide information on natural climate variability and early warning for storm events are crucial in keeping Ngaraard's residents safe.

Additionally, it will be important to understand and track how climate change will add to these dynamics. With time, sea level rise will amplify the flooding and abrupt coastal changes that typhoons bring. With a higher mean sea level, storm surge will be able to reach further inland, increasing the severity of flooding. Accelerated sea level rise will inhibit the subsequent process of accretion and increase erosion. Climate change could also change the frequency or intensity of storms, which will be important to forecast for Ngaraard.

KEY MESSAGE

Know your physical/environmental setting—*using locally-relevant indicators to understand the predict the impacts of a changing climate will help to ensure that products and services are appropriate to time and place.*

Given the impacts of climate on the coast, Ngaraard is navigating a path forward, ranging from agricultural research to spatial planning. "During the typhoon, most of our taro plants were destroyed by the salt water. And what Palau Community College is doing is they have more than five species of taro and they're trying to figure out which of the taro is more resilient to saltwater." With these developments, Ngaraard's agriculture will have a better chance of surviving coastal flooding events.

Another adaptation measure, discussed by Temengil and the assessment team, is relocating vulnerable infrastructure, including the town's girls' school located a few hundred feet from the beach, and residents who live close to the coast. This solution will not be as easily implemented as planting saltwater-resistant taro. The community, which has become accustomed to coastal living, doesn't favor uprooting. "That's something to the island people that's very, very difficult—to relocate."

"I can tell you that, you know, if I talk to my own villagers on the east coast they'll say no, we're not moving we're going to stay on our land. And that's a little bit different than when the typhoon hit," said Temengil. "When the typhoon actually hit us, they were thinking about moving. Now that things have really calmed down, then it's not in their agenda."

With the impacts of Typhoons Bopha and Haiyan freshly imprinted on the beaches, yards, and building foundations, Ngaraard residents easily saw the benefit of moving inland. As their memory of the typhoon erodes with time, so too does the community's motivation to relocate. Evoking that memory, Temengil said, is the key to engaging residents.

"They would be open, if you really show them the impacts—the damage to them from climate change. Right now if you're talking to them, you're just talking to them."

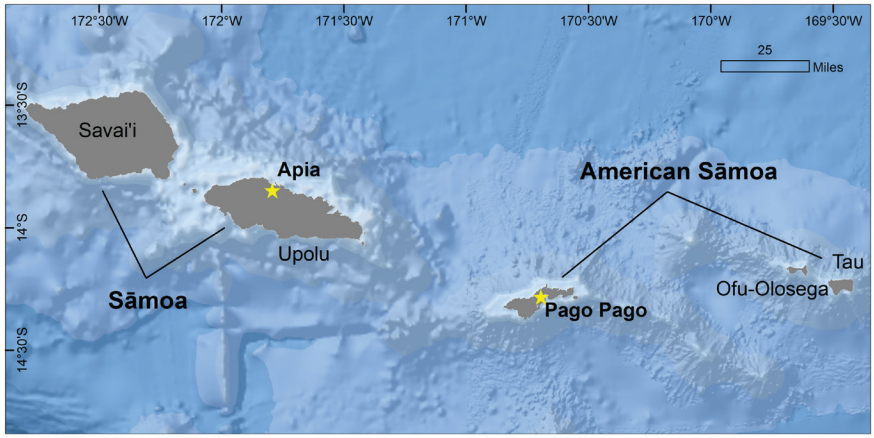
Understanding the cultural context—the values, history, and collective memory of the community—pertaining to adaptation decisions, such as relocation, is crucial to making those solutions work. Without the desire and support of the community, coastal planning will see little success.

KEY MESSAGE

Know your social/cultural setting—*understanding community values, aspirations, and perspectives, as well as the sensitivity of critical assets and community adaptive capacity will drive adaptation from the bottom up.*

"We didn't think about typhoons. Then we were hit by this super typhoon and everybody said it was an issue. We have to do this, we have to do that, to prepare for next time. But then, you know, months go by. Nothing is happening and no disaster comes our way, we tend to forget about it. Until it hits us. And this is what you call a lesson learned."

Symbiosis: Responding to Coral Bleaching in the Two Sāmoas



The Two Sāmoas region, comprised of Sāmoa and American Sāmoa. Map by Laura Brewington.

Coral reefs get their structure from calcium carbonate skeletons built by individual corals (animals), which take their many shapes and colors from symbiotic algae called zooxanthellae that inhabit small cavities in the coral tissues. These algae are responsible for much more than just the coral's color—they also give it most of the nutrients needed for life and growth. The algae and coral skeleton together build the complex, textured neighborhoods that foster reef ecosystems: striped, spotted, and camouflaged fish, invertebrates that are soft-bellied or armored, and occasional prowling shadows of predators, along with hundreds more life forms. The symbiotic relationship that makes all of this life possible is fragile. If stressed, coral can expel the algae from its tissue in a process called coral bleaching. Without the food the algae provides, the now-pale coral stops growing, may die, and the once vibrant neighborhoods are lost.

Changes in water temperature, acidity, nutrient concentrations, and other stressors can cause bleaching. In the Pacific, mass coral bleaching is often related to phases of ENSO, a semi-cyclical climate phenomenon that can raise ocean temperatures and cause bleaching. El Niños can also lower sea levels in Sāmoa and American Sāmoa (the Two Sāmoas) exposing reefs to air and increased sunlight that cause bleaching and other damage. This phenomenon is so well documented that the Sāmoan language has a distinct word, *taisama*, for the stench of dying reefs exposed to the air during periods of low sea level brought by El Niño. Additionally, increasing ocean temperatures in a changing climate will make coral bleaching events more common. Reefs around the world are at risk and marine managers are working to protect them, using information about climate variability and climate change to inform actions.

KEY MESSAGE

Be aware that impacts due to a changing climate exist along with (and often exacerbate) impacts from a myriad of non-climate stressors—*climate adaptation will be most effective when it is integrated with disaster risk reduction, sustainable development, ecosystem-based management, and other such multi-sectoral approaches to planning and policy development.*

"The Territory decided—with some major coral bleaching events happening internationally," said Kristine Buchianeri, the Coral Reef Advisory Group (CRAG) Coordinator for the Territory of American Sāmoa, "that we wanted to create a territorial coral bleaching response plan, which was in 2011." The diverse reefs of the Two Sāmoas region in the Western South Pacific have experienced coral bleaching with increasing frequency in the past three decades.

The Two Sāmoas region experienced coral bleaching and death during the 2015 El Niño event, such as this bleached coral pictured in American Sāmoa. Source: Climate Signals.

The CRAG spent about a year developing a draft of the plan, consulting with community members and partner agencies including the American Sāmoa Department of Marine and Wildlife Resources, the National Park, the Community College, the Environmental Protection Agency, and multiple offices from within NOAA. "From those conversations, we realized that there were a lot more coral threats that might potentially negatively affect the coral in American Sāmoa so we expanded it to include multiple threats and changed the name to Assessment and Rapid Reef Response Plan. So the other threats included in the plan are crown of thorns outbreak, storm damage, and coral disease—with the idea that no matter what kind of threat hits the coral, we would collaboratively respond and react together as an interagency group," said Bucchianeri. The document was published in 2013, but the CRAG continues to update and expand it to address new science and threats. "We don't like to call it final. We refer to it as a living document—we change it and edit it."

The Sāmoan language has a distinct word, taisama*, for the stench of dying reefs exposed to the air during periods of low sea level brought by El Niño.*

The plan takes a creative, adaptive approach to addressing threats. "We call it a 'Choose Your Own Adventure Novel,'" explained Bucchianeri, referring to the series of children's books in which the reader chooses the actions of the main character. In the case of the response plan, CRAG chooses different actions to respond to the event depending on the severity of bleaching. Some of those measures include community education, reducing land-based sources of pollution, or seasonal closures of herbivorous fish species—by grazing on the algae that can smother corals, herbivores provide areas for new corals to settle and grow.

For the CRAG to effectively implement their response plan, they will need to employ local climate information. Sea level data associated with El Niño, available from the Pacific ENSO Applications Climate (PEAC) Center among other sources, will be an important variable to track in order to effectively respond to *taisama*. For sea surface temperature

In addition to coral bleaching, the reefs of the Sāmoas region face threats such as crown-of-thorns starfish that prey on coral. Source: National Marine Sanctuary of American Sāmoa.

data, the CRAG relies on a combination of information from the Weather Service Office in American Sāmoa's capital of Pago Pago, local monitoring, and the NOAA Coral Reef Watch (CRW), which produces outlooks for sea surface temperature with associated risk of coral bleaching.

Though useful approximations, the CRW products the CRAG was using were regional outlooks without specific reference to the Sāmoas region. Sea surface temperature can vary widely within a region so localized information can be crucial to understanding and responding to bleaching. "We don't have a lot of data or information that's specifically local," said Bucchianeri. "I think we could use some of these services to be more specifically based in American Sāmoa."

At the Climate Services Dialogs held by NOAA in partnership with the Two Sāmoas Initiative in Sāmoa and American Sāmoa in 2013, local marine managers approached CRW about producing outlooks specific to the Sāmoas. "We had asked if it was possible to put in a virtual station for Sāmoa—just to monitor the sea surface temperature," said Juney Ward, Principal Marine Conservation Officer of the Ministry of Natural Resources and Environment (MNRE) of Sāmoa, which is similarly developing a coral reef response plan, in partnership with the Fisheries Division of the Ministry of Agriculture and Fisheries and the Secretariat of the Pacific Community (SPC), which will address coral bleaching and other threats to reefs.

KEY MESSAGE

Commit to robust and sustained monitoring and assessment—*the maintenance and expansion of existing monitoring networks will lead to an improved ability to understand and predict a changing climate and associated impacts over both the short- and long-term.*

In response to the CRAG and MNRE's request, CRW created a "virtual station" for the Sāmoas region which reports a forecast for local sea surface temperature and a qualitative coral bleaching risk from 'No Stress' through 'Warning' up to 'Alert Level 2'. The inter-agency coordination of the CRAG, MNRE, and CRW to create a climate service that benefits both marine management agencies will improve bleaching response in the region. As a result of this collaboration, the CRAG and MNRE began exchanging emails on threat conditions and extent on their respective reefs which will further benefit them as they work on similar plans.

CRAG and MNRE exchanged emails to assess respective conditions related to a rising coral bleaching alert level at the Sāmoas Region virtual station in March 2015. "We just started to see some bleaching in the last month or six weeks," said Bucchianeri, "and the projected water temperatures are looking not very good for our coral."

"Some of our team were out just yesterday trying to get baseline surveys on the areas we identified as priorities in the plan to assess current baselines so we can measure the progression of bleaching—which hopefully doesn't

happen," said Bucchianeri. Resources and attention devoted to monitoring reef conditions both before and during bleaching or other reef threats are required to establish baselines and verify model forecasts.

As part of their monitoring, MNRE engages with community members who are often some of the first witnesses of changes to reef ecosystems. MNRE asks tour operators, fishermen, and recreational swimmers to notify them of unusual bleaching or crown-of-thorns outbreaks.

"Because sometimes the communities will see the changes before us and we'll actually get the information quite late. So we're trying to build on and strengthen our collaboration with communities so that when they're seeing changes in their reef system, they can immediately inform us and we're able to respond early and document these changes. And also to help them realize that when we're experiencing mass bleaching, that there's certain things that need to be done so that we're not adding extra pressure to the reefs that are already being impacted by the bleaching."

KEY MESSAGE

Engage with the community and other stakeholders early and often—*building community ownership and participation from the beginning leads to more positive, sustainable outcomes.*

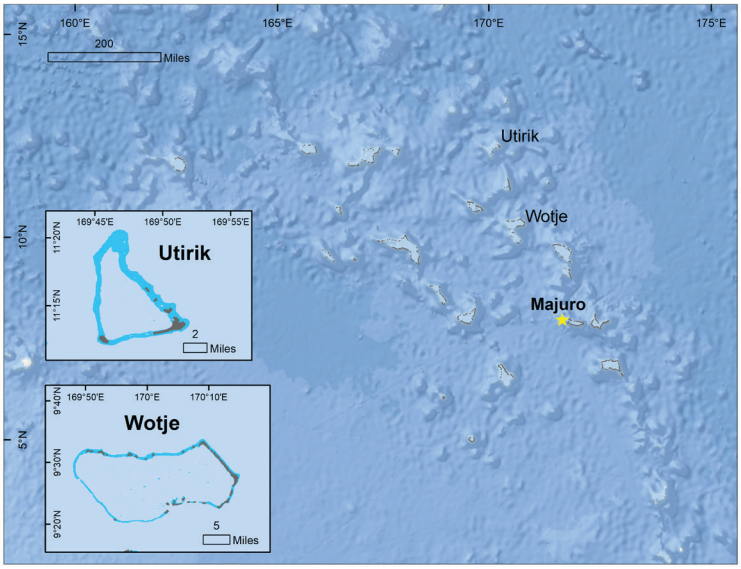
This community involvement serves multiple purposes—increasing monitoring capacity while spreading conservation messages and thereby decreasing human stressors on the reef. Just as the CRAG engaged a number of stakeholders and community members in their response plan, community engagement is key to successful development of climate services.

MNRE had intended to create a coral bleaching response plan for quite some time and the 2015 bleaching event lent an extra sense of urgency to complete it. "There was never a time that we sat down until now, when we are actually experiencing the bleaching," said Ward. "We're now sitting down and getting on top of that bleaching response plan."

At the CRAG, Bucchianeri and her team took this opportunity to test and improve their plan. "We're taking notes, because this is the first bleaching event that we've actually used the Assessment and Rapid Reef Response Plan for. So we're just taking notes to see if it's good, if it works, if it needs to be improved for next time," said Bucchianeri.

When Drought Brings Sickness, Part I: Water-Borne Disease in the Marshall Islands

In late 2012, the months leading up to the dry season were much drier than normal in the northern atolls of the Marshall Islands, known as "the outer islands". Wotje and Utirik Atolls received only 28% and 25%, respectively, of their normal rainfall for September through November. By the beginning of 2013, precipitation in the outer islands was already at a huge deficit. "We were looking at the seasonal outlook for rain and it was saying by January, February, March, it's not looking like it's getting any better," recalled Reggie White of the Weather Service Office in Majuro. "The people from the outer northern islands were calling in and saying, 'We are in need of water,'" said White.



Wotje and Utirik Atolls in the Marshall Islands. Map by Laura Brewington.

That January, 13 local governments in the outer islands requested assistance from the national government in dealing with the drought. The ground was cracking and the leaves were turning; the lower atmosphere became drier and the groundwater saltier. The government declared a state of emergency on April 19. By the time the government declared a state of emergency, however, wells in the outer islands had long since run dry, and people were beginning to make the journey to the capitol of Majuro. Household freshwater sources like catchment systems became increasingly limited, and staple crops like bananas, breadfruit, and pandanus were dying. Furthermore, on the heels of the emergency declaration, assessment teams sent to the outer islands found that groundwater was too salty and people were suffering associated health problems including gastritis, diarrhea, vomiting, abdominal pain, fever, and hepatitis. Poor sanitation and hygiene that accompanied the lack of water further exacerbated many of these illnesses.

Drought on Ailuk Atoll in 2013. Source: United Nations Development Programme.

The Marshall Islands experiences regular outbreaks of water-borne disease, and in January 2020 a Climate Services Dialog for the health sector was held in Majuro with participants from government, the health sector, the Weather Service Office, and regional and national disaster

management offices. Participants first documented all of the historical disease outbreaks they could remember. They included diseases such as cholera, typhoid, gastrointestinal illnesses, conjunctivitis, and rotavirus. Certain water-borne (and food-borne) disease outbreaks in the Marshall Islands appear to be related to certain types of climate and weather events. For example, low rainfall and sea levels associated with El Niño events result in scarce drinking water, which elevates incidence of diarrheal disease, conjunctivitis, scabies, and influenza. The La Niña conditions that often follow an El Niño (above-average rainfall and higher sea levels) have been associated with ciguatera.

Disease early warning and response systems need to be culturally appropriate, linked to traditional knowledge, tailored to diverse audiences, and delivered by trusted messengers through established pathways.

The Marshall Islands' climate is classified as maritime tropical, which means it is humid with moderate temperatures year-round. It is also characterized by spring and fall transitions between "wet and wetter" for the southern islands, whereas the northern islands experience "wet and dry" seasons. In addition to tropical cyclones, other types of extreme events include drought, which tends to be associated with El Niño events, and coastal flooding that occurs when high tides combine with large waves. Well-recognized periods of drought occurred in 1982–83, 1991–92, 1997–98, 2015–16, and 2018–19. The occurrences of such events are likely to change in frequency, magnitude, and duration in light of a changing climate. Coastal flooding has also occurred many times over the last 40 years. At the Kwajalein tide gauge, for example, high water events that occurred less than once a year on average in the 1960s, occurred 22 times a year during the 10-year period beginning in 2005.

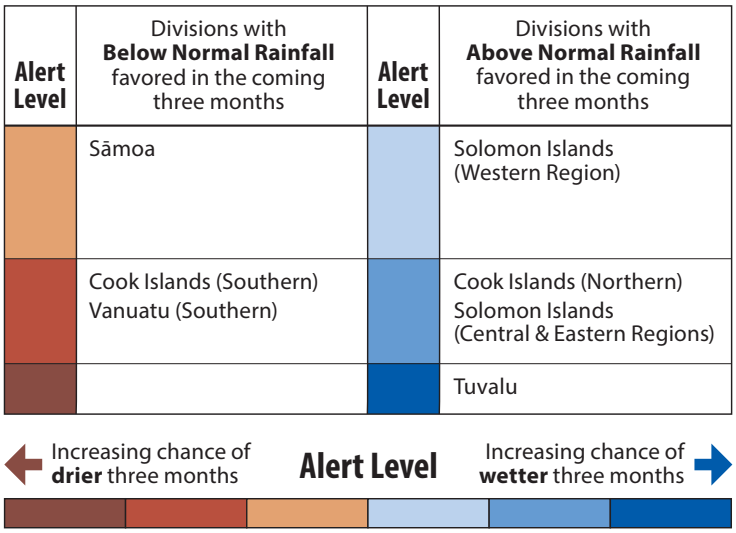
Participants at the First National Climate and Health Dialog document historic disease outbreaks and timelines of climate events. Source: David Krzesni.

Currently, there are a range of actions, sources of information and partnerships in play before, during, and after water-borne disease outbreaks. When an outbreak is suspected, for example, officials from the Ministry of Health and Human Services inform their national and international partner agencies, procure supplies, and initiate clean-up campaigns to prepare communities and households. The Ministry of Health also analyzes data available from previous water-borne disease outbreaks. In the existing system, however, most of these mechanisms are not operationalized until there is already a diagnosed outbreak.

KEY MESSAGE

Commit to robust and sustained monitoring and assessment—*the maintenance and expansion of existing monitoring networks will lead to an improved ability to understand and predict a changing climate and associated impacts over both the short and long term.*

Although certain water-borne (and food-borne) disease outbreaks in the Marshall Islands appear to be related to certain types of climate and weather events, such relationships are not clearly established. Further research is need to identify not only the causal relationship but thresholds, time lags and other such information necessary to support decision-making. Recognizing that climate and weather is one of many stressors, such research should also consider other social, economic and environmental factors. This information would inform the development of monitoring and early warning systems.



The Red Cross produces a seasonal "rainfall watch" for the Pacific Islands region. Source: The Red Cross Red Crescent Climate Centre.

Increased stakeholder engagement and making people more aware of climate/weather phenomena and associated health risks would also help support a more pro-active, preventative-based response system. Content needs to be culturally appropriate, linked to traditional knowledge, tailored to diverse audiences, and delivered by trusted messengers through established pathways. This includes training for practitioners at the national level to help understand and use climate and weather information; training where, as a primary provider of climate and weather information, the National Meteorological Service plays a leading role. It might also include expanding the extension agent model currently employed by the Red Cross by training people, particularly in the outer islands as "climate/weather champions". A quarterly newsletter or similar publication could provide information about drought, tropical cyclones, and coastal inundation packaged for the health care sector.

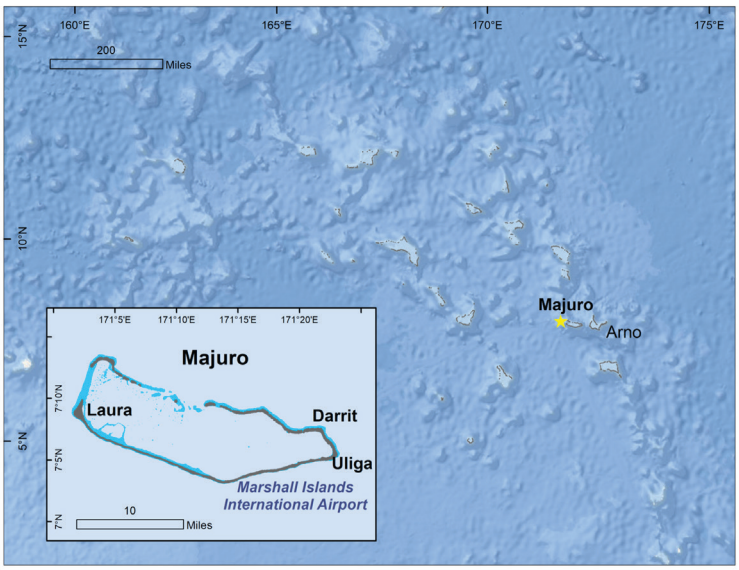
KEY MESSAGE

Direct attention to the alignment and coordination of activities*—integrated program planning and product development will maximize efficiency and effectiveness (by minimizing gaps and overlaps, and maximizing information consistency and messaging), as well as enrich the potential for local to regional capacity development.*

Considerable information is collected by multiple agencies and organizations throughout disease outbreaks. Debriefings that occur after such events could be expanded to include additional analysis leading to the development of lessons learned. Such information could be used to enhance preparation for and response to subsequent outbreaks, and support modifications to policy. In the health sector, National Weather Service Offices are ideally placed to play a major role in climate services delivery by serving as a national source for high-quality weather and climate observations, and producing sector-specific seasonal climate outlooks.

When Drought Brings Sickness, Part II: Vector-Borne Disease in the Marshall Islands

"The Marshall Islands has been in a state of health emergency for seven months," said Jack Niedenthal, Secretary of Health for the Marshall Islands during his opening remarks at the January 2020 Climate Services Dialog for the health sector, held in the nation's capital of Majuro. Health Secretary Niedenthal described the resounding health impacts of climate change that are being observed in the Marshall Islands: "This is not about waiting for the sea level to rise, weather to change, that's not what's driving this. It's climate change health impacts. This is the new normal," he continued, "this is something we have to be leery of."



Majuro, the capital of the Marshall Islands. Map by Laura Brewington.

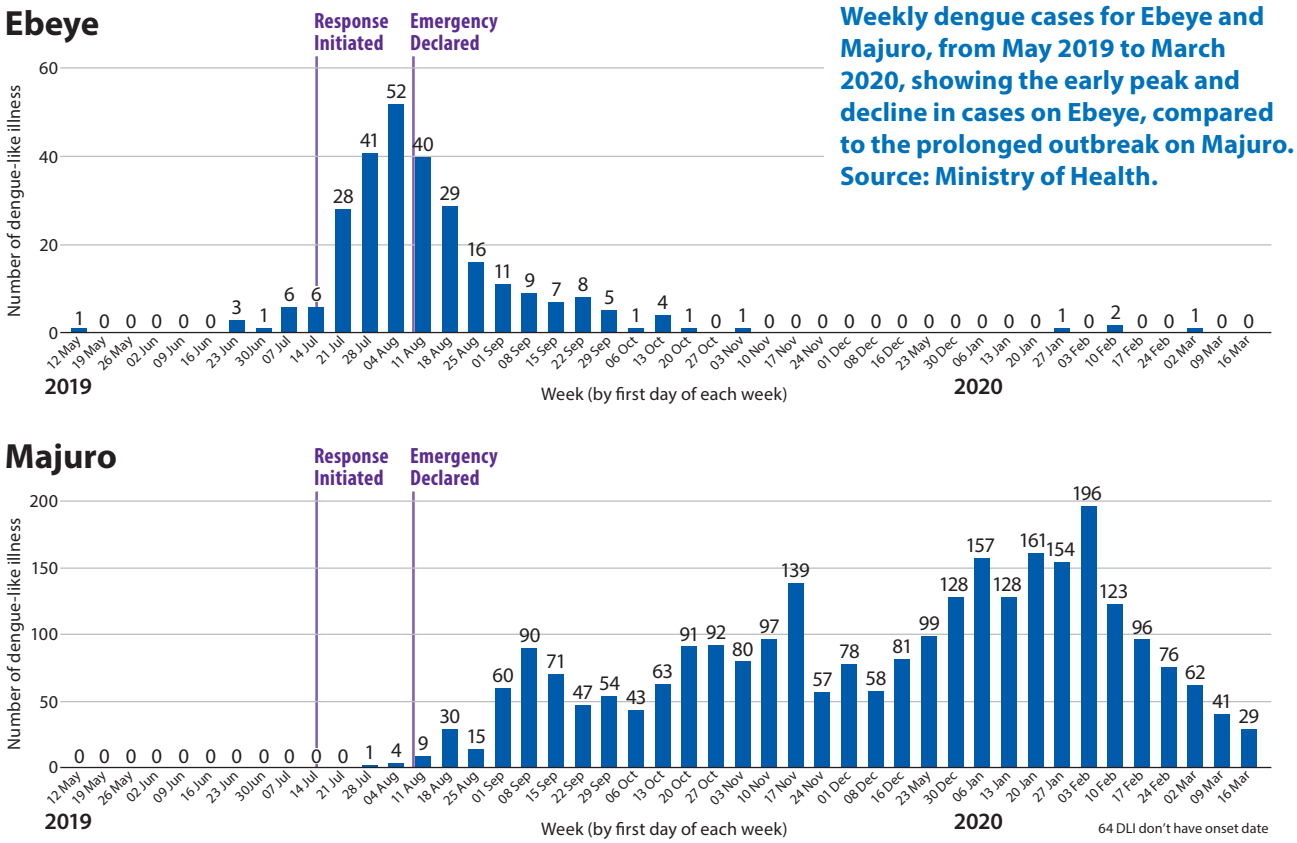
Rewind to May 2019, when a passenger returned to Ebeye from the neighboring Federated States of Micronesia. Unknown to them, they were infected with dengue fever, a vector-borne illness that is transmitted by mosquitos and causes high fever and painful body aches. The Marshall Islands had just begun to recover from a recent drought event following some of the driest and hottest years on record. During such periods, many households store water in outdoor receptacles that become breeding grounds for mosquitos. Cases of dengue fever multiplied rapidly, first on Ebeye and then in nearby Majuro, home to half of the nation's 53,000 citizens.

The Marshall Islands has documented recurring vector-borne disease outbreaks since the early 1990s, including dengue fever, Zika virus, and chikungunya. Over the same time period, repeat drought and inundation events were also recorded. Climate change is a threat multiplier and may lead to increases in the number and type of events that trigger or elevate the risk of a disease outbreak. The Pacific Islands region is prone to prolonged periods of drought, particularly in the western Pacific during El Niño events. In addition, heavy rainfall as a result of changing storm patterns leads to local or widespread regional flooding. Certain climate and weather events, such as drought and extreme rainfall or inundation, appear to be related to vector-borne disease outbreaks in the Marshall Islands.

KEY MESSAGE

Engage with the community and other stakeholders early and often*—building community ownership and participation from the beginning leads to more positive, sustainable outcomes.*

Throughout the hottest months of 2019 (July, August, and September), the number of new dengue cases increased exponentially, first on Ebeye and then on Majuro. On Ebeye, the outbreak was quickly brought under control, and involving the traditional leaders was key. Monthly clean-ups were spearheaded by the local leaders: every Saturday,



Weekly dengue cases for Ebeye and Majuro, from May 2019 to March 2020, showing the early peak and decline in cases on Ebeye, compared to the prolonged outbreak on Majuro. Source: Ministry of Health.

residents of Ebeye were required to spend the mornings or afternoons cleaning around their personal homes and areas to reduce mosquito breeding grounds.

In Majuro, however, the outbreak raged on. Residents described wearing long sleeves and using insect repellant at first, but as the outbreak continued into the latter half of the year, many grew tired of the discomfort and stopped taking these preventative measures. Emergency protocols were put in place to respond, including the creation of a dengue ward at the Majuro hospital and the arrival of foreign doctors and nurses to relieve sick and exhausted local staff members. Vector surveillance and control activities inspected and fumigated homes, vessels, schools, and churches. Twice-weekly Health Alert radio broadcasts, regular mass text messages, and the Ministry of Health Facebook page provided information about ongoing activities, situation reports, and warnings.

The dengue outbreak that began early summer 2019 cost the nation over US$2 million—"think of all the things we could have done with that money [had we contained the outbreak]. Climate change is not just rising sea level and weather change. It's health, it's disease, and it's impacting people right now."

As the outbreak evolved into a national state of emergency, a travel restriction was put into place that restricted the movement of individuals between the nation's islands and atolls, stranding many away from their homes, families, and jobs. This decision resulted in a brief drop in the number of new cases until the government lifted the restriction in early December for the holidays. Public health officials were deployed to outer island health centers to ensure testing and treatment continued; at the same time, widespread public celebrations for the upcoming holiday season

caused cases in Majuro to increase sharply once again. By January 2020, it was estimated that over 8,000 Marshallese (15% of the resident population) may have contracted dengue fever, and one death, a child, had been attributed to the outbreak.

To better understand how the health sector receives and utilizes climate information, and to improve the provision of climate services in the context of health, the first National Climate Change and Health Dialog was held in Majuro in January, 2020. During the Dialog, participants from the national government, the Ministry of Health and Human Services, the World Health Organization and other policy and student organizations were divided into small groups and asked to describe the actions that are currently in place for before, during, and after a vector-borne disease outbreak such as dengue fever. When an outbreak is suspected, for example, officials inform their national and international partner agencies, procure supplies, and initiate clean-up campaigns to prepare communities and households. The Ministry of Health also analyzes data from any previous vector-borne disease outbreaks. In the existing system, however, most of these mechanisms are not operationalized until an outbreak has already been diagnosed.

Secretary of Health Jack Niedenthal warns of the compounding interactions between climate change and disease at the 2020 Climate Change and Health Dialog. Source: Ministry of Health.

Given that we know periods of drought can lead to increased vector populations in the Marshall Islands, it's possible to forecast a drought in the region up to three months in advance and begin to prepare supplies and other resources (the "Ready" component of Columbia University's Ready-Set-Go framework). Quarterly outlooks from the National Weather Service Office in Majuro and the Asia-Pacific Data Resource Center can also contribute to health sector readiness.

This is also the time to implement communication plans. Most people in the Marshall Islands have access to the radio, so this is the most effective form of media for disseminating news of a health outbreak or emergency. Meanwhile, the weather station is part of the National Disaster Management Council. Social media pages like Facebook also provide users with important public health-related information. Those who don't have access to radio, television, or the internet need community outreach through school groups, peer to peer connections, or churches. Councils for each district hold their own regular meetings, and monthly village meetings with traditional leaders then report to the Mayors to generate a regular information sharing platform. All of these mechanisms help to engage traditional knowledge and work at both the local and national levels to improve public health awareness.

The Ready-Set-Go climate action plan framework. Source: International Research Institute for Climate and Society at Columbia University.

KEY MESSAGE

Know your social/cultural setting*—understanding community values, aspirations, and perspectives, as well as the sensitivity of critical assets and community adaptive capacity will drive adaptation from the bottom up.*

Further underscoring the need for climate early warning systems, it can take at least three months to order and receive health supplies ahead of an outbreak. With a three to six month lead time for an El Niño event, which typically brings drought, the government can put in requests to partners for aid and supplies in time to receive them before a subsequent outbreak. While waiting for long-term supplies and aid, the World Health Organization can provide emergency supplies for two to three weeks, and the US Centers for Disease Control and Prevention can provide a month's worth of supplies, to cover any temporal gaps. Weekly drills during the "Ready" stage could help residents prepare for behavioral changes that will need to occur during the outbreak and encourage regular local clean-ups. Meanwhile, in addition to public and media messaging, the government can coordinate outreach to community groups (e.g., schools, churches, etc.) who would then communicate directly with their constituents. Once the drought has begun (the "Go" stage), information from past outbreaks and experiences can guide changes in behavior by linking knowledge, skill, and practice.

Health Secretary Niedenthal estimates that the dengue outbreak that began early summer 2019 has cost the nation over US$2 million—"think of all the things we could have done with that money [had we contained the outbreak]," he said. "Climate change is not just rising sea level and weather change. It's health, it's disease, and it's impacting people right now." Shortly after the 2020 Climate and Health Dialog concluded, the WHO declared the COVID-19 outbreak a global pandemic, and given the still-dire dengue situation on Majuro, the Marshall Islands—along with most other Pacific Island countries—was forced to close its borders for the entire year that followed. The compound impacts of climate change, disasters, and disease present significant challenges for the region, especially in places where health systems and infrastructure are already under stress. As preliminary guidance for how to reduce the impacts of disease through climate early warning, the following recommendations for the health sector emerged from the Dialog, and are being incorporated into the country's National Adaptation Plan for climate change:

- **Improve coordination** between government agencies in response to health threats. Currently there is no sector-wide coordination mechanism for health and international partners in the Marshall Islands, whereas in other countries they meet every six months, three months, or even monthly.
- **Train the health sector** to take advantage of advance climate information. The Majuro National Weather Service Office and the Asia-Pacific Data Research Center Marshall Islands Climate Outlook already offer online quarterly outlooks for precipitation in time to anticipate a drought. Taking early action based on these and other tools can help reduce the impacts and severity of recurring disease outbreaks.
- **Incorporate climate education** and information into the K–12 education curriculum. Students who participated in the Dialog are eager to be more involved in climate-related activities and want to encourage their peers and family members to be more vigilant about the health-related risks of climate change.

KEY MESSAGE

Be aware that impacts due to a changing climate exist along with (and often exacerbate) impacts from a myriad of other non-climate stressors—*climate adaptation will be most effective when it is integrated with disaster risk reduction, sustainable development, ecosystem-based management, and other such multi-sectoral approaches to planning and policy development.*

Notes