

# PREPARING FOR A CHANGING CLIMATE

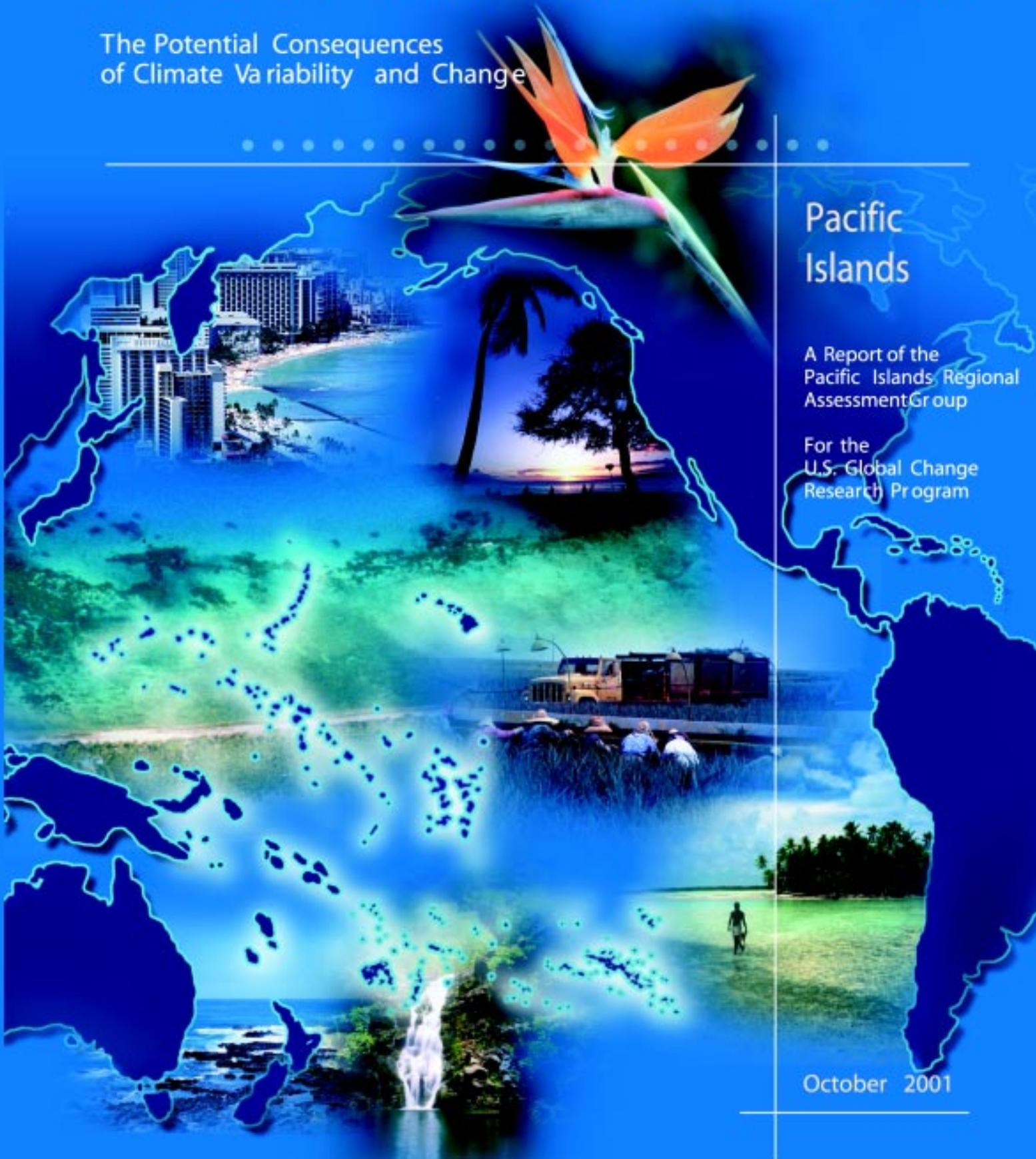
The Potential Consequences  
of Climate Variability and Change

## Pacific Islands

A Report of the  
Pacific Islands Regional  
Assessment Group

For the  
U.S. Global Change  
Research Program

October 2001





*"The impacts of the 1997-1998 El Niño are fresh in our minds, and the latest reports from the work of the Intergovernmental Panel on Climate Change (IPCC) confirm what all of you already know changes in climate matter to individuals, communities, businesses and governments who call islands home. Your valuable natural resources, traditional ways of life, critical economic sectors, community support infrastructure, and, to a great extent, your future, depend on developing an effective response to the challenges presented by climate variability and change." (Morrison, 2000)*

## Overview and Objectives

This brochure summarizes the key findings and recommendations of the Pacific Islands Regional Assessment of the Consequences of Climate Variability and Change (the Pacific Assessment) conducted as a regional contribution to the first U.S. National Assessment of the Consequences of Climate Variability and Change (see back cover for details). The Pacific Assessment sought to nurture the critical partnerships necessary to develop and use climate information to understand and respond to the challenges and opportunities presented by climate variability and change. Based on extensive involvement of experts and stakeholders from diverse knowledge groups, the assessment aimed to combine research and analyses with dialogue and education.

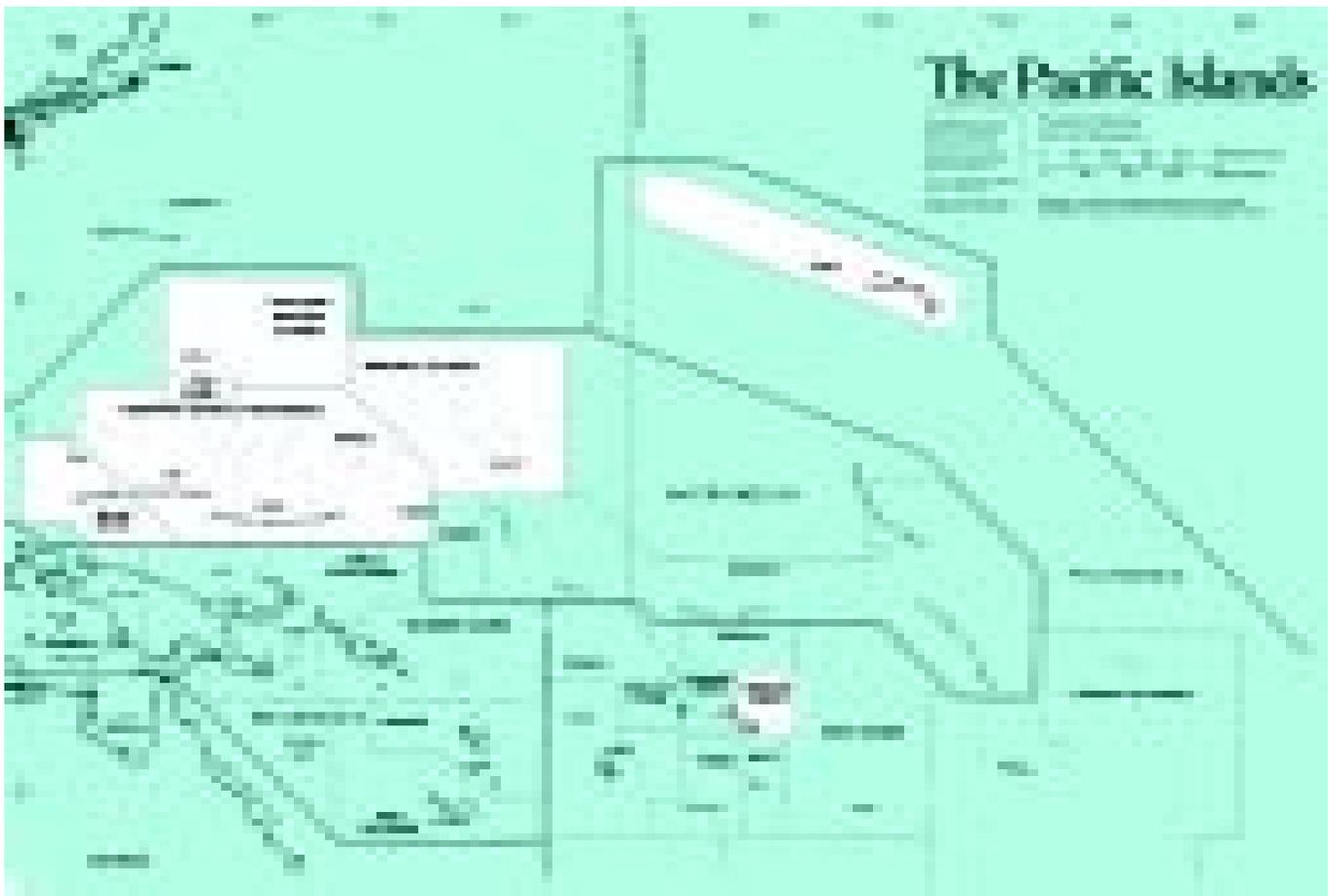
In the end, the Assessment was an exciting and highly interactive process involving over 200 participants who were engaged through small discussion groups and two key workshops organized to encourage and accommodate broad-based regional participation in research and dialogue. **The Pacific Assessment sought to achieve two, mutually supportive objectives:**

- development of a more complete understanding of the regional consequences of climate variability for Pacific Island jurisdictions, considering economic, social and other environmental stresses; and,
- support for a dialogue among scientists, governments, businesses and communities in the Pacific Region that promotes the use of climate information to support decision-making.

This dialogue allows diverse stakeholders to develop a shared understanding of climate effects and possible responses, and to use climate information to support decision-making. The concept of shared learning and joint problem-solving emerged as a defining characteristic of the Pacific Assessment and reflects an evolving paradigm of assessments as a process of dialogue among scientists and stakeholders.

## The Region

The Pacific Assessment focused on the American Flag Pacific Islands, which include Hawai'i, Guam, American Samoa and the Commonwealth of the Northern Mariana Islands, and the U.S.-affiliated Pacific Islands, which include the Federated States of Micronesia (Yap, Pohnpei, Kosrae and Chuuk), the Republic of the Marshall Islands, and the Republic of Palau.



## “Climate change and variability”

is used within this report to acknowledge two types of changes in the earth’s climate system.

**Climate “variability”** refers to relatively short-term variations in the natural climate system, such as the patterns associated with the ENSO cycle or the Pacific Decadal Oscillation (PDO).

**Climate “change”** is used in the IPCC context to refer to long-term changes from decades to centuries associated with increasing concentrations of greenhouse gases. Because variability and change both present significant challenges and opportunities to Pacific Island communities, both are addressed in this report.

## The Climate Context

Consistent with guidelines for the National Assessment, participants in the Pacific Assessment were provided with a projection of climate change over the next 100 years based on the results of two coupled ocean-atmosphere models: the first generation coupled a general circulation model of the Canadian Center for Climate Modeling and Analysis (CGCM1) and a similar general circulation model used by the United Kingdom’s Hadley Centre for Climate Prediction and Research (HADCM2).

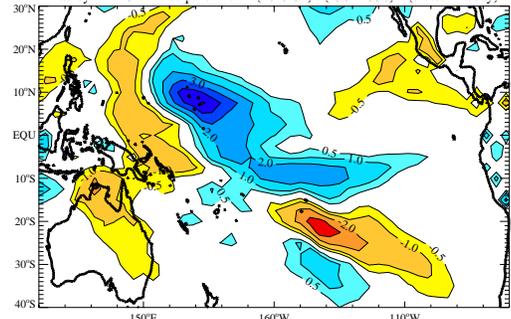
These two models were run for 100+ years, ending in 2100, using the core greenhouse-gas emissions scenario for the National Assessment, which is a 1% rate of annual increase in CO<sub>2</sub>, and commensurate changes in sulfate aerosols (the GHG+A scenario). The 1% rate of increase is based on rates of observed increases modified by estimates of how the current sources of emissions are likely to change in the future; as such, it is deemed plausible as a “business as usual” case with little policy intervention anticipated in the future.

## Summary of Model Runs

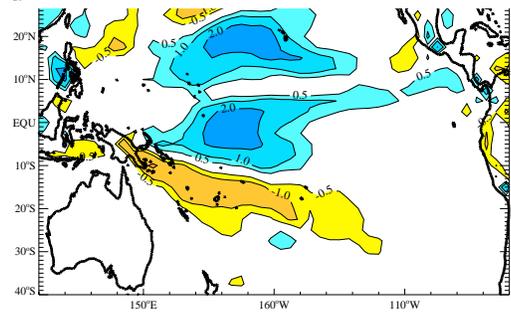
These model-based climate-change scenarios highlight the following important issues that were central to discussions of vulnerability in the Pacific Assessment:

- a general warming trend in surface air temperatures across the region, with implications for human settlements and marine and terrestrial ecosystems;
- a net regional enhancement in the hydrological cycle with a trend toward higher precipitation in some areas, but with important subregional differences that include drier conditions in some areas and uncertainties about the potential effects of changes in hurricanes and tropical storms that often provide a large percentage of rainfall in certain areas;
- potential changes in natural climatic variability, including the possible emergence of a persistent El-Niño-like condition that could affect rainfall, tropical storms and ocean conditions, and, in turn, economically important fisheries and coral reefs (see figure below);
- potential changes in hurricanes and tropical cyclones associated primarily with variations in Sea Surface Temperature (SST) and with possible changes in ENSO, as well as long-term changes in the normal SST;
- increased ocean temperatures, with implications for temperature-sensitive resources like coral reefs and fisheries; and,
- changes in sea level, including both periodic changes associated with ENSO events and a long-term rise in sea level.

Hadley HADCM2 precip for DJF (2025-2034) - (1961-1990) (units mm/day)

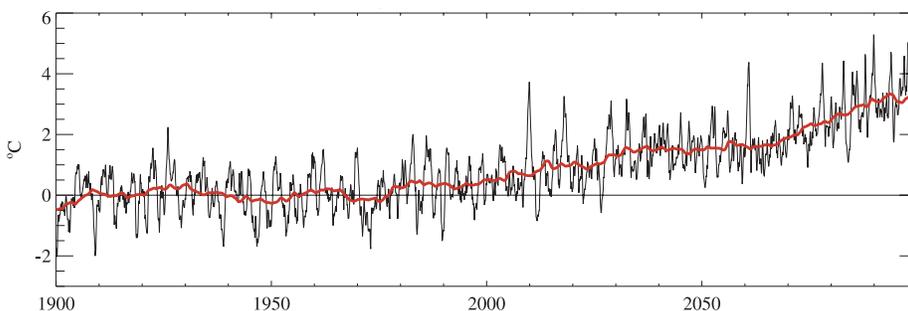


Hadley HADCM2 precip for JJA (2025-2034) - (1961-1990) (units mm/day)



Projected changes in total precipitation change for 2025-2034 (for December, January, February and June, July, August), in units of mm/day.

## Hadley Niño 3 SST anomaly index



Monthly Niño-3 SST anomaly time-series (thin black line) for the period 1900-2099. The El Niño 3 region is defined as 5° N to 5° S and 150° W to 90° W, with the base years for the climatology defined as 1950-1979. The thick red line is the 10-year running average. Units are in °C.

## Vulnerable Activities

Understanding how the climate system works requires a study of bio-geo-physical processes. Understanding why climate matters requires a study of the interaction of climate with environmental and social systems at various time and space scales. To date, interest in climate change has developed in the context of physical and biological impacts with limited exploration of social and economic effects. However, understanding what climate change and variability mean for ecological and social systems, and how we might respond, requires more than an understanding of basic processes and biophysical impacts. The application of vulnerability studies to the climate problem promises to enrich not only our understanding of social-climate interactions, but also our ability to respond to change and extreme events (see definition of “vulnerability” in the box at right).

Climate variability and change pose both challenges and opportunities for human communities that are simultaneously navigating changing demographic, economic, social and political conditions. Understanding how social systems respond to climate change and variability requires knowledge of how they are affected by those conditions today and how they might respond in the future if those conditions change. The Pacific Assessment encouraged and supported exploration of climate vulnerability in the context of six activities:

- **Providing access to fresh water;**
- **Protecting public health;**
- **Ensuring public safety in extreme events and protecting community infrastructure;**
- **Sustaining agriculture;**
- **Sustaining tourism; and,**
- **Promoting wise use of marine and coastal resources.**

The full text of the report documents the potential impacts, sensitivity and resilience in each sector. The report also identifies critical research needs. The summary provided here focuses on the opportunities and challenges for enhancing resilience in island communities.

## Sustaining Tourism

Tourism remains a significant contributor to the economies of Hawai'i, Guam and the CNMI, and is considered to offer economic growth potential for most of the jurisdictions addressed in the Assessment. The unique terrestrial and marine ecosystems that draw many tourists to the islands of the Pacific are already under stress from existing population and pollution. Sea-level rise, changes in temperature and rainfall and changes in ocean temperature could exacerbate those stresses. In addition, as a water-intensive sector, tourism is highly sensitive to any changes that affect water supply. Discussions also highlighted how changes in tropical storm patterns could have direct consequences for coastal facilities and infrastructure. Key findings include:

- Tourism is extremely climate-sensitive—provides an opportunity for leadership
- Extreme events provide a galvanizing focus
- Address the “keys” to tourism – safety, health and infrastructure—proactive planning
- Opportunity to look at alternative infrastructure options & changes in governance systems (e.g., facilities siting, design & construction; land use)
- Address consequences for natural systems
- Partnership among government, industry and the public is essential—recognize the numerous stakeholders
- Opportunities for community dialogue and public-private partnerships
- Develop baseline information on current conditions and vulnerabilities
- Establish effective weather/climate information system(s)—two-way dialogue
- Education a key



## Providing Access to Freshwater

As one participant noted, “Water is gold.” Water’s value is even greater in island settings where surface water is limited (if it exists at all), aquifers are small and fragile, and potable water may be available only from rooftop catchment systems. Climate change or protracted anomalous conditions can have extreme effects on water supply. Discussions during the Pacific Assessment reinforced the importance of addressing the adequacy and long-term stability of island water resources. They also highlighted the importance of effects on freshwater resources as an underlying factor in determining the consequences of climate variability and change for most activities considered in the Assessment. Recommendations to enhance resilience are summarized below.

<b>Natural</b>	<ul style="list-style-type: none"> <li>• Protect and restore watersheds</li> <li>• Conserve, recover and reuse water</li> <li>• Integrate water- and land-use management</li> <li>• Evaluate existing assets (from all systems) and develop unused/alternative sources</li> </ul>
<b>Human and Institutional</b>	<ul style="list-style-type: none"> <li>• Improve infrastructure and increase capacity</li> <li>• Explore traditional and customary practices for water resource management to supplement/adjust existing management regimes (e.g., Ahupua'a Resource Management System in Hawaii)</li> <li>• Plan for the long-term emphasizing self-sufficiency</li> <li>• Recover, treat and reuse wastewater</li> <li>• Promote water conservation</li> <li>• Review and revise permit regulatory regimes to enhance resilience and reduce vulnerability to climate variability and change</li> <li>• Use climate forecasts and information in decision-making— establish targeted climate information systems building on examples like PEAC</li> <li>• Improve climate and water resource monitoring (including socioeconomic data)</li> <li>• Address population and demographic issues</li> <li>• Promote education and awareness</li> </ul>
<b>Economic</b>	<ul style="list-style-type: none"> <li>• Provide economic incentives for water conservation, recovery and reuse</li> <li>• Plan for extremes (particularly droughts)</li> <li>• Develop public/private partnerships especially among large-scale users (including the military)</li> <li>• Develop businesses targeted at water resource management systems climate forecasts and information in decision making</li> <li>• Promote public awareness and conservation in hotels, restaurants and other gathering places</li> <li>• Promote information exchange and dialogue</li> </ul>

## Vulnerability

is described as a “multidimensional concept involving at least exposure the degree to which a human group or ecosystem comes into contact with particular stresses; sensitivity the degree to which an exposure unit is affected by exposure to any set of stresses; and resilience the ability of the exposure unit to resist or recover from the damage associated with the convergence of multiple stresses.” (Clark et. al., 2000)<sup>1</sup>.

## Protecting Public Health

The current state of public health in the Pacific Islands is sensitive to climate variability and change largely through effects on infectious diseases, fresh-water resources and food supplies. A number of infectious diseases in Pacific Island communities are climate-sensitive, including dengue, leptospirosis, malaria, filariasis, cholera, Ross Valley fever, influenza and other upper respiratory infections, gastroenteritis and cryptosporidiosis. In Pacific Island communities, the impact of droughts on subsistence agriculture and food supplies can also pose a significant climate-related health risk. Participants identified a number of actions that would reduce vulnerability; those recommendations are summarized below.

- Improve hospitals and other healthcare facilities, especially infrastructure related to acute care
- Improve water resource and sanitation infrastructure
- Improve the communication of climate information to the health sector and enhance the capabilities of local meteorological services and climate research programs in the Pacific
- Enhance public health surveillance systems in the Pacific
- Enhance healthcare education and training programs
- Improve emergency services delivery systems
- Update and implement comprehensive emergency management programs that address preparedness as well as response
- Update and implement healthcare plans that emphasize preventative care
- Integrate existing climate information (e.g., ENSO forecasts) into healthcare and emergency-services planning on a regular basis
- Enhance efforts to integrate traditional knowledge and practices into discussions of climate and health, including the engagement of traditional leaders and teachers
- Integrate information on climate variability and change into planning and decision-making in key sectors, most notably water resource management and agriculture
- Pursue community planning and economic development programs that encourage a shift toward sustainability, particularly in water usage and agriculture
- Enhance education and training programs, including technical training for healthcare practitioners and climate scientists, as well as public awareness and outreach programs at the local level
- Improve the ways in which information about climate and health

## Public Safety & Community Infrastructure

Island coastal communities have a long history of weathering extreme events. In considering the challenges of ensuring public safety and protecting community infrastructure, a number of climate-related hazards of concern were identified, including droughts; fires (as a secondary hazard often associated with drought conditions); typhoons, hurricanes and severe cyclones (with wind, wave, and rain/flooding hazards); floods and heavy rains (with mud and landslide hazards); episodic high surf conditions; sea-level variation (on various time scales) and long-term sea-level rise (with coastal inundation hazards). Recommendations to enhance resilience include:

- Pro-active, comprehensive emergency management planning – emphasize prevention & preparedness
- Improve climate monitoring and prediction; integrate climate information (e.g. ENSO forecasts)
- Monitor changes in sea level; periodically update inundation maps and planning assumptions
- Shift to more sustainable approaches to water resource management (and agriculture)
- Enhance government-wide communication, planning & coordination
- Conduct island-level vulnerability assessments
- Embed emergency preparedness and response in
- Sustainable development planning
- Implement/improve existing hazard mitigation policies and measures
- Enhance attention to/integration of traditional knowledge and practices
- Strengthen education, public awareness & dialogue



## Sustaining Agriculture

Agriculture, both commercial and subsistence, remains an important part of the economies of many of the islands addressed in this Assessment. As evidenced by the effects of the 1997/1998 El Niño event in the Pacific, climate-related changes in rainfall and tropical storm patterns present problems for agriculture in island communities. Two categories of vulnerability were identified for the agricultural sector; the first includes vulnerabilities related to the physical environment and the second includes social, political and institutional practices. As is the case with all activities addressed in the Assessment, the most critical of these risks are extreme events that can have severe impacts on local and regional agricultural production. Pursuing the Carolinian principle of “meninkairoir” – looking ahead/taking the long view -- participants recommended the following steps to reduce vulnerability:

- Establish closer link between science and agricultural community
- Integrate climate information in drought mitigation plans
- Reduce “information gap” between providers & users of climate information
- Enhance education, public awareness and dialogue
- Develop more resilient agricultural systems
- Encourage diversification (vs. mono-crop agriculture)
- Consider drought and/or salt-resistant varieties
- Improve land use & resource management policies
- Protect against invasive and alien species
- Pursue comprehensive land use management policies and practices; regulation may be necessary
- Improve communication and coordination across levels of government and among activities (e.g., agriculture and water resources)



## Marine and Coastal Resources

The effects of climate variability and change on marine and coastal resources can be categorized in two ways -- effects on human populations and effects on the natural resources upon which they depend. Coral reef ecosystems provide shoreline protection and habitat for important coastal and pelagic fish species. Healthy reefs are important assets for tourism and fishing industries as well as for residents of many islands but reefs are considered highly vulnerable to long-term climate change. Similarly, coastal and marine fisheries, including extremely valuable near-shore fish species as well as the pelagic or highly migratory tunas and billfishes are also affected by climate variability and change. In order to enhance resilience, participants suggested:

- Flexible management approaches (e.g. adaptive management)
- Routine integration of climate information into planning and regulatory regimes
- Policies that recognize that ecosystems are dynamic; ability to accommodate surprises
- Precautionary approaches to resource allocation
- Reduce risk of economic losses
- Regional revenue sharing to mitigate the financial effects of year-to-year variability in stock distribution
- Harvest a range of resources
- Stock enhancement, aquaculture, mariculture
- Integrated Coastal Zone Management
- Engage experts from affected communities
- Coordination among sectors and across levels of government
- Controlling introduction of invasive and alien species
- Education and awareness programs

## Shared Principles

Participants in the Pacific Assessment were asked to consider not only the effects of climate in island settings but also what island communities could do to respond to those effects. In addition to the sector-specific findings and recommendations described in the full report, a number of shared principles have emerged to guide climate response strategies in Pacific Island communities:

- Respect the unique circumstances of island communities, and the political, cultural, economic and environmental diversity among island communities;
- Strengthen partnerships among scientists, businesses, governments and communities through a continuous dialogue that identifies information needs and supports decision-making;
- Pursue flexible resource management and response options that accommodate surprises and facilitate adaptation to natural variability;
- Emphasize a proactive, precautionary approach to addressing the consequences of climate variability and change, and provide for continuous integration of new science and decision-making;
- Leverage the capabilities and resources of existing programs and organizations to respond to climate variability and change;
- Address stresses and constraints on critical infrastructure such as water distribution systems, and on community services like public health;
- Enhance access to climate information to better address today's problems while developing new insights and planning for the future; and,
- Recognize the need to secure and sustain the necessary human and fiscal resources, and pursue education, training and capacity-building as a fundamental commitment.

## Research Requirements

A number of critical information gaps and high-priority research needs were identified that should be addressed to reduce vulnerability to climate changes. In addition to data on climate change at the local or regional level in the Pacific Islands which are often missing or inaccessible, specific priorities for future research include:

- Enhancing efforts to monitor, document, understand and model climate processes and consequences at local, island, national and regional levels;
- Strengthening support for research and observing systems for meteorological/atmospheric, oceanographic and terrestrial variables in Pacific Islands, including the engagement of local observers and practitioners in the design and operation of climate observing systems;
- Improving information on the nature and consequences of climate conditions such as temperature, rainfall, tropical storms and trade winds, as well as patterns of natural variability (including ENSO and PDO) and how they might change;
- Developing reliable projections of climate change and predictions of climate variability on various timescales;
- Improving baseline information, including that on the physical, human and built environments, to better support monitoring and assessment studies at local, island, national and regional scales;
- Improving historical data sets that incorporate observations and insights from scientific and traditional sources (including anecdotal data) to better document past climate variability and the resilience of Pacific Island communities and ecosystems;
- Improving understanding of extreme events, from the frequency and severity of tropical cyclones and ENSO events to trends in heavy precipitation, including current patterns of frequency and severity and improved projections of how those patterns might change;
- Enhancing information on patterns of resource use, ecosystem change and species diversity at local, island, national and regional levels, including information from local practitioners on habitat changes and resource availability in areas traditionally used for subsistence gathering and fishing;

The full report includes a summary of specific research and information needs in each of the six sectors.



### For More Information

The full text of the Pacific Assessment report is available online at :

[www2.EastWestCenter.org/climate/assessment](http://www2.EastWestCenter.org/climate/assessment)

Hard copies may be requested by email to Eileen Shea ([shea@EastWestCenter.org](mailto:shea@EastWestCenter.org)) or by writing to the following address:

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<sup>1</sup>Clark et al. 2000. *Assessing vulnerability to global environmental risks. Report of a Workshop on Global Environmental Change Challenges for Research, Assessment and Decision Making. Research and Assessment Systems for Sustainability Science Program Discussion Paper 2000-12. Harvard University, Cambridge, MA.*

## Building and Sustaining Critical Partnerships

Successful implementation of Assessment objectives requires long-term capacity building and development of new partnerships that can help reduce the vulnerability of island communities to climate change by:

- improving access to and use of information on climate variability and change to support decision-making;
- conducting additional research and analysis to improve our understanding of the sensitivity and exposure of island communities, and to enhance their resilience;
- supporting education and dialogue in communities, through which governments, businesses, resource managers and citizens can prepare for the challenges of climate variability and change; and,
- developing effective local, national and regional strategies to respond to climate variability and change.

Perhaps the most important conclusion drawn from the 18-month effort was that the Pacific Assessment should be a continuing process with an overarching goal of nurturing critical partnerships to develop climate information to support decision-making. These partnerships will enhance the ability of scientists and decision-makers throughout the Pacific to understand and respond to the challenges and opportunities presented by climate variability and change.

In this context, the Assessment can be viewed as part of a critical scientific and decision support system that will bridge the science-decisions “information gap” identified during the March 1998 Workshop and recognized as a problem throughout the Assessment. This bridge will help develop and convey new scientific insights that link global-scale processes to local impacts; it will also allow experts, decision-makers and information brokers to integrate their individual skills and informational assets to address climate-related problems along a continuum of time and space scales.

Other recommendations also emerged from discussions of cooperative partnerships during the Assessment; they include:

- Strengthen and sustain institutions and programs like the PEAC that support decision-making by providing and applying climate information;
- Integrate traditional cultural knowledge and practices by engaging traditional leaders, teachers and practitioners;
- Enlist the aid of religious and spiritual leaders to strengthen efforts to understand and respond to climate variability and change;

- Leverage the capabilities of information brokers skilled in the interpretation and translation of scientific, technical and cultural information, especially organizations like national meteorological services, universities, research institutions, scientific/environmental/economic organizations, and industry and professional associations;

- Encourage continued regional collaboration to strengthen individual and collective efforts;

- Pursue multidisciplinary scientific investigations to improve understanding of climate processes and consequences, and to foster partnerships with international climate science programs (e.g. World Climate Research Program efforts, including CLIVAR and the Global Climate Observing System, and research projects conducted under the auspices of the International Geosphere-Biosphere Programme and the International Human Dimensions of Global Change Program);

- Pursue partnerships with private companies, particularly in areas such as agriculture, tourism, water-resource management and infrastructure development;

- Establish cross-sectoral teams (e.g., water managers, emergency preparedness experts and public health officials) to address common problems arising from climate variability and change;

- Support interisland cooperation in climate and health in order to leverage investments in areas such as disease control infrastructure, drugs and insecticides;

- Encourage integration of climate-related policies, plans and decisions across levels of government and between donor agencies; and,

- Enlist decision-makers in the identification of climate information needs, then establish “science user teams” to develop and regularly improve climate information products to meet those needs.

Regardless of whether one thinks of climate assessment as a multidisciplinary, integrated scientific endeavor, or as a traditional approach to participatory resource management, the successful engagement of experts from all knowledge groups requires a shared commitment to a sustained effort to identify and respond to real problems facing people in the Pacific Islands. Participants in this Assessment are committed to this process and will pursue funding to ensure that partnerships established early in the assessment can be maintained and enhanced.

## Next Steps: A Look to the Future

Rather than an end product, this report on the Pacific Assessment represents the beginning of a sustained process of dialogue and information exchange among scientists, businesses, governments and communities in the region. Working together, these diverse stakeholders can coordinate and leverage their assets and expertise to support a climate information partnership that will:

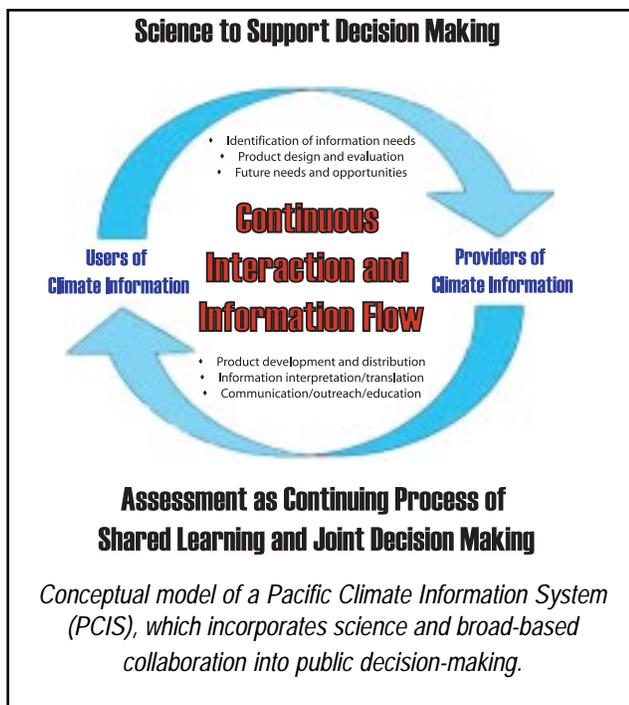
- clarify the information needs of decision-makers and identify critical information gaps to help guide future research;

- improve access to climate information and explore the use of innovative communication and decision-support tools;

- provide access to critical data and translate research results into useful information; and,

- increase the number of professionals who develop and use climate information to support decision-making, and expand education and training opportunities for them.

Together we can combine our individual assets and collective insights into a new paradigm of climate awareness and response. We can embrace the opportunity to use new scientific insights to improve the use of climate information to support decision-making. And we can and will surmount the challenges of climate variability and change and establish a closer partnership between the people of the Pacific and the climate system that sustains us.



# Pacific Islands Contribution to the National Assessment on the Potential Consequences of Climate Change for the United States

The overall goal of the National Assessment is to analyze and evaluate what is known about the potential consequences of climate variability and change for the Nation in the context of other pressures on the public, the environment, and the Nation's resources. The National Assessment process has been broadly inclusive, drawing on inputs from academia, government, and the public and private sectors, and interested citizens. Starting with broad public concerns about the environment, the Assessment is exploring the degree to which existing and future variations and changes in climate might affect issues that people care about.

The National Assessment has three major components:

1. Regional analyses: Workshops and assessments are characterizing the potential consequences of climate variability and change in selected regions spanning the United States. The reports from those activities address the interests of those in the particular regions by focusing on the regional patterns and texture of changes where people live. Most workshop reports are already available and regional assessment reports will become available as they are completed (see <http://www.usgcrp.gov/usgcrp/nacc/background/regions.htm>).
2. Sectoral analyses: Workshops and assessments are being carried out to characterize the potential consequences of climate variability and change for major sectors that cut across environmental, economic, and societal interests. The sectoral studies analyze how the consequences in each region affect the Nation, making these reports national in scope and of interest to everyone. The sectors being focused on in this first phase of the ongoing National Assessment include Agriculture, Forests, Human Health, Water, and Coastal Areas and Marine Resources. These assessment reports will become available on the web as they are completed; see <http://www.usgcrp.gov/usgcrp/nacc/default.htm>.
3. National overview: The National Assessment Synthesis Team had responsibility for summarizing and integrating the findings of the regional and sectoral studies with the broader literature, and then drawing conclusions about the importance of climate variability and change for the United States. Both the overview and foundation reports are available on the web at: <http://www.usgcrp.gov/usgcrp/nacc/default.htm>.

Each of the regional, sectoral, and synthesis activities is being led by a team comprised of experts from both the public and private sectors, from universities and government, and from the spectrum of stakeholders.



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