Pacific Roadmap for Strengthened Climate Services 2017 – 2026

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Acknowledgements

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Foreword

The understanding of climate and its influence on every aspect of our lives is an essential part of good decision making, for individuals and societies. Nowhere is this truer than in the Pacific, where our islands and our vast ocean experience tropical cyclones and typhoons, earthquakes, volcanic eruptions, tsunami, drought, storm surges and flash floods. As the global climate grows less predictable and extreme events become more common, the role of our meteorological and climate services is increasingly vital.

Pacific island countries are vulnerable to almost every kind of climate extreme: natural disasters can destroy assets and livelihoods; waterborne diseases and pests become more prevalent during heat waves, floods and droughts; crop failure from reduced rainfall; and spikes in food prices that follow extreme weather[1]. Our national meteorological services have achieved remarkable advances in recent years and already their inputs have helped good preparation, well-designed warning systems and effective responses to lessen the impact of many extreme events.

This Pacific Roadmap for Strengthened Climate Services is a guide to identifying and implementing the most critical priorities for each Pacific island country, ensuring its government and communities have reliable and well-understood information on their climate. It is a "road map" rather than a "route map". On a road map, one can typically see several alternative routes between a starting point and a destination. A route map describes the details of a particular journey. This Roadmap provides overall guidance for the generation and delivery of climate services in the Pacific region, recognising that no single approach will suit all countries and territories. Each Pacific country with its own priorities and starting point can use it to develop its own route map or implementation plan to deliver the climate services it requires.

The Roadmap is closely aligned with the Global Framework for Climate Services, a United Nations initiative led by the World Meteorological Organization to guide the development and application of science-based climate information and services to support decision-making in climate sensitive sectors. This alignment will help the Roadmap's users draw on the wealth of information and practices being developed around the world to manage the risks and opportunities posed by climate variability, and to adapt to climate change.

As colleagues of the Pacific National Meteorological and Hydrological Services, we endorse this Roadmap and encourage all partners to support them in their implementation of it.

David Hiba

Director,

Solomon Island Meteorological Service

Chair, Pacific Meteorological Council, 2017

[1] IDA.worldbank.org

Executive Summary

This document fulfils the request of the 3rd Pacific Meteorological Council (PMC) and the First Pacific Ministerial Meeting on Meteorology at their meetings in July 2015 for the development of a Pacific Roadmap for Strengthened Climate Services (PRSCS). The Roadmap prioritises key actions identified for implementing the Global Framework for Climate Services (GFCS) that are most relevant to the island nation states and territories of the Pacific. It recognises the need initially to expand on the five original GFCS focus areas: agriculture and food security; disaster risk management; sustainable energy; health; and water, by adding fisheries and tourism. It may be appropriate at a later stage to consider additional focus areas.

While the GFCS is primarily concerned with the provision of services that relate to climate variability and change, weather and climate are essentially on a time continuum: it is not always clear where on that continuum one should switch from talking about one to talking about the other. For example, drought, which takes weeks or months to develop, is generally considered at the shorter end of the climate scale. Yet a drought can be broken in 24 hours by a single severe weather event, such as a tropical cyclone. At the other end of the spectrum, the boundaries between what are loosely referred to as climate variability and climate change are often equally blurred. It is important to recognise the arbitrariness of these boundaries when developing weather, climate variability and climate change services, especially when users of the services don't make such a distinction. As with any service, the focus should be on the needs of the 'customer'. Funding for developing systems (often in the form of aid) is sometimes tied to one and not available for another and this too can be inconsistent with users' needs. For many Pacific National Meteorological and Hydrological Services and National Disaster Management Offices, the small scale of operations mandates a more integrated and flexible approach to services and also with regard to the establishment of observing systems and other support infrastructure.

Another related concern addressed by this Roadmap is the welcome but often time-limited funding for projects aimed at delivering equipment, computing hardware and software, as well as often complex turn-key tools and systems for generating specific climate services, including interactive websites. Ideally the legacy aspects of such systems delivered by time-limited funding should be addressed from the outset. There are now several climate monitoring and forecasting tools, as well as much observing system infrastructure, in place following a decade or so of activity which are at risk of faltering in the absence of sources of ongoing funding. This Roadmap attempts to identify the most significant of these projects. Allied to this concern is the need for adequate training programs for recipient countries. While most projects involve initial training on the tools and systems delivered, there is a need for in-region educational institutions to offer more generalised courses and other training opportunities on an ongoing and regular basis. Services and information systems should be transitioned for operation in-region wherever possible and a focus on capacity building is essential for this.

There has been considerable progress in upgrading and developing new systems for collecting and securing meteorological and oceanographic data, but the collection of data in the seven priority areas that show the effects of climate variability and change has been inconsistent. Such data are critical for identifying the often-complex effects of climate variability and change on agriculture, water management, human health, etc. It is important for NMHSs to engage with national agencies to identify which data and forms of data should be collected. NMHSs also need to agree with national agencies on the types and formats of meteorological and oceanographic data and derived information those agencies need themselves.

It is encouraging to see proposals to enhance Pacific institutional capacity to coordinate and support the delivery of national climate services. The establishment of the Pacific Climate Change Centre (hosted by SPREP and funded by the Government of Japan in collaboration with the Government of Samoa) and the development of a Regional Climate Centre Network led by WMO (with contributions from several Member countries) should be strongly supported by development partners: they will be critical in stabilising and sustaining the delivery of climate services at the national level.

PREFACE

Climate services provide information about the climate in a way that assists decision-making by individuals and organisations, including government, industry and civil society sectors. The services must be developed with input from these users and with access mechanisms that serve their needs.

Climate services are built on a foundation of high-quality data from national and international databases on temperature, rainfall, wind, soil moisture, and ocean conditions. Climate services involve the preparation of atlases, risk and vulnerability analyses, assessments, and projections and scenarios of near and longer-term changes in climate. These data and information products are integrated with non-meteorological data, such as agricultural production, health trends, population distributions in high-risk areas, and road and infrastructure maps to support climate risk management across a wide range of weather and climate sensitive socio-economic activities.

For climate services to be effective, there must be close collaboration between the providers and users of climate information from national to community level. Climate services require NMHS, for example, to engage directly with intermediate and end users in order to fully understand their information needs and objectives. In turn, to ensure they make appropriate decisions, information users require an understanding of the significance and limitations of the data and information being provided, and the means to integrate them with traditional knowledge and experience in their respective areas of interest. Effective mechanisms must be established to facilitate this collaboration.

Enhancing climate services is one of the priorities of the Pacific Island Meteorological Strategy (PIMS) 2017–2026. To address this particular priority, the 3rd Pacific Meteorological Council (PMC) and the First Pacific Ministerial Meeting on Meteorology at their meetings in 2015 requested the development of a Pacific Roadmap for Strengthened Climate Services (PRSCS). The need for a PRSCS was discussed at a WMO Regional Consultation on Climate Services for Pacific Small Island States held in Rarotonga, Cook Islands from 31 March – 04 April 2014, and the concept was further refined in subsequent Pacific Islands Climate Services (PICS) Panel meetings, including the need for an action plan.

1. Purpose of the Roadmap

The principal objective of the Roadmap is to prioritise key actions identified for implementing the GFCS that are relevant to the island nation states and territories of the Pacific Region.

The Roadmap focuses on the needs of both climate service providers and the key sectors that rely on their information and advice to inform planning and decision-making. It provides a guiding framework for the development of national and regional climate services targeting the Pacific priority areas. While every effort has been made to be as comprehensive as possible in identifying key actions it is inevitable that time will lead to changes in emphasis and focus, and so there needs to be a process for reviewing them from time to time.

The success of the Roadmap will be judged firstly on the extent to which the providers of weather and climate information (NMHSs and intermediate users that add further value) can put in place specific actions for generating and delivering services, and secondly on the end-user engagement to co-generate tools and products for building resilience and sustainable development in their respective areas.

It is important to recognise that this Roadmap has a Pacific-wide domain of interest and hence is intended to act as a guide and resource for the development of more specifically targeted implementation plans for delivering climate services at national levels.

The key outputs of this Roadmap are expressed in the form of Actions Required within the respective GFCS pillars and within the GFCS and supplementary high priority areas.

A "road map" is distinct from a "route map". On a road map, one can typically see several alternative routes between a starting point and a destination. A route map in contrast describes the details of a particular journey. Thus, we can consider this Roadmap document as providing overall guidance for the generation and delivery of climate services in the Pacific region, recognising that no single approach will suit all countries and territories. Using this document as a guide, each country and territory or organisations with its different priorities and starting point can begin to develop its own route map or implementation plan to deliver the climate services it requires.

2 Background

2.1 Foundations

The development of the Pacific Roadmap for Strengthened Climate Services (PRSCS) is premised on the following:

- Climate variability and change present major challenges to the Small Island Developing states of the Pacific and Papua New Guinea[2], and demands are growing across the region for climate services to help reduce the impacts and support adaptation.
- There are platforms and activities in the region upon which to build and expand more advanced climate services.
- National Meteorological and Hydrological Services (NMHSs) are qualified and committed to providing climate services but they are too often constrained by a lack of human and financial resources to develop and deliver those services.
- Targeted capacity building activities for NMHSs in Pacific Island Countries and Territories (PICTs) and their national partner organisations are crucial for improving the provision of climate services.
- Climate services should be aimed at assisting the development of effective government policies, meeting the needs of communities in general, and supporting the specific needs of industry and commerce.

[2] It is implicit throughout this document that mention of Pacific Islands also includes Papua New Guinea

- There will likely be requirements for climate services within some communities and development sectors to be tailored in content and delivery depending, for example, on gender differences or people with specific disabilities.
- The main weather and climate related areas of concern to the Pacific region include: sea level rise, salt water intrusion, drought, flooding / inundation, human migration, the ocean environment (e.g. tides, swells, waves, coral bleaching, acidification), and impacts on health (e.g. malaria and dengue), water resources, agriculture and food security, fisheries (e.g. over-fishing and invasive species and inland fisheries), energy needs and tourism.
- Developing and implementing the Roadmap within the Global Framework for Climate Services (GFCS) will enable it to draw on the wealth of information and practices being developed around the world to manage the risks and opportunities posed by climate variability, and to adapt to climate change.

Several guiding principles were identified during the GFCS Pacific consultation process:

- Strengthen the mechanisms for interactions among national institutions;
- Need to engage with organisations working at the community/local level; and
- Use where possible of open source systems, and computing tools that obviate the financial burdens often associated with proprietary systems, such as ongoing licence fees.

The World Meteorological Organization (WMO) together with the Pacific Meteorological Council (PMC) and all Pacific partners can lead in facilitating and negotiating finances for resources to expedite the implementation of the Roadmap, acknowledging especially the key supporting roles of PMC and its panels.

2.2 Global Framework for Climate Services

The Global Framework for Climate Services (GFCS), formed as the principal outcome of the 2009 World Climate Conference 3:

- Provides the international mechanism for coordinated actions to support and enhance the quality, quantity and application of climate services.
- Builds where appropriate on existing efforts, focussing on meeting user needs to provide the greatest benefits possible from knowledge about the climate.
- Provides widespread social, economic and environmental benefits through more effective climate and disaster risk management.
- Supports research in the development and implementation of climate change adaptation measures, many of which will require climate services not currently available.
- Aims to link the outputs of scientific research to the products generated by service providers that will then serve the practical needs of end users.
- Benefits climate change mitigation activities by providing information that supports the development of renewable energy infrastructure and other mitigation measures such as reforestation.
- Aims to ensure that every country is better equipped to meet the challenges of climate variability and change.

The development of a Climate Services Information System (CSIS) is one of the five pillars of GFCS. The five priority areas of the GFCS are: Agriculture and Food Security, Disaster Risk Reduction, Health, Water, and Energy.[3]

3 Energy was added as a priority subsequently to the development of the GFCS Implementation Plan

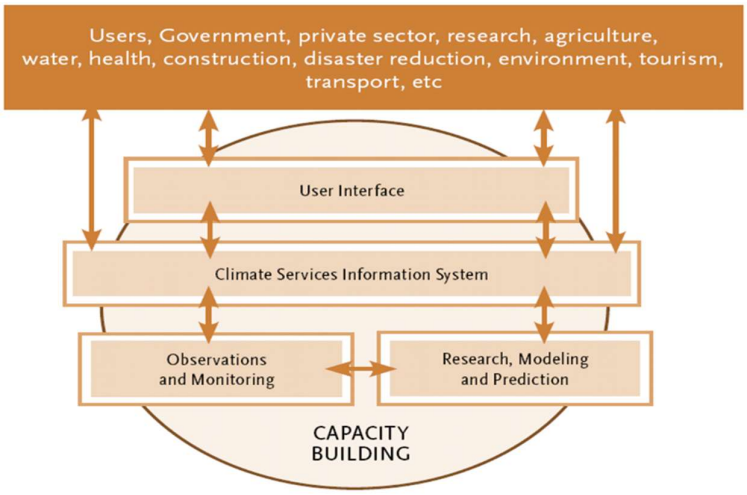


Figure 1: Schematic outline of the Global Framework for Climate Services

While Fisheries is implicit in the GFCS Agriculture and Food Security priority, in-country consultations and a workshop[4] on the Roadmap decided to identify Fisheries (including Aquaculture) as a separate priority given its special economic significance for Pacific Island countries. Further, the climate services for Fisheries are likely to be significantly different to those required for Agriculture. Tourism was also singled out as an increasingly high priority area for Pacific Island countries. For example, for the December quarter of 2016, Fiji's earnings from tourism stood at $471.5 million, an increase of over 15% above the December quarter of 2015 – comparable to the revenue from all other exports combined[5].

3 Pacific Roadmap Fundamentals

3.1 Vision

Governments, civil societies and communities making informed decisions on safety, wellbeing and prosperity from integrating climate and weather information in their decision-making process based on sound science and established indigenous knowledge.

3.2 Objective

The implementation of climate services in the Pacific that maximise benefits and manage risks through the application of scientifically based climate information integrated with sector and indigenous knowledge to support planning, policy and practice on regional and national scales.

3.3 Principles

Building on the principles identified at the GFCS Pacific Consultation meeting[6] and Pacific Islands Meteorological Strategy 2017-2026, the Roadmap is founded and shall be implemented and monitored with the following:

i. Pacific focus within a global context: the work of the National Meteorological and Hydrological Services (NMHSs) is primarily focused on effective delivery of weather, climate,

4 Pacific Roadmap for Strengthened Climate Services Workshop, Nadi, Fiji, October 2016
5 Source: Fiji Bureau of Statistics

6 Regional Consultation on Climate Services for Pacific Island States & Related Meetings, Rarotonga, Cook Islands, 23 March – 4 April 2014

water and ocean services for the benefit of Pacific peoples and communities. Their work is aligned with global frameworks and contributes to global understanding

ii. Gender and minorities empowerment: NMHSs recognise and support the need to operate and deliver services in ways that considerations of the needs of women, young boys and girls, people living with disabilities and vulnerable groups will be taken into account: NMHSs are committed to pursuing strategies and structures to increase the involvement of everyone in the development, communication and implementation of their services.

iii. Value for money: NMHS services are essential to communities, villages, districts, at national and regional levels and are often delivered within limited resources. Where appropriate, services may be delivered by NMHSs with greater resources in support of those with less. In some cases, depending on available resources, it may be more efficient to deliver certain services and support at a regional level, subject to bilateral and multilateral agreements.

iv. Sharing information: NMHSs are committed to sharing data in line with international obligations and national policies, in particular, the World Meteorological Organization (WMO) commitment to free and unrestricted exchange of meteorological and related data and products, in particular Resolution 40 (CG-XII), Resolution 25 (CG-XIII), and Resolution 60 (CG-17) - the last of which is directed specifically at the international exchange of climate data and products to support implementation of the GFCS.

v. Partnerships: partnerships among NMHSs, their governments and stakeholders, with public and private sectors, with non-government organisations / civil society organisations (NGOs/CSOs), with WMO and other UN agencies, with regional and sub-regional inter-governmental agencies, and with donors and technical partners are critical to the success of this Roadmap. A coordinated approach enhances effectiveness in: increasing and using resources; targeting effort and managing potential overlap between agencies, organisations and development partners; and effective delivery of services to customers.

vi. Continuing Research: advanced climate science underpins informed decision making. On-going research is needed to ensure that NMHSs are able to improve their services and the advice they provide to their governments and communities. Climate research must be systematically integrated into climate services.

vii. Stakeholder Engagement: it is essential to engage continually with stakeholders and customers to ensure weather, climate, water and ocean products and services meet their decision-making needs and are tailored and accessible.

viii. Utilising open-source systems: use where possible of open-source systems, focusing on software tools without proprietary implications.

3.4 Potential Funding Mechanisms for the Roadmap

Many sources of funds exist to help developing countries address climate change, both through collecting and analysing national data and through the application of data and information to planning and implementing adaptation measures.

As well as direct support from national government budgets, NMHSs may resource weather and climate services through direct payment from the users of tailored information, such as aviation and maritime industries, hydro-power authorities and agricultural industries.

Agencies currently supporting Pacific NMHSs either directly or through regional programs include the World Meteorological Organization (WMO), the National Oceanic and Atmospheric Administration (NOAA) of the USA, the Australian Bureau of Meteorology (BOM), the Meteorological Service of New Zealand Ltd (MetService), the National Institute of Water and Atmospheric Research (NIWA) of New Zealand, Meteo-France, the Japanese International Cooperation Agency (JICA), the Finland Ministry of Foreign Affairs and the Finnish Meteorological Institute, the World Bank, the European Union, the Asian Development Bank, the Asia Pacific Network for Global Change Research and the development organisations of

Australia, New Zealand, USA, Korea and Canada.

SPREP is sometimes able to secure funds for NMHSs, and may also be able to help countries apply to major funding agencies such as the World Bank's International Development Association, the Green Climate Fund, and the Global Environment Facility and the Adaptation Fund. SPREP and SPC can also lobby external donors, e.g. through the Global Framework for Climate Services, to support long term programs, rather than the more usual three or four-year projects. Often, effective activities become degraded or even lost when project funding expires – long term support allows lessons to be learnt, best practices to be developed, and successful activities to be expanded and replicated.

Keeping the Pacific Meteorological Council (PMC) and the SPREP based Pacific Meteorological Desk Partnership (PMDP) informed about all activities can help with maintaining the continuity of valuable climate service activities.

4 GFCS Pillars

The Roadmap is built upon the five GFCS pillars (Figure 1):

- *User Interface Platform*: a structured means for users, climate researchers and climate information providers to interact at all levels;
- *Climate Services Information System*: the mechanism through which information about climate (past, present and future) will be routinely collected, stored and processed to generate products and services that inform often complex decision-making across a wide range of climate-sensitive activities and enterprises;
- *Observations and Monitoring*: to ensure that climate observations and other data necessary to meet the needs of end-users are collected, managed and disseminated and are supported by relevant metadata;
- *Research, Modelling and Prediction*: to foster research towards continually improving the scientific quality of climate information, providing an evidence base for the impacts of climate change and variability and for the cost-effectiveness of using climate information;
- *Capacity Development*: to address the particular capacity development requirements identified in the other pillars and, more broadly, the basic requirements for enabling any Framework related activities to occur.

Under each of the GFCS pillars there are numerous actions that can be undertaken regionally and/or nationally to support the development of climate services in the Pacific. The most important of these actions are listed below under their respective GFCS pillar and priority areas. In the Pacific, there are good examples of projects, products, tools and services that align with recommended actions, several of these examples have been provided below. These examples can be replicated/extended/improved by NMHSs as appropriate to their unique circumstances and national requirements.

4.1 User Interface Platform

The GFCS User Interface Platform (UIP) provides a structured means for users, researchers and climate service providers to interact at the global, regional and national levels to ensure that user needs for climate services are met. Its objective is to promote effective inclusion of climate considerations in decision-making. The driver for NMHSs and users to develop more useful climate information can be generated by the need to make climate-related decisions.

The UIP aims for four outcomes:

- Feedback from user communities;
- Building dialogue between climate service users and those responsible for the observation, research and information system pillars;
- Improving climate literacy in the user community, and literacy of the climate community in user needs; and

- Developing monitoring and evaluation measures for the climate services.

4.1.1 Communication

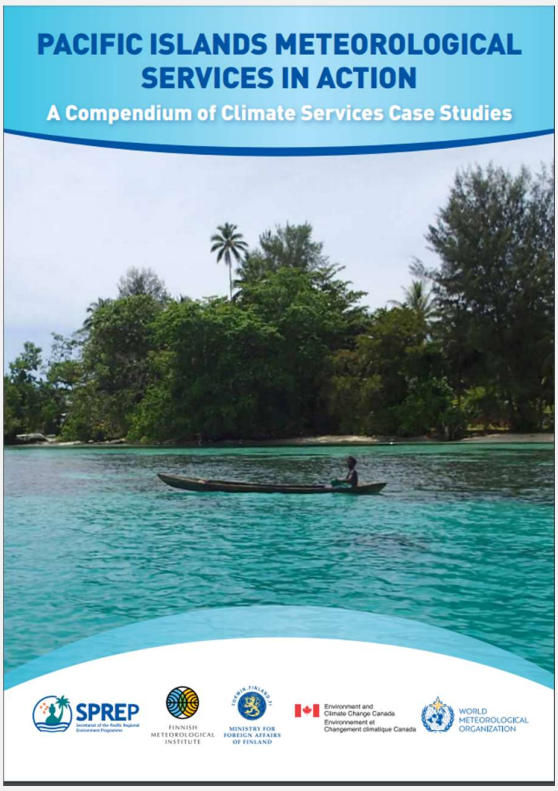
As outlined in PIMSs, “NMHSs are committed to pursuing strategies and structures to increase the involvement of women in the development, communication and implementation of their services. NMHSs recognise and support the need to operate and deliver services in ways that empower women and meet the needs of the most vulnerable in society.”

Two communication strategies can improve the overall effectiveness of the Roadmap: gathering examples and case studies that demonstrate the value of climate services, and economic benefits analysis.

PKOs 3 and 9 in PIMS outline national and regional actions for improving communication mechanisms, most of which are applicable to climate services. The compendium compiled by SPREP and the Pacific Island Climate Services (PICS) Panel funded by the FINPAC project is an example of the communications that can be undertaken to support the Roadmap

Pacific Islands Meteorological Services in Action: A Compendium of Climate Services Case Studies

In a large, diverse region like the Pacific, clear and concise communication of both successes and lessons learned is vital for further effective development. A workshop was created to help participants develop stories to "tell the world what the Pacific is doing on climate services.” The week-long writing workshop or "writeshop" created a space for climate service providers to learn outreach writing skills and how to analyse their own efforts. The "writeshop" was coordinated by the Secretariat of the Pacific Regional Environment Programme (SPREP) and the World Meteorological Organization (WMO) with support from the Australian Bureau of Meteorology through its Climate and Oceans Support Program (COSPPac) and Environment and Climate Change Canada. This first "writeshop" for climate services in the Pacific was a productive and intense week of growth for the participants, resulting in 20 stories for a regional compendium.



http://www.wmo.int/gfcs/node/1027

Figure 3: FINPAC Compendium of climate services case studies

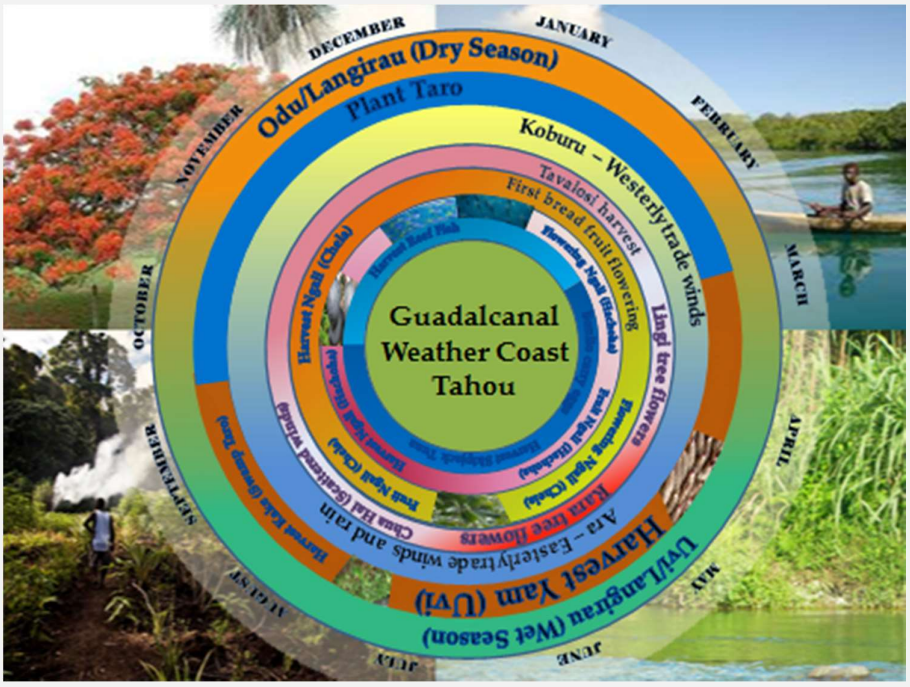
4.1.2 Indigenous or Traditional Knowledge

For hundreds of years, Pacific communities have survived and prospered using weather and climate indicators to inform decisions, based on their observation of the behaviour of plants and animals, temperature and rainfall, and astronomical indicators such as stars and the sun. There are concerns that, for many reasons, these skills are starting to disappear or become less relevant, including knowledge-holders not being able to pass the information on to the next generation and unexpected impacts of land-use and climate change on the traditional indicators. There have been significant improvements in the skill of seasonal forecasting over the last 20 years in the Pacific region, and there is likely further potential value to be gained through the incorporation of traditional data and scientific data in making important adaptation and planning decisions within an overall risk framework. By judiciously combining traditional knowledge with conventional forecasts it should be possible to produce a valuable forecast product for improved decision-making, risk management and disaster prevention that is optimally tuned for adoption by indigenous subsistence farmers.

The incorporation of the traditional forecasts into NMHS products has the potential to significantly improve forecast communication while expanding the spatial and temporal relevance of the forecasts. Experience elsewhere shows that the resultant forecasts and climate communication products are more likely to be trusted by the community, particularly when expressed in local language.

Linking Climate Science with Traditional Knowledge

The Climate and Ocean Support Program in the Pacific (COSPPac) in partnership with four National Meteorological Services (Vanuatu, Niue, Solomon Islands and Samoa) is documenting existing traditional knowledge used for forecasting and will attempt to produce an integrated forecast which uses both traditional knowledge and western data. The traditional knowledge collected will also be used as a tool for communicating climate messages to local communities.



Seasonal calendars, such as this one produced by the SIMS together with the Komu'valu community, are an example of tools used to in communication of climate messages to the community.

http://cosppac.bom.gov.au/traditional-knowledge/

Figure 4: Linking climate science with traditional knowledge

Multi-level, multi-stakeholder partnerships for effective climate services: FINPAC project

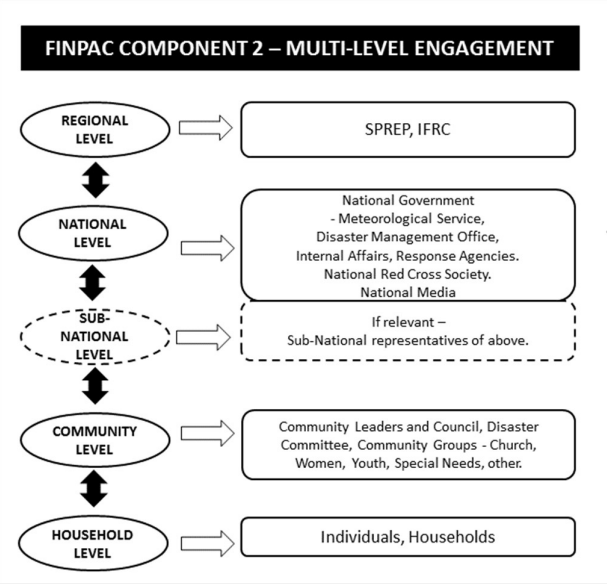
FINPAC (Finnish Pacific Project) is a regionally coordinated meteorological project targeting the adaptation needs of Pacific Island communities in responding to the effects of climate change.

Implementation methodologies

To achieve the objectives of the community based component of the FINPAC project, community workshops have been held, community action plans created or revised, and implementation of a pilot project undertaken by communities.

Arrangements for Capacity-Building and Technology Transfer

For climate services to be effective, there must be close collaboration between the providers and users of climate information. Component 2 of FINPAC, for example, has been aimed at developing the capacity of NMHSs to meet the growing needs of communities to prepare for and respond to changing weather patterns and climate trends using meteorological services. Community Disaster Risk Reduction and Early Warning System pilot projects were implemented across 8 Pacific Island countries between 2014 and 2016.



Coordination mechanisms/ governance structure

The FINPAC project is coordinated by SPREP and the community component is implemented in collaboration with the International Federation of Red Cross and Red Crescent Societies, NMHSs and National Red Cross Societies. There is also close involvement of National Disaster Management Offices.

Partner(s)

SPREP, the International Federation of Red Cross and Red Crescent Societies, NMHSs, National Red Cross Societies, National Disaster Management Offices, NGOs, Pacific Island communities, Finnish Meteorological Institute.

Figure 5: Multi-level, multi-stakeholder partnerships for effective climate services: FINPAC project

4.1.3 Pacific Islands Climate Outlook Forum (PICOF)

The PICOF is the Pacific's regional climate outlook forum (RCOF) platform that allows real-time regional climate outlook products to be routinely provide and opportunities to discuss them with Sectors.

The Pacific Climate Outlook Forum are organise annually with a special focus on Sector and are co-organised and co-supported by the PICS Panel and various partners in the region. The main objectives and emphasis of the PICOF are to bring together national, regional and international experts on climate services to produce climate outlooks based on inputs from NMHSs, regional partners and global centres of climate predictions. PICOF ensures consistency in the access to and the interpretation of climate information for the Pacific. Through interaction with socio-economic sectors, PICOF assesses the likely implications of the

climate outlook on the most critical sectors in the Pacific region or subregion and explores ways in which information can be used.

PICOFs are usually held in October every year. There are two distinct seasonal cycles in the Pacific region, with contrasting features between the north and the south: having the PICOF in October is ideal to provide information for the wet or tropical cyclone season (November to April) for the southern parts of the Pacific region, while October marks the transition period to the dry season in the northern parts of the Pacific region and ends around April.

To ensure consistency in the advice being provided throughout the Pacific region, the Australian COSPPac project, the New Zealand ICU and the USA PEACC have been collaborating in regular on-line climate outlook forums.

4.1.4 National Climate Outlook Forums/National Climate Consultations

Building upon the Pacific Island Climate Outlook Forum (PICOF), the purpose of the National Climate Outlook Forums (NCOFs)/National Climate Consultations (NCCs) is to extend and increase access to and use of climate outlooks and other climate information and products by users at the national level. It also facilitate consistency in the use of climate information by all national user sectors and communities. Through NCOFs/NCCs, an effective means of disseminating climate information, and of fostering dialogue between NMHSs and users at national scales should be established. This has already been piloted in a few Pacific island countries with the potential for expansion.

4.1.5 Climate Early Warning System (CLEWS)

The Climate Early Warning System (CLEWS) was developed by the New Zealand National Institute for Water and Atmosphere (NIWA) for Samoa with funding from the Global Environment Fund administered by UNDP. CLEWS aims to draw together historical experience, traditional knowledge, science-based observations and modern communications technology to help warn people about changing risk levels. The CLEWS was developed primarily for agriculture and health outcomes, but will eventually be extended to provide information for other sectors of the Samoan economy. The system helps keep track of current climate developments, supports seasonal forecasts, and helps improve analyses of climate trends and risk factors. The CLEWS project clearly has potential to be extended to other Pacific Island countries.

4.1.6 PEAC Center Quarterly Bulletin

The NOAA/UH Pacific El Nino-Southern Oscillation (ENSO) Applications Climate Center, issues a quarterly bulletin providing information on climate variability related to the ENSO climate cycle for the U.S.-Affiliated Pacific Islands (USAPI). The bulletin is intended to supply information for the benefit of those involved in such climate-sensitive sectors as civil defence, resource management, and developmental planning in the various jurisdictions of the USAPI. The Pacific ENSO Update is published quarterly, with supplemental special editions on important changes in ENSO conditions as may be required from time to time.

https://www.weather.gov/peac/

4.1.7 Hawaii and US Affiliated Pacific Islands Climate Summary

This resource is part of the Hawaii and USAP Climate Summary, which includes a) the quarterly "Hawaii and US Pacific Islands Region Climate Impacts and Outlook". The quarterly outlook draws on the PEAC 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 and b) the website itself, which includes information used to develop the quarterly outlook in the form of a “dashboard” that aggregates climate variability-related content via links to products and information from a mix of primarily US agencies, institutions, and organizations.

http://www.pacificcis.org/dashboard/

4.1.8 Regional and National Actions for User Interface Platform

Number	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	Sustain the annual Pacific Islands Climate Outlook Forum	Regional
2	Include representatives from relevant priority areas and regional agencies in Pacific Islands Climate Outlook Forums and regular meetings	Regional
3	Provide guidance on improving communication between NMHSs and between NMHSs and their stakeholders both regional and national (e.g. Pacific RCC, PICOF, NDMOs, private sector, sectoral stakeholders)	Regional
4	Encourage programs of action for public/private partnerships	Regional
5	Facilitate regular dialogue between providers of climate data and statistics related to climate change, climate research scientists and policy makers involved with the UN Framework Convention on Climate Change and other related international environmental programs and conventions	Regional
6	Invest in NMHSs (providers) to deliver improved gender-sensitive services and scale up good practices	Regional
7	Engage with the IPCC process to ensure that Pacific concerns about and actions on climate change contribute to and benefit from global climate science	Regional
1	Develop communication strategies targeting the PRSCS priority areas: Agriculture and Food Security, Disaster Risk Management, Health, Water, Energy, Tourism and Fisheries	Regional and National
2	Coordinate communication within NMHSs, and between NMHSs and their stakeholders (eg. Pacific RCC, NDMOs, private sector, sectoral stakeholders).	Regional and National
3	Information & communications needs assessment conducted with end-users/stakeholders	Regional and National
4	Promote the collection and use of gender-disaggregated data	Regional and National
5	Engage with social and behavioural science research to help improve information and communication mechanisms, leading ultimately to improved decision-making across gender and vulnerable communities	Regional and National
6	Devise communication strategies that recognise potential gender-specific barriers to accessing weather and climate information, both technological and cultural	Regional and National
7	Identify through workshops and other consultative processes the meteorological data and product requirements that will address the specific needs of Pacific Island priority areas.	Regional and National

8	Promote the availability of meteorological data and related services for priority areas	Regional and National
9	Participate in and contribute to Regional Climate Outlook Forums, including online/phone hook-ups such as the Pacific Island Climate Outlook Forum	Regional and National
10	Document preparatory actions taken in different sectors at various levels based on the assessment of risk	Regional and National
1	Develop mechanisms (e.g. social media analytics, surveys, face-to-face meetings) to collect feedback from users and clients to evaluate appropriateness of timing and content of information products.	National
2	Engage at the community level to ensure effectiveness of information exchange.	National
3	Establish/formalise regular seasonal or bi-annual National Climate Outlook Forums (NCOF)	National
4	Include representatives from relevant sectorial agencies in national climate outlook forums (NCOF)	National
5	Develop and implement national climate services communication strategies	National
6	Establish consultative processes for priority areas stakeholders (companies, ministries, development partners) and the NMHS to identify, design and implement required climate services for each sector	National
7	Establish a scientifically-based quality control mechanism for the entire service production chain	National
8	Regular systematic review of user feedback of value and relevance of climate services.	National
9	Interact with key user communities on the best form of presentation and use of seasonal predictions.	National
10	Establish MOUs or informal/formal working arrangements between Sectors and NMHS detailing roles and responsibilities	National
11	Ensure climate services are integrated into government policies at national and community level	National
12	Explore opportunities for the use of traditional knowledge and traditional calendar in sector	National
13	Issue seasonal predictions and advisories in local languages whenever possible	National
14	Translating terms into local dialect	National

Table 1: User Interface Platform National and Regional Actions

4.2 Climate Services Information System

The Climate Services Information System is the principal mechanism through which information about climate (past, present and future) is routinely collected, stored and processed to generate products and services that inform decision-making processes, often complex, across a wide range of climate-sensitive activities and enterprises (Figure 5). It is the means by which research outputs and technological developments are transformed into improved operational climate information.

This section outlines the basic services that form the backbone of the climate service structure for all countries and territories. These services are normally carried out by NMHSs and are critical for the effective development of other climate services that may be more relevant in one country than another due to geographical and climatological differences, or which target specific industries and activities, e.g. agriculture, health, water resources and tourism. Also identified are the infrastructure and systems required to support these basic services.

Sound programs of nationally oriented climate services provide the basis and indeed the rationale for establishing a complementary set of supporting regionally oriented climate services.

Historical and real-time datasets of in situ, satellite-based and modelled parameters (rainfall, temperature, humidity, atmospheric pressure, wind speed, etc.).

- Forecasts of rainfall, temperature and their extremes from the next minute to decades
- Climate change projections
- Monitoring and early warning information
- Forecasts of seasonal climate variables targeted to particular risks (e.g., dry spells, start and end of the rainy season, etc.)
- Historical variability of climate variables
- Assessment of historical performance of short-term to seasonal forecasts
- Probabilistic post-processing of forecasts

A number of externally funded programs over the past decade have provided critical infrastructure and tools to support the delivery of climate data products and services throughout the Pacific region.

Many climate-related activities (programs) in support of Pacific Island countries are actually project based, which means that funding is only guaranteed for the life of the project. While there has been some continuity through the results and activities of projects being picked up and carried forward by subsequent related projects, it is essential that the long-term funding for critical observing, data, monitoring and prediction systems for climate is addressed at the national and regional levels.

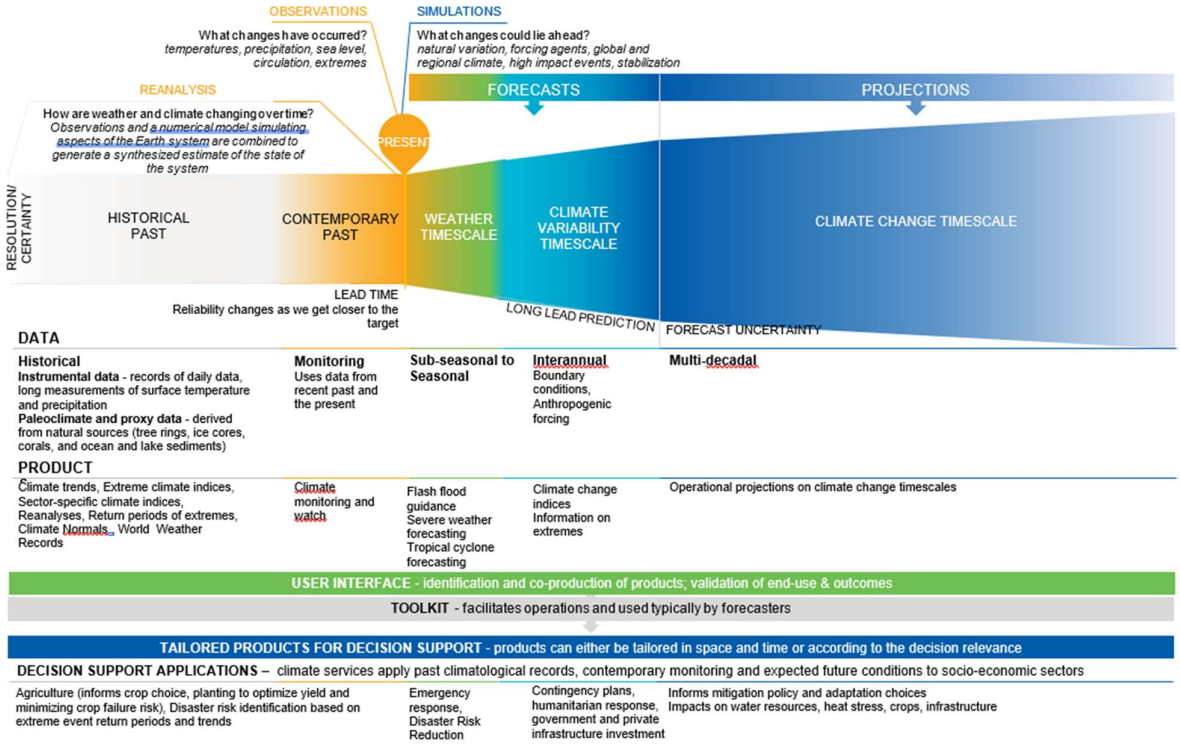


Figure 6: Data and Products for Climate Services[7]

4.2.1 Regional Climate Centre Network in the Pacific

Regional Climate Centres (RCCs) are Centres of Excellence that assist WMO Members in a given region to deliver better climate services and products, including regional long-range forecasts, climate monitoring and climate data services, and to strengthen their capacity to meet national climate information needs.

The PICS Panel has drafted an Implementation Plan for establishing a Regional Climate Centre Network in the Pacific (Pacific RCC Network). It is proposed that the demonstration phase of the RCC will commence in August 2017. An important function of the RCC is to issue a Climate Watch.

The proposed RCC structure is flexible and open and can evolve according to the region's requirements. The region is very large and individual island nations within the region often cover large areas of ocean, so there will be many challenges to providing an effective and useful RCC. It is envisaged that close collaboration will develop between the Pacific and Southeast Asian RCCs in RA V.

It is anticipated that the RCC will take the lead on developing a standardised climate product suite to address regional requirements.

[7] Source: WMO

CLEWS: Climate Early Warning System

The Climate Early Warning System (CLEWS) has been developed by the New Zealand National Institute for Water and Atmosphere (NIWA) for Samoa with funding from the Global Environment Fund administered by UNDP. CLEWS aims to draw together historical experience, traditional knowledge, science-based observations and modern communications technology to help warn people about changing risk levels. CLEWS was developed primarily for agriculture and health outcomes, but will eventually be extended to provide information for other sectors of the Samoan economy. The system helps keep track of current climate developments, supports seasonal forecasts, and helps improve analyses of climate trends and risk factors. The CLEWS project clearly has potential to be extended to other Pacific Island countries.

The CLEWS project has enabled the Samoa Meteorology Division to provide seasonal climate forecasts to different sectors such as Tourism, Agriculture, Forestry and the Public Health office.

> *"We provided them with climate forecasts three months ahead so, for farmers, if there was going to be a dry rainfall spell they could plan for this, with the public health if a wet rainfall spell is expected, they can plan for possible vector borne diseases."*
>
> *The forecasts have helped several climate sensitive sectors plan and prepare for the effects of different climate systems at least three months in advance. The establishment of the Climate Early Warning System in Samoa has been a cross-cutting project that saw us work with other sectors who have benefited from the advance information."*
>
> Mulipola Ausetalia Titimaea, Director of the Samoa Meteorology Division.

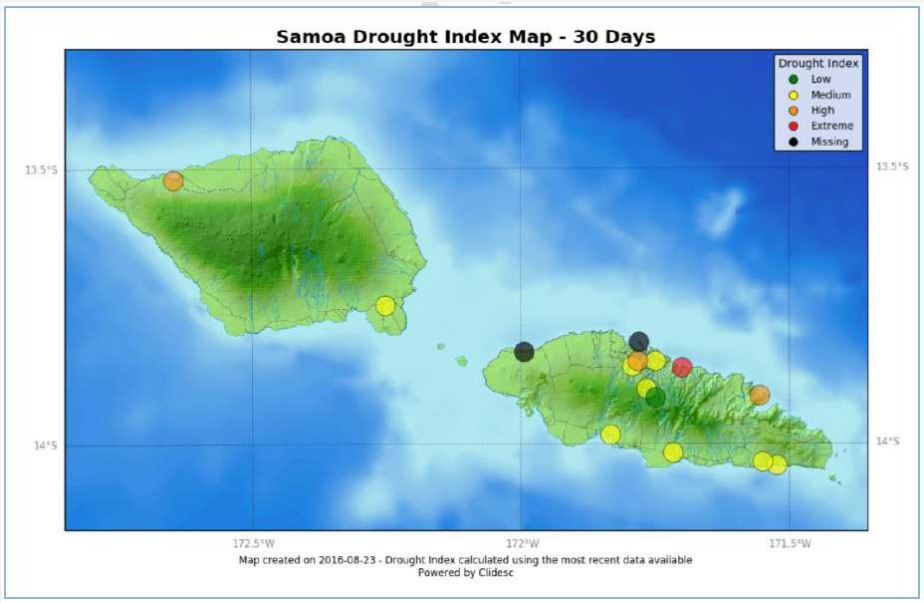
When the project first began in Samoa, one of the key challenges was the lack of resources and ability to carry out the necessary analytical work for Climate Early Warning Systems. A range of training and work attachments have since been undertaken to build the skills of Samoa Met staff but there are now new challenges to overcome.

"The biggest lesson learnt is to ensure that there is a sustainability plan in place before the project cycle and funding ends"

Figure7: Climate Early Warning System (CLEWS)

CLImate Data for the Environment Services Application Client (CLIDEsc)

CliDEsc is a commercial open-source applications and product generator platform provided by NIWA and installed on the CliDE server to enable additional national analyses and views of climate data, through time series, maps and other products.



CLIDEsc display of a drought index for Samoa

Figure 8: CLIDEsc, Samoa

4.2.2 Regional and National Actions for Climate Services Information System

Also refer to PKOs 4 and 7 in PIMS 2017–2026.

NUMBER	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	Develop guidelines and suites of standardised products for PICOFs	Regional
2	Establish and sustain Pacific RCC Network	Regional
3	Establish agreements between RCC-Network and global information providers to sustain access to the global data and products	Regional
4	Ensure RCC-Network has operational access to climate information produced at national level	Regional
5	Develop guidelines and suites of standardised products for the Pacific RCC	Regional
6	RCC Network to provide a range of regionally oriented Climate Services Products	Regional
7	Continue or support operational seasonal forecast and related resource tools, including web sites developed	Regional
1	Develop or implement a range of routine climate monitoring tools and products that encapsulate the monthly, seasonal variations and longer-term changes in climate	Regional and National

2	Issue regular bulletins on the status of the varying climate, e.g. on seasonal or bi-annual and annual basis.	Regional and National
3	Apply best practice to the communication of NMHS information products	Regional and National
4	Define, build and make available a Pacific Climate Services Toolkit at the regional and national levels	Regional and National
5	Incorporate Traditional Knowledge, practices and language in the information / impact forecasts	Regional and National
6	Establish as a matter of high priority the extent to which data resource tools and information web sites developed under project funding will continue to be supported and kept operational.	Regional and National
1	Develop a standard suite of data products that can be made available to users on a regular basis or quickly on demand	National
2	Engage with the intermediate user community in the development of customised climate products and services	National
3	Develop operating procedures for climate Information at national and community levels	National
4	Package information in a useful format for decision makers (eg. community members, people of influence).	National
5	Utilise the available on-line tools for mapping local climate trends and projections	National
6	Provide weather and climate warnings and information products more relevant and accessible to sectors	National

Table 2: Climate Services Information Systems National and Regional Actions

4.3 Observations and Monitoring

The Observations and Monitoring Pillar is one of the foundational pillars upon which the success of the Global Framework for Climate Services will rest. For effective climate services to be delivered, observations of appropriate types and of adequate quality and quantity must be made, and these observations must be available at the right place and at the right time.

This Pillar relies heavily on existing observational programs, activities, and initiatives. The Roadmap promotes increasing data observations needed to provide climate services to users for agriculture and food security, health, water, disaster risk reduction and energy. This will require full engagement of partners at the global, regional, and national levels in its programs and working mechanisms such as the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS), and the Global Terrestrial Observing System (GTOS). This Pillar also covers initiatives fostering integration of different observing systems such as the WMO Integrated Global Observing System (WIGOS). Pacific Key Outcomes (PKO) 8 in PIMS list national and regional actions to improve or extend the Pacific observation network.

Ideally, new data networks should be established to enable a coherent description in space and time of the major characteristics of a nation's climate and, where possible, some of the more critical smaller scale features. The latter will generally be determined from a mixture of geographical and socio-economic perspectives, e.g. the need to define agriculturally productive zones or urban areas that are vulnerable to climate induced extremes. The relatively small scale of many inhabited islands of the Pacific poses special problems in this regard, and consequentially considerable effort should be put into getting the right balance between the ideal and what is affordable.

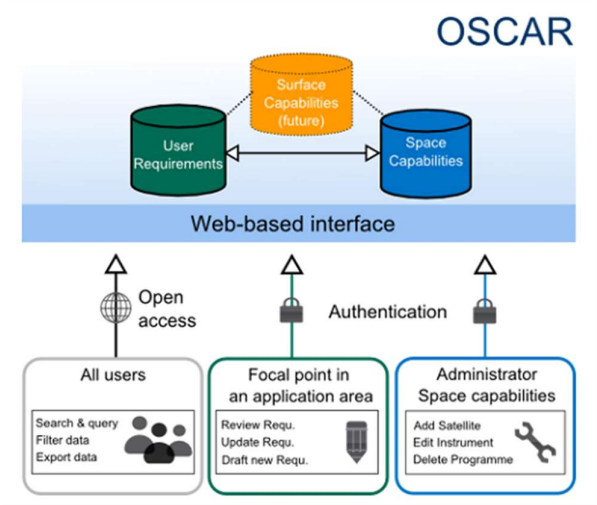
The up-front costs of installing data gathering (observing) networks can be high as can be the ongoing system maintenance and operating costs for effective monitoring of climate variability and change over time. The operation of climate data networks requires a very significant long-term commitment, mostly by governments but on occasions also by those industries with long-term investments in natural and cultivated resources. The time-scale of the commitment should generally be considered in terms of decades. It is critical that such forward planning is built into policies and budgets. It is important also to maximise the synergy for such networks to serve both weather and climate services.

The collection, quality control, archiving and curation of climate data are fundamental to the development and operation of all climate services. It is expected that all countries participating in the GFCS will undertake these functions with respect to historical and future climate observations collected within their respective jurisdictions. Considerable progress has been made in rescuing and recovering data from paper-based climate data records across the Pacific. The last 20 years have seen the introduction of standard archiving procedures and materials, the digitisation of many if not most paper-based climate data, and the development of computerised database systems tailored to the specific smaller scale needs of Pacific Island countries. Together these advances now provide a sound basis for the further development of climate data services in particular, and perforce a wide range of other climate services.

The principles and procedures for establishing and operating effective climate data services are well documented in the *WMO Guide to Climatological Practices* and the *Annex to the Implementation Plan of the Global Framework for Climate Services – Climate Services Information System Component*.

WMO Observing Systems Capability Analysis and Review tool (OSCAR)

The World Meteorological Organization in cooperation with other partners in the Global Framework for Climate Services program have developed a tool for assessing the needs and requirements for very wide range of climate and application variables - OSCAR (Observing Systems Capability Analysis and Review tool).



Many of the variables and applications are not attuned to the needs of Pacific Island Meteorological Services. Hence, there would be value in developing specific guidelines for using OSCAR that are more relevant for Pacific Island Countries.

https://www.wmo-sat.info/oscar/

Figure 9: World Meteorological Organisation (WMO) Observing Systens Capability Analysis and Review tool (OSCAR)

While efforts on the recovery and digitisation of past data will continue to decline over time, as the sources of undigitised data dry up, it is important that the knowledge, skills and systems are retained. It is well recognised that research in data processing and statistics can lead to the need for further reanalysis and reconstruction of past records.

The following tools are available for supporting the development and implementation of national Climate Data Services.

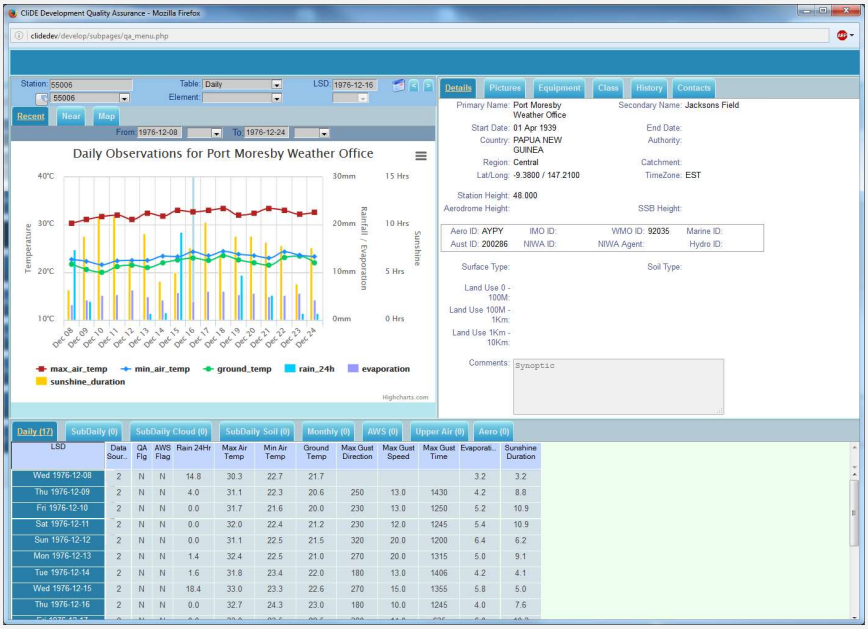
4.3.1 Pacific Tropical Cyclone Data Portal

The Southern Hemisphere Tropical Cyclone Data Portal provides information on past tropical cyclone activity in the Pacific Islands and Timor-Leste by plotting tracks of cyclones in the Southern Hemisphere from 1969. The tool allows users to examine paths and characteristics of past tropical cyclone events and determine their proximity to a particular location.

http://www.bom.gov.au/cyclone/history/tracks/

Climate Data for the Environment (*CliDE)*

CliDE is a climate database management system that has been installed in Timor-Leste and 14 countries in the Pacific to record, store and access historical and recent meteorological data. CliDE provides each country with a central database for meteorological records, with key entry forms, quality assurance tools, reports and data dumps. It has been developed with Australian Government and WMO funding using open-source software. It employs a web-based user interface, which has led to a highly reliable and user-friendly relational database system.



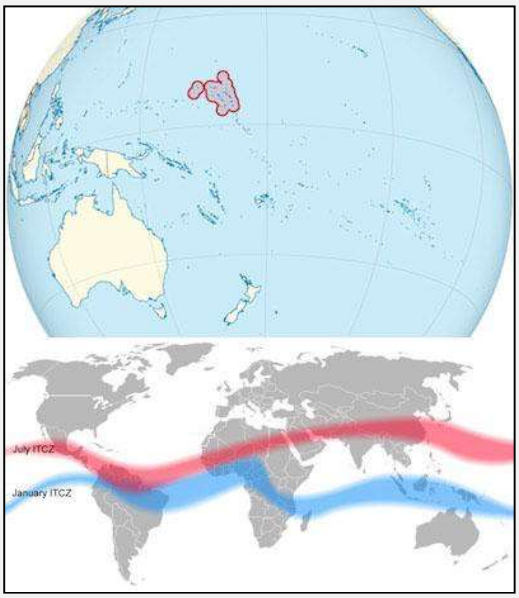
CliDE display of observational data from PNG

http://www.bom.gov.au/climate/pacific/about-clide.shtml

Figure 10: Climate Data for the Environment (CliDE)

From the Pacific Islands Climate Storybook - "It's Falling from the Sky but Not Hitting the Ground": Drought in the outer atolls of the Marshall Islands in 2013

The dry season annually hovers over the low-lying atolls of the Republic of the Marshall Islands (RMI) 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 RMI, known as the outer islands. Wotje and Utrik Atolls, two of the outer islands, received only 28 percent and 25 percent, respectively, of their normal rainfall for September through November.



The top map shows the Republic of the Marshall Islands (RMI).

The bottom map shows the average locations of the Intertropical Convergence Zone (ITCZ) during July and January: the dynamic location of this global band of clouds is one factor controlling precipitation over RMI.

In responding to the needs of the community for information during onset and course of the drought, several key messages emerged:

- Know your social and cultural setting – understanding community assets critical to and the adaptive capacity of the community will drive adaptation from a grassroots level.

- 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 maximize consistency of information and messaging), as well as enrich potential for local to regional capacity development.

- 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 terms.

Following the drought, the RMI 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 Utrik down to Majuro – will improve prediction of future droughts. As the observational knowledge of on the ground conditions from the outer islands proved invaluable, WSO Majuro and WFO Guam continued training communities on when and how to communicate drought indicators. Thus, when the next drought creeps up, the response can be earlier and more effective.

Figure 11: Drought in the Republic of Marshal Islands

4.3.2 Pacific Climate Change Data Portal

The Pacific Climate Change Data Portal is a user-friendly tool that allows the user to visualise historical climate data in the form of trends, running and long-term averages. As the largest web based data source for the Pacific region, this tool currently provides users access to more than 100 individual observation sites across the Pacific Islands and Timor-Leste, and includes trends in rainfall and temperature extremes

http://www.bom.gov.au/climate/pccsp/

The scope of routine monitoring activities and analyses that can be carried out is very broad. Again, the *WMO Guide to Climatological Practices* provides examples of standard monitoring and analysis tools that can serve a wide range of user needs.

The monitoring of temperature and rainfall at point locations and over specific areas continues to be one the mainstays of the basic suite of climate services provided by NMHSs. There are many ways of presenting climate-monitoring information, for example in the form of time series of monthly average temperature and monthly accumulations of rainfall, or as anomalies from recognised long-term monthly means.

In view of the special significance of wind speed and direction across much of the trade wind belt of the Pacific Ocean due to variations in the El Niño/Southern Oscillation cycle, special attention should be given to the representativeness and reliability of wind records, and to monitoring their variability over time.

In addition, the low-lying nature of many islands and atolls in the Pacific renders them highly susceptible to rises in sea level. Routine monitoring of sea level should be a mandatory requirement under the PRSCS.

4.3.3 Pacific Sea Level Monitoring

The COSPPac Pacific Sea Level Monitoring Project (PSLMP) project and its part predecessor the South Pacific Sea Level Climate Monitoring Project (SPSLCMP) represent more than 20-year commitment by the Australian Government's to monitoring sea level in the Pacific. PSLMP and SPSLCMP have facilitated the installation of numerous tide gauges around the Pacific. There is now more than 25 years of data accumulated from these sites and used appropriately, this 25-year sea level record can assist in determining trends in sea level over the long term and help inform projects on coastal inundation and coastal development.

http://www.bom.gov.au/pacific/projects/pslm/

Seasonal Prediction of Sea Level Anomalies in the Western Pacific developed by PACCSAP now provides seasonal forecasts for sea level generated by POAMA.

The frequency and intensity extreme events have taken on special significance because of climate change, which almost certainly is being induced or enhanced by human activities. The attribution of individual extreme events to climate change, human induced or otherwise, is complex. It is essential, therefore, that special care be taken in the recording and documentation of extreme events. It may be that very useful information can be gleaned from the written records of events occurring before the institution of a formal meteorological record. Often the descriptions of such events will tell of heights of floods and the destructive force of winds.

With the exception of drought, PRSCS does not deal with Multi-Hazard early warning systems (MHEWS). They are dealt with by other Pacific-wide programs. More information on MHEWS in the Pacific can be found in PIMS.

Drought is a special case of an extreme meteorological event that occurs over relatively shorter climate time-scales, e.g. typically months to perhaps a few years[8]. Monitoring the onset, extent and retreat or cessation of drought is arguably the most important climate service carried out at the national level. Given its significance to a wide range of national activities, e.g. agriculture and water availability in general, it is essential that NMHSs are actively engaged with government and community groups in the development

[8] Note the distinction between drought and aridity; the latter becomes established when over a very long period there is a preponderance of years with very low rainfall totals. In contrast, drought is typically associated with rainfall deficiencies persisting over much shorter periods, e.g. a few months to a few years.

and implementation of measures to mitigate the effects of drought. Due to the generally slow onset of drought, NMHSs are typically at the frontline in identifying its approach. There are various drought-monitoring systems available and it is important that the community at large is well informed on the features of whatever system is in use can understand how the information is presented.

In addition to the COSPPac sea level monitoring project, the University of Hawaii Sea Level Center carries out the following related activities:

a) Serves multiple roles in support of real-time oceanographic operations as well as climate and oceanographic research. The UHSLC collaborates with agencies within host countries to install and maintain a global network of tide gauge stations that range in utility from tsunami warning to global sea level rise. The growing UHSLC network consists of more than 80 stations. The data are routinely processed, analyzed, and distributed at varying levels of temporal resolution and quality control that fill multiple end-user needs. UHSLC datasets are used for assimilation into operational numerical models, the calibration of satellite altimeter data, the production of oceanographic products, and research on various time-scales from decadal climate fluctuations to short-term extreme events. UHSLC real-time data contribute to the Pacific Tsunami Warning Center and other operational warning agencies. Over the years the UHSLC has participated in national and international research programs including NORPAX, TOGA, WOCE, GODAE and CLIVAR.; and

b) The UH Sea Level Forecast: Sea level anomaly extremes affect tropical Pacific islands, often with too little warning to mitigate risks. By compiling monthly sea level anomaly predictions from multiple statistical and dynamical (coupled ocean-atmosphere) models, which are typically skillful out to at least 6 months in the tropical Pacific, improved outlooks are achieved. We deliver an experimental real-time forecast of monthly mean sea level anomalies and information that can be used to reduce impacts associated with sea level extremes.

The Multi-model Ensemble Sea Level Forecasts for Tropical Pacific Islands product was developed by a partnership between scientists at the UHSLC, NOAA's NCEI (Pacific Region) and Pacific ENSO Applications Climate Center, Australia's Bureau of Meteorology seasonal forecasting operations, and New Zealand's National Institute of Water and Atmospheric Research. This partnership combines resources to deliver the most recently available sea level predictions from multiple forecast models. By clicking on the map and forecast tab, you can check which models are available this month for each station.

http://uhslc.soest.hawaii.edu/

4.3.4 Regional and National Actions for Observations and Monitoring

Also refer to PKO 8 in PIMS 2017-2026.

NUMBER	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	Establish a national policy on data exchange that will facilitate access to the data by intermediate and end users	Regional
1	Review the range of parameters and observing systems critical for monitoring local climate variability and change within the atmosphere, land surface and ocean domains	Regional and National
2	Ensure as far as possible that observing systems are optimised to meet the standards required for both weather forecasting and climate needs	Regional and National
3	Develop a subset of guidelines using WMO/OSCAR as a base, in association with local organisations in the key priority areas, agriculture, health, etc	Regional and National
4	Implement and sustain a suitable relational climate data base system	Regional and National
5	Secure continuing support for data portals.	Regional and National
6	Increased spatial mapping of key variables utlising open source Geo-statistical tools	Regional and National
7	Develop and submit proposals for funding to establish, restore or replace observing stations including appropriate data communication systems	Regional and National
8	Identify development of environmental databases and procedures for data collection	Regional and National
9	Develop or implement a range of routine climate monitoring tools and products that encapsulate the monthly, seasonal variations and longer term changes in climate	Regional and National
10	Explore the use of modern data collection and analysis systems for routine climate monitoring, e.g. satellite and instruments remote sensing, GIS information and analyses from Global Climate Prediction Centres	Regional and National
11	Establish a climate reference station	Regional and National
1	Perform observing system gap analyses and prioritise options for network repair, expansion and/or enhancements, including the need for automatic weather stations (AWS) especially on outer islands	National
2	Establish a funded maintenance schedule for observing system equipment including AWSs	National

4	Assess the volume of climate records that have not been digitised and/or quality controlled, and develop a data rescue and data entry program, including where necessary submission in a suitable funding proposal	National

Table 3: Observation &Monitoring National and Regional Actions

4.4 Research, Modelling and Prediction

There is limited capability and capacity in NMHS in the Pacific to conduct or contribute to research programme. Climate science research are generally done at more advanced institutions such as BoM, NIWA, NOAA, APCC, Météo-France and universities, with the World Climate Research Programme (WCRP) providing an international co-ordinating framework.

Implementation of the Roadmap requires further expansion of climate research frontiers especially for developing climate knowledge to be applied across a wide range of socio-economic sectors. Through various projects and programme, there have been significant improvements in scientific understanding of the climate, its change and variability. There is still a huge gap in the applications of climate science in priority sectors.

The needs of some intermediate and end users will be satisfied by simply providing access to either the raw or processed data derived from the historical or real-time observations. Care should be taken in delivering raw data records, and users should be made aware that they might contain errors or biases that render the records misleading. Users should generally be encouraged to use data that have been subject to rigorous quality control and homogenisation procedures. The latter is critical for removing biases in records induced by factors other than broad-scale weather and climate patterns. Similarly, any analysis of climate data provided should be supported by peer-reviewed literature to ensure best-practice climate science is being implemented.

The process undertaken in this pillar can be outlines as: 1) research to integrate multiple sources of data; 2) assess predictability skills: 3) Coordinated Regional Climate Downscaling Experiment (CORDEX)[9]; and 4) reanalysis.

http://www.cordex.org/

4.4.1 Global Producing Centres for Long-Range Forecasts

WMO has designated centres making global seasonal forecasts as WMO Global Producing Centres for Long-Range Forecasts (GPCLRFs). This forms an integral part of the WMO Global Data-Processing and Forecasting System (GDPFS).

Through this designation process, GPCLRFs adhere to certain well-defined standards, aiding the consistency and usability of:

- Fixed forecast production cycles
- Standard sets of forecast products
- WMO-defined verification standards (for retrospective forecasts).

A comprehensive set of standard verification measures has also been defined, and is known as the WMO Standard Verification System for Long-Range Forecasts (SVSLRF).

The Australian Bureau of Meteorology is a GPCLRF, issuing products such as ENSO Wrap Up, Tropical Cyclone outlooks and dynamic model (POAMA) outlooks.

http://www.bom.gov.au/climate/ahead/#tabs=Outlooks-and-monitoring

[9] The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships.

4.4.2 Seasonal to Interannual Climate Prediction

Several initiatives have been developed and implemented over the past several years to improve capacity in forecasting on seasonal to interannual time-scales in the Pacific. Critical to forecasting success in the region is an ability to predict the effects on various climate parameters locally due to the onset, progression and transitions of phases of the El Niño/Southern Oscillation (ENSO) phenomenon.

4.4.3 Seasonal Climate Outlook for Pacific Island Countries (SCOPIC)

SCOPIC was developed to provide Pacific Island nations with an accessible, stand-alone seasonal climate prediction system. The software is derived from the Australian statistically based seasonal forecasting system that determines forecast probabilities from historic data. The software also provides graphics and texts to support the outlooks, including skill tests, hindcasts, data browsing, statistical analyses, scatter plots, and a drought-monitoring tool. SCOPIC is currently operational in 13 countries (Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Niue, Papua New Guinea, Palau, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu). These countries are included in the COSPPac Red Cross Bulletin (this bulletin is circulated to Red Cross posts only). SCOPIC is currently the only operational seasonal forecast system implemented locally by NMHSs.

4.4.4 PASAP Portal

The Pacific Adaptation Strategy Assistance Program (PASAP) Portal provides seasonal forecasts from a coupled dynamical climate model POAMA (Predictive Ocean Atmosphere Model for Australia). Gridded forecasts are presented using a navigable map overlain with geospatial information. Point forecasts for selected meteorological stations are also available, along with seasonal forecasts of large-scale climate drivers such as ENSO.

POAMA, developed jointly by the Australian Bureau of Meteorology and CSIRO Marine and Atmospheric Research, is a dynamical (physics based) climate model used for multi-week to seasonal through to inter-annual climate outlooks. It is a state of the art long-range forecast system using ocean, atmosphere, ice, and land data observations to initiate outlooks up to nine months ahead. As the domain of interest for Australia encompasses much of the Pacific, POAMA is ideally suited for operational application in Pacific Island countries.

Forecasts for the Pacific region are available to NMHSs through the Pacific Adaptation Strategy Assistance Program (PASAP) Portal.

http://www.bom.gov.au/climate/pacific/about-pasap-portal.shtml

4.4.5 Climate and Oceans Support Program in the Pacific (COSPPac) Bulletin

The COSPPac Bulletin provides a comprehensive summary of major drivers of climate variability across the Indo-Pacific region. Included are reports on the status of ENSO, the Madden-Julian Oscillation, cloud cover, rainfall, and oceanic conditions. The bulletin provides a forecast synthesis for the Pacific region incorporating forecasts from SCOPIC and ensemble forecasts generated by the APEC Climate Center (APEC) based in Korea from nine contributing dynamical models. The COSPPac Bulletin replaced the South Pacific Seasonal Outlook Reference Material, first issued in May 2000 in response to a request for up-to-date climate monitoring and prediction information, following the 1997-98 El Niño event, made at the Sixth Regional Meteorological Services Directors Meeting in Tahiti, 1999.

http://cosppac.bom.gov.au/products-and-services/climate-bulletin/

4.4.6 Republic of Korea: Pacific Islands Climate Prediction Services Project (RoK PI-CLIPS)

The RoK PI-CLIPS project objective is the development of region-specific downscaling methodologies for inclusion in a climate prediction system, taking into consideration the unique geological features of Pacific Island countries. It is intended to complement and build upon other Pacific forecasting initiatives. Three-monthly rainfall and temperature forecasts are derived from the APEC Climate Centre multi-model ensemble (MME) of all available dynamical model forecasts provided by WMO Global Producing Centres (GPCs) that generate seasonal forecasts. APCC and the Pacific Met Desk Partnership provide guidelines and

training for participating NMHSs in analysing forecast products for application in decision-making processes. The outlooks are made available through the SPREP Pacific Climate Change Portal.

https://www.pacificclimatechange.net/document/republic-korea-pacific-islands-climate-prediction-services-project-consensus-rainfall

4.4.7 Sea Level Anomalies

Seasonal prediction of sea level anomalies in the Western Pacific is focused on the development and verification of seasonal forecasts for sea level for Pacific Partner Countries. These forecasts are generated using the Australian Bureau of Meteorology's Predictive Ocean-Atmosphere Model for Australia (POAMA). The web portal delivers gridded forecasts and skill maps using a navigable map overlain with geospatial information. Sea level anomaly plume plots are also available.

http://www.bom.gov.au/climate/pacific/about-sea-level-outlooks.shtml

Information on sea level anomalies is also available from the University of Hawaii Sea Level Centre.

http://uhslc.soest.hawaii.edu/

4.4.8 Ocean Temperature Extreme Forecasts

High ocean temperatures can lead to coral bleaching episodes. Seasonal prediction of extreme, ocean temperatures can provides seasonal forecasts of coral bleaching risk. These forecasts are generated using the Australian Bureau of Meteorology's Predictive Ocean Atmosphere Model for Australia (POAMA). Gridded forecasts for ocean temperature and thermal stress, and associated skill maps, are presented using a navigable map overlain with geospatial information.

http://www.bom.gov.au/climate/pacific/about-seasonal-extremes.shtml

4.4.9 Decadal and Longer-Term Change Monitoring and Projections

Small islands around the world are facing serious and immediate challenges from climate change. Many people living in the Pacific islands and East Timor are reporting changes in their climate. Climate change along with overlying climate variability presents significant challenges for the priority economic activities in this roadmap. Following the growth in awareness of the impacts of climate change in the Pacific region specific scientific information is now becoming available on a country-by-country basis. This growth in scientific knowledge will provide critical support to adaptation plans for the future.

The *Pacific Climate Change Data Portal* provides access to raw and homogenised temperature and rainfall data for the South Pacific. Users are able to view trends in historical climate data on annual and seasonal time scales over any period of interest (where data is available). Users are also able to view data averages and running averages over three to 15 year periods.

http://www.bom.gov.au/climate/pccsp/

Pacific Climate Futures Version 2.0 is a free web-based climate impacts decision-support tool developed initially by the Australian government funded Pacific Climate Change Science Program (PCCSP) and further refined by the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) Science Program. It provides national and some sub-national climate projections for East Timor and 14 Pacific countries: Cook Islands (two sub-regions), Federated States of Micronesia (two sub-regions), Fiji, Kiribati (three sub-regions), Marshall Islands (two sub-regions), Nauru, Niue, Palau, Papua New Guinea (two sub-regions), Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

https://www.pacificclimatefutures.net/en/

SimCLIM is a commercial software tool designed to facilitate the assessment of risks from climate change for sustainability officers, consultants, policy makers, academics, non-governmental and governmental organizations and students.

SimCLIM uses the latest CMIP5 climate data. Maps, graphs and charts of various aspects of climate change can be generated spatially and for sites, for cities, provinces/states, nations, and the world.

http://cmip-pcmdi.llnl.gov/

http://www.climsystems.com/simclim/

4.4.10 Regional Actions for Research, Modelling and Prediction

Also refer to PKO 5 in PIMS 2017-2026.

NUMBER	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	Continue to support and foster research into sub-seasonal climate prediction in the Pacific region	Regional
2	Provide research support to the development of a Pacific Climate Services Toolkit	Regional
3	Develop decision-support data analysis that overlay multiple types of information (e.g. for current agriculture production: soil analysis, with climate projections, or rain and temperature for human health applications)	Regional
4	Establish an optimum space scale for seasonal outlooks to inform island and community scale activities	Regional
1	Conduct or facilitate studies linking traditional climate and weather knowledge and science	Regional and National
2	Identify and document any systematic deficiencies in the seasonal forecasting system, e.g. poor performance at a particular time scale, time of the year, or phase of the ENSO cycle	Regional and National
3	Support and foster research into impact-based forecasting	Regional and National
4	Calculate and analyse statistical properties of extremes in weather and climate, including extreme event probabilities	Regional and National
5	Analyse probabilities of occurrence and intensity of extreme events from sub-seasonal to multi-annual ranges	Regional and National
6	Modelling of hydrological cycles and impacts for agriculture, water and hydropower production	Regional and National
7	Promote and encourage cross-disciplinary research linking climate services, priority areas and gender	Regional and National
8	Develop, implement and monitor the accuracy and reliability of a seasonal climate outlook/prediction service	Regional and National
1	To provide the basis for strengthened support to the activities of the NMHSs and the PRSCS conduct assessments of the value, usefulness and economic benefits of climate services	National

Table 4: Research Modeling & Prediction National and Regional Actions

4.5 Capacity Development

Capacity development refers to investment in people, practices, policies and institutions to stimulate and systematically develop capacities in the Pillars of the GFCS.

The single most common concern expressed by respondents to the recent PRSCS climate services benchmarking exercise (Annex 1) was the need for more comprehensive and systematic training of personnel across all facets of the climate service spectrum. This is also linked to PKO-9 of the PIMS. There are opportunities for training of Pacific Island personnel in the climate sciences offered through individual targeted projects and through WMO training programs.

Under the GFCS Capacity Building pillar, it is envisaged that NMHSs in Pacific Island would make proposals to facilitate fast-tracking climate services development. It is proposed that successful NMHSs or consortia of NMHSs would propose a detailed work-plan for implementation with deliverables based on specific requirements contained in the invitation for proposals. Capacity development interventions could be based on partnerships with more developed NMHSs; such arrangements have been working well for the last decade or so on climate related initiatives in the Pacific. The partnerships would involve mentoring as well as enhancements of expertise, and would overcome operational bottlenecks.

http://gfcs.wmo.int/sites/default/files/GFCS_Concept%20Note_JN16854_en.pdf

4.5.1 Benchmarking Climate Service Provision

An exercise to benchmark the capabilities of Pacific Island NMHSs to deliver climate products and services was recently carried out. The information was compiled through in-country consultation and via email and represents a snapshot of NHMS climate services across the Pacific. A number of required actions could be inferred from the results of the survey. These actions have been included throughout this Roadmap in general terms. The specific actions required to address priorities for improvement in the delivery of climate services in individual countries will be spelt out in more detail in the implementation plans/route maps to be prepared for each country.

According to the GFCS NMHS climate services can be categorised as *Essential* to *Advanced,* as per the figure below. While Pacific NMHSs do have access to long-term climate projections and decadal climate predictions, it is not common that the science required for these services is being undertaken in the Pacific. Similarly, there are occurrences of customised climate products and climate application tools in some Pacific NMHSs but it is not the norm. Pacific NMHSs have arguably not reached what the GFCS define as Advanced Climate Services, however it is quite possible that they can reach this level over the coming decade.

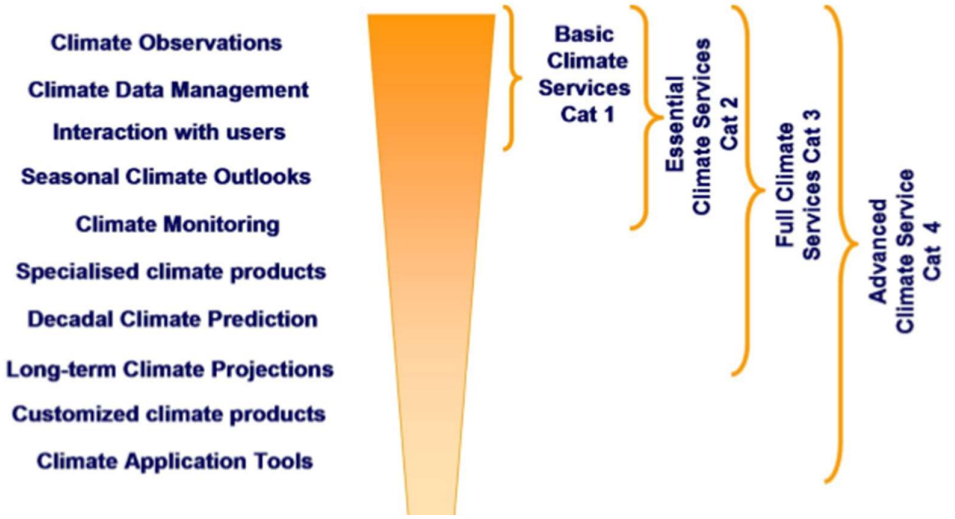


Figure 12: Types of climate products and services by category of national climate service provider.

4.5.2 Gender Mainstreaming

The Conference on the Gender Dimensions of Weather and Climate Services was a landmark international forum addressing how to equally empower women and men to build safer, stronger and more resilient societies through the provision and use of gender-sensitive weather and climate services. The Conference developed recommendations to facilitate the incorporation of gender and weather and climate services into the work of United Nations agencies, civil society, regional and local authorities and the private sector.[10]

SPREP has designed a toolkit to support climate change practitioners in the Pacific islands region to integrate gender into their programs and projects. It is aimed at climate change professionals working in national governments, non-governmental organisations, regional and international organisations who are involved in managing and implementing climate change programs

https://genderinsite.net/sites/default/files/pacificgenderclimatechange.pdf

4.5.3 Monitoring and Evaluation

The PMC has primary responsibility for monitoring progress towards the outcomes set out in PRSCS. The PMC is supported by the Pacific Meteorological Desk Partnership Secretariat, which informs the PICTs and collaborating partners on progress towards achieving the outcomes of PRSCS.

To enable the PMC to carry out its monitoring role, the PMDP Secretariat with the PICS Panel will provide progress reports on implementation of the PRSCS. These progress reports will be based on the PRSCS Implementation Plans.

The PMDP and PICS Panel will coordinate with NMHSs so they can provide:

- A biennial report of progress towards achieving the outcomes of PRSCS to be presented at the biennial PMC meetings.

Based on these reports and other information available to it, the PMC will provide feedback and guidance where necessary on implementation of PRSCS.

On behalf of PMC, the PMDP and the PICS Panel will provide regular reports to the SPREP Council meeting to give members an opportunity to provide feedback on progress towards implementing the outcomes and actions in PRSCS.

[10]https://public.wmo.int/en/resources/meteoworld/gender-dimensions-of-weather-and-climate-services -

4.5.4 Regional and National Actions for Capacity Development

Also refer to PKO 9 in PIMS 2017-2026.

NUMBER	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	Develop Regional Partnerships and Networks for Enhancing Climate Services Capacities including the provision of mentoring and other tangible support by more established NMHSs	Regional
2	Regularly review options for upgrading or introducing new methods and systems for seasonal prediction and develop strategies and plans for operational implementation of the improvements within NMHSs, including required training programs and the development of "toolkits"	Regional
3	Establish Pacific Regional Climate and Meteorological Training Centre	Regional
4	Establish a dedicated Help Desk to exchange information on best practice and to facilitate cooperation between other regions with similar issues to the Pacific, e.g. the Caribbean	Regional
5	Engage with and monitor the outcomes of the various Pacific Meteorological Council panels and forums, in particular the Pacific Island Climate Services (PICS) Panel	Regional
6	Transfer knowledge of adaptation options between countries with similar climate/priority areas based concerns	Regional
7	Encourage NMHSs to develop education and outreach programmes with a particular emphasis on science education for girls and women	Regional
1	Provide training of Met technicians, Met observers and calibration of AWS	Regional and National
2	Install technological tools and processes to improve capability of national climate services	Regional and National
3	Identify where IT expertise can be sourced to assist with the maintenance of data management computing systems (hardware and software), either in-house or externally	Regional and National
4	Train NMHS staff in communicating effectively with media, communities and users	Regional and National
5	Conduct capacity building and training programs on the use of existing and new products and services	Regional and National
6	Facilitate or provide training for NMHS on: • Observing system practices, installation and maintenance; • Data base management and product delivery systems; • Climate monitoring and prediction practices and techniques; • The effects of climate variability and change in priority areas	Regional and National

7	Use the WMO Competency Framework for climate services in developing, maintaining and improving staff skills	Regional and National
8	Conduct training of personnel in the priority sectors on how to interpret meteorological/climate information	Regional and National
9	Establish collaboration with regional and international academic institutions to carry out further research and to seek opportunities for fellowships/scholarship awards to carry out nationally based research	Regional and National
10	Advocate for the need for scholarships for climatology studies at undergraduate and postgraduate level along with relevant technical training	Regional and National
11	Build capacity by participating in formal arrangements for knowledge sharing at national, regional and international levels	Regional and National
12	Conduct training programs on resource mobilisation that address both local and international opportunities	Regional and National
13	Provide training on Pacific Climate Futures and other similar tools	Regional and National
1	Enhance the capacity of service-delivery sectors to use tailored weather and climate information for informed decision-making at all levels (from policymakers to community members)	National
2	Develop national capacity development strategies	National
3	Develop in-house social media/media liaison/ communication expertise	National

Table 5: Capacity Building National and Regional Actions

5. Priority areas for the Pacific

Through a comprehensive consultative process[11], Pacific Island Countries and Territories have adopted the five priority areas of the Global Framework for Climate Services GFCS (Agriculture and Food Security, Disaster Risk Management[12], Health, Water, and Energy) and added a further two priorities, viz. tourism and fisheries

This section deals with each priority area in turn, providing a generalised summary of the key issues and a table of regional and national actions relevant to each GFCS pillar. These lists are indicative only as the individual national implementation plans, as they are prepared, should provide more specific and tailored information. Several good examples of projects and tools that rely on or provide climate information have also been included, other useful examples of climate resilient projects can be found in the "Pacific Islands Meteorological Services in Action: "A Compendium of Climate Services Case Studies".

5.1 Agriculture and Food Security

There are several ongoing programs and projects underway within the GFCS from local to global scales for improving the management of climatic risks in agriculture, such as early warning systems and agricultural advisories for farmers, policy planners, industry and other stakeholders. The prerequisites for these

[11] Regional Consultation on GFCS for Small Island Developing States in the Pacific, Raratonga, Cook Islands, March-April 2014, and Pacific Roadmap for Strengthened Climate Services Workshop, Nadi, Fiji, October 2016.
[12] Aligns with the Pacific Disaster Risk Management

services are managed and maintained state-of-the-art systems for measuring and recording weather variables; standardized data exchange protocols; systems for data storage, assimilation and dissemination; short, medium and extended range weather forecasts; and seasonal climate forecasts at desired spatial and temporal scales. Good quality and reliable weather and climate data are essential for climate risk assessment, and mapping of crop distribution, phenology, yield potential and vulnerability indicators including adaptation capacity, land suitability and surface and groundwater availability. Fortunately, advanced tools such as automatic weather stations, global circulation models, regional climate models, numerical weather prediction models, and downscaling techniques are more widely available to address stakeholder needs for value-added information[13].

Year-to-year climate variability has a large influence on agricultural production. Longer-term systematic changes in climate, which are modifying historical measures of climate variability, have introduced a new complicating factor. At higher latitudes, some producers may benefit from a longer growing season, while others in arid and semi-arid areas may experience increased water shortages. Any increase in the frequency and intensity of extreme events such as floods and droughts will affect grain, horticultural, forestry and livestock production. Typical agricultural studies and activities in Pacific Island countries that climate services can support would include:

- The responses of traditional crops, e.g. sweet potato, cassava, taro, banana, breadfruit and yam to existing environmental drivers (e.g. climate variability and extremes, soil and nutrient interactions)[14].
- Understanding the responses of island crops to enhanced CO_2.
- Developing and enhancing the capacity to model crop and cropping systems.
- Estimating appropriate stocking rates for those areas involved in commercial animal husbandry,
- Identifying farming system adaptation strategies given the risk profiles associated with both climate variability and change.
- Examining the economic value of specific operational seasonal climate forecasts in supporting agronomic management decisions for the production of Pacific staple food crops, e.g. assessing the risk of shortages in specific food crops.
- Development of a Communication, Partnership and Engagement Strategy

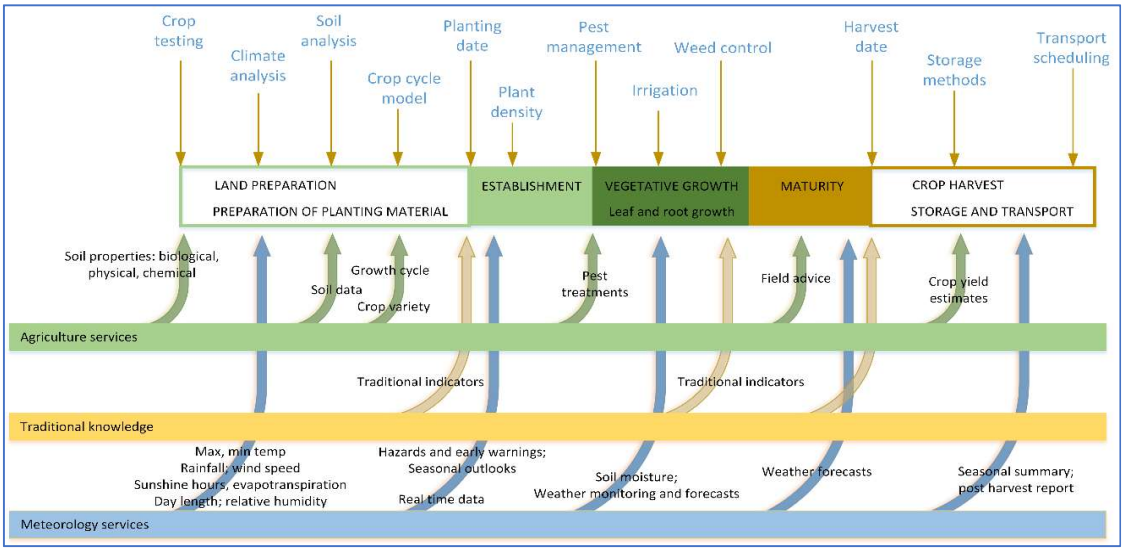


Figure 13: Crop management decision time-line: a workflow model

[13] Managing Climatic Risks to Combat Land Degradation and Enhance Food security: Key Information Needs: P.K. Aggarwal, W.E. Baethegan, P. Cooper, R. Gommes, B. Lee, H. Meinke, L.S. Rathore and M.V.K. Sivakumar. World Climate Conference 3, Procedia Environmental Sciences 1 (2010) 305–312 Available online at www.sciencedirect.com

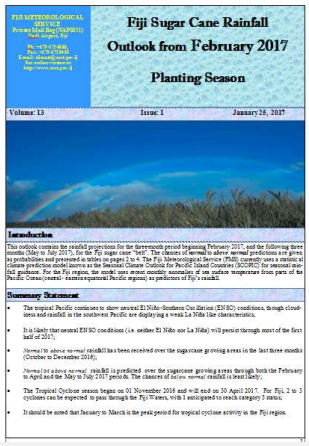
[14] Pacific Root Crops: http://www.fao.org/docrep/013/am014e/am014e04.pdf

Improving crop production in Pacific Island countries - Rainfall outlooks for the Fiji sugar cane planting season

The outlooks prepared by Fiji Meteorological Service (FMS) provide estimates of rainfall for three-month periods for the Fiji sugar cane belt. The chances of normal to above normal precipitation are given as probabilities. The service currently uses the COSPPac statistical climate prediction model known as the Seasonal Climate Outlook for Pacific Island Countries (SCOPIC) for seasonal rainfall guidance (see Section 4.1.3). Based on the rainfall outlook, the Sugarcane Institute of Fiji issues planting advisory for farmers. The information is disseminated through a special bulletin.

The sugarcane growing areas have received *normal* to *above normal* rainfall during the past 3 months and the same is expected for next 3 months. The predicted weather will favour rapid weed growth and growers must adopt integrated weed management that includes manual weeding followed by weedicides application to control the weeds. Fertilizers must be applied by early February for all plant and ratoon cane. Drainage is another area that growers need to focus on and ensure that the field and main drains in and around their farms are cleaned to allow easy drainage of excess water from the fields to avoid water logging conditions.

Source: Sugar Research Institute of Fiji


Fiji Sugar Cane Rainfall Outlook from February 2017

Planting Season

Volume: 13 Issue: 1 January 26, 2017

Introduction

Summary Statement

http://www.met.gov.fj/SOutlook.pdf

Understanding the responses of taro and cassava to climate variability

This project seeks to understand the impact of climate variability on key Pacific production systems. It employs the crop-modelling framework Agricultural Production System siMulator (APSIM) to understand how specific taro and cassava varieties respond to changes in climate in Pacific Island countries, and to identify strategies for farming system adaptations.

http://aciar.gov.au/project/hort/2012/011

Figure 14: Example O-A Rainfall outlooks for sugar cane in Fiji

5.1.1 Climatological Data for Agriculture

Clearly rainfall and more specifically deficiencies in expected rainfall totals during a crop's growing season are a critical factor in determining productivity. Hence the detection of incipient drought and its onset, the monitoring of its duration and severity are primary climate services for agriculture. Assessing the risk of future drought on seasonal time-scales using predictive tools is also a crucial climate service

The WMO OSCAR[15] project provides a comprehensive description of meteorological data needs for agriculture. Work needs to be carried out, through a workshop and other consultative processes on extracting subsets of these requirements that address the specific needs of Pacific Island countries.

http://www.wmo-sat.info/oscar/applicationareas/view/7

5.1.2 Agricultural Data

Considerable effort continues on digitising weather and climate records across the Pacific. Unfortunately, the availability of historical crop production data in digitised forms is considerably more fragmented. Ideally, a complementary effort is needed to digitise historical data on crop production and other relevant agricultural parameters by region/island wherever the data are available. Further, systematic recording

[15] Observing Systems Capability Analysis and Review (OSCAR) is a resource tool developed by WMO in support of earth observation applications, studies and global coordination.

and archiving of future data on agricultural characteristics, e.g. soil types, and production should be introduced where such activities do not already exist.

OSCAR (Observing Systems Capability Analysis and Review) is a resource tool developed by WMO in support of earth observation applications, studies and global coordination. The following table shows the environmental variables recommended by OSCAR for measurement to serve the needs of Agriculture. It will be important for this table to be reviewed and refined to meet the needs of the Pacific region.

Subdomain	Variables		
Basic atmospheric	Air specific humidity (at surface) Wind speed over the surface (horizontal)	Air temperature (at surface) Wind vector over the surface (horizontal)	Atmospheric temperature
Clouds and precipitations	Accumulated precipitation (over 24 h)	Precipitation intensity at surface (liquid or solid)	Precipitation intensity at surface (solid)
Aerosols and radiation	Downward short-wave irradiance at Earth surface	Fraction of Absorbed PAR (FAPAR)	
Ocean	pCO2		
Land surface	Fire fractional cover Land surface temperature Snow cover Soil type Soil temperature	Fire temperature Leaf Area Index (LAI) Snow water equivalent Vegetation type Wind gust	Land cover Normalised Difference Vegetation Index (NDVI) Soil moisture at surface Evapotranspiration
Atmospheric chemistry	O3		

Figure 15: Recommended environmental variables for Agricultural sourced from WMO OSCAR

Development of crop calendars should also be encouraged, for example along the lines of that prepared for the Vanuatu Ministry of Agriculture with support from the SPC/GIZ[16] project *Coping with Climate Change in the Pacific Island Region* (see following table).

[16] South Pacific Commission / Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Crop Calendar

Crop type	Harvesting season	Spacing	Planting season
Ol Krop we yu save harvestem afta lo 1 manis kasem 3 manis			
Radish	1 - 1.5 months AP	0.25m X 0.25m	Year round
Island cabbage	1 - 1.5 months AP	0.5m X 0.5m	Year round
Chinese cabbage	2 months AP	0.4m X 0.3m	March - September
Bean	2 months AP	0.7m X 0.5m	March - August
Lettuce	2 - 3 months AP	0.4m X 0.3m	March - September
Parsley	2 - 3 months AP	0.4m X 0.2m	March - October
Tomato	2 - 3 months AP	0.7m X 0.6m	February - September
Water melon	2 - 3 months AP	2m X 1.5m	Year round
Ol Krop we yu save harvestem lo 3 manis kasem 6 manis			
Beetroot	3 months AP	0.4m X 0.2m	March - August
Irish potato	3 - 4 months AP	0.8m X 0.4m	April - September
Kumala	3-5 months AP	1m X 0.5m	April - September
Egg plant	4 - 5 months AP	0.7m X 0.6m	Year round
Spring onion	4 - 6 months AP	0.4m X 0.2m	March - July
Ol Krop we yu save harvestem lo 6 manis igo antap			
Onion	6 - 7 months AP	0.4m X 0.2m	April
Cassava (Manioc)	6 to 9 months AP	1m X 1m	Year round
Ol Krop oli gat ol spesifik manis blo harvestem			
Yam	April to June	1m X 1m	August - September
Pineapple	November to January	1.5m X 0.4m	January - June
Ol Krop we yu save harvestem thru aot lo yia			
Island taro	Year round	1m X 1m	Year round
Taro Fiji	Year round	1.5m X 1m	Year round
Dwarf banana	Year round	2.5m X 2.5m	Year round
Pawpaw	Year round	2.5m X 2.5m	Year round

Figure 16: Example 0-A: Crop Calendar for Vanuatu for selected crops

AP: After planting

Crop calendar for the major crops in Vanuatu with information arranged by harvest season (shortest to longest), which shows the planting, growth and harvesting timings and periods for different crops. The calendar suggests benefits to be gained in attuning climate services to the needs of specific crops. As also can be seen from this table, there is now considerable diversification in agriculture in some Pacific Island countries beyond the traditional subsistence crops such as cassava, taro and yam.

5.1.3 Regional and National Actions for Agriculture

NUMBER	LEAD GFCS PILLAR	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	User Interface	With agriculture advisers/extension officers, develop drought management plans for different subsistence and cash crops	National
2	Climate Services Information System	Map Normalised Differential Vegetation Index (NDVI) estimates from satellites	Regional
3	Climate Services Information System	Prepare agrometeorological advisories, crop calendars, crop models, seasonal outlooks for crop yield forecasts	Regional and National
4	Climate Services Information System	Provide drought, irrigation and seasonal climate advisories to assist farmers	National
5	Observations and Monitoring	Explore the use of agricultural extension officers as a resource for collecting routine meteorological and other agricultural data.	National
6	Research, Modeling and Prediction	Source estimations of (potential) evapotranspiration from climate models	Regional and National
7	Research, Modeling and Prediction	Explore the impacts of climate change and changing seasonality on agriculture (e.g. salt water intrusion etc)	Regional and National
8	Capacity Building	Increase the capacity of agrometeorology personnel	Regional and National

Table 6: Agriculture National and Regional Actions

5.2 Disaster Risk Management

There are growing needs and opportunities for increasing disaster resilience in Pacific Island Countries and Territories. With appropriate use of meteorological, hydrological and climate information as part of a comprehensive multi-sector, multi-hazard, and multi-level approach, considerable achievements can be realized.

The emergence of skill in seasonal to interannual climate prediction provides opportunities to make earlier assessments of natural hazard risk and disaster potential. For instance, seasonal climate outlooks help governments assess the likelihood – and hence manage the consequences of excessive or deficient rainfall and tropical cyclones. Historical data have traditionally been used for analysis of hazards patterns. This is no longer adequate because hazard characteristics are likely changing due to climate change. For instance, a 100-year flood or drought may have become a 30-year flood or drought or, simply said, more severe events could happen more frequently in the future.

Climate services that support risk assessments from several weeks through seasonal to decadal time scales are therefore needed. Such assessments in turn inform long-term investments and strategic planning on,

for instance, coastal zone management, development of new building codes and the retrofitting of infrastructure to withstand more frequent and severe hazards. They also allow more targeted planning for disaster response.

5.2.1 Risk Management Strategies

Subsequent risk management strategies could involve:

(a) Avoiding the dangers;
(b) Reducing the severity of impacts;
(c) Controlling/reducing the consequences (coping and adaptation measures);
(d) Transferring or spreading the risks through insurance;
(e) Responding appropriately to disasters through effective disaster management;
(f) Recovering or rehabilitating as soon as possible.

The major weather and climatological hazards affecting Pacific Island countries are tropical cyclones and associated storm surges, severe thunderstorms, coastal inundation, flooding and drought. All these hazards, with the exception of drought, can be associated with tropical cyclones. Thus, the key climatological assessments to be made are more often than not, related to elevated risks of tropical cyclones or droughts. For the most part, throughout the Pacific the National Meteorological Services provide weather and climate information services on these hazards to their counterpart National Disaster Management Offices. In the case of tropical cyclones, NMHSs will also act as a conduit for information provided by the responsible Regional Tropical Cyclone Warning Centre.

The International Strategy for Disaster Reduction *Sendai Plan for Disaster Risk Management* provides an effective framework within the following four priorities for action for organising relevant climate services:

Priority 1. Understanding disaster risk

Disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be used for risk assessment, prevention, mitigation, preparedness and response.

Priority 2. Strengthening disaster risk governance to manage disaster risk

Disaster risk governance at the national, regional and global levels is very important for prevention, mitigation, preparedness, response, recovery, and rehabilitation. It fosters collaboration and partnership.

Priority 3. Investing in Disaster Risk Management for resilience

Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment.

Priority 4. Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction

The growth of disaster risk means there is a need to strengthen disaster preparedness for response, to take action in anticipation of events, and to ensure capacities are in place for effective response and recovery at all levels. The recovery, rehabilitation and reconstruction phase is a critical opportunity to build back better, including through integrating Disaster Risk Management into development measures.

https://www.unisdr.org/we/coordinate/sendai-framework

National Disaster Management Offices (NDMOs) are generally the key target organisations for the delivery of climate risk assessments prepared and issued by NMHSs. Some NDMOs are also involved in data collection and monitoring and, in most if not all cases, the NDMOs have the responsibility for declaring droughts or other states of emergency.

Disaster Risk Management in Pacific Island countries

The Cook Islands Geo Portal project is designed as an information centre for disaster risk response and management. It fosters collaboration and continual improvement of emergency response working in partnership with the public, government ministries and key stakeholders, to promotes best practices before, during and after disasters. It consists of early warning information sourced from the Cook Island Meteorological Service, Emergency Management Cook Islands and internationally recognised online weather systems. It provides information on emergency response and access to GIS maps and information.

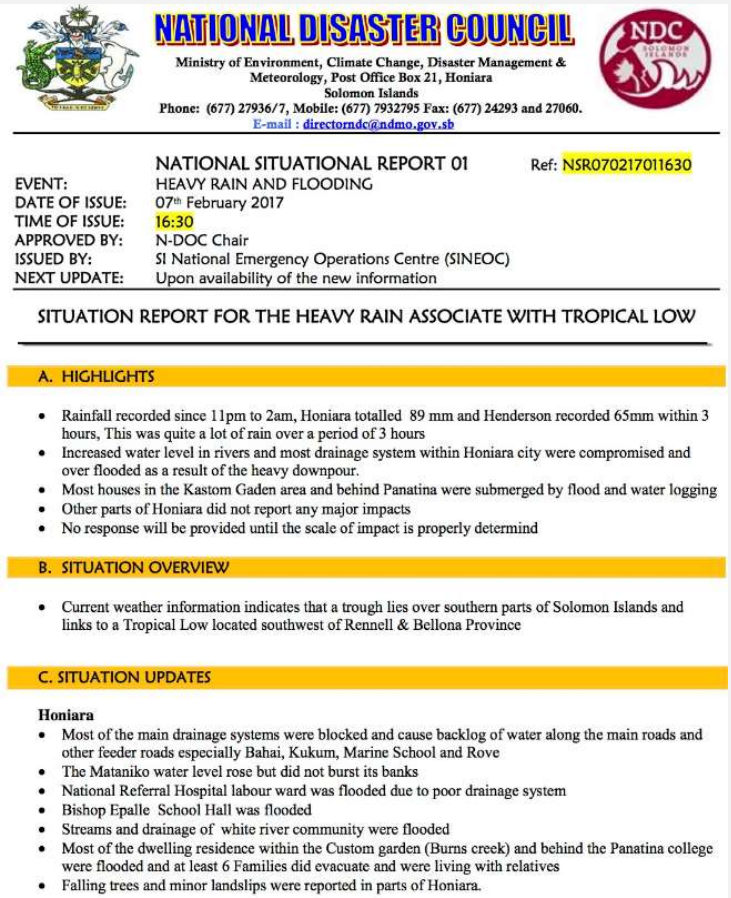
http://www.emci.gov.ck/

Figure 17: Example 0-B: Disaster Risk Management in Cook Islands

Disaster Risk Management in Pacific Island Countries – Solomon Islands National Disaster Management Office (NDMO)

Most Pacific countries have established systems for providing cyclone alerts and inundation and flood warnings to their NDMOs. In the Solomon Islands, the NDMO transmits such warnings immediately by radio throughout the country, advising communities of probable impacts and on how they should prepare for and respond to sudden extreme events. The NDMO uses the technical information from the NMHS, on cyclone categories for instance, and explains its practical implications, with tailored advice for areas of the country likely to be more or less affected. Here's what Mr Loti Yates, Director of the Solomon Islands National Disaster Management Office had to say:

"The relationship between NDMO and met service is really good. Such is the way that we think, when the forecasting area issues a heavy rain alert or weather watch advice, that is a trigger for the NDOC to issue a public safety alert. It's now mainstreamed into the system - it's automatic. The Forecasting area will say provinces 'abc' will be experiencing heavy rain for the next 48 hours. The NEOC duty officer will send out a what to do/what not to do message, this will happen minutes after the forecast, the public safety warning will come out. Our warning and alerting arrangements are working well."



NATIONAL DISASTER COUNCIL

Ministry of Environment, Climate Change, Disaster Management & Meteorology, Post Office Box 21, Honiara
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NATIONAL SITUATIONAL REPORT 01 Ref: NSR070217011630

EVENT:	HEAVY RAIN AND FLOODING
DATE OF ISSUE:	07th February 2017
TIME OF ISSUE:	16:30
APPROVED BY:	N-DOC Chair
ISSUED BY:	SI National Emergency Operations Centre (SINEOC)
NEXT UPDATE:	Upon availability of the new information

SITUATION REPORT FOR THE HEAVY RAIN ASSOCIATE WITH TROPICAL LOW

A. HIGHLIGHTS

- Rainfall recorded since 11pm to 2am, Honiara totalled 89 mm and Henderson recorded 65mm within 3 hours, This was quite a lot of rain over a period of 3 hours
- Increased water level in rivers and most drainage system within Honiara city were compromised and over flooded as a result of the heavy downpour.
- Most houses in the Kastom Gaden area and behind Panatina were submerged by flood and water logging
- Other parts of Honiara did not report any major impacts
- No response will be provided until the scale of impact is properly determind

B. SITUATION OVERVIEW

- Current weather information indicates that a trough lies over southern parts of Solomon Islands and links to a Tropical Low located southwest of Rennell & Bellona Province

C. SITUATION UPDATES

Honiara

- Most of the main drainage systems were blocked and cause backlog of water along the main roads and other feeder roads especially Bahai, Kukum, Marine School and Rove
- The Mataniko water level rose but did not burst its banks
- National Referral Hospital labour ward was flooded due to poor drainage system
- Bishop Epalle School Hall was flooded
- Streams and drainage of white river community were flooded
- Most of the dwelling residence within the Custom garden (Burns creek) and behind the Panatina college were flooded and at least 6 Families did evacuate and were living with relatives
- Falling trees and minor landslips were reported in parts of Honiara.

An example of a Heavy Rain and Flooding situational report issued by Solomon Islands National Disaster Council.

Figure 18: Example 0-C: Solomon Islands National Disaster Management Office

5.2.2 Regional and National Actions for Disaster Risk Management

NUMBER	LEAD GFCS PILLAR	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	User Interface	Improve the communication of seasonal forecasts as a risk management tool (simplify language, identify possible impacts etc.)	National
2	User Interface	Collaborate with NDMO on awareness training out in the community.	National
3	Climate Services Information System	Integrate climate analyses and forecasts into general and sector specific disaster risk reduction and response systems.	Regional and National
4	Climate Services Information System	Assess on an ongoing basis the risks of Tropical cyclone, flood and drought.	Regional and National
5	Climate Services Information System	Risk analysis, e.g., flood risk maps, drought risk maps	National
6	Climate Services Information System	Establish and/or strengthen a national Climate Risk Early Warning System (CREWS)	National
7	Climate Services Information System	Develop a national drought response plan and nstitute a national drought monitoring and early warning system. The system should meet the specific needs of government drought policy-making and declarations, as well as the needs of climate sensitive industries.	National
8	Observations and Monitoring	Collect historical disaster-related data, including loss and damage assessments and statistics (Hotspots).	Regional and National
9	Research, Modeling and Prediction	Convene a regional group of experts to review projects and activities related to coastal flooding including sea level rise and extremes; evaluate the current state of applied research in this area pertaining to seasonal as well as long-term forecasting, and identify opportunities for coordination and collaboration among regional organizations, universities, and government agencies towards more efficient and effective development and delivery of products and services.	Regional
10	Research, Modeling and Prediction	Calculate and analyse statistical properties of extremes in weather and climate, including extreme event probabilities.	Regional and National

11	Research, Modeling and Prediction	Analyse probabilities of occurrence of extreme events from sub-seasonal to multi-annual ranges.	Regional and National
12	Research, Modeling and Prediction	Develop systems for the early warning of severe weather events and climate extremes with different lead times, e.g., heat waves, dust storms.	Regional and National

Table 7: Disaster Risk Management National and Regional Actions

5.3 Energy

Energy systems are critical for economic and social development, however sustainable development requires sustainable energy systems. Energy is used by all the national economic and societal sectors but the generation of energy by combustion of fossil fuels such as coal, oil, and gas is the cause air pollution at the local scale and source of carbon emissions at larger scale. All the countries of the Pacific Region under the Paris Agreement have committed to a set of targets to reduce carbon emission through their National Determined Contributions. Additionally, the use of fossil fuels to support the energy sector is often a significant expenditure for Pacific Island Governments.

Energy production, including the efficiency of production, is very sensitive to meteorological and climate events. The efficiency and effectiveness of energy systems, especially of the renewable form, will be strongly determined over their lifetimes by paying close heed to local climatic conditions during both the design and operational phases. Solar radiation and wind fields will be needed in support of projects for the development of solar and wind power, as well as hydrometeorological information at catchment domain is needed for hydropower operations. Thus, partnerships and stakeholder engagement in applying weather and climate information, including the hydrological cycle, to energy systems development and production are needed. Such arrangements will support policymaking and management decisions aimed at achieving an optimal balance between supply and demand as well as at driving behavioural changes to energy efficiency and savings.

5.3.1 Principal Energy Sources

The principal means of energy generation in Pacific Island countries are:

- Oil-fired diesel generators - used whenever other sources are insufficient to meet normal needs. They can be very costly to operate as a principal source of energy, due to the high price of fuel and its transportation.
- Hydropower - available on larger islands where there is suitable topography for constructing reservoirs, e.g. Fiji and Samoa. Their effectiveness can be severely diminished during extended periods of low rainfall/drought.
- Wind generators - can be scaled to meet many levels of demand. They are very effective during persistent periods of trade wind flow.
- Solar photovoltaic electricity systems - can be scaled to some extent to meet a range of demands. Efficiency is subject to levels of cloud cover and of course they only operate during daylight hours.
- Solar water heating systems - similar to photovoltaic systems in terms of effectiveness but are mostly suitable for use on single building scale.

Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project (PIGGAREP)

SPREP is currently supporting member countries in wrapping up the PIGGAREP, which has been implementing appropriate mitigation measures through renewable energy activities. PIGGAREP, has been instrumental in raising the profile of renewable energy in the PICs. With its software-related focus, it has complemented bi-lateral, regional and multilateral efforts involving renewable energy infrastructure in the region. These activities were carried out through targeted training workshops that address specific needs and current renewable energy developments of members, reviews and evaluation of renewable energy projects on the ground, conduct of resources monitoring and feasibility studies and the documentation and dissemination of best practices and lessons learnt from the renewable energy installations in and outside of the region.

The PIGGAREP is implemented in a coordinated manner with related national and regional activities. The country team approach is used for coordinating activities at the national level while the CROP Energy Working Group is the forum for coordinating PIGGAREP activities with those of its members, such as the Secretariat for the Pacific Community (SPC), Pacific Power Association (PPA), University of the South Pacific (USP), Pacific Islands Forum Secretariat (PIFS) and SPREP.

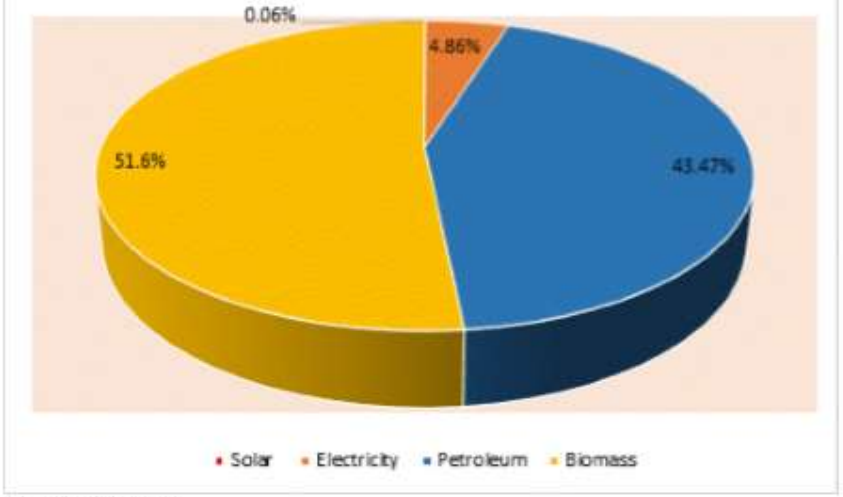
http://www.sprep.org/Pacific-Islands-Greenhouse-Gas-Abatement-through-Renewable-Energy-Project/about-piggarep

Figure 19: Example 0-D: Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project

Renewable Energy in Kiribati

The Government of Kiribati through its Energy Planning Unit has conducted pilot trials on wind and solar powered water pumps and is investigating utilising wave energy. The Kiribati Energy Planning Unit is using observation data provided by the Kiribati Meteorology Service to determine the best sites for wind and solar power facilities. Additionally, the EPU require information on drought conditions as drought affects the life of wet batteries in solar power points. Well-managed and sited renewable energy equipment would reduce the need for the diesel that consumes a large proportion of the government's budget. This work has been undertaken in partnership with the governments of Italy, UAE, Korea.

Figure 14: Share of Energy Output by Source, Kiribati, 2014



Source: MPWU

http://www.mfed.gov.ki/sites/default/files/Kiribati%20Development%20Plan%202016%20-%2019.pdf

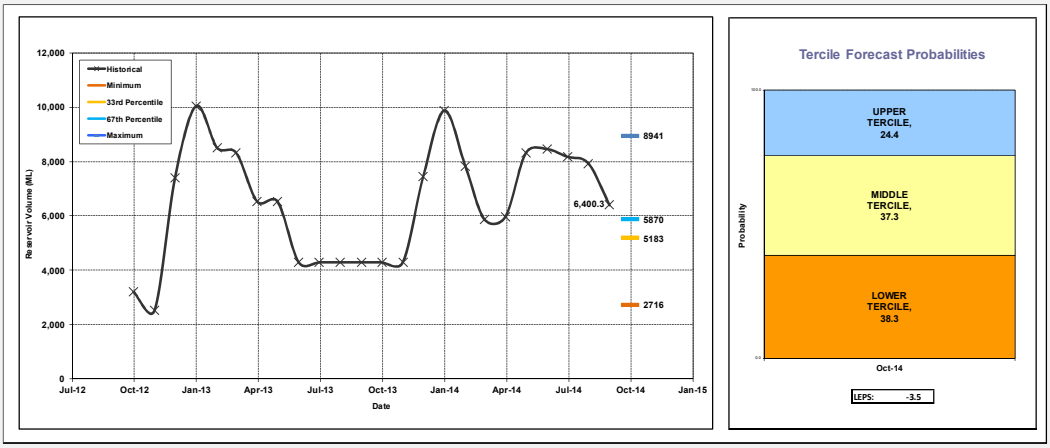
Figure 20: Example 0-E: Renewable Energy in Kiribati

Renewable energy use in Samoa and the Samoan Water Storage Forecasting Tool

The manager of the Afulilo hydroelectric facility in Samoa has been working with the Samoa Meteorological Service and the Australian Bureau of Meteorology COSPPac team since 2012 to develop a system, now operational, using seasonal rainfall predictions to manage the dam's water levels. Long-range forecasts allow the dam's manager to order extra diesel if low rainfall is probable, and so to avoid disruption to power supplies. The dam now provides 25% of the energy required for Upolu* and the model has helped achieve large savings through a reduction in the use of diesel.

Half of Samoa's energy already comes from renewable sources of which hydroelectricity is a major part. Currently Samoa is able to service power requirements using only renewable energy on weekends and during holidays and is on track to be a 100% renewable energy country in the near future*.

Afulilo Dam, Samoa.



Samoan Water Storage Forecasting Tool

* *Taken from in-country consultations with the Samoan EPC in February 2016.*

Figure 21: Example 0-F: Renewable energy in Samoa

5.3.2 Regional and National Actions for Energy

NUMBER	LEAD GFCS PILLAR	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	User Interface	Establish a consultative process for energy stakeholders [companies, ministries, development partners] and the NMHS to identify and implement required climate services for the energy sector, e.g. for: Implementation of water balance models for hydro-power dam management	Regional and National
2	Climate Services Information System	Develop tailored climate values, including predictions, targeted specifically for energy system needs.	Regional and National
3	Climate Services Information System	Where representative data already exists, develop tailored data sets specific to energy sector applications, e.g. wind climatologies, wave climatologies, heating and cooling degree days, water temperatures, and streamflow.	National
4	Observations and Monitoring	Access to and installation of necessary wind, solar, rainfall and wave monitoring systems.	Regional and National

Table 8: Energy National and Regional Actions

5.4 Health

The Pacific Islands are some of the most vulnerable in the world to the health impacts of climate change. Due to their unique geography, socio-economic condition and demographics they have limited capacity to manage and adapt to the myriad health risks a changing climate brings.[17]

Clean air and water, adequate food and shelter are fundamental to human health and are heavily affected by weather and climate, as are the distributions and transmission of many diseases. Severe weather events and prolonged climate anomalies such as hot or cold spells and drought are directly or indirectly responsible for many deaths throughout the year, and can exacerbate the spread of diseases. Variations in weather and climate also affect the incidence of non-communicable diseases, such as cardiovascular and respiratory diseases, through exposure to poor air quality. Furthermore, the spread of many communicable water-borne and vector-borne diseases is also modulated by variations in weather and climate, with accompanying high societal and economic costs.

Understanding the often-complex relationships between climate and health is fundamental to mitigating the associated risks. Accordingly, the health and climate services communities must work together to ensure that climate information is interpreted and applied effectively. Some of the highest priority climate-sensitive health risks in the Pacific are listed in the Table below[18].

"*Disasters cause an increased risk of vector- and rodent-borne diseases (including dengue, malaria, chikungunya, zika, leptospirosis), food- and water-borne diseases (including cholera, cryptosporidium,*

[17] McIver, Lachlan, et al. "Health impacts of climate change in Pacific island countries: a regional assessment of vulnerabilities and adaptation priorities." *Environmental health perspectives* 124.11 (2016): 1707.
[18] McIver, Lachlan, et al. "Health impacts of climate change in Pacific island countries: a regional assessment of vulnerabilities and adaptation priorities." *Environmental health perspectives* 124.11 (2016): 1707.

rotavirus, E.coli infection, giardia, shigella, typhoid, hepatitis A), and biotoxin-mediated illness (ciguatera and shellfish poisoning).

In the western Pacific countries (such as Papua New Guinea and the Solomon Islands) where droughts are foreseen during El Niño, diarrhoeal diseases due to scarcity of potable water will be the major concern as well as infectious and respiratory illnesses.[19]*"*

On a timescale of weeks to seasons, predictions provide outlooks for climate-sensitive diseases that are linked to changing environmental conditions, such as vector-borne diseases like malaria and dengue fever, or diseases that increase in severity with the onset of dust in the dry season, such as meningococcal meningitis, and end with the start of the rainy season. Understanding these relationships provides opportunities to plan interventions, such as mobilizing community health workers to raise awareness of health risks in vulnerable communities and to increase the readiness of the health care system to respond to epidemic outbreaks[20].

The link between climate variability in tropical regions and the prevalence of malaria, for example, in a given season or year is well established. However, climate is not the only factor involved and it's important that any disease forecast model employed incorporates appropriate health data and is tuned to the specifics of the area in which it is to be used. A model developed for Vanuatu may not be especially useful, for example, in Fiji or Samoa without modifications.

http://cosppac.bom.gov.au/products-and-services/malaria-early-warning-system/

[19] WHO, Pacific Technical Support, "El Nino and health in the Pacific", 2015

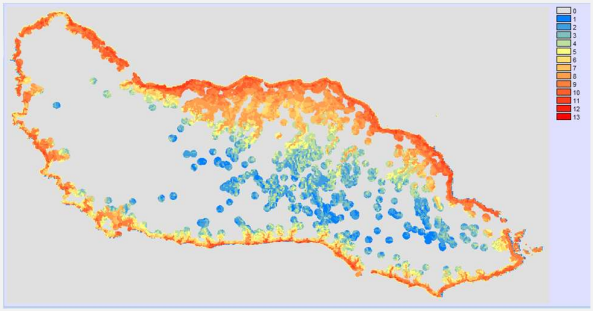
[20] D.P. Rogers, M.A. Shapiro, G. Brunet, J-C. Cohen, S.J. Connor, A.A. Diallo, W. Elliott, K. Haidong, S. Hales, D. Hemming, I. Jeanne, M. Lafaye, Z. Mumba, N. Raholijao, F. Rakotomanana, H. Teka, J. Trtanj, and P.-Y. Whung. 2010, *Health and climate – opportunities*. World Climate Conference 3 paper. Available online at www.sciencedirect.com

Malaclim

Across the Southwest Pacific, as in most tropical regions, the links between rainfall and malaria have long been documented: In the Solomon Islands, for example, there are still remnants of the pipes laid by the British in the 1940s to drain brackish water into the ocean. It is only recently, however, with the advent of sufficiently accurate and reliable three-month climate outlooks that climate forecasting has become a practical weapon in the arsenal of measures to battle malaria.

Analyses of rainfall figures since 1998 indicate with strong confidence that low rainfall associated with El Niño between October and December will result in a higher risk of malaria over the following six months. In contrast, normal or high rainfall between October and December generally results in a medium or lower risk of malaria. Higher rainfall means greater drainage of water and less stagnant water in which mosquitoes can breed.

In the Solomon Islands, the COSPPac MalaClim Forecasting tool is now being used operationally by the Solomon Islands Meteorological Service and the National Vector-Borne Disease Control Program to produce rainfall–malaria outlooks for northern Guadalcanal and Central Province.



An example of a Malaria Transmission Suitability Map for Guadalcanal Province, Solomon Islands based on ecological preferences of the main mosquito vector and locations of human settlements.

http://www.met.gov.sb/malaclim

Figure 22: Example 0-G: Malaclim Solomon Islands

Climate-sensitive health risk	Country												
	Cook Islands	FSM	Fiji	Kiribati	Marshall Islands	Nauru	Niue	Palau	Samoa	Solomon Islands	Tonga	Tuvalu	Vanuatu
Direct effects													
Health impacts of extreme weather events[a]	x	x			x	x	x	x	x	x	x	x	x
Heat-related illness[b]	x					x	x			x			x
Indirect effects													
Water security & safety (including water-borne diseases)[c]	x	x	x	x	x	x	x	x	x	x	x	x	x
Food security & safety (including malnutrition & food-borne diseases)[d]	x	x	x	x	x	x	x		x	x	x	x	x
Vector-borne diseases[e]	x	x	x	x	x	x	x	x	x	x	x	x	x
Zoonoses[f]		x	x					x					
Respiratory illness[g]	x	x			x	x	x	x		x		x	x

Figure 22: Highest priority climate-sensitive health risks in individual Pacific Island Countries (with each country's highest priorities indicated by "x")

5.4.1 Regional and National Actions for Health

NUMBER	LEAD GFCS PILLAR	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	User Interface	Enhance community awareness of potential impacts on human health of climate variability and change.	Regional and National
2	User Interface	Contribute to advisories on threats to health associated with weather and climate variability such as how to reduce outbreaks of diarrhoeal disease during floods.	Regional and National
3	Climate Services Information System	Develop disease specific early warning systems, e.g. Malaclim, for local implementation.	National
4	Climate Services Information System	Issue early warning bulletins of conditions conducive to pests and diseases	National
5	Observations and Monitoring	Address data needs, including the collection of more valid and comprehensive health statistics, at the appropriate local, regional and temporal scales.	Regional and National
6	Observations and Monitoring	Where appropriate monitor air quality.	Regional and National

7	Observations and Monitoring	Monitor sea temperatures for conditions conducive to Ciguatera outbreaks.	Regional and National
8	Research, Modeling and Prediction	Develop models that combine climate parameters with disease vector and economic information	Regional
	Research, Modeling and Prediction	Support research into expanding the knowledge of climate sensitive diseases of national importance through participation in national and regional research initiatives and projects.	Regional and National

Table 9: Health National and Regional Actions

5.5 Water

Water is fundamental to life. Population growth, urbanization, and agricultural use have increased demand for water throughout Pacific Island countries. At the most basic level, people need freshwater supplies for drinking, but even resources for this purpose are being severely stretched in some locations especially when there is an extended downturn in rainfall. Groundwater reserves are being depleted and low-lying atolls are being contaminated by salt-water intrusion due to seal level rise and storm surges.

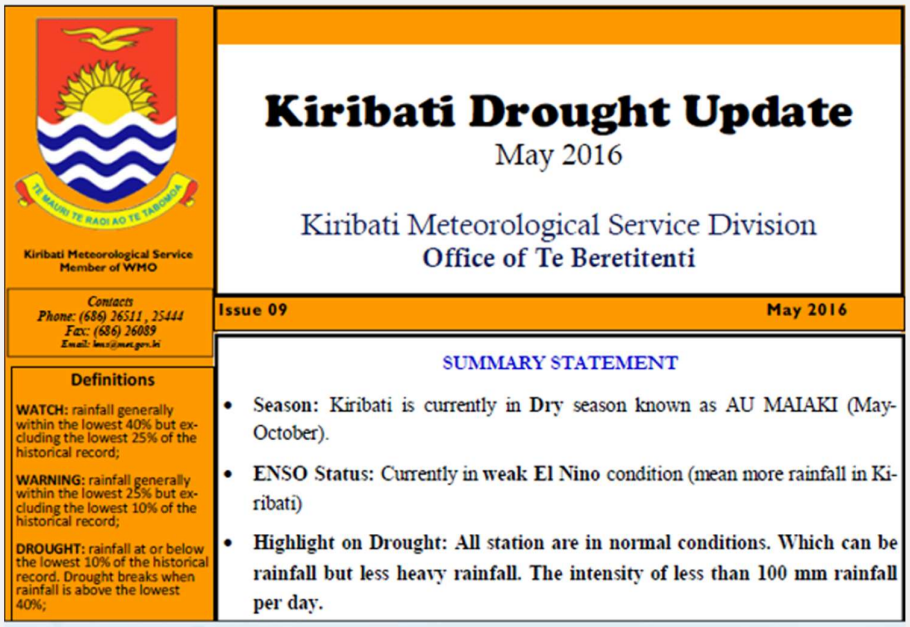
Climate and water data collected on weekly, seasonal and annual timescales and at regional, national and local levels are essential to the development of effective water management strategies, including flood and drought preparedness and response.

As for agriculture, climate data and information underpin water resource planning; the management of current supplies; and assessments of future needs for both community and industrial scale uses.

Calculations of the frequency and duration of heavy rainfall, probable maximum precipitation, low-flow and flood forecasting all require cooperation between NMHSs, NDMOs and water managers.

SCOPIC Drought Monitor

The SCOPIC drought-monitoring tool developed by COSPPac enables Pacific NMHSs to predict the probability of a typically low rainfall and to advise their countries' disaster managers when the point is reached at which a meteorological drought exists. Early warning of such slow onset events allows water managers to conserve resources and organise extra storage. Farmers can make planting and harvesting decisions informed by an understanding of the level of certainty of drought in an upcoming season. Governments prepare for delivery of emergency supplies if drought becomes very severe, drawing on historical data of known high-risk hotspots.



Kiribati Meteorological Service
Member of WMO

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Definitions

WATCH: rainfall generally within the lowest 40% but excluding the lowest 25% of the historical record;

WARNING: rainfall generally within the lowest 25% but excluding the lowest 10% of the historical record;

DROUGHT: rainfall at or below the lowest 10% of the historical record. Drought breaks when rainfall is above the lowest 40%;

Kiribati Drought Update

May 2016

Kiribati Meteorological Service Division
Office of Te Beretitenti

Issue 09 **May 2016**

SUMMARY STATEMENT

- **Season:** Kiribati is currently in **Dry** season known as AU MAIAKI (May-October).
- **ENSO Status:** Currently in **weak El Nino** condition (mean more rainfall in Kiribati)
- **Highlight on Drought: All station are in normal conditions. Which can be rainfall but less heavy rainfall. The intensity of less than 100 mm rainfall per day.**

Example of a drought bulletin issued by Kiribati Meteorological Services: The purpose of the bulletin is to provide warning of the impact of drought on the water reserve.

Figure 23: Example 0-H: SCOPIC Drought Monitor in Kiribati

Conjunctive use of water in Nauru

The Pacific Adaptation to Climate Change (PACC)* program undertook a demonstration project in Nauru aimed at enhancing community resilience to drought through the provision of solar water purifiers in selected households, in the Aiwo district.

"Solar water purifiers are solar panels connected to a distillation unit. The system receives impure water, and through a distillation process driven by solar energy, pure water is collected and diverted into a storage tank. Each panel can produce around 20 L of water per day, which meets WHO standards for drinking water.

Nineteen households each had four solar panels fitted, providing 80 L of additional potable water per day per household. During a drought, this can be used for drinking, cooking and if in sufficient quantity, personal bathing. Even when not under drought conditions this is a useful and safe potable water supply. The system is operated by the household and does not require any major maintenance. The lifespan of the solar purifier is 15 years and no replacement of material is expected during this time" - Guidelines for the design of a conjunctive water supply system in Nauru. Apia, Samoa: SPREP, 2014.

Table 1. Conjunctive water uses for an average household having access to groundwater in Nauru.

Water source	Above average rainfall	Low rainfall	Extended drought
Rainwater	▪ All uses	▪ Drinking only	▪ Not used (storage empty)
Seawater (desalinated)	▪ Not used (no need)	▪ Drinking only	▪ Drinking only
Groundwater	▪ Outdoor ▪ Laundry	▪ Outdoor ▪ Laundry ▪ Personal bathing	▪ Outdoor ▪ Laundry ▪ Personal bathing ▪ Cooking

Note: This table is derived from the findings in Bouchet and Sinclair (2010).The use of groundwater is not in fact recommended for personal bathing, laundry and cooking due to the high contamination from faecal bacteria.

*PACC is a GEF and Australian Government funded project

Figure 24: Example 0 I: Conjunctive use of water in Nauru

5.5.1 Freshwater Resources

There is a large diversity in freshwater resource characteristics in the Pacific which relate to:

- Physical nature of islands (size, topography, geology, etc.)
- Local and broad-scale climate
- Hydrology and water availability
- Demography (total population, percentage of urban and rural)
- Culture
- Degree of economic development

Common or naturally occurring sources of freshwater include groundwater, surface water and rainwater. Less common and generally more expensive sources include desalination, importation and recycling of wastewater, e.g. for agriculture. Small islands in particular have more limited water resources, which are more susceptible to natural hazards including droughts, floods, tropical cyclones, earthquakes, tsunamis, volcanic eruptions, landslides, and sea level rise.

Other water related issues affecting many Pacific Island countries include: water quality degradation; insufficient knowledge of water management practices resulting from insufficient education and training and institutional capacity; the use of inappropriate technology and methods; and an overall weak water governance. Some significant improvements have been made in recent years but more effort and, where necessary, external financial and knowledge resources are needed.

5.5.2 Regional and National Actions for Water

NUMBER	LEAD GFCS PILLAR	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	User Interface	Establish cooperative interactions between NMHSs and water authorities and organisations on weather and climate related water resource management issues	Regional and National
2	Climate Services Information System	Predictions of seasonal flow for major rivers.	Regional and National
3	Climate Services Information System	Development of drought management plans including strategies for rainwater, surface water and groundwater	National
4	Observations and Monitoring	Implement hydrological/hydro-meteorological monitoring systems	National
5	Observations and Monitoring	Database for hydrological data storage	National
6	Observations and Monitoring	Incorporate water quality measures in monitoring tools and systems	National

Table 10: Water National and Regional Actions

5.6 Fisheries and Aquaculture

"*Pacific island countries are sometimes referred to as big ocean developing states since they are the custodians of 20% of the 50 largest exclusive economic zones. They rely heavily on the ocean and coastal environments for their livelihoods, particularly for food security and the economic benefits associated with fisheries*"[21]

Fish stocks and their rate of replenishment are quite sensitive to climatic variability and longer-term climate change with different fish populations responding in different ways. For example, changes in the distribution patterns of migratory fish varieties have been observed in association with normal seasonal cycles and with multi-year El Niño-scale variations in the ocean environment. Longer-term climate change and its manifestation within the ocean environment can be expected to affect the reproduction, recruitment and growth of oceanic fish species.

To prevent overfishing and rebuild overfished stocks under changing and uncertain environmental conditions, effective partnerships between fisheries scientists and managers and climate service providers are required.

The International Workshop on Climate and Oceanic Fisheries, in Rarotonga, Cook Islands October 2011, *inter alia* reviewed the current understanding and status of marine and oceanic climate and climate variability, in particular in the South Pacific and also the effects of climate and climate variability on seasonal

[21] Smith, G, "Abstract: The COSPPac Ocean Portal: Providing ocean information for applications in western Pacific small island developing states", 2015

to decadal time scales on oceanic fisheries, including through an evaluation of available historical data on marine climate and oceanic fish abundance;

http://www.wmo.int/pages/prog/wcp/agm/meetings/wofish11/

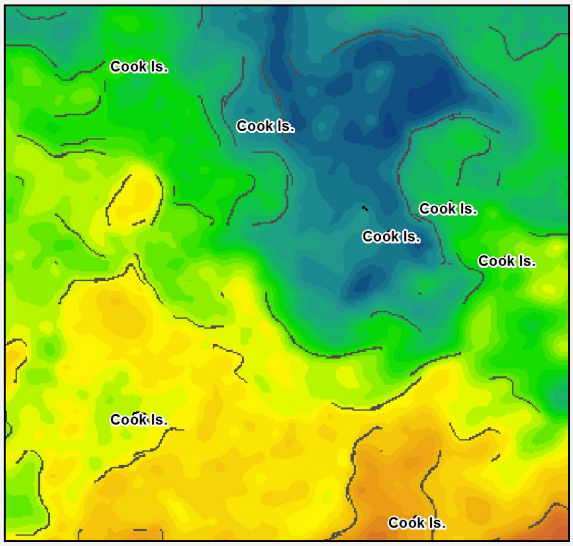
While there has been a significant growth in aquaculture throughout the Pacific, less attention has been given to the actual effects of climate variability on productivity or the potential effects of climate change. The potential affects were addressed however in the report of a workshop in Noumea, New Caledonia in June 2012 sponsored by FAO/Secretariat of the Pacific Community on *Priority adaptations to climate change for Pacific fisheries and aquaculture: Reducing risks and capitalizing on opportunities*

http://www.fao.org/docrep/017/i3159e/i3159e.pdf

COSPPac Ocean Portal

The COSPPac ocean portal provides Pacific island countries with ocean related information that has direct applications in the fields of fishing, tourism, coral reef management, shipping, risk management, planning, and ocean monitoring.

The ocean portal can provide scientific information to assist Pacific Islands in decision making for fisheries management and provides benefits such as: allowing estimates of fish populations to regulate licensing and provide sustainable catch limits, ensuring adequate fishing capture for subsistence fishing, security management of unlicensed poachers at fertile grounds etc.



An example of front detection using high resolution Sea Surface Temperature in the Cook Islands from the COSPPac Ocean Portal. Fronts indicate areas of possible upwelling, upwelling regions constitute about 1% of the ocean, yet are said to account for 50% of the fisheries catch worldwide.

http://cosppac.bom.gov.au/products-and-services/ocean-portal/

Figure 25: COSPPac Ocean Portal

5.6.1 Regional and National Actions for Fisheries and Aquaculture

NUMBER	LEAD GFCS PILLAR	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	User Interface	Encourage collaborative efforts between meteorological, oceanographic, biological and fisheries researchers and management agencies to better monitor and understand the impacts of short-term variability and longer-term change on oceanic fisheries	Regional
2	User Interface	Develop a fisheries Climate EWS	Regional and National
3	User Interface	Identify risk assessment or management evaluation tools that incorporate climate variability in order to improve the ecosystem-approach to management of fisheries.	Regional and National
4	User Interface	Identify how weather and climate tools can inform integrated coastal zone management relevant to coastal fisheries and marine aquaculture.	Regional and National
5	Climate Services Information System	Provide downscaled coastal information for use in Fish Aggregation Device programs	Regional
6	Climate Services Information System	Develop national ocean services portal (this can be done by national tailoring of a regional portal such as the COSPPac Ocean Portal).	National
7	Observations and Monitoring	Oceanic and coastal fisheries management organisations to inform their members about the advantages of making and reporting relevant marine meteorological and ocean observations to the various WMO/IOC (Intergovernmental Oceanographic Commission) observation and information systems	Regional and National
8	Observations and Monitoring	Ensure long-term commitments to monitoring systems for assessing fish stock status and to the conduct of routine integrated ecosystem assessments.	Regional and National
9	Observations and Monitoring	Undertake lagoon monitoring for aquaculture	National
10	Research, Modeling and Prediction	Improve understanding of the sensitivity of pearl and sea weed industries to rising sea temperatures.	Regional and National
11	Research, Modeling and Prediction	Contribute to the understanding of the impacts of climate change on fisheries and aquaculture	Regional and National

12	Research, Modeling and Prediction	Crown of Thorns starfish outbreaks and linkages to climate information	Regional and National
13	Research, Modeling and Prediction	Conduct climate and sea-surge modelling for areas at risk and to inform new coastal development	Regional and National

Table 11: Fisheries and Aquaculture National and Regional Actions

5.7 Tourism

The tourism sector is one of the largest and fastest growing global industries and as elsewhere is a significant contributor to national and local economies in Pacific Island countries and Territories. The interface between climate and tourism is multifaceted and complex, as climate represents both a vital resource to be exploited and an important limiting factor that poses risks to be managed by the tourism industry and tourists alike. All tourism destinations and operators are climate-sensitive to a degree and climate is a key influence on travel planning and the travel experience[22]. The tropical and sub-tropical Pacific provides a near ideal base on which to build a tourism industry due to the relatively benign climate. With the exception of tropical cyclones and periods of low rainfall, conditions are generally favourable for tourists year-round. Key variables for the region from both a weather and climate perspective are: sunshine, temperature, rainfall and wind.

Also important are open and sheltered sea conditions for boating, fishing and surfing, and sea temperatures in coral reef zones, which when high can lead to coral bleaching episodes.

https://coralreefwatch.noaa.gov/satellite/index.php

Given the relatively stable year-round climate when compared to other higher latitude tourist destinations, there may be value in implementing the Climate Index for Tourism (CTI), which considers thermal, aesthetic and physical aspects of weather in relation to beach tourism.

http://link.springer.com/article/10.1007/s00484-007-0134-3

Communicating with the tourism sector with respect to risk assessment for an upcoming season can at times be problematic, due to attendant economic risks to tourism operators and local businesses servicing the industry. An outlook that portends an increased risk of tropical cyclones, for example, has the potential for deterring tourists from visiting a particular country. Close dialogue between the NMHS and tourist operators and service providers is therefore very important whenever such risks are being highlighted.

Additionally, Target 12.b of Goal 12 in the UN Sustainable Development Goals is to "develop and implement tools to monitor sustainable development impacts for sustainable tourism which creates jobs, promotes local culture and products"

https://sustainabledevelopment.un.org/content/documents/7891Transforming%20Our%20World.pdf)

[22] *Weather and Climate Information for Tourism*, D. Scott and C. Lemieux. World Climate Conference 2010, Procedia Environmental Sciences Volume 1, 2010, Pages 146-183

The changing shoreline of the Rock Islands of Palau

The SPC/GIZ Coping with Climate Change in the Pacific Islands Region (CCCPIR) programme undertook a study on mapping of shorelines and coastal changes in the Rock Islands, Koror State.

Shoreline processes are highly dynamic and vulnerable to seasonal wave and wind effects as well as longer-term climate drivers like ENSO. Unfortunately, *"Shoreline erosion is affecting several important recreational and tourist beach areas in the Rock Islands. The government has expressed concern over the instability of these beach areas, given their importance as destinations for large numbers of tourists (up to 100/site/day). Tourism, particularly beach and water activities in the Rock Islands, are a major attraction and source of revenue to Palau; hence there is significant urgency to address the shore instability in those key tourist beach areas."* - Ngemaes, M, "Sands on the move: The changing shoreline of the Rock Islands of Palau", 2014

Figure 6. Time series images of Kemur Beab Beach, produced by Colin (2011), showing the newly accreted western shore area.

http://www.spc.int/coping-with-climate-change-in-the-pacific-islands-region-cccpir-programme/palau/

Figure 26: Example 0-J: Rock Islands of Palau

5.7.1 Regional and National Actions for Tourism

NUMBER	LEAD GFCS PILLAR	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	User Interface	Establish a consultative process for tourism stakeholders [companies, ministries, development partners] and the NMHS to identify and implement required climate services for the tourism sector	Regional and National
2	User Interface	Include representatives from tourism agencies in national climate outlook forums and regular meetings.	National
3	**Climate Services Information System**	Establish a Climate EWS for tourism	National
4	Capacity Building	Identify through workshops and other consultative processes the climate and ocean services that will address the specific needs of Pacific tourism sector	Regional and National

Table 12: Tourism National and Regional Actions

6 Partnerships and Linkages

6.1 Global and Regional Linkages

Partnerships are critical to the successful implementation of the Roadmap. To be effective, the Roadmap must be clearly linked with the activities of other governmental departments and agencies, technical partners and the private sector, and must work in concert with other global and regional frameworks.

The PMC acknowledges the importance of aligning actions in the Roadmap with the WMO Strategic Plan and RA V Operating Plan (2016-2019), the Global Framework on Climate Services (GFCS), the Pacific Islands Meteorological Strategy, the Framework for Resilient Development in the Pacific, and other relevant regional and international initiatives.

More specifically, the information in this document should be read in conjunction with the Pacific Islands Meteorological Strategy 2017–2026, where national and regional actions pertaining to disaster risk management, improving climate services, integrated observing and communication systems and co-ordinated support for NMHSs and PMC are detailed.

Figure 2: The key global and regional linkages can be summarised. Although each of the related regional policies and strategies originated from separate global institutions, there are clear linkages at the regional level where the regional frameworks contribute

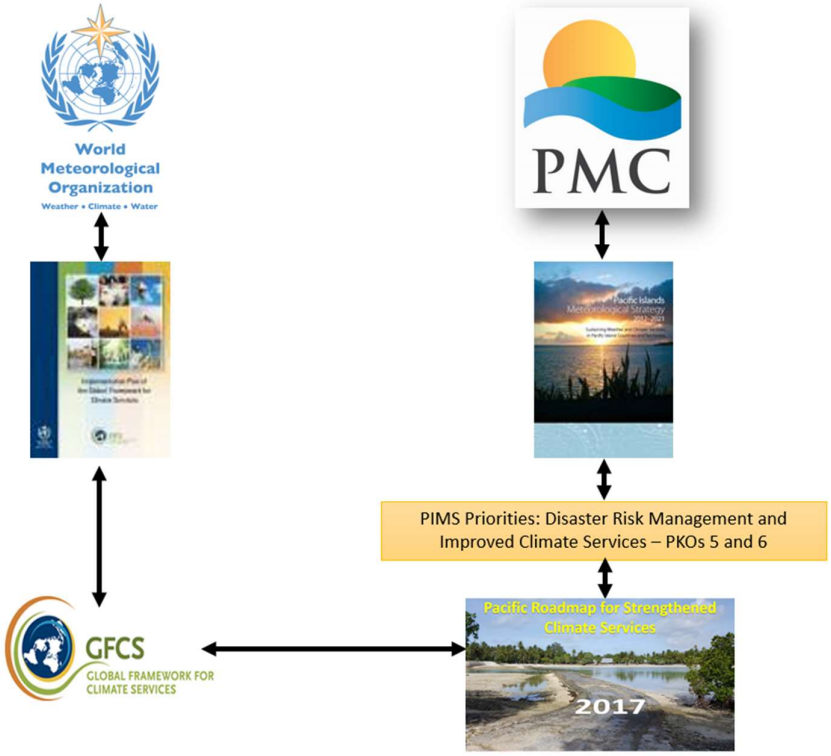


Figure 3: How the PIMS priority area of "Disaster Risk Management" and "Improved Climate Services" will be actioned through the implementation of the Pacific Roadmap for Strengthened Climate Services (PRSCS)

6.2 Regional Organisations, Programs and Projects

The Secretariat of the Pacific Regional Environment Programme (SPREP), the Pacific Community (SPC) and the University of the South Pacific (USP) are key Pacific Region focal points for climate related project development, implementation, capacity building, funding, and coordination. In general, all United Nations affiliated agencies such as WMO through its Regional Association V Office based in SPREP, UNDP with its Pacific office in Fiji, and many governmental aid programs collaborate closely with these bodies.

6.2.1 SPREP

The Secretariat of the Pacific Regional Environment Programme (SPREP), based in Apia, Samoa, has been charged by the governments and administrations of the Pacific region with the protection and sustainable development of the region's environment. SPREP's strategic priorities are:

- Climate Change, including climate variability;
- Biodiversity and Ecosystem Management;
- Waste Management and Pollution Control; and
- Environmental Monitoring and Governance.

https://www.sprep.org/

6.2.2 USP

The University of the South Pacific (USP) has several campuses in Pacific Island countries. Through its research theme on Environment, Sustainable Development and Climate Change, USP is well placed to provide both training, capacity building and research opportunities for the implementation of this Roadmap; a regional approach to the development of suitable training and research programs is required.

https://research.usp.ac.fj/?page_id=56

6.2.3 Pacific Community (SPC)

The SPC[23], based in Noumea, New Caledonia and Suva, Fiji, is the principal scientific and technical organisation in the Pacific region. SPC's strategic organisational objectives are:

- Strengthen engagement and collaboration with Pacific Community members and partners
- Strengthen our technical and scientific knowledge and expertise
- Address members' development priorities through multi-disciplinary approaches
- Improve our planning, prioritisation, evaluation, learning and innovation
- Enhance the capabilities of our people, systems and processes

http://www.spc.int/

6.2.4 Climate and Oceans Support Program in the Pacific (COSPPac)

The Climate and Oceans Support Program in the Pacific (COSPPac) is an Australian Government initiative supporting 14 Pacific Island countries to adapt to and mitigate the impacts of climate variability and change. COSPPac works with NMHSs and Lands and Survey Departments (LSDs) in the Islands to build tools that can forecast and monitor climate and ocean parameters, and communicate this information to communities, businesses and Governments. COSPPac was preceded by the Pacific Islands Climate Prediction Project (PI-CPP), which ran from 2003-2012 and South Pacific Sea Level and Climate Monitoring Project (1991-2012).

http://cosppac.bom.gov.au/products-and-services/

http://cosppac.bom.gov.au/pacific-islands-climate-prediction-project/

[23] SPC - formerly the Secretariat for the Pacific Community

6.2.5 Finnish Pacific (FINPAC) Project

The Finnish-Pacific (FINPAC) Project on 'Reduced vulnerability of Pacific island country villagers' livelihoods to the effects of climate change' has provided NMHSs with the capacity and a range of tools to deliver and communicate weather and climate services in a timely manner. The project is also working with communities to strengthen their ability to use and apply meteorological data and information, and to develop appropriate plans to address climate change and disasters.

https://www.sprep.org/finpac/

6.2.6 Republic of Korea: Pacific Islands Climate Prediction Services Project

The aim of ROK PI CLIPS is to build the capacity of Pacific Island NMHSs to provide seasonal climate prediction information. It is funded by the Government of Korea through the Pacific Island Forum Secretariat (PIFS) and implemented by the APEC Climate Center (APCC) and SPREP.

https://www.pacificclimatechange.net/project/republic-korea-pacific-islands-climate-prediction-services-project

6.2.7 Regional Disaster Resilience in the Pacific Small Island Developing States (RESPAC)

RESPAC is an initiative of the Government of the Russian Federation in partnership with the United Nations Development Programme (UNDP) Pacific Office. The project is supporting the strengthening of early warning systems and climate monitoring capacity in order to enhance preparedness and planning mechanisms for managing disaster recovery processes and support post disaster recovery efforts.

https://sustainabledevelopment.un.org/partnership/?p=14656

6.2.8 Regional Integrated Multi-Hazard and Early Warning System (RIMES)

RIMES is focussed on Africa and Asia, with Timor Leste a principal small island focus in the Indo-Pacific region. RIMES aims at providing services to its participating Member States in the following areas:

- Earthquake & Tsunami Watch services to the National Tsunami Warning Centres
- Weather, Climate and Hydrological Research and Development to National Meteorological and Hydrological Services
- Capacity Building in End-to-End Early Warning to national and local level institutions within national early warning frameworks

http://www.rimes.int/key_services.php

6.2.9 Pacific Climate Change Centre

A Pacific Climate Change Centre (PCCC), facilitated by the Grant Aid Program of the Government of Japan, is to be established shortly and hosted by SPREP. The Centre will strengthen and sustain the delivery of climate information and services to Pacific island countries and territories. Activities will include the application of both prediction of climate variability and long-term projection tools in support of planning and decision-making on climate and disaster risk management. It will also provide a dedicated training and meeting space to take on new challenges and developments, particularly in relation to climate science.

6.2.10 Pacific RISA

The Pacific Regional Integrated Sciences and Assessments (Pacific RISA) program, implemented by NOAA[24], supports USA-affiliated Pacific island and coastal communities in adapting to the impacts of climate variability and change. The Pacific RISA mission includes the following objectives:

- Meet critical climate information needs in the Pacific Region through multidisciplinary climate research, assessment, education, and training;
- Provide integrated, locally relevant climate information to decision makers and communities in the Pacific Region;
- Enhance regional and local capabilities to manage climate risks, build resilience in key sectors, and support sustainable development;

[24] NOAA: National Oceanic and Atmospheric Administration

- Promote collaboration among Pacific regional, US national, and international institutions and programs providing climate information products and services.

http://www.pacificrisa.org/about/program-objectives/

6.3 Multi-lateral programs and projects

6.3.1 Pacific Climate Change

Several government aid agencies and international organisations support a wide range of resilience-building projects in Pacific Island countries and territories related to climate variability and change, and to disaster risk management. The Pacific Climate Change Portal managed by SPREP provides comprehensive information on many of these projects.

https://www.pacificclimatechange.net/projects

6.3.2 GEF

Many projects have been initiated with climate change issues in mind and with international funding through the Global Environment Facility (GEF). The GEF is a partnership of 18 bodies including UN agencies, development banks, national entities and international NGOs working to address environmental issues. It is the financial mechanism for five major international conventions, one of which is the UNFCCC. It can fund national activities through accredited agencies, who help with administration and reporting.

http://www.thegef.org

6.3.3 GFCS

The GFCS is a UN-led initiative spearheaded by WMO to guide the development and application of science-based climate information and services in support of decision making in climate sensitive sectors. The main sources of GFCS funding are Members' contributions to the GFCS Trust Fund or through bilateral and multi-lateral investments for projects in selected countries or regions

http://www.wmo.int/gfcs/funding

6.3.4 UNDP

The United Nations Development Programme supports Pacific countries in progressing towards achievement of the Sustainable Development Goals. Its programs target the most vulnerable – women and the young – through inclusive and pro-poor approaches. With its support, Pacific countries are improving their effective and sustainable management of environmental and natural resources.

http://www.undp.org

6.3.5 UNDP -PRRP

The UNDP Pacific Risk Resilience Programme (PRRP) works with Pacific island countries and their people to mainstream the risks they face from climate change and disasters into development planning and processes.

http://www.pacific.undp.org/content/pacific/en/home/operations/projects/environment_and_energy/PRRP.html

6.3.6 FAO

The United Nations Food and Agriculture Organisation works with its partner countries to improve their food security with both technical advice and practical help. Most recently in the Pacific, FAO supplied subsistence growers and cash crop farmers in Vanuatu with emergency provisions and seeds of fast growing food plants after the country was devastated by Tropical Cyclone Pam. Its targeted assistance helped

Vanuatu's people restore their food sources and livelihoods quickly and avoid the catastrophic famine a severe cyclone can bring.

http://www.fao.org/3/a-i5331e.pdf

6.3.7 Red Cross

The Red Cross provides a sustainable disaster management network across the Pacific. In the Pacific, the Red Cross has worked with COSPPac for several years to combine national seasonal forecasts with disaster preparation activities: Pacific National Red Cross Societies use local forecasts predicting above or below normal rainfall to, for instance, stockpile supplies, alert communities to the likely risk and undertake community awareness and training. The Red Cross partnered with SPREP to support community early warning systems as part of the regional FINPAC project and, through in-community networks, is able to entrench early warning early action at the community level.

The Red Cross has now progressed to Forecast-Based Financing (FbF) – using credible predictions of humanitarian disasters to release funds for early action before the onset of the event. Access to finance before the impacts begin to be felt allows Red Cross organisations to mitigate or even prevent those impacts, for instance by bringing in stores of food before a famine begins. Over time, the Red Cross expects to be able to show that despite the risk of occasionally preparing for disasters that don't eventuate, FbF saves both lives and money.

http://www.ifrc.org/
http://www.climatecentre.org/programmes-engagement/forecast-based-financing

6.3.8 WFP

The United Nations' World Food Programme helps its partner countries to develop strategic plans for food security, continually analyses the risk of shortages around the world, provides humanitarian relief and supports countries' own work in strengthening their capacities to respond to disasters.

http://www1.wfp.org/overview

There are also several projects funded on a bilateral basis from developed country governments active in the region. The following regional projects, for example, focus on climate variability within the overall climate change context.

6.3.9 Green Climate Fund

The Green Climate Fund (GCF) provides opportunities for countries to access funds to support national adaptation and mitigation priorities. It is a unique global initiative to respond to climate change by investing into low-emission and climate-resilient development. GCF was established by 194 governments to limit or reduce greenhouse gas emissions in developing countries, and to help adapt vulnerable societies to the unavoidable impacts of climate change. Given the urgency and seriousness of the challenge, the Fund is mandated to make an ambitious contribution to the united global response to climate change.

7 Institutional Support and Governance

In the Pacific, numerous mechanisms provide Institutional support and governance. Some of these bodies/mechanisms are noted below.

7.1 Pacific Meteorological Council

The Pacific Meteorological Council (PMC) is a specialised subsidiary body of SPREP, established at the Fourteenth Regional Meteorological Services Directors meeting in Majuro, Republic of the Marshall Islands, July 2011 to facilitate and coordinate the scientific and technical programs and activities of the NMHSs. The PMC provides policy relevant advice at SPREP Meetings on the needs and priorities of its member

countries and territories in relation to meteorology (weather and climate) and related fields. The PMC meets every two years. The Roadmap will be launched at the fourth PMC meeting in Honiara in August 2017.

The Roadmap (PRSCS) is designed to guide NMHSs, the PMC, SPREP, other regional organisations and partners on the type of priority activities to be implemented to make the best possible contribution to the wellbeing of PICTs' communities.

The PMC will take responsibility for ensuring coordination at the regional level and for advocating for the PRSCS with development partners. The PMC will oversee initiatives taken to implement the PRSCS at a regional level. It will ensure appropriate accountability for regional activities' funds, and promote activities that are aligned with the actions set out here.

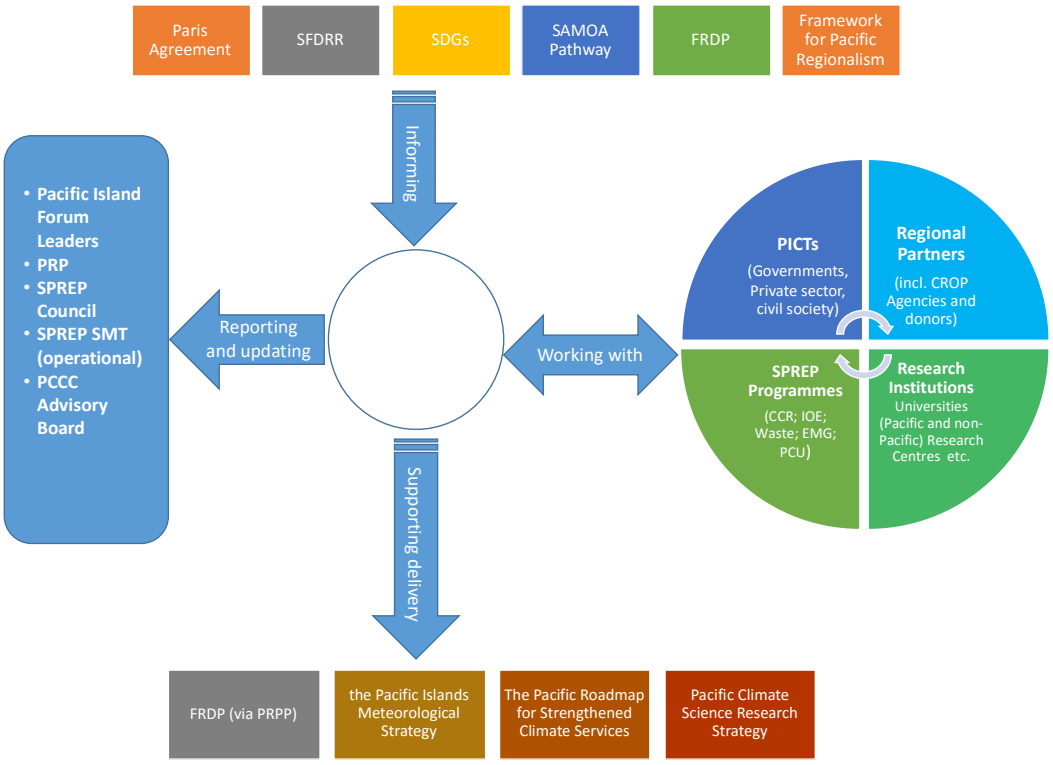
The PMC has established six panels to provide it with specialist advice as required. Each panel has a detailed Action Plan aligned with PIMS, managed by its members.

The panels are as follows:

- Pacific Islands Marine and Ocean Services (PIMOS) Panel
- Pacific Islands Climate Services (PICS) Panel
- Pacific Islands Education, Training and Research (PIETR) Panel
- Pacific Islands Aviation Weather Services (PIAWS) Panel
- Pacific Islands Communications and Infrastructure (PICI) Panel.
- Pacific Islands Hydrology (PIH) Panel

7.2 Pacific Climate Change Centre

The Pacific Climate Change Centre (PCCC) will be the regional centre of excellence for climate change information, research and innovation, hosted at SPREP. The PCCC will be instrumental in improving the availability and usability of the wealth of knowledge available to the region by building relationships with and between producers and users of knowledge. Outputs generated by the PCCC will focus on usability and credibility. The PCCC will enhance capacity within national meteorological services which play a key role in enhancing our understanding of current and future climate change impacts at national and sub-national levels. SPREP's role as the lead node for the Pacific RCC will be delivered at the PCCC.



7.2.1 Pacific Meteorological Desk Partnership

The PMC is supported by the Pacific Meteorological Desk Partnership (PMDP), which is based at and managed by SPREP. The PMDP serves as the Secretariat for the PMC and coordinates regional weather and climate services. The PMDP has two core components: the Apia-based Secretariat, and the development partners' component.

The PMC's mandate and terms of reference are determined by member countries' Leaders at the Annual SPREP Meeting. The PMDP (through the SPREP Secretariat) informs the SPREP Annual Meeting on the operation of the PMC and on progress on the implementation of and achievement of the PRSCS.

The PMDP will continue to help the PMC and NMHSs to secure resources to implement the PRSCS, address priorities and challenges, and report to the PMC.

7.3 Pacific Islands Climate Services Panel

The Pacific Island Climate Services Panel (PICS Panel) was endorsed by the Second Meeting of the PMC to serve in the capacity of an advisory committee to the Council on climate services matters in the Pacific region. The purpose of the PICS Panel is to provide technical and strategic advice to the PMC on matters related to the strengthening of climate services at the community, national and regional levels.

The PICS Panel developed an Action Plan, consisting of the following overarching themes and key action points:

1 Improve coordination, continuity and integration of projects, programmes and initiatives that support climate services at national, regional and global levels
   - 1.1 Establish and/or strengthen a regional platform that will lead on the issues of Climate Services (GFCS Regional Workshop to establish a PICS Panel)
   - 1.2 Set up regional and national registries for climate service projects, programmes and activities (SPREP, PaCIS)
   - 1.3 Establishment of a RCC (network) node for the Pacific Island region (PICS Panel advising PMC)

2 Strengthen the basic and core functions and capabilities of NMHSs for robust and sustained data collection & management, analysis of data and quality assurance, production and dissemination of products, research and modelling

- 2.1 Review the existing strategies and identify the gaps on existing and future requirements for the co-production of core climate information and prediction services (PICS Panel advising PMC)
- 2.2 Identify a standardized product suite and methodologies to address regional requirements (PICS Panel advising PMC)
- 2.3 Expand multi hazard EWS including end-to-end system of data collection, advisories and product dissemination to all countries (RCC)
- 2.4 Restore non-functional observing stations, maintain existing networks and expand the number of stations on outer islands (NMHSs and local partners)
- 2.5 Build, sustain and enhance the capacity of NMHS in the production, use, translation and verification of seasonal outlooks and other climate products (NMHSs and regional partners)

3 Enhance avenues and modes of multi-way communication and feedback between climate services providers and users to enhance the uptake and use of relevant and tailored climate services down to the communities and individuals

- 3.1 Learn from experiences, identify opportunities and determine a set of best practices of communications in the region (NMHSs and partners)
- 3.2 Collect, document, archive and verify indigenous knowledge on climate indicators and impacts (NMHSs and partners)
- 3.3 Request access to timely and accurate impact data and indicators from sectors (i.e. yield statistics) (NMHSs and National Government Agencies)
- 3.4 Ensure research priorities are linked to national, regional and global frameworks and driven by user requirements (NMHSs and partners)
- 3.5 Increase the number of users and their awareness and capabilities to uptake and use climate services (NMHSs and partners)

https://www.sprep.org/attachments/Publications/PMC-2_Meeting_Report.pdf

7.4 Pacific Regional Climate Centre Network

RCCs are Centres of Excellence that assist WMO Members in a given region to deliver better climate services and products, including regional long-range forecasts, climate monitoring and climate data services, and to strengthen their capacity to meet national climate information needs. The primary 'clients' of an RCC are NMHSs in the region and in neighbouring areas. RCC responsibilities should be regional in nature and not duplicate or replace services provided by NMHSs. The Pacific RCC is a shared and distributed responsibility for the region.

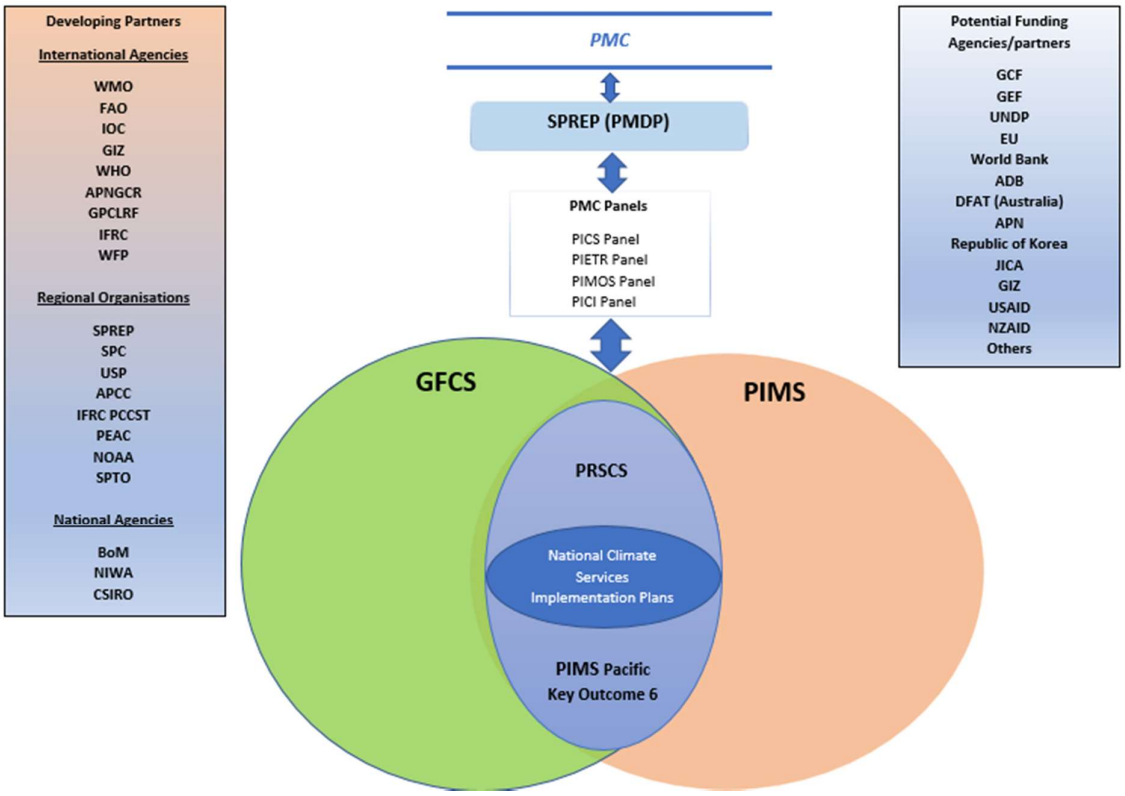


Figure 4: Strategies and Partners supporting the implementation of the Pacific Roadmap for Strengthened Climate Services (PRSCS)

8 National Climate Services

WMO Guidelines on "Development of the Global Framework for Climate Services at the National Level[25]" provide guidelines for NMHSs to develop national implementation plans for climate services at the national level. The document outlines a three-phased approach:

1 Assessing the baseline (what are the capacities of the country in the five pillars, who are the stakeholders/users/clients/partners, what climate services are currently provided).
2 Initial national consultation workshop (a national dialogue should be established between the NMHS and the users).
3 Elaboration of the action plan.

Some key actions that NMHS may wish to consider when developing their national climate services implementation plans are included in Figure 20 under each of the GFCS pillars. Figure 20 also illustrates how, through the implementation of both regional and national action plans, climate services can be conceived of as an integrated set of cascading operational systems that deliver end-user products tailored to support each of the priority sectors.

8.1 Regional and National Actions for National Climate Services

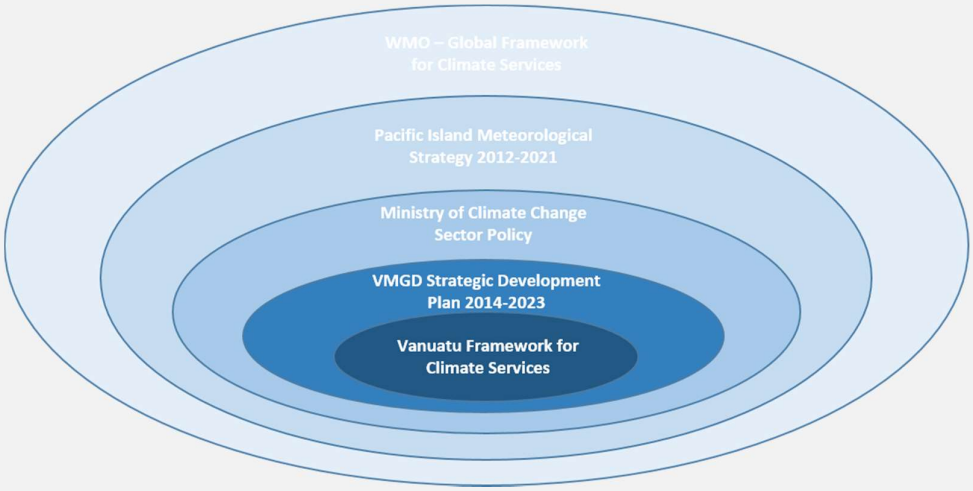
[25] http://www.gfcs-climate.org/sites/default/files/events/Regional%20Workshop%20on%20Climate%20Services%20at%20the%20National%20Level%20for%20the%20LDCs%20in%20Asia//GuidetoClimateServicesattheNationalLevelFinalOctober2012.pdf

NUMBER	ACTION	NATIONAL ACTIVITY / REGIONAL ACTIVITY
1	Support the development of implementation plans or frameworks for climate services at the national level	Regional and National

Table 13: National Climate Services National and Regional Actions

Vanuatu Framework for Climate Services

The Vanuatu Meteorology and Geo-Hazards Department (VMGD) provides a range of national climate-related services. The goal of the *Vanuatu Framework for Climate Services* (VFCS) is to provide a route map to ensuring that climate services for Vanuatu are of world-class standard, sustainable, are reaching all end-users, and are effectively helping people manage and adapt to climate variability and change in Vanuatu.



This "shell-like" structure illustrates how the VFCS fits in relation to key national, regional and international strategies, policies, frameworks and plans.

The VFCS includes the following key features:

a) The linkages with existing global, regional and national frameworks, strategic plans and policies;
b) The capacities and capabilities of both the providers and receivers of climate information;
c) The climate products and services currently being provided and ideas for what products still need to be developed; and
d) The mechanisms and requirements for improving the communication, dissemination and use of climate information.

Two pressing needs have been identified by the VFCS:

1. The need to develop through consultation with key stakeholders, tailored climate products (including training on their use); and
2. The need for improvements to and formalisation of mechanisms for communicating and disseminating climate information (including the use of Ministerial directives with the provision of authority for action).

*The Vanuatu Framework for Climate Services was written by NIWA.

Figure 5: Vanuatu Framework for Climate Services

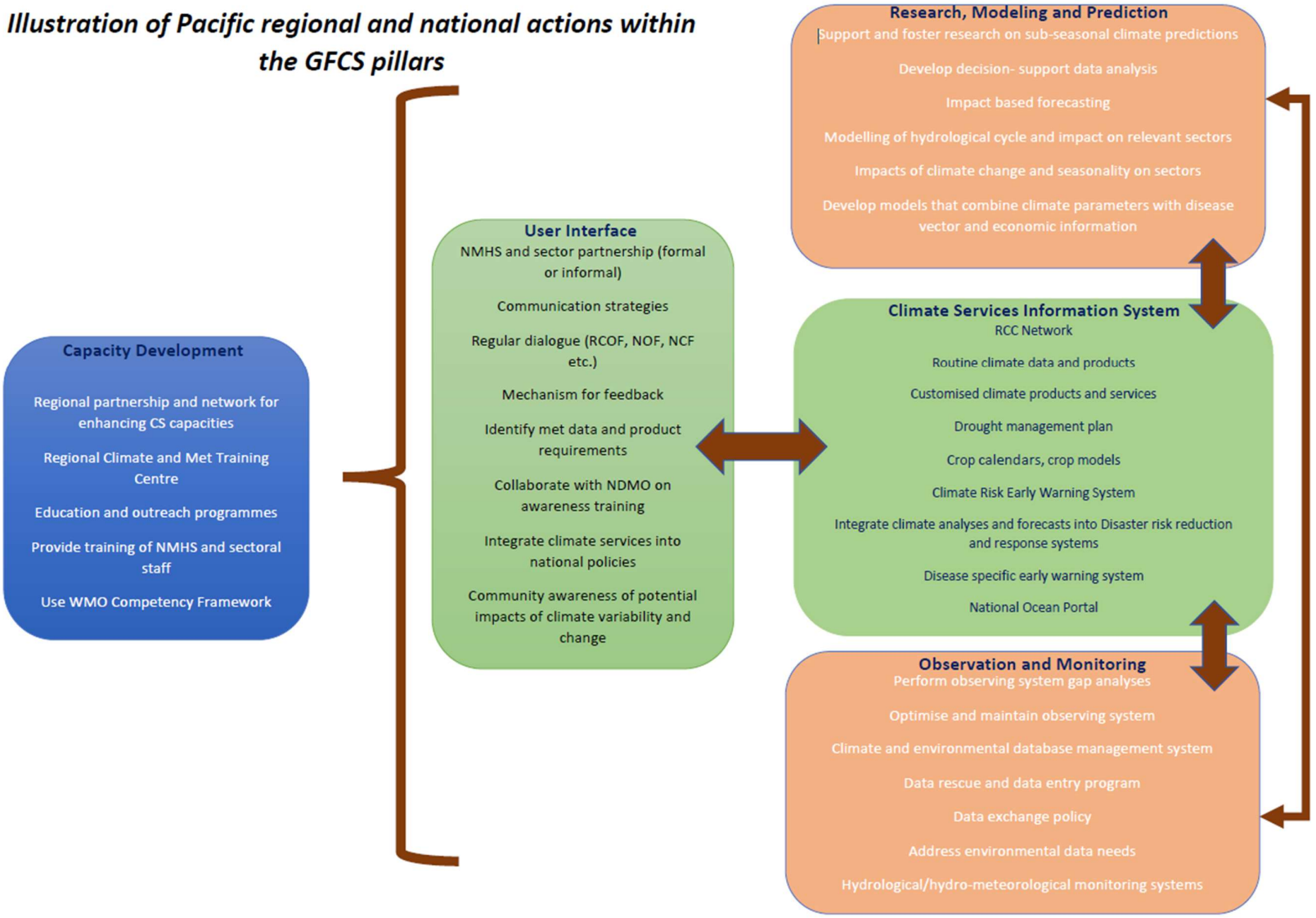


Figure 6: Illustration of Pacific regional and national actions within the GFCS pillars

9 Glossary

ADB	Asia Development Bank
APEC	APEC Climate Center
APNGCR	Asia Pacific Network for Global Change Research
APSIM	Agricultural Production Systems sIMulator
AWS	Automatic Weather Station
BoM	Australian Bureau of Meteorology
CCCPIR	Coping with Climate Change in the Pacific Island Region (SPC/GIZ project)
CDMS	Climate Data Management System
CLEWS	Climate Early Warning System
CliDE	Climate Data for the Environment
CliDEsc	Climate Data for the Environment Services Application Client
COSPPac	Climate and Oceans Support Program in the Pacific
CREWS	Climate Risk Early Warning System
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CSIS	Climate Services Information System
CSO	Civil Society Organisation
CTI	Climate Index for Tourism
DRR	Disaster Risk Reduction
ENSO	El Niño Southern Oscillation
EWS	Early Warning System
FAO	Food and Agriculture Organization of the United Nations
FbF	Forecast-based Financing
FINPAC	Finnish Pacific Project
FRDP	Framework for Resilient Development in the Pacific
FSM	Federated States of Micronesia
GCF	Green Climate Fund
GCOS	Global Climate Observing System
GDPFS	WMO Global Data Processing and Forecasting System
GEF	Global Environment Facility
GFCS	Global Framework for Climate Services
GIS	Geographical Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOOS	Global Ocean Observing System
GPC	WMO Global Producing Centres
GPCLRF	WMO Global Producing Centres for Long-Range Forecasts
GTOS	Global Terrestrial Observing System
IFRC	International Federation of Red Cross and Red Crescent Societies
IFRC PCCST	IFRC Pacific Country Cluster Support Team
IOC	Intergovernmental Oceanographic Commission
JICA	Japan International Cooperation Agency

LSDs	Lands and Survey Departments
MHEWS	Multi-Hazard Early Warning system
NCF	National Climate Forums
NCOF	National Climate Outlook Forums
NDMO	National Disaster Management Office
NGO	Non-Government Organisation
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
NMHSs	National Meteorological and Hydrological Services
NOAA	National Oceanographic and Atmospheric Administration (USA)
NZMet	New Zealand Meteorological Service
OSCAR	Observing Systems Capability Analysis and Review
PACC	Pacific Adaptation to Climate Change
PACCSAP	Pacific-Australia Climate Change Science and Adaptation Planning
Pacific RISA	Pacific Regional Integrated Sciences and Assessments
PaCIS	Pacific Climate Information System
PASAP	Pacific Adaptation Strategy Assistance Program
PCCC	Pacific Climate Change Centre
PCCP	Pacific Climate Change Science Program
PEACC	Pacific El Nino-Southern Oscillation (ENSO) Applications Climate Center
PICI	Pacific Island Communications and Infrastructure
PICOF	Pacific Climate Outlook Forum
PICS	Pacific Island Climate Services
PICTs	Pacific Island Countries and territories
PIETR	Pacific Islands Education, Training and Research
PIGGAREP	Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project
PIMOS	Pacific Islands Marine and Ocean Services
PIMS	Pacific Islands Meteorological strategy
PKO	Pacific Key Outcomes
PMC	Pacific Meteorological Council
PMDP	Pacific Meteorological Desk Partnership
POAMA	Predictive Ocean Atmosphere Model for Australia
PRRP	Pacific Risk Resilience Programme
PRSCS	Pacific Roadmap for Strengthened Climate Services
PSLMP/SPCLMP	Pacific Sea Level Monitoring Project
RA V	WMO Regional Association 5
RCC	Regional Climate Center
RCOF	Regional Climate Outlook Forum
RESPAC	Regional Disaster Resilience in the Pacific Small Island Developing States
RIMES	Regional Integrated Multi-Hazard and Early Warning System
RMI	Republic of the Marshall Islands
ROKPI CLIPS	Republic of Korea: Pacific Islands Climate Prediction Services Project
SCOPIC	Seasonal Climate Outlook for Pacific Island Countries
SDG	The United Nation's Sustainable Development Goals
SOI	Southern Oscillation Index

SPC	The Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SVSLRF	WMO Standard Verification System for Long-Range Forecasts
TK	Traditional (Climate) Knowledge
UIP	User Interface Platform
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAPI	United States-Affiliated Pacific Islands
USP	University of the South Pacific
WFP	World Food Programme
WIGOS	WMO Integrated Global Observing System
WMO	World Meteorological Organization