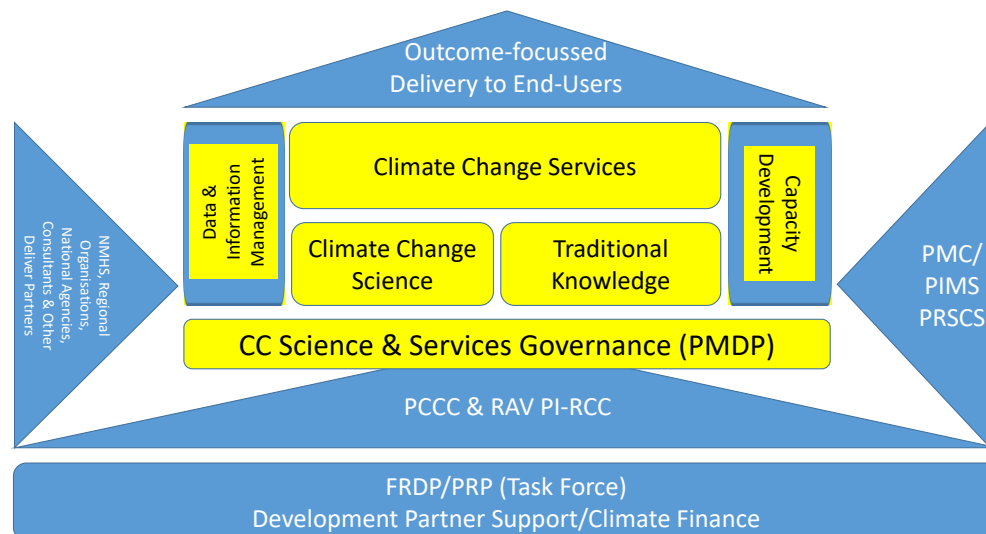


Pacific Climate Change Science and Services Research Roadmap: at a glance

The *Pacific Climate Change Science and Services Research Roadmap* provides a consensus and strategic approach to facilitating prioritisation, management, coordination and delivery of climate change science and services research and associated traditional knowledge in the Pacific. The ultimate aim is to facilitate the development and application of science-based and traditional knowledge to deliver on-ground impacts and enhance resilience to climate change in the Pacific.

The Roadmap has six key pillars that describe in summary the scope in terms of the types of data, information and associated capabilities that might need to be developed and implemented in order to address the priority gaps and needs of designated end-users and other climate change stakeholders in the Pacific:

- Climate change science
- Traditional knowledge
- Capacity development
- Climate change services
- Data and information management
- Governance: oversight and administration



This Roadmap does not intend to specify immediate priorities for climate change science and services research, but rather to broadly define the boundaries and thereby to provide an indicative initial scope of gaps and needs.

Climate change science

Managing the significant changes on land, in the atmosphere and in the oceans due to climate change must be informed by robust and consensus-driven science.

This pillar focuses on the key physical and biological climate variables, and their importance for different sectors. It identifies observational needs and their link to large-scale climate. The requirements associated with projecting future climate change, and the detection and attribution of extreme events and observed changes are also addressed, as is the value of traditional knowledge to complement and/or validate the physical science.

Gaps and needs

- Multiple (atmospheric and oceanic) climate and related environmental variables, hazards/extremes and associated impacts:
 - air temperature
 - rainfall (incl. floods and drought)
 - Soil moisture
 - Ground water (incl. levels and portability)
 - Stream flow and surface water (eg lakes and wetlands)
 - sea surface temperature (incl. marine heatwaves)
 - sea level and wind waves
 - tropical cyclones
 - ocean acidification
 - coral bleaching
 - reef ecosystem 'health' (incl. nutrients and water quality)
 - radiation
 - atmospheric and ocean circulation
 - Hailstorm, humidity, wind speed/direction
- Current and historical climate, large-scale climate processes, climate variability and ENSO, other climate modes, SPCZ, Madden Julian Oscillation (MJO), Pacific Decadal Oscillation (IPO)
 - Seasonal cycles & observed trends
 - Extremes analysis
 - Longer-term
 - Sub-seasonal cycles and related modes such as tropical waves, MJO influence.
- Climate, oceanic & related observations – linking the data to the tools (modelling etc)
 - Observed trends (historical and current climate)
 - Seasonal cycles
 - Station and gridded data
 - Satellite and ocean observations
 - Digitisation and visualisation of data
 - Traditional Knowledge
 - Geo-spatial (topography and bathymetry) observations (incl. GIS, LIDAR etc)
 - Bio-physical data
 - Socio-economic data
 - Data management, and QAQC/homogenisation
 - Observational reanalysis data
 - Utility of observational data to meet needs for applying projections e.g. rainfall data, rainfall gauges/collection network etc
 - Sectoral datasets and associated anecdotal 'Rules of Thumb'
 - Climate Change attribution and events related to natural variability
- Projections of future climate (mean and extremes)
 - Range of climate futures, including direction and magnitude of change
 - Range of projection methods including global and (downscaled) regional models
 - Model evaluation
 - Dealing with uncertainty in projections
 - Validated confidence statements (including through observations)
 - Fit for purpose models and model ensembles
 - Range of downscaling methods (dynamical and statistical), including multiple limited area modelling (e.g. CORDEX)

- Enhance (GCM) model development to better simulate Western tropical Pacific climate system.
- Intensity and movement of cold front
- Impact modelling (sector specific)
- Cascading effects (coincidence of extremes)
- Decision support tools (for sectoral risk assessments)
- Application of observed data for model validation and for developing application-ready data
- Support for Pacific networking as part of global modelling community (e.g. ACCESS and CORDEX), with initial focus on better understanding existing model applications and outputs
- Limitations of model outputs and applications (noting spatial and temporal resolution to capture local

effects/finer scale outputs and existing projections data is often too coarse resolution to inform climate change services for NMS/sectors; (e.g. test new rainfall predictors in SCOPIC, oceanic and atmospheric parameters. See if they can be used alongside the usual Niño3.4)

- Detection and attribution of extreme events & impacts
- Guidance materials for understanding and applying climate change science
- Pacific IPCC engagement and authorship of publications with emphasis on enhanced Pacific contributions in co-authorship of scientific articles according to national institutional research guidelines

Traditional knowledge

The ability of our Pacific communities to understand, record, forecast weather and climate in the past through traditional means, has been an important factor for successfully responding to seasonal variability and extreme weather and climate events.

This pillar focuses on mainstreaming and integrating traditional knowledge (TK) with climate science, knowledge brokering and research. The legacy for Pacific TK is to ensure that it contributes in a meaningful way to decision making and planning, policies, adaptation measures, sustainable development and climate change resilience.

Gaps and needs

- Mainstreaming and integration
 - Collection:
 - Protocols (incl. consent forms)
 - Management of TK intellectual property (incl. cultural sensitivity, commercialisation, etc.)
 - Storage, monitoring and validation
 - Citizen science approach to monitoring and validation, plus supplementing TK and science observations
 - Documenting existing TK for communication and knowledge brokering
 - Reconciling TK with science, including validation and harmonising learnings, detection and attribution, etc.
 - Integrating TK and science to facilitate outreach
- Policies - policies that directly help to promote maintenance and restoration of living TK systems as sources of social-ecological resilience.
- Knowledge brokering and communication
 - Translation (where possible) into local languages – including vulnerable groups (women, children and those with disabilities)
 - Platforms and mediums
 - Inclusion of TK into project design
 - Facilitating linkages (e.g. between climate and TK scientists, between science and adaptation specialists, etc.)
 - Sharing TK best practices (e.g. at regional meetings)

- Research
 - Demonstration-style case studies and communication products and tools for:
 - outreach/awareness raising
 - capacity development/inter-generational knowledge transfer
 - Environmental indicators of ecosystem changes (e.g. plants, animals, oceanic, navigational, atmospheric, astronomical, landscapes, etc.)
 - TK coping (adaptation) strategies – linking indicators of ecosystem change and TK adaption management.
 - Time lapse – indicators (what indicators are changing which are not)
 - PhD students to work with NMHSs and local communities to address gaps, collect data, monitoring, verification and integration.

Capacity development

Capacity development refers to investment in people, practices, policies and institutions to stimulate and systematically develop capacities in the other pillars of this Roadmap.

This pillar focuses on target groups for climate change science and services research and by association their capacity development needs and how these needs can be strengthened. These target groups include communities, National Meteorological and Hydrological Services, sectors, government ministries and partners, private sector, and regional agencies.

Gaps and needs

- Human resource capacity – equipping individuals with the knowledge, skills, tools and training to enable them to generate research and communicate and use decision-relevant climate information
- Infrastructure capacity – enabling access to the resources that are needed to implement infrastructure to generate, archive, quality control, communicate, exchange and use climate data and decision-relevant information and products, including on the supply side instruments for observing networks, data management systems, computer hardware and software, internet access, communication tools, manuals and scientific literature, with similar things on the demand side but potentially much more diverse
- Create programme such as – research internship programs, young scientists
- Programs for officers from national met services.
- Procedural capacity – defining, implementing and advancing best practices for generating and using climate change information
- Institutional capacity – on the supply side elaborating management structures in the NHMSs for climate change research, processes, policies and procedures that enable effective research, not only within organizations but also in managing relationships between the different organizations and sectors (public, private and community, including international collaboration) with similar requirements on the demand side but once again more diverse.

Climate change services

Climate change services are the primary means by which science-based climate change data and information is turned into knowledge, and then by outreach mechanisms into on-ground impact for those stakeholders.

This pillar focuses on the products and mechanisms required for the effective delivery of climate change services in the Pacific.

Gaps and needs

- Application-ready data sets that:
 - are sector specific (e.g. hazard maps for agriculture, tourism, health, etc.)
 - include sector-specific impact projections, i.e. are useable, 'top-down' products
 - include a range of plausible climate futures
 - use a reliable and accessible medium to deliver and display products/data
 - translate to simple productions and local languages
 - communicate uncertainty in climate projections in a non-technical way
- Educational materials for school curriculum at primary and secondary level
- Technical/non-technical guidance materials that:
 - focus on access to and application of the science by end-users
 - use case studies to demonstrate applications
 - separate materials by target groups (e.g. sectors, communities, policy makers, fishermen farmers, etc.)
 - capture past experiences to allow sustainability of ongoing activities/projects, and build up work
 - guide education and teaching around technical science and linkage to TK
 - follow a two-way process (up and down technical/non-technical)
 - document climate change science mainstreaming at sectoral level.
- Decision-support tools (online, desktop and mobile applications) including:
 - use of flow chats
 - Interactive tools/maps
 - tools that give reference to geo-position on local scale
 - tools that explore integrated options for planning/adaptation/mitigation.
 - Technical trainings – computer programming skills are essential for post-data processing of climate change since data. E.g. R, python, (open source tools).
- Communication collateral including:
 - visualised data, fact sheets, posters, brochures, manuals, summary reports
 - videos, digital images/simulations
 - radio programmes for isolated communities
 - face-to-face communication, including climate change science awareness (discussions, presentations, etc.) with communities, decision makers, sectoral practitioners such as farmers, fishers, engineers, policy-makers, etc.
 - local language translations.
- Journal papers and special technical reports documenting:
 - climate change science-based information relevant to the needs of Pacific Island countries (to be linked to relevant provisions of the TK and capacity development pillars)
 - Pacific Islanders collaborating with international partners in research activities and then on purpose to allow regional lead authors and co-authors capacity building (e.g. through attachment) with PCCC, SPREP, etc.

- Regional coordination through existing institutions (e.g. USP, SPREP) to promote Pacific Island country research findings and other relevant documented findings at international negotiation or at IPCC.
- Scenario analysis that is:
 - sector and location specific
 - over relevant timescales, including short-term (current climate change), medium term (to 2030) and longer term (2030 to 2100)
 - indicative of both range and most plausible future climate
 - inclusive of mean and extreme condition, including coincidence of extremes (cascading impacts)
- Inputs to climate change hazard analysis, vulnerability, risk/impact assessment for:
 - national and sectoral level assessments
 - stocktake of existing assessments, reports, etc. to identify priorities, hotspots before any new assessments/analysis
 - inclusion of different climate change science-based scenarios to ascertain the need (or otherwise) for mitigation purposes
 - different levels of assessment (rapid/first pass to more detailed/comprehensive) at sectoral level.

Data and information management

Climate change science and services research is for the most part conducted to raise awareness, enhance understanding and to inform policy development, planning and associated decision-making. This is not possible in an effective and efficient way if the relevant data and information are not shared widely with end-users, with an emphasis on discoverability, accessibility, understanding, applicability (relevance and usefulness), credibility/legitimacy.

This pillar plays a critical role in ensuring sharing, application, storage and associated long-term archiving of data/information for the benefit of both providers and users.

Gaps and needs

- Management arrangements:
 - Data must be available first before integrating, and there is a need to undertake an audit to identify all available sources of climate change science and services data and information
 - Strengthening existing regional portals developed and managed for climate change analysis and reporting as part of routine business and climate change-related projects, programs and other initiatives
 - Review status (capacity/capability) of NMHSs in relation to integrated knowledge management systems, in particular to identify agreements and relevant processes and protocols to follow for sharing of data and information (noting links to data content of PIMS)
 - Increase emphasis on strengthening sharing of open-source data by NMHSs with existing portal(s), noting however that there are challenges as often no-one is assigned to do the task; need to define appropriate roles and responsibilities
 - How to resource, who resources, opportunities for other partners/sectors to get involved and

- collect data and make available (e.g. aviation, navigation etc)
- Digital data storage and management (desktop & mainframe):
 - Need for online 'self-help' tools including technical training and guidance to do analysis and to produce needed products
 - Accessing raw data is a challenge to some extent, including limitations of data digitisation, how to find/access raw data, managing large raw data sets, infrastructure needs to store and process data etc
 - Data to be provided under different signpost/headings to assist users on
- where to access which data to enhance accessibility.
- Computing and communications infrastructure:
 - Build capacity of locals to run climate models and storing of data for use by different groups of people, including researchers, PhD students, technical specialists etc
 - Greater emphasis on desktop systems capacity (software, hardware, personnel) to run model applications to inform national/sectoral needs

Governance: oversight and administration

This pillar describes the proposed governance arrangements for the oversight and coordination of the Roadmap implementation and management in a way that is inclusive of all stakeholders and which is complementary to and aligned with other relevant regional strategies, frameworks and initiatives which collectively address the climate change science and service research needs of Pacific stakeholders. These include in particular:

- The Framework for Resilient Development in the Pacific (FRDP) and the associated governance arrangements through the Pacific Resilience Partnership (PRP)
- The Pacific Meteorological Council (PMC), the Pacific Islands Meteorological Strategy (PIMS) and expert panels of the PMC
- The proposed functions of the new Pacific Climate Change Centre (PCCC) and the existing WMO RAV Pacific Islands Regional Climate Centre (PI-RCC) presently in demonstration phase;
- The Pacific Roadmap for Strengthen Climate Services (PRSCS) 2017-2026

Gaps and needs

- Action plan development and reporting:
 - How to prioritise specific actions for climate change science and services research at national/sub-national (sectoral) level
 - Provision of guidance for national climate change focal points and donors
 - Initial focus on better use of existing climate change science products/services to facilitate
- sectoral engagement (including all existing programs)
- Facilitating enhanced Pacific engagement of the IPCC for the sixth assessment report, with initial emphasis on increased contributions from Pacific Island authors and increased content directly relevant to the Pacific Islands context.
- Using existing country mechanisms for monitoring and evaluation reporting, engagement, etc.; also need a nominated

- country focal point to drive the Roadmap including enhancing/empowering existing sectoral climate change focal points to make a start (i.e. optimise use of existing resources and support, including from existing delivery partners where appropriate)
- Communicating the important role of key stakeholders at all levels (regional, national, sub-national) in the governance arrangements, including:
 - the specific role of regional and national universities (e.g. facilitation of retention of graduates in the Pacific, flow of research data and information from graduate/post-graduate students to NMHSs and sectors etc)
 - identification of advocates/focal points for the Roadmap to build a climate change science and services research community of practice incorporating technical specialists from throughout the knowledge value chain
 - Clearly defining the role of the Pacific Met Desk Partnership in provision of secretariat support for the Roadmap, noting existing limitations on capacity within NMHSs
 - Developing and implementing due diligence arrangements for new and existing projects to avoid duplication and to realise synergies using:
 - standardised templates for brief descriptions (metadata), including abstract, timelines, key contacts, etc.
 - stepwise guidance for new projects/activities to facilitate engagement, coordination, collaboration, cost-efficiencies, data access, etc.
 - protocols for managing Pacific IP including TK in the delivery of the Roadmap.
 - Developing the Roadmap's principles of engagement to include the need for 'improved' sharing of resources, expertise and data between countries, facilitating linkages, synergies etc. across government at national level to improve services; noting also 'ownership' issues of data, IP and the role of relevant existing MOUs, agreements, protocols etc as to how these arrangements work re data sharing/mobilisation and how this works in each country
 - Putting the Roadmap in place in the 'Pacific Way'.
 - Collaboration with regional academic institutions such as USP, FNU to engage interested research postgrad students in research topics that are of regional interest.
 - Clear mechanism for linking sectors and meteorological services at national levels, and so regional levels.

Next steps/for more information

It is intended that the Action Plan referred above will be developed on a consultative basis through the existing PMC/expert panel process and associated regional stakeholder network, perhaps aligned with the biennial meetings of the PMC (TBC). In the interim, initial priorities for implementation of the Research Roadmap are likely to include:

- Enhanced Pacific engagement of the IPCC 6th Assessment Report process, including facilitating the preparation and publishing of relevant IPCC Working Group I and II science-based information in the peer-reviewed literature for citation in AR6, with specific emphasis on increasing the level of Pacific Islander authorship, and
- Development of the 'next generation' of CMIP6 climate change projections for the Pacific for purposes of updating the existing published climatology for the region and partner Pacific Island Countries to ensure best available, internationally bench-

marked scientific data and information is available for application by all relevant stakeholders

For more information on the further development and implementation of the Research Roadmap, including the proposed Action Plan, please contact:

Pacific Met Desk Partnership, SPREP