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#1

Climate Change and Freshwater in the Pacific

Adapting to global change in the freshwater and sanitation sector

"Better water, better life, better world" *

IRD Institut de recherche pour le développement

DLR

SPC Secretariat of the Pacific Community
CPS Secrétariat général de la Communauté du Pacifique

ministry of science + innovation
TE PŪNAHA HIRINGA WHAKAEA

APRE Agenzia per la Promozione della Ricerca Europea

MCST Malta Council for Science & Technology

ANU The Australian National University

USP The University of the South Pacific

euro Research Support

Key Messages

- The UN General Assembly, supported by many European Union (EU) countries, called on Members to provide developing countries with resources, to build capacity and transfer technology, in order to provide safe, clean, accessible and affordable drinking water and sanitation for all. The majority of PICTs will not meet the Millennium Goals for water and sanitation by 2015, largely due to capacity and resource constraints. This will constrain economic and social development.

- The large donor programmes in water and sanitation in the Pacific have had limited success and require a more comprehensive knowledge base for higher impact.

- Despite projected climate-change related sea level rises in the Pacific, non-climate factors pose greater risks to water security than climate-change out to year 2030, even for high CO2 emission scenarios. The most vulnerable areas are densely populated urban and peri-urban settlements, remote communities, and communities in low-lying islands. These should have high priority for research, development and innovation projects.

- Available freshwater in PICTs is coupled to large-scale ocean-atmosphere interactions.

- Some challenges in freshwater and sanitation in PICTs are common to developing countries elsewhere in the world. Others are unique to the Pacific and involve the complex and diverse interactions of their remoteness, geography, hydrogeology, climate, social, cultural, and economic contexts, and their limited capacities and resources to respond to challenges and tensions as communities move from subsistence to developed economies. The unique setting of each PICT means that the largest unit suited to a consistent approach is the country level.

- Concerted, interdisciplinary knowledge-based approaches are necessary for developing sustainable, solutions to the complexity of PICTs severe ENSO-related droughts floods, cyclones, population growth, development, urbanisation, land use change, waste production, governance failures and predicted climate change impacts.

- Island communities have sound local institutions, resilient social systems, are sensitive to environmental change and have a high degree of equity. These, with their kinship-based, trans-national networks, form a limited capacity to adapt to threats and change. This capacity can be greatly enhanced by scientific networks and research partnerships involving regional and European researchers with complementary skills linking into already established regional networks and bi-lateral research partnerships. The focus of networks and partnerships should be on sustainability, adaptation, innovation and capacity building.

- A consortium between European, regional and local actors is the most effective way of carrying out the proposed research programme through a series of small, up to three-year, pilot projects in selected high priority locations in an initial design phase for scaled-up projects.

- The investments proposed here that will help PICTS meet Millennium Development Goals, adapt to global change and ensure economically sustainable development, are:

    - Effective and efficient ways to develop and translate water and sanitation policy and plans into accepted community practice;
    - Understand and manage water availability and quality and adapt to global and local change in vulnerable island environments;
    - Develop innovative technologies to enhance management, use, conservation, monitoring, and analysis of freshwater systems in dispersed, remote islands;
    - Develop innovative coupled renewable energy – water supply and storage systems and distributed energy systems, in small, remote islands; and
    - Increase the impact of large donor water and sanitation programmes by identifying and addressing knowledge gaps and cultural, social, technological, institutional and scale mismatches between donor and recipient countries.

Abstract

The United Nations (UN) resolved in 2010 that access to adequate, safe freshwater is a basic human right. Many Pacific island countries will not meet the Millennium Goals for water and sanitation. These vulnerable and very diverse Pacific island counties and Territories (PICTs) face unique challenges in sustainable development, especially in water and sanitation. Access to and the availability of safe freshwater and appropriate sanitation are continuing, highest priority concerns for communities and industries. These are reflected in unacceptably high incidences of water-borne illnesses and deaths. While island communities have shown remarkable resilience to change over the past 4,000 years, recent challenges are escalating with development, population growth, increasing urbanisation and changed land use. These are likely to worsen with the impacts of climate change, especially rising sea-levels and temperatures. Even now, frequent, severe El Niño-Southern Oscillation (ENSO)-related droughts, floods, as well as major cyclones disrupt safe freshwater supplies. Regional policy frameworks focus on economic growth, sustainable development, good governance and security. At national levels, however, water governance is generally poor and the capacity and resources available within most PICTs restrict their ability to respond to current challenges.

Island communities have remarkable local strengths. The pooling and sharing of knowledge and experience through regional agencies and wider networks involving Europe provides additional support. Building on these, targeted, integrated research provides the basis for: increasing knowledge of the interaction of climate drivers and water resources; improving governance and management; developing capacity and skills; establishing sustainable and safe water supply and sanitation systems; sustaining economic development and adapting to global change. In addition, investments in water and sanitation research proposed here will improve the effectiveness of donor and aid programmes and assist Pacific island countries to fulfil their international, regional and national obligations and to adapt to global change.

* Chorus of 2010 Nauru World Water Day jingle composed and sung by 10 year old Angle Halstead from the Republic of Nauru.

Significance of the Sector

Freshwater is crucial for sustainable human and economic development in all sectors and in our supporting ecosystems. Its scarcity is increasing globally while water quality is declining with population growth, development, urbanisation, and environmental transformation (UNWWAP, 2006). Climate-change is predicted to exacerbate the vulnerability of water resources and the risks to supplying adequate safe freshwater through increases in temperatures, sea levels and the frequency of extreme events. This is especially so in PICTs.

Safe Freshwater, a Basic Human Right

In recognition of these challenges, the UN General Assembly in 2010 adopted a resolution, with strong support from many European Union (EU) and Pacific island countries, calling on States and international organisations to provide financial resources, build capacity and transfer technology, particularly to developing countries, in scaling up efforts to provide safe, clean, accessible and affordable drinking water and sanitation for all (UN, 2010). This resolution recognised access to safe and adequate supplies of water and sanitation as a basic human right. In line with the Millennium Development Goals, the Assembly expressed deep concern that over 880 million people were without access to safe drinking water and more than 2.6 billion lacked access to basic sanitation. It was alarmed that 1.5 million children under five years old died each year as a result of water- and sanitation-related diseases, and acknowledged that safe, clean drinking water and sanitation were integral to the realisation of all human rights. In developing states in the Pacific, infant death rates due to diarrhoeal diseases are unacceptably high compared with developed economies in the region (Figure 1).

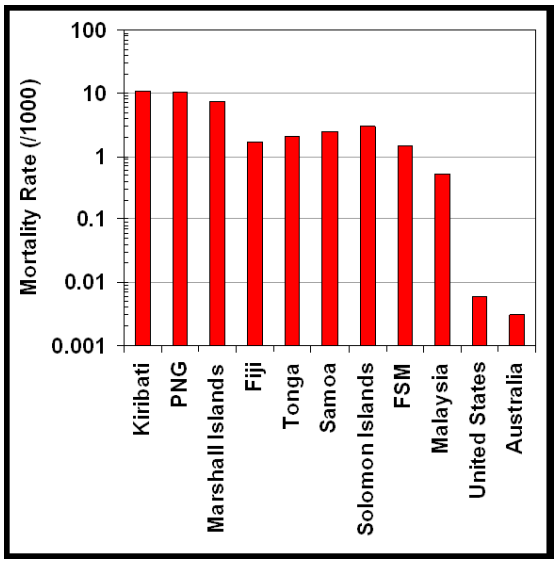

Figure 1. Comparison of infant (<5 yrs) mortality rates per 1000 due to diarrhoeal diseases for selected Pacific countries (data from WHO 2005a)

Access to Safe Freshwater in the Pacific

The poor rates of progress in the Pacific region towards meeting basic human water needs in access rates to improved sanitation and safe drinking water have not improved significantly in the Pacific since 1990 (Duncan, 2011). Recognising this and the unique and vulnerable geographic and physical characteristics (UNDESA, 1994), as well as the fragile nature of water resources in small island countries, the leaders and responsible ministers of 17 PICTs and East Timor endorsed the Pacific Regional Action Plan (RAP) on Sustainable Water Management in 2003 (SOPAC and ADB, 2003). The RAP recognises the fundamental importance of safe freshwater to the health and well-being of Pacific island residents, their environments, agriculture, forestry, animal production and island economies.

Spatial Variability of Island Water Resources

Understanding the extreme spatial variability in water resources across the region is central to appreciating why water is significant in island lives. A summary of the mean annual rainfall of 14 independent self-governing Pacific Island Countries (PICs), Cook Islands, Federated States of Micronesia (FSM), Fiji, Kiribati, Nauru, Niue, Palau, Papua New Guinea (PNG), Republic of Marshall Islands (RMI), Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu and East Timor covering the period from mostly the late 1940s or early 1950s is given in Table 1. This illustrates the wide diversity in rainfall and water sources used in the region. These sources of fresh water range from extremely large, fast flowing mountain rivers in Papua New Guinea, Fiji, the Solomons, Vanuatu, and New Caledonia, smaller streams and coupled groundwater systems in East Timor, Samoa and the Cook Islands, to thin fresh groundwater lenses underlain by seawater in Niue

and Tonga, to vulnerable shallow fresh groundwater lenses in the low lying atolls and islands in Kiribati, Federated States of Micronesia (FSM) and the Marshall Islands, to islands that almost solely have to rely on rainwater harvesting or desalination such as in Fongafale atoll, Tuvalu or Nauru.

The water resources of the PICTs span global extremes, with annual water availability in Papua New Guinea having around 120,000 m^3 per person per year while Fongafale atoll in Tuvalu, some islets in the Gilbert Group in Kiribati and Nauru having no significant, permanent freshwater resources and are reliant on rainwater harvesting and desalination The vulnerabilities in the freshwater and sanitation sector across the region are both varied and complex (van der Velde et al., 2007; While and Falkland, 2011, Falkland, 2011; Duncan, 2011, PSCCP 2011 a,b).

Mean data, however, does not convey the actual situation in the Pacific where rainfalls are subject to frequent ENSO-related extremes, oscillating between droughts and floods and show major spatial variations within larger countries. This variability is reflected in the coefficient of variability (Cv) in Table 1. Of particular note are the extreme Cvs of the two central Pacific counties of Kiribati and Nauru, which are directly impacted by the passage of the Pacific Warm Pool. In these two countries almost all domestic rainwater tanks fail during droughts. The 10-fold variation in the range of mean annual rainfall in PNG illustrates the enormous spatial variability in larger PICTs which presents significant management challenges.

Understanding Temporal Variability of Rainfall

In order to assess why the sector is so significant in PICTs it is important to understand their marked diversity and the extreme spatial and temporal variability of their current climates. Climate and especially rainfall across the region are driven by the large scale Intertropical Convergence Zone, the South Pacific Convergence, the West Pacific Monsoon (Figure 2, the equatorial migration of the Pacific warm pool during El Niño- Southern Oscillation (ENSO) events, which have significant impacts on the distribution of rainfall in the Pacific (Figure 3), and by cyclones. As a result of the migration of the Pacific warm pool, island annual rainfalls, particularly in the central Pacific, such as in Kiribati and Nauru have a strong correlation with sea surface temperatures (Figure 4) and are subject to frequent, long droughts as the Pacific warm pool moves back and forth along the equator due to ENSO oscillations and longer-term variations of

Country	Mean annual rainfall (mm) at the capital	Coefficient of variation (Cv) of annual rainfall at the capital	Range of mean annual rainfall in country (mm)	Main freshwater resources
Cook Is	2,000	0.20	1,800 – 4,500	SW, GW, RW
FSM	4,700	0.12	2,600 – 8,200	SW, GW, RW
Fiji	3,000	0.19	1,500 – 6,000	SW, GW, RW, D (tourist resort only)
Kiribati	2,000	0.47	900 – 3,100	GW, RW
Nauru	2,100	0.54	2,100	D (regular use), RW, GW (limited)
Niue	2,100	0.24	2,100	GW, RW
Palau	3,700	0.13	3,200 – 4,300	SW, GW, RW
PNG	1,100	0.24	900 – 9,000	SW, GW, RW
RMI	3,300	0.15	2,200 – 3,300	GW, RW, D (emergency)
Samoa	2,900	0.20	2,500 – 7,500	SW, GW, RW
Solomon Is	2,000	0.20	1,800 – 9,000	SW, GW, RW
Tonga	1,700	0.24	1,700 – 2,500	GW, RW, SW (limited)
Tuvalu	3,500	0.20	2,400 – 4,000	RW (primary), GW (limited), D (emergency)
Vanuatu	2,100	0.27	2,000 – 4,000	SW, GW, RW
East Timor	900	0.32	700 – 3,000	SW, GW, RW

Table 1. Summary of the rainfall characteristics of independent, self governing Pacific Island Counties and East Timor over the past 50 to 65 years (Falkland, 2011).

Annual rainfall to nearest 100 mm. Cv = standard deviation/mean. RW = rainwater, GW = groundwater, SW = surface water, D = desalination.

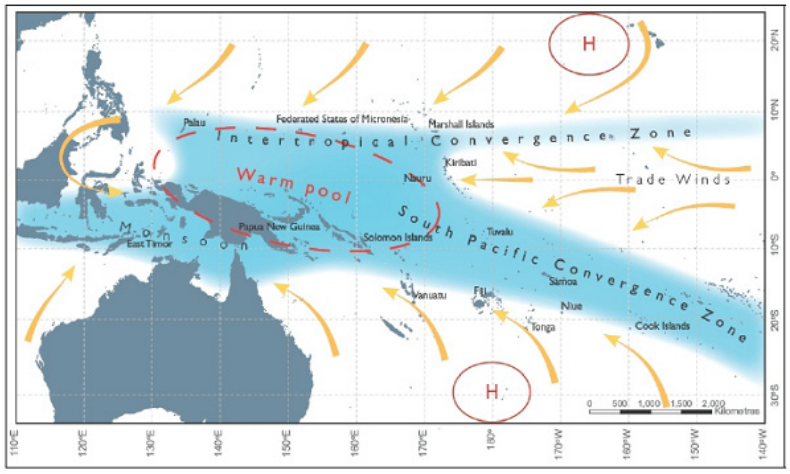

Figure 2. The main climatic features, Intertropical Convergence Zone, South Pacific Convergence, the West Pacific Monsoon and the Pacific warm pool in the November to April period in the Pacific (PCCSP, 2010).

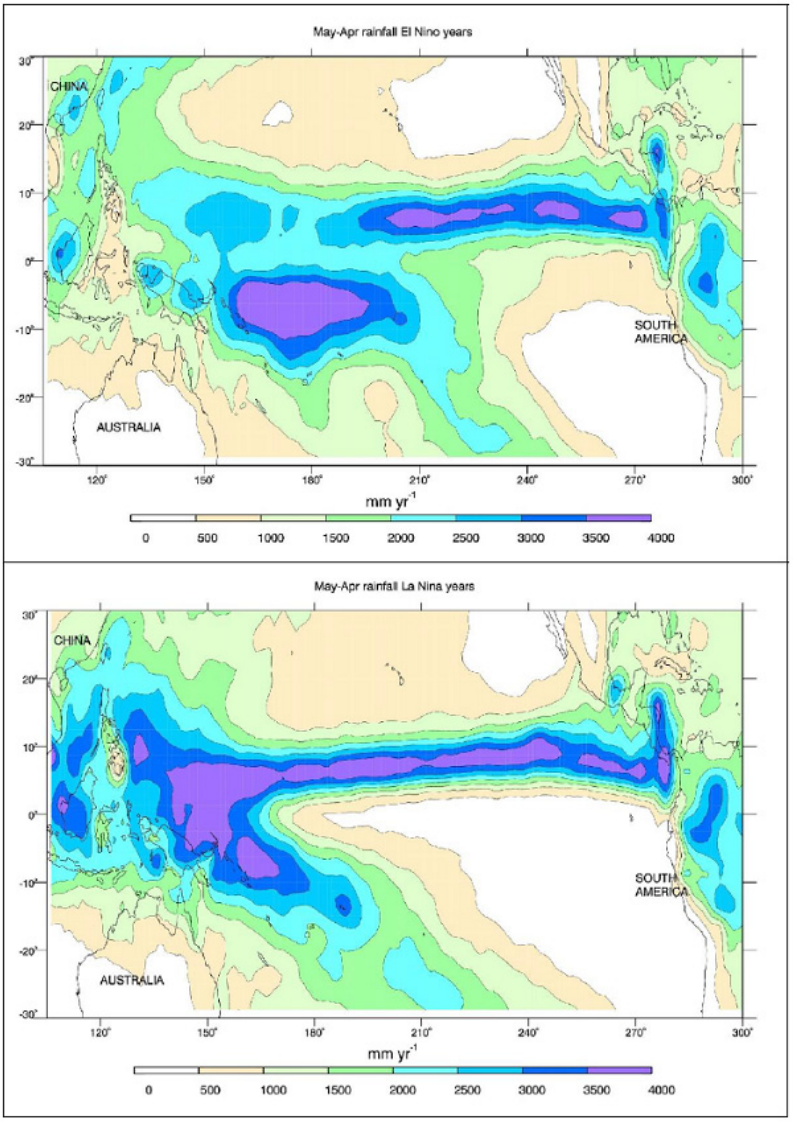

Figure 3. Distribution of mean annual (May to April) rainfall in the Pacific during El Niño (top) and La Niña (bottom) events for the period 1979 to 2008 (Falkland, 2011).

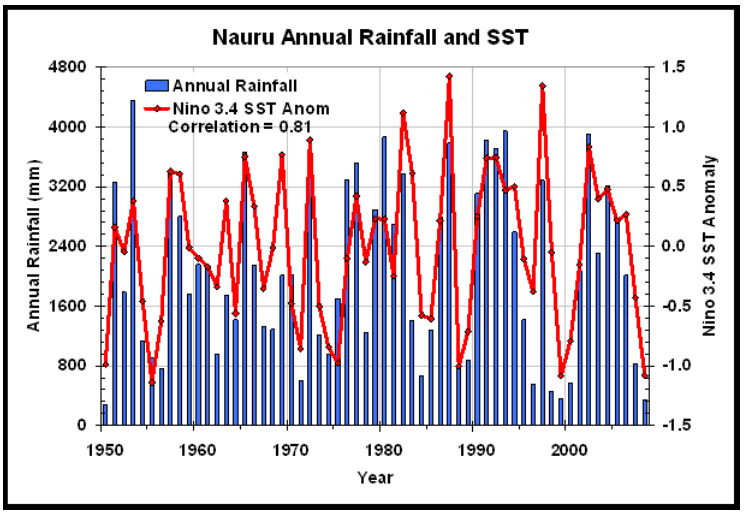

Figure 4. Strong correlation between the large variability of annual rainfall in the central western Pacific island nation of Nauru and the variability of annual sea surface temperature (SST) anomaly in Niño 3.4 region of the central-western Pacific (White and Falkland, 2012b).

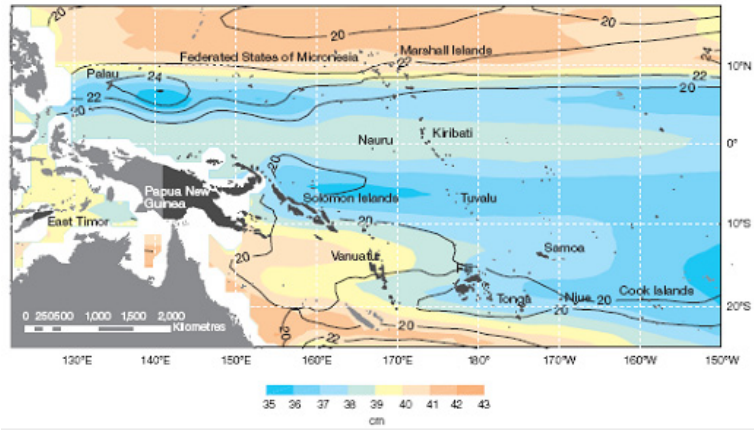

Figure 5. Projected sea level rises in the Pacific for 2030 due to global warming (ABoM and CSIRO, 2011).

the Interdecadal Pacific Oscillation (IPO, ABoM and CSIRO, 2011a, Kuleshov et al., 2012).

The very strong relation between sea surface temperature, Southern Oscillation Index and rainfall and the amount of groundwater available in many PICs provides a basis for predicting the probability of below average rainfall several months in advance. The SCOPIC program (ABoM, 2012) for independent Pacific island countries is designed to provide seasonal climate forecasts in the Pacific, three months in advance. This is being supplemented using dynamical model-based Predictive Ocean Atmosphere Model for Australia (POAMA, Kuleshov et al., 2012) which has regional relevance. Increasing ocean temperatures, increasing ocean pH and rising sea levels due to global warming are a principal concern, especially the last in low islands where they are a major threat to long-term survival (Figure 5).

Variability, Capacity and External Investment in the Sector

It is widely understood that human existence, economic growth and continued health of environments are all dependent of adequate, safe freshwater. Those dependencies, however are amplified and intensified in PICTs because of the spatial and temporal variability of rainfall, described above and the general limited capacity, resources and understanding. Because of that the significance of the sector has been recognised by major aid and donor programmes, including the European Development Fund (EDF), Global Environment Fund (GEF), UN Development (UNDP), Environment Programmes (UNEP), World Bank (WB), Asian Development Bank (ADB) and bilateral country aid programmes such as AusAID, NZaid and USaid. These have invested heavily in improving access to safe drinking water, appropriate sanitation and strategies for adapting to

variability and global change. The success rates of these large and expensive programmes have been variable and with limited sustainable results. There is an urgent need for research to improve their effectiveness and to contribute to capacity building (White and Falkland, 2011).

Regional and National Policy Frameworks

Pacific Islands Forum

The Pacific Islands Forum (PIF) consists of 16 independent and self-governing Pacific states: Australia; Cook Islands; Federated States of Micronesia; Fiji; Kiribati; Nauru; New Zealand; Niue; Palau; Papua New Guinea; Republic of Marshal Islands; Samoa; Solomon Islands; Tonga; Tuvalu and Vanuatu. New Caledonia and French Polynesia are Associate Members and Forum Observers include Tokelau, Wallis and Futuna, the Commonwealth, the United Nations, ADB, and WB, with Timor Leste as Special Observer. The PIF formulates regional policy directed at stimulating economic growth, enhancing political governance and regional security , and strengthening regional cooperation and integration.

The Pacific Islands Forum Secretariat (PIFS) supports PIF policy development. Policy implementation occurs through the 10 members of the Council of Regional Organisations in the Pacific (CROP), including Secretariat of Pacific Communities (SPC), the Secretariat of the Pacific Regional Environment Programme (SPREP) and University of the South Pacific (USP). The Applied Geoscience and Technology Division (SOPAC) of SPC has principal responsibility for water resources while SPREP has lead responsibility for climate change and environment programmes. These CROP agencies as well as regional non-government organisations (NGOs) are important in supporting national agencies in member countries.

The PIF Leaders' vision is for a region of peace, harmony, security, economic prosperity, where diversity of the Pacific cultures, traditions and religious beliefs are treasured and good governance is exemplified. Key components of the vision are: Sustainable management of resources; observance of democratic values; and forming of partnerships with neighbours and beyond to develop knowledge and ensure a sustainable economic existence (PIF, 2004).

To give effect to this vision, the PIF developed the 2005 Pacific Plan as the principal focus of the Forum and its Secretariat (PIF, 2004) to underpin key regional sectoral policy frameworks.

The Pacific Plan

The 2005 Pacific Plan for Strengthening Regional Cooperation and Integration (Revised 2007; PIFS, 2007) identifies regional priorities under the four key goals: economic growth; sustainable development; good governance; and security. Actions identified under Economic Growth of relevance to water and sanitation are: *improved efficiency and effectiveness of infrastructure development and associated service and delivery; and increased private sector participation in, and contribution to, development*.

Actions within the Sustainable Development goal directly relevant to water include development and implementation of: *National Sustainable Development Strategies …in line with the Millennium Development Goals; the Pacific Regional Action Plan on Sustainable Water Management; policies and plans for waste management; and international financing for sustainable development, biodiversity and environmental protection and climate change in the Pacific; and adaptation and mitigation efforts linked to the Pacific Climate Change Framework 2006-2015…; including public awareness, capacity building and improving governance, risk and vulnerability assessments.*

Under the Good Governance goal activities pertinent to water include: *enhance governance mechanisms, including in resource management; upgrade and extend country and regional statistical information systems and databases across all sectors; and develop a strategy to support participatory democracy and consultative decision-making.* Finally under security there are two actions relevant to water: the development and implementation of: *policies and plans for the mitigation and management of natural disasters; and plans for urbanisation.*

It is significant that in the list of regional priority actions in the Pacific Plan, climate change is viewed as

a subset of the broader and more immediate goal of sustainable development.

The Pacific Regional Action Plan on Sustainable Water Management

The Pacific Plan specifically calls for implementation of the 2003 Pacific Regional Action Plan (RAP) on Sustainable Water Management (SOPAC and ADB, 2003). The RAP was developed after wide-ranging, multi-stakeholder, national consultations held throughout the region. The RAP, endorsed by all member countries in 2003, identified priority actions under six themes:

I. Water Resources Management;
II. Island Vulnerability;
III. Awareness;
IV. Technology;
V. Institutional Arrangements; and
VI. Finance.

It outlined the needs of the water and sanitation sector to cope with current and future pressures on often limited water resources caused by increasing populations, development, non-climate hazards, as well as climate variability and climate change.

Actions identified in the RAP focussed on using integrated water resource management to:

- improve the knowledge base;
- identify appropriate water extraction and treatment technologies;
- increase capacity;
- introduce risk assessment and management;
- engage communities in co-management at all levels;
- disseminate information;
- improve water governance;
- promote regional cooperation;
- reduce water demand, wastage and unaccounted losses;
- protect water sources; and
- ensure water supply and sanitation systems are sustainable.

These actions remain as relevant today within most member states as they were in 2003.

The Pacific Framework for Action on Drinking Water Quality and Health

In parallel with the RAP, Ministers of Health for the Pacific Island Countries called upon Member States, national, regional and international partners to strengthen national drinking water quality standards and monitoring capabilities. The World Health Organisation (WHO) Workshop on Drinking Water Quality Standards and Monitoring in Pacific Island Countries (Nadi, Fiji; 7-10 Feb. 2005) developed the Pacific Framework for Action on Drinking Water Quality and Health (WHO, 2005b). The Framework was designed to support the implementation of drinking water quality actions envisioned in the overarching RAP. It provided 21 recommendations under the 6 RAP themes:

1. Protection of water sources such as springs, rivers, groundwater and rainwater catchments from contamination and overuse must be a priority to ensure quality.
2. Technical support should be provided to develop national drinking water quality standards that are dynamic and implemented in stages as necessary.
3. The use of Water Safety Plans should be encouraged in the Region, and countries should be supported with manuals, guidelines and training on the use and implementation of this tool.
4. Effort should be expanded at regional and national level to assess risks posed by toxic chemicals and pathogens in drinking water.
5. Human resources should be developed for drinking water safety, including drinking water quality monitoring, data management and information systems.
6. Research should be promoted and supported, and the scientific knowledge base should be strengthened to support the development of effective, efficient, and equitable policies and plans related to drinking water quality and health.
7. Emergency preparedness plans should adequately address drinking water quality issues, and water safety plans should address risks posed by potential emergencies.
8. The fragile environments of very small islands and their role in managing source water quality and quantity should be respected and protected.
9. Human resources should be developed to strengthen countries capacities for raising com-

munity awareness related to water quality and health risks, source water protection, household-level water treatment and safe storage.
10. Community awareness and community-based action programmes on safe water supply and sanitation should be developed and expanded in rural and remote areas and in urban areas alike.
11. Community-based water quality testing and source protection programmes should be supported in rural and remote areas as well as in urban areas.
12. Government awareness should be raised and political commitment should be strengthened to support actions for safe water supply and sanitation.
13. Technical assistance and training should be provided for strengthening drinking water quality management, including monitoring, operation, calibration and maintenance of any related equipment.
14. Adequate equipment for drinking water quality management should be provided.
15. Research should be supported to develop appropriate field-test kits for use in remote and rural areas.
16. Adequate equipment for water and wastewater treatment should be provided.
17. Rainwater harvesting programmes should be supported by improving water quality through approaches such as "first-flush" devices and community-based water quality testing.
18. National and regional partnerships should be built to develop standards and guidelines and legislation in order to ensure provision of safe drinking water, and to establish national water quality committees that could oversee development of water safety plans.
19. Communication and information exchange between agencies involved with water quality data collection should be strengthened. This should include exchange and joint analysis of drinking water quality data and disease surveillance data between water supply agencies and health authorities.
20. Governments should, as a priority, develop and implement appropriate financial mechanisms to support sustained supplies of safe drinking water and sanitation services to both rural and urban communities to fulfil the MDG targets.
21. External agencies should be encouraged to support specific activities in the region where governments are unable to sustain provision of safe drinking water and sanitation services.

These recommendations on drinking water quality reflect both the extent of the problems faced in the region and the level of concern over water quality.

Pacific Islands Framework for Action on Climate Change 2006-15

The Pacific Islands Framework for Action on Climate Change (PIFACC) 2006-2015 (SPEP, 2005) recognises that climate change and sea level rise present significant risks to the sustainable development of PICTs and that, in the long-term, they may threaten the very existence of some. The goal of PIFACC is to ensure Pacific island people build their capacity to be resilient to the risks and impacts of climate change by: implementing adaptation measures; enhancing governance and decision making; improving understanding of climate change; building up education, training and awareness; contributing to global greenhouse gas reduction; and, forming partnerships and enhancing cooperation. PICTs' recognise that the implementation of PIFACC is complementary to international sustainable development strategies such as the Mauritius Strategy, Agenda 21 and the Johannesburg Plan of Implementation (JPI), as well as the achievement of the internationally agreed development goals, including those in the Millennium Declaration.

Global Climate Change Alliance: Pacific Small Island States, 2011-14

The EU's Global Climate Change Alliance (GCCA), established in 2007 aims to strengthen dialogue, exchange experiences and cooperation on climate change with developing countries most vulnerable to climate change, especially small island developing states. SPC and the EU are supporting the Cook Islands, FSM, Kiribati, the Marshal Islands, Nauru, Niue, Palau, Tonga and Tuvalu to address adverse impacts of climate change through the Global Climate Change Alliance: Pacific Small Island States (GCCA:PSIS; SPC, 2012) focusing on four areas:

1. Supporting countries to mainstream climate change into national and sector response strategies;
2. Implementation of national adaptation activities;
3. Enhancing climate change information exchange with PICTs; and
4. Building regional capacity to deliver adaptation finance and technical assistance.

This €11.4 million project will also support countries in development of planning processes.

SPC Applied Geoscience and Technology Division (SOPAC) Strategic Plan 2011-15

As part of its transition from an independent Commission to a Division of SPC, SOPAC developed a regional strategic plan for 2011-15 (SPC-SOPAC, 2010). SOPAC's goal is: *Apply geoscience and technology to realise new opportunities for improving the livelihoods of Pacific countries.* Its purpose is to ensure PICTs are better able to:

- Monitor and assess natural resources, systems and processes;
- Develop, manage and govern their natural resources; and
- Manage vulnerability and risks in their countries.

SOPAC's four key result areas are:

1. Natural resources, systems and processes monitored and assessed.
2. Natural resource developed and managed and governance strengthened.
3. Vulnerability and risks managed.
4. Service into Member Countries and the Division efficiently and effectively delivered.

The first three are delivered through three technical work programmes:

1. Oceans and Islands;
2. Water and Sanitation;
3. Disaster Reduction.

The Water and Sanitation Programme component of the strategic plan identified a number of critical issues including:

- The uniquely fragile water resources of PICTs and their vulnerability to natural hazards;
- Unsafe and inadequate water supplies;
- Pressures of increasing demand, urbanisation and economic development and pollution of water sources;
- Health impacts of water and sanitation systems;
- Impaired governance and resource monitoring and assessment;
- Limited community engagement;
- Potential impacts of climate change.

SOPAC's Water and Sanitation Programme is structured to address these critical issues through the three key technical result areas.

Pacific Regional Environment Programme (SPREP) Strategic Plan 2011-15

The mandate given to SPREP when it was established in 1993 is: *to promote cooperation in the Pacific region and provide assistance in order to protect and improve its environment and ensure sustainable development for present and future generations*. SPREP's 2011-15 Strategic Plan (SPREP, 2010) identifies four priorities with a range of corresponding strategies relevant to the water sector:

1. Climate change
   - Provide support for developing and implementing appropriate adaptation and disaster risk reduction measures;
   - Strengthen cooperative partnerships and engagement;
   - Enhance and build capacity for applied research on meteorology, climatology and oceanography;
   - Develop and implement education, awareness and communication strategies;
   - Promote low-carbon development, and renewable energy and energy efficient measures.

2. Biodiversity and ecosystem management
   - Promote and support management and conservation of island, coastal and marine ecosystems.

3. Waste management and pollution control
   - Support legislation, regulation, financial instruments and education campaigns for minimising pollution and managing wastes;
   - Encourage collection analysis and reporting of data on waste, hazardous chemicals and pollution;
   - Build capacity to implement waste, hazardous chemical and pollution control.

4. Environmental monitoring and governance
   - Strengthen national policy frameworks and implementation processes for environmental governance;
   - Strengthen national environmental legislation with a focus on adaptation and mitigation measures;

- Support mainstreaming of environmental governance policies and initiatives related to climate change, sustainable biodiversity, ecosystem and waste management;
- Strengthen capacity at national and regional levels to implement effective environmental monitoring and assessment processes;
- Develop a regionally appropriate State of Environment reporting programme.

There are common themes in the strategic plans of both SOPAC and SPREP:

- The fragile and vulnerable nature of PICT environments;
- The need for improved monitoring and assessment;
- The need for improved governance, capacity building and community engagement;
- Hazard risk reduction and adaptation to climate change; and
- Sustainable development.

National Sustainable Development Strategies and Visions

At the national level, PICTs are also taking action to address climate change through national sustainable development strategies, vision statements or their equivalent which are linked to national budgetary, planning processes, Ministry Operational Plans (MOPs) and are consistent with Millennium Development Goals (MDGs) and the JPI. Most island countries in the Pacific have now developed intermediate to long term sustainable development plans, strategies and vision statements, such as the Papua New Guinea Vision 2050 (GoPNG, 2011) and the Nauru National Sustainable Development Strategy 2005-2025 (GoN, 2009a) or shorter term development strategies, such as the Strategy for the Development of Samoa 2008-2012 (GoS, 2008).

In many of these, water is included under themes such as infrastructure and utilities, environmental sustainability, or disaster risk reduction. Goals such as: *Increase access to clean water and sanitation; Develop and improve infrastructure for safe water supplies and sanitation; Protection of freshwater sources; Increase hydropower production; Improve water governance; address climate change and disaster management;* and *Enhance capacity and resources* are common in water sector components of the strategies.

The strengths of these national strategies are that they: are linked directly to national budgetary, planning processes, and MOPs; have measurable performance targets; and identify agencies and organisations responsible for implementation. In reviews of MOPs and the strategies, however, it is often found that progress is severely limited by restricted resources or capacity, especially in the smaller island nations (see e.g. GoN, 2009b). A limitation of many national sustainable development strategies is that water is simply viewed as an infrastructure issue. The all pervasive nature of water and its fundamental importance to the environment, society and the economy is therefore unrecognised, as is the essential role of communities. This contributes to the poor outcomes of some aid and donor sector programs.

National Water Governance Frameworks

Impaired governance is claimed to be the main obstacle to better and more equitable water sharing and improved water supply and services in many water-stressed countries (Solanes and Jouravlev, 2006; UNWWAP, 2006). Governance is one of the four key priorities of the 2005 Pacific Plan (PIFS, 2007) and a strategy identified in the Plan under the Governance priority is: *Improved transparency, accountability, equity and efficiency in the management and use of resources in the Pacific*. This strategy recognises that there are significant challenges in the governance of natural resources in the region which are especially evident in the water sector as identified in the Pacific RAP (SOPAC and ADB, 2003).

Problems identified by the RAP included the general absence of: national government water policy; implementation plans; water resource legislation; and national peak community-government water bodies; as well as the lack of capacity and resources to develop and implement them. Public policy can be viewed as an authoritative response by government to public issues or problems that provides leadership, direction, coordination and resources (Bridgman and Davis, 2004) but in some PICTs policy processes are poorly developed.

While regional policy frameworks can provide broad guidance, the many islands that make up PICTs, each have unique set of water resource, ecological, development and management pressures interlinked with their own cultural, geographical and climatic environments and associated stresses and

vulnerabilities (Duncan, 2011). This means that the largest unit that is suited to a consistent approach is the country level, so national water governance frameworks are critically important and should be the focus of effort.

A summary of the current state progress in water governance in 14 selected independent Pacific Island Countries (PICs) as well as East Timor is shown in Table 2. The absence of national policy, legislation, implementation plans and whole-of-government and community national steering committees in some PICTs means that: government priorities in the sector remain unspecified; resources are not directed towards particular needs; the roles and responsibilities of government agencies are not clearly defined; and, in many cases, there is no legal protection for water sources (White and Falkland, 2011). In addition, there is a general absence of peak national water and sanitation bodies made up of members drawn from relevant Ministries, agencies and community organizations to advise government.

Several of the countries in Table 2 have had draft water policies, plans and legislation, prepared with external assistance, for several decades but these have not been submitted to parliament for consideration and endorsement. Despite regional goals and national development strategy goals, there is a general reluctance to endorse national water policies and plans, enact national water legislation, define rights and responsibilities, adopt whole-of-government approaches, and involve communities in planning and managing water and related land resources. This appears to be partly due to: capacity and resource limitations; poorly developed or absent policy process; and the politically sensitive customary property rights of landowners over water (White et al., 1999; White and Falkland, 2012 a).

Attempts to propose adaptation strategies in the water and sanitation sector without a clear statement of government priorities and goals in the sector, without clear directions and assignment of responsibilities to agencies, in the absence of plans to implement policy and devoid of the legal underpinning and the force of regulations, and without active community support, are pointless. Establishing the institutional basis for water is a first key step in adaptation.

Country	Water and Sanitation Policy	Water Legislation	IWRM Plans or Similar	National Water and Sanitation Committee or Similar
Cook Is				
FSM				
Fiji				
Kiribati				
Nauru				
Niue				
Palau				
PNG				
RMI				
Samoa				
Solomon Is				
Tonga				
Tuvalu				
Vanuatu				
East Timor				

= Absent
= Draft
= Enacted

Table 2. Summary of water governance progress in 14 selected PICs and East Timor (modified from Falkland 2011).

Status of Research on the Vulnerability of the Sector

Assessment of Vulnerability of Water Resources

A recent report for the Pacific Adaptation Strategy Assistance Program, of the Australian Department of Climate Change and Energy Efficiency (Falkland 2011) compared the vulnerability of water resources and risks to water security from both climate change and non-climate factors to the year 2030. The report considered East Timor and the 14 self-governing PICs selected by the Pacific Climate Change Science Program (PCCSP): Cook Islands; Federated States of Micronesia (FSM); Fiji; Kiribati; Nauru; Niue; Palau; Papua New Guinea (PNG); Republic of Marshall Islands (RMI); Samoa; Solomon Islands; Tonga; Tuvalu; and Vanuatu. The report used the projections of the impacts of climate change and associated sea level rise on water resources and water supplies in the selected island countries from the PCCSP (ABoM and CSIRO, 2011). The projections considered several carbon dioxide emission scenarios and 18 Global Climate Change Models (GCMs) to project future climate scenarios in the 14 selected PICs and East Timor.

Main Vulnerabilities

The report concluded that, despite projected sea level rises (Figure 5), non-climate factors posed much greater risks to water security than climate change out to year 2030 throughout the region, even for high CO2 emission scenarios. The most vulnerable areas identified were densely populated urban and peri-urban settlements, remote communities, and communities in low-lying areas, particularly those in low coral atolls and carbonate islands (Falkland, 2011).

The factors of most importance were:

- Increasing water demands due to population growth and development. in some urban areas these projected increases lie between 70% and 240% (Honiara, Solomon Islands) by 2030;
- Large unaccounted for water losses and leakages from pipelines of up to 85%;
- Pollution of water resources due to population growth, agricultural development (van der Velde et al., 2007), industrialisation, deforestation, mining, increasing urbanization and inward migration (Ward, 1999) with consequent major health impacts;
- Salinisation of fresh groundwater due to seawater intrusion caused by over-pumping and mining;
- Poor water governance and management, which are particularly evident during droughts; and
- Conflicts arising from property rights disputes between land owners and governments.

These factors were most critical in urban and peri-urban situations in low atolls and in remote rural communities. While most of these issues have long been identified in PICTs and detailed in the lead up to the Pacific RAP, the report particularly emphasised that the non-climate factors of increasing water demand due to populations expanding by natural growth and inward migration coupled with leakage losses from pipe systems and storages pose much greatest risks to water security out to year 2030 than any due to projected climate change impacts (Figure 6). The report also noted that there were major uncertainties in the PCCSP GCM rainfall projections. The spatial scale of the GCMs used is much larger than most of the PICs considered and none of the GCMs can adequately model the extremely important ENSO events and IPO cycles which are key factors in rainfall across the region (Falkland, 2011).

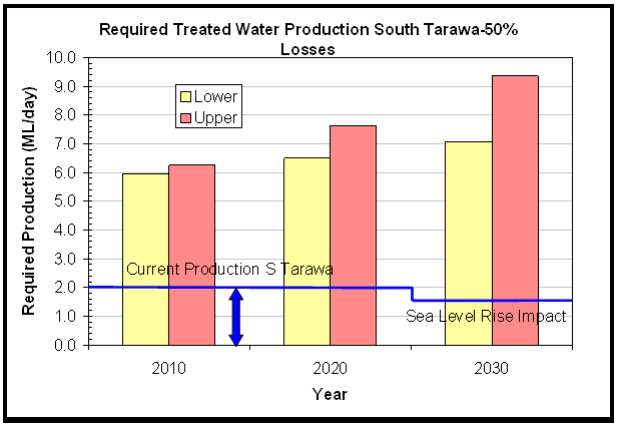

Figure 6. Estimates of the required daily production of treated freshwater required to supply both the demand of the growing population of urban South Tarawa, Kiribati as well as the estimated current 50% losses from the reticulation system for upper and lower bounds of population estimates. The estimates are compared with the sustainable yield of the only treated groundwater source in South Tarawa. A 20% decrease in yield due to sea level rise is expected by 2030 (White, 2010). Households make up the shortfall by using contaminated household wells.

Duncan (2011) has also examined the threats to freshwater resources due to environmental change in 7 selected islands out of about 853, assumed representative of the 14 PICs in Table 1, using a vulnerability index approach which considered resource stresses, development pressures, ecological insecurities, and management challenges. Duncan also stressed the diversity of contexts in PICs. He found that water resources management provides the greatest challenge regionally, across nearly all islands, with the other significant challenge being the delivery of the fundamental human needs of improved drinking water and sanitation. He concluded that the 7 islands studied fell into three broad groups:

- Low-lying islands which are under severe resource and environmental stress, with significant development pressure and a need for improved water management and governance (Fongafale atoll, Tuvalu; Majuro Atoll, Marshall Islands; and the single island nation of Nauru);
- Larger volcanic islands with adequate water resources, but significant to severe water management and governance challenges in managing available resources, in particular provision of drinking water and sanitation (New Guinea, Paua New Guinea and Viti Levu, Fiji);
- Moderate-sized volcanic islands with adequate water resources, significant water management and governance challenges in managing the available resources, but a reasonably high-level of provision of improved drinking water and sanitation (Rarotonga, Cook islands and Upolu, Samoa).

The study noted, as did Falkland (2011), that the limited availability of data across the region hinders assessment and planning. The report saw that the greatest challenge facing PICs in water resource management is limited technical and governance capacity. There is minimal capacity within countries to respond to the day-to-day vulnerability threats, let alone the frequent natural disasters which sweep the region. It concluded that the broad lack of enabling national policies and legislation, and the lack of capacity to implement existing strategies must be tackled in order to reduce regional, national and island freshwater vulnerability.

Major aid and donor projects throughout the region over four decades have attempted to address vulnerability of water resources and reduce risk to water supplies. Their success has been variable and limited. A key factor has been that most have focussed on single issues, such as infrastructure, have not been integrated, have failed to recognise the unique contexts of PICTs and have not built on the strengths of local communities. In addition, the customs and rights of subsistence living are not matched to the demands of the highly urbanised island environments in population centres in PICTs experienced in many PICTs in their transition to developed economies (Jones, 1997; White et al., 1999).

Proposed Adaptations and Supporting Policies

Rational Approach to Adaptation in PICTs

In the face of the uncertainties surrounding the magnitude and timing of climate change (Barnett, 2001), its impacts and lack of detail of ecosystem functions in PICTs, Barnett (2005) concluded that the only rational adaptation strategy is: "*to develop the general capacity of a society to cope with change by building up its institutional structures and human resources while maintaining and enhancing the integrity of ecosystems*". In this view, any activity towards ecologically sustainable human development, including improved governance, constitutes adaptation. He concluded that, despite the limited financial, technological and infrastructure resources in PICTs, their communities' well-developed local institutions, resilient social systems, sensitivity to environmental change and high degree of equity, together with their kinship-based, transnational networks are the basis for considerable capacity to adapt to climate change and indeed global change more generally.

Dovers (2009) has argued that challenges faced in adapting to climate change are not new. Humans have had to cope with the extremes of climate variability for a long time and he cited examples in developed countries covering: water management; local and regional economic vulnerability research; biodiversity; health and well-being in remote communities; energy reform; and emergency and disaster management. Since the main vulnerabilities identified above by Falkland (2011) and Duncan (2011) are non-climate change factors, existing

strategies for addressing these are appropriate adaptation strategies.

Adaptation Strategies

Falkland (2011) identified a number of regional and local adaptation strategies to reduce the vulnerability of freshwater in PICTs and decrease risks to water supplies in PICTs. These can be broadened to:

- **Improve national and local water governance.** This strategy incudes: research on improving public policy processes in PICTs; removing barriers to policy development and implementation in PICTs and in building public support for water policy goals; research on effective ways of incorporating of communities at all levels including peak bodies in water resource development and management; provision of regional training on public policy processes; research on conflict reduction mechanisms in areas with customary property rights (Dray et al., 2006); introduction of national policies with clear goals, unequivocal assignment of responsibilities and unambiguous directions to agencies; development of realistic, medium term plans to implement policy; incorporation of plan objectives in Ministry Operational Plans; enactment or revision of legislation to underpin policy and implementation and to protect freshwater sources; establishment of national peak bodies including community representatives; setting up of village or local water committees to protect water sources, conserve water, and promote wise use; ensuring that water supply and sanitation agencies are adequately resourced, are accountable and have legal bases.

- **Increase understanding of water resources, climate drivers and water supply systems through improved assessment and enhanced monitoring.** This strategy includes: research on catchment and groundwater yields in high intensity rainfall, tropical environments; research on the use of remote sensing for water resource assessment in PICTs; research on the climate drivers, their relation to island and their prediction in the Pacific; research on effective, low-cost monitoring systems for remote, dispersed water systems and countries with limited capacity; regional training on water resource assessment and monitoring; national assessment of the quantity, sustainable yields and quality of water resources; the distribution and variability of water sources; increasing understanding of the drivers of local climate, their spatial and temporal variability and trends; monitoring of the rate of extraction of water and its impact on water availability and quality; monitoring of water supply rates, water use and losses; and establishing water databases and reporting systems.

- **Increase the protection of freshwater sources from contamination and misuse.** This strategy includes: research on land uses which minimise pollution risks in areas with shallow groundwater; research on the effective design and implementation of incentive schemes and regulations to minimise contamination; research on empowering communities to protect water resources and water supply systems; provision of regional training on water source protection; ensuring that there is adequate legal protection for water sources; removal of any perverse incentives, policies and laws; increasing community awareness of the vulnerability of water sources to contamination and the appropriate uses of community water sources; providing incentives for landowners and local communities to protect water sources; forming local are water source management committees; and developing school educational campaigns on protection and use of water.

- **Control demand and decreasing unaccounted losses.** This strategy includes: research on engaging communities in controlling demand in PICTs; research on demographic and urban planning in PICTs; research on leak detection in intermittent flow provision of regional training on demand control and detection and reduction of water losses; introduction of equitable and fair demand management schemes; introduction of leak detection programmes; assessment of capabilities and resources of water supply agencies; and development of strategic and operational plans of water supply agencies; promotion of public awareness campaigns on water use and wastage; establishment of local area or village water committees; and school education campaigns on conserving water.

- **Provide appropriate and sustainable water supply and sanitation systems.** This strategy includes: research on the use of renewable energy sources in water production, distribution and treatment systems; research on minimis-

ing energy use in water supply and sanitation systems; research on sanitation systems which minimise water use and pollution; research on co-management of water supply and sanitation systems; research on design and operation of community rainwater harvesting systems; research on the impacts of reject brines from desalination plants on near-shore aquatic ecology; development of low maintenance systems for remote, dispersed low-density rural populations; regional training on the design of low-maintenance water supply and sanitation systems; regional training on regional training on design, operation and maintenance of rainwater systems; and regional training on operation, maintenance and management of financially and environmentally sustainable water supply and sanitation systems.

- **Improve risk planning and emergency management under extreme events of floods, droughts and coastal inundation.** This strategy includes: research on extreme event frequency in PICTs; research on effective ways of development of incorporating climate predictions (Kuleshov et al., 2012) into risk planing for extreme events; research on emergency response mechanisms for remote, dispersed rural, island communities; provision of regional training on the development of risk plans and emergency management strategies for floods, droughts and inundation; development of regional extreme event warning systems; training on the use of climate predictions in risk planning and emergency management.

- **Enhance capacity and provide training opportunities in the water and sanitation sector.** This strategy includes: research on the design and operation of regional networks to enhance local capacity in remote island situations; research on remote-learning systems to pool information and experiences; development of regional training schemes covering all aspects of water and sanitation in island situations; regional provision of training schemes and opportunities for the sharing of information and experiences.

- **Build on the local community strengths by providing information and increasing their participation at all levels.** This strategy includes: research on effective ways of engaging the community at all levels in water planning, management, protection and use and in developing culturally acceptable sanitation systems; research on the most effective ways of providing information to communities and schools remote, dispersed communities and in urban and peri-urban communities; research on management systems which foster community participation; regional training on empowering and engaging the community in the sector; regional training on the dissemination of information to remote, dispersed communities; regional training on engaging urban and peri-urban communities.

These strategies are consistent with Barnett's (2005) rational adaptation strategy, with the Pacific RAP and the key emphases of the Pacific Plan.

Supporting Policies

There are both regional and national components to policies to support adaptation strategies.

Regional Level

1. Establish a consortium of regional research providers and CROP agencies and NGOs to develop a mid- to long-term research programme addressing the key vulnerabilities in the water and sanitation sector related to sustainable development and adaptation to global change.
2. Refine regional climate prediction forecasting schemes and provide regional advice on extreme events.
3. Provide regional training on policy processes, effective water governance instruments and risk planning and emergency management for extreme events.
4. Provide regional training on the key competencies in designing, planning integrated management, operating and maintaining efficient water supply and safe sanitation systems including demand management.
5. Establish a regional learning network to share information and experiences in the water and sanitation sector.
6. Provide regional training in effective means of engaging urban and remote dispersed communities in the co-management and protection of water supply and sanitation systems at all levels.
7. Develop integrated context-specific approaches to water and sanitation donor and aid programmes, which take into account the environmental, climatic, socio-economic and cul-

tural aspects, include relevant regional agencies and are of sufficiently long term to be successful.

National Level

1. Ensure that sustainability is the key driver of all government initiatives in the water and sanitation sector.
2. Review and develop national water and sanitation policies, implementation plans, legislation and regulations with clear goals and objectives as well as clear directions and assignment of responsibilities to management, supply and protection agencies and establish whole-of-government-community peak sector committees to oversee the policy process.
3. Develop politically-acceptable plans, regulations and incentive schemes to address current and future water demands and reduce water losses.
4. Develop incentive schemes and regulations to protect and conserve water sources.
5. Identify acceptable land uses in water supply areas with minimise risks of contamination.
6. Develop risk management and emergency management plans for extreme events of floods, droughts, heat extremes and coastal inundation.
7. Develop information systems and incentive schemes to enable community participation in water planning, design, management and protection at al levels.
8. Provide adequate resources and appropriate capacity building programmes for all agencies in the water and sanitation sector.

Research, Development and Innovation Areas Needing Action in the Pacific

In the water sector in the Pacific, by concentrating on adaptation strategies to address key sector vulnerabilities, research, development and development needs tend to merge. Nonetheless there are significant knowledge gaps to be filled, developments to be initiated and innovations to be introduced in order to ensure the long-term sustainability and improve the resilience of the sector. It is stressed, however, that these areas must be considered as parts of an integrated approach.

Research

- Current GCMs are of too coarse a scale for most PICTs and do simulate the key ENSO or IPO climate drivers. In addition, predictions on evapotranspiration, a fundamental component of the hydrologic cycle, are unavailable for emission scenarios. Research is required to fill these knowledge gaps.
- Refinement of seasonal forecasting techniques in PICTs (Kuleshov, 2012).
- Variability of the major climate drivers and the relation between these climate drivers and water availability and the use of this information in seasonal forecasting.
- Estimation and prediction of extreme events, floods, droughts; and coastal inundation.
- Runoff generation and catchment yield in high intensity rainfall, tropical environments.
- Research is required on measuring groundwater recharge, and sustainable groundwater yields across a range of tropical environments and on evapotranspiration from shallow groundwater systems.
- Estimating the impacts of sealevel rise on groundwater yield from shallow groundwater lenses and coastal groundwater sources.
- The rainfall elasticity of stream flow (Chiew, 2006) is a measure of the disproportionate change in response of stream flow to changes in rainfall. Apart from New Caledonia, there is little reliable information on rainfall elasticity of stream flow in other PICTs such as PNG, Solomon Islands, Vanuatu and East Timor. This is a key factor in determining catchment yield response to future climate changes.
- Evapotranspiration data across the region is poor and there is a need for research on remote techniques to provide reliable evapotranspiration data.
- Stream flow and groundwater data in most PICTs are poor and of short duration. Rainfall data in rural and remote locations is similarly deficient. Research is required to develop sensing, reporting and analysis technologies that can operate reliably in harsh, remote locations.
- Topographic information on low coral islands is at too coarse a resolution to permit estimation of impacts of sealevel rise. High resolution surveys are required.
- Determining the impacts of reject brines from desalination plants on near-shore aquatic ecology in tropical regions.

- Identifying land use practices in water source areas which minimise risks of pollution and off-site impacts.
- Data on per capita water use, industrial, commercial and institutional water demand is scarce across the Pacific. There is a need to develop a regional database on demand.
- Research on overcoming barriers to and gaining pubic support for the introduction of water policy, implementation plans, legislation, regulations and incentive schemes.
- Identification of mechanisms to reduce conflicts over water sources in areas with customary property rights.
- Exploration of incentive schemes and community engagement strategies for protecting water sources and conserving water.
- Research on transferring water and sanitation information to communities in remote and isolated areas and in urban and peri-urban areas where traditional support mechanisms may be weak.

Development

- Development of capacity for constructing risk and emergency management plans incorporating predictions of climate extremes.
- Developing capacity in effective public water and sanitation policy processes in PICTs.
- Development and strengthening of regional networks to share information and experiences and build local capacity in smaller PICTs.
- Development of Pacific-focussed training modules, suitable for distance education, for water resource, water supply and treatment and sanitation using integrated approaches.
- Development of skills in monitoring, assessment and reporting.
- Capacity building in the establishment and maintenance of databases.
- Developing capabilities in community engagement.

Innovation

- Research and development of energy efficient water supply technologies, particularly on the improved efficiency of desalination processes.
- Coupling of water supply, distribution and treatment systems to low-maintenance, robust renewable energy sources.
- Development of reliable, low maintenance, low cost water treatment systems for remote communities.
- Development of acceptable low-freshwater use sanitation systems which minimise contamination and pollution.
- Optimised conjunctive use strategies for surface and groundwater systems and groundwater and harvested rainwater systems in areas of large rainfall variability.
- Monitoring climate, water resource parameters water supply, distribution and treatment systems in remote locations and dispersed islands in a major difficulty, particularly in PICTs with limited trained staff. The development of reliable technologies to permit the collection, storing, analysis, and reporting would permit improved management of water resources and water supplies.
- Development of effective, low-maintenance water treatment systems which can operate in remote locations using renewable energy sources.

Mid-Term Investments Required in Research, Development and Innovation

Faced with the broad range of research, development and innovation areas needing action, the Brussels meeting focussed on those which had the potential to decrease the vulnerability of the sector, improve the success rate of development and aid projects, and had the potential to maximise benefits to islanders.

The most pressing needs identified that required urgent attention were:

- Improved access to safe and adequate supplies of water and sanitation especially during frequent droughts;
- Preventable water-borne illnesses and deaths in the Pacific are tragically high;
- Adequate water supplies are essential for development;
- Some urban locations in the Pacific already cannot supply demand of treated water reliably;

- Heavy reliance on fossil fuels in water production, treatment and distribution systems;
- Growing demand, development, urbanisation and land use change are threatening the sustainability and safety of water supplies; and
- Governance in the sector needs to be strengthened with increased community participation.

The pervasive nature of governance and the apparent limited progress in the area point to the need for an overarching mid-term investment as well as projects which address particular research priorities.

1. Policy to Practice: Community Implementation of Policies and Knowledge

This project recognises the current gaps between regional water policy goals and their implementation as well as the absence in a majority of PICTS the region of national policies, implementation plans, legislation and regulations and peak national government-community bodies. It acknowledges that successful implementation requires adequate resources and the support of the whole community. It also recognises the inherent strengths and cultures of local communities in the Pacific and the seminal contribution that successful policy implementation can make to adaptation.

The overall aim of this project is to provide knowledge on the most effective ways of developing widely-supported water and sanitation policies in PICTs and of catalysing their implementation by their communities as an adaptation to global change.

This project is planned to be a regional project and can be carried out as a staged process.

The project has a number of components:

- **Learning from the past and from regional successes** – What were the characteristics that enabled Pacific peoples to survive extreme climate variability in the past? Are they applicable in highly urban situations? How can traditional knowledge systems be applied? How have successful policies, plans and legislation been developed? How have communities been involved in the process? What are the knowledge bases required for successful policies? As societies transition from subsistence to developed, what are the strategies that enable successful implementation of policy?

- **Identification of constraints and limitations** – What are the institutional reforms necessary for successful policy implementation? Do customary property rights, traditions and practices limit successful implementation? What politically acceptable mechanisms are available to remove constraints? What water right regimes are appropriate? Does competition between domestic, institutional, industrial and agricultural sectors for water constrain implementation? Are knowledge transfer and information sharing mechanisms adequate and appropriate for community engagement?

- **Identification and implementation of co-management** – With government capacity limited in many PICTs, involving the community in co-management is a rational and positive adaptation strategy. In what areas of water source protection, water extraction, distribution, use and treatment can the community co-manage? What co-management structures are successful? Are they country specific? Can community rainwater harvesting schemes be co-managed and linked to conjunctive use with traditional water supply systems? What support and incentives are required for community co-management? How can co-management be made sustainable and what are the mechanisms to address volunteer-burn-out?

- **Approaches.** What methods are available for developing policies, plans and legislation that engage communities? What methods are available for empowering local communities to support and implement policies? Have they been trialled in PICTs? Are country and island specific approaches required? How are conflicts resolved efficiently? What institutions are required for negotiation and conflict resolution? Are they culturally specific?

- **Training and capacity building.** What skills are needed by government agencies and organisations to foster successful policy implementation? What incentive schemes are available for training? What skills in policy and implementation are needed for community representatives in co-management organisations and community groups? What are effective ways of building capacity in isolated, remote island situations? How can regional organisations increase their effectiveness?

2. Managing Water Demand, Losses and Impacts of Development on Water Quality

In countries with limited land areas and vulnerable water sources, urbanisation, development, land use change, population growth and inward migration pose the greatest threat to the availability and quality of water supplies. You cannot manage what you do not know, so a critical element in this project is developing systems to estimate water uses, losses and water quality. It is planned that this project will initially be carried out in countries with small, low-lying, and vulnerable islands.

The goal of this project is to provide knowledge on effective strategies to control water demand and losses and to minimise the impacts of urbanisation, development, land use change and climate extremes on water availability and quality.

It is planned to implement this project in selected PICTs that span the geographic range from high, large islands to low, small islands.

The project has a number of components:

- Community engagement, empowerment and participation;
- Estimating sustainable yields and minimising seawater intrusion;
- Monitoring and analysis of water use, losses and water quality;
- Demand management techniques in PICTs;
- Regulation and legislative requirements;
- Managing demand under variability and change;
- Use of integrated water resource planning and management;
- Use of seasonal forecasting in demand management and water planning;
- Risk assessment and management;
- Minimising losses;
- Managing conjunctive use with rainwater harvesting;
- Strategies for protecting water sources;
- Land use in water source areas and urban and water source area planning;
- Appropriate sanitation systems for islands with limited freshwater;
- Requirements of water treatment systems;
- Impacts of waste water discharge on nearshore ecology.

3. Improving Monitoring and Management of Freshwater Systems Using ICT

A sound knowledge base is required for adaptive management of freshwater systems in any country. In PICTs this is particularly so because of the variability of rainfall largely due to fluctuating sea surface temperatures and the increased vulnerability of island water resources. For PICTs, gathering that knowledge presents significant challenges because of the often widely spatially dispersed and remote locations of island water resources, their temporal variability in response to the fluctuations of large-scale climate-drivers and the limited resources and capacity of government agencies to monitor those resources, their drivers, their use and quality. ICT has the potential to increase knowledge acquisition, its analysis, use and dissemination and to raise awareness as well as in early evaluation of new knowledge, in emergency management and in informing the public of risks.

The overall aim of this project is to develop low maintenance, reliable monitoring, management, warning and reporting systems using ICT to improve data capture, analysis, reporting and information dissemination in remote island situations with limited capacity.

The components of this project are:

- Remote resource monitoring systems and reliability tests;
- Improving water supply, distribution and treatment systems monitoring;
- Data storage and automatic analysis and reporting systems;
- Improving early warning systems;
- Tracking water use and losses;
- Monitoring rainwater harvesting systems;
- Emergency warning systems and weather forecasting;
- Informing the community using ICT;
- Management and maintenance of ICT systems;
- National and regional water resource and sanitation databases.

4. Minimising Energy Use in Water Production, Distribution and Treatment Systems

Water production, distribution and treatment systems in PICTs have a heavy reliance on fossil fuels to pump and treat water. In Nauru, in the central western Pacific, one third of the annual power con-

sumption is used just to produce freshwater. The potential for the use of renewable energy and distributed energy systems for power production in the Pacific is large, but the remoteness of locations and the complexities of some renewable energy sources mean that their application is limited.

The aim of this project is to develop coupled, low maintenance, robust renewable-energy water production, distribution and treatment systems which are suitable for use in harsh, remote island locations.

The components of this project are:

- Efficient, reliable water pumping and extraction systems;
- Improved, lower energy-demand distribution systems;
- Reliable water treatment systems for remote locations;
- Improved efficiency desalination systems;
- Impacts of reject brines from desalination plants on near-shore ecology;
- Hybrid renewable energy systems;
- Energy storage systems;
- Management and maintenance of coupled systems;
- Legislative, institutional and management structures required;
- Capacity building and training.

5. Improving the Success Rates of Water and Sanitation Donor and Aid Programmes

Over the past four decades very costly water and sanitation projects have been carried out across the Pacific under donor and aid programmes. The success rate of these has been variable and limited and the institutional learning has also been limited.

The aim of this project is to determine the factors, conditions and contexts which produce sustainable benefits from aid and donor-funded projects in the water and sanitation sector.

This project has several components:

- Engaging aid and donor organisations;
- Collation of information;
- Analysis of contexts;
- Review of immediate outcomes;
- Review of sustained outcomes;
- The role of regional agencies and organisations;
- Synthesis of results.

Investment Strategies for Bridging the Research, Development and Innovation Needs of the Sector

The water resources, geographic and socio-economic contexts of PICTs are extremely diverse. A broad, generic approach to water and sanitation sector challenges is, therefore, unlikely to be locally relevant. The capacity of the majority of PICTs to deal with the knowledge gaps in the water and sanitation sector is limited and the number of people employed in the sector is generally small. For this reason, a staged, incremental approach is suggested using a consortium of research providers, CROP agencies, NGOs and development organisations with their already established regional programmes on Climate Change, Water and Sanitation and Sustainability and networks.

The strategy here is to build on established networks rather than confuse the situation by starting *de novo*. The above projects are designed so that can be run in smaller stages. It is suggested that smaller scale pilot projects be initiated in selected countries across the region, with inputs from the relevant CROP agencies, and NGOs targeting PICTs and island locations within PICTs that are the most vulnerable and expanding from there using the lessons learned.

Expected Impacts of Investments

This policy brief has proposed modest research, development and innovation investment strategies directed at key international priorities outlined in the MDGs, JPI and the regional priorities identified in the Pacific Plan, and the Pacific RAP, and focussed on the identified key vulnerabilities of the sector.

The strategy of forming a consortium of regional research providers, CROP agencies, NGOs and development organisations ensures that research outcomes can be transferred efficiently into adaptation strategies and sustainable development strategies. At the completion of these projects it is expected that there will be:

1. Improved water governance throughout the region;
2. Successful implementation of international, regional and national policies and plans;
3. Improved knowledge and understanding of the quality, quantity and use of national water resources;
4. Improved understanding concerning the variability of island water resources and its relation to the regional climatic drivers;
5. Improved monitoring, analysis and reporting of water resources and climate parameters in remote, harsh environments using robust technology;
6. Reduced risks and improved emergency risk management during extreme events;
7. Increased community engagement and participation at all levels;
8. Improved protection and conservation of water sources;
9. Decreased incidences of water born diseases;
10. Increased reliability of water supplies and improved sanitation services;
11. Increased use of renewable energy for water production, distribution and treatment; and
12. An increase in the long-term success rate of donor and aid projects in the water and sanitation sector.

Because of the all-pervasive nature of freshwater, it is expected that improvements in the water and sanitation sector will have flow-on benefits to other sectors, particularly health, agriculture, forestry and risk and emergency management.

Risks

The large uncertainties in future long-term rainfall predictions in the Pacific due to the coarse grid-size of current GCMS and the fact that they do not simulate the fundamentally important ENSO events or the longer-term Interdecadal Pacific Oscillation (IPO) mean that focussing on these predictions as a basis for identifying research, development and innovation needs involves considerable uncertainties and risks. Faced with these uncertainties, the most effective strategy, and one of least risk is to concentrate on research that assists the general capacity of societies in PICTs to cope with change by building up their institutional structures and human resources while maintaining and enhancing the integrity of their ecosystems (Barnett, 2005).

The identified main vulnerabilities of the water and sanitation sector in the region out to the year 2030 are due to non-climate change factors (Falkland, 2011), so focussing on research and adaptation strategies related to institutional structures, building human capacity, forming a consortium between research providers, CROP agencies and NGOs in the sector and addressing key current vulnerabilities minimises uncertainty, lowers risks and maximises the potential for useful outputs and rapid uptakes. Another risk is that external research providers may fail to appreciate the unique social, cultural, environmental and economic contexts in the Pacific and thus provide research outputs which are of little relevance to PICTs. The formation of a consortium between research providers, CROP agencies, NGOs and development and donor agencies adopts an integrated, context-specific approach which addresses this risk.

Proposed Steps for a Mid-Term Implementation

In building up research networks in the Pacific, it is fundamentally important that the focus is on the particular priorities and needs of Pacific partners. Many of these have already been identified in Regional meetings, policy frameworks and national vulnerability assessments. These have been used here to identify research investments.

Because of the relatively small number of Pacific Country researchers, and the already long-estab-

lished working networks in the Pacific between regional research providers, CROP agencies, NGOs and Pacific island partners, it is proposed that as a first step, a consortium between these actors be formed to carry out the research programme.

The limited number of Pacific Country researchers also means that a large research programme is likely to swamp the region and the researchers. It has been proposed throughout this brief that a series of smaller up to three-year pilot projects be conducted in selected high priority locations in an initial phase. In accord with this, the research projects in the water and sanitation sector have been designed to be carried out as staged projects.

Using this staged approach as an adaptive learning process, the final stages call for an expansion of the successful pilot projects across the region over a 4 year period. The 7 year length of this project provides sufficient time for the building of trust, relationships and ensures the sustaining of capacity building and programme outcomes.

The Pacific has enormous natural capital. This is a major opportunity to concentrate research connected immediately with the sustainable use and management of the Pacific's key natural resource, freshwater, and to provide tangible benefits to Pacific island peoples.

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