

GAFSP: Vulnerability analysis and climate resilience guidance

**Assessments of climate vulnerability and resilience options
for agriculture in FSM, RMI, Kiribati, Tuvalu**

Working paper

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Executive Summary

Climate variability and change

- FSM, Kiribati, RMI and Tuvalu are among the most vulnerable countries in the world to climate change.
- The main current climate risks of relevance to agriculture are drought and tropical cyclones. The limited water availability and low elevation of the small atoll islands makes them particularly vulnerable to these extreme weather events.
- Certainties associated with climate change include sea level rise, rising temperatures and temperature extremes, and increased rainfall and extreme rainfall events (except in Tuvalu). There is more uncertainty relating to future drought risk and considerable uncertainty relating to changes in tropical cyclones. Global evidence suggests fewer but more intense tropical cyclones in future.

The regional context for climate resilience

- The Framework for Resilient Development in the Pacific (FRDP) provides broad guidance that encompasses: an integrated approach aimed at enhanced resilience to climate change and natural disasters; low carbon development; strengthened disaster preparedness, response and recovery.
- The FRDP aligns strongly with integrated approaches that are increasingly evident in individual countries and is broadly consistent with the principles of climate smart agriculture (CSA) and the building of resilience in communities and their local environments.

Climate smart agriculture and a virtuous circle resilience approach

- Climate smart agriculture (CSA) first emerged in 2009 and encompasses three objectives: Sustainably increasing productivity and incomes; building resilience to climate change; reducing and/or removing GHG emissions.
- CSA is an integrated, interdisciplinary, approach that needs to be tailored to specific situations and requires comprehensive capacity building.
- A virtuous circle resilience approach is aligned with the principles of CSA, but places much stronger emphasis on sustainable management of waste streams and building diverse and resilient food systems that address basic household needs as a priority while enhancing and protecting the environment.

Climate smart agriculture varieties and practices

- The atoll permaculture work of Jasper Bonie in the outlying islands of the Solomon Islands is of high relevance to the proposed project. Jasper is now a Priest in Temotu Province but is continuing his agriculture work with remote communities. Linkages with this work are recommended if at all possible.
- In FSM there is evidence of very successful community engagement activities, focused on agriculture and gardening, involving a range of expertise and a number of NGOs. The project needs to establish fully where this expertise lies, which NGOs are still active, and identify clearly where the gaps are both geographically and in terms of community needs.
- In Kiribati it is recommended that there be a focus on cataloguing and replanting of as many of the 200 traditionally used edible pandanus varieties as possible. Relevant recommendations prepared in the SECAP prepared for the Kiribati KOIFAWP project include: identifying and addressing gaps in pre-existing island reports; introducing food preservation methods; adopting a virtuous circle approach with a specific focus on atoll permaculture, food preservation, management and recycling of all biological waste streams, and seed saving.
- The project is strongly aligned with the five priority strategic action areas identified in RMIs 2013 Food Security Policy. The recently initiated Readiness for El Niño (RENI) project in RMI is of high relevance to the project and it is essential for synergies to be developed.

- The Tuvalu Agriculture Strategic Marketing Plan (TASMP) has a strong emphasis on local food production and consumption. There have been, and are, a number of relevant projects in Tuvalu. Currently active is the Taiwanese Horticulture expansion project, which has involved extensive gardening work in Funafuti and is currently focused in Vaitupu. It is essential for linkages to be formed with this project with a focus on adding value. The previous GEF Integrated Water Resources Management (IWRM) project focused on establishing compost toilets, with compost used as a source of fertiliser for gardening, is also very relevant work that needs to be replicated more widely.

Water, hydrology and seawater intrusion issues

- The freshwater and seawater issues are similar across all four countries with many water and sanitation initiatives either undertaken in the past or presently underway. This report only captures projects that were relatively accessible from an internet search. A thorough stocktake and review of what has been, and is being, done is required to identify clearly where this project can add value in each of the four countries.
- The project should pay particular attention to the current Readiness for El Niño (RENI) initiative funded by the EU (due for completion by the end of 2020) and the recently approved GCF project for RMI. The latter in particular is a major new initiative.
- Extension of the IWRM composting toilet initiative in Tuvalu needs to be actively considered. This work has been promoted as a success story. Composting toilets provide a sensible, practical, solution for all atoll islands and other communities where there are water limitations and/or freshwater contamination issues. They save water, significantly reduce groundwater contamination and provide a valuable source of fertiliser for gardening.

Cost-effective energy solutions

- Solar drying is likely to be the most cost-effective energy solution for processing and storage, and potential sale, of surplus crops.
- Relevant work has already been undertaken in the region focused on development of suitable low-cost solar dryers. This brief review has identified two relevant initiatives but there will likely be more and more in-depth investigation of options is needed.
- Traditional fermentation techniques are another viable option for processing surplus crops from breadfruit in particular. From the literature review it appears that such practices are still common in FSM in particular, although using modern utensils rather than pits for fermentation. The potential of drawing on existing knowledge and experience needs to be explored further.
- For small, isolated, atoll islands in particular the focus needs to be on supporting greater food security and building climate resilience, with a secondary focus on processing for sale.

Climate services

- There are a number of initiatives underway throughout the Pacific Island region aimed at improving climate services.
- There is increased emphasis on engagement with communities, but much still needs to be done.
- A simple approach for knowledge enhancement and empowerment of local communities is to introduce manual rain gauges. Recording rainfall, together with monitoring local knowledge indicators, is a simple and powerful way to empower people towards more effective management of their limited water resources.

Climate variability and change in FSM, Kiribati, RMI and Tuvalu

Key points

1. FSM, Kiribati, RMI and Tuvalu are among the most vulnerable countries in the world to climate change.
2. The main current climate risks of relevance to agriculture are drought and tropical cyclones. The limited water availability and low elevation of the small atoll islands makes them particularly vulnerable to these extreme weather events.
3. Certainties associated with climate change include sea level rise, rising temperatures and temperature extremes, and increased rainfall and extreme rainfall events (except in Tuvalu). There is more uncertainty relating to future drought risk and considerable uncertainty relating to changes in tropical cyclones. Global evidence suggests fewer but more intense tropical cyclones in future.

Climate variability and risk

The island countries of FSM, Kiribati, RMI and Tuvalu have varying degrees of exposure to climate risk, both within and between their territorial boundaries. Collectively they can be considered as among the most vulnerable countries to climate change in the world, specifically due to the high exposure of Kiribati, RMI and Tuvalu to sea level rise. Unfortunately this high vulnerability isn't captured in international assessments of risk such as the annual World Risk Index¹. Of the four countries this index only covers Kiribati at present due to lack of data for the other three.

The main current climate risks of relevance to agriculture are drought and tropical cyclones. Both are influenced by the El Niño Southern Oscillation (ENSO) phenomenon. Drought can occur in all four countries, even in the Marshall Islands where annual rainfall averages more than 3000mm. This is due to the coarse, porous atoll soils (which predominate in all countries except FSM), shallow freshwater lenses and limited water storage capacity (in many, but not all, cases).

Droughts are quite common in Kiribati and when they do occur are particularly serious in the South Gilberts, where average rainfall is lower. Abnormally dry years occur most commonly during La Niña events. A traditional indicator of drought in Kiribati is when coconut trees progressively wither because of insufficient rainfall and declines in the fresh water lens. Despite its high rainfall RMI can experience drought, influenced by a distinctive drier period from January to March which can be more severe and prolonged in drier years. For example the severe El Niño event of 1997-1998 resulted in significant reductions in crop yields². The exposure of the North Pacific countries of FSM, RMI and Palau to drought is reflected in the recently started EU-funded 'Readiness for El Niño' (RENI) project³.

Tropical cyclones (referred to as typhoons in FSM and RMI) are a threat to FSM, RMI and Tuvalu, as summarised in Table 1 below. FSM is exposed to the highest number of tropical cyclones overall, with 37 that have been damaging (Category 3 or higher) in the 30-year period from 1981-2011. Tuvalu experiences much fewer tropical cyclones, with only 3 that were damaging over the same period. However, due to its low elevation and small land area the impacts of a cyclone can be severe and long-lasting. This is noted in a study on the effects of storm surge from Cyclone Pam in 2015 ... *"In Tuvalu, 70% of households live less than 200 m from the coastline and with an elevation of no*

¹ <https://weltrisikobericht.de/english-2/>

² Muliagatele Joe Reti. 2008. An Assessment of the Impact of Climate Change on Agriculture and Food Security in the Pacific: A case study in the Republic of the Marshall Islands.

³ <http://ccprojects.gsd.spc.int/eu-north-pacific-reni/>

more than 5 m above sea-level. Households are thus acutely vulnerable to storm surges caused by cyclones even if the cyclone itself passes very far away.”⁴

Table 1⁵: Details of tropical cyclones experienced in FSM, RMI and Tuvalu

	FSM	RMI	Tuvalu
Cyclone season	June and November	June and November	November and April
Number of cyclones that develop within or crossed the EEZ (between 1977 and 2011 for FSM and RMI, and from 1969/70 to 2010/11 for Tuvalu)	average of 71 cyclones per decade	average of 22 cyclones per decade	average of 8 cyclones per decade
Frequency in El Niño years	88/decade	50/decade	12/decade
Frequency in La Niña years	38/decade	3/decade	3/decade
Neutral season average	84/decade		
Percentage that became severe (Category 3 or stronger) within the EEZ between 1981 and 2011	37/212 (17%)	13/71 (18%)	3/24 (13%)

Climate change

There are a number of certainties with climate change in the four North Pacific Islands, which reflect the global situation (see Table 1). The levels of greenhouse gases (GHGs) currently in the atmosphere will ensure that temperatures (on average and through extreme high temperatures) will continue to rise over coming decades, even if drastic measures are taken to reduce emissions. There will be more extreme rain events, with increased average rainfall in all countries except Tuvalu. El Niño and La Niña events will continue to occur but it is unclear as to whether their frequency and intensity will change. As a significant sink for heat generated by the atmosphere and for carbon dioxide the Pacific Ocean will continue to experience increased acidification, increased coral bleaching and sea level rise will continue. Droughts are projected to decline in frequency overall but these change are less certain. The projected changes in droughts need to be carefully qualified. Drought in the Pacific Islands is strongly linked to the ENSO phenomenon. Given the uncertainties associated with the future intensity and frequency of El Niño and La Niña events it would be unwise to assume that the frequency of drought might decline in the future, and the possibility of more severe droughts needs to be accounted for.

Table 2⁶: Summary of projected changes in climate for all four countries

⁴ Tausi Taupo & Ilan Noy. 2017. At the Very Edge of a Storm: The Impact of a Distant Cyclone on Atoll Islands. EconDisCliCha (2017) 1:143–166. DOI 10.1007/s41885-017-0011-4

⁵ Sourced from: Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

Climate variable	FSM	Kiribati	RMI	Tuvalu
El Niño and La Niña events	Will continue to occur in the future (<i>very high confidence</i>), but there is little consensus on whether these events will change in intensity or frequency			
Annual mean temperatures and extremely high daily temperatures	Will continue to rise (<i>very high confidence</i>)			
Average rainfall and extreme rain events	Projected to increase (<i>medium confidence</i>), with more extreme rain events (<i>high confidence</i>)	Projected to increase (<i>high confidence</i>), along with more extreme rain events (<i>high confidence</i>)	Average rainfall is projected to increase (<i>high confidence</i>), along with more extreme rain events (<i>high confidence</i>)	It is not clear whether mean annual rainfall will increase or decrease, the model average indicating little change (<i>low confidence</i>), with more extreme rain events (<i>high confidence</i>)
Droughts	Projected to decrease (<i>medium confidence</i>)	Projected to decline in frequency (<i>medium confidence</i>)	Projected to decline in frequency (<i>medium confidence</i>)	Projected to decrease slightly (<i>low confidence</i>)
Ocean acidification	Is expected to continue (<i>very high confidence</i>)			
Coral bleaching	The risk will increase in the future (<i>very high confidence</i>)			
Sea level	Will continue to rise (<i>very high confidence</i>)			

The biggest issue for all Pacific Islands is sea level rise. The impacts will be profound, particularly for low-lying atoll communities and countries and will compound any future impacts associated with other changes (e.g. future droughts will likely be exacerbated due to shallower aquifers and less available land). Continued rising sea levels will result in significant losses of land, continued intrusion of seawater into already fragile fresh water aquifers and displacement of people. Changes will be non-linear, and will be particularly influenced by the increasing risk of positive feedbacks in Greenland, the Arctic and Antarctic which could lead to rapid acceleration of ice melt and sea level rise.

Island communities are therefore operating within a limited timeframe with a progression of impacts that will increasingly disrupt their lives and associated responses required. In the short to medium term the focus needs to be on addressing current environmental and socio-economic issues within a context of increasing influence from climate change. Increasing food security, with a focus on a balanced nutrition diet, is a high priority within this context. For the long term, such a focus is helping build the resilience of individuals and communities and providing them with important skills for their future well-being and survival, even if they are forced to relocate to new environments.

⁶ Sourced from: Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

The regional context for climate resilience

Key points

1. The Framework for Resilient Development in the Pacific (FRDP) provides broad guidance that encompasses: an integrated approach aimed at enhanced resilience to climate change and natural disasters; low carbon development; strengthened disaster preparedness, response and recovery.
2. The FRDP aligns strongly with integrated approaches that are increasingly evident in individual countries and is broadly consistent with the principles of climate smart agriculture (CSA) and the building of resilience in communities and their local environments.

In the late 1990s the GEF-funded Pacific Island Climate Change Assistance Programme (PICCAP)⁷ provided training, capacity building, and technical assistance to 10 Pacific Island countries, including the four countries included in this GAFSP proposal. This was aimed at supporting countries in preparing their First National Communications, required as signatories to the United Nations Framework Convention on Climate Change (UNFCCC). A core part of this work was focused on vulnerability and adaptation assessment, drawing on IPCC impact assessment guidelines developed in the early 1990s⁸. Since the early 2000s there has been a shift away from this linear assessment approach, with an increased focus on climate resilience. In the Pacific this arose from both the evolving research in this area and increasing calls from Pacific Island countries for adaptation action. At the same time there has been an increased recognition over time of the strong interplay between climate change adaptation and disaster risk management. This resulted, for example, in Tonga producing the first Joint National Action Plan for Climate Change Adaptation and Disaster Risk Management (JNAP)⁹ in the region.

The evolution of approaches summarised above has been reflected regionally over time. At the Pacific Island Forum Leaders meeting in 2012 it was decided to develop an integrated approach to addressing climate change and disaster risk management in the Pacific Islands region. This decision resulted in the Framework for Resilient Development in the Pacific: An Integrated Approach to Address Climate Change and Disaster Risk Management (FRDP)¹⁰. This integrated framework superseded the Pacific Disaster Risk Reduction and Disaster Management Framework for Action (commonly referred to as the Regional Framework for Action or RFA) and the Pacific Islands Framework for Action on Climate Change (PIFACC).

The FRDP is a guideline for all stakeholders (national and local government, civil society and communities, private sector, regional organisations and other development partners) aimed at building resilience to climate change and all natural hazards. The rationale for this integrated approach is very clear, with a strong inter-relationship between climate change and climate-related hazards, and approaches to building resilience that are universally relevant. Furthermore it acknowledges the limited resources and capacity within Pacific Island Countries as well as the common linkages to underlying development issues.

⁷ <https://www.thegef.org/project/pacific-islands-climate-change-assistance-project-piccap>

⁸ Carter, T.R., M.L. Parry, H. Harasawa, and S. Nishioka, 1994, *IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations*, Working Group II of the Intergovernmental Panel on Climate Change, University College London, United Kingdom, and Center for Global Environmental Research, Tsukuba, Japan.

⁹ The Kingdom of Tonga. 2010. Joint National Action Plan on Climate change Adaptation and Disaster Risk Management 2010–2015.

¹⁰ SPC, SPREP, PIFS, UNDP, UNISDR and USP. 2016. Framework for Resilient Development in the Pacific: An Integrated Approach to Address Climate Change and Disaster Risk Management [FRDP] 2017 – 2030

The FRDP has three goals:

1. Strengthened integrated adaptation and risk reduction to enhance resilience to climate change and disasters
2. Low carbon development
3. Strengthened disaster preparedness, response, and recovery

It provides a Strategic Objective and Outcome for each of these three goals, and a set of broad Priority Actions for each of the main stakeholder groups (government, civil society, private sector).

As is clear in its title the FRDP is only a Framework, intended to guide countries in their policy and planning processes relating to climate change. However, it strongly aligns with in-country approaches which are reflected in particular through the integrated plans that have now been developed by a number of countries in the region. It is also strongly aligned with the principles of climate smart agriculture (CSA).

Climate-smart agriculture and a closed circle resilience approach

Key points

1. Climate smart agriculture (CSA) first emerged in 2009 and encompasses three objectives: Sustainably increasing productivity and incomes; building resilience to climate change; reducing and/or removing GHG emissions.
2. CSA is an integrated, interdisciplinary, approach that needs to be tailored to specific situations and requires comprehensive capacity building.
3. A virtuous circle resilience approach is aligned with the principles of CSA, but places much stronger emphasis on sustainable management of waste streams and building diverse and resilient food systems that address basic household needs as a priority while enhancing and protecting the environment.

Climate smart agriculture

The climate smart agriculture (CSA) concept first emerged in an FAO report in 2009. The focus was, and still is, the need to frame climate change responses within the context of achieving food security through the sustainable transformation of agriculture¹¹. Climate smart agriculture recognises that agriculture will both be impacted by climate change and is a major source of the climate change problem. Practical solutions are needed that address, as much as possible, both climate change adaptation and mitigation while also achieving food security. Climate smart agriculture therefore encompasses the following three objectives:

- i) Sustainably increasing productivity and incomes;
- ii) Building resilience to climate change;
- iii) Reducing and/or removing GHG emissions.

“Climate-smart agriculture seeks to re-orient agriculture by taking these objectives into consideration and informing farmers’ decisions. It is an interdisciplinary approach that is not limited to a single set of practices. Its application is tailored to specific situations using information from many sources. It requires comprehensive capacity-development efforts at various levels to promote behavioural changes and to enhance institutional and political settings, while strengthening organizations and institutions and building the individual capacities of various stakeholders. Since it focuses on broader

¹¹ Lipper, L., McCarthy, N., Zilberman, D., Asfaw, S., Branca, G. 2018. Climate Smart Agriculture: Building Resilience to Climate Change. FAO. <https://link.springer.com/content/pdf/10.1007%2F978-3-319-61194-5.pdf>

social and ecological outcomes it requires the participation of both farming communities and decision-makers and an understanding of the synergies and trade-offs.”¹²

Three key points from the above quote are:

- i) It is an interdisciplinary approach that is not limited to a single set of practices;
- ii) It’s application is tailored to specific situations using information from many sources;
- iii) It requires comprehensive capacity-building efforts at various levels.

Resilience

An integral part of climate smart agriculture, is a focus on building resilience in food production systems. Resilience is defined by the IPCC as:

“The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation.”

A resilience publication prepared by the International Institute for Environment and Development (IIED)¹³ challenged what the authors identified as linear ‘vicious cycle’ systems with the need for transformation towards circular ‘virtuous circle’ systems¹⁴. A virtuous circle approach for agriculture brings together many of the elements identified for climate smart agriculture. A key difference however, not clearly articulated for climate smart agriculture, is that a virtuous circle approach has a strong emphasis on sustainable management of waste streams. This is of high importance in a world that is both increasingly resource constrained and is increasingly confronted with widespread pollution of air, land and water as a result of human endeavour.

The issues of climate change, food security and environmental pollution are all brought into sharp focus in the microcosmic environments of Pacific Island countries. Within this context a ‘virtuous circle’ climate smart agriculture approach is of particular relevance. For example, in an atoll village environment issues of food security, water security, waste management and human health (e.g. NCDs, exposure to diarrhoea through faecal coliform contamination of groundwater) are all closely inter-linked, and all are being impacted already by climate change.

A virtuous circle, climate smart agriculture, approach for Pacific Island countries is shown schematically in Figure 1 below. This schematic provides a context for three of the issues addressed in the remainder of this working paper: climate smart agriculture varieties and practices; water and hydrology issues (including salt water intrusion); and cost effective energy solutions for post-harvest, value addition and efficient transport/logistics. The other two issues addressed are: assessing viability of establishing and operating local disaster risk (reserve) funds; and a brief discussion on climate services.

¹² FAO. 2018. Climate Smart Agriculture Training Manual: A reference manual for agricultural extension agents.

¹³ Andy Jones, Michel Pimbert and Janice Jiggins, 2011. *Virtuous Circles: Values, Systems, Sustainability*. IIED and IUCN CEESP, London.

¹⁴ The terms virtuous circle and vicious cycle “refer to complex chains of events that reinforce themselves through a feedback loop. A virtuous circle has favorable results, while a vicious circle has detrimental results.”

https://en.wikipedia.org/wiki/Virtuous_circle_and_vicious_circle.

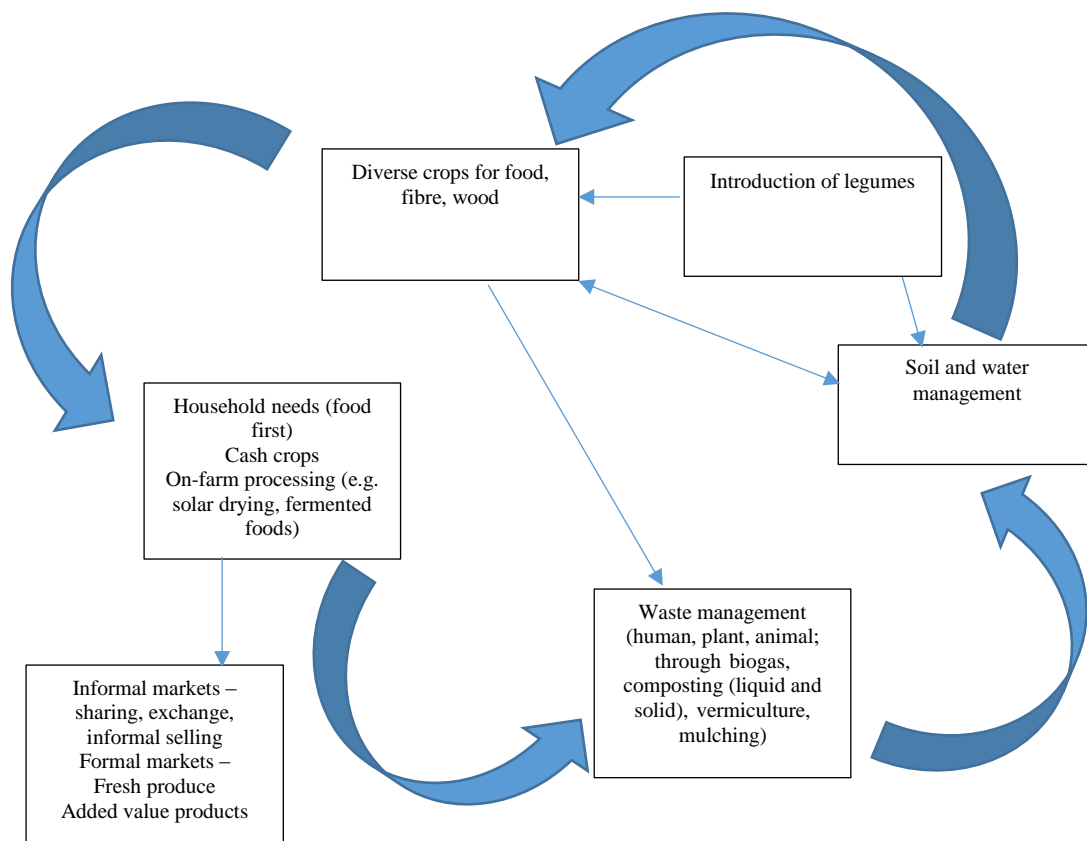


Figure 1: A virtuous circle climate smart agriculture approach for Pacific Island countries

Climate smart agriculture varieties and practices

While there are variations between and within countries, all four share common features and issues, with the exception of the higher islands of FSM, which provide significant challenges to agriculture. Key features and issues in common include: coarse, porous and low fertility calcareous soils; limited land; limited water; lack of biodiversity; and a high reliance on low nutritional quality imported food coupled with limited diversity in traditional diets. Depletion of traditional fisheries further compounds food security issues. In many cases this is due to over-fishing and high levels of wastage from commercial (and sometimes illegal) fishing operations.

This section begins with a summary of relevant initiatives in the wider Pacific Island country region aimed at addressing the above issues, with a particular focus on the atoll permaculture work of Jasper Bonie in the outlying islands of the Solomon Islands (Ontong Java and Temotu Province). This is followed by country summaries, which provide a brief overview of relevant information from agriculture plans and policies and details on key projects of relevance.

Key points and recommendations

1. The atoll permaculture work of Jasper Bonie in the outlying islands of the Solomon Islands is of high relevance to the proposed project. Jasper is now a Priest in Temotu Province but is continuing his agriculture work with remote communities. Linkages with this work are recommended if at all possible.
2. In FSM there is evidence of very successful community engagement activities, focused on agriculture and gardening, involving a range of expertise and a number of NGOs. The project needs to establish fully where this expertise lies, which NGOs are still active, and identify clearly where the gaps are both geographically and in terms of community needs.
3. In Kiribati it is recommended that there be a focus on cataloguing and replanting of as

many of the 200 traditionally used edible pandanus varieties as possible. Relevant recommendations prepared in the SECAP prepared for the Kiribati KOIFAWP project include: identifying and addressing gaps in pre-existing island reports; introducing food preservation methods; adopting a virtuous circle approach with a specific focus on atoll permaculture, food preservation, management and recycling of all biological waste streams, and seed saving.

4. The project is strongly aligned with the five priority strategic action areas identified in RMI's 2013 Food Security Policy. The recently initiated Readiness for El Niño (RENI) project in RMI is of high relevance to the project and it is essential for synergies to be developed.
5. The Tuvalu Agriculture Strategic Marketing Plan (TASMP) has a strong emphasis on local food production and consumption. There have been, and are, a number of relevant projects in Tuvalu. Currently active is the Taiwanese Horticulture expansion project, which has involved extensive gardening work in Funafuti and is currently focused in Vaitupu. It is essential for linkages to be formed with this project with a focus on adding value. The previous GEF Integrated Water Resources Management (IWRM) project focused on establishing compost toilets, with compost used as a source of fertiliser for gardening, is also very relevant work that needs to be replicated more widely.

Regional - the ACOM food security project in Ontong Java

Ontong Java is an outlying atoll that administratively is part of the Solomon Islands. It has a land area of 12km² and a Polynesian population of approximately 2000.

In 2010 the Anglican Church of Melanesia (ACOM) initiated a climate change and food security project in Ontong Java with initial funding of approximately USD25,000 from the US based Episcopal Relief & Development Program. This proposal, developed by Mr Jasper Bonie¹⁵, was focused on addressing the identified food security situation in Ontong Java, through the introduction of a system that Mr Bonie referred to as 'Atoll Permaculture'¹⁶. Key issues identified were: poor soils, salinization of giant taro pits, water deficits, limited crop diversity, lack of gardening skills, food deficits, the need for culturally appropriate interventions. This was a 3 year project due for completion at the end of 2012.

Jasper's work on Ontong Java was focused on establishing what he refers to as Atoll Permaculture. *"Our Atoll Permaculture gardening system will be a multi-storey structure using fruit trees, root crops and vegetables. We would like to create a farming system that is permanent, self mulching, self sustaining and self regenerating and that it can provide a good source of food. We would also like to create a system that will demand less time and has low maintenance cost. We can imagine a forest of food where food can be collected when required"*¹⁷. Four demonstration plots, each 60x60m were established on the island of Luaniua. This is one of the two inhabited islands on Ontong Java. The system originally developed in Temotu Province (previously known as the Santa Cruz Islands) was used as the basis for the design and development of an agro-forestry structure, incorporating an alley cropping system to accommodate light and shade tolerant crops (see Annex 1 for the initial

¹⁵ Jasper trained at the Queensland Agriculture College in 1979-80 and subsequently worked for the Solomon Islands government for 20 years. He was posted to Temotu Province and there worked to design a farming system that he called "Improved Temotu traditional agriculture". He developed this by observing what locals were doing and adding value to this. He began his work on developing this system in 1987 and in 1993 published a booklet on the system. After leaving his government position he worked for a while on food security with World Vision then spent two years in theological college. He was then asked to implement the food security project on Ontong Java,

¹⁶ J. M. Bonie. 2010. Climate Change Project Ontong Java: Food Security, An Assessment and Plan of Action

¹⁷ ACOM Project Field Report, April 2011 (available on request from the author of this Working Paper)

system design). The Leucina tree was used as a N-fixer for initial shading and to help build soil fertility. Jasper had tried other legume species but this is the only one that had survived and grown well in the salty soils. Trials were also being considered with Koronivia and Vetiver grass. Many of the planting materials were sourced from Temotu Province because it is free from the serious crop diseases which affect other provinces.

In addition to implementation of the demonstration plots there was training on Atoll Permaculture and work had begun on a manual. The intention was to extend the work on Luaniua to Pelau which is the other main inhabited island of Ontong Java and to other low-lying atolls in Melanesia. While the immediate focus was on development and implementation of Atoll Permaculture to address food security issues it was recognized that the long-term solution to climate change on low-lying atolls will be relocation.

The ACOM project networked with both the Pacific Adaptation to Climate Change (PACC) project and the Kastom Gaden Association since it began. Jasper contributed to some of the vulnerability and adaptation assessment work done under PACC. Links with KGA were focused on assistance with supply of planting materials through its Planting Material Network.

The PACC project subsequently employed Jasper to build on the ACOM funded work. The final report from this project¹⁸ provides comprehensive documentation of the atoll permaculture garden design, including lists of plants species and guidance for establishing an atoll permaculture garden. This material is also included in the earlier ACOM progress reports¹⁹. Lessons learned from this work have been extracted from the final project report and are presented in Annex 1. Overall there was very strong engagement with and support from the community, with a desire for this work to be expanded and supported further.

Jasper Bonie is now occupied as an Anglican minister in Temotu Province but is continuing with his atoll permaculture work, currently focused on a demonstration of an updated system on the Reef Islands.

FSM agriculture

The FSM Agriculture Policy (2012-2016) has eight Policy Goals, Development Outcomes and Strategies, including:

1. Increased sustainable production (and productivity) of traditional farming systems to provide for household nutrition, traditional needs and cash incomes;
2. More product value adding through efficient value chains with a focus on Increased opportunities and capacity for processing and value addition of traditional farm products;
3. Enhanced environmental services and sector resilience to natural disasters and climate change, including:
 - a. Promotion of environmentally friendly production systems
 - b. Community-based approaches for management of natural resources

The FSM-SDP Volume 1 recognises that *“Small traditional subsistence and near subsistence farmers are a difficult extension target, requiring very different strategies from commercial farmers. One State Director of Agriculture freely admitted that he and his staff did little if anything for traditional farmers.”* It further states *“A number of agencies are using a community-based approach. They recognize farmers are reluctant to openly share knowledge, and are suspicious of outsiders and new ideas. But once a new technology has been demonstrated in the community, with time to absorb the*

¹⁸ J.M. Bonie. 2012. A Report on Climate Change Adaptation Intervention in Pelau Island in the Ontong Java Atoll.

¹⁹ Copies have previously been provided to Tawfiq (in 2018), but I'm happy to share them on request with others.

concept and information, and the message has been reinforced, farmers do respond. A community approach can work, with homogenous groups, using a gentle approach and regular follow up to allow shyness to be overcome and messages to be absorbed and recognizing that work in agriculture has lower priority than say funerals. Using multiple avenues of contact, e.g. radio/tv, interpersonal, workshops, is also important.”

Relevant projects:

1. **PASAP and SPC project**²⁰ *“The two-year PASAP project identified the best performing varieties of drought- [sweet potato] and salt-tolerant [taro] food crops, and strengthened local communities’ capacity to adapt to climate change.”*
2. **USAID project on “Enhancing the Climate Resilience of Atoll Communities on Yap Island”**²¹. *The College of Micronesia (COM)-FSM Yap Cooperative Research and Extension division trained 120 households in atoll communities in soil management, climate-smart gardening and water harvesting techniques to build their resilience to climate change impacts. The climate-smart gardening included: small-plot intensive farming, micro-gardening, container home-gardening, agroforestry and integrated farming. The communities subsequently received training in value addition and marketing, including products such as breadfruit pancakes and pumpkin jams.*
3. **The FSM-SDP** identifies several relevant projects being undertaken in the late 1990s and early 2000s:
 - a. *The Natural Resource Conservation Service (NRCS) have been doing community based extension by working with groups of farmers (20-30) who are organized by the village chief. The key is grassroots involvement in the initial planning, where the needs are determined by the community, from which the type of service required can be determined. NRCS believes there many opportunities to “tweak” traditional agriculture to improve both yields and profitability;*
 - b. *The Pohnpei Conservation Society (PCS) started in 1997. Today it has 19 staff and a \$350,000 budget funded independently of government. They work with farmers to encourage agriculture in the lowlands and to discourage encroachment into the high forest areas;*
 - c. *The Yap agriculture garden program (Sudal Victory Garden Project) is joint-funded by Salvation Army, Red Cross UNDP and Yap State Dept. of Agriculture. It assists with establishing food gardens by providing funds for seeds, fertilizer, tools, fencing, etc. The ultimate aim is to form a cooperative from the successful grantees, with a market outlet based around a local supermarket.”*

Kiribati agriculture

The Agriculture Strategic Plan 2013-2016 identified five key challenges for agriculture in Kiribati:

1. Shallow, calcareous, porous, soils
2. Limited water availability
3. Narrow genetic base, and loss of biodiversity. *“Some of the varieties of species like pandanus, taro, breadfruit, coconuts, dwarf banana, traditional fruits and sources of traditional medicines are now endangered. Mangroves and some of the coastal and inland*

²⁰ <https://www.pacificclimatechange.net/project/pacific-adaptation-strategy-assistance-program-pasap>

²¹ <https://www.climatelinks.org/blog/enhancing-climate-resilience-atoll-communities-yap-island-fsm>

forests are disappearing. In Kiribati there were over 200 varieties of edible pandanus, which used to produce food even in severest of droughts, but many are disappearing now. Oral history supports this observation. There is not enough replanting to replace the pandanus destroyed by deforestation and fire outbreaks, and young people tend to ignore this traditional food source. Natural biodiversity on atolls is narrow, and some of it is starting to be lost, endangering food security.”

4. Pests and diseases
5. Costs of farm inputs

Key recommendations from the SECAP prepared for the Kiribati KOIFAWP:

- Identify key gaps in the 2012 island reports (prepared for the Southern Gilberts) and work on addressing these, with a focus towards facilitating much clearer understanding of the specific social and environmental situation in the different islands, and within each island. Interventions, focused not just on home gardening and water tanks but with a more integrated climate resilience context, can then be tailored more specifically to the needs and capacity of each community.
- Knowledge on traditional food preservation needs to be brought together and shared.
- Four specific measures are recommended based on the virtuous circle principles, which would help develop a much stronger climate resilience focus to the whole project. These measures include: a much stronger focus on management and use of all biological waste streams, including composting of human waste; drawing on the successful atoll permaculture work in Temotu Province and Ontong Java in the Solomon Islands; seed saving, drawing on the experience of the Farmers Support Association²² in Vanuatu; and food preservation, drawing on local traditional knowledge and previous work in Vanuatu supported by FAO

RMI agriculture

Five Priority Strategic Action Areas are identified in RMIs 2013 Food Security Policy:

1. Stimulating sustainable local food production and preparation and better linking producers to consumers.
2. Strengthening access to nutritious food for vulnerable households and individuals.
3. Educating the public about food security and nutrition and encouraging home gardening.
4. Facilitating efficient national food distribution channels.
5. Building safety, quality and resilience into food supply and production systems.

Relevant projects:

1. **The European Union funded Readiness for El Niño (RENI) project**, launched in 2018, is focused on addressing some of these five action areas in the drought prone northern islands of RMI. It is initially focused in Ailuk, a rural environment, and Santo-Kwajalein, a semi-urban environment. The focus is on food security measures which include *“increasing the availability of local food crops, especially more drought resilient crops, improving soil management practices, and establishing nurseries. Women especially will be involved in home gardening and trained in food preservation methods. Local area disaster management*

²² <https://www.facebook.com/farmsupportassociation/>

plans will also be prepared.”²³ It is expected that results will be shared with residents and farmers in Enewetek, Mejit, Utrik and Wotho²⁴.

Tuvalu agriculture

The Tuvalu Agriculture Strategic Marketing Plan (TASMP) 2016-2025 is focused on increasing resilience to climate change through a strong focus on local food production and promotion of traditional handicrafts. Of eight ‘common threads’ in the plan, the following are of particular relevance:

1. *Increased sale and consumption of local food with emphasis on the ‘Go Local’ campaign;*
2. *Increased production of local food through organic farming, which includes development of the ‘pulaka’ pit system.*

Relevant projects:

1. **The Global Climate Change Alliance: Pacific Small Island States (GCCA:PSIS) Project: Improving Agro-forestry Systems to Enhance Food Security and Build Resilience to Climate Change in Tuvalu**²⁵. The overall objective of this EUR 0.5 million project was to ‘*Increase resilience to climate change impacts in Tuvalu*’ with a specific focus on enhancing food security. The project was ended on 30th June, 2015. It was focused on benefitting the 6,194 people living in the urban capital Funafuti (55% of the population) as well as one outer island. The key result areas were : “(i) *Enhanced understanding of agro-forestry among community members, land owners, and Kaupule through awareness raising, capacity building and training;* (ii) *Improved agro-forestry system implemented in demonstration sites in Funafuti and one outer island;* (iii) *Marketing potential and access evaluated;* and (iv) *Enhanced coordination and capacity of the Department of Agriculture.*”

The project expected to have close coordination with other relevant projects including the UNDP- NAPA projects, Australia - SPC CePaCT Nursery Project, Taiwan ICDF Horticulture project, and SPC- GIZ CCCPIR climate change coordination project.

2. **The Taiwanese Horticulture expansion project Tuvalu**²⁶. This project has previously involved development and expansion of a demonstration farm in Funafuti, but due to land limitations is not able to expand further. The focus has now shifted to the island of Vaitupu, with the following specific work components:

“Establishing an agricultural workstation in Vaitupu.

Guiding twelve staff at the workstation to raise output to 330 tons of fruits and vegetables.

Training four teachers specializing in nutritional promotion to design a set of nutritional promotion programs.

Enhancing intake of fruits and vegetables by providing students with up to 80 tons of fruits and vegetables for group meals and holding 10 nutrition-related activities.

To the end of March 2019, the following activities have been completed:

- *Reclaimed 3 hectares via the Elisefou Agricultural Station on Vaitupu.*

²³ The EU – North Pacific – Readiness for El Nino Project <http://ccprojects.gsd.spc.int/eu-north-pacific-reni/>

²⁴ <https://www.spc.int/updates/news/2018/07/republic-of-marshall-islands-strengthens-food-security-measures-ahead-of>

²⁵ <http://ccprojects.gsd.spc.int/wp-content/uploads/2016/07/10.-Tuvalu-Factsheet.pdf>

²⁶ <https://www.icdf.org.tw/ct.asp?xItem=29117&CtNode=29823&mp=2>

- *Built an irrigation facility with over 200 tons of storage capacity on Vaitupu.*
 - *Managed a total of 31.80 hectares on the main island, Funafuti (Fatoaga Fisfia and home gardens 8.22 hectares; Vaitupu 23.58 hectares).*
 - *Produced a total of 1003130 fruits and vegetables seedlings (Funafuti:762760; Vaitupu: 240370)*
 - *Produced 183.79 tons of fruits and vegetables at the two agricultural centers (Funafuti:100.12 tons; Vaitupu:83.67 tons)*
 - *Produced 1118 tons of organic compost (Funafuti:505 tons; Vaitupu:613 tons)*
 - *Conducted 8 demonstration activities.*
 - *Conducted 32 training workshops”*
3. **GEF Pacific IWRM project in Tuvalu**²⁷ - *Implementing Sustainable Water Resources and Wastewater Management in Pacific Island Countries”* In Tuvalu this project focused on the installation of demonstration compost toilets. Dry compost toilets use minimal water and produce compost that can safely be used for food production. Concerns around smell and safety were addressed with communities through the construction of demonstration toilets, workshops and awareness campaigns. Forty demonstration toilets were constructed with co-financing obtained to construct another 60 due to the level of interest. A video of this work was produced²⁸, which highlighted use of the compost for home gardening. The project generated interest around the Pacific with demonstration toilets built in Tonga, Nauru (in schools) and the Marshall Islands.

Water, hydrology and seawater intrusion issues

Availability of freshwater is a fundamental issue, in particular for the atoll islands that predominate in Kiribati, RMI and Tuvalu and which prevail in FSM beyond the main high islands. The presence of shallow freshwater lenses in many cases is compounded by increased population pressure, increased contamination from human waste and seawater intrusion, and the impacts of extreme weather events, in particular drought and tropical cyclones.

This section provides country summaries which give a brief overview of relevant water issues and details on key projects of relevance.

Key points and recommendations

1. The freshwater and seawater issues are similar across all four countries with many water and sanitation initiatives either undertaken in the past or presently underway. This report only captures projects that were relatively accessible from an internet search. A thorough stocktake and review of what has been, and is being, done is required to identify clearly where this project can add value in each of the four countries.
2. The project should pay particular attention to the current Readiness for El Niño (RENI) initiative funded by the EU (due for completion by the end of 2020) and the recently approved GCF project for RMI. The latter in particular is a major new initiative.
3. Extension of the IWRM composting toilet initiative in Tuvalu needs to be actively considered. This work has been promoted as a success story. Composting toilets provide a sensible, practical, solution for all atoll islands and other communities where there are water limitations and/or freshwater contamination issues. They save water, significantly reduce groundwater contamination and provide a valuable source of fertiliser for gardening.

²⁷ <http://www.pacific-iwrm.org/videos/Tuvalu-GEF-IWRM-Composting-Toilets.html>

²⁸ <https://www.youtube.com/watch?v=9Ra1bDxxyG0>

FSM water issues

Water related issues in FMS are the same as commonly experienced in other Pacific Island countries, including: watershed management; atoll water security; the effects of climate variability, waste disposal impacts and sanitation²⁹. Sanitation is an issue of major concern, particularly in atoll communities where the commonly used pit latrines are the primary source of groundwater contamination and associated risk with infectious diarrhoea. The FSM IWRM report³⁰ states that ... *“The example of Tuvalu developing a model of successful composting toilets, will be a great addition to the FSM IWRM Project especially in relation to rural sanitation coverage, with time and time again sanitation being mentioned as the highest priority issue across many of FSM’s communities.”* The sanitation issue is strongly linked to the security of water supply on atolls in particular, but also in coastal locations of larger islands. An analysis of the groundwater resources on the atoll islands of FSM found that *“... of the 105 atoll islands considered only 6 would retain a fresh body of groundwater able to sustain the community during a drought similar to that experienced in 1998.”*³¹

Relevant projects:

- 4. The Global Climate Change Alliance: Pacific Small Island States (GCCA:PSIS) Project: ‘Increasing coastal water security for climate change in selected FSM state outlying islands’ project.** This implementation period for this project, which supported nine smaller Pacific Island countries was 19 July 2011, to 19 November 2016³². In FSM the focus on the project was on *“providing rainwater catchment systems and improving water infrastructure in Fais Island, an outlying island of Yap State, and supporting assessment and design work in Eot and Udot Islands, two lagoon islands in Chuuk State”* aimed at increasing the capacity and quality of household and communal rainwater catchment systems.³³
- 5. The European Union funded Readiness for El Niño (RENI) project.** This project was launched in 2018 and is due for completion in November 2020. *“In FSM, water security in Kapingamarangi in Pohnpei State and Yap Proper in Yap State have been selected. In Kapingamarangi, a remote atoll near the equator, community rainwater catchments will be refurbished and replaced, while In Yap Proper abandoned community water systems e.g. wells, will be refurbished so as to provide “point water sources” during drought for community as well as people living in other areas of Yap Proper. The sites are all near the capital Colonia.”*³⁴

Kiribati water issues

Groundwater is an important water source in Kiribati. However, the amount of water and its quality is very variable, dependent on the physical characteristics of individual atoll islands, the location of communities and their activities. Many *“are highly vulnerable to salinization due to natural recharge variations and groundwater abstraction. Determining the sustainable yield from freshwater lenses is*

²⁹ Johnston Mathew. 2012. Federated States of Micronesia IWRM Outlook Summary and NWTF Report

³⁰ Ibid

³¹ R.T. Bailey and J.W. Jensen. 2011. Groundwater resources analysis of atoll islands in the Federated States of Micronesia using an algebraic model. Technical Report No. 134. Water and Environmental Research Institute of the Western Pacific. University of Guam.

³² <http://ccprojects.gsd.spc.int/wp-content/uploads/2016/07/1.-GCCA-PSIS-overall-factsheet.pdf>

³³ The Global Climate Change Alliance: Pacific Small Island States project in Federated States of Micronesia (FSM):

Increasing coastal water security for climate change in selected Federated States of Micronesia (FSM) state outlying islands

³⁴ <http://ccprojects.gsd.spc.int/wp-content/uploads/2018/08/RENI-Factsheet-ver.July18.pdf>

challenging because the lens response during drought periods and the long-term effects of pumping are both difficult to predict"...³⁵. The pressure on these limited, fragile, water resources is high with many freshwater lenses "either in danger of contamination with brackish water if overexploited, or it is already brackish."³⁶ With the competing needs for water (crops, animals, human) together with contamination, *harvesting rainfall is an important option for both domestic and agricultural use.*

Relevant project:

UNICEF. 2014. Harvesting Rainwater to Improve Access to Safe Drinking Water and Adapt to Climate Change: Spotlight on Kiribati. *"In collaboration with the government and the European Union, UNICEF is implementing a water and sanitation project in the outer islands of Kiribati covering all 16 atolls and half of all the villages in the Gilbert Group. UNICEF is focusing on installing new rainwater harvesting systems with safe storage facilities. Specific goals of the programme include enhancing the community's ownership and capacity to ensure sustainable operation and maintenance."*³⁷

RMI water issues

As with all atoll island countries RMIs water resources are very fragile "due to its small size, lack of storage, and limited fresh-water capacity. The situation is multiplied by limited investments made in water and sewage management and infrastructure... Already, some of the country's fresh-water lens have been contaminated with brine, from over extraction and coastal movements from human development practices and erosion."³⁸ Despite its high annual rainfall, with averages higher than 3000mm, RMI is prone to water shortages and is "a graphic demonstration that high rainfall does not necessarily mean water supply security."³⁹ One solution being employed during droughts is the use of temporary 'suitcase' size sea water reverse osmosis (SWRO) plants which are flown or shipped to the outer islands. A recent drought impact study⁴⁰ highlighted the fragility of groundwater resources in RMI. Results showed that "Average lens thickness during typical seasonal rainfall is approximately 4 m, with only 30% of the islands maintaining a lens thicker than 4.5m and 55% of the islands with a lens less than 2.5 m thick. Thicker lenses typically occur for larger islands, islands located on the leeward side of an atoll due to lower hydraulic conductivity, and islands located in the southern region of the RMI due to higher rainfall rates. During drought, groundwater on small islands (<300 m in width) is completely depleted. Over half (54%) of the islands are classified as "Highly Vulnerable" to drought."

Relevant project:

Green Climate Fund project 'Addressing Climate Vulnerability in the Water Sector (ACWA) in the Marshall Islands'. This USD18.6 million, 7-year, project supported by UNDP and with USD6 million from the RMI government has recently (July 2019) been approved by the Green Climate Fund. The project "aims to secure year-round access to safe freshwater for over 15,500 people living on 24 of

³⁵ Post, V.E.A.; Bosserelle, A.L.; Galvis, S.C.; Sinclair, P.J.; Werner, A.D. (2018). On the resilience of small-island freshwater lenses: Evidence of the long-term impacts of groundwater abstraction on Bonriki Island, Kiribati. *Journal of Hydrology*, page 1-43

³⁶ Agriculture and Livestock Division. *Agriculture Strategic Plan 2013-2016*. Republic of Kiribati

³⁷ UNICEF. 2014. *Harvesting Rainwater to Improve Access to Safe Drinking Water and Adapt to Climate Change: Spotlight on Kiribati*. https://www.unicef.org/environment/files/Kiribati_rainwater_harvesting_2014.pdf

³⁸ Johnston, M. 2013. *Republic of Marshall Islands Water & Sanitation Sector: Final Report*.

³⁹ Gale, A. and deBrum, H. 2017. *Water Challenges in the Marshall Islands: Managing drought in a high rainfall atoll country*. *Water e-journal: Volume 2, No 2*. <https://doi.org/10.21139/wej.2017.018>

⁴⁰ Barkey, B.L. and Bailey, R.T. 2017. *Estimating the Impact of Drought on Groundwater Resources of the Marshall Islands*. *Water* 2017, 9, 41; doi:10.3390/w9010041

RMI's most vulnerable outer atolls and islands (with at least 20 litres of drinking water person per day). ...At the local level, the project will focus on improving rainwater harvesting systems and storage for homes and communities, including improved guttering and downpipes and additional storage. Groundwater wells will be protected from king tides, storm surges and contamination by raising the height, covering them and installing hand pumps. Residents will receive training in efficient water management while newly established community-based water committees will be trained and engaged in drought contingency planning. Public awareness campaigns will promote water conservation."⁴¹

Tuvalu water issues

Tuvalu has very little reliable groundwater. This is attributed to the very coarse coral gravels and sands which "cannot sustain substantial fresh groundwater lenses to the extent that exists in other atoll countries in the region."⁴² As a result the primary source of freshwater is from rainwater collected from household and communal buildings. Where salinity levels are lower groundwater has historically provide a secondary source of non-potable water, and in times of prolonged drought has been used as a source of drinking water on some islands. However, the use of groundwater "has been severely compromised by pollution from inadequate sanitation systems on Funafuti, and there is an increasing threat that this could also occur on the outer islands."⁴³ There is a shortfall in the amount of collected rainwater, with an estimated total storage capacity to sustain the total population for 54 days without rain. The 2011 Sustainable and Integrated Water and Sanitation Policy⁴⁴ concludes that "the behaviour and daily practices of the people is the underlying problem. This is exacerbated by leaked tanks/cisterns and taps, damaged and poor fixing of rain gutters."

Relevant project:

GEF Pacific IWRM project in Tuvalu⁴⁵ - *Implementing Sustainable Water Resources and Wastewater Management in Pacific Island Countries*. This project was focused on introducing composting toilets to address the contamination issues that exist throughout the Pacific Islands from the use of pit latrines. With minimal water required they provide a sustainable solution for water limited atoll islands and have the additional benefit of providing suitable compost material for fruit and vegetable production. It proved to be a very successful project. "From a baseline of little interest in composting toilets to a success story other countries are looking to emulate, the Tuvalu GEF Pacific IWRM project has demonstrated the value of engaging stakeholders. This core IWRM and project approach has facilitated a national-level change in attitudes to sanitation and water management, development of a national water and sanitation policy framework, increased water security and is dramatically increasing access to improved sanitation in Tuvalu. Initially, the project struggled to find families to trial the first ten compost toilets. A communication and engagement campaign involving innovative strategies including a toilet roadshow, a competition to name the Tuvaluan designed toilet (the 'Falevatie'), focus groups and targeted media campaigns and numerous school and community sessions were built around a sound technical solution. Less than three years later over 25% of Funafuti's households (275 families) are seeking to install compost toilets."⁴⁶

⁴¹ <https://www.adaptation-undp.org/green-climate-fund-pours-186-million-towards-water-resilience-marshall-islands>

⁴² SOPAC. 2007. National Integrated Water Resources Management Diagnostic Report: Tuvalu. SOPAC Miscellaneous Report 647.

⁴³ Ibid

⁴⁴ Government of Tuvalu. 2011. Sustainable and Integrated Water and Sanitation Policy

⁴⁵ <http://www.pacific-iwrm.org/videos/Tuvalu-GEF-IWRM-Composting-Toilets.html>

⁴⁶ GEF Pacific IWRM Project Results Note. 2012. Integrated Sustainable Wastewater Management (Ecosan) for Tuvalu. <http://www.pacific-iwrm.org/rsc/Pacific-IWRM-Results-Note-Tuvalu-2013.pdf>

Cost-effective energy solutions

Key points and recommendations

1. Solar drying is likely to be the most cost-effective energy solution for processing and storage, and potential sale, of surplus crops.
2. Relevant work has already been undertaken in the region focused on development of suitable low-cost solar dryers. This brief review has identified two relevant initiatives but there will likely be more and more in-depth investigation of options is needed.
3. Traditional fermentation techniques are another viable option for processing surplus crops from breadfruit in particular. From the literature review it appears that such practices are still common in FSM in particular, although using modern utensils rather than pits for fermentation. The potential of drawing on existing knowledge and experience needs to be explored further.
4. For small, isolated, atoll islands in particular the focus needs to be on supporting greater food security and building climate resilience, with a secondary focus on processing for sale.

The remoteness and small size of many Pacific islands is a major issue in terms of meeting the basic food needs of many communities and in providing economic opportunities. The latter is further complicated by the fact that many communities still use traditional systems of gifting and exchange, often governed by family obligations. Remoteness is a double edged sword. On the one hand it fosters greater independence and self-reliance, with remoter communities tending to rely more on traditional food sources and less on the poor nutritional quality imported foods (e.g. low quality rice and noodles), although there has been a generational shift with younger people developing a preference for imported food⁴⁷. On the other hand, with infrequent shipping services, remote communities can suffer severely in times of shortage, during times of drought and following a damaging tropical cyclone. Together with remoteness of many islands, the limited land areas available for agriculture severely limits the quantity of production and the harsh conditions of atoll environments in particular create significant challenges for both quantity and quality. Within this context and following a climate smart agriculture approach, the primary focus ought to be on promoting processing of surplus crops with the aim of increasing food security and building climate resilience. Sale of surplus either within country or overseas is a desirable goal, but ought to be secondary to the need to build self-reliance and resilience.

Post-harvest storage and processing options for small Pacific islands are very limited. A traditional technique for storage of surplus breadfruit is through fermentation in leaf-lined pits^{48, 49}. This was previously widely practised throughout the Pacific. It is no longer common in Polynesia but

⁴⁷ as noted in the Tamana Island Report (2008) in Kiribati, "Where lack of cargoes used to not bother the islanders, it is now a big bother specifically for the growing generation who grew up on bread, doughnuts and rice amongst others. With the availability of fishing equipment to individual fishermen, the older generations are generally not seriously affected by these cargo shortages as they still live on coconuts, fish, pandanus cuisine and toddy." <http://www.climate.gov.ki/about-kiribati/island-reports-2012/>

⁴⁸ W.G.L. Aalbersberg, C.E.A. Lovelace, K. Madhoji & S.V. Parkinson (1988) Davuke, the traditional Fijian method of pit preservation of staple carbohydrate foods, *Ecology of Food and Nutrition*, 21:3, 173-180, DOI: [10.1080/03670244.1988.9991030](https://doi.org/10.1080/03670244.1988.9991030)

⁴⁹ Ragone, Diane. (2002). Breadfruit Storage and Preparation in the Pacific Islands. Conference: Vegeticulture in Eastern Asia and Oceania, At The Japan Center for Area Studies, National Museum of Ethnology, Osaka, Volume: JCAS Symposium Series 16. pp 217-232.

fermented breadfruit is still made in Micronesia, although more commonly using large metal pots or plastic containers rather than pits⁵⁰.

Drying is another technique for preserving surplus foods, with traditional drying methods documented for breadfruit⁵¹. More recently there has been some activity relating to the use of solar driers. There are numerous ways for building a solar drier, some more effective than others and with varying costs. A low cost system applicable to the Pacific was developed for use in Vanuatu in 2011 by an engineering student from the University of New South Wales⁵² who was motivated to “*create a unit that would allow families to dry and sell the abundant fruits and nuts found through the South Pacific island nation.*” This until was subsequently further promoted by SPC/GIZ⁵³. Another solar dryer for use in the Pacific Islands was developed by staff from Brigham Young University⁵⁴. A study in Fiji assessed three different types of dryer: an indirect dryer, a cabinet dryer and a direct dryer with natural convection. All successfully dried the test crops of papaya and pineapple, but the direct cabinet dryer was found to be the most effective⁵⁵.

Drying presents the best opportunity for a cost-effective energy solution for processing of surplus food crops to a transportable size. The advantage of drying is that processed crops can be packaged and stored for when transport services are available. However, the limited availability and low reliability of transport services for many small atoll islands is a significant issue. There are also limited alternative, low-cost, energy solutions for the transport services that exist. International air transport to the main centres provides an opportunity for sale to other counties, but costs are high, quantities will mostly be very small, and air transport has a very high carbon footprint. For land and marine transport there has been some investigation of coconut oil as a biofuel substitute for diesel fuel in Kiribati, FSM and RMI⁵⁶.

The potential of processing local food crops has been recognised for some of the four countries. For example in RMI it was recommended “*that government should to consider the local processing of food crops into more marketable commodities such as chips, flour, etc., that have longer shelf-life and are easier and lighter to transport.*”⁵⁷

⁵⁰ Ibid

⁵¹ Ibid

⁵² Fruit-bearing solar crop dryer could provide for thousands (2011, January 11) retrieved 13 August 2019 from <https://phys.org/news/2011-01-fruit-bearing-solar-crop-dryer-thousands.html>

⁵³ SPC/GIZ Coping with Climate Change in the Pacific Island Region. 2013. Enhanced food security and alternative income opportunities through solar fruit drying on Pele Island, Vanuatu. Briefing Note. .

⁵⁴ Rowe, Jonathan P.; Russon, Jonathan K.; and Steele, Frost M., "Solar Dryer Construction and Use Manual Version 2.0 2007" (2007). All Faculty Publications. 938. <https://scholarsarchive.byu.edu/facpub/938>

⁵⁵ Rupantri Raju. 2010. Effectiveness of Solar Drying on Local Fruits https://www.researchgate.net/publication/265468885_Effectiveness_of_Solar_Drying_on_Local_Fruits

⁵⁶ Wade, Herbert. 2005. Demonstration projects to showcase the business angle of renewable energy service delivery in the Pacific Islands. Apia, Samoa: SPREP.

⁵⁷ Muliagatele Joe Reti. 2008. An Assessment of the Impact of Climate Change on Agriculture and Food Security in the Pacific: A case study in the Republic of the Marshall Islands.

Viability of establishing and operating local disaster risk (reserve) funds

Climate services

Key points and recommendations

1. There are a number of initiatives underway throughout the Pacific Island region aimed at improving climate services.
2. There is increased emphasis on engagement with communities, but much still needs to be done.
3. A simple approach for knowledge enhancement and empowerment of local communities is to introduce manual rain gauges. Recording rainfall, together with monitoring local knowledge indicators, is a simple and powerful way to empower people towards more effective management of their limited water resources.

Up until the late 1980s/early 1990s there was a comprehensive climate station network in many Pacific Island countries. Much of this information was captured in a series of country climate summaries produced by the former New Zealand Meteorological Service. The decline in data collection is reflected in Kiribati with historical records for a total of 33 sites currently held in the New Zealand National Institute of Water and Atmospheric Research (NIWA) climate database. However, over the last 20 years data have only been consistently recorded in Tarawa. This decline in data collection and availability is reflected in the Australian Bureau of Meteorology and CSIRO climate and climate change analysis for Kiribati⁵⁸, which uses data from only two sites, Tarawa and Kiritimati.

There are currently a number of initiatives underway in the Pacific aimed at addressing identified climate needs. In the North Pacific island countries of FMS and RMI the agency with responsibility for climate data is NOAA, but they have very few resources committed to improving climate services⁵⁹. NIWA has a programme underway focused at improving access to, and use of, climate data through development of in-country applications with a tool known as CliDE⁶⁰. Their current plans include improving services, include some additional instrumentation, in Tuvalu beginning in mid-2020⁶¹. They have plans for similar work in FSM and RMI beyond 2020 and have on-going work in Kiribati with drought monitoring and other activities.

SPREP are now hosting a climate services portal with information on past and current projects as well as links to country meteorological services⁶². A relatively new initiative is the WMO RA-V Pacific Regional Climate Centre (RCC) Network⁶³. According to the website this network is “a virtual

⁵⁸ Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

⁵⁹ See <http://pacificislandsclimate.org/csdialogs/>

⁶⁰ CliDE (Climate Data for the Environment) was developed by the Australian Bureau of Meteorology in consultation with NIWA. It is a relational database management system distributed under the terms of the GNU General Public License as published by the Free Software Foundation.

⁶¹ Personal Communication, Alan Porteous, Group Manager, Climate Data and Applications, NIWA

⁶² <https://www.pacificmet.net/>

⁶³ <https://www.pacificmet.net/rcc>

Centre of Excellence that assists National Meteorological and Hydrological Services (NMHSs) in the Pacific Islands region to deliver better climate services and products and to strengthen their capacity to meet national climate information and service delivery needs.”

Another initiative, developed in partnership between two New Zealand agencies is a programme called RiskScape⁶⁴. They have developed a water resource module which has tested and developed in RMI and Tuvalu. This tool is aimed at guiding decision making and increasing preparedness relating to water resources management in advance of an El Niño event. *“The module is designed so that atoll countries can estimate their current and future water resources based on various rainfall and water consumption scenarios.”*

A critical gap in climate services, often discussed but with still much to be done, is engagement with communities to increase their knowledge and awareness of climate, climate risks and climate change. According to Alan Porteous from NIWA⁶⁵ ... *“I’d say there is a lot more engagement now in trying to make this happen. In all the meetings I go to there are (for example) media training sessions which help with dissemination of information at community level. Quite a bit of work has been done on traditional knowledge and this has raised awareness of changing conditions and the need for dialogue between communities and government agencies. So you get things like early warning systems being built with communication pathways that involve community leaders and communicators. So I’d say a lot is happening but more is needed.”*

The gap between climate services enhancement and community engagement or outreach was highlighted in Samoa during the project design mission for the IFAD funded Farming as a Business in Samoa (FAB Samoa) project. A Climate Early Warning System (CLEWS) drawing on the CliDE tool, was developed through the Integrating Climate Change Risks in the Agriculture and Health Sectors in Samoa (ICCRAHSS) project⁶⁶. However this has not been fully operationalised and relevant information is not presently reaching farmers to support their decision making. The basic reason given by the Samoan Meteorological Service was that they had identified the need for dedicated Agro-met officer but lacked the financial resources to employ someone for this position.

A recommendation made in the Social, Environmental and Climate Assessment Procedures (SECAP) report for phase 2 of the KOIFAWP project in Kiribati was to introduce simple manual rain gauges and educate people in the basics of daily rainfall recording. By owning the recording of rainfall in their village and island they will begin to understand and appreciate more clearly why and when they need to be more consciously conserving their water. This could be readily combined with local indicators of drought, such as the dying of coconut palms. This sort of approach is likely to be a lot more effective at community level than software based tools that are informing people sitting at desks in the meteorological offices of each country. The latter certainly have their place, but simple and practical approaches are required at community level that are focused on knowledge enhancement and empowerment.

⁶⁴ <https://www.riskscape.org.nz/international-projects>

⁶⁵ Personal Communication, Alan Porteous, Group Manager, Climate Data and Applications, NIWA

⁶⁶ MNRE and MAF. 2017. Climate Services to Agriculture through the Climate Early Warning System.

Annex 1 – Reference material used

International and regional

World Risk Report 2018

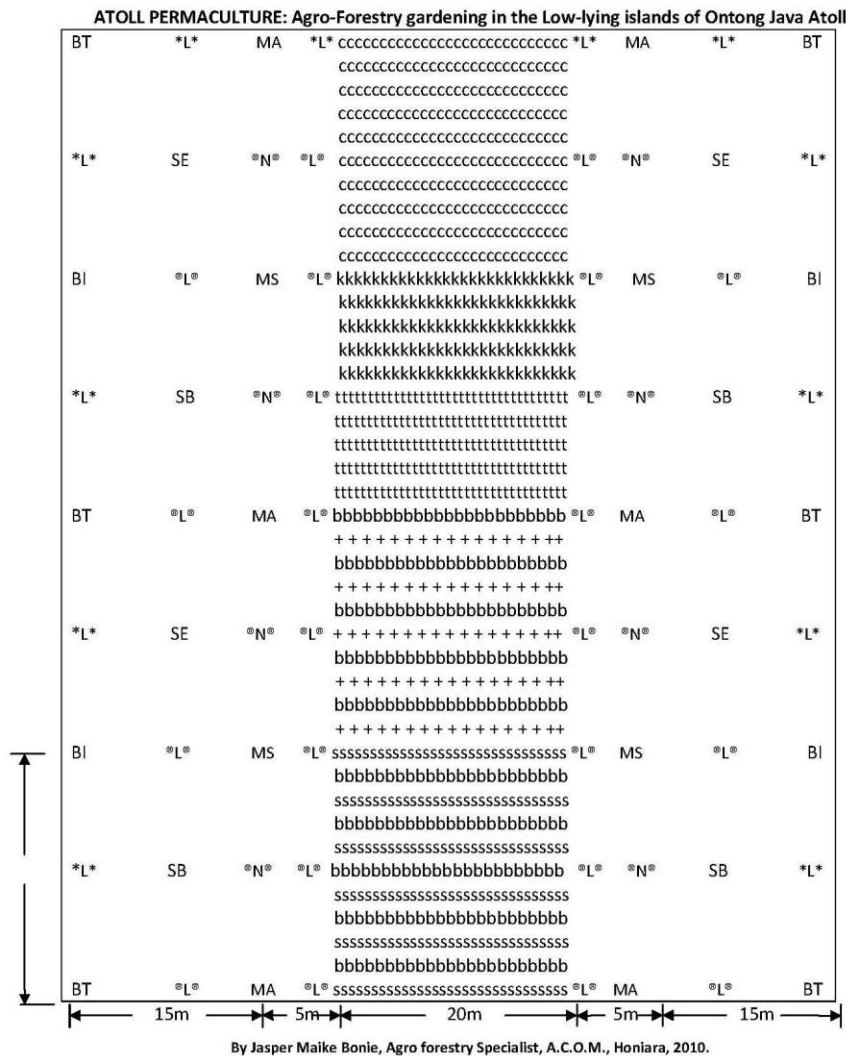
“Vanuatu continues to be the country with the highest disaster risk in the WorldRiskIndex 2018. With Tonga, the Philippines, the Solomon Islands, Papua New Guinea, Brunei Darussalam, Fiji, Timor-Leste, and Kiribati, a total of nine island nations are among the 15 countries with the highest risk. In regards to continents, all in all, Oceania (16.58) has the highest median of WorldRiskIndex Values.”

FSM, RMI and Tuvalu not included in analysis due to missing data

Ontong Java Atoll Permaculture projects

Atoll Permaculture design, from ACOM project report

Note: This design has now been revised by Jasper Bonie



Crops Selected for Atoll Permaculture (60mx60m Plot)

Symbol	Amount	Common name	Botanical name
BT	6	Alite	Terminalia cattapa
BI	4	Polynesian chestnut	Inocarpus fagiferus
MA	6	Breadfruit	Artocarpus altilis
MS	4	Funny Face	Spondias cyathera
SE	4	Rose apple	Eugenia malaccensis
SB	4	Local avocado	Burkela obovata
L	44	Lusina	Leucaena leucocephala
N	8	Cut nut	Barringtonia procera
b	95	Banana	Musa sapientum
c	70	Cassava	Manihot esculenta
p	70	Kumara	Ipomoea batatas
k	40	Kongkong taro	Xanthosoma
t	200	True taro	Colocasia esculenta
s	60	Stem taro/giant taro	Alocasia esculenta
+	50	Topia	
*	16	Shade pana	Dioscoria esculenta
®	64	Pacific yam	Numularia esculenta
¥	-	Swamp taro	Cyrtosperma

Crop Performance

Generally, all crops that have been introduced are performing satisfactorily, although, there are signs of plant nutrient deficiency. Crops need heavy mulching for satisfactory performance.



3. Stem taro interplanted with banana and pawpaw



4. Rows of true taro (Selfish taro)

Extract from final PACC report by Jasper Bonie

Please refer to the final report for details on identified crops, planting plans, and other relevant details.

Lessons Learned from the project

1. More interest

More people would like to participate in the project. It was explained that only the 4 plots will be assisted now until crops are ready to be harvested when surplus planting materials will be shared out to the others. In this particular phase of the project, only four plots will be assisted.

2. Challenges

There are challenges, which continue to influence how the activities are going to be implemented:

- i) Transport to the islands continues to be difficult because of unreliable shipping. Shipping to the atoll goes to the islands on ad hoc basis. It is more or less greatly influenced by the harvesting of Beach-der-mer. Shipping is more frequent to the islands when beach-der-mer harvesting is open. At present, it is closed indefinitely.*
- ii) Supply of planting materials is a great need. For the kind of agriculture system as ITTA-ALLEY or Atoll Permaculture the total amount of crop species and the number of planting materials for each species are greatly increased.*
- iii) There is a need to identify plants to help with the production of biomass to improve the soil. Identification of plant species to help with the production of biomass to help with the improvement of the soil cannot be overlooked. Soils of Ontong Java are mostly sandy and therefore efforts to assist the soil must identify and introduce leguminous and non-leguminous plants.*
- iv) Lack of nitrogen fixing Bacteria is one of the major cause of plants not growing well. This can be seen on the plant leaves and stems.*
- v) The need to erect water tanks to help to provide water for the plants. Water is a scarce resource because atolls have neither rivers nor streams. Wells have become brackish due to salt-water intrusion. This area has been achieved.*
- vi) It would be necessary to stay alert for any crop pest and disease outbreaks. The need to stay alert is more necessary because of the introduction of new crops. However, it is believed that this will not cause a great fear, as there is only one staple crop that is the swamp taro. This crop is quite hardy and naturally resistant to many crop pests and diseases.*
- vii) Community issues need to address by the House of Chiefs and it would impact project activities*
- viii) Lack of water to maintain the growth of crops that have been planted*
- ix) Lead farmers do not have the background knowledge on agriculture*
- x) Strong wind and rough seas is quite dangerous to travel within the lagoon*
- xi) Limitation of land for agricultures purposes*

3. Findings

- i) Backyard farming is practiced by most peoples in Luaniua and Pelau*
- ii) Most people are interested and committed to be part of the demonstration activities*
- iii) Supply of more water tank is essential for plant watering and household use. This is because of water scarcity and saline of underground water which they depend much on. House of Chiefs must be informed when proposing plans for communicated*

- iv) *More awareness on the introduced farming systems that was introduced so that people in the communities are aware of the benefits of it.*
- v) *Not only the agriculture areas have been affected by the impact of climate change impacts, coastal erosion have also destroyed part of the agriculture areas as well*
- vi) *Need a full-time Agriculture Officer on the ground to provide close support to the local farmers*
- vii) *Traditional methods of drying of sea-foods such as fish and shellfish should be improved since they depend much on it for daily foods. At the moment the equipments they use are not up to health standards*

4. Lessons learned

- i) *There are more people interested and who would like to give up there pieces of land for the program to assist with the supply and planting of crops.*
- ii) *A network of NGO's and government agencies may be advantageous to be partners so they can assist each other in various ways, as they may need.*
- iii) *Atoll Permaculture is a new concept to the people of Pelau so it would take some time to work out its structure, form and to realise the short, medium and long-term benefits. Training will be an essential part to convey the information, which the people need to acquire.*

5. Recommendations

- i) *MAL need to recruit fulltime field officers to assist the farmers*
- ii) *Senior MAL/Research Officers to accompany teams who will be travelling to the atoll communities*
- iii) *Field officers in Malaita Province to conduct monitoring visit to the low lying atolls.*
- iv) *PACC-MAL needs to recruit 1 field staff especially, a person from Pelau to do the monitoring and assessment of the project for future purposes*
- v) *Need frequent monitoring to ensure the demonstrations are closely monitored and get feed backs from the lead farmers*
- vi) *Other Ministry's should also accompany on such missions as it is not only climate change issue that affects the communities of the low lying atolls*
- vii) *Other government projects within the Ministry of Agriculture should also focus the implementation on the low lying communities to ensure cost are shared equally.*
- viii) *That the Lead Ministry to provide co-financial support with PACC Project to support MAL intervention on the low lying communities*
- ix) *Build a temporary house for MAL/Climate Change Officers to use when doing work at Ontong Java.*
- x) *There is a need for PACC PMU to recruit 4 casual workers to assist with farm work in the 4 plots.*
- xi) *MAL PACC Project to support other remaining farmers who are interested to set-up their plots on the next field visit*

The EU – North Pacific – Readiness for El Nino Project <http://ccprojects.gsd.spc.int/eu-north-pacific-reni/>

The European Union (EU) – North Pacific – Readiness for El Niño (RENI) project is about communities working to secure food and water resources ahead of drought. The three-year (July 2017 – November 2020) project is funded with € 4.5 million from the EU and implemented by the Pacific Community

(SPC) in collaboration with the governments and peoples of the Federated States of Micronesia (FSM), Marshall Islands (RMI) and Palau.

In FSM, water security in Kapingamarangi in Pohnpei State and Yap Proper in Yap State have been selected. In Kapingamarangi, a remote atoll near the equator, community rainwater catchments will be refurbished and replaced, while In Yap Proper abandoned community water systems e.g. wells, will be refurbished so as to provide “point water sources” during drought for community as well as people living in other areas of Yap Proper. The sites are all near the capital Colonia.

In RMI, food security in two remote, drought prone, northern atolls, Ailuk, a rural environment, and Santo-Kwajalein, a semi-urban environment has been selected. Food security measures include increasing the availability of local food crops, especially more drought resilient crops, improving soil management practices, and establishing nurseries. Women especially will be involved in home gardening and trained in food preservation methods. Local area disaster management plans will also be prepared.

Climate change

Federated States of Micronesia

SOPAC. 2007. National Integrated Water Resource Management Diagnostic Report: Federated States of Micronesia. SOPAC Miscellaneous Report 636

- Increased frequency and intensity of tropical storms (typhoons).
- Global climate changes and sea level rise.
- El Nino – Southern Oscillation phenomena.
- Increased fluctuations in precipitation patterns (e.g. flooding and drought).

Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

Climate

- *Warming trends are evident in annual and half-year mean air temperatures for Pohnpei since 1951. The Yap mean air temperature trend shows little change for the same period.*
- *Extreme temperatures such as Warm Days and Warm Nights have been increasing at Pohnpei consistent with global warming trends. Trends in minimum temperatures at Yap are not consistent with Pohnpei or global warming trends and may be due to unresolved inhomogeneities in the record.*
- *At Pohnpei, there has been a decreasing trend in May–October rainfall since 1950. This implies either a shift in the mean location of the Inter-Tropical Convergence Zone (ITCZ) away from Pohnpei and/or a change in the intensity of rainfall associated with the ITCZ.*
- *There has also been a decreasing trend in Very Wet Day rainfall at Pohnpei and Consecutive Dry Days at Yap since 1952. The remaining annual, half-year and extreme daily rainfall trends show little change at both sites.*
- *Tropical cyclones (typhoons) affect the Federated States of Micronesia mainly between June and November. An average of 71 cyclones per decade developed within or crossed the Federated States of Micronesia’s Exclusive Economic Zone (EEZ) between the 1977 and 2011*

seasons. Tropical cyclones were most frequent in El Niño years (88 cyclones per decade) and least frequent in La Niña years (38 cyclones per decade). The neutral season average is 84 cyclones per decade. Thirty-seven of the 212 tropical cyclones (17%) between the 1981 and 2011 seasons became severe events (Category 3 or stronger) in the Federated States of Micronesia’s EEZ. Available data are not suitable for assessing long-term trends.

Climate Projections

For the period to 2100, the latest global climate model (GCM) projections and climate science findings indicate:

- El Niño and La Niña events will continue to occur in the future (very high confidence), but there is little consensus on whether these events will change in intensity or frequency;
- Annual mean temperatures and extremely high daily temperatures will continue to rise (very high confidence);
- Average annual rainfall is projected to increase (medium confidence), with more extreme rain events (high confidence);
- Drought frequency is projected to decrease (medium confidence);
- Ocean acidification is expected to continue (very high confidence);
- The risk of coral bleaching will increase in the future (very high confidence);
- Sea level will continue to rise (very high confidence); and
- Wave height is projected to decrease in December–March (low confidence), and waves may be more directed from the south in the June–September (low confidence).

Kiribati

Kiribati SECAP prepared for KOIFAWP, 2018

Droughts are quite common in Kiribati and when they do occur are particularly serious in the South Gilberts, where average rainfall is lower. Traditionally drought is regarded as a period when coconut trees progressively wither because of insufficient rainfall and declines in the fresh water lens. Based on analysis of rainfall data⁶⁷ Butaritari in the North Gilberts receives high rainfall amounts in all years, whereas the Central and South Gilbert Islands can experience abnormally dry years (see Table 1 below), particularly during La Niña events (high SOI values) as noted above.

Table 1. Record annual rainfall amounts (mm)

Station	Period	Annual rainfall			Annual rainfall		
		Highest	Year	SOI	Lowest	Year	SOI
Butaritari	1945-84	4365	1959	0	1447	1950	16
Tarawa	1947-84	3452	1972	-8	395	1950	16
Banaba	1905-84	4448	1919	-1	362	1917	2
Beru	1945-84	3085	1972	-8	247	1950	16
Arorae	1951-81	3100	1972	-8	375	1962	2

⁶⁷ Ibid

Results from Global Climate Models (GCMs) over the last 20 years have consistently shown increased temperatures, increased rainfall and sea level rise as the main consequences of climate change that are already affecting Kiribati. There are different degrees of certainty with these different changes. Summaries of the key changes and the degree of confidence with each are documented in the report prepared by the Australian Bureau of Meteorology and the CSIRO⁶⁸, as follows:

- El Niño and La Niña events will continue to occur in the future (*very high confidence*), but there is little consensus on whether these events will change in intensity or frequency;
- Annual mean temperatures and extremely high daily temperatures will continue to rise (*very high confidence*);
- Average rainfall is projected to increase (*high confidence*), along with more extreme rain events (*high confidence*);
- Droughts are projected to decline in frequency (*medium confidence*);
- Ocean acidification is expected to continue (*very high confidence*);
- The risk of coral bleaching will increase in the future (*very high confidence*);
- Sea level will continue to rise (*very high confidence*); and
- Wave height is projected to decrease in December–March (*low confidence*), waves may be more directed from the south in October (*low confidence*).

A key point to note from this analysis is that the projected decline in drought frequency is highly dependent on changes in El Niño and La Niña events and as stated “*there is little consensus on whether these events will change in intensity or frequency*”.

Another very important point to consider is the combined effect of all of these changes on the small, low-lying, islands of Kiribati. Higher temperatures will increase evapotranspiration which could lead to drier conditions at times, depending on the timing and intensity of rainfall events and also taking into account the fact that rainfall percolates very quickly through the porous coral soils of the atolls. Sea level rise will lead to loss of productive and habitable land with increasing intrusion of seawater into already limited freshwater lenses. Rising ocean temperatures and ocean acidification will have significant, severe, impacts on marine life.

Despite its low ranking in the annual World Risk Report⁶⁹, ranked as 165th in 2017 (which is a somewhat bizarre artefact of the way in which this index is derived), Kiribati is clearly highly vulnerable to climate change and associated sea level rise.

Republic of the Marshall Islands

Republic of the Marshall Islands Joint National Action Plan for Climate Change Adaptation & Disaster Risk Management 2014 - 2018

⁶⁸ Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

⁶⁹ <https://weltrisikobericht.de/english-2/>

Muliagatele Joe Reti. 2008. An Assessment of the Impact of Climate Change on Agriculture and Food Security in the Pacific: A case study in the Republic of the Marshall Islands.

“It is not clear whether increased temperatures will directly affect subsistence and commercial crops in the RMI. The scenarios of future temperature change for the middle of the next century indicate a rise of 1.6 – 2.9°C, implying a climate that is considerably different from that of the present. While changes in crop production and behavior are expected to occur as a result of temperature changes, what and how much of such change will occur remains unclear.

Unlike temperatures, there is strong evidence in the RMI that rainfall variations directly affect crop yield and production. For example, during the El Niño season of 1997-1998, significant reductions in most crop yields was reported. It is not known if El Niño events will increase in frequency and intensity in future or whether average rainfall will decrease.

However, if they do, it is highly likely that agriculture production will be adversely affected and hence traditional food crops will be in short supply. The scenario of higher rates of sea level rise and increased incidence of extreme events such as droughts and tropical cyclones could result in increased salinity of the soils and freshwater lens, thus impairing food production. This impact could have severe effects on pit taro which is an important subsistence crop for much of the RMI.”

“Majuro’s average annual rainfall is 3237 mm, distributed monthly as shown in Figure 4. Although rainfall is relatively high each month, there is a distinctly drier period from January to March. This pattern is more pronounced when extreme dry conditions prevail and the dry extends through April as shown in Figure 5 for the most severe droughts on record.”

Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

Current Climate

- *Warming trends are evident in both annual and half-year mean air temperatures at Majuro (southern Marshall Islands) since 1955 and at Kwajalein (northern Marshall Islands) since 1952.*
- *The frequency of Warm Days has increased while the number of Cool Nights has decreased at both Majuro and Kwajalein. These temperature trends are consistent with global warming.*
- *At Majuro, a decreasing trend in annual rainfall is evident since 1954. This implies either a shift in the mean location of the Inter-Tropical Convergence Zone (ITCZ) away from Majuro and/or a change in the intensity of rainfall associated with the ITCZ. There has also been a decrease in the number of Very Wet Days since 1953. The remaining annual, seasonal and extreme rainfall trends at Majuro and Kwajalein show little change.*
- *Tropical cyclones (typhoons) affect the Marshall Islands mainly between June and November. An average of 22 cyclones per decade developed within or crossed the Marshall Islands Exclusive Economic Zone (EEZ) between the 1977 and 2011 seasons. Tropical cyclones were most frequent in El Niño years (50 cyclones per decade) and least frequent in La Niña years (3 cyclones per decade). Thirteen of the 71 tropical cyclones (18%) between the 1981/82 and 2010/11 seasons became severe events (Category 3 or stronger) in the Marshall Islands EEZ. Available data are not suitable for assessing long-term trends.*

Climate Projections

For the period to 2100, the latest global climate model (GCM) projections and climate science findings indicate:

- *El Niño and La Niña events will continue to occur in the future (very high confidence), but there is little consensus on whether these events will change in intensity or frequency;*
- *Annual mean temperatures and extremely high daily temperatures will continue to rise (very high confidence);*
- *Average rainfall is projected to increase (high confidence), along with more extreme rain events (high confidence);*
- *Droughts are projected to decline in frequency (medium confidence);*
- *Ocean acidification is expected to continue (very high confidence);*
- *The risk of coral bleaching will increase in the future (very high confidence);*
- *Sea level will continue to rise (very high confidence); and*
- *Wave height is projected to decrease in the dry season (low confidence) and wave direction may become more variable in the wet season (low confidence).*

Tuvalu

Australian Bureau of Meteorology and CSIRO (2014). Climate Variability, Extremes and Change in the Western Tropical Pacific: New Science and Updated Country Reports. Pacific-Australia Climate Change Science and Adaptation Planning Program Technical Report, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia.

Current Climate

- *Annual and May–October mean and maximum air temperatures at Funafuti have increased since 1933. The frequency of night-time cool temperature extremes have decreased and warm temperature extremes have increased. These temperature trends are consistent with global warming.*
- *Annual and half-year rainfall trends show little change at Funafuti since 1927. There has also been little change in extreme daily rainfall since 1961.*
- *Tropical cyclones affect Tuvalu mainly between November and April. An average of 8 cyclones per decade developed within or crossed the Tuvalu Exclusive Economic Zone (EEZ) between the 1969/70 to 2010/11 seasons. Tropical cyclones were most frequent in El Niño years (12 cyclones per decade) and least frequent in La Niña years (3 cyclones per decade). Only three of the 24 tropical cyclones (13%) between the 1981/82 and 2010/11 seasons were severe events (Category 3 or stronger) in the Tuvalu EEZ. Available data are not suitable for assessing long-term trends.*

Climate Projections

- *For the period to 2100, the latest global climate model (GCM) projections and climate science findings indicate:*
- *El Niño and La Niña events will continue to occur in the future (very high confidence), but there is little consensus on whether these events will change in intensity or frequency;*
- *Annual mean temperatures and extremely high daily temperatures will continue to rise (very high confidence);*

- *It is not clear whether mean annual rainfall will increase or decrease, the model average indicating little change (low confidence), with more extreme rain events (high confidence);*
- *Incidence of drought is projected to decrease slightly (low confidence);*
- *Ocean acidification is expected to continue (very high confidence);*
- *The risk of coral bleaching will increase in the future (very high confidence);*
- *Sea level will continue to rise (very high confidence); and*
- *December–March wave heights and periods are projected to decrease slightly (low confidence).*

Tauisi Taupo & Ilan Noy. 2017. *At the Very Edge of a Storm: The Impact of a Distant Cyclone on Atoll Islands*. *EconDisCliCha* (2017) 1:143–166. DOI 10.1007/s41885-017-0011-4

“The study of cyclone risk for small low-lying islands is important as the intensity of cyclones in the Pacific is predicted to increase and sea levels are predicted to rise. In many ways, a small island developing state like Tuvalu can serve as the ‘canary in the coal mine’ pointing to the emerging risks that are being generated as we increasingly experience the impacts of climatic change. In Tuvalu, 70% of households live less than 200 m from the coastline and with an elevation of no more than 5 m above sea-level. Households are thus acutely vulnerable to storm surges caused by cyclones even if the cyclone itself passes very far away. In order to investigate the impacts of cyclones on low-lying atoll islands, we conducted a survey in Tuvalu after the islands incurred severe damage from storm surges generated by Tropical Cyclone Pam (March, 2015).”

“We first observed that poor households suffered far more losses and damages relative to their income than the non-poor. This inequity has previously been reported in urban areas in developing countries as poor households are more likely to live in floodplains or on steep hillsides. Yet, it is less expected on a Pacific Island where locational decisions of households are mostly dictated by generations-old land tenure rather than through market mechanisms that force low-income households to locate in riskier areas. Having summarized the aggregate impact of the cyclone storm surge on households, we then examined the role of the hazard, exposure to it, and vulnerability to cyclones in shaping these losses.”

Tauisi Taupo, Harold Cuffe and Ilan Noy. 2018. *Household vulnerability on the frontline of climate change: the Pacific atoll nation of Tuvalu*. *Environ Econ Policy Stud* <https://doi.org/10.1007/s10018-018-0212-2>

“... hardship levels are higher in the urban area (see Fig. 1) compared to the rural outer islands. The proportion of households who are potentially vulnerable to falling into hardship if there is a shock is also higher in the urban area and is increasing.”

“Households on the urban region of Funafuti are also more exposed and vulnerable to disasters than most of the outer islands, because of their proximity and direction of exposure to the coast, and low elevation (see Fig. 3). We also find that not only are the poor more likely to reside in areas prone to disasters in both the rural islands and the capital, they also tend to migrate internally and externally less compared to non-poor households. This observation may end up being important in the future if migration becomes the only viable adaptation option to sea-level rise—as many observers foresee. As migration becomes more necessary, a further related concern is that those who will be most exposed and, therefore, the most desperate to migrate will have the least ability to do so. This may lead to ‘trapped populations’ that also lack the ‘voice’ to express their plight and mobilize assistance.”

Climate smart agriculture

Federated States of Micronesia

PASAP and SPC. 2013. Securing food resources in the Federated States of Micronesia

<https://www.pacificclimatechange.net/document/securing-food-resources-federated-states-micronesia>

FSM has developed a food security and climate change policy. The PASAP and SPC was focused on identifying adaptive solutions for agriculture and communities. *“The two-year PASAP project identified the best performing varieties of drought- and salt-tolerant food crops, and strengthened local communities’ capacity to adapt to climate change.”*

Work involved:

- Identifying drought-tolerant sweet potato and salt-tolerant taro varieties, by conducting field trials
- Educating communities on how to identify the above
- Teaching agricultural methods based on locally grown produce and focused on how to manage and adapt to the changing environment
- Increasing awareness and knowledge about climate change impacts on food security

Next steps were identified as follows:

In line with FSM’s national food-security policy, national and state governments are considering the best options for securing national food resources through working with researchers, NGOs and the community to:

- *integrate climate change risk considerations into coastal management policies*
- *include community-based adaptation activities in land-use policies*
- *conduct further research into the impacts of climate change on food systems*
- *include atoll and rural communities in climate-action projects*
- *protect agroforestry and mangrove areas*
- *develop climate-change and food-security awareness and education campaigns*
- *collate and update geographic data to allow for better informed environmental and developmental management decisions.*

Enhancing the Climate Resilience of Atoll Communities on Yap Island, FSM

<https://www.climatelinks.org/blog/enhancing-climate-resilience-atoll-communities-yap-island-fsm>

On Yap Island in the Federated States of Micronesia (FSM), four atoll communities—about 800 people from the outer islands who have migrated to the main island—have gained a reputation for growing good-quality vegetables. Restaurants on this island now buy greens regularly from the home gardeners in these communities, rather than rely on imported produce. More importantly, the atoll communities can now access nutritious and reliable food sources on Yap.

Through a grant from USAID’s Pacific-American Climate Fund, the College of Micronesia (COM)-FSM Yap Cooperative Research and Extension division trained 120 households in atoll communities in soil management, climate-smart gardening and water harvesting techniques to build their resilience to

climate change impacts.

With improved access to land and water, the communities were trained in climate-smart agriculture techniques, including small-plot intensive farming, micro-gardening, container home-gardening, agroforestry and integrated farming. Through these alternative crop production methods, communities have been empowered to increase and sustain crop productivity.

The next step was training the atoll communities in value addition and marketing. The college's nutrition team taught these communities to make value-added food products such as breadfruit pancakes and pumpkin jams to sell.

FAO. 2014. Policy measures to increase local food supply and improve food security in the Federated States of Micronesia

A core issue is the impact on NCDs from increased dependence on imported food with low nutritional value (starchy, fatty, high sugar content). Recommendations are:

Exempt agriculture and agribusiness from the proposed VAT

Design and implement a health 'excise' on unhealthy food

Develop a school feeding program based on local nutritious foods, providing health benefits to school children and secure income to farmers, to be funded by the unhealthy food 'excise'

Work with farmers to help them gain better access to loans (e.g. by identifying and strengthening relevant value chains)

Form a Food Policy Council

Department of Resources and Development. 2012-2016. Federated States of Micronesia Agriculture Policy

"The FSM Strategic Development Plan (2004-2023) calls for an agreed vision and adherence to a national agriculture policy framework."

AGRICULTURE SECTOR VISION

"By 2023, FSM will have a vibrant, robust and productive agriculture sector that sustainably supports food security, healthy lifestyles, strong social safety nets, and promotes a greener economy. The sector will provide good employment and income generation opportunities, economic growth and a decreased trade deficit. This will help ensure a happy, healthy, prosperous and peaceful nation."

Policy Goals, Development Outcomes and Strategies:

1. A well resourced and properly focused agriculture sector operating within a stable and consistent policy framework
 - a. Strengthening agricultural and socio-economic data
 - b. Establish an Agricultural Policy Working Team
 - c. Develop a Medium Term Expenditure Framework
2. Enhanced capacity of sector stakeholders
 - a. Improved access to Technical and Vocational Training opportunities in agriculture
 - b. Strengthened capacity of government agriculture institutions to facilitate, coordinate and partner with the private sector and civil society
3. Increased sustainable production (and productivity) of traditional farming systems to provide for household nutrition, traditional needs and cash incomes
 - a. Increased sustainable production (and productivity) of traditional and semi-commercial farming systems – through research, extension, reviewing pricing policies, strengthening biosecurity services.
4. Increased volumes of saleable agricultural products to be marketed by the private sector into domestic and export markets

- a. Develop robust domestic and export market supply chains
- b. Improve quality, safety and consistency of supply
- c. Seek favourable trading agreements with key trading partners
- 5. More product value adding through efficient value chains
 - a. Increased opportunities and capacity for processing and value addition of traditional farm products
- 6. Strengthened domestic and international transport linkages
 - a. Review of transport service
 - b. Consider supporting a dedicated freight coordinator
- 7. Enhanced synergies between the agriculture and tourism sectors
 - a. Increased access of small-scale producers to the tourist market
- 8. Enhanced environmental services and sector resilience to natural disasters and climate change
 - a. Promotion of environmentally friendly production systems
 - b. Community-based approaches for management of natural resources
 - c. Strengthening of regulatory frameworks to support environmentally friendly production systems
 - d. Assessing and considering the impacts of climate change

FSM-SDP Volume 1

4.2.2 Traditional agriculture has been misunderstood and overlooked

“Small traditional subsistence and near subsistence farmers are a difficult extension target, requiring very different strategies from commercial farmers. One State Director of Agriculture freely admitted that he and his staff did little if anything for traditional farmers.”

“R&D for traditional agriculture has been limited. One comment was that there has been no research outcome of any value to farmers since 1994 when intercropping with spices research work was done. A further complaint is that, even if research is undertaken, the results are never properly disseminated. Another is that R&D programs reflect the interests and hobbies of researchers, not the needs of farmers (e.g., the banana germ plasm R&D effort).”

“A number of agencies are using a community-based approach. They recognize farmers are reluctant to openly share knowledge, and are suspicious of outsiders and new ideas. But once a new technology has been demonstrated in the community, with time to absorb the concept and information, and the message has been reinforced, farmers do respond. A community approach can work, with homogenous groups, using a gentle approach and regular follow up to allow shyness to be overcome and messages to be absorbed and recognizing that work in agriculture has lower priority than say funerals. Using multiple avenues of contact, e.g. radio/tv, interpersonal, workshops, is also important.”

The Draft Strategic Goals and Policies for the agriculture sector are:

4.3.2 Strategic Goal 1: A well resourced and properly focused agriculture sector consistently operating within a stable policy framework

4.3.3 Strategic Goal 2: To Increase production of traditional farming systems for home nutritional and traditional needs and cash incomes.

“The Natural Resource Conservation Service (NRCS) have been doing community based extension by working with groups of farmers (20-30) who are organized by the village chief. The key is grassroots

involvement in the initial planning, where the needs are determined by the community, from which the type of service required can be determined. NRCS believes there many opportunities to “tweak” traditional agriculture to improve both yields and profitability.

There are a number of other civil society groups in FSM successfully using the same approach. Two examples are:

- *The Pohnpei Conservation Society (PCS) started in 1997. Today it has 19 staff and a \$350,000 budget funded independently of government. They work with farmers to encourage agriculture in the lowlands and to discourage encroachment into the high forest areas;*
- *The Yap agriculture garden program (Sudal Victory Garden Project) is joint-funded by Salvation Army, Red Cross UNDP and Yap State Dept. of Agriculture. It assists with establishing food gardens by providing funds for seeds, fertilizer, tools, fencing, etc. The ultimate aim is to form a cooperative from the successful grantees, with a market outlet based around a local supermarket.”*

4.3.4 Strategic Goal 3: Increased volumes of saleable surpluses to be marketed by the private sector into local and regional markets.

4.3.5 Strategic Goal 4: Promote environmentally sound and sustainable production.

Kiribati

T. Otiuea, N. Teariki-Ruatu, E. Timeon, J.A. Francis, and J. Dietershagen. 2019. The agriculture-nutrition nexus in Kiribati. CTA Technical Brief 15

Key recommendations

- Enhance multi-stakeholder coordination, joint planning and complementary implementation to create greater synergy.
- Increase resilience of local farming and fishing communities to the effects of climate change, taking account of the differences between atolls.
- Urgently address ineffective protection laws that contribute to the over-exploitation and unsustainable development of coastal fisheries and marine resources.
- Carefully plan and execute education campaigns and training programmes on agricultural and nutritional issues targeting specific age groups; specifically children under five and women of child-bearing age.
- Revive interest in traditional knowledge and preservation techniques to increase availability and consumption of nutritious, local foods and fish. A public-private-community based approach that is embedded in local customs should be adopted.
- Identify at least 5-10 priority nutrient dense commodities (crops and fish) and develop action plans in support of food and nutrition security, agribusiness and value chain development and income generation.

Agriculture and Livestock Division. Agriculture Strategic Plan 2013-2016. Republic of Kiribati

Major challenges for crop production:

6. Shallow, calcareous, porous, soils
7. Limited water availability
8. Narrow genetic base - There are few food plants that are native to atolls and are tolerant of harsh atoll conditions, like pandanus. Coconut, Colocasia and Cytosperma taros, banana (*Musa* spp) and breadfruit (*Artocarpus altilis*) were introduced by indigenous people. The cultivation of these plants requires control and modification of the environment. Most of the

introduced food plant and forestry species are not very tolerant of salinity and harsh atoll conditions. Some of the varieties of species like pandanus, taro, breadfruit, coconuts, dwarf banana, traditional fruits and sources of traditional medicines are now endangered. Mangroves and some of the coastal and inland forests are disappearing. In Kiribati there were over 200 varieties of edible pandanus, which used to produce food even in severest of droughts, but many are disappearing now. Oral history supports this observation. There is not enough replanting to replace the pandanus destroyed by deforestation and fire outbreaks, and young people tend to ignore this traditional food source. Natural biodiversity on atolls is narrow, and some of it is starting to be lost, endangering food security.

9. Pests and diseases

10. Costs of farm inputs

Forestry challenges - The major challenge for forestry is the disappearance of native forest trees and traditional agroforestry systems.

Republic of the Marshall Islands

Muliagatele Joe Reti. 2008. An Assessment of the Impact of Climate Change on Agriculture and Food Security in the Pacific: A case study in the Republic of the Marshall Islands.

“The Republic of the Marshall Islands (RMI) has identified the development of subsistence agriculture as a key strategy for the support of its rapidly growing population. The most important food crops are copra, breadfruit and pandanus. These crops used to be abundant during their seasons but harvests are reported to have been disrupted by climatic extremes such as typhoons and droughts in recent years. Prolonged periods of drought over the past twenty years caused changes to the water tables which in turn affected taro and breadfruit production during the period. This situation is expected to worsen with future climate change and has the potential to seriously affect the government’s strategy for the development of the subsistence agriculture sector.”

“The steady shift away from the use of traditional subsistence crops especially in the urban and more populated centers is also making efforts to revive the agriculture sector difficult. Increased preference and reliance on imported foods on the other hand is putting pressure on the national economy and have implications for nutrition and health. Given these situations, the local processing of traditional crops would appear to be a reasonable and viable goal for efforts to revive the agriculture sector.”

FAO. Marshall Islands and FAO: Partnering to improve food security and income earning opportunities.

Summarise priorities identified in FAOs Country Programming Framework (CPF) for 2013-2017.

Three priority outcomes:

- Strengthened policy, legislative, regulatory and strategic planning frameworks for food and nutrition security
- Increased availability, access and utilization of local food
- Strengthened capacity for environmental management and resilience (including disaster preparedness, emergency response and climate change)

Strengthening local food production

“Over the years, large-scale consumption of non-traditional foods has caused a major shift in dietary patterns, contributing to a significant increase in nutrition-related diseases as well as an escalating food import bill. Under a regional programme for food security in the Pacific Island Countries, with a

view to boosting local food production and increasing household income, FAO has provided assistance for the establishment of home gardens. Following the 2008 food price crisis, vegetable and poultry inputs were provided as a further means of enhancing the food security and nutritional status of vulnerable households and communities. Targeted technical assistance has also been provided to boost aquaculture and banana production.”

<https://www.spc.int/updates/news/2018/07/republic-of-marshall-islands-strengthens-food-security-measures-ahead-of>

Republic of Marshall Islands strengthens food security measures ahead of future droughts

“Communities in the remote, drought prone, northern atolls of the Republic of Marshall Islands (RMI) are trialling new food security measures to increase the availability of local food crops, expand the use of drought resistant crop varieties, improve soil management practices, and establish nurseries.

These efforts are part of the European Union – North Pacific – Readiness for El Niño (RENI) project, implemented by the Pacific Community (SPC). The project is a response to the severe 2015-2016 El Niño drought, and will enhance the resilience of communities to potential shocks and insecurities resulting from future droughts.

RENI has adopted a participatory approach to this project, which incorporates the rights and vulnerabilities of women and marginalised groups. National and local area consultations were held early in 2018 to ensure that the voices of local communities in RMI were heard and that the project activities address their practical needs. Following this planning process, a detailed project design document was finalised by the Government of RMI and SPC in July 2018.

The initial food security activities of RENI will be trialled in Ailuk, a rural environment, and Santo-Kwajalein, a semi-urban environment. The experiences from these trials will then be shared with residents and farmers in Enewetek, Mejit, Utrik and Wotho. Throughout the entire process SPC staff will be working closely with the RMI agencies responsible for natural resources, internal affairs and disaster management.”

Wayne Nelles. 2018. Building the Evidence Base on the Agriculture Nutrition Nexus: Marshall Islands. CTA Working Paper 18/03.

Identified needs

Agronomic-marine, environmental and value-chain needs

- More value-added processing, transport and marketing;
- Salt tolerant, “climate smart” and drought-resistant plant or tree varieties;
- Local community nurseries and centres for local genetic resources conservation, seed saving, cultivation and cuttings propagation on each of the Outer Islands;
- More space for school gardens with full-time care-takers and teacher coordinators;
- Long-term renewal and investment in the coconut and copra industry.

Education, extension and technical support needs

- More technical support and human or financial resources for the Outer Islands, especially in partnership with relevant government authorities and NGOs;
- Improved and expanded farm extension services implemented by adequately educated and trained extension workers;
- Updated, more relevant technical and vocational education and training (TVET);
- More public awareness, education (non-formal and formal) and teacher training on nutritional or food security values of traditional plants or native species in local diets.

Core research needs

- Better available, accessible and systematically collected agricultural statistics, since existing RMI agriculture data is poor while some sources, indicators and findings from different studies or external sources conflict or are not comparable;
- More agronomic, interdisciplinary and social sciences research on FNS issues.

Main action recommendations

- Monitor, assess, strengthen and scale-up best practices (and good intentions) from recent initiatives (e.g. Wellness Center, school gardens, organic farm training, etc.).
- Evaluate the implementation and impacts of RMI's 2013 Food Security Policy.
- Conduct a full nation-wide agriculture and food system census to collect and analyse economic, agronomic, social, environmental and value chain data in one place.
- Begin new long-term collaborative, participatory research in cooperation with international agencies and academic institutions on the diverse barriers or constraints and incentives, enabling factors and policy options to healthier and more sustainable diets, agri-food systems, market opportunities, procurement and value chains.
- Develop a clear cross-sectoral strategy and national plan (through public, private, producer, community collaboration) to substantially increase local agriculture production and processing (in support of value chain development), and with measurable targets (linked to SDGs) to encourage self-sufficiency and healthier diets and reduce food import dependency. Adequate government funding, private sector investment and donor support must be mobilised for successful implementation, monitoring and evaluation. As an initial pilot, ten priority traditional agroforestry, roots/tubers, vegetables and marine species that are important for food and nutrition security, have income generation potential and can be branded as unique RMI should be targeted.

Republic of Marshall Islands Food Security Policy, October 2013

Five Priority Strategic Action Areas

1. Stimulating sustainable local food production and preparation and better linking producers to consumers.
2. Strengthening access to nutritious food for vulnerable households and individuals.
3. Educating the public about food security and nutrition and encouraging home gardening.
4. Facilitating efficient national food distribution channels.
5. Building safety, quality and resilience into food supply and production systems.

Tuvalu

Global Climate Change Alliance: Pacific Small Island States Project Design Document. Improving Agro-forestry Systems to Enhance Food Security and Build Resilience to Climate Change in Tuvalu.

The overall objective of the EUR 0.5 million project is to 'Increase resilience to climate change impacts in Tuvalu'. The purpose is to 'Enhance food security in Tuvalu'. The implementation period for this project will begin immediately after the required parties have signed the agreement and ends on 30th June, 2015. The project will benefit the 6,194 people living in the urban capital Funafuti (55% of the population) as well as one outer island yet to be selected. The key result areas are as follows: (i) Enhanced understanding of agro-forestry among community members, land owners, and Kaupule through awareness raising, capacity building and training; (ii) Improved agro-forestry system

implemented in demonstration sites in Funafuti and one outer island; (iii) Marketing potential and access evaluated; and (iv) Enhanced coordination and capacity of the Department of Agriculture.

This project attempts to lessen the negative impacts of climate change and urbanization in Funafuti and outer islands through reviving traditional integrated farming practices combined with innovative 'climate ready' crops and trees. The project will demonstrate intensive agricultural production on under-utilized land, while diversifying crop varieties available nationally. Such outputs will help to stabilize local food supplies, thereby enhancing food security and building resilience to economic shocks, extreme events, and the predicted effects of climate change. Specifically the project will establish integrated agro-forestry demonstration sites on two islands, where unproductive trees will be thinned, the soil will be enhanced, and the sites replanted with trees and crops sourced from within Tuvalu, as well as imported from the Secretariat of the Pacific Community's (SPC) climate ready plant collections developed by the Centre for Pacific Crops and Trees (CePaCT). An extension team from the Department of Agriculture will train the land owners and communities in the cultivation and usage of the crops in this integrated agro-forestry farming system. Training and awareness raising will be a key component of the project, and will target farmers, women's groups, and school children.

The capacity of the Department of Agriculture will be enhanced by providing technical staff for the duration of the project, by offering overseas attachments to selected technical officers, by strengthening the department to gather data on successful crop and tree varieties, and by re-equipping their Agricultural Research Station for the purpose of holding national stock of plant varieties. Potential economic benefits of the agricultural yields will be determined by an Agricultural Marketing Plan, and may include producing coconut products and pandanus juice, as well as selling the fruits and vegetables in the Funafuti market and stores. Strengthening local farmers' cooperatives and associations will complement this process.

The project will ensure close coordination with other actions, e.g. the UNDP- NAPA projects, Australia - SPC CePaCT Nursery Project, Taiwan ICDF Horticulture project, and SPC- GIZ CCCPIR climate change coordination project. The project is consistent with the Te Kakeega II: National Strategy for Sustainable Development (NSSD) 2005–2015 four key policy objectives related to agriculture: (i) reverse the decline in subsistence agriculture production; (ii) increase the availability of land for agriculture; (iii) increase the production and consumption of local produce; and (iv) mitigate climate change related agricultural impacts. The project aims to specifically address these key policy objectives and the corresponding priorities stated in the Te Kakeega II: NSSD through an integrated agro-forestry approach.

Government of Tuvalu. 2016. Strategic Marketing Plan 2016-2025.

Funded by the GCCA: PSIS project above

The overarching goal of the Tuvalu Agriculture Strategic Marketing Plan (TASMP) is to increase the resilience of the Tuvalu people in relation to climate change by fostering a sustainable domestic trading platform for local food and other local produce, mainly traditional handicrafts. In pursuit of this noble goal, a review of various documents relating to agriculture in Tuvalu, combined with the findings and outcomes of the consultations held in Tuvalu and abroad (particularly in Fiji), identified issues and challenges (Chapter 6) and a total of 38 recommendations were developed (Chapter 5).

From these issues and recommendations, eight common threads were identified that depict general thematically focused development areas, which the TASMP process will follow (detailed in Appendix B).

The eight common threads are as follows:

- 1. Restructuring and strengthening of agriculture, which includes an organisational arrangement restructure for the Department of Agriculture (DOA);*
- 2. Increased sale and consumption of local food with emphasis on the 'Go Local' campaign;*
- 3. Increased production of local food through organic farming, which includes development of the 'pulaka' pit system;*
- 4. Revival of production of traditional quality handicrafts, which includes the establishment of minimum quality standards for handicrafts and educating the younger generation on the range of skills necessary in making handicrafts;*
- 5. Research and development with emphasis on the branding and development of export and cultural industries;*
- 6. Changing the mindsets and attitudes of the people to accept and 'Go Local' by streamlining the campaign into all levels of the school curriculum;*
- 7. TASMP implementation through the use of the Strategic Action Plan Framework (SAPF – Chapter 6) and Six Months Rolling Implementation Plan (6mRIP – Chapter 7); and*
- 8. Financing the TASMP which includes identifying recurrent costs and preparing specific project proposals.*

The TASMP process will not only strengthen the resilience of the Tuvalu people against the negative impacts of climate change, but the population will also be healthier with fewer incidences of non-communicable diseases (NCDs). However, it does require political commitment by leaders – the Tuvalu Government and the administrative directorate must successfully design and implement an effective 'Go Local' food campaign.

Arthur Webb. 2007. Tuvalu Technical Report. Assessment of Salinity of Groundwater in Swamp Taro (*Cyrtosperma chamissonis*) "pulaka" Pits in Tuvalu. EU EDF8-SOPAC Project Report 75

*"Swamp taro (*Cyrtosperma chamissonis*) locally known as pulaka is grown in Tuvalu and throughout the Central Pacific atolls as a starch crop. In past times, it had an important role as a daily food crop and although today it is fast being replaced by imported starch products (e.g. rice and flour), swamp taro still has a significant place in the diet and culture of the Central Pacific atoll peoples.*

Atoll soils are extremely poor and crop cultivation of any sort in these environments presents great challenges. Since soils are predominantly derived from carbonate reef-borne material and are relatively young, they are poorly developed, lack structure and texture and are very porous with poor water holding capacity (Barr 1992). Additionally, atoll soils are naturally deficient in nutrients required for successful crop growth and due to their high pH, important micro-nutrients such as, iron and zinc (already present in very low concentrations) are made less available for plant uptake (Barr 1992; Webb 1994). The natural depressions and excavated pits used to grow swamp taro present one of the best opportunities to circumvent these agronomic limitations."

Horticulture expansion project Tuvalu.

<https://www.icdf.org.tw/ct.asp?xItem=29117&CtNode=29823&mp=2>

The Government of Tuvalu has recognized of the outcomes of the demonstration farm managed in cooperation with Taiwan. To date, the area of the farm has increased five-fold, but due to land limitations in Funafuti (about 2.6 square kilometers), there is no more vacant land that the government could provide through which to expand the scale of cultivation at the site.

With the long distances between Tuvalu's eight outer islands and the uncertain schedule of transport

ships, the emphasis of agricultural extension activities was originally focused on the capital. The largest outer island, Vaitupu (home to about 20 percent of the population), has been unable to receive the benefits of the crops provided by the demonstration farm. The government's national development strategies (*Te Kakeega II Mid-Term Review: Action Plan 2015*) specify "increased production and consumption of local produce" as the country's main agricultural development strategy, while the WHO has been similarly clear that an inadequate intake of vegetables is one of the 10 most important factors influencing mortality throughout the world.

The problem of low intake of fruits and vegetables is particularly serious in Vaitupu.

The project's specific work components will include:

- a. Establishing an agricultural workstation in Vaitupu.
- b. Guiding twelve staff at the workstation to raise output to 330 tons of fruits and vegetables.
- c. Training four teachers specializing in nutritional promotion to design a set of nutritional promotion programs.
- d. Enhancing intake of fruits and vegetables by providing students with up to 80 tons of fruits and vegetables for group meals and holding 10 nutrition-related activities.

To the end of March 2019, the following activities have been completed:

1. Reclaimed 3 hectares via the Elisefou Agricultural Station on Vaitupu.
2. Built an irrigation facility with over 200 tons of storage capacity on Vaitupu.
3. Managed a total of 31.80 hectares on the main island, Funafuti (Fatoaga Fisfia and home gardens 8.22 hectares; Vaitupu 23.58 hectares).
4. Produced a total of 1003130 fruits and vegetables seedlings (Funafuti:762760; Vaitupu: 240370)
5. Produced 183.79 tons of fruits and vegetables at the two agricultural centers (Funafuti:100.12 tons; Vaitupu:83.67 tons)
6. Produced 1118 tons of organic compost (Funafuti:505 tons; Vaitupu:613 tons)
7. Conducted 8 demonstration activities.
8. Conducted 32 training workshops.

Water and hydrology

Federated States of Micronesia

R.T. Bailey and J.W. Jensen. 2011. Groundwater resources analysis of atoll islands in the Federated States of Micronesia using an algebraic model. Technical Report No. 134. Water and Environmental Research Institute of the Western Pacific. University of Guam.

"Results indicate that of the 105 atoll islands considered only 6 would retain a fresh body of groundwater able to sustain the community during a drought similar to that experienced in 1998."

Johnston Mathew. 20???. Federated States of Micronesia IWRM Outlook Summary and NWTf Report

"The water related issues impacting the FSM are the common issues facing almost all other PIC's with; Sanitation Coverage, Waste Disposal, Climate Variability, Watershed Management and Atoll Water Security. The common problems throughout the Pacific need a regional wide approach. The outcomes from each of the individual country programmes and a regional support network are the best ways to highlight international best practices. The example of Tuvalu developing a model of

successful composting toilets, will be a great addition to the FSM IWRM Project especially in relation to rural sanitation coverage, with time and time again sanitation being mention as the highest priority issues across many of FSM's communities."

The Global Climate Change Alliance: Pacific Small Island States project in Federated States of Micronesia (FSM): Increasing coastal water security for climate change in selected Federated States of Micronesia (FSM) state outlying islands

"The 'Increasing coastal water security for climate change in selected FSM state outlying islands' project is providing rainwater catchment systems and improving water infrastructure in Fais Island, an outlying island of Yap State, and supporting assessment and design work in Eot and Udot Islands, two lagoon islands in Chuuk State. The capacity and quality of household and communal rainwater catchment systems will be increased. The project will also provide information and resources to improve water systems maintenance, water conservation, and water education as well as contributing to the hydrological knowledge base with respect to the outlying islands of FSM."

"Documentary - In 2013, a short documentary, Adapting to Climate Change in FSM: the Food and Water Security Dimension, was prepared and distributed as part of a regional series. The video focuses on food and water resource challenges in many small low-lying island nations."

SOPAC. 2007. National Integrated Water Resource Management Diagnostic Report: Federated States of Micronesia. SOPAC Miscellaneous Report 636

"For FSM as a whole, the main source of fresh water are surface water, groundwater and rainwater. The primary source of fresh water in most of the Island States comprises of both underground, surface water and rainwater; the small islands for each state are fully dependable on rain water and shallow wells due to the low elevation of the islands."

"In the FSM's atolls, raised coralline islands, and in those coastal areas composed of coral sand deposits and lagoon sediments, the freshwater lens which "floats" on the underlying denser seawater is tapped through shallow, hand-dug wells to supplement the rainwater catchments and storage tanks which are widely used and commonly the main source of drinking water in the outer islands."

"Major water resource management issues for FSM include:

- Vulnerability to climate change.*
- Deforestation of watersheds and resultant sedimentation of lagoons and coastal areas.*
- Water related disease through poor sanitation and lack of effective wastewater treatment.*
- Lack of awareness of water related diseases, hygiene and sanitation.*
- Cross subsidising of water supply through electricity production and the long term sustainability of this.*
- Lack of capacity in water resource management.*
- Loss of biodiversity through deforestation and lagoon degradation."*

Kiribati

Agriculture and Livestock Division. Agriculture Strategic Plan 2013-2016. Republic of Kiribati

On the atolls both the limited quantity of water available and the quality of the water are limiting. Underground freshwater lenses are the major source of water on the larger atolls. Where there is

underground water, it is either in danger of contamination with brackish water if overexploited, or it is already brackish. Harvesting rainfall is an important option for both domestic and agricultural use. Competition for water by different sectors (crops, animals and human) is putting great pressure on the limited water resources on the atolls.

Government of the Republic of Kiribati. 2008. National water resources policy: Water for Healthy Communities, Environments and Sustainable Development

Priority Issues Addressed by the Policy:

- The high rate of preventable deaths and illnesses due to water-borne diseases;
- Contamination of fresh groundwater sources by human settlements and sanitation;
- Impacts of climate variability and change on the availability of fresh water;
- Difficulties in protecting, conserving and managing freshwater sources;
- Growth in demand for water especially in urban areas;
- Inequities in provision of services to schools, hospitals, clinics, rural, outer island and urban communities;
- Limited collection and use of rainwater;
- Large unaccounted for losses and leakages in water reticulation systems;
- Financially and hydrologically unsustainable water supply systems;
- Constraints on development due to limited water supplies;
- Inadequate knowledge and monitoring of the nation's freshwater resources;
- Decrease in the number of trained water specialists and technicians;
- Limited community participation in freshwater management and conservation;
- Limited community understanding of responsible water use and protection; and
- A need for enhanced water education in schools.

Ian White. 2007. A Whole-of-Government Approach to Water Policy and Planning. Final Report. Republic of Kiribati Pilot Project.

Post, V.E.A.; Bosserelle, A.L.; Galvis, S.C.; Sinclair, P.J.; Werner, A.D. (2018). On the resilience of small-island freshwater lenses: Evidence of the long-term impacts of groundwater abstraction on Bonriki Island, Kiribati. Journal of hydrology (2018), page 1-43

“Groundwater on islands occurs in the form of freshwater lenses that serve as an important water resource for local inhabitants. These lenses are highly vulnerable to salinization due to natural recharge variations and groundwater abstraction. Determining the sustainable yield from freshwater lenses is challenging because the lens response during drought periods and the long-term effects of pumping are both difficult to predict”.....

“Modelling indicates that when monthly recharge inputs fall below around 2500 m³/d (i.e., a flux of 1.7 mm/d) plus the abstraction rate, the lens tends to contract. Thus, despite the highly distributed and extensive abstraction network on Bonriki Island, a significant amount of recharge is eventually lost to submarine groundwater discharge. The long-term freshwater storage trend indicates that Bonriki Island's lens is still contracting after 27.5 years of pumping, and lens thinning is threatening to impact the water supply salinity. This means that even permeable, small islands like Bonriki may take at least two decades to realise new equilibrium conditions that reflect pumping stresses, which is an important consideration in assessing the sustainable yield of small islands, in particular those less resilient to pumping than Bonriki.”

UNICEF. 2014. Harvesting Rainwater to Improve Access to Safe Drinking Water and Adapt to Climate Change: Spotlight on Kiribati

“UNICEF is working with the Ministry of Public Works and Utilities and island councils to promote the use of rainwater harvesting at communal buildings with suitable corrugated iron roofs such as traditional meeting places (maneabas), health centres, churches and schools.”

“In collaboration with the government and the European Union, UNICEF is implementing a water and sanitation project in the outer islands of Kiribati covering all 16 atolls and half of all the villages in the Gilbert Group. UNICEF is focusing on installing new rainwater harvesting systems with safe storage facilities. Specific goals of the programme include enhancing the community’s ownership and capacity to ensure sustainable operation and maintenance.”

Government of the Republic of Kiribati. 2008. National Water Resources Implementation Plan. Sustainable Water Resource Management, Use, Protection and Conservation. A 10 year Plan.

SOPAC. 2007. National Integrated Water Resource Management Diagnostic Report: Kiribati. SOPAC Miscellaneous Report 636

“Numerous studies, reports and national consultations have identified the key priorities in Kiribati. The key challenges in the water resource sector are: limited freshwater resources; sustainability of water harvesting; impacts of settlement and land use on water quality; fragmented control, management and protection of water resources; increasing demands for water resources; insufficient knowledge and understanding of water resources nationwide; social and environmental impacts of water abstraction proposals; land ownership in water reserves; limited use of rainwater harvesting; lack of community understanding and appreciation of responsible water management; lack of conservation incentives; limited community involvement in water resource management and protection; impacts of human waste; lack of national water policy and legislation; impacts of droughts and storm surges on groundwater; and predicted impacts of climate change.”

“In the water and sanitation services sector the challenges are: highly variable and inadequate levels of service; high levels of leakage and unaccounted for water loss at household levels; low levels of cost recovery and non-financially viable operations; increasing water demand and usage; limited available and relevant technical skills and capacity; insufficient knowledge and understanding for planning and management; inadequate attention paid to wastewater disposal and sanitation; inadequate appreciation of responsible water management and use by communities; limited community involvement in water service planning, management and delivery; uncoordinated development across sectors; deteriorating water quality and quantity at supply sources; inappropriate land use in water reserves; and in rural areas, lack of safe water supplies and sanitation.”

Republic of the Marshall Islands

SOPAC. 2007. National Integrated Water Resources Management Diagnostic Report: Republic of the Marshall Islands. SOPAC Miscellaneous Report 639.

“Majuro, Ebeye and the Outer Islands of the RMI face both water quantity and quality challenges. The two main water utilities continue to face financial and operational challenges. Conservation and demand management remain weak. Water resources assessment and monitoring remains limited (although this is slowly improving).”

“The RMI faces increasing vulnerability from floods and other natural and man-made disasters and yet its disaster preparedness capacity remains fundamentally weak. This becomes especially problematic with unsustainable development practices and the potential threats posed by climate change.”

Johnston, M. 2013. Republic of Marshall Islands Water & Sanitation Sector: Final Report.

“RMI has a uniquely fragile water resource network due to its small size, lack of storage, and limited fresh-water capacity. The situation is multiplied by limited investments made in water and sewage management and infrastructure. Furthermore, until recently little attention has been paid to the potential effects of climate related extremes on RMI’s current water resources, especially with regards to salt-water intrusion, which negatively affects the limited freshwater lens on some of the lower-lying islands and atolls. On the Majuro Atoll, where over 50% of the population reside, the water supplies rely on the airport runway catchment area, from where water is piped to the city’s principal reservoir, and the Laura freshwater lens. Hygiene and sanitation continue to be a concern and a particular challenge is to manage a sewage system without contaminating the ground-water lens. Already, some of the country’s fresh-water lens has been contaminated with brine, from over extraction and coastal movements from human development practices and erosion.”

“There are many donor funded water programs that cover various aspects of the water sector from education programs to supplying rainwater catchment tanks. Furthermore there are specialized climate change and disaster risk management programs that focus programs on drought resistance and climate change adaptation measures protecting groundwater lenses.”

“There are, however, many areas within the water and sanitation sector that require further programs and management actions in such fields as public systems, rainwater catchments, groundwater, water quality and human health, emergency preparedness, water conservation and outreach programs.”

“According to the RMI 2011 Census, rainfall catchment supplies over 79% of the household water supplies. Increases in population on the two urban islands Majuro and Kwajalein (Ebeye), pose a significant challenge to meeting future water needs. The country has made only limited investments in water and sewage management and infrastructure.”

Report includes a summary of relevant projects in RMI (see table beginning on p. 28, Section 5 Programs)

Barkey, B.L. and Bailey, R.T. 2017. Estimating the Impact of Drought on Groundwater Resources of the Marshall Islands. Water 2017, 9, 41; doi:10.3390/w9010041

“Results highlight the fragility of groundwater resources for the nation. Average lens thickness during typical seasonal rainfall is approximately 4 m, with only 30% of the islands maintaining a lens thicker than 4.5m and 55% of the islands with a lens less than 2.5 m thick. Thicker lenses typically occur for larger islands, islands located on the leeward side of an atoll due to lower hydraulic conductivity, and islands located in the southern region of the RMI due to higher rainfall rates. During drought, groundwater on small islands (<300 m in width) is completely depleted. Over half (54%) of the islands are classified as “Highly Vulnerable” to drought.”

Marshall Islands: Protecting drinking water from drought and sea level rise.

<https://www.undp.org/content/undp/en/home/ourwork/ourstories/Marshall-Islands-Protecting-drinking-water.html>

PACC Project

Highlights

- 20% of the population is affected by extreme droughts that threaten drinking water and crops.
- The project helped increase freshwater stores, which can now last 3-4 months in an emergency.
- 186 solar water purifiers will be delivered to communities in the outer islands.

Gale, A. and deBrum, H. 2017. Water Challenges in the Marshall Islands: Managing drought in a high rainfall atoll country. Water e-journal: Volume 2, No 2.
<https://doi.org/10.21139/wej.2017.018>

“Water resources and supply vary widely across the Marshall Islands. The discussion has been broken into three groups:

- *Majuro – country capital, highly urbanised, approximately 28,000 people*
- *Ebeye – highly urbanised, approximately 10,000 people*
- *Outer Islands – traditional living, populations from a few hundred to 1800 across 22 atolls*

The discussion in this paper will focus primarily on drought management for Majuro, with brief discussions on Ebeye and the outer islands to demonstrate the diversity of approaches.”

Conclusions

The Marshall Islands are a graphic demonstration that high rainfall does not necessarily mean water supply security. Quantifiable understanding of the various factors influencing water security, along with sensible management practices by appropriately qualified and experienced water managers are prerequisites. Application of experiences from the 2016 drought, along with previous droughts, means that the communities of the Marshall Islands are much better placed to manage future droughts.

Key conclusions are:

- 1.** *Water resource management in the RMI requires a number of diverse approaches in the widely dispersed atoll country with specific conditions for different communities, from highly urbanised in Majuro and Ebeye to small communities on outer islands*
- 2.** *Majuro is dependent on rainwater harvesting and surface runoff and thus is subject to rapid development of drought conditions (two to four weeks of no rainfall) for the 75 percent of the community who are not connected to MWSC’s public supply system. Those connected to MWSC’s system had a reliable water supply throughout the 2016 drought.*
- 3.** *Ebeye is essentially drought-proof due to its primary source of water being SWRO, but there is considerable pressure on KAJUR providing reliable operations and maintenance practices to avoid a major outage, resulting in an artificial “drought”.*
- 4.** *The outer islands are highly reliant on temporary “suitcase” size SWRO plants that are flown or shipped to the outer islands at the onset of the drought and are returned to MWSC for warehousing between droughts.*
- 5.** *Water resources will be an ongoing challenge for RMI but continuing development of good planning and management practices by the leaders of MWSC and KAJUR and a better understanding of drought management by the general community will mean that 3000 mm of rain per year will be adequate!*

Tuvalu

SOPAC. 2007. National Integrated Water Resources Management Diagnostic Report: Tuvalu. SOPAC Miscellaneous Report 647.

The islands of Tuvalu are generally composed of very coarse coral gravels and sands. The coarse sediments cannot sustain substantial fresh groundwater lenses to the extent that exists in other atoll countries in the region. In Tuvalu the primary freshwater source is from stored household and communal rainwater. The overall available water resources are only partly known, and in most of the outer islands the available groundwater and its quality is largely unknown. The estimated demand for freshwater in the main population centre of Funafuti is close to the estimated sustainable freshwater yields indicating vulnerability to variations in climate.

Groundwater salinity levels vary, but it is historically a non-potable secondary source in areas where salinity levels are not prohibitive. In times of prolonged drought it has also been a source of drinking water on some islands. Its use as a secondary source has been severely compromised by pollution from inadequate sanitation systems on Funafuti, and there is an increasing threat that this could also occur on the outer islands. Waterborne diseases are common and exact a significant toll on the health, wellbeing and productivity of the population. The coastal areas of Funafuti are a major source of livelihood and also contain marine biodiversity of conservation value.

These areas are also under threat from poor solid and liquid waste management.

There is a need to refurbish or supplement fresh water resources by repairing rainwater harvesting systems, increasing household and community rainwater storage and investigating and expanding the use of groundwater resources.

There is no centralised sewerage system and 100% of households depend upon onsite wastewater systems and/or practices, so wastewater/sanitation management is entirely in the hands of the community. Most households also rely on individual or communal rainwater tanks so water management is largely in the hands of the community. Householders require training as follows:

- demand management including use of water saving devices, leakage control and adaptation to climate variability;*
- design, construction and maintenance of rainwater harvesting systems;*
- design, construction and maintenance of effective and appropriate waterborne sanitation systems;*
- design construction and maintenance of waterless sanitation zero discharge systems (including method of treatment, advantages and disadvantages, cost);*
- water quality monitoring and protection including use of filters and first flush mechanisms; and*
- training in hygienic construction and maintenance of wells should also be provided to households in relevant locations. Training should draw on traditional understanding of groundwater management.*

Government of Tuvalu. 2011. Sustainable and Integrated Water and Sanitation Policy

Tuvalu has approximately a total of 55,966.06 KL of available rainfall for a population of 10,264. Using the 101 litres as a standard of individual consumption per day, Tuvalu will have enough water just for 54 days without rain. Tuvalu has been struck by drought in the past. The worst scenario was in 2011. In 1950 Tuvalu was struck by drought in which Tuvalu went without rain for 109 days. In 1971, a drought also occurred with lowest rainfall recorded for this year. In 1999, a drought also occurred. Most recent drought was in September 2011. Most people even decision makers will ask "what volume of storage capacity is enough to sustain a population of 10,264?". To survive a drought period of no rainfall for about 5 continuous months, Tuvalu needs 150,000m³ of water storage

facilities. If Funafuti population is 5199, the required volume of water to survive a 5 month of no rain is 79,000 KL.

The provisions of enough storage facilities is an interim solution to water problems of Tuvalu, it does not solve the root causes of the problem. Factors that do contributed to the water problems lies in the hands of individuals in the Household level. The behavior and daily practices of the people is the underlying problem. This is exacerbated by leaked tanks/cisterns and taps, damaged and poor fixing of rain gutters.

Cost effective energy solutions

W.G.L. Aalbersberg, C.E.A. Lovelace, K. Madhoji & S.V. Parkinson (1988) Davuke, the traditional Fijian method of pit preservation of staple carbohydrate foods, Ecology of Food and Nutrition, 21:3, 173-180, DOI: [10.1080/03670244.1988.9991030](https://doi.org/10.1080/03670244.1988.9991030)

“The traditional Pacific method of food staple preservation by fermentation in pits has been studied. The details of the method as performed in Fiji are discussed as well as the nutritional and chemical changes undergone by breadfruit during this fermentation. The taste acceptability of the product was tested as well as ways to adapt the procedure to modern conditions. The process is a lactic acid fermentation and the nutritional quality of the preserved food is similar to the fresh one. The fermentation can be effected using less labour and materials than was used in the traditional method.”

Ragone, Diane. (2002). Breadfruit Storage and Preparation in the Pacific Islands. Conference: Vegeculture in Eastern Asia and Oceania, At The Japan Center for Area Studies, National Museum of Ethnology, Osaka, Volume: JCAS Symposium Series 16. pp 217-232.

Breadfruit (Artocarpus altilis, A. mariannensis, and hybrids) has long been an important staple crop in Oceania. The starchy fruit is typically cooked by roasting whole or halved fruits in an open fire or earth oven, boiling, or occasionally frying as chips. A popular preparation is made from mature or ripe cooked breadfruit that is grated or pounded, mixed with coconut leaves, wrapped in leaves and baked. In many islands, these starchy puddings are the main form in which breadfruit is consumed. Steamed or boiled breadfruit is pounded until it becomes pastelike or doughy. Since breadfruit is a seasonal crop that produces much more than can be consumed fresh, islanders have developed innovative techniques to utilize large harvests and store fruits for future use. The most widespread method is fermenting breadfruit in a leaf-lined pit. This semi-anaerobic process reduces the fruits to a sour doughy paste called ma, mahi, masi, madrai, mahr, namandi, furo, or bwiru, which supplements and enhances the daily diet of fresh breadfruit. Fermented breadfruit can last for a year or more, and is removed and eaten at various stages of fermentation depending upon cultural rituals, need, and taste preferences. Fermented breadfruit is still made every season throughout Micronesia; however, this once common practice is disappearing elsewhere in the Pacific islands. This paper discusses traditional and contemporary methods of breadfruit preservation and use in Oceania focusing on its importance and significance in cultural practices and identity on the island of Pohnpei. Breadfruit (Artocarpus altilis, A. marianensis, and hybrids) have long been an important staple crop in Oceania. The starchy fruit is typically cooked by roasting whole or halved fruits in an open fire or earth oven, boiling, or occasionally frying as chips. A popular preparation is made ...

Wade, Herbert. 2005. Demonstration projects to showcase the business angle of renewable energy service delivery in the Pacific Islands. Apia, Samoa: SPREP.

“...the proposed demonstration project for Group II countries [Kiribati, FSM and RMI] is the development of coconut oil as a biofuel substitute for diesel fuel for power generation and both land and marine commercial transport. The demonstration project is proposed for RMI ...”

Fruit-bearing solar crop dryer could provide for thousands (2011, January 11) retrieved 13 August 2019 from <https://phys.org/news/2011-01-fruit-bearing-solar-crop-dryer-thousands.html>

"A solar crop dryer developed by a UNSW photovoltaic and solar energy engineering student has the potential to provide a living for thousands of people throughout Vanuatu. Talia Curtis, 29, who developed the solar tunnel dryer as part of her Masters thesis, wanted to create a unit that would allow families to dry and sell the abundant fruits and nuts found through the South Pacific island nation.

"I want to create a design that could be built out of easily accessible materials," says Talia of her bamboo, wood, corrugated iron and polythene film construction which she adapted from a German design."

SPC/GIZ Coping with Climate Change in the Pacific Island Region. 2013. Enhanced food security and alternative income opportunities through solar fruit drying on Pele Island, Vanuatu. Briefing Note.

NOTE: This appears to be based on the solar dryer developed above

"The solar fruit dryer uses solar energy to naturally dry and preserve fruits, nuts, fish or meat. A 1-watt solar panel is sufficient to power two fans that blow solar-heated air around the inside of the dryer. The dryer does not require batteries and works during both sunny and cloudy weather conditions. Drying mangos can take as little as two days and the product can last for up to a year. The programme encourages villagers to expand the planting of fruit and nut trees as a way to financially benefit from sustainable land use and also adapt to climate change."

Rowe, Jonathan P.; Russon, Jonathan K.; and Steele, Frost M., "Solar Dryer Construction and Use Manual Version 2.0 2007" (2007). All Faculty Publications. 938.

<https://scholarsarchive.byu.edu/facpub/938>

"This work was done to enable the people of the Pacific islands to meet some of their food requirements in times of need by enabling them to preserve some of their indigenous crops for storage in times of emergency.

This manual is developed for the use of those interested in drying of food products in the Pacific Island areas. The dryer was developed for use in the Pacific area, but can easily be adapted for use in most any area of the world."

[Rupantri Raju. 2010. Effectiveness of Solar Drying on Local Fruits](https://www.researchgate.net/publication/265468885_Effectiveness_of_Solar_Drying_on_Local_Fruits)

https://www.researchgate.net/publication/265468885_Effectiveness_of_Solar_Drying_on_Local_Fruits

"Postharvest losses of surplus seasonal fruits are a major problem in Fiji and other Pacific Islands. Drying is one of the cheapest and most efficient methods to preserve these surpluses, but there are losses with open sun drying due to contamination by pests and dust.

*Three different types of solar dryers were selected to dry 60kg of papaya (*Carica papaya*) and pineapple (*Ananas cosmusas*). The dryers used were: indirect dryer, cabinet dryer and direct dryer with natural convection.... The direct cabinet dryer was the most effective ...*

The conditions in the Pacific make the use of solar energy for drying food economical and environmentally sustainable as it uses a renewable energy source."

Federated States of Micronesia

FAO CPF (year?)

Improved product development, marketing systems and market access for high value specialty commodities.

Processing of seasonally abundant crops (i.e., breadfruit) could be explored to extend shelf-life and availability. Local farmers/producers need assistance for gradual and smooth transition from solely subsistence to combine with market driven production.

Republic of the Marshall Islands

Muliagatele Joe Reti. 2008. An Assessment of the Impact of Climate Change on Agriculture and Food Security in the Pacific: A case study in the Republic of the Marshall Islands.

Government should consider local processing of traditional food crops into more marketable commodities such as chips, flour or oil that have longer shelflife and are easier and lighter to transport.

Local markets for traditional crops are very limited not only in the urban centers but also in the outer islands. Many Marshallises are said to have lost the taste for local food and it is uncertain therefore if extra efforts to revive interest in traditional crops will result in increased consumption. In light of this uncertainty, it is recommended that government should to consider the local processing of food crops into more marketable commodities such as chips, flour, etc., that have longer shelf-life and are easier and lighter to transport. Processing can also create job opportunities for the large number of Marshallese who are presently unemployed.

Local disaster risk (reserve) funds

Climate data and services

Personal Communication from Alan Porteous, Group Manager, Climate Data and Applications, NIWA:

“Climate services in the NH are mostly handled by NOAA as you I’m sure are aware. You’ve probably discovered the link below – I’m not sure how active or up to date this is; NOAA has few resources committed to this work. We are gradually developing CliDE/CliDEsc services in the countries you mention – Tuvalu will probably be in June next year with some additional instrumentation and then looking at sector needs. FMS and RMI are further out but are planned. There’s further work in Kiribati ongoing with drought monitoring etc. Slow going”

Regarding community engagement:

“I’d say there is a lot more engagement now in trying to make this happen. In all the meetings I go to there are (for example) media training sessions which help with dissemination of information at community level. Quite a bit of work has been done on traditional knowledge and this has raised awareness of changing conditions and the need for dialogue between communities and government agencies. So you get things like early warning systems being built with communication pathways that involve community leaders and communicators. So I’d say a lot is happening but more is needed.”

You might find some useful examples on the SPREP page www.sprep.org

SECAP recommendation for Kiribati:

- Introduce simple manual rain gauges and educate people in the basics of daily rainfall recording. By owning the recording of rainfall in their village and island they will begin to understand and appreciate more clearly why and when they need to be more consciously conserving their water.

SPREP portal:

<https://www.pacificmet.net/projects>

Program for implementing the Global Framework for Climate Services (GFCS) at Regional and National Scales. <https://www.pacificmet.net/project/strengthening-climate-services> This project is funded by Environment and Climate Change Canada (ECCC) through the World Meteorological Organization (WMO) and implemented by SPREP and the Pacific Meteorological Council (PMC) through the Pacific Island Climate Services (PICS) Panel (link to PICS Panel: www.sprep.org/meteorological-services/PICS-Panel). The GFCS project in Pacific commenced on 1 July 2015 and will finish on 31 March 2018. **The Goal of the Programme** is to enhance resilience in social, economic and environmental systems to climate variability and climate change through the development of effective and sustainable Regional and National Climate Services under the GFCS in selected regions and countries.

[NOAA](http://www.noaa.gov)

<http://pacificislandsclimate.org/csdialogs/>

“Climate services dialogs are workshops designed to share climate knowledge, diagnose and enhance existing climate services, and build climate stories that can be shared within different sectors and communities. The [climate stories](#) help inform regional and local decision makers about the impacts of climate change and variability, highlighting key messages and best practices with respect to the development and delivery of [climate services](#).”

<https://www.riskscape.org.nz/international-projects>

What is the RiskScape Water Resource Module?

Will you have enough water when the next El Niño event occurs? If you knew this ahead of time, what could you do to prevent water shortages before they occur?

By using the RiskScape Water Resource Module, the Republic of the Marshall Islands (RMI) and Tuvalu governments can now better prepare for and respond to future rainfall shortages and drought. Tested and developed for the RMI and Tuvalu, the module is designed so that atoll countries can estimate their current and future water resources based on various rainfall and water consumption scenarios.

Another thing that’s fairly new with plenty of stuff in the pipeline is

<https://www.pacificmet.net/rcc>

The WMO RA-V Pacific Regional Climate Centre (RCC) Network

The WMO RA-V Pacific Regional Climate Centre (RCC) Network is a virtual Centre of Excellence that assists National Meteorological and Hydrological Services (NMHSs) in the Pacific Islands region to deliver better climate services and products and to strengthen their capacity to meet national climate information and service delivery needs.

Users of the information presented here are requested to contact their respective Pacific Island National Meteorological and Hydrological Service for country-specific climate information and guidance.

Kiribati SECAP, 2018

Historical rainfall data (from the 1950s to the mid 1990s) are available for all of the South Gilbert islands. These need to be obtained from the Kiribati Meteorological Service so that graphs of annual and seasonal rainfall can be produced. The project could introduce simple manual rain gauges and educate people in the basics of daily rainfall recording. By owning the recording of rainfall in their village and island they will begin to understand and appreciate more clearly why and when they need to be more consciously conserving their water.