



PACC Demonstration Guide: Integrating climate risk into coastal road design in Kosrae, Federated States of Micronesia



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Integrating climate risk into coastal road design
in Kosrae, Federated States of Micronesia**

TABLE OF CONTENTS

Acknowledgements	iv
Executive summary	v
Abbreviations	vi

1. INTRODUCTION	1
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2. BACKGROUND AND CONTEXT	2
2.1. The Federated States of Micronesia	2
2.2. Kosrae State	2
2.3. Policy and institutional context	3
2.3.1. National policy	3
2.3.2. Kosrae State policy	4
2.4. Climate	4
2.4.1. Current climate	4
2.4.2. Projected climate	5
2.5. Risks and vulnerabilities of the coastal zone	5
2.5.1. Climate-related risks and vulnerabilities	5
2.5.2. Non-climate drivers of risk	6

3. THE DEMONSTRATION PROJECT	7
3.1. Objectives, outcomes and outputs	7
3.2. Preparatory phase	7
3.2.1. Selection of project and site	7
3.2.2. Linkages with strategic policy and planning	8
3.2.3. Institutional framework for the project	9
3.2.4. Community engagement	9
3.2.5. Addressing gender	9
3.3. Situation and problem analysis	10
3.3.1. CLIMAP study	10
3.3.2. Community consultation	10
3.4. Solution analysis	10
3.4.1. Identifying the options	10
3.4.2. Cost–benefit analysis	11
3.4.3. Selection of option	11
3.5. Demonstration design	11
3.6. Implementation	12
3.6.1. Road improvements	12
3.6.2. Installation of monitoring equipment	12
3.7. Monitoring and evaluation	13
3.8. Communications and knowledge management	13
3.9. Upscaling and replication	14

4. MAINSTREAMING CLIMATE RISK AT THE STRATEGIC LEVEL	15
5. SUSTAINABILITY, RELEVANCE, EFFECTIVENESS AND EFFICIENCY	16
5.1. Sustainability	16
5.2. Relevance	16
5.3. Effectiveness	16
5.4. Efficiency	17
6. LESSONS LEARNED	18
REFERENCES	19
APPENDIX 1. FSM PACC PROJECT LOGFRAME	20

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This report is an output of the Federated States of Micronesia (FSM) PACC project. It was written by Jonathan McCue and Martin Le Tissier, and reviewed by Simpson Abraham (FSM PACC Project Coordinator), Carlos José Cianchini (FSM PACC Assistant Project Coordinator), Dr Netatua Pelesikoti (SPREP), Peniamina Leavai (SPREP) and Damien Sweeney and Martin Pritchard (Pacific Research and Evaluation Associates).

EXECUTIVE SUMMARY

In the Federated States of Micronesia (FSM), the Pacific Adaptation to Climate Change (PACC) project focused on coastal zone management on the island of Kosrae, and specifically the 'climate proofing' of a section of island road. The choice of project was influenced by earlier work under the Asian Development Bank (ADB)-funded Climate Adaptation in the Pacific (CLIMAP) project in 2005, which identified the need for climate proofing of the road, and carried out various assessments and analyses, but did not complete the on-the-ground work.

CLIMAP identified the need to complete the Tafunsak to Walung section of the Kosrae circumferential road. The circumferential road on Kosrae plays a vital transport role for the people of the island, and also directs the location of other infrastructure and development. It is therefore critical to the resilience of the community that the road be able to withstand current and future impacts of climate and sea.

The CLIMAP analyses found that the original road design had been based on inaccurate rainfall data, i.e. they had not accounted for increases in rainfall in the design and engineering. The road had been built with drainage works designed for a maximum hourly rainfall of 178 mm, which supposedly had a return period of 25 years. An analysis of more reliable data indicated that an hourly rainfall with a return period of 25 years is 190 mm. By 2050, however, the hourly rainfall with a 25-year return period is projected to increase to 254 mm as a consequence of climate change. Based on these results some aspects of the road design were amended, specifically the culverts were redesigned to accommodate the higher rainfall.

The first section transects a mangrove area, and here the road was raised to accommodate predicted sea level rise, and new larger culverts were placed in order to maintain hydrological connectivity between the seaward mangroves and those mangrove areas landward of the road. For the second section of the road, the surface was improved and larger culverts added in order to accommodate the potential levels of run-off from land seaward from the revised rainfall predictions. The new road was completed and officially opened in May 2014.

In addition to the engineering works for the road, climate and sea level monitoring equipment was installed in November 2011 as part of the PACC project, to support and inform climate-sensitive decision making and planning.

In parallel with the demonstration project, the FSM PACC project team has had some significant achievements in mainstreaming of climate risk into Kosrae State policy and regulations, notably its contributions to the passing of a Climate Change Act (enacted in 2011), and amended regulations for development that require climate change impacts to be considered in all development projects and EIA processes. The project also contributed to the revision and update of the Kosrae Shoreline Management Plan, which mainstreams climate risk into this key management plan for the State's coastline and coastal communities.

A lesson learned from the FSM PACC project is the importance of basing project design on latest information. The project was largely based on preparatory work carried out in 2004 under the ADB CLIMAP case study and the design standards manual for road infrastructure produced in 1987, and apart from updating rainfall projections, further updates were not carried out. A second lesson is that information on the processes and practices for developing sustainable climate-proof infrastructure needs to be captured, made available, and mainstreamed into regulations where appropriate.

ABBREVIATIONS

ADB	Asian Development Bank
CBA	Cost–benefit analysis
CLIMAP	Climate Adaptation in the Pacific (project)
DTI	Department of Transportation and Infrastructure
EIA	Environmental impact assessment
GDP	Gross domestic product
ITCZ	Inter Tropical Convergence Zone
KIRMA	Kosrae Island Resource Management Authority
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
OEEM	Office of Environment and Emergency Management
PACC	Pacific Adaptation to Climate Change (programme/project)
PACCSAP	Pacific Australia Climate Change Science and Adaptation Planning program
PCCSP	Pacific Climate Change Science Program
SDP	Strategic Development Plan
SMP	Shoreline Management Plan
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

1. INTRODUCTION

The Pacific Adaptation to Climate Change (PACC) programme is the largest climate change adaptation initiative in the Pacific region, with projects in 14 countries and territories. PACC has three main areas of activity: practical demonstrations of adaptation measures; driving the mainstreaming of climate risks into national development planning and activities; and sharing knowledge in order to build adaptive capacity. The goal of the programme is to reduce vulnerability and to increase adaptive capacity to the adverse effects of climate change in three key climate-sensitive development sectors: coastal zone management, food production and security, and water resources management. The programme began in 2009 and ended in December 2014.

In the Federated States of Micronesia (FSM), the PACC project adopted the sectoral theme of coastal zone management and focused specifically on the island and State of Kosrae, one of the four States that make up the country of FSM. The choice of sector and project was influenced by earlier work under the Asian Development Bank (ADB)-funded Climate Adaptation in the Pacific (CLIMAP) project in 2005 (Hay et al., 2005). This earlier project identified the need for climate proofing of the Kosrae coastal road, and carried out various assessments and analyses but did not complete the on-the-ground work. In discussions with the State Government and national stakeholders, it was agreed that the PACC project would continue this work and climate proof the road as a demonstration of practical adaptation measures.

The circumferential road around Kosrae plays a vital transport role for the people of the island, and also directs the location of other infrastructure and development. The majority of residential property developed over the last decades is along the main paved sections of road. Likewise the power distribution network (power lines and poles) runs along the road. It is therefore critical to the resilience of the community that the road be able to withstand current and future impacts of climate and sea.

The PACC-improved road section moves inland, traversing coastal mangrove swamp towards the base of the more inland volcanic parts of the island. The project is leading the way by demonstrating how coastal roads will need to be relocated to avoid increasing risks due to sea level rise. In addition, although not a direct objective of the PACC project, the purpose of the circumferential road and its links to the existing coastal road is to promote relocation of communities away from the vulnerable shoreline as well as to provide escape routes to safer higher ground during extreme weather events.

In parallel with the demonstration project, the PACC team contributed to significant advances in mainstreaming of climate risks into development policy and planning for Kosrae, and made major steps in raising awareness and building knowledge on climate change and adaptation measures.

This report focuses specifically on the demonstration project, with a brief summary of the achievements in mainstreaming and knowledge building. Aimed primarily at climate change practitioners across the Pacific region, it describes the project from inception and early planning stages, through design and implementation, to monitoring and evaluation, with a focus on lessons learned along the way and best practices identified. As with the demonstration guides from the other PACC projects, the hope is that future projects can build on the experiences of PACC, contributing to a more resilient Pacific region.

2. BACKGROUND AND CONTEXT

2.1. The Federated States of Micronesia

The Federated States of Micronesia (FSM) is a group of approximately 600 islands in the western Pacific Ocean. These islands vary from small islets that disappear at high tide to atolls to large volcanic islands with land area of more than 80 km². Approximately 65 of the islands are inhabited. The country is comprised of four states – Chuuk, Kosrae, Pohnpei and Yap – which each have a considerable degree of autonomy.

The mainstays of the FSM economy are subsistence farming and fishing. There is limited tourism due to lack of access and facilities, although it has increased in recent years with a number of small hotels opening in Pohnpei, Yap and Kosrae. Geographic isolation and poorly developed infrastructure are major impediments to FSM's economic growth, and poverty is among the highest in the Pacific region. FSM has, in general, made only limited progress towards achieving the Millennium Development Goals by 2015.

The public sector plays a central role in the economy; the national and state-level governments employ over half of the country's workers and government services and public enterprises account for 38% of GDP. Since the 1995 Economic Summit, the private sector has been a focus of economic development. There are now 22 private, locally owned construction companies. All road maintenance is performed by locally owned companies.

Additional country information is presented in Table 1.

Table 1. Geographic, socio-economic and demographic information for FSM (from EU-GCCA, 2013).

Geographic coordinates	Lat. 1° S to 14° N, long. 135° W to 166° E
Total land area	701 km ²
Length of coastline	6,112 km
Exclusive economic zone	2,980,000 km ²
Population (2011 estimate)	102,360
Population forecast (2015)	100,609
Annual population growth rate	-0.4%
Population density	146 per km ²
Access to improved water supply (2006 estimate)	94%
Access to improved sanitation facilities (2013 estimate)	26%
Human Development Index	0.645

2.2. Kosrae State

Kosrae State comprises the single island of Kosrae, the easternmost island in FSM, with an area of 112 km² (Figure 1). Kosrae is a volcanic island surrounded by mangroves and coastal strand forests that have been historically used for lumber and fuel by residents. About 70% of the land is mountainous, with steep, heavily vegetated watersheds and unstable slopes. Invasive vegetation is prolific and has taken a foothold in every watershed (e.g. climbing vines such as *Antigonon leptopus*). The remaining land is more gentle slopes, coastal strip

and mangroves. The coast is characterised by a fringing reef broken by four natural harbours: Lelu in the east, Utwe in the south, Okat in the north-west and Yela in the west. About 70% of Kosrae’s population and infrastructure are located in the low-lying coastal areas, and hence are very vulnerable to climate change and sea level rise.

The population of approximately 8,247 (2000 census) is largely dependent upon fishing and farming for their livelihood. The major population centres are Lelu and Tafunsak. The economy is dominated by US Government grant funding and other external assistance with tourism (918 visitors in 2012) the only other significant foreign revenue earner.

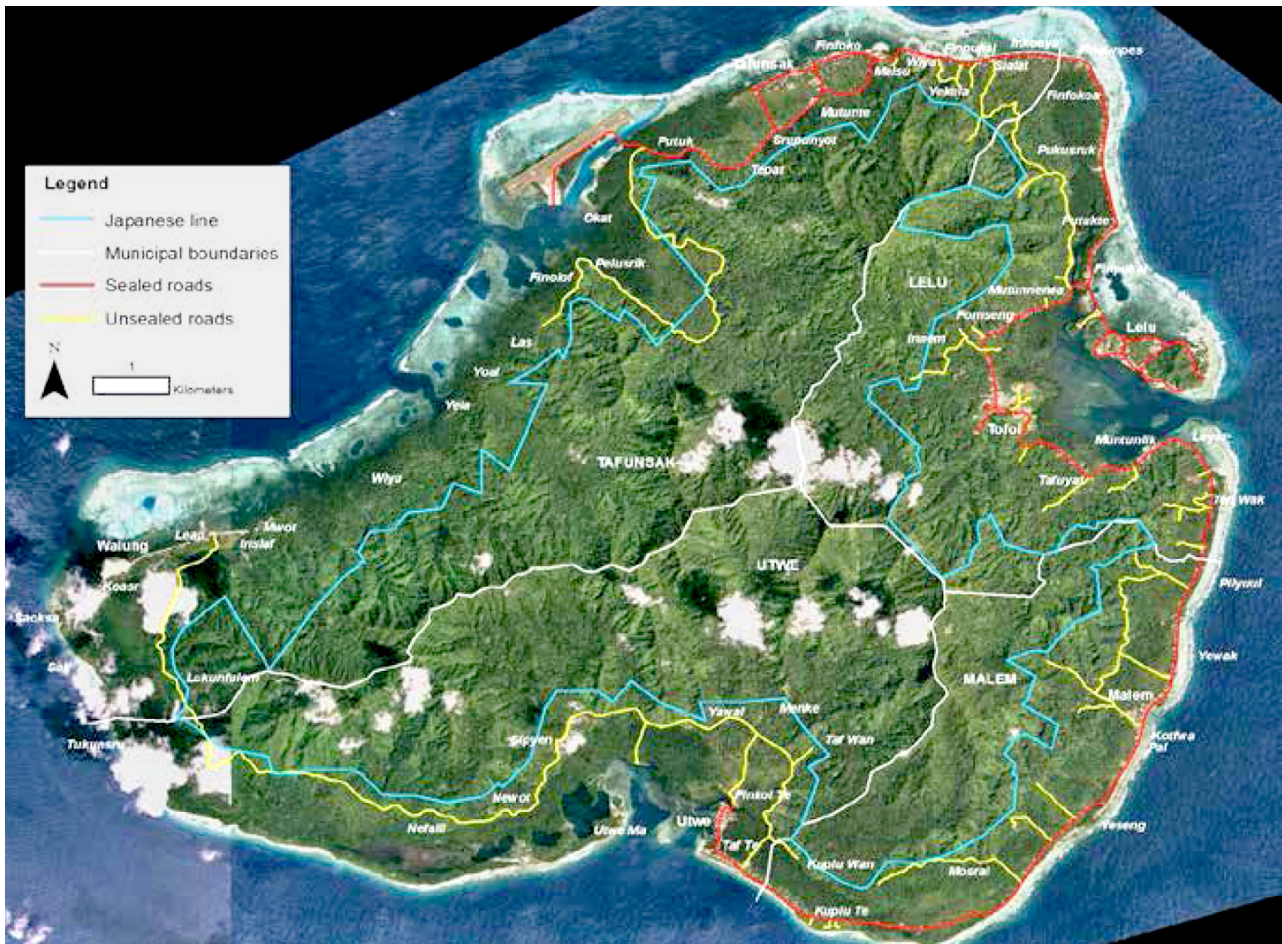


Figure 1. Map of Kosrae.

2.3. Policy and institutional context

2.3.1. National policy

The Strategic Development Plan (SDP) for FSM provides a road map for social and economic development for the 20 years 2004–2023. The SDP and the Infrastructure Development Plan (IDP) both recognise the need for mitigation and adaptation measures to limit the impacts of climate change.

FSM developed a Multi-State Hazard Mitigation Plan in 2005, and in 2009 a national Climate Change Policy was adopted. The country developed a combined Policy for Climate Change Adaptation and Disaster Risk Management in 2013. This is being implemented through State Joint Action Plans for Climate Change and Disaster Risk Management. The Office of Environment and Emergency Management (OEEM) is the focal point for all government climate change activities.

FSM currently has no national strategy for coastal zone management.

2.3.2. Kosrae State policy

The Kosrae Strategic Development Plan (2013–2024) guides the State’s development. Currently, Kosrae is the only State in FSM with a climate-responsive SDP. The SDP recognises that “the most prudent approach to addressing effects of naturally occurring events (climate change or disaster risks) long term would be to divert development and settlement along the coast to inland and higher grounds” (SDP 2013–2024, p. 29). The Environmental Results and Targets No. 6 states that by 2023 capacity is strengthened at all levels to climate change adaptation, and management and mitigation of risks of disasters enhanced so that communities are resilient to impacts of climate change and disaster risks. Resilience to climate change is also included within strategies for agriculture.

Kosrae has a Shoreline Management Plan (SMP), first developed in 2000 and revised and updated in 2014 with input from the PACC project (Ramsay et al., 2014). Acknowledging the major threat of climate change, the SMP sets out the principles for coastal development in Kosrae over the coming decades, and details eight key strategies for increasing the resilience of Kosrae’s coastal communities:

- Strategy 1: Continued development and strengthening of community awareness including outreach activities with a focus on effective natural coastal defence and Kosrae-relevant climate change impacts and adaptation options.
- Strategy 2: Amendment of the Kosrae Integrated Resource Management Authority (KIRMA) Regulations for Development Projects to incorporate climate change considerations and strengthening of regulation implementation to support successful long-term risk reduction and adaptation.
- Strategy 3: Over the next one to two generations the primary coastal road network and associated infrastructure currently located on the beach/storm berm is developed inland away from long term erosion and coastal inundation risk.
- Strategy 4: Ensure new development (property, infrastructure) is located away from areas at risk from present and future coastal hazards or is designed with coastal hazards in mind.
- Strategy 5: Implement a program to encourage existing residential property owners to reposition homes away from areas of high risk from present and future hazards. This may be a staged approach over time as homes are routinely replaced or renovated. Objective prioritisation of properties most at risk should also be explored.
- Strategy 6: Incorporate a grant component in to the housing loan program to help encourage new property to be constructed in areas not exposed to coastal, river floor or landslide hazards.
- Strategy 7: Commence community and state discussions to develop a relocation strategy and identify potential approaches to support relocation from areas exposed to coastal hazards where no alternative land is available.
- Strategy 8: A strategic approach is adopted for the ongoing provision of coastal defences. These should be considered only where it is a sustainable long-term option, or where it is accepted as a transitional approach to protecting areas over the short to medium term to enable relocation strategies to be implemented.

2.4. Climate

2.4.1. Current climate

The following climate information is taken from the Pacific Climate Change Science Program (PCCSP) and the Pacific–Australia Climate Change Science and Adaptation Planning Program (PACCSAP) (Australian BoM and CSIRO, 2011, 2014).

In FSM there is little seasonal variation in temperature, with less than 1.5°C between the average temperature of the hottest and coolest months (Figure 2). The country has two distinct seasons – a wet season from November to April and a dry season from May to October (Figure 2). Rainfall in FSM is affected by the movement of the Inter-Tropical Convergence Zone (ITCZ). During the wet season, the ITCZ strengthens and moves north close to

FSM. The West Pacific Monsoon also impacts rainfall, bringing additional rain during the wet season. FSM's climate also varies considerably from year to year due to the El Niño-Southern Oscillation. El Niño events are associated with drier conditions and occasional droughts. Fires, water shortages and food shortages occur during severe dry events. During La Niña events, above-average numbers of tropical storms occur as well as more rainfall. Droughts, typhoons, storm waves, flooding and landslides all affect FSM.

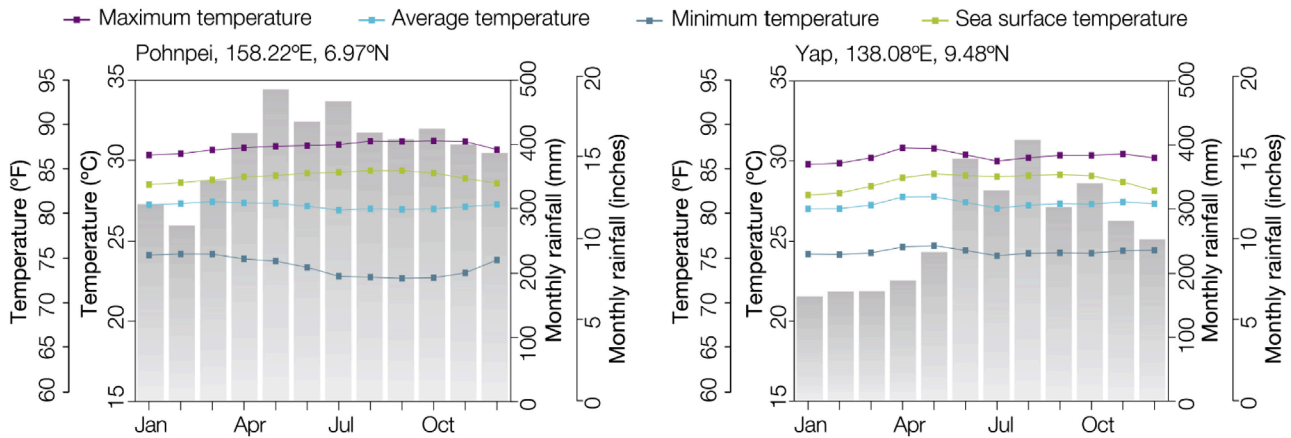


Figure 2. Mean monthly temperature and rainfall for Pohnpei and Yap (FSM). (Source: Australian BoM and CSIRO (2011), with permission.)

2.4.2. Projected climate

According to PCCSP and PACCSAP (Australian BoM and CSIRO, 2011, 2014), for the period to 2100, the latest global climate model (GCM) projections and climate science findings for FSM indicate that:

- 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 June–September (low confidence).

A number of studies suggest that global warming could accentuate the current climate regimes and the changes that come with ENSO events (Hay and Pratt, 2013).

2.5. Risks and vulnerabilities of the coastal zone

2.5.1. Climate-related risks and vulnerabilities

The coastal zone is particularly vulnerable to increased rainfall, sea level rise, and extreme events such as tropical cyclones. Each of these contributes to a heightened risk of flooding and inundation, which in turn threaten coastal infrastructure, including existing coastal protection structures. The majority of communities and infrastructure in

Kosrae are located in the coastal zone, and are already vulnerable to climate and sea impacts; without adaptation measures this vulnerability will increase with the projected impacts of climate change.

Between November 2007 and February 2008, for example, Kosrae experienced high sea levels which caused severe flooding of low-lying land and coastal erosion, particularly to the south of Malem. Similarly, between December 1999 and February 2000, higher than normal spring tides coinciding with strong winds and large waves resulted in flooding and wave overwashing, causing damage to properties located on the shoreline, particularly at Finaupes, Finfokoa and further south at Malem.

2.5.2. Non-climate drivers of risk

In addition to the climate-related impacts, there are increasing stresses placed on coastal zones and coastal infrastructure from anthropogenic factors. These non-climate factors add to and compound the climate and sea-related risks to Kosrae's coastal zone infrastructure.

- Poor coastal zone management and planning: for example, there are no land use regulations, or associated building regulations/codes.
- Poor design and engineering of coastal infrastructure: for example, road design has not taken account of sediment movement patterns or run-off, leading to problems with erosion and flooding. Embankments adjacent to roads are also poorly designed and there are frequent land slips.
- Poorly maintained roads: the lack of a rigorous road maintenance programme is exacerbating damage from sea and weather factors.
- Coast mining: a lack of affordable building material has encouraged communities to mine coastlines and reefs for sand and gravel, reducing the natural shoreline protection function and leading to shoreline erosion.
- Poor governance of the coastal zone, with a lack of protective legislation and poor enforcement of regulations where they exist.

The PACC project aimed to address both climate and non-climate related risks to the Kosrae coastal road. Strengthening the resilience of the road infrastructure is a 'no-regrets' development that will reduce the vulnerability of the communities to all risks, including those linked to climate, as well as increasing individual and community adaptation choices.

3. THE DEMONSTRATION PROJECT

3.1. Objectives, outcomes and outputs

The goal of the FSM PACC demonstration project was 'To contribute to reduced vulnerability and increased adaptive capacity to adverse effects of climate change in FSM (Kosrae)'.

With coastal zone management as the priority focus, the objective was to 'climate proof' coastal infrastructure, both through on-the-ground activities and also by mainstreaming climate risk into relevant policy and planning for the coastal zone. To achieve this objective, the three outcomes sought by the project, and related outputs, were as follows.

Outcome 1: Policy/plans mainstreamed to build resilience in the context of emerging climate risks. This aimed to strengthen the institutional framework, policies and plans and the capacity of key government and community decision makers to include climate change risks in key decisions in their sustainable resource development programmes. The outputs identified to reach this outcome were:

- Output 1.1: Revised EIA guidelines incorporating climate change adaptation and disaster risk reduction for KIRMA to use against all infrastructure projects in Kosrae;
- Output 1.2: Existing environmental regulations modified to include climate change;
- Output 1.3: Climate-proofed Shoreline Management Plan developed and approved;
- Output 1.4: Revised Kosrae Strategic Development Plan (SDP 2013–2023) to incorporate climate change adaptation and disaster risk reduction;
- Output 1.5: New Kosrae State Climate Change Act developed/enacted.

Outcome 2: Climate-proofed road segment is resilient to extreme rainfall events and sea level rise. The selected pilot site was the Kosrae circumferential road, Tafunsak to Walung (sections RS3 and RS4), and the aim was to modify the road construction so that it would withstand increased torrential rain and surface water run-off, raised sea level and storm waves. The outputs required were:

- Output 2.1: Demonstration project delivered – climate-proofed road sections RS3 and RS4 (totalling 7 km) designed to withstand an extreme rainfall event (<254 mm/hour);
- Output 2.2: Technical guide produced on road design and construction to incorporate climate change risks/considerations.

Outcome 3: Increased understanding of climate change impacts and awareness of how to adapt and build resilience at pilot sites (community level). The outputs set were:

- Output 3.1: National communications plan developed and actioned;
- Output 3.2: Knowledge management products produced;
- Output 3.3: Sharing of best practice at national, regional, and international scales.

The project logframe, including indicators, targets and details of data collection contributing to the achievement of these outputs and outcomes, is given in Appendix 1.

3.2. Preparatory phase

3.2.1. Selection of project and site

The selection of the PACC pilot project in FSM was made based on a prior assessment carried out under the Asian Development Bank's Climate Adaptation in the Pacific (CLIMAP) project (Hay et al., 2005). CLIMAP identified the need to complete the Tafunsak to Walung section of the Kosrae circumferential road (Figure 3), and analyses

found that the original road design had been based on inaccurate rainfall data, i.e. they had not accounted for increases in rainfall in the engineering and design. The ADB study identified the priority to retrospectively 'climate proof' the existing section of road from Tafunsak and showed that such a retrospective action was cost effective.

The decision to continue the earlier work under the CLIMAP project and climate-proof the section of road fulfilled the requirements for PACC project selection, which were:

- A strong alignment with the Government's existing programmes;
- All necessary baseline assessments have been carried out, and additional activities are ready for implementation; and
- Ability to co-finance and ability to deliver.

The fact that climate analyses and assessments had already been carried out under CLIMAP gave the PACC project a useful foundation. These assessments had however been done several years before, and ideally the PACC project would have carried out new studies, including feasibility or cost-benefit studies, which might have benefited the project implementation and results. Nonetheless, the project stakeholders agreed that this was an appropriate and worthwhile demonstration project to be funded by PACC.

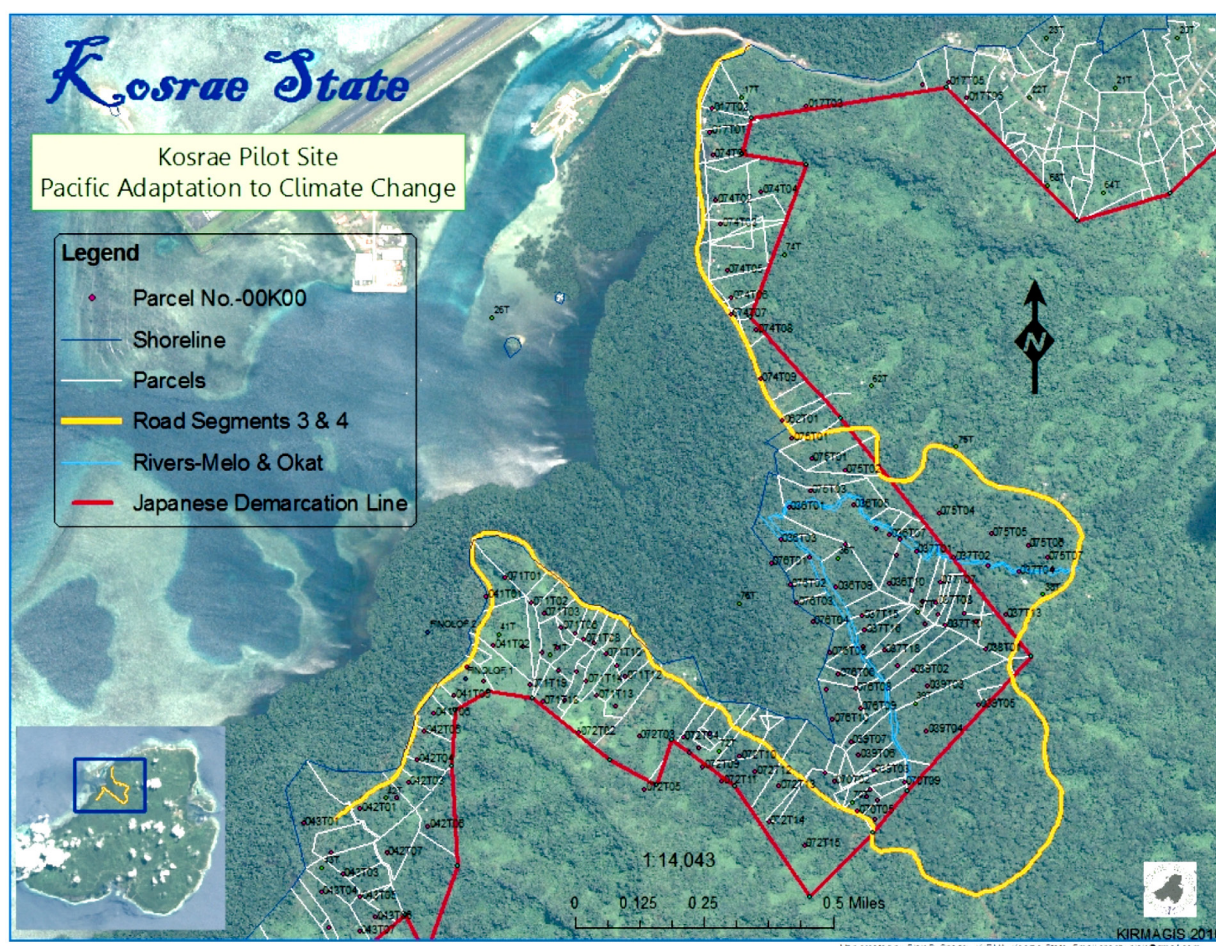


Figure 3. The demonstration project site on Kosrae.

3.2.2. Linkages with strategic policy and planning

The PACC demonstration project aligns with both national and Kosrae State policy and plans. In particular, the project is closely aligned with the recently revised Shoreline Management Plan (Ramsay et al., 2015). For example, the project has carried out a great deal of awareness raising on climate change and the need for adaptation at the community level (Strategy 1); has worked to incorporate climate change risk into Regulations for Development (Strategy 2); and part of the coastal road has been relocated inland under the demonstration project (Strategy 3).

3.2.3. Institutional framework for the project

In FSM, all climate change programmes, projects and activities are coordinated by the Office of Environment and Emergency Management (OEEM) which also serves as the secretariat for the National Sustainable Development Council (NSDC).

The PACC project was implemented jointly in Kosrae by KIRMA and the Department of Transportation and Infrastructure (DTI).

3.2.4. Community engagement

In the early stages of the project, a communications plan was developed that provided a framework for community engagement as the project progressed. Target audiences included the general public in Kosrae, decision makers on Kosrae and at the national level, development partners and the media. The project aimed to raise awareness on climate change and its impacts, the vulnerability of the coastal zone and coastal communities, the need for adaptation measures, and the PACC project itself.

The PACC project team had a dedicated staff member responsible for communications and outreach. During the course of the project he organised many briefings, seminars and activities for Kosrae communities, targeting for example schools, leaders, and men and women's groups. Popular activities included a song writing contest, with the winning songs played on the local radio station, and an art competition for schoolchildren.

The following communications products were produced to support awareness raising activities:

- Posters on the FSM PACC Project, climate change, and climate change adaptation;
- Two cartoons on climate change and adaptation;
- A brochure about the project;
- Factsheets on State Law 10-2, weather monitoring, seawalls, coastal development, mangroves, coral reef and typhoons;
- A booklet on housing in coastal areas;
- Photo stories on the PACC project, the pilot road, Kosrae Shoreline Management Plan, adapting to climate change, and coastal erosion;
- PowerPoint presentations on coastal erosion, protected areas and climate change, tides and waves, adapting to climate change and climate change awareness;
- A video clip on the FSM PACC project, and a second video in preparation at time of writing;
- A blog (fsm_pacc.blogspot.com), with 101 posts and 24,149 page views since May 2012;
- A quarterly newsletter starting in 2012, sent to local, national and regional institutions;
- Office of the Governor's Update – News from FSM PACC project shared with local offices almost weekly.

3.2.5. Addressing gender

FSM has no national gender policy in place (SPC, 2012). The FSM Strategic Development Plan (SDP) 2004–2023 does, however, include a strategic goal to mainstream gender issues into decision-making, policies and development plans.

A Gender Action Plan was developed for the PACC programme (PACC, 2014), with objectives including:

- Adaptation measures in selected pilot communities, and all replication and up-scaling activities, address gender-specific vulnerabilities and result in gender-specific benefits for both women and men;
- Women and men at local and national levels acquire technical knowledge and skills to be able to plan for and respond to climate change risks.

Efforts were made by the FSM PACC team to increase gender awareness and to build capacity for integrating gender into project activities. For example, the project team has developed gender-sensitive indicators that will help to better understand the benefits of the project for women and for men (see logframe in Appendix 1). Specific activities that had a gender focus were:

- Working with the mayors of four municipalities and villages to organise community visits to increase the role of women in coastal clean-up activities;
- A gender workshop in collaboration with Kosrae's Women's Association attended by 15 women;
- A workshop on gender issues in relation to climate change as part of a wider SPREP activity.

3.3. Situation and problem analysis

3.3.1. CLIMAP study

The initial situation and problem analyses were carried out in 2004 under the ADB-funded CLIMAP project (Hay et al., 2005). The series of case studies, titled 'Climate proofing – A risk-based approach to adaptation', included assessments of the risks arising from current climate variability and extremes, and also factoring in projected climate change. As part of the study, FSM had a climate risk profile prepared for the first time.

The CLIMAP project carried out a reassessment of the road design. Projections used the Hadley Centre (United Kingdom) Global Climate Model (GCM) with best judgement of model sensitivity, and the SRES A1B greenhouse gas emission scenario.

The drainage works for the original road design (both built and yet to be built sections) were based on a maximum hourly rainfall of 178 mm. This value was thought to have a recurrence interval of 25 years, but was derived using hourly rainfall data for Washington, DC, USA, since no hourly rainfall data exist for Kosrae. The observed data were adjusted subjectively to approximate Kosrae conditions. The CLIMAP study used hourly rainfall data for Pohnpei, adjusted by the ratio of the mean annual rainfalls for Kosrae and Pohnpei. Based on these data, an hourly rainfall of 178 mm was found to have a recurrence interval of 23 years; however the design rainfall was intended to be the hourly rainfall with a return period of 25 years. For present conditions this is 190 mm. But using the climate model and projection above, it was found that by 2050 the hourly rainfall with a 25 year return period will have increased to 254 mm.

3.3.2. Community consultation

Consultations with the Tafunsak community carried out early in the PACC project helped to clarify the current situation and the problems faced by the people of Kosrae.

3.4. Solution analysis

3.4.1 Identifying the options

The primary purpose of the project was to complete the road around the island of Kosrae and provide all-weather land access to the remote village of Walung (population 230) in the southwest of the island (see Figure 1).

The ADB climate proofing case study (Hay et al., 2005) related to the 9.8-km portion of RS4 that lies north of the Yela Valley. The as yet unbuilt portion is 6.6 km in length. The remainder (3.2 km) had already been constructed, with drainage works designed for an hourly rainfall of 178 mm.

The three major issues to be addressed, according to Hay et al. (2005), were:

- determining the hydraulic design features for the road up to, and beyond, the Yela Valley crossing;
- choosing among the options for routing across the Yela Valley, of which there were five;
- determining the hydraulic design features for each of the above options.

Stakeholder consultations resulted in the decision to focus on the first of the three issues. The choice of a route across the Yela was problematic, due to the need to traverse or circumnavigate a large freshwater swamp that is dominated by *Terminalia carolinensis* (locally known as *ka*) and flooded by the Yela River. The Yela ka swamp is officially designated as an Area of Biological Significance.

3.4.2. Cost–benefit analysis

The CBA work was undertaken during the CLIMAP project (Hay et al., 2005), with no further analysis prior to implementation in 2012.

A recommendation that the design of the road be modified so the drainage works could accommodate an hourly rainfall of 254 mm was accepted by the state government of Kosrae and a climate-proofed design was prepared and costed by state employees. The incremental cost of climate proofing the road design and construction for the unbuilt section was in the vicinity of \$511,000. While the capital cost of the climate-proofed road would be higher than if the road were constructed to the original design, the accumulated costs, including repairs and maintenance, would be lower after only about 15 years. This is because repair and maintenance costs would be lower for the climate-proofed road.

The CBA showed that it is more costly to ‘climate proof’ retroactively – US\$776,184 for a 3.2 km section of existing road (US\$243,000 per km) as opposed to US\$511,000 to ‘climate proof’ 6.6 km of new road (US\$77,000 per km). However, the CBA concluded that the retroactive climate proofing is still a cost-effective investment, with an internal rate of return of 13%.

Based on the information available, the Government of the State of Kosrae decided it would not proceed with construction of the northern section of the new road until additional funds were available.

3.4.3. Selection of option

Through focused consultation with key stakeholders, it was agreed that a programme of engineering works would be implemented as follows:

1. Construction of the road to join Walung village that will improve access into and out of Tafunsak.
2. The drainage works to be upgraded on 7 km section of the road to accommodate a maximum hourly rainfall of 254 mm.

3.5. Demonstration design

The original road design was prepared by Barrett Consulting in 1987. The design standards for the road were based on 1984 work produced by the American Association of State Highway and Transport Officials, with a recommendation that they be periodically reviewed and updated to meet changing conditions.

The design of the road drainage culverts for the demonstration project needed to be based on the latest climate change scenarios. The CLIMAP analyses found that the original Kosrae coastal road had been built with drainage works designed for a maximum hourly rainfall of 178 mm, which supposedly had a return period of 25 years. An analysis of more reliable data indicated that an hourly rainfall with a return period of 25 years is 190 mm. By 2050, however, the hourly rainfall with a 25-year return period is projected to increase to 254 mm as a consequence of climate change.

Based on these results some aspects of the road design were amended, specifically the culverts were redesigned to accommodate the higher rainfall. However, most of the original design specifications remained as in the original 1987 manual.

Careful consideration was given to the placement of culverts and drainage channels, to ensure that their placement is in line with the natural drainage patterns within the watershed, to facilitate effective drainage from higher portions of the road to the sea. The road design also took careful consideration of natural tidal flows where the road bisects swamp and mangrove areas.

3.6. Implementation

3.6.1. Road improvements

Project activities began in 2009, with most studies and construction work carried out between 2012 and 2014.

Once the project had completed extensive road infrastructure preparatory work, in mid-2012 an open tender process was used to find a suitable contractor. Four contractors responded, and the contract was awarded on the basis of contract value and the proposed timeline for completion of the construction activities. A 'notice to proceed' was issued to the winning bid to complete the works within 200 calendar days from 28 January 2013.

The first section transects a mangrove area, and here the road was raised to accommodate predicted sea level rise, and new larger culverts were placed in order to maintain hydrological connectivity between the seaward mangroves and those mangrove areas landward of the road. For the second section of the road, the surface was improved and larger culverts added in order to accommodate the potential levels of run-off from land seaward from the revised rainfall predictions. Figure 4 shows new large culverts in place.

The physical works involved the following:

1. Road surface levelling and shoulder clearing;
2. Road surface raising by 46 cm for 180 m;
3. Installation of larger diameter culverts – both replacements and additional – with concrete channel ends. A total of 12 box culverts and 17 cross-drainage pipes and side drainage were installed along the 7 km of road segment constructed to cater for a rainfall intensity of 254 mm/h;
4. Strengthened embankments and/or side ditches.

The new road was completed and officially opened in May 2014.



Figure 4. New culverts installed by the project.

3.6.2. Installation of monitoring equipment

In addition to the engineering works for the road, climate and sea level monitoring equipment was installed in November 2011 as part of the PACC project, to support and inform climate-sensitive decision making and planning. A team from New Zealand's National Institute of Water and Atmospheric Research (NIWA) carried out the following:

- Installation at Okat Airport of a high intensity rainfall monitoring and solar radiation station;
- Installation of a sea level recorder at Lelu harbour at the Marine Resources dock;
- Installation of temporary sea level monitoring stations in order to develop an improved understanding of the variability in tides and sea levels around Kosrae (at Okat, Walung and Utwe);

- Surveying of the coastal erosion monitoring network established in 1995 by SOPAC and expanded by KIRMA in 2000;
- Training for the inspection and maintenance of installed equipment.

Data from the monitoring stations go directly to NIWA and are then shared with KIRMA and the national weather service at Pohnpei.

3.7. Monitoring and evaluation

The monitoring and evaluation (M&E) process is an ongoing activity from day one of project implementation and a vital part of the demonstration project. The M&E process is used to assess whether or not the project is reaching intended objectives, and what can be modified or improved in order to deliver expected outcomes.

The project logframe (Appendix 1) details quantitative and qualitative indicators that have been set for the FSM PACC demonstration project. Ongoing monitoring is needed to assess the road design, e.g. increased ability to dissipate rainwater through the increased diameter culverts.

All State assets/infrastructure, for example roads, pipelines, government buildings, harbours etc., are under the responsibility of DTI. An asset management programme has recently been put in place that will capture all records of repairs and maintenance.

The project undertook a road and household users survey in May and October 2014. Community responses were that the new road has improved journey times to schools, fishing grounds and homes. The garden flooding problems previously experienced at very high tides have not occurred since the road has been completed. In addition, before the road was climate proofed, high tides resulted in salt water inundation for the whole area (impacting on food crops), but since the road has been elevated this has not happened.

About 10 households and 50 landowners are currently benefiting from the upgraded road. In addition, some householders are (at their own cost) starting to relocate inland (using the improved road) as a result of better access to ancestral lands and access to improved farmlands. Services such as electricity have been installed by the State along the road.

3.8. Communications and knowledge management

Community engagement on Kosrae was guided by a communications plan developed early in the project, and activities and communications products targeting this audience are described in Section 3.2.4.

Other key target audiences were identified by the project, at both national and regional levels, and communications products were developed and disseminated. Examples include news stories published on the PACC webpages (www.sprep.org/pacc) and further circulated in the online newsletter *Climate Change Matters*; and a 'country brief' describing the project and targeting decision makers across the region. Information and case studies were also drawn from the FSM PACC project in synthesis publications, in particular the PACC Experiences series (see for example [PACC Experiences No. 5: Reducing vulnerability of island coasts](#)).

For communications and knowledge management targeting audiences beyond FSM, the PACC webpages (www.sprep.org/pacc), and in particular the FSM PACC project webpage (www.sprep.org/pacc/fsm), has been the main dissemination tool used to share information and knowledge generated by the project. Outputs are also being shared through the [Pacific Climate Change Portal](#), and other online information hubs, such as the [Climate & Development Knowledge Network](#), [Eldis](#) and [ReliefWeb](#).

The PACC project team also made presentations on the FSM PACC project at the following national, regional and international meetings and conferences:

- 1st Disaster Risk Management and Climate Change conference in FSM;
- 4th Environmental Conference in FSM;

- FSM Women's Conferences 2013, 2014;
- Micronesians in Island Conservation, Chuuk;
- 3D Modelling Workshop, Solomon Islands;
- UNFCCC COP-18 in Qatar.

3.9. Upscaling and replication

The demonstration project has great upscaling potential both on Kosrae and across the other three States of FSM as engineering capacity has been developed significantly on Kosrae. For example, staff from the DTI have been involved in construction of the new road, building their capacity to consider climate change factors in road design. This experience should now be nurtured to encourage upscaling and replication around FSM.

At the time of writing (March 2015) funding has been secured through China Aid to pave the east coast part of the road to Walung. There is however a concern that this next phase may not apply the design standards developed under the PACC project, which would prove detrimental to road resilience.

4. MAINSTREAMING CLIMATE RISK AT THE STRATEGIC LEVEL

In parallel with the demonstration project, the FSM PACC project team has had some significant achievements in mainstreaming of climate risk into Kosrae State policy and regulations, notably its contributions to the passing of a Climate Change Act (State Law 10-7, enacted in 2011), and amended Regulations for Development that require climate change impacts to be considered in all development projects and EIA processes.

Under the Kosrae Climate Change Act 2011, all new infrastructure developments, especially roads and buildings, are required to take climate change into consideration in their design and construction. This is facilitated under the revised Environmental Impact Assessment (EIA) regulations. These regulations describe the types of activities and developments that require a development review permit, and may trigger the requirement for an EIA, as well as introduce a fee for the permits.

A new EIA guideline has been developed to be used by KIRMA's Permitting Unit, other government agencies, NGOs and community, to enable compliance to the EIA process (in draft form at time of writing). The EIA guideline includes:

- A description of Kosrae's EIA process;
- How to identify an activity or development that requires a permit;
- The required content of an Environmental Impact Statement (EIS);
- The consultation process to be followed.

SPREP and the Regional PACC Programme Management Unit assisted with this mainstreaming activity by organising workshops in FSM in 2011 and 2012, to help develop the new EIA regulations.

The new Climate Change Law is the first of its kind in FSM and the northern Pacific. It is consistent with FSM's Nationwide Climate Change Policy 2009. The project also contributed to the revision and update of the Kosrae Shoreline Management Plan (SMP), which mainstreams climate risk into this key management plan for the State's coastline and coastal communities.

5. SUSTAINABILITY, RELEVANCE, EFFECTIVENESS AND EFFICIENCY

5.1. Sustainability

Seven km of road has been upgraded to reduce its vulnerability to flooding and intense rainfall. The new road withstood a heavy rainfall event after the project was completed (2014). The key sustainability features of the road design that contribute to its durability include the retrofitting of culverts and drains that can withstand 254 mm/h rainfall events. In addition to the durable design, DTI staff (who are responsible for the maintenance of the road) have been trained on specific road maintenance issues including how to clear the culverts after extreme rainfall events. However, a robust monitoring and maintenance programme has not at time of writing been put in place.

To ensure wider sustainability beyond the PACC-improved section, the principles and practice of incorporating climate modelling and climate projections into road design need to be incorporated as standards for all future road developments in Kosrae and FSM.

For longer term resilience, many coastal roads will need to be relocated inland to avoid sea level rise and flooding. The PACC road section provides a demonstration of this approach, with the new section built inland. This also promotes relocation of communities away from the vulnerable shoreline, which will lead to resilience for communities in the longer term.

The Kosrae SMP (2014) also contributes to sustainability of the project, by providing a framework for resilient development that incorporates climate risk.

5.2. Relevance

The demonstration project is highly relevant to both national and State priorities. It aligns with key national and State policies, for example, it directly addresses the climate risk related priorities identified in the national SDP for FSM, the SDP for Kosrae and reflects the recommendations set out in the Kosrae SMP (2014). Coastal adaptation is also noted as a high priority in the FSM national climate change policy (2009).

The new Kosrae EIA regulations are highly relevant for other development projects that need to consider climate change related risks. These regulations need to be replicated and implemented in the other three States of FSM, and potentially, adapted for use in other parts of the Pacific. Being able to understand flood risk inundation is a critically important aspect of any engineering design on the coast, and being able to incorporate climate and sea level projections makes this a highly useful and relevant tool.

5.3. Effectiveness

The various project activities have all contributed to the overall demonstration project being effective. These include all Outcome 1 activities such as the preparation of the new Kosrae Climate Change Act, the revised EIA regulations and updates to the Kosrae SMP, and the Outcome 3 tasks including climate change awareness raising and community consultations and events held during the project. Overall the PACC FSM project has been effective from an engineering perspective. Interviews with users of the road indicate that the road no longer floods during heavy rains and also protects residents from ocean storm surge events.

The road has not been in situ for a long enough period to be tested by any very extreme rainfall events. A regular road performance monitoring programme (still to be put in place by DTI) is needed to provide the data to assess this.

5.4. Efficiency

The PACC project built on an earlier project which provided the baseline assessments for the project. While some of these should have been updated at the start of the PACC project, they contributed to cost-effectiveness for the PACC project.

The abilities of the FSM PACC Project Coordinator in facilitating engagement of the PACC project team with key agencies such as KIRMA contributed significantly to the success of the project and its efficiency.

6. LESSONS LEARNED

The following are the main lessons derived from the FSM PACC project, which may be used to inform similar projects in the Pacific region in the future.

- Project design should be based on latest information. The PACC project in Kosrae was largely based on preparatory work carried out in 2004 under the CLIMAP case study and the design standards manual for road infrastructure produced in 1987. Where previous studies are used to underpin a project it is critically important that they are updated to reflect any changes in any aspect of the situation, problem or solution. For example, the CBA, which is critical to assist governments to prioritise, design and implement their projects, was completed in the early 2000s and not updated prior to the start of the engineering works in 2012.
- Information on the processes and practices for developing sustainable climate-proof infrastructure needs to be captured, made available, and mainstreamed into regulations where appropriate. The PACC project made some advances in this with the revised EIA regulations, but more is needed, for example on the application of climate change data and modelling. This information (design codes and standards) needs to be legitimised into national legislative processes with engineering manuals and standards updated.
- Community engagement by the project, while very effective in raising awareness on climate change generally, could have been more closely linked with the demonstration project. The project provided an opportunity to help the communities explore adaptation options linked to the new climate-proof road. For example, it is a wider goal of the FSM and Kosrae government to encourage relocation away from the more vulnerable coastal areas, and the relocated road is a first step towards that objective. The project could have provided a platform for discussions around this important issue.
- Projects should be carried out under an appropriate strategy rather than as stand-alone activities. Although the SMP was revised in parallel with the demonstration project, the links between the two were tenuous. Without an overarching strategy in place, individual projects risk becoming sidelined as one-off events rather than embedded in a coherent and climate-responsive strategy.

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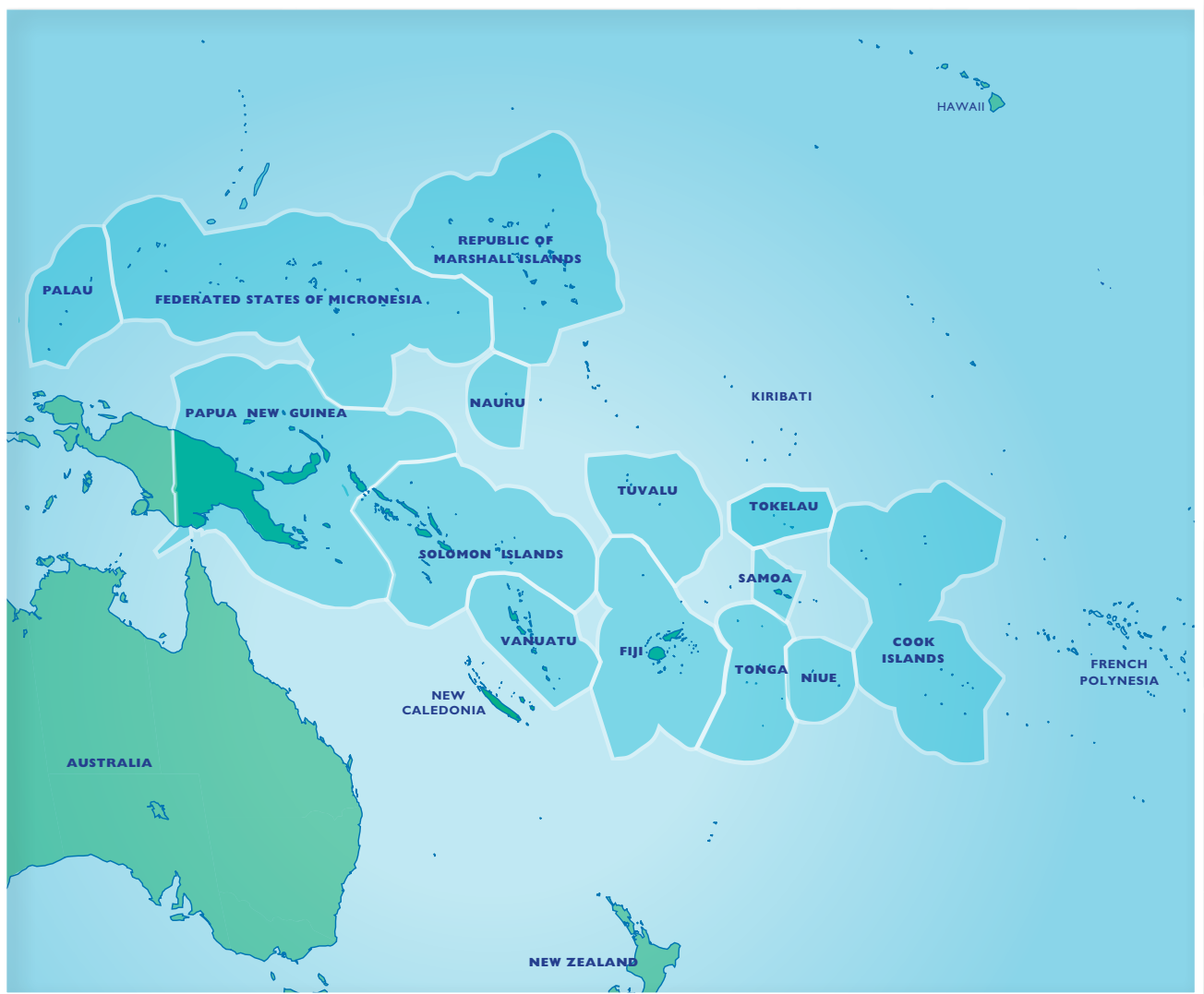
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APPENDIX 1. FSM PACC PROJECT LOGFRAME

PROJECT DESCRIPTION	INDICATOR	SOURCE/DATA COLLECTION METHOD	BASELINE	TARGET
<p>GOAL:</p> <p>To contribute to reduced vulnerability and increased adaptive capacity to adverse effects of climate change in FSM (Kosrae)</p>				
<p>Outcome 1:</p> <p>Policy/plans mainstreamed to build resilience in the context of emerging climate risks</p>	<p>No. of on-ground changes informed by revised EIA Guideline by strengthened institutions/approval body (practice change from BAU) OR % of new roadwork projects applying the CC-proofed road guidelines</p> <p>No. of govt. agencies/institutions to include in their structure/incorporate provisions of CC Act into their operations</p> <p>No. of new projects funded be revised national plans/policies meet donor criteria</p> <p>Sector plans (at ministerial/ department level) modified in line with revised policy (use of policies/ coordination processes)</p> <p>Gender sensitive practices</p> <p>Existence of an approval body to ensure climate proofing provisions are enforced/carried out</p>	<p>The Kosrae Shoreline Management Plan</p> <p>Nationwide Climate Change Policy</p>	<p>Currently road works do not integrate CCA/ DDR</p>	<p>By the end of the project (and beyond) 100% of new road works apply guidelines state wide</p>
	<p>Backstopping support from a No. of govt. agencies/institutions/NGOs/ international organisations/CBOs in partnership with PACC influence as our way forward. E.g. GCCA, IOM, MCT, GIZ, SPC, PPCR, JICA and others</p>			<p>At least 3 non-PACC partners involved</p>
<p>Output 1.1: Revised EIA guidelines incorporating CCA/DRR for KIRMA to use against all infrastructure projects in Kosrae</p>	<p>Guidelines for CCA/DRR</p>	<p>Revised EIA Guideline</p>	<p>Existing EIA Guideline doesn't include CCA/ DRR</p>	<p>By the end of the project, the revised EIA guideline will be used by KIRMA and other agencies for all infrastructures (IDP)</p>
<p>Output 1.2: Existing environmental regulations modified to include CC</p>	<p>Changes/amendments to existing environmental regulation to include CCA/DRR</p>	<p>Existing environmental regulation</p>	<p>Existing environmental regulation does not address CCA/ DRR</p>	<p>The changes and amendments to the existing regulations will be used for all infrastructures (IDP)</p>

PROJECT DESCRIPTION	INDICATOR	SOURCE/DATA COLLECTION METHOD	BASELINE	TARGET
Output 1.3: Climate proofed Shoreline Management Plan developed and approved	Completed shoreline management plan Gender integrated	SMP	2000 Kosrae Shoreline management plan needs to be CC proofed	CC proofing of the Kosrae Shoreline Management plan (SMP) by the end 2013
Output 1.4: Revised Kosrae Strategic Development Plan (SDP 2013–2023) to incorporate CCA/DRR	Revised Kosrae SDP 2013–2023	Kosrae SDP	The current Kosrae SDP does not address CCA/DRR	The revised Kosrae SDP 2013–2023 incorporates CCA/DRR
Output 1.5: New Kosrae State CC Act developed/ enacted	CC Act enacted	CC Act	No CCA/DRR legislation	Enactment of CC Act 2011 (SL 10-2)
Outcome 2: Climate proofed road segment is resilient to extreme rainfall events and sea-level rise	Occurrence of damage to road from extreme rainfall event (<254mm/ hour) or sea-level rise No. of days of interruptions (hazardous event) to use of R3 and R4 during extreme rainfall (<254 mm/ year) and high tide No. of people and communities benefiting from project (gender disaggregated) (road and wider beneficiaries e.g. market users farmers access to the farm land, increase local productions. etc.) Community satisfaction with PACC project (gender disaggregated)	DTI and KIRMA inspection report (Information from people residing around the project site – their experience on the use of the road by both pedestrians and vehicles. The demand of using the road is increasing. Around 20 plus vehicles per day using the road for diff. purposes (farming, visitors, people residing at the site) SEA PACC results	Road is damaged from extreme rainfall events >174 mm/ hour, <254 mm/ hour and is inundated during high tide events	No damage to road from extreme rainfall event (<254mm/hour) or high tide/sea-level rise when these events occur. <1 day of interruptions when these events occur
	Cost of demonstration component per household / per person	Finance data		No target set
Output 2.1: Demonstration project delivered – Climate-proofed Road Segment 3 and RS 4	Km (and % of total) of road vulnerable roads and no. roadway structures retrofitted/redesigned/ upgraded to withstand 254 mm hourly rainfall and sea-level height (to be determined)	Mapping, land use plan, SDP, Project reports etc.		7 km of road improved

PROJECT DESCRIPTION	INDICATOR	SOURCE/DATA COLLECTION METHOD	BASELINE	TARGET
Output 2.2: Demonstration guideline report on Kosrae road project (technical synthesis) for road design and constructions to incorporate climate change risks/ considerations	National coastal infrastructure (roads and airports) guideline (draft/final) (Gender-sensitive) EIA technical guidelines developed Usefulness/satisfaction with guideline	Guideline itself, EIA stated in the SDP, LUP	EIA guideline exists but does not integrate/ include climate change risks	Updated documents – New EIA guideline completed by end Aug 2014 Collaboration partners KIRMA, DTI, Planning Office, DREA, Municipal Govt, Dept. Health, CBO, Women’s Org, Youth Org.)
Outcome 3: Increased understanding of CC impacts and awareness of how to adapt and build resilience at pilot sites (community level)	No. of men, women and institutions trained Change in understanding of CC impacts Change in awareness of how to adapt to CC Perception of resilience (means to adapt) No. of people/percentage, gender disaggregated No. of actions taken up (gender disaggregated) from lessons etc.	Awareness materials		By the end of the project, community members of four municipalities and six govt institutions including women receive knowledge and communication products
Output 3.1: National communications plan developed and actioned	Plan developed % of actions implemented from plan No. docs on website	Final comms plan Website content Annual Work Plan 2014		
Output 3.2: Knowledge Management Products produced	No. of products	Guidelines Stories Lessons		KM products produced
Output 3.3: Sharing of best practice at national, regional, international levels	No. of national meetings/workshops attended No. of international meetings attended	Meeting/ workshop agenda participating lists Trip reports/ travel receipts Feedback from participants who attended the meetings Press releases		



PACC – building adaptation capacity in 14 Pacific island countries and territories



PACIFIC ADAPTATION TO CLIMATE CHANGE (PACC) PROGRAMME

The PACC programme is the largest climate change adaptation initiative in the Pacific region, with activities in 14 countries and territories. PACC is building a coordinated and integrated approach to the climate change challenge through three main areas of activity: practical demonstrations of adaptation measures, driving the mainstreaming of climate risks into national development planning and activities, and sharing knowledge in order to build adaptive capacity. The goal of the programme is to reduce vulnerability and to increase adaptive capacity to the adverse effects of climate change in three key climate-sensitive development sectors: coastal zone management, food security and food production, and water resources management. PACC began in 2009 and is scheduled to end in December 2014.

The PACC programme is funded by the Global Environment Facility (GEF)'s Special Climate Change Fund (SCCF) and the Australian Government with support from the United Nations Institute for Training and Research (UNITAR) Climate Change Capacity Development (C3D+). The Secretariat of the Pacific Regional Environment Programme (SPREP) is the implementing agency, with technical and implementing support from the United Nations Development Programme (UNDP).

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PACC TECHNICAL REPORTS

The PACC Technical Report series is a collection of the technical knowledge generated by the various PACC activities at both national and regional level. The reports are aimed at climate change adaptation practitioners in the Pacific region and beyond, with the intention of sharing experiences and lessons learned from the diverse components of the PACC programme. The technical knowledge is also feeding into and informing policy processes within the region.

The Reports are available electronically at the PACC website: www.sprep.org/pacc, and hard copies can be requested from SPREP.

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