Statistical analysis of field impact assessment data

Provisional findings

Prepared for SPREP

By NIWA

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Climate, Freshwater & Ocean Science

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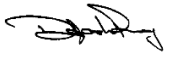
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Contents

Executive summary

The Global Climate Change Alliance Plus Scaling Up Pacific Adaptation (GCCA+ SUPA) project has undertaken an impact analysis. The analysis was designed and tested with information from previous adaptation interventions completed in the past five years in four countries: Tonga, Palau, Cook Islands, and the Federated States of Micronesia. As part of this impact analysis, household surveys and focus group data ('social data') were collected for each of the target communities.

This report summarises the results of the social data. We explore whether and what statistical relationships exist between household characteristics, interventions, and environmental changes. The data provide a basis for formulating hypotheses about the impacts of adaptation interventions.

The preliminary findings of the household surveys highlight that it is difficult to attribute life satisfaction, feelings of preparedness, or perceived risk to any specific adaptation intervention. When assessing the impact on community attributes, it is necessary to have available both baseline and post-implementation data for the same variables.

There does not appear to be a strong statistical relationship between life satisfaction, risk perception, and preparedness. However, a meta-analysis of social data from all four countries revealed the following significant statistical relationships:

- Employment and concrete dwellings are associated with improved life satisfaction.

- Increased temperature, more flooding, and reduced beach area are associated with reduced life satisfaction.

- Larger water tanks are associated with feeling more prepared.

- Higher education and communicable disease are associated with a perception of higher risk.

We assess how the social data can be used within the Draft Impact Assessment Framework and make recommendations for collecting data for future impact assessments under the framework. These recommendations include:

- Consider the need for a control group when developing a sampling strategy.

- More data consistency checks.

- Include questions to directly ask about the impact of the intervention.

- Include follow-up questions to better understand responses to key indicators.

- Develop an objective measure of preparedness such as *actions already taken*.

- Separate risk and preparedness questions for drought and flood risk.

- Use the survey results to refine questions for focus groups.

- Record whether households have elderly occupants.

1 Introduction

The Global Climate Change Alliance Plus – Scaling up Pacific Adaptation (GCCA+ SUPA) project is intended to support the potential scaling up of climate change adaptation measures. The 4.5 year project (2019-2023) is funded with € 14.89 million from the European Union (EU) and implemented by The Pacific Community (SPC) in partnership with the Secretariat of the Pacific Regional Environment Programme (SPREP) and the University of the South Pacific (USP), in collaboration with the Governments and Peoples of Cook Islands, Federated States of Micronesia (FSM), Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Tonga and Tuvalu.

The Overall Objective of the GCCA+ SUPA project is to enhance climate change adaptation and resilience within ten Pacific Island countries. The specific objective is to strengthen the implementation of sector-based, but integrated, climate change and disaster risk management strategies and plans.

The project is intended to generate outputs for three components:

- **Knowledge management:** An impact methodology will be designed to assess past adaptation interventions. After testing in three countries, this will be integrated into a user-friendly database module, which can be added to existing national climate change portals with the intention to inform national decision-making. SPREP manages this project component.

- **Capacity building:** Focusing on local area stakeholders and especially sub-national governments, a needs analysis will be conducted, following which accredited training in resilience will be delivered in each country informed by local contexts. USP manages this component.

- **Scaling up resilient development measures in specific sectors:** Following the design of criteria for scaling up, countries will select specific focus sectors and implement the scaling up of past successful climate change adaptation interventions through enhancement, expansion, strengthening or replication. This will be supported by mainstreaming climate and disaster resilience into sector policies, plans and budgets. SPC manages this component.

This report documents work conducted under SPREP's component 1: Knowledge management.

1.1 Impact analysis

Under the SPREP component of the project, effort has been directed to the development of an impact analysis methodology[1] that will be designed and tested with information on previous adaptation interventions completed in the past five years in four countries: Tonga, Palau, Cook Islands, and FSM.

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[1] https://www.sprep.org/sites/default/files/documents/tenders/IA_Methodology.pdf

Key criteria for assessing past interventions include:

- Effectiveness.

- Sustainable social and behavioural changes (e.g., enhanced decision making skills for women and vulnerable groups).

- Successful lessons and practices.

- Overall sustainability of completed climate change adaptation interventions.

The target users of the impact methodology are policy makers, disaster risk reduction managers, public health practitioners, budget planners in national and local authorities, regional organisations, non-government organisations, and interest groups in the public-private sector. The methodology was motivated by the need for objective assessment of projects. The impact methodology is a relatively simple framework intended to aid these practitioners in planning climate change adaptation interventions.

The Draft Impact Assessment Framework comprises four key result areas:

1. Vulnerable people and communities.

2. Health, wellbeing, food and water security.

3. Ecosystem services.

4. Infrastructure and the built environment.

Indicators and sub-indicators for a spectrum of adaptation interventions were selected from those used by donors such as the Green Climate Fund, Global Environment Facility, and Adaptation Fund. Criteria for inclusion of indicators in the assessment methodology included scalability, coverage of different biophysical conditions, availability of data, and ease of measurement. There are five indicators for coastal protection adaptation, four indicators for resilient agriculture and seven indicators for water security. Some of the indicators are intended to be measured by field assessment surveys of the adaptation intervention. Other indicators require secondary assessment in the form of spatial mapping or household surveys and focus groups.

The impact methodology indicators and sub-indicators for coastal protection (C), resilient agriculture (A), and water security (W):

- C1. The indicator tracks effectiveness of the structural design built to protect the coast from frequent storm surge, flooding and sea level rise.

- C2. The indicator tracks the area of beach recharged with sand and beach condition over time before and after structures were built.

- C3. The indicator aims to ascertain level of community management actions taken to protect the coastline.

- C4. The indicator aims to ascertain level of awareness and community sense of safety with protection of property and land.

- C5. The indicator documents the number of assets and asset value to track investment in coastal protection structural measures.

- A1. The indicator tracks level of increase in food supply sourced locally in correlation to increase in farmers utilising crop/livestock seed banks.

- A2. The indicator assesses the state of agriculture planning and distinguishes between integrated planning and subsector planning.

- A3. The indicator assesses progress towards an enabling framework for farmers' increased access to technical support /innovation for increased crop/livestock production and yield.

- A4. The indicator tracks the soil health practices and areal extent of land under eco-agricultural production (e.g., Integrated farming, inter cropping, contour).

- W1. The indicator tracks water source and condition as proxy to measuring improved drinking water coverage.

- W2. The indicator assesses the improved state of water facilities and increase in water availability

- W3. The indicator tracks level of improvement to existing water harvesting systems.

- W4. The indicator tracks the capacity to operate and manage the water supply system.

- W5. The indicator ascertains if there is improved access to safe water by households, the special needs vulnerable group (disability, elderly, widows, single others) and community.

- W6. The indicator aims to ascertain the level of participation, awareness and sense of improved sanitation standard.

- W7. The indicator tracks investment in water security measures at one place over time.

The impact assessment methodology has now been tested in the four trial countries (Tonga, Palau, Cook Islands, FSM) and is presently being integrated into a user-friendly database module which can be added to existing national climate change portals.

1.1.1   Household surveys and focus groups

The stated objectives of the household surveys and focus groups were to:

1. Gauge the level of awareness of, preparedness for and quality of life in, managing unavoidable risks to climatic change.

2. Determine whether the adaptation measures introduced in the community remain adequate to changing conditions.

Household surveys and focus group data were collected by national consultants contracted by SPREP in the four trial countries. The household surveys were implemented in KoBo Toolbox and included questions on four key impact areas: health, food and water security, ecosystem services, infrastructure and the built environment. The five sections of the household survey are mapped to these result areas (Table 1-1).

Table 1-1:   Household survey section key result areas.

	1. Vulnerable people and communities	2. Health, wellbeing, food and water security	3. Ecosystem services	4. Infrastructure and the built environment
Survey section	A. Household information	B. Livelihood & energy use	C. Awareness of changes to climate and environment	
	B. Livelihood & energy use	D. Public health		
	E. Household preparedness			

The focus group sessions were conducted by national consultants in each country, focusing on their community's perceptions of the intervention and their coping mechanisms for extreme weather events. Respondent requirements and scripts varied by country.

1.2   Purpose

The purpose of this report is to analysis the household survey and focus group data to support the development of the impacts database and manage the impacts analysis of field data from the four trial countries in developing the impacts analysis methodology. SPREP (via the GCCA+SUPA project) contracted NIWA to undertake statistical analysis and reporting of the field impact assessment data collated from trial countries of the adaptation impacts' analysis methodology. Specifically, NIWA is contracted to:

- Explore whether and what statistical relationships exist between households, communities, and the impact of incremental adaptation in identified areas.

- Examine results of household and focus group surveys on vulnerable groups and the impact(s) of the adaptation intervention on livelihoods and safety, influence of an adaptation on the socio-economic status of benefited families, the disability, elderly, women, youth, and children in the targeted community.

- Examine the degree to which the results aim to provide a basis for formulating hypotheses about impact of the adaptation effort (i.e., those environmental and social interactions that will merit qualitative analysis and those for which qualitative analyses should be carried out).

- Report on the statistical analysis of field impact assessment social data from each of the four trial countries and to design Randomised Control Tests to test the hypotheses and make policy recommendations.

1.3   Structure of this report

Based on the data provided by national consultants, an analysis of the social data has been conducted for each country. The results of the analysis for Tonga, FSM, Palau and Cook Islands, are provided in Sections 3 to 6. Section 7 of this report provides the results of a statistical analysis of the pooled data from all four countries. Section 8 provides insight and suggestions for the development / refinement of an impacts database.

2   Methodology

The methodology for data analysis was the same for Tonga, FSM, Palau and Cook Islands and comprised data validation, summarisation, analysis of statistical relationships, and assessment of whether the results can provide evidence of impact for the relevant adaptation interventions.

Data were checked for completeness and concordance with the geographic location of the adaptation intervention. Benchmark data were compiled from country census information to assess the socio-demographic composition of the samples. Data were then aggregated and tabulated by area of the adaptation intervention.

The sample sizes are too small to perform analysis on specific vulnerable groups such as the disabled, elderly, women, youth, and children. However, the presence and size of vulnerable groups in each sample is noted.

The data were analysed, where sample size allowed, for statistical relationships between adaptation impacts and the key outcome variables: life satisfaction, risk perception, and community preparedness.

3   Tonga

3.1   Tonga Adaptation projects

Coastal adaptation intervention projects in Tonga include a lagoon entrance revetment at ʻAhau and mangrove restoration and rock revetment at Makaunga (Figure 3-1).
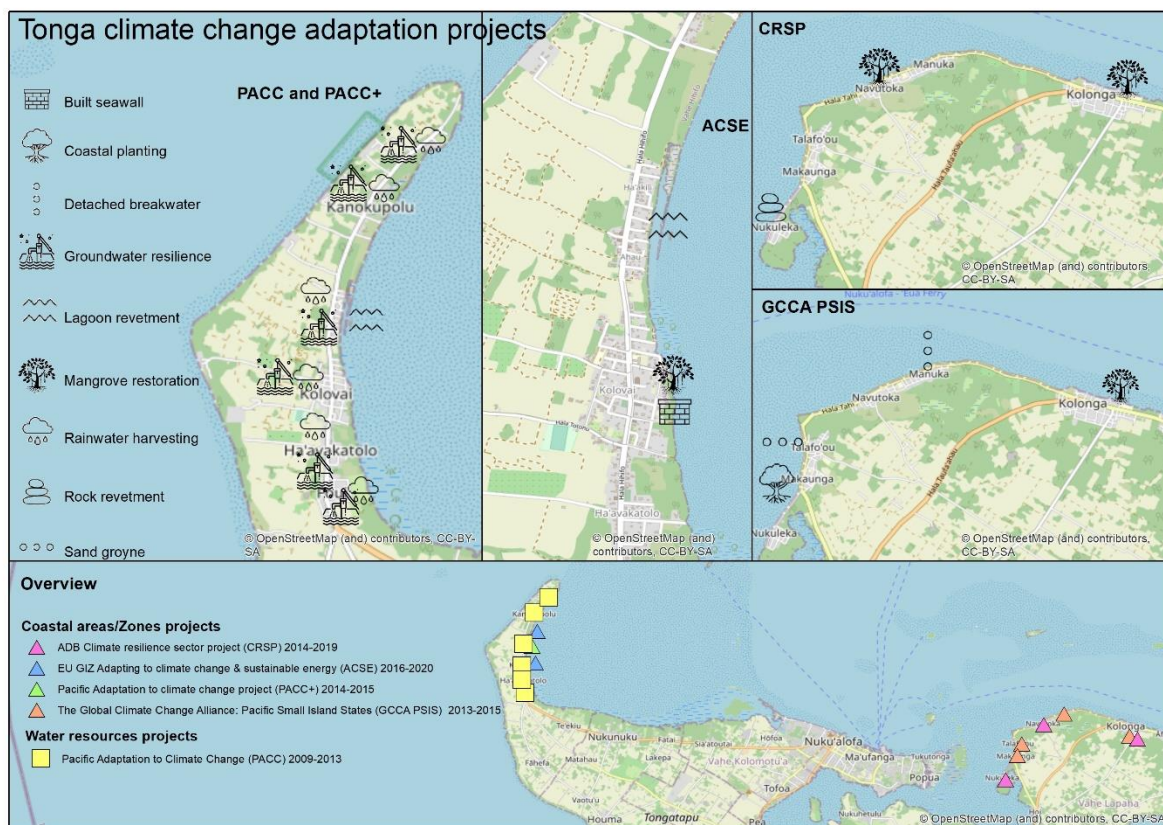
Figure 3-1:   Map of adaptation interventions.

Preliminary data was collected using a survey of 109 households in October 2021 and focus groups with 28 individuals in November 2021.

The objective of this report is to identify general themes within the responses, explore potential statistical relationships, and assess how the data can be used within the Draft Impact Assessment Framework.

3.2   Household survey

3.2.1   Section A: Household information

The sample comprised 109 households, representing a large proportion (78 and 60%) of total households according to the 2021 household estimates (Tonga Statistics Department, 2021).

Table 3-1:   Sample size.

Villages	2021 Household Listing total	Sample	% of households
ʻAhau	85	66	78%
Makaunga	72	43	60%

The average household size is 7.0 occupants in ʻAhau and 6.8 in Makaunga. This is larger than the 2021 national household listing, which reports 6 occupants for ʻAhau households and 5.8 for Makaunga households.

Table 3-2:   Number of people in sampled households.

Number of people	ʻAhau	Makaunga	Grand Total
Women	119	78	197
Men	112	55	167
Children	233	160	393
Total occupants	464	293	757
Employed males	33	25	58
Employed females	23	21	44

Table 3-3:   Household size.

Number of people	ʻAhau	Makaunga	Grand Total
1	4 (6%)	0	4 (4%)
2	3 (5%)	4 (9%)	7 (6%)
3	5 (8%)	2 (5%)	7 (6%)
4	5 (8%)	6 (14%)	11 (10%)
5	9 (14%)	4 (9%)	13 (12%)
6	9 (14%)	6 (14%)	15 (14%)
7	6 (9%)	5 (12%)	11 (10%)
8	6 (9%)	6 (14%)	12 (11%)
9	4 (6%)	1 (2%)	5 (5%)
10	2 (3%)	2 (5%)	4 (4%)
>10	13 (20%)	7 (16%)	20 (18%)
Average size	7.0	6.8	6.94

Respondents were more likely to be female, with 61% of the sample stating their household role as "mother". Table 3-4:   Household role of respondent.

Role	ʻAhau	Makaunga	Grand Total
Father	12 (18%)	12 (28%)	24 (22%)
Mother	41 (62%)	25 (58%)	66 (61%)
Other	13 (20%)	6 (14%)	19 (17%)

Vulnerable households include those hosting the elderly, those with disabilities, and/or those with single parents. The sample includes 17 vulnerable household respondents: 12 households with disabled members and 5 single parent households. No households hosted both disabled members and a single parent. The survey did not ask age, so it is unknown which households have elderly occupants.

Table 3-5:   Vulnerable households.

Vulnerability	ʻĀhau	Makaunga	Grand Total
Households with a disability	7 (11%)	5 (12%)	12 (11%)
Single parent households	2 (3%)	3 (7%)	5 (5%)

The survey includes several questions about dwelling construction, appliances, and other household infrastructure. Most dwellings in ʻĀhau are concrete construction, which is assumed to be more durable but may be more difficult to adapt (raise) or move in response to changing conditions. However, respondents who live in concrete dwellings are more likely to say they expect to make permanent adjustments to their home.

Table 3-6:   Dwelling construction.

Type	ʻĀhau	Makaunga	Grand Total
Corrugate iron	1 (2%)	2 (5%)	3 (3%)
Wooden/bamboo	22 (33%)	22 (51%)	44 (40%)
Concrete	43 (65%)	19 (44%)	62 (57%)

The stock of household appliances may generally be expected to have a statistical relationship with life satisfaction, but the effect is insignificant in this sample.

Table 3-7:   Household appliances.

Appliance	ʻĀhau	Makaunga	Grand Total
Beds	63 (95%)	41 (95%)	104 (95%)
Gas stove	61 (92%)	41 (95%)	102 (94%)
Refrigerator	55 (83%)	40 (93%)	95 (87%)
Washing machine	51 (77%)	36 (84%)	87 (80%)
Radio/cd player	48 (73%)	34 (79%)	82 (75%)
TV/video	45 (68%)	33 (77%)	78 (72%)
Grass cutting machine (lawnmower)	13 (20%)	14 (33%)	27 (25%)
Sewing machine	4 (6%)	9 (21%)	13 (12%)
Kerosene cooker	3 (5%)	0	3 (3%)
Other	65 (98%)	42 (98%)	107 (98%)

Other household infrastructure includes the presence of flush toilet, water tank and well.

Table 3-8:   Other household infrastructure.

Infrastructure type	ʿAhau	Makaunga	Grand Total
Telephone TFL	65 (98%)	41 (95%)	106 (97%)
Flush toilet	63 (95%)	41 (95%)	104 (95%)
Water tank	55 (83%)	35 (81%)	90 (83%)
Computer	19 (29%)	6 (14%)	25 (23%)
Internet	15 (23%)	2 (5%)	17 (16%)
Pit toilet	5 (8%)	1 (2%)	6 (6%)
Vaka	1 (2%)	4 (9%)	5 (5%)
Outboard	0	1 (2%)	1 (1%)
Dug well	0	0	0

Almost a fifth of households in both areas have no water storage tank. Two of the households with no water tank have someone with a disability, and one is a single-parent household. Of the households that do have tanks, most are in a size range of 5,000-10,500L.

Table 3-9:   Water tank capacity.

Capacity	ʿAhau	Makaunga	Grand Total
None	11 (17%)	8 (19%)	19 (17%)
<5,000L	18 (27%)	5 (12%)	23 (21%)
5,000L-10,500L	34 (52%)	29 (67%)	63 (58%)
10,500L-20,000L	3 (5%)	1 (2%)	4 (4%)
>20,500L	0	0	0

1.1.1. Section B: Livelihood & energy use

Life satisfaction

Most respondents said their life had improved compared with five years ago. A statistical analysis using ordered logit reveals that the most significant explanatory factors, in order of decreasing size, are having a female head of the household (positive), having a tertiary education (negative), Makaunga village (positive), and employment (positive).

It is not possible to attribute any of the change in life satisfaction to adaptation interventions as no specific question addressed this, so improvements in satisfaction could be due to other reasons. It would be appropriate to ask follow-up questions about the reasons for answering as they did.

Table 3-10:   Life satisfaction compared with 5 years ago.

Satisfaction	ʿAhau	Makaunga	Grand Total
Much worse	1 (2%)	0	1 (1%)
A bit worse	4 (6%)	2 (5%)	6 (6%)
The same	6 (9%)	9 (21%)	15 (14%)
A bit better	46 (70%)	23 (53%)	69 (63%)
Much better	9 (14%)	9 (21%)	18 (17%)
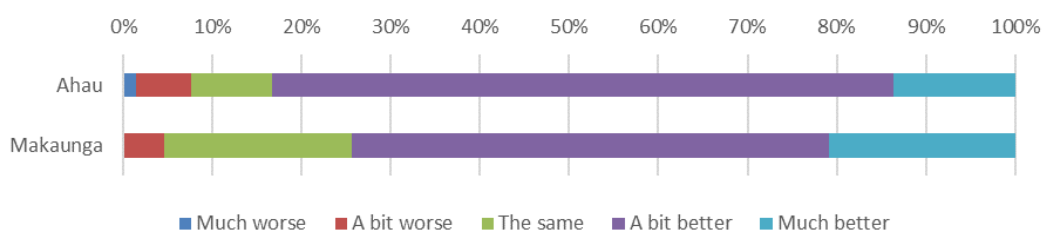
Figure 3-2:   Change in life satisfaction by village.

Household employment and sources of income

Employment is a significant contributing factor to life satisfaction. Just over half of respondents have someone currently employed. Income sources other than salaries were only questioned if no-one was employed. The information cannot be compared with data from the Household Income and Expenditure Survey (HIES) (Tonga Statistics Department, 2016) which reported proportion of income from each source rather than proportion of households.

Table 3-11:   Count of households with income sources.

Values	ʻAhau	Makaunga	Grand Total
Employment	37 (56%)	23 (53%)	60 (55%)
From selling vegetables, root crops	9 (14%)	12 (28%)	21 (19%)
From selling fish and other seafood	5 (8%)	3 (7%)	8 (7%)
From selling mats, handicrafts	13 (20%)	14 (33%)	27 (25%)
Canteen/shop	1 (2%)	2 (5%)	3 (3%)
Remittances	4 (6%)	10 (23%)	14 (13%)
Other	4 (6%)	0	4 (4%)

Household expenditure

Most respondents ranked children and household expenses as their largest expenditure category, and education third. The expenditure information is not directly comparable with HIES 2016, which categorised expenditure by consumption and non-consumption groups. In HIES 2016 the proportion of expenditure on church donations is much higher than education expenses. It is not known whether people categorised expenses differently (for example, whether transport, lunch, and clothing are included as education expenses) in the two surveys, or if there has been a significant change since 2016.

Table 3-12:   Rank of expenditure categories from highest (1) to lowest (5).

Expenditure category	ʻAhau	Makaunga	Grand Total
Children	2.1	2.3	2.2
Household expenses	2.6	2.7	2.6
Education	2.7	2.5	2.6
Church	3.0	3.0	3.0
Community obligations	4.5	4.6	4.5

The questions about household animals and subsistence farming might be considered indicators of wealth, food security, or resilience. The questions help establish a baseline to which future data can be compared.

Table 3-13:   Household animals and livestock.

Type of animal	ʻĀhau	Makaunga	Grand Total
Dogs/cats	61 (92%)	38 (88%)	99 (91%)
Pigs	45 (68%)	36 (84%)	81 (74%)
Chicken	40 (61%)	22 (51%)	62 (57%)
Cattle	18 (27%)	9 (21%)	27 (25%)
Horses	2 (3%)	3 (7%)	5 (5%)
Ducks	1 (2%)	2 (5%)	3 (3%)
Other	1 (2%)	2 (5%)	3 (3%)

Just over a third of respondents said they harvest for subsistence. The most common subsistence activity was craft making (36 households), followed by "other" (31 households), and fishing (23 households).

Table 3-14:   Households harvesting for subsistence.

Harvest for subsistence	ʻĀhau	Makaunga	Grand Total
No	23 (35%)	17 (40%)	40 (37%)
Yes	43 (65%)	25 (58%)	68 (62%)

1.1.2.   Section C: Awareness of environment

Almost every respondent agreed that a healthy ocean and lagoon are important for culture and family health.

Table 3-15:   Environmental awareness statements.

Statement and response	ʻĀhau	Makaunga	Grand Total
It does not matter what happens to the ocean and lagoons			
Agree	0	1 (2%)	1 (1%)
Disagree	65 (98%)	42 (98%)	107 (98%)
I don't know	1 (2%)	0	1 (1%)
Having a healthy ocean & lagoon is a very important part of my culture			
Agree	66 (100%)	42 (98%)	108 (99%)
Disagree	0	1 (2%)	1 (1%)
My family's health is linked to the health of ocean and my lagoon			
Agree	66 (100%)	41 (95%)	107 (98%)
Disagree	0	1 (2%)	1 (1%)
I don't know	0	1 (2%)	1 (1%)

The greatest environmental changes that people perceived since the adaptation interventions were an increase in temperature, an increase in rainfall, a decrease in fish die-off, and an increase in vegetation (the latter for ʻAhau only).

Table 3-16:   Perceived changes to the local environment.

	Increased a lot	Increased a bit	Stayed the same	Decreased a bit	Decreased a lot
Number of trees	21 (19%)	15 (14%)	19 (17%)	27 (25%)	24 (22%)
Other types of vegetation e.g mangroves	34 (31%)	17 (16%)	13 (12%)	13 (12%)	12 (11%)
Variety of animals and birds	11 (10%)	14 (13%)	32 (29%)	26 (24%)	22 (20%)
Number of insects/pests	30 (28%)	19 (17%)	31 (28%)	17 (16%)	4 (4%)
Variety of fish and coral life in lagoon	18 (17%)	24 (22%)	20 (18%)	18 (17%)	17 (16%)
Number of fish	20 (18%)	27 (25%)	14 (13%)	19 (17%)	17 (16%)
Fish die-off	0	5 (5%)	1 (1%)	3 (3%)	31 (28%)
Amount of seaweed and algae	14 (13%)	20 (18%)	17 (16%)	9 (8%)	16 (15%)
Rainfall	48 (44%)	26 (24%)	19 (17%)	9 (8%)	3 (3%)
Temperature, heat	48 (44%)	49 (45%)	6 (6%)	3 (3%)	0
Beach area	11 (10%)	15 (14%)	35 (32%)	9 (8%)	29 (27%)
Lagoon	9 (8%)	3 (3%)	24 (22%)	6 (6%)	16 (15%)
Flooding	10 (9%)	14 (13%)	42 (39%)	4 (4%)	15 (14%)
Storm surges	12 (11%)	24 (22%)	30 (28%)	5 (5%)	12 (11%)

Figure 3-3: **Perceived changes to the local environment by village.**

Perceptions of climate change

All but one individual agreed that climate change is happening. Most respondents agreed that it is caused by human-related greenhouse gas emissions.

Table 3-17: **Perceptions of the causes of climate change.**

Climate change causes	ʻAhau	Makaunga	Grand Total
Human activity that led to the emission of dangerous greenhouse gases	58 (88%)	41 (95%)	99 (91%)
Loss of trees	51 (77%)	25 (58%)	76 (70%)
A hole in a protective layer of gas that covers the planet called ozone layer	30 (45%)	29 (67%)	59 (54%)
Population growth	9 (14%)	4 (9%)	13 (12%)

Climate change causes	ʻAhau	Makaunga	Grand Total
Forces of nature	5 (8%)	1 (2%)	6 (6%)
Migration	4 (6%)	0	4 (4%)
Don't know	7 (11%)	1 (2%)	8 (7%)

1.1.3. Section D: Public health

The questions about information and maintenance of water systems relate to indicator W4, capacity to operate and manage the water supply system.

Most respondents received information about water system maintenance from community meetings or the media. Just over a third of respondents said they had never received any information.

Table 3-18:   Source of information regarding the maintenance and proper care of rainwater system and septic tank.

Source of information	ʻAhau	Makaunga	Grand Total
A sanitation aid officer visited my house	11 (17%)	2 (5%)	13 (12%)
It was discussed at a community meeting	31 (47%)	15 (35%)	46 (42%)
My church group discussed it	5 (8%)	3 (7%)	8 (7%)
Heard from the media	16 (24%)	17 (40%)	33 (30%)
I've never received maintenance information about my rainwater system or septic tank	27 (41%)	15 (35%)	42 (39%)

Half of the respondents said they clean their rainwater collection roof at least yearly, but a third said they never cleaned it.

Table 3-19:   Frequency of cleaning roof, gutters and storage tank.

Frequency	ʻAhau	Makaunga	Grand Total
Every six months	20 (30%)	10 (23%)	30 (28%)
Every year	16 (24%)	9 (21%)	25 (23%)
Every two years	9 (14%)	10 (23%)	19 (17%)
We have never cleaned it	21 (32%)	13 (30%)	34 (31%)

Respondents cleaned their septic systems less regularly, and almost half of them said they had never cleaned it.

Table 3-20:   How long since sceptic tank was last pumped out and cleaned.

Sceptic tank was last pumped out and cleaned:	ʻAhau	Makaunga	Grand Total
No septic system	3 (5%)	2 (5%)	4 (4%)
1 year ago	12 (18%)	6 (14%)	18 (17%)
Less than 5 years ago	16 (24%)	10 (23%)	26 (24%)
Less than 10 years ago	2 (3%)	3 (7%)	5 (5%)
More than 10 years ago	5 (8%)	0	5 (5%)
Septic system never been cleaned	28 (42%)	21 (49%)	49 (45%)

Statistical analysis of field impact assessment data

Almost all respondents said they had a clean and functional toilet, with soap available. A few people had problems with flies or rats or sewerage after heavy rain.

Table 3-21:   Sanitation issues.

Sanitation issue	ʿĀhau	Makaunga	Grand Total
Have problems with sewage	10 (15%)	0	10 (9%)
Have a functional toilet	65 (98%)	43 (100%)	108 (99%)
Have soap	61 (92%)	42 (98%)	103 (94%)
Have problems with flies or rats	14 (21%)	11 (26%)	25 (23%)

1.1.4. Section E: Risk and preparedness

The risk perception question is relevant to indicator C4: level of awareness and community sense of safety. More than half of respondents felt their community was at high risk during extreme weather events.

Table 3-22:   Perceived risk level of community during extreme weather events.

Perceived risk level	ʻAhau	Makaunga	Grand Total
High risk	37 (56%)	25 (58%)	62 (57%)
Medium risk:	24 (36%)	13 (30%)	37 (34%)
Low risk	2 (3%)	2 (5%)	4 (4%)
No risk	1 (2%)	3 (7%)	4 (4%)
I don't know	2 (3%)	0	2 (2%)

Most respondents, however, said they are prepared or very prepared for extreme weather. Respondents who believe the risk is high or low say they are more prepared than people who think the risk is medium. Without knowing what actions households have taken to prepare, it is difficult to know if different people have the same definition of preparedness. It is possible that people who feel the risk is low have taken little action but feel prepared enough.

Table 3-23:   Household preparedness for a drought or cyclone.

Preparedness of household	ʻAhau	Makaunga	Grand Total
Very prepared	28 (42%)	17 (40%)	45 (41%)
Prepared	24 (36%)	12 (28%)	36 (33%)
Quite prepared	3 (5%)	6 (14%)	9 (8%)
Not very prepared	9 (14%)	7 (16%)	16 (15%)
Not prepared	2 (3%)	1 (2%)	3 (3%)
Grand Total	28 (42%)	17 (40%)	45 (41%)
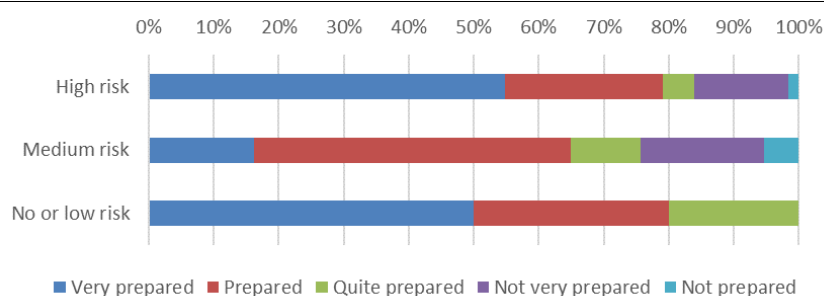
Figure 3-4:   Risk perception vs. preparedness.

Actions

The majority (73%) of respondents stated that they would evacuate in an emergency. Just over half stated that they have an emergency plan to follow. The question does not allow people to differentiate their answers for the different events. Evacuation might not be needed for a drought, for example.

Table 3-24:   Actions people would take in the event of a drought/cyclone/tsunami.

Action	ʻAhau	Makaunga	Grand Total
Raise an alarm	43 (65%)	34 (79%)	77 (71%)
Keep on top of weather reports	61 (92%)	42 (98%)	103 (94%)
Follow emergency plan	36 (55%)	28 (65%)	64 (59%)
Evacuate to safe place	50 (76%)	30 (70%)	80 (73%)
Have emergency supplies e.g., torches, medication, food, fuel	57 (86%)	43 (100%)	100 (92%)
Pray to God	46 (70%)	43 (100%)	89 (82%)

Question QE4 asks what measures people are likely to adopt in the future. It would be useful to know which measures they have already introduced as these would be omitted in the answers. Respondents considered that they were likely or very likely to do all the adaptation actions, which could either mean they have already done them, or have not done any of them. "Learn to swim" has the lowest score but this could be because respondents can swim. Respondents living in concrete dwellings were more likely to say they expect to make permanent adjustments to their home.

Table 3-25:   Likelihood of taking action in the future.

Action	Very likely	Quite likely	Not very likely	Not at all likely
Make permanent adjustments to my home	55 (50%)	8 (7%)	4 (4%)	4 (4%)
Make temporary adjustments to my home	53 (49%)	7 (6%)	0	10 (9%)
Have disaster preparedness plan	62 (57%)	1 (1%)	1 (1%)	6 (6%)
Learn to swim	43 (39%)	31 (28%)	1 (1%)	13 (12%)
Store water into buckets ready	53 (49%)	0	0	1 (1%)
Learn first aid	49 (45%)	22 (20%)	2 (2%)	3 (3%)
Listen to weather forecast	41 (38%)	0	0	2 (2%)
Stock up on food	45 (41%)	7 (6%)	0	2 (2%)
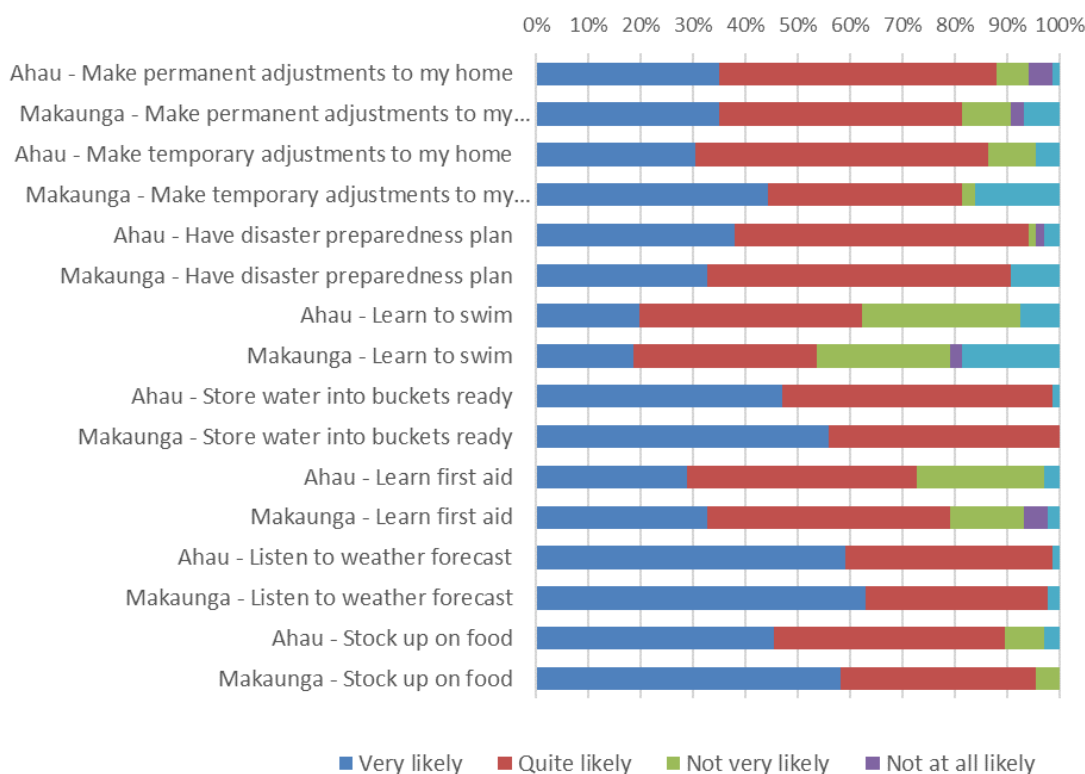
Figure 3-5: **Comparison of action likelihood by village.**

Almost all respondents stated they know the community evacuation plan and who to contact. Almost everyone stated they would contact the town officer, usually in combination with relatives, church or police if evacuation was necessary.

Table 3-26: **Evacuation knowledge.**

Question	ʻAhau	Makaunga	Grand Total
Knows the evacuation plan of their community	66 (100%)	42 (98%)	108 (99%)
Knows who to contact to let them know family is safe	62 (94%)	42 (98%)	104 (95%)

3.3   Correlations and regressions

Data collected in the household surveys were analysed for relationships in responses to different questions. There are positive correlations between change in life satisfaction, employment, concrete dwellings, number of appliances, and female gender. There is a positive correlation between risk and preparedness, and between preparedness and likelihood of taking future actions to adapt to extreme weather events.

The correlation plot (Figure 3-6) shows whether the correlation between each pair of variables is positive (blue) or negative (red). Statistical significance of the pairwise relationship is indicated by the size of each circle. A large circle indicates a p-value less than 0.01, medium is 0.05 to 0.01, small is 0.1 to 0.05, and no circle means the relationship is not significant.
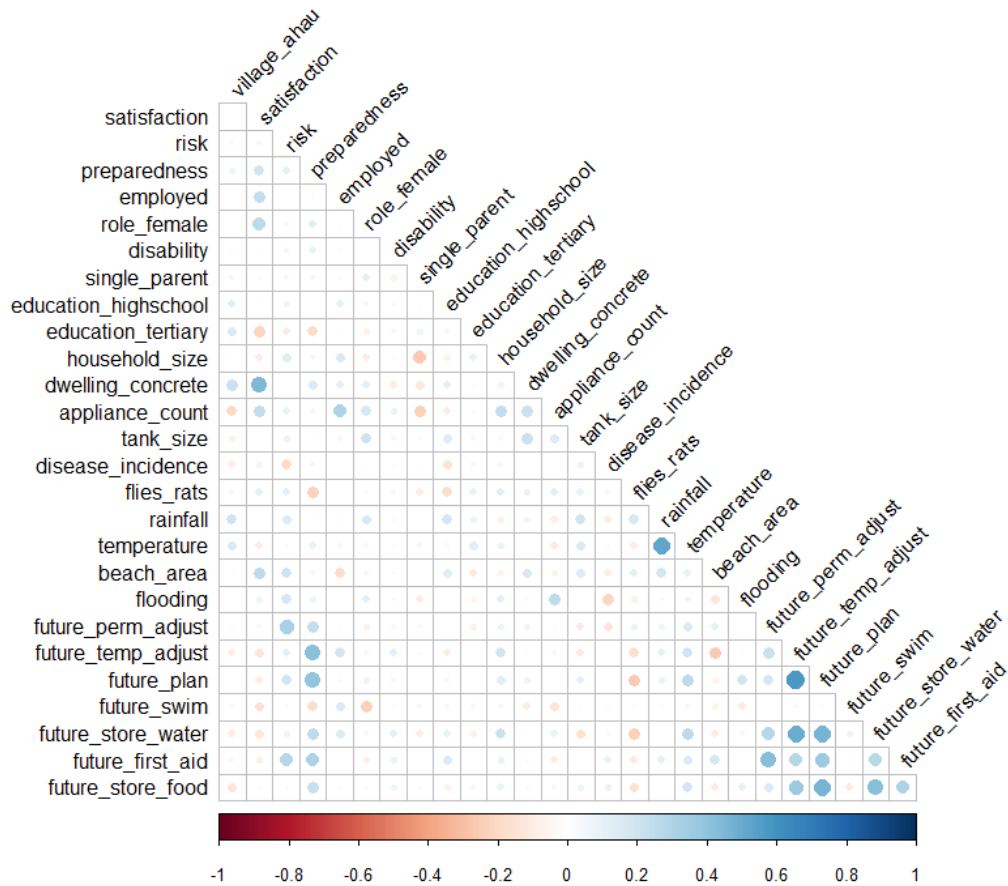
Figure 3-6: **Correlations in Tonga household survey data.**

An ordered logit regression was used to test for variables with a significant relationship with life satisfaction. The overall model fit was good (McFadden pseudo r-squared = 0.28), but few variables were statistically significant. Being employed, female, and having a concrete dwelling were associated with improved satisfaction.

The regression coefficients presented in Table 3-27 indicate whether the variable is associated with improved (a positive coefficient) or worse life satisfaction (a negative coefficient) after controlling for the other variables. Larger coefficients in absolute terms indicate a stronger effect. For example, concrete dwelling has a larger coefficient (2.626) than employment (1.284) which suggests a bigger impact. The standard error indicates how different the population mean is likely to be from the sample mean, assuming the sample is representative and unbiased. The t value is the coefficient divided by standard error and is a measure of the precision of the coefficient. The p value is the probability that the true coefficient is zero (i.e., the variable has no effect on satisfaction). A low p value indicates that the association is unlikely to have been observed by chance. The threshold for statistical significance is a p value less than 0.05.

Table 3-27:   Ordered Logit for satisfaction compared with 5 years ago.

Parameter	Coefficient	Std. Error	t value	p value
Village = Āhau	-0.378	0.502	-0.754	0.45
Employed	1.284	0.497	2.583	0.01*
Role = female	1.265	0.537	2.354	0.02*
Education = high school	-0.562	2.588	-0.217	0.83
Education = tertiary	-1.447	0.641	-2.258	0.45
Harvests for subsistence	0.342	0.483	0.708	0.48
Concrete dwelling	2.626	0.629	4.179	0.00*
Number of appliances	0.108	0.183	0.593	0.55
Has a computer	0.305	0.579	0.527	0.60
Has cattle	0.378	0.534	0.708	0.48
Has chicken	-0.410	0.465	-0.882	0.38
Gas cooking	-0.244	0.645	-0.378	0.71
Tank size (000s L)	-0.101	0.065	-1.558	0.12
Disability	0.048	0.657	0.073	0.94
Household size	-0.042	0.062	-0.671	0.50
Constants				
Much worse|A bit worse	-2.249	1.383	-1.627	0.104
A bit worse|The same	0.231	1.074	0.215	0.830
The same|A bit better	1.944	1.059	1.835	0.066
A bit better|Much better	6.948	1.345	5.165	0.000

* indicates 5% significance

Regressions were run for preparedness and risk perception, but none of the household variables were statistically significant predictors.

1.2.   Focus group results

The focus group results include responses from 19 people in Āhau and nine in Makaunga.

1.2.1. Visit frequency

In Makaunga most people said they visit the coast daily. Most Āhau participants visit once a week or less often. Almost every person said they walk there, with only one person travelling by car.
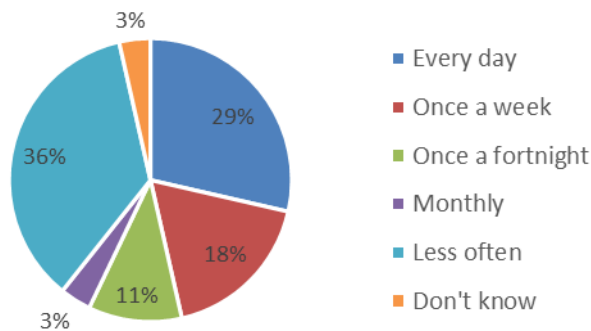
Figure 3-7:   Visit frequency.

1.2.2.   Main reasons for visiting the coast

Over half the participants said their main reason for visiting the local coast is to fish while just under half said the main reason is to relax (i.e., stroll, picnic, or enjoy the cool breeze). Six people, all in ʻAhau, said they go to observe the sea or inspect the rock barrier. People could nominate several reasons at once to visit the coast. Other uses of the beachfront include soaking pandanus and growing mangroves.

Table 3-28:   Main reason for visiting the coast.

Main reason for visiting	ʻAhau	Makaunga	Grand Total
Fishing	11	6	17
Relaxation	8	5	13
Monitor and inspect	6	0	6
Other	1	0	1

1.2.3.   Rating of the reclaimed beach area/park

Most participants thought the cleanliness, refreshment facilities and safety were good or very good. However, people in Makaunga rated cleanliness lower on average, with three people rating it as poor. Makaunga participants also considered the cost of parking/visiting was poor and rated availability and facilities worse than the ʻAhau participants. Since almost all respondents say they walk

to the coast, it is unclear why they think the cost of parking or visiting is poor. Perhaps the cost of transport limits their ability to visit coastal areas further away.
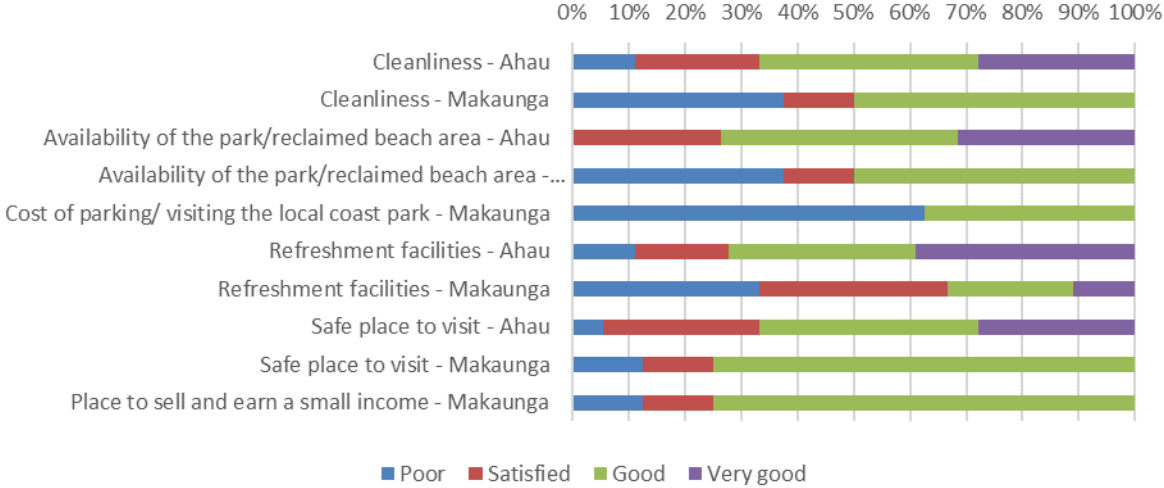
Figure 3-8: Rating of the reclaimed beach area/park.

3.3.1 Performance of the coastal adaptation

Most participants considered that the groynes/revetment infrastructure have been helpful in protecting their coastline. Three out of 28 said it had not (two in ʻĀhau and one in Makaunga).

3.3.2 Other benefits of the coastal adaptation

When considering the benefits of the coastal adaptation work, 13 participants (46%) considered that the groynes and revetment protected the land or community, or improved safety. Four participants stated that the area is cleaner or tidier. This is not necessarily directly attributable to the adaptation intervention, however.

One participant considered that children enjoy using the groyne for jumping into the sea. One person said the revetment keeps animals from damaging mangroves, and another person thought that the inability to fish in front of a revetment was a benefit as it allows sea life to recover.

3.3.3 Impact on daily tasks

Six participants in ʻĀhau (32%) and four in Makaunga (45%) agreed that the groynes/ revetment infrastructure had impacted the way they carry out daily tasks. The question about changes in use of the coastal area helps shed some light on whether the impact is positive or negative.

3.3.4 Changes in use of the coastal area

Eighteen participants said there are no changes in the way they use the coastal area, even though five people said it had impacted their daily tasks.

Two people in ʻĀhau said they had to change their fishing practices by moving further out from the shoreline because of the revetment. Two people in Makaunga said they visit less often. One person in Makaunga said that children can no longer swim there because of the rock revetment, and another said that coastal access is now more difficult in Makaunga. In the ʻĀhau group, one person

said they enjoy the area more but do not specify why, while another person said there is more mud, which presumably decreases their satisfaction.

3.3.5 Cyclone experience

All but one participant stated that their household/ community had been able to manage during Cyclone Gita in February 2018. However, it is unclear what "manage" means in this question.

3.3.6 Maintenance

When asked who takes care of maintenance, most participants in ʻAhau answered it was the Town Officer or the whole community, or both. In Makaunga the most common answer was the Government. When asked who *should* be responsible for upkeep, most participants said the whole community. Three people in Makaunga said it should be the Town Officer.

3.3.7 Recommended changes

When participants were asked what changes they would recommend if the projects were repeated, three people said make the revetment bigger, stronger, or more durable. Two people recommended to collect more community feedback. One person recommended the appointment of a committee for post-implementation maintenance, and one person suggested the need to develop a plan in order to maintain access to the sea.

3.3.8 Life satisfaction

Similar to the household survey results, most participants said their life is a bit better than five years ago. Makaunga participants had a better average rating than the ʻAhau participants.

3.3.9 Being informed and having a role

The majority (82%) of participants said they want a role in helping their community deal with climate impacts, which is probably why they were at the focus group. Almost half of them said they were not very well informed, however.

3.3.10 Biggest worry

When asked "which is your biggest worry at the moment", the most frequent answer was "not having a safe place to swim and play at the beach" (43% of participants). Several people also worried about being healthy, having clean water and electricity. Makaunga participants were more likely to worry about shelter, perhaps because Makaunga has fewer concrete dwellings.
"Other" answers included inadequate roads, the revetment not being strong enough, poor internet reception, and a loss of foreshore.

Table 3-29:   Biggest worry at the moment.

Biggest worries	ʻAhau	Makaunga	Total
Not having a safe place to swim and play at the beach	7	5	12
Not being healthy	7	3	10
Not having enough clean water to drink	7	1	8
Not having enough electricity	5	1	6
Not having adequate shelter (safe roof for my family)	1	4	5
Not having enough food to eat	3	0	3
Other	3	1	4

3.4   Tonga conclusions

Regarding survey Objective 1, the household survey results show a high level of awareness of climate change. The results show a willingness to undertake actions to prepare for climate risks but does not supply information on actions people may have already undertaken. The focus group results provide qualitative information about the perceived impacts of the adaptations but does not make the link with quality-of-life indicators. For example, several focus group participants said the revetment affected where they can fish, but it is not known whether or to what extent this affects their wellbeing.

Survey Objective 2 is to determine whether the adaptations remain adequate. The household survey results show that people still feel the risk to their community is medium or high, so they may not feel the adaptations are adequate. However, respondents also feel very prepared overall. The focus group results revealed a desire to make the structures stronger, more durable, or improve maintenance. Now that the social data (household survey and focus group results) have provided a baseline, it would be useful to ask about risk and preparedness again in future to test for changes over time.

4 Federated States of Micronesia (FSM)

Nukuoro Atoll in FSM was the target of an Adaption Fund project to improve water security. Data for the impact assessment was taken from two sites: Nukuoro Atoll in Pohnpei municipality, and Lohd village on Pohnpei acting as control site. Data for both sites was provided in the form of a broad household social survey in October and November 2021. In addition to the household survey, focus groups about water security were conducted on Nukuoro Atoll in November 2021.

4.1 Adaptation Fund project

Over 2018-2022, the Adaptation Fund project "Enhancing the climate resilience of vulnerable island communities in the Federal States of Micronesia" was delivered, the objective of which was to reduce the vulnerability of communities to drought and flood-related climate and disaster risks. Activities conducted comprised:

- Repair and installation of Water Harvesting and Storage Systems (WHSS) in six atoll islands including Nukuoro Atoll.

- Repair of household rainwater harvesting and storage systems and construction of community rainwater harvesting and storage systems.

- Promotion of self-composting toilets and construction of demonstration units at community facilities.

- Training on sanitation, health and water conservation.

4.2 Nukuoro Atoll

Nukuoro (Figure 2-1) is an atoll in Pohnpei state with a population of 210 people in 104 households according to the 2010 FSM census. Groundwater resources are susceptible to saltwater intrusion and surface pollution. The population of Nukuoro Atoll are highly vulnerable to water and vector-borne diseases due to poor water quality (Adaptation Fund, 2013).

Under the Adaptation Fund project, a community WHSS (well and tank) was installed on the atoll, in order to improve water quality and provide additional storage for water security. The Nukuoro Atoll focus group notes suggest that their private rainwater tanks have not yet been repaired, so the intervention is currently a community well and tank.

Figure 4-1: **Nukuoro Island, FSM.** Source: Google Maps

4.3   Pohnpei Island

Lohd village is in the southeast corner of Pohnpei Island. Lohd was not included in the Adaptation Fund project and has not received any other recent intervention. It was included in the household survey in order to provide baseline data about the village, and perhaps to serve as a control for the intervention in Nukuoro Atoll. However, the two locations are quite different (main island versus an atoll), so it is not possible to identify whether measured differences are due to the intervention or some other factor.

The 2010 FSM census does not report separate statistics for each village, so it is not possible to benchmark the Lohd survey responses against census data.

Figure 4-2:   Lohd, Pohnpei Island, FSM. Source : Google Maps

4.4   Household Survey

The household survey data included 30 households in Lohd, Pohnpei (percentage sample size unknown), and 37 households on Nukuoro Island (36 per cent of the 104 households in total).

4.4.1   Section A: household information

Survey respondents were most commonly the father in the household, especially in Lohd where only two women were interviewed.

Table 4-1:   Role in household of interviewee.

Role in household	Nukuoro	Lohd	Total
Father	17 (46%)	28 (93%)	45 (67%)
Mother	11 (30%)	2 (7%)	13 (19%)
Other	9 (24%)	0	9 (13%)
Total	37	30	67

The total number of people living in the sampled households is 136 people for Nukuoro Atoll (65 per cent of the population) and 207 for Lohd. There were significantly more male respondents than female in the household survey sample, but the 2010 census had even numbers of men and women in Nukuoro.

Table 4-2:   Number of people in sampled households.

Population of sampled households	Nukuoro	Lohd	Total
Number of men	53 (39%)	69 (33%)	122 (36%)
Number of women	30 (22%)	60 (29%)	90 (26%)
Number of children	53 (39%)	78 (38%)	131 (38%)
Total people	136	207	343

The households were significantly larger in Lohd, with an average size of 6.9 people per household compared to 3.7 in Nukuoro Atoll. In the 2010 census the average household size on Nukuoro Atoll was 4.7 people. Small households may be over-represented in the sample.

Table 4-3:   Household size.

Number of individuals	Nukuoro	Lohd	Total
1	13 (35%)	0	13 (19%)
2	7 (19%)	1 (3%)	8 (12%)
3	1 (3%)	1 (3%)	2 (3%)
4	4 (11%)	7 (23%)	11 (16%)
5	0	2 (7%)	2 (3%)
6	4 (11%)	7 (23%)	11 (16%)
7	1 (3%)	0	1 (1%)
8	5 (14%)	4 (13%)	9 (13%)
9	1 (3%)	1 (3%)	2 (3%)
>9	1 (3%)	7 (23%)	8 (12%)
Average size	3.7	6.9	5.12
Total people	136	207	343

Based on survey responses, the Nukuoro Atoll residents were more highly educated on average, with 24 interviewees (64%) having at least a high school education. This is higher than in the 2010 census where 55% of men in Nukuoro Atoll had at least high school education, suggesting that educated people are over-represented in the sample. In Lohd only seven interviewees (23%) had a high school or greater education, which is much lower than the census figure of 58% for Pohnpei Island.

Table 4-4 :   Highest education level.

Highest education level	Nukuoro	Lohd	Total
Primary school	13 (35%)	23 (77%)	36 (54%)
High school/College	23 (62%)	7 (23%)	30 (45%)
Tertiary	1 (3%)	0	1 (1%)

Vulnerable populations

The number of households hosting members with a disability was five in Nukuoro Atoll and six in Lohd. In addition, there were four single parent households in Nukuoro Atoll (of which two were headed by women) and one in Lohd. The age of occupants is unknown, but one household was

headed by a grandmother. In the 2010 census there were 12 people aged over 60 years in Nukuoro Atoll.

Dwellings, appliances and infrastructure

The total number of dwellings on Nukuoro Atoll was 77, and many households had more than one dwelling. Lohd respondents tended to own just one dwelling, despite having more people in the households. Most dwellings in Nukuoro Atoll were thatched, while none were thatched in Lohd.

Table 4-5:   Dwelling number and type.

Dwelling number and type	Nukuoro	Lohd	Total
Number of dwellings	77	38	115
Iron construction	8 (22%)	21 (70%)	29 (43%)
Bamboo construction	6 (16%)	14 (47%)	20 (30%)
Concrete construction	1 (3%)	14 (47%)	15 (22%)
Thatched construction	36 (97%)	0	36 (54%)

Lohd residents were more likely to own gas stoves, TVs, refrigerators and radios, but reported having no beds. The lack of beds is possibly a transcribing error. Nukuoro Atoll households had more kerosene cookers. The "other" appliances comprised a laptop and two washing machines.

Table 4-6:   Appliances owned by household.

Appliance type	Nukuoro	Lohd	Total
Radio	5 (14%)	11 (37%)	16 (24%)
Gas stove	20 (54%)	29 (97%)	49 (73%)
Kerosene cooker	26 (70%)	13 (43%)	39 (58%)
Beds	12 (32%)	0	12 (18%)
Sewing machine	4 (11%)	7 (23%)	11 (16%)
TV	4 (11%)	18 (60%)	22 (33%)
Refrigerator	1 (3%)	15 (50%)	16 (24%)
Other	8 (22%)	0	8 (12%)

Most Nukuoro Atoll households use solar-powered lighting, while most Lohd households use mains power for lighting.

Table 4-7:   Lighting energy sources.

Energy source	Nukuoro	Lohd	Total
Kerosene	2 (5%)	1 (3%)	3 (4%)
Benzene	1 (3%)	1 (3%)	2 (3%)
Own generator	4 (11%)	0	4 (6%)
Village generator	0	0	0
Mains power	0	28 (93%)	28 (42%)
Solar	36 (97%)	6 (20%)	42 (63%)

Households in both areas predominantly have pit toilets. For freshwater supplies, Nukuoro Atoll households have a mix of water tanks and wells with tanks dominating, while Lohd households only have tanks. Lohd households are more likely to have internet, phones and computers, while Nukuoro Atoll households have motorboats and vaka (a type of boat).

Table 4-8:   Household infrastructure.

Household infrastructure	Nukuoro	Lohd	Total
Freshwater			
Well	23 (62%)	0	23 (34%)
Tank	32 (86%)	18 (60%)	50 (75%)
Waste			
Pit toilet	25 (68%)	29 (97%)	54 (81%)
Flush toilet	0	5 (17%)	5 (7%)
Transport and fishing			
Outboard motorboat	7 (19%)	1 (3%)	8 (12%)
Vaka	16 (43%)	0	16 (24%)
Communications			
Internet	0	23 (77%)	23 (34%)
Phone	3 (8%)	8 (27%)	11 (16%)
Computer	2 (5%)	6 (20%)	8 (12%)

Most of the rainwater tanks are under 5,000 litres in capacity. A large proportion (73%) of Lohd households use drums to store water.

Table 4-9:   Water storage capacity.

Water storage capacity	Nukuoro	Lohd	Total
Drums	4 (11%)	22 (73%)	26 (39%)
Tank <5000L	24 (65%)	17 (57%)	41 (61%)
Tank 5000-10000L	9 (24%)	0	9 (13%)
Tank >10,000L	0	0	0

4.4.2   Section B: Livelihood & energy use

Most people in Lohd said their life is better than it was five years ago, although respondents from Nukuoro Atoll had more variable views. The proportion of respondents whose lives deteriorated was higher in Nukuoro Atoll compared to Lohd (19% versus 3%) but Nukuoro Atoll also had 16% of respondents say their lives were much better, compared with none in Lohd.

Table 4-10:   Life satisfaction compared with 5 years ago.

Life satisfaction	Nukuoro	Lohd	Total
Much worse	1 (3%)	0	1 (1%)
A bit worse	6 (16%)	1 (3%)	7 (10%)
The same	9 (24%)	7 (23%)	16 (24%)
A bit better	15 (41%)	19 (63%)	34 (51%)

Much better	6 (16%)	0	6 (9%)
Don't know	0	3 (10%)	3 (4%)
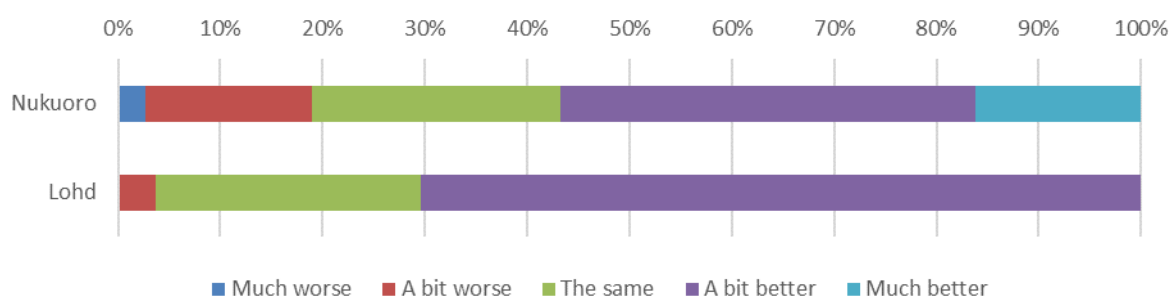
Figure 4-3: Life satisfaction compared with 5 years ago.

Employment and spending

Of surveyed households in Nukuoro Atoll, 23 host employed individuals while 17 of the Lohd households hosted employed individuals. This represents 28% and 13% of adults in sampled households respectively. The 2010 census had 31% of Nukuoro Atoll adults formally employed. This disparity raises questions about the representativeness of the sampling for Lohd and the resulting reliability of data.

Table 4-11: Number of people employed.

Employment	Nukuoro	Lohd	Total
Count of households with at least one person employed	18 (49%)	13 (43%)	31 (46%)
Count of employed men	17 (32%)	15 (22%)	32 (26%)
Count of employed women	6 (20%)	2 (3%)	8 (9%)

Nukuoro Atoll residents identified a variety of other income sources such as primary industries and retail, with the "other" category including livestock, kava and oil. Lohd residents predominantly earn other income from fish, seafood, and remittances.

Table 4-12: Non-employment income sources.

Income source	Nukuoro	Lohd	Total
Crops	2 (5%)	8 (27%)	10 (15%)
Fish and seafood	1 (3%)	17 (57%)	18 (27%)
Handicrafts	7 (19%)	0	7 (10%)
Shop	1 (3%)	0	1 (1%)
Remittances	6 (16%)	14 (47%)	20 (30%)
Other	12 (32%)	1 (3%)	13 (19%)

Lohd residents are more likely to own fishing nets, while Nukuoro Atoll residents are more likely to have handlines.

Table 4-13: Fishing gear owned by household.

Type of gear	Nukuoro	Lohd	Total
Speargun	22 (59%)	19 (63%)	41 (61%)
Net	2 (5%)	20 (67%)	22 (33%)
Handline	32 (86%)	5 (17%)	37 (55%)
Trap	2 (5%)	1 (3%)	3 (4%)
Other Gear	1 (3%)	0	1 (1%)

Lohd residents were more likely to say they spend the largest amount of income on household expenses rather than other categories. Both groups ranked "community" as the category of lowest expense.

Table 4-14: Average rank of spending categories, by amount.

Spending category	Nukuoro	Lohd	Grand Total
Household	2.0	1.1	1.6
Church	2.9	2.6	2.8
Children	2.7	3.2	2.9
Education	3.2	3.6	3.4
Community	4.3	4.4	4.3

Households in both communities own pigs, chickens and cats or dogs. Nukuoro Atoll residents are less likely to own cats or dogs than Lohd residents. No household owned cattle, horses or ducks.

Table 4-15: Animals and livestock owned.

Type of animal owned	Nukuoro	Lohd	Total
Pigs	34 (92%)	29 (97%)	63 (94%)
Chickens	32 (86%)	29 (97%)	61 (91%)
Cats or dogs	18 (49%)	30 (100%)	48 (72%)

Subsistence

The majority of households (73% for Nukuoro Atoll and 83% for Lohd) harvest for subsistence purposes. Most households collect water at least once a week, and fish a few times per week. Nukuoro Atoll residents have more tanks and are more likely to say they never have to collect water; however, many households with tanks still collect water regularly.

Table 4-16: Water collection frequency.

Water collection frequency	Nukuoro	Lohd	Total
Everyday	8 (22%)	5 (17%)	13 (19%)
Few times a week	4 (11%)	11 (37%)	15 (22%)
About once a week	4 (11%)	4 (13%)	8 (12%)
Few times a month	3 (8%)	1 (3%)	4 (6%)

Water collection frequency	Nukuoro	Lohd	Total
Once a month	3 (8%)	1 (3%)	4 (6%)
<Once a month	0	1 (3%)	1 (1%)
Never	15 (41%)	7 (23%)	22 (33%)

Nukuoro Atoll residents are more likely to do crafting (51%) compared with Lohd (17%). Most households also harvest firewood for cooking, although 10 households in Lohd use gas rather than firewood. Respondents in both locations use a variety of fuels for various activities. Lohd residents are less likely to use diesel for generation or kerosene for lighting because they have mains electricity, while 11% of Nukuoru Atoll respondents said they use no fuel of any type, which is possibly a data entry error. Most households use fewer than 5L of fuel per week for each use category, but one or two households use 6-10L.

Table 4-17: Use of fuels.

Fuel use	Nukuoro	Lohd	Total
Diesel generator	33 (89%)	10 (33%)	43 (64%)
Kerosene for lighting	32 (86%)	11 (37%)	43 (64%)
Grass cutting, outboard, chainsaw	33 (89%)	26 (87%)	59 (88%)
Fuel for transport	32 (86%)	30 (100%)	62 (93%)
Kerosene for cooking	33 (89%)	29 (97%)	62 (93%)
Gas for cooking	33 (89%)	29 (97%)	62 (93%)
Outboard for fishing/picnic	31 (84%)	13 (43%)	44 (66%)

4.4.3 Section C: Awareness of environment

All of the Lohd interviewees and 84% of Nukuoro Atoll respondents agreed that climate change is happening. One person disagreed that climate change is happening and five said they did not know. Most people attributed climate change to human activity and greenhouse gases. Nukuoro Atoll residents also blamed the hole in the ozone layer, while Lohd residents also blamed migration.

Table 4-18: Perceived causes of climate change.

Climate change causes	Nukuoro	Lohd	Total
Human activity that led to the emission of dangerous greenhouse gases	27 (73%)	30 (100%)	57 (85%)
Population growth	12 (32%)	24 (80%)	36 (54%)
Loss of trees	22 (59%)	7 (23%)	29 (43%)
A hole in a protective layer of gas that covers the planet called ozone layer	17 (46%)	0	17 (25%)
Forces of nature	14 (38%)	1 (3%)	15 (22%)
Migration	0	13 (43%)	13 (19%)
Don't know	7 (19%)	1 (3%)	8 (12%)

There were significant differences in environmental changes perceived by Nukuoro Atoll and Lohd respondents. Lohd residents perceived a large decrease in number of trees, vegetation, fish and coral. Nukuoro Atoll residents reported mixed opinions and perceived that rainfall had decreased. Both groups stated a belief than temperature has either stayed the same or increased.

Both groups were also more likely to say that flooding and storm surges have increased rather than decreased, although a large proportion said they did not know.
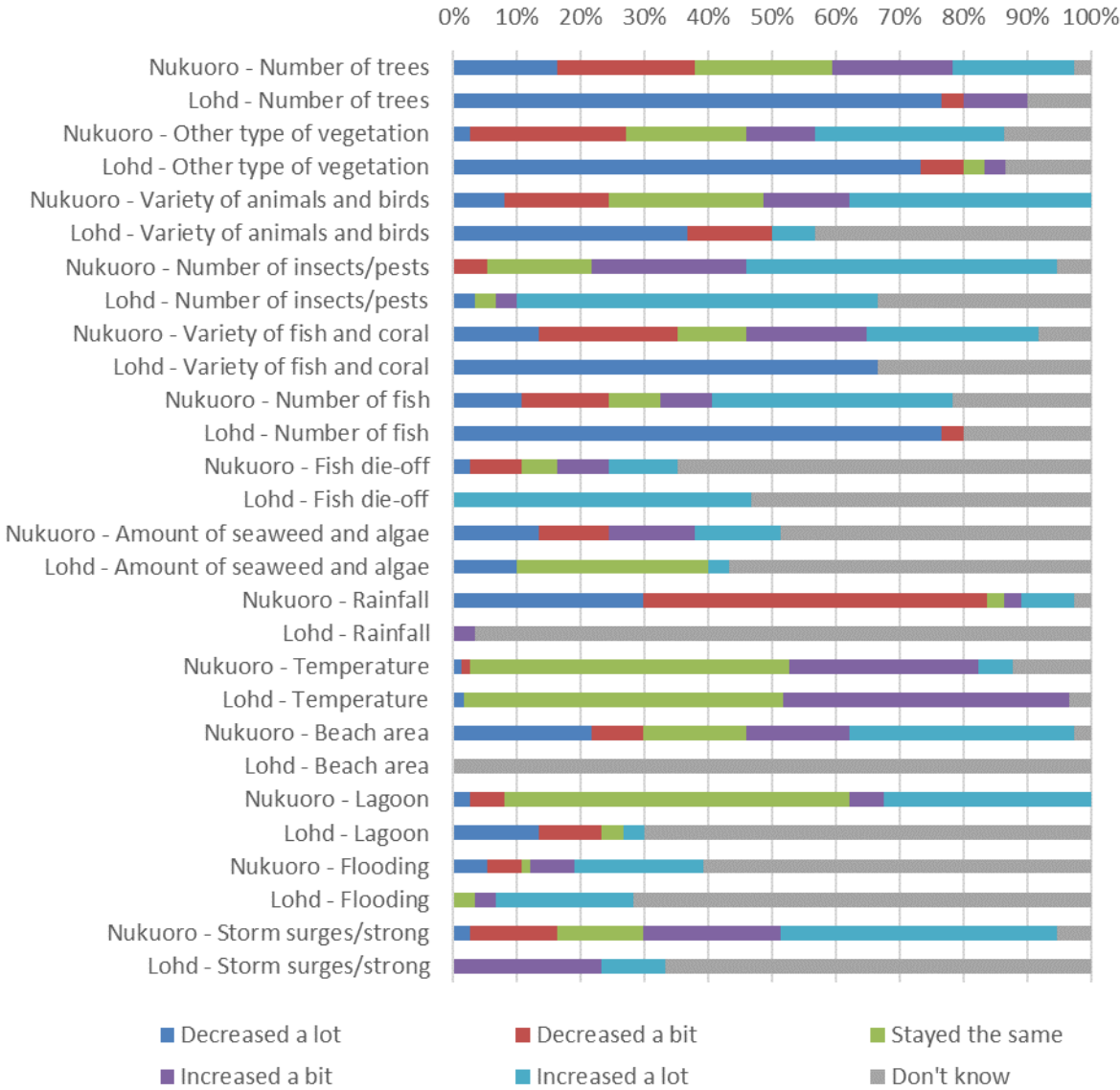
Figure 4-4:   Environmental changes.

4.4.4   Section D: Public health

More than half of Nukuoro Atoll respondents said they heard about sanitation at a community meeting. Most Lohd respondents said they had received no information. This may be due to the adaptation intervention in Nukuoro Atoll.

Table 4-19:   Sources of sanitation information.

Source of information	Nukuoro	Lohd	Total
A sanitation aid officer visited my house	8 (22%)	8 (27%)	16 (24%)
It was discussed at a community meeting	21 (57%)	9 (30%)	30 (45%)
My church group discussed it	2 (5%)	2 (7%)	4 (6%)
Heard from the media	2 (5%)	3 (10%)	5 (7%)
None	15 (41%)	23 (77%)	38 (57%)

Nukuoro Atoll residents are far more likely to say they clean their roof and tank regularly.

Table 4-20:   Frequency of cleaning roof, gutters and tank.

Frequency of cleaning roof, gutters and tank	Nukuoro	Lohd	Total
Every six months	17 (46%)	4 (13%)	21 (31%)
Every year	8 (22%)	3 (10%)	11 (16%)
Every two years	4 (11%)	4 (13%)	8 (12%)
We have never cleaned it	8 (22%)	19 (63%)	27 (40%)

Only three people (all in Lohd) said they had a sceptic system and two of those cleaned it out a year ago. The other household had never cleaned their system. Half of Lohd Atoll households said they have problems with sewerage or bad smells at least sometimes. No Nukuoro Atoll households had a problem. Most Nukuoro Atoll respondents said their toilet is functional, while most Lohd respondents said their toilet is not clean enough. It is possible the difference is due to the Adaptation Fund project to promote composting toilets: it is unknown how many households use composting toilets.

Table 4-21:   Toilet functionality.

Statement	Nukuoro	Lohd	Total
Yes, our toilet is functional	25 (68%)	4 (13%)	29 (43%)
No, it is not clean	0	20 (67%)	20 (30%)
No, it does not work properly	5 (14%)	5 (17%)	10 (15%)
No, it's not of a type and/or in a location that is acceptable to me	6 (16%)	1 (3%)	7 (10%)

Nukuoro Atoll residents were more likely to have soap available (92%) than Lohd residents (47%).

Food safety

Half of Nukuoro Atoll respondents had received information regarding the safe handling, preparation and storage of raw meat in the household, but none of the Lohd respondents had. The difference may be attributed to the Adaptation Fund project which included health and sanitation education.

Less than half of Nukuoro Atoll respondents said they always prepare raw meat with a separate board, knife and cloth. The majority said they wash everything afterwards. Four people said they have problems with keeping meat frozen, and it is unclear whether other people have problems, or do not freeze meat at all. Lohd respondents did not answer these questions, so it is not possible to draw any conclusions about whether receiving information is associated with better food safety practices.

Table 4-22:   Food safety responses.

Food safety	Nukuoro	Lohd	Total
Have received information about food safety	19 (51%)	0	19 (28%)
Problems keeping meat frozen	4 (11%)	N/A	N/A
Separate preparation of raw meat	16 (43%)	N/A	N/A
Wash everything after preparing raw meat	32 (86%)	N/A	N/A

Communicable disease

19 people in Nukuoro Atoll reported at least one incident of diarrhoea and/or vomiting, compared with only two people in Lohd. Around half of these people reported at least one visit to a health clinic. People who did not report, said they only report serious illness.

Table 4-23:   Incidence of diarrhoea and/or vomiting within the past year.

Whether there has been a disease incidence	Nukuoro	Lohd	Total
No, we did not report it	8 (22%)	28 (93%)	36 (54%)
Yes, but we did not report it to the nurse practitioner at the health clinic	13 (35%)	1 (3%)	14 (21%)
Yes, we reported it to the nurse practitioner at the health clinic	16 (43%)	1 (3%)	17 (25%)

Of those who reported disease, ten people said the response was quick with good information, three said the response was slow, three said there was a lack of good information, and one person in Lohd said there was no response. Most people who did not report disease said they would only do so if it was serious.

Solid waste

Nukuoro Atoll respondents are more likely to bury or burn solid waste, while more Lohd residents use a pit instead. Nukuoro Atoll residents have a greater problem with overflowing waste but most people in both areas have problems with flies and rats.

Table 4-24:   Solid waste responses.

Waste statement	Nukuoro	Lohd	Total
Waste is regularly buried or burnt	31 (84%)	13 (43%)	44 (66%)
Kitchen/household waste is put in a dug pit	5 (14%)	17 (57%)	22 (33%)
Often have solid waste overflowing prior to disposal	25 (68%)	6 (20%)	31 (46%)
Problems with flies and rats in and around the waste disposal area	30 (81%)	22 (73%)	52 (78%)

Standing water

Most people said they have standing water near their house, either in uncovered tanks, tyres, or taro patches (other category) in Nukuoro Atoll. Most people in Lohd said they do not know what to do about the standing water. Some respondents in Nukuoro Atoll said they empty containers, but more than half do nothing. There may not be much people can do about the poor drainage.

Table 4-25:   Sources of standing water.

Sources of standing water	Nukuoro	Lohd	Total
Uncovered tanks	13 (35%)	18 (60%)	31 (46%)
Tires	3 (8%)	11 (37%)	14 (21%)
Poor drainage	9 (24%)	0	9 (13%)
Other	9 (24%)	2 (7%)	11 (16%)

4.4.5   Section E: Risk and preparedness

Most of the people in Lohd said they feel the risk to their community during extreme weather events is high. People in Nukuoro Atoll were split between medium risk (43%) and high risk (51%).

Table 4-26:   Perception of risk during extreme weather events.

Perceived risk level	Nukuoro	Lohd	Total
None	0	0	0
Low	0	0	0
Medium	16 (43%)	1 (3%)	18 (27%)
High	19 (51%)	27 (90%)	46 (69%)
Don't know	2 (5%)	2 (7%)	4 (6%)

People in Nukuoro Atoll were more likely to say they are prepared or quite prepared for a drought or cyclone. In contrast, only four people in Lohd said they felt prepared.

Table 4-27:   Preparedness of household.

Preparedness	Nukuoro	Lohd	Total
Very prepared	0	0	0
Prepared	7 (19%)	0	7 (10%)
Quite prepared	13 (35%)	4 (13%)	17 (25%)
Not very prepared	7 (19%)	13 (43%)	20 (30%)
Not prepared	7 (19%)	3 (10%)	10 (15%)
Not at all prepared	2 (5%)	4 (13%)	6 (9%)
Don't know	1 (3%)	5 (17%)	6 (9%)

Despite the fact that Lohd residents perceive a higher risk, Nukuoro Atoll respondents were more likely to say they would take actions such as raise an alarm, follow a plan, evacuate, and have emergency supplies following a warning. Few Lohd residents said they would do these actions. Nukuoro Atoll residents (24%) were more likely to know about their community evacuation plan compared with Lohd (7%). Nukuoro Atoll residents (59%) are also more likely to know who to contact to let them know their family is safe than Lohd (7%).

Table 4-28:   Actions people would take following a drought/cyclone/tsunami warning.

Actions	Nukuoro	Lohd	Total
Raise alarm	18 (49%)	10 (33%)	28 (42%)
Keep on top of weather reports	18 (49%)	0	18 (27%)
Follow emergency plan	19 (51%)	3 (10%)	22 (33%)
Evacuate to safe place	19 (51%)	9 (30%)	28 (42%)
Have emergency supplies	17 (46%)	2 (7%)	19 (28%)
Pray to God	27 (73%)	30 (100%)	57 (85%)
Don't know	4 (11%)	0	4 (6%)

Regarding future actions that people might take to deal with extreme events, Nukuoro Atoll respondents appeared to be significantly more likely to take all actions than Lohd respondents (Figure 5). Most Lohd people said they are unlikely to have a disaster plan, learn to swim, learn first aid, listen to the forecast, or stock up on food, while more than half of Nukuoro Atoll residents say they are likely to do these things. It is not known whether this difference is an impact of the Adaptation Fund project, or due to some other difference between the communities. Having baseline and post-implementation data would resolve the issue.
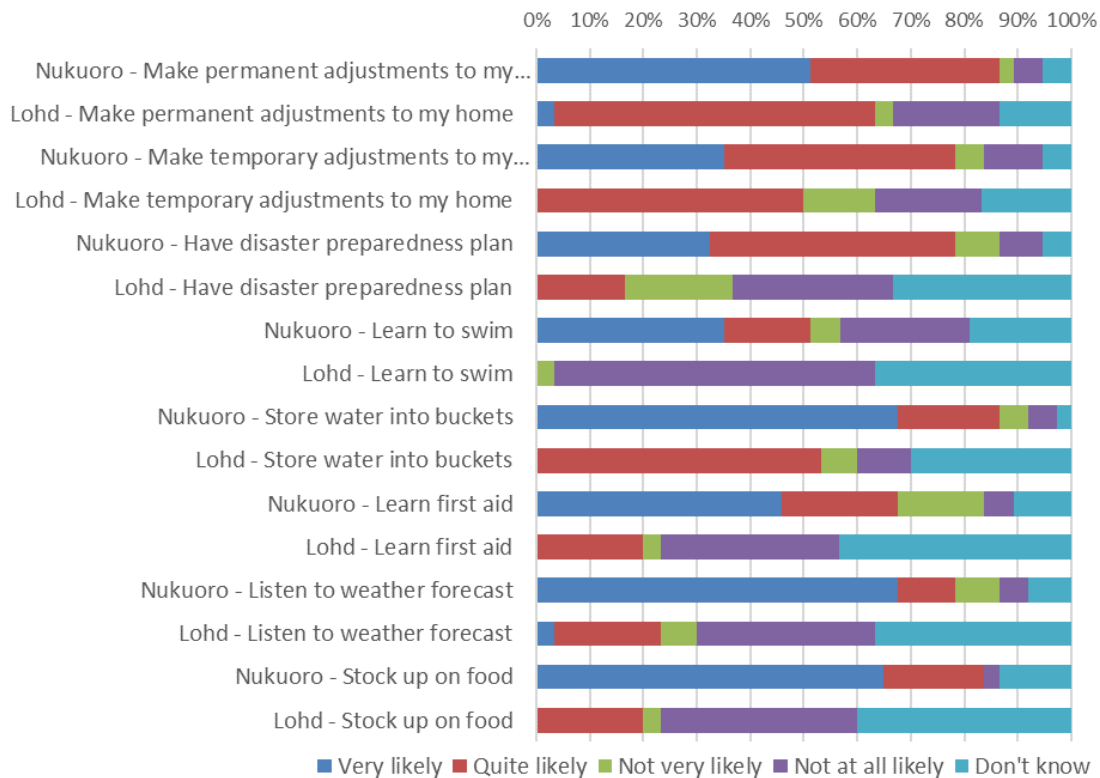
Figure 4-5:   Likelihood of taking future actions.

4.5   Focus group results

There were three focus groups in Nukuoro Atoll about the Adaptation Intervention Fund project, comprising of council members, youth and women. All three groups communicated a similar message, that they appreciated additional water security but thought it should be a priority of the project to repair existing household tanks rather than provide new community facilities.

4.5.1   Nukuoro Atoll Local Government Council Members

The Council members felt the project is of benefit to the few households that do not have their own tanks but thought the priority should be to repair private tanks rather than construct the community tank and well. They felt that the community is resilient to drought. They remembered previous events and thought the community was quick to recover.

4.5.2   Nukuoro Atoll youth

Youth participants thought it was a good project but felt that it took a while. They thought the community was resilient and could repair their own tanks if they had the proper materials.

4.5.3   Nukuoro Atoll women

Women participants were concerned about the state of their private water tanks. They said that the well pump is difficult to use but it is good to have an additional water source for emergencies.

4.6   Correlations and regressions

Data provided in the household surveys were analysed for relationships. There are correlations between location, household, risk, preparedness, and environmental variables (Figure 2-4). For example, Nukuoro Atoll residents tend to have thatched dwellings, smaller households, rainwater tanks, a higher incidence of disease, lower risk perception, and more willingness to take future actions. Respondents with improved life satisfaction tend to perceive higher risk and feel less prepared, a counter-intuitive result.

The correlation plot (Figure 4-6) shows whether the correlation between each pair of variables is positive (blue) or negative (red). Statistical significance of the pairwise relationship is indicated by the size of each circle. A large circle indicates a p-value less than 0.01, medium is 0.05 to 0.01, small is 0.1 to 0.05, and no circle means the relationship is not significant.
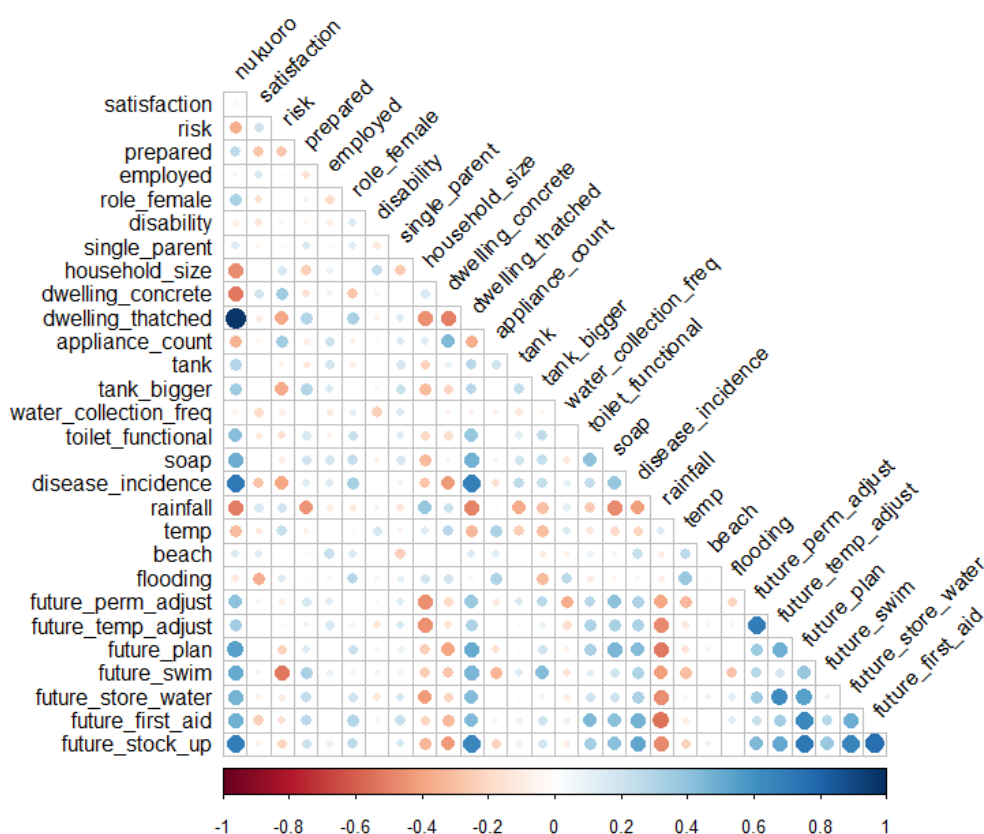
Figure 4-6 :   Correlation plot of household, risk, preparedness and environmental change variables.

The ordinal logit regression coefficients presented in

Table 4-29 indicate whether the variable is associated with improved (a positive coefficient) or worse life satisfaction (a negative coefficient) after controlling for the other variables. Larger coefficients in absolute terms indicate a stronger effect. The standard error indicates how different the population mean is likely to be from the sample mean, assuming the sample is representative and unbiased. The t value is the coefficient divided by standard error and is a measure of the precision of the coefficient. The p value is the probability that the true coefficient is zero (i.e., the variable has no effect on satisfaction). A low p value indicates that the association is unlikely to have been observed by chance. The threshold for statistical significance is a p value less than 0.05.

Few effects are statistically significant, despite having a good overall fit[2]. Improved life satisfaction is associated with living on Nukuoro Atoll. Thatched dwellings, communicable disease, more appliances, and being prepared have negative associations. The negative impact of appliances and being prepared seem counter-intuitive but may be caused by correlation with other factors. For example, people might be prepared because they have already experienced the negative impacts of a climate event. If having a rainwater tank has a positive effect on life satisfaction, the impact cannot be detected in this data because almost every Nukuoro Atoll household has a tank.

Table 4-29:   Ordinal logit regression estimates for life satisfaction.

Variable	Coefficient	Standard error	p-value
Nukuoro	17.377	0.698	<0.01*
Employed	0.851	0.710	0.23
Education = primary	-1.296	0.781	0.10
Education = tertiary	-2.279	2.971	0.44
Concrete dwelling	1.314	1.027	0.20
Thatched dwelling	-16.739	0.698	<0.01*
Iron dwelling	-1.916	1.002	0.06
Tank	0.037	0.734	0.96
Tank larger than 5000L	1.052	1.235	0.39
Disability	-0.746	0.870	0.39
Single parent household	-0.243	1.119	0.83
Household size	0.028	0.112	0.80
Number of appliances	-0.429	0.218	0.05*
Has a flush toilet	-2.798	1.449	0.05
Disease incident	-3.308	0.959	<0.01*
Prepared	-1.723	0.736	0.02*
Much worse|A bit worse	-9.321	2.073	<0.01*
A bit worse|The same	-6.674	1.663	<0.01*
The same|A bit better	-4.660	1.563	<0.01*
A bit better|Much better	0.152	1.412	0.91

*indicates 5% significance

4.7   FSM conclusions

There are significant differences in survey results for the two locations. The Nukuoro Atoll households are smaller, thatched, have no access to mains electricity, and most of them have rainwater tanks. The rate of communicable disease is high. People report having noticed reduced rainfall and perceive the risk from extreme weather events to be medium-high. Nevertheless, Nukuoro Atoll residents believe they are prepared for extreme weather events.

The Lohd households are larger, have more iron and concrete dwellings, have mains power, and lower rates of communicable disease. However, they have fewer rainwater tanks, lower education

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[2] McFadden pseudo r-squared = 0.28

levels, and report having noticed decreases in trees, vegetation, animals, and fish. Lohd residents reported feeling unprepared and consider risk to their community of extreme weather events is high.

Respondents at the two locations report similar life satisfaction, but the responses from Nukuoro Atoll are more variable, with people who have thatched dwellings reporting lower life satisfaction.

Nukuoro Atoll households already had private rainwater tanks before the intervention so it is not possible to say whether the differences in preparedness and risk perception between Nukuoro Atoll and Lohd are caused by the adaptation fund intervention, or the pre-existing tanks, or some other factor. However, this survey data will provide a useful baseline to measure the impact of any future interventions in both locations.

5 Palau

5.1 Palau adaptation projects

The Republic of Palau is an island country located in the western Pacific Ocean. The country contains approximately 340 islands, forming the western chain of the Caroline Islands in Micronesia, and has an area of 466 square kilometres. Palau is exposed to many climate change impacts including sea level rise, higher temperatures, more intense rainfall, and increased frequency and intensity of extreme weather events such as typhoons and droughts. These impacts pose threats to water and food security in Palau.

Assessment of the vulnerability of communities to climate change and the potential impact of adaptation was conducted for two case studies:

- Enhancing sustainable livelihoods on Babeldaob island, and

- Improving rainwater infrastructure on Angaur island.

5.1.1 Enhancing Sustainable Livelihoods

The purpose of the project "ACSE-Enhancing Sustainable Livelihoods through Demonstration of Environmentally Friendly Integrated Food Production System" (2016-2018) was to demonstrate environmentally friendly integrated food production systems in Palau. The adaptation project aimed to enhance sustainable livelihoods and strengthen capacities to adapt to the adverse effects of climate change[3].

Farming in Palau has declined, and the country has experienced decreased access to high quality local food sources (ACSE 2021). Land degradation issues coupled with food safety and water concerns are serious constraints to the integration of livestock to existing agricultural systems to improve livelihoods. The conventional system of raising livestock, particularly pigs, involves cleaning pens of animal waste which requires large volumes of water. This practice leads to unsustainable water usage and the untreated water that runs off farms creates environmental and health safety risks. Conventional livestock practices also make soil more vulnerable events such as a flood.

The adaptation project established pilot dry litter piggeries in five different communities on Babeldaob Island, Palau, in Ngchesar, Aimeliik, and Ngaraard states. A dry litter system incorporates the use of carbon-rich mulch, sloping pen floors, and requires no water for pen clean-up. The pig waste is mixed into the carbon-rich materials and discharged out of the pens by the pigs. The mix of waste and mulch is then composted to provide high quality compost for gardens. The system reduces flies, odour, and risk of water contamination by eliminating run-off. The project provided five participants with facilities, a superior breed of pig, high-quality feed, and training on animal husbandry, horticulture, and composting.

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[3] https://www.pacificclimatechange.net/sites/default/files/documents/GIZ-ACSE-PL_project-brief_FINAL.pdf
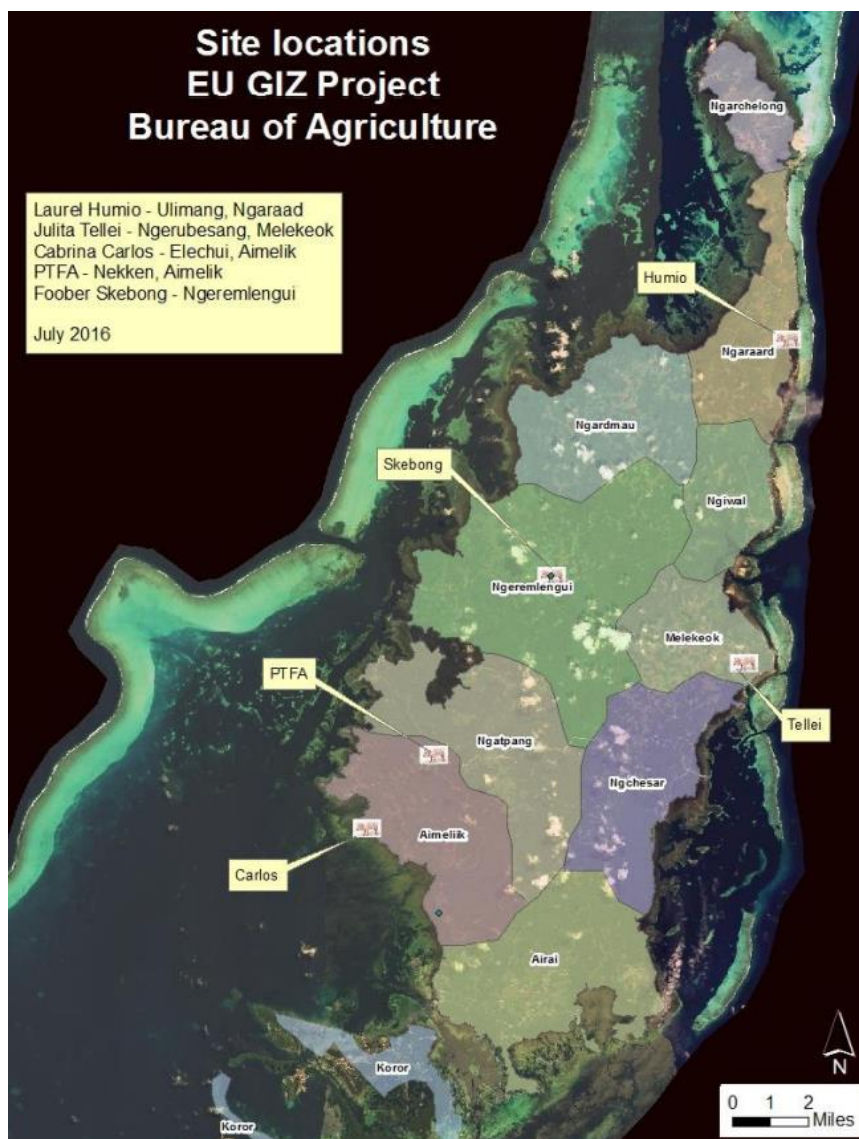
Figure 5-1: **Demonstration piggery locations.** Source: Palau Conservation Society (2021).

5.1.2 Water infrastructure in Angaur

Angaur is a small platform limestone island located South of the main islands of Palau. It is accessible by boat and by plane. It has a small community consisting of some 44 households and 119 individuals according to the 2015 Palau census.

Figure 5-2: **Location of Angaur Island.** Source: Google Maps

Households in Angaur have access to brackish piped water from the island's water lens. This piped water is used for bathing and cleaning. Drinking and cooking water is provided by rainwater catchment tanks. More than half of the households in Angaur do not have water tanks. Those that do not have water tanks, access water from neighbouring relatives or from the school and community centre. A number of people who access the school water tank boil the water before drinking.

Angaur has been the recipient of significant water security investments by the Palau Government in recent years. Palau has accessed funding support from bilateral and regional partnerships and international funding mechanisms to develop water supply in Angaur. The project GCCA PSIS-Improving rainwater infrastructure (2013-2015) provided a SPC-funded solar operated water treatment plant and community centre water tank. The solar-powered treatment plant is currently inoperable, however.

There is also a current Department of Interior (US Government) project to provide every household with a water tank, but many have not yet been connected. The fact that the project is incomplete means that the household survey does not provide strictly pre-or-post adaptation data. The survey data will be a useful baseline to measure the impact of the household water tank project if another survey is conducted when that project is complete.

5.2   Palau Household survey

The household survey comprises data from five dry litter piggery farmers on Babeldaob Island (case study 1) and 22 households on Angaur Island. The piggery pilot included six farms so this survey implies a sample rate of 83 per cent for piggery famers on Babeldaob and a sample rate for 48 per cent of the population for Angaur households.

The following data analysis differentiates between these two groups in order to assess if there are any significant differences between them. However, the small number of piggery farmers means that it is not possible to control for other differences between the two islands, so results should be interpreted with caution.

According to the 2015 census, there are 119 people and 44 households in Angaur Island state. The total number of households in Ngchesar, Aimeliik, and Ngaraard states are 79, 96, and 128 respectively. The sample of five piggery farmers (Babeldaob) is small and was not intended to be representative of the population.

5.2.1   Section A: Household

There were even numbers of male and female survey respondents in Angaur. Most of the piggery respondents were the father of their household. Only one household (in Angaur) had a resident with a disability.

Table 5-1:   **Role in household of interviewee.**

Role in household	Houses on Angaur	Piggery farmers on Babeldaob	Total
Father	9	4	13
Mother	9	1	10
Other	4	0	4
Total	22	5	27

The sampled households represent a population of 116 people. There were relatively equal numbers of adults and children in the households.

Table 5-2:   **Number of people in sampled households.**

Population of sampled households	Houses on Angaur	Piggery farmers on Babeldaob	Total
Number of men	25	5	30
Number of women	25	6	31
Number of children	43	12	55
Total people	93	23	116

The Babeldaob piggery households had an average of 4.6 people, while the Angaur households had 4.2 people. The surveyed households are considerably larger than the average household size in Angaur, which was 2.7 people in the 2015 census (Palau Office of Planning and Statistics, 2015).

Table 5-3:   Household size.

Number of individuals in household	Houses on Angaur	Piggery farmers on Babeldaob	Total
1	2		2
2	3	2	5
3	5		5
4	1		1
5	6	1	7
>5	5	2	7
Average	4.2	4.6	4.3
Total people	93	23	116

All but two respondents had at least high school or college education, and one respondent also had tertiary level education. "College" in Palau includes post-high school occupational training according to the Palau census. The 2015 census recorded that 22% of adults in Angaur had only primary school education, and four people had university degrees.

Table 5-4:   Highest education level.

Highest education level	Houses on Angaur	Piggery farmers on Babeldaob	Total
Primary school	2 (9%)	0	2 (7%)
High school/College	20 (91%)	4 (80%)	24 (89%)
Tertiary	0	1 (20%)	1 (4%)
Total	2 (9%)	0	2 (7%)

There are more dwellings than households because a few households have multiple dwellings. The majority of dwellings in Angaur have bamboo construction, often in combination with iron or concrete.

Table 5-5:   Dwelling construction type.

Construction material	Houses on Angaur	Piggery farmers on Babeldaob	Total
Iron	7 (28%)	3 (50%)	10 (32%)
Bamboo	20 (80%)	3 (50%)	23 (74%)
Concrete	14 (56%)	4 (67%)	18 (58%)
Total dwellings	25	6	31

Every household has mains power and uses this for their primary source of lighting. Every household owns a gas stove, refrigerator and beds. Most households also have a television.

Table 5-6:   Appliances owned by households.

Appliance type	Houses on Angaur	Piggery farmers on Babeldaob	Total
Radio	9 (41%)	1 (20%)	9 (41%)
Gas stove	22 (100%)	5 (100%)	22 (100%)
Kerosene cooker	0	0	0
Beds	22 (100%)	3 (60%)	22 (100%)
Sewing machine	6 (27%)	1 (20%)	6 (27%)
TV	16 (73%)	4 (80%)	16 (73%)
Refrigerator	22 (100%)	5 (100%)	22 (100%)
Other	4 (18%)	0	4 (18%)

Only a third of the Angaur households have a rainwater tank. None of the respondents had a private well. Most households have flush toilets and a phone. According to the 2015 census, 20 households (45%) in Angaur had a rainwater cistern. It is not clear why this survey sample had a lower proportion of tanks than in the 2015 census. The Babeldaob piggery farmers were more likely to have a tank, computer and internet. This is consistent with the 2015 census, in which Angaur residents have lower rates of computer ownership and internet access than residents of Babeldaob.

Table 5-7:   Household infrastructure.

Household infrastructure category	Houses on Angaur	Piggery farmers on Babeldaob	Total
Water sources			
Tank	8 (36%)	3 (60%)	8 (36%)
Well	0	0	0
Sanitation			
Pit toilet	5 (23%)	0	5 (23%)
Flush toilet	18 (82%)	5 (100%)	18 (82%)
Transport and production			
Vaka	0	0	0
Outboard motor boat	1 (5%)	0	1
Weedicide container	2 (9%)	0	2
Communications			
Phone	17 (77%)	5 (100%)	17 (77%)
Computer	1 (5%)	2 (40%)	1 (5%)
Internet	2 (9%)	3 (60%)	2 (9%)

All water tanks had a capacity of 5000 litres or less. Most households with no tank had drums for storing water.

Table 5-8:   Water storage capacity.

Water storage capacity	Houses on Angaur	Piggery farmers on Babeldaob	Total
None	3 (14%)	2 (40%)	3 (14%)
Drums	12 (55%)	0	12 (55%)
Tank <5000L	7 (32%)	3 (60%)	7 (32%)
Tank >5,000L	0	0	0

5.2.2   Section B: Livelihoods

Life satisfaction

Respondents were asked how satisfied they are compared with five years ago. Around half of Angaur respondents said they feel about the same. Two people said their lives are now worse: one due to lower income, while the other respondent gave no reason.

Of the eight people across both groups who said their lives had improved, six said they had better income or jobs, and five mentioned family (some people gave both reasons). One respondent said his life was better because he is "typhoon aware". Although no explanation of this awareness was given, it is possible that because the respondent feels better about life, he is more able to prepare. None of the respondents mentioned water security as a reason for their life satisfaction/ dissatisfaction.

Two of the piggery farmers on Babeldaob said their life satisfaction has not changed and two said it is worse (both said due to COVID). Of the three piggery farmers who continued to keep pigs, two said their life is the same and one said it is worse.

Table 5-9:   Life satisfaction compared with 5 years ago.

Count of individuals who say their life is now:	Houses on Angaur	Piggery farmers on Babeldaob	Total
Much worse	0	0	0
A bit worse	2 (9%)	2 (40%)	2 (9%)
The same	13 (57%)	2 (40%)	13 (57%)
A bit better	5 (22%)	0	5 (22%)
Much better	2 (9%)	1 (20%)	2 (9%)
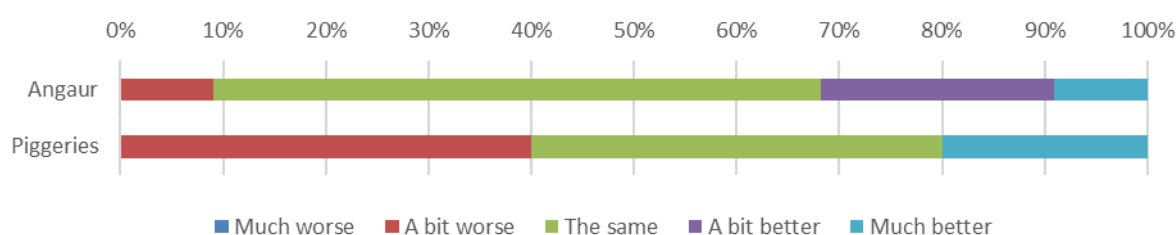
Figure 5-3:   Life satisfaction compared with 5 years ago.

There were 23 Angaur households (86%) with at least one member in paid employment: 92% of men and 64% of women were employed. In the 2015 census only 71% of men and 45% of women were

employed in Angaur, suggesting that employment rates have increased. Other sources of income included crops (five households) and fish or seafood (one household). In the Babeldaob households, 80% had at least one person employed.

Table 5-10: Employment.

Employment	Houses on Angaur	Piggery farmers on Babeldaob	Total
Count of households with at least one person employed	19 (86%)	4 (80%)	23 (85%)
Count of employed men	23 (92%)	4 (67%)	27 (87%)
Count of employed women	16 (64%)	5 (83%)	21 (68%)

Respondents were asked to rank in order from highest (1) to lowest (5) what their household spends income on. The highest ranked category was household expenditure (food, bills), followed by children.

Table 5-11: Average rank of spending categories, by amount.

Spending category	Houses on Angaur	Piggery farmers on Babeldaob	Total
Household	1.3	1.8	1.4
Children	2.4	2.6	2.4
Community	3.5	3.2	3.5
Education	3.8	3.6	3.7
Church	4.0	3.8	4.0

Fishing and subsistence

Most respondents in both groups said someone in their household fishes. Both men and women fish, with 22 respondents say that the father or a male relative fishes, and 19 say that the mother or a female relative fishes. The most common fishing gear used are spearguns and handlines. Only 12 people said that they fish for subsistence. Since the other respondents do not sell the fish, this implies fishing is recreational or an additional food source, which may offset household food expenditure.

Table 5-12: Fishing gear used by households.

Fishing gear type	Houses on Angaur	Piggery farmers on Babeldaob	Total
Speargun	14 (74%)	4 (80%)	14 (74%)
Net	2 (11%)	0	2 (11%)
Handline	18 (95%)	4 (80%)	18 (95%)
Trap	0	0	0
Other Gear	2 (11%)	2 (40%)	2 (11%)

Nine respondents said that they collect water for subsistence, three of them daily. One respondent stated that they also conduct crafting for subsistence purposes.

The majority of households on Angaur have dogs or cats. Just under a quarter of households have chickens. Only three people in the Babeldaob sample said they currently have pigs.

Table 5-13: Livestock and pets owned by household.

Type of animal owned	Houses on Angaur	Piggery farmers on Babeldaob	Total
Chicken	5 (23%)	1 (20%)	5 (23%)
Pigs	0	3 (60%)	0
Dogs/cats	17 (77%)	2 (40%)	17 (77%)
Other	0	0	0

Energy

All households use gas for cooking. None use firewood. Most households use 6-10 kg of gas per week for cooking. The largest use of fuel is for transport, with households using at least 6 litres and some more than 20 litres of fuel per week.

Table 5-14: Fuel type and quantity used per week.

Fuel type and use	Quantity used per week (L or kg)			
	<5	6-10	10-20	>20
Diesel generator	2	1		
Kerosene for lighting	2			
Grass cutting, outboard, chainsaw	9	18		
Fuel for transport		8	14	4
Kerosene for cooking	1			
Gas for cooking	3	23	1	
Outboard for fishing/picnic	3			

5.2.3   Section C: Awareness of environment

Only two people across both sample groups agreed with the statement that "it does not matter what happens to the ocean and lagoons". Every respondent agreed with the statements about the importance of a healthy ocean and lagoon.

Table 5-15: Number of households agreeing with environmental statement.

Environmental statement	Houses on Angaur	Piggery farmers on Babeldaob	Total
It does not matter what happens to the ocean and lagoons	2	0	2
Having a healthy ocean & lagoon is a very important part of my culture	22	5	27
My family's health is linked to the health of ocean and my lagoon	22	5	27

Climate change

Fourteen respondents agreed that climate change is happening, and eight said they did not know. Only 13 people believed that human activity is a cause of climate change. Other respondents indicated forces of nature, loss of trees, or that they do not know the cause.

Table 5-16:   Believed causes of climate change.

Climate change cause	Houses on Angaur	Piggery farmers on Babeldaob	Total
Human activity that led to the emission of dangerous greenhouse gases	8	5	13
Population growth	2	1	3
Loss of trees	3	3	6
A hole in a protective layer of gas that covers the planet called ozone layer	2	2	4
Forces of nature	7	1	8
Migration	0	0	0
Don't know	7	0	7

When asked what environmental changes people had perceived over the past 10 years, there was unanimous agreement that temperature had increased (Figure 1-4). Most respondents also said that the occurrence of algae, rainfall and storm surges had increased. Most respondents said that the beach area and the variety and quantity of fish and coral have decreased. Perceptions of number of trees, vegetation, animal and bird life were mixed. Few respondents stated that they had noticed changes in flooding occurrence or the lagoon.
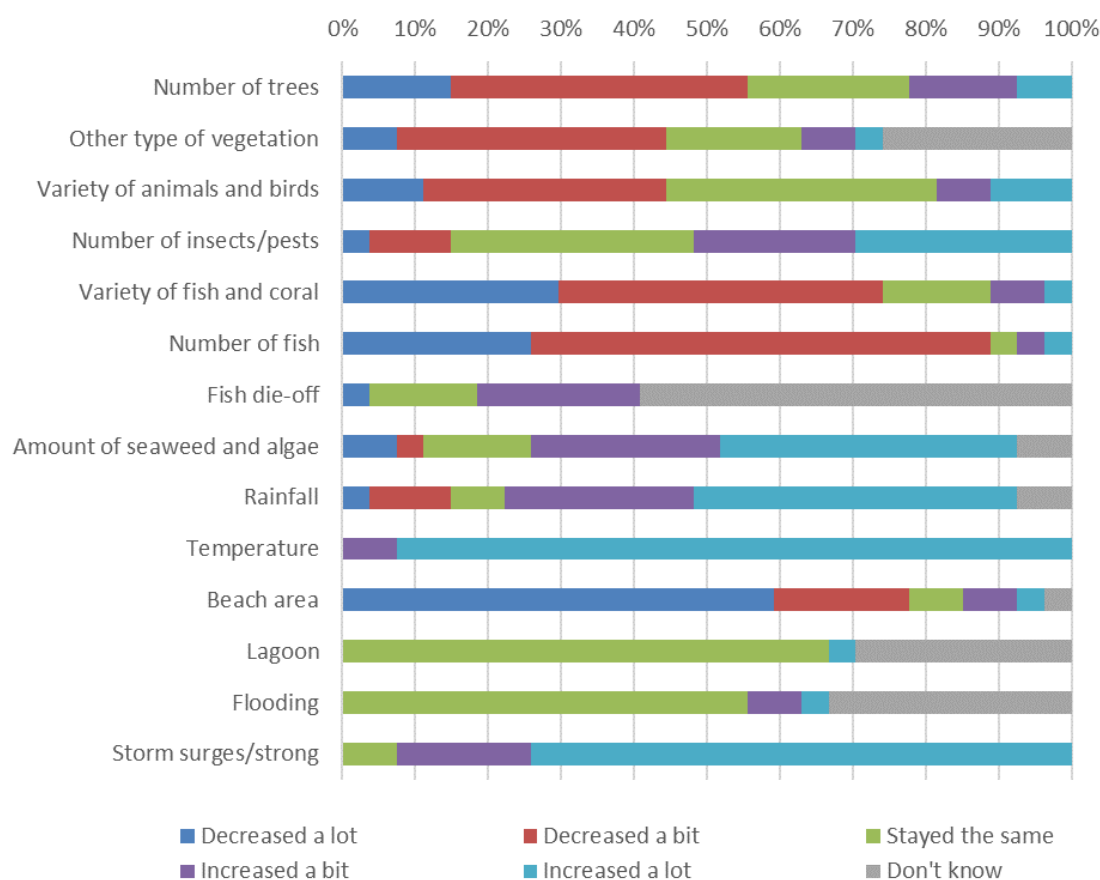
Figure 5-4:   Environmental changes over the past 10 years perceived by respondents.

Awareness of adaptation interventions

Respondents were asked if they were aware of any climate change adaption work in their community. Thirteen respondents in Angaur and all five people in the Babeldaob piggeries sample said yes. Respondents in Angaur mentioned that they have, or will be getting, water tanks soon as part of an adaptation project. In the Babeldaob group, four respondents observed the piggery intervention project and one respondent mentioned a plan to construct stone barriers for coastal protection.

Angaur respondents who were not aware of the water tank program were then told about it. Most people (17) correctly identified the purpose was to improve water security. Five people gave no answer.

All but two respondents from Angaur said they have been living in the area since before the commencement of the project to install a community tank at the school. Eight respondents in Angaur perceived changes caused by the water project and said they can now access water more easily. Several respondents mentioned that many household tanks are not yet connected.

In the Babeldaob group, two respondents said the piggeries adaptation project had improved their income. The other three respondents said they had not noticed a change. None of the piggery farmers mentioned environmental improvements as a benefit from the project.

Table 5-17:   Awareness of climate adaptation work.

Number of respondents who:	Houses on Angaur	Piggery farmers on Babeldaob	Total
Were aware of any climate change adaptation work in the community	13	5	18
Have noticed changes caused by the intervention	8	2	10

5.2.4   Section D: Public health

Most respondents stated they had never received any information regarding the maintenance and proper care of a rainwater system or septic tank. Of the minority that did, one respondent in Angaur said a Sanitation Officer visited their house, one respondent said maintenance and care was discussed at a community meeting, and four respondents stated that they had received information through the media. It is unknown whether the Sanitation Officer was associated with the Adaptation Fund project.

More than half of Angaur respondents said they clean their roof, gutters and tank at least once a year. However, many households are still in the process of getting tanks or had them installed only recently so these responses may not reflect long-term behaviour. People in the Babeldaob group clean their systems rarely or never.

Table 5-18:   Frequency of cleaning of roof, gutters, and tank.

Frequency	Houses on Angaur	Piggery farmers on Babeldaob	Total
Every six months	5 (29%)	0	5 (23%)
Every year	7 (41%)	0	7 (32%)
Every two years	0	2 (40%)	2 (9%)
We have never cleaned it	5 (29%)	3 (60%)	8 (36%)

Frequency	Houses on Angaur	Piggery farmers on Babeldaob	Total
Total	17	5	22

Angaur respondents never cleaned their sceptic tank, and when asked for a reason, they said they were not aware that it needed cleaning. Three respondents in the Babeldaob group had cleaned their tank in the past five years, while the others considered that this task was either too expensive, unpleasant, or they did not know how to clean the tank.

Table 5-19: How long since sceptic tank was last pumped out and cleaned.

When sceptic tank was last cleaned	Houses on Angaur	Piggery farmers on Babeldaob	Total
1 year ago		1	1
Less than 5 years ago		2	2
Septic system never been cleaned	20	1	21
No septic system	2	1	3

Every respondent said their toilet is clean and functional and always has soap available for washing hands. Seven people in Angaur (32%) and one Babeldaob piggery farmer said they have problems with sewerage or bad smells after heavy rain.

Food safety

When asked if they had every received information regarding the safe handling, preparation and storage of raw meat in the household, four people (all in Angaur) said yes. Two of these respondents had received a visit from the Health Ministry and the other two stated that they had attended a community meeting where the safe handling, preparation and storage of raw meat was discussed. Eleven respondents stated that they have problems keeping meat frozen. Eleven respondents said they prepare raw meat separately and then wash preparation equipment, as recommended in food safety guidelines.

Table 5-20: Raw meat responses.

Count of individuals who:	Houses on Angaur	Piggery farmers on Babeldaob	Total
Have received information about safe handling of raw meat	4	0	4
Have problems keeping meat frozen	9	2	11
Prepare raw meat separately and then wash equipment	9	2	11

Half of all respondents agreed that someone in their family had suffered from an incidence of diarrhoea and/or vomiting within the last year. Only five respondents had reported this to a health clinic. Of those who did report it, respondents stated that the response was quick with good information provided. People who did not report the diarrhoea and vomiting said they would only do so if the person were seriously ill. Respondents who experienced an incident in the past year were more likely to say they prepare meat safely now.

Table 5-21:   Communicable disease incidence.

Did anyone in the family suffered from an incidence of diarrhoea and/or vomiting within the last year	Houses on Angaur	Piggery farmers on Babeldaob	Total
No	11 (50%)	3 (60%)	14 (52%)
Yes, but did not report it to the nurse practitioner at the health clinic	7 (32%)	1 (20%)	8 (30%)
Yes, and reported it to the nurse practitioner at the health clinic	4 (18%)	1 (20%)	5 (19%)

Solid waste

Only one respondent (in Angaur) said they often have solid waste overflowing prior to disposal. Most people said their waste is buried or burned regularly, but four people said it is thrown out to sea or beachfront. The Babeldaob piggery farmers seem to have more of a problem with flies and rats (60% of respondents) than Angaur residents (32%).

Table 5-22:   Responses to solid waste questions.

Count of individuals who agree with statement:	Houses on Angaur	Piggery farmers on Babeldaob	Total
Waste is regularly buried or burnt	4 (18%)	2 (40%)	6 (22%)
Kitchen/household waste is put in a dug pit	9 (41%)	0	9 (33%)
Waste is thrown to the sea/ beachfront	3 (14%)	1 (20%)	4 (15%)
Often have solid waste overflowing prior to disposal	1 (5%)	0	1 (4%)
Problems with flies and rats in and around the waste disposal area	7 (32%)	3 (60%)	10 (37%)

Standing water

Eighteen respondents reported there are sources of standing water near their home. The most common cause is poor drainage (10 individuals), with a further three individuals having uncovered water tanks. Almost every respondent stated they clear containers of standing water, but that would not solve a problem of poor drainage.

5.2.5   Section E: Risk

A quarter of the respondents in Angaur believe their community is at high risk from extreme weather events (Table 1-23). Another quarter believe the risk is medium, and the remainder perceive low or no risk. The piggery farmers on Babeldaob Island believe the risk is low or medium.

Table 5-23:   Perceived risk to community during extreme weather events.

Perceived risk level	Houses on Angaur	Piggery farmers on Babeldaob	Total
None	2 (9%)	1 (20%)	3 (11%)
Low	8 (36%)	2 (40%)	10 (37%)
Medium	5 (23%)	2 (40%)	7 (26%)
High	6 (27%)	0	6 (22%)
Don't know	2 (9%)	0	2 (7%)

Most Angaur respondents said their household is at least "quite prepared" for a drought or cyclone. Five people did not know. Two of the Babeldaob piggery farmers felt unprepared.

Table 5-24:   Household preparedness for a drought or cyclone.

Preparedness of household	Houses on Angaur	Piggery farmers on Babeldaob	Total
Very prepared	1 (5%)	1 (20%)	2 (7%)
Prepared	5 (23%)	0	5 (19%)
Quite prepared	9 (41%)	2 (40%)	11 (41%)
Not very prepared	2 (9%)	2 (40%)	4 (15%)
Not prepared	0	0	0
Not at all prepared	0	0	0
Don't know	5 (23%)	0	5 (19%)

Based on survey responses, there does not appear to be a strong relationship between risk perception of respondents and their preparedness, as prepared households include people with both low and high perceptions of risk. However, people may have different definitions of preparedness depending on how high they believe the risk to be.
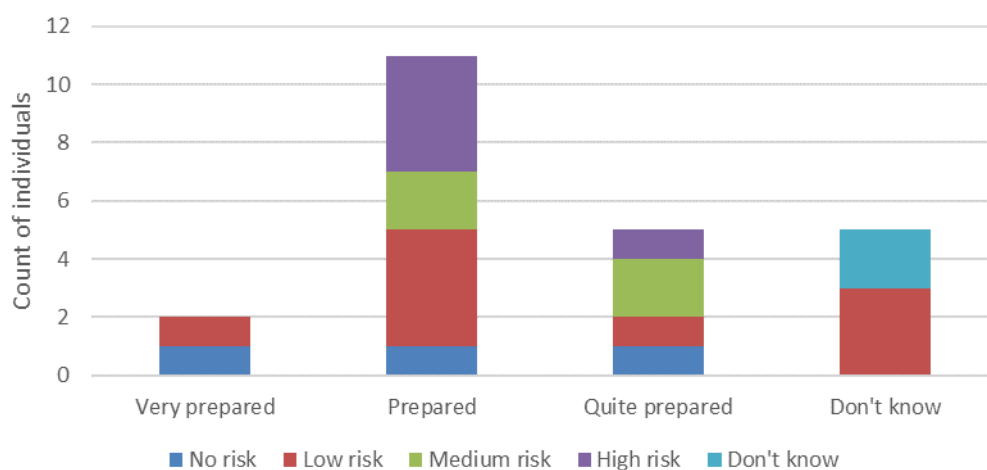
Figure 5-5:   Risk perception versus preparedness.

In the event of an extreme weather event, most people said they would follow an emergency plan, evacuate, and have emergency supplies (Table 1-25). Thirteen respondents in Angaur and all five of the Babeldaob piggery farmers stated that they know the evacuation plan for their community. These same people also say they know who to contact in an emergency. The people they would contact include Government or rangers, family, or Red Cross. There are eight respondents in Angaur who did not know what the community plan is or who to contact.

Table 5-25:   Actions people would take in the event of a drought/cyclone/tsunami.

Count of individuals who would:	Houses on Angaur	Piggery farmers on Babeldaob	Total
Raise an alarm	2 (9%)	0	2 (7%)
Keep on top of weather reports	7 (32%)	2 (40%)	9 (33%)
Follow an emergency plan	13 (59%)	4 (80%)	17 (63%)
Evacuate to safe place	17 (77%)	5 (100%)	22 (81%)
Have emergency supplies	15 (68%)	4 (80%)	19 (70%)
Pray to God	6 (27%)	0	6 (22%)
Other	1 (5%)	0	1 (4%)

Regarding future actions that households might take to deal with extreme weather events, fewer than half of all respondents said they would be likely to make permanent adjustments to their homes (Figure 1-6). More than half said they would make temporary adjustments, make a disaster plan, learn to swim, store water, learn first aid, listen to forecasts, and stock up on food. Only two of the Babeldaob piggery farmers were willing to learn to swim.
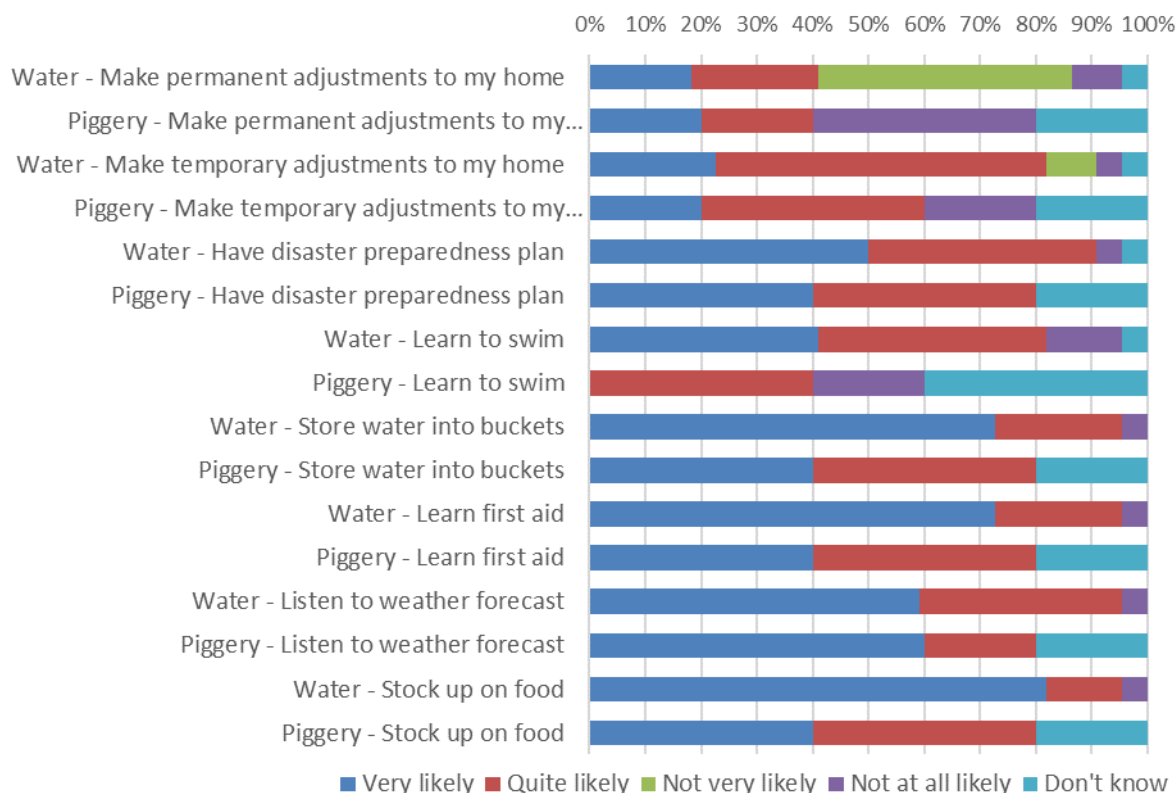
Figure 5-6: **Likelihood of taking future actions to deal with extreme weather events.**

5.3   Palau focus groups

Two focus groups were conducted. The first was conducted by the SPREP National Consultant to investigate community perspectives on water security measures in Angaur. The other focus group was run by the Palau Conservation Society in September 2021 to investigate outcomes of the dry litter piggeries project in Babeldaob.

5.3.1   Angaur water security focus group

The focus group summary assessment report says that the Angaur community takes an active role in the management of household and communal water systems. Households that have water tanks maintain them, and teachers maintain and manage the school water tank. The household survey revealed that some households have never cleaned their rainwater collection systems, although it is possible they were installed only recently. The water tank at the school improved conditions for households that have no tanks and reduced the pressure on households' own supplies.

Despite an active and community-driven level of water ownership, the Angaur community have not been able to diagnose or repair the inoperable solar-powered treatment plant. An inability to repair their infrastructure is therefore a significant barrier to improving water security.

5.3.2   Enhancing Sustainable Livelihoods focus group

The Palau team conducted focus group interviews on the integrated farming (dry litter piggery) project to capture the perceptions of a subset of the Palau community population on Palau's climate change adaptation interventions and the impacts (personal, household, societal benefit) resulting from the interventions.

The focus group summary report says that only two of the six Babeldaob farms involved in the project sustained full integrated farming after the project. Two farms ceased piggery operation and two farms continued pig production but had no gardens.

The two farms that ceased production did so because ownership changed, and the new owners already had full-time jobs. The Babeldaob piggery farmers who did not maintain gardens said they did not have enough assistance or space to grow vegetables. The two farmers who were able to maintain integrated production had full time laborers and access to capital. Barriers to the success of the project included low quality of livestock, the need for expensive imported feed, and frequent shortages of feed.

The focus group summary report states that there needs to be more of a focus on enabling mechanisms at the Palau Bureau of Agriculture to improve adaptive capacity and food security.

5.4   Palau correlations and regressions

Data collected in the household surveys were analysed for relationships. There are negative correlations between:

- household size and preparedness,
- disease incidence and perceived increases in rainfall, and
- life satisfaction and increased rainfall.

There are positive corelations between:

- employment and life satisfaction,
- concrete dwelling construction and number appliances, and
- perceived increases in flooding and beach area, and willingness to make permanent and temporary adjustments to the home.

In a small observational dataset such as this household survey it is not possible to disentangle the impact of a single variable or indicate the direction of causality.

The correlation plot (Figure 5-7) shows whether the correlation between each pair of variables is positive (blue) or negative (red). Statistical significance of the pairwise relationship is indicated by the size of each circle. A large circle indicates a p-value less than 0.01, medium is 0.05 to 0.01, small is 0.1 to 0.05, and no circle means the relationship is not significant.
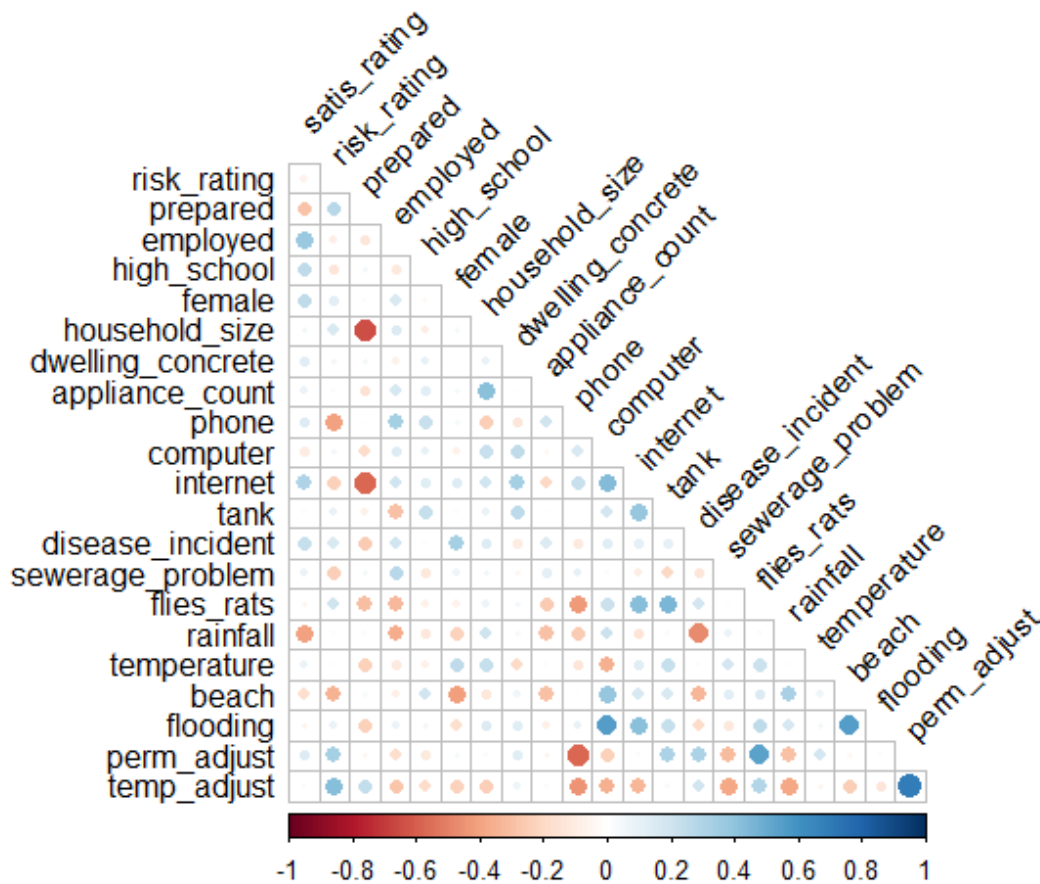
Figure 5-7: **Correlation plot of household, risk, preparedness and environmental change variables.**

The ordinal logit regression coefficients presented in Table 5-26 indicate whether the variable is associated with improved (a positive coefficient) or worse life satisfaction (a negative coefficient) after controlling for the other variables. Larger coefficients in absolute terms indicate a stronger effect. The standard error indicates how different the population mean is likely to be from the sample mean, assuming the sample is representative and unbiased. The t value is the coefficient divided by standard error and is a measure of the precision of the coefficient. The p value is the probability that the true coefficient is zero (i.e., the variable has no effect on satisfaction). A low p value indicates that the association is unlikely to have been observed by chance. The threshold for statistical significance is a p value less than 0.05.

The most significant variables are having at least one person in the household employed, and a high school or better education. Ownership of a computer appears to have a negative effect on life satisfaction, while access to the internet is positive. However, few households have computers or internet so the effect may be an anomaly.

Table 5-26: **Ordinal logit regression for life satisfaction.**

Parameter	Value	Standard error	t value	p value
Household employed	3.563	0.526	6.771	<0.01*

Parameter	Value	Standard error	t value	p value
High school education	3.706	0.157	23.604	<0.01*
Female respondent	0.784	0.805	0.973	0.330
Concrete dwelling	0.475	0.929	0.511	0.610
Water tank	0.000	0.000	-0.019	0.985
Household size	0.018	0.185	0.096	0.924
Disease incident	0.140	0.362	0.388	0.704
Computer	-2.708	0.601	-4.507	<0.01*
Internet	1.585	0.652	2.432	0.015*
Much worse|A bit worse	-4.728	0.014	-345.891	<0.01*
A bit worse|The same	4.329	1.132	3.824	<0.01*
The same|A bit better	8.510	1.152	7.387	<0.01
A bit better|Much better	10.029	1.271	7.894	<0.01

5.5   Palau conclusions

The adaptation intervention to install household water tanks in Angaur is not complete, so this household survey data cannot be used to measure the impact of the intervention. However, it will be useful baseline data if there is a follow-up survey sometime after the tanks have been installed and in use for a period of time.

The sample of Babeldaob piggery farmers is too small to do any statistical analysis specifically about the impact of the piggery adaptation intervention. The farmers who still own pigs do not have improved life satisfaction, and the focus group summary explained the difficulties with the project.

6 Cook Islands

6.1 Introduction to the Cook Islands project

Mangaia is the southern-most island in the Cook Islands group, located approximately 200 km southeast-east of Rarotonga. The Mangaia is a raised coral atoll (locally known as Makatea) due to its uplifted fossil coral cliffs. Mangaia is the second largest island within the Cook Islands group in terms of landmass. Mangaia is divided into size districts (puna) and has three villages – Oneroa, Tamarua, and Ivirua. Two types of adaptation intervention have occurred in Mangaia in recent years: water security and marine conservation.

6.1.1 Water security and the Adaptation fund SRIC-CC Program

All three villages have gravity-fed water supplies with different intakes, constructed in the 1980s. Tamarua village in 2006 reported low flows and increased debris due to corrosion of the pipeline. A Strengthening the Resilience of Our Islands and Our Communities to Climate Change Programme (SRIC) project (completed in 2018) upgraded the Tamarua water system with new pipes and repaired the water intake. The project objective was "the provision of reliable, and more secure water supply for the Tamarua village" (Adaptation Fund, 2012).

The SRIC project also aimed to expand the use of vector-borne disease control techniques though education and awareness (e.g., boiling drinking water). Most households already had a back-up water supply, having purchased their own 6000 litre water tanks with the assistance of NZAID. The location and condition of water tanks were surveyed as part of the project.

6.1.2 Marine conservation and the Kei'ā Rā'ui adaptation project

Rā'ui refers to a short- or long-term limitation on resource zones or resource use for the purpose of allowing the natural resources to recover. The Kei'ā Rā'ui project involved working with the Mangaia Island Council and Aronga Mana o te Puna (Chiefs of the District) to set up and manage a rā'ui in the Kei'a district for marine conservation. When traditional leaders decide stocks have recovered, a rā'ui is lifted and the area is opened for fishing or harvest. There are other marine rā'ui at Tava'enga, Ivirua, and Tamarua. In 2018, the puna of Kei'a, Tava'enga, Ivirua, and Tamarua each had approximately half of their nearshore waters closed to harvest.

Figure 6-1: **Location of Kei'a district on Mangaia Island.**Source : Google Maps

6.2 Household survey

The household survey data comprises 33 households with five in Ivirua Village, 19 in Oneroa Village, and nine in Tamarua Village. The number of people in sampled households totals 154. According to the 2016 census, there are 499 usual residents on Mangaia. The sample therefore represents 30% of the population. The small sample size of each Village makes it difficult to detect any statistically significant differences between villages. Results should therefore be interpreted with caution.

6.2.1 Section A: household information

Nineteen respondents were the father of the household and 14 were the mother.

Table 6-1: **Role in household of interviewee.**

Role	Ivirua	Oneroa	Tamarua	Grand Total
Father	3 (60%)	9 (47%)	7 (78%)	19 (58%)
Mother	2 (40%)	10 (53%)	2 (22%)	14 (42%)

Table 6-2: **Number of occupants of sampled households.**

Occupants of sampled households	Ivirua	Oneroa	Tamarua	Total
Number of men	7	20	9	36
Number of women	7	26	13	46
Number of children	13	39	20	72
Total people in household	27	85	42	154

The average household had 5.2 people, which is larger than the census average of 3.8 for the southern Cook Islands.

Table 6-3:   Household size.

Number of people in household	Ivirua	Oneroa	Tamarua	Grand Total
1	0	2 (11%)	0	2 (6%)
2	0	1 (5%)	3 (33%)	4 (12%)
3	0	3 (16%)	0	3 (9%)
4	2 (40%)	2 (11%)	2 (22%)	6 (18%)
5	0	4 (21%)	1 (11%)	5 (15%)
6	1 (20%)	1 (5%)	0	2 (6%)
>6	2 (40%)	5 (26%)	1 (11%)	8 (24%)
Average size	0	2 (11%)	0	2 (6%)

There is a relatively high proportion of people with tertiary-level education (36%). Most respondents had at least high school education (79%)

Table 6-4:   Highest education level.

Highest education level	Ivirua	Oneroa	Tamarua	Grand Total
Primary school	0	4 (21%)	0	4 (12%)
High school/College	2 (40%)	9 (47%)	3 (33%)	14 (42%)
Tertiary	2 (40%)	6 (32%)	4 (44%)	12 (36%)
No answer	1 (20%)	0	2 (22%)	3 (9%)

Vulnerable populations
One household had a person with a disability. There were three single-parent households, with two of these headed by a mother.

Dwellings, appliances and infrastructure
The total number of dwellings is 57, and around half of households had more than one dwelling. The most common type of dwelling is concrete.

Table 6-5:   Dwelling number and construction.

Dwelling number and construction	Ivirua	Oneroa	Tamarua	Grand Total
Total number of dwellings	12	29	16	57
Iron	0	5 (26%)	2 (22%)	7 (21%)
Wood/bamboo	0	2 (11%)	2 (22%)	4 (12%)
Concrete	5 (100%)	18 (95%)	9 (100%)	32 (97%)

Most households have a gas stove, beds, a TV and refrigerator. Every household uses mains power for lighting, similar to the rest of the Cook Islands.

Table 6-6:   Appliances owned by household.

Appliance type	Ivirua	Oneroa	Tamarua	Grand Total
Radio	0	4 (21%)	3 (33%)	7 (21%)
Gas stove	5 (100%)	19 (100%)	9 (100%)	33 (100%)
Kerosene cooker	0	0	0	0
Beds	5 (100%)	19 (100%)	9 (100%)	33 (100%)
Sewing machine	4 (80%)	11 (58%)	8 (89%)	23 (70%)
TV	4 (80%)	19 (100%)	7 (78%)	30 (91%)
Refrigerator	3 (60%)	17 (89%)	8 (89%)	28 (85%)
Other	0	3 (16%)	2 (22%)	5 (15%)

Almost all households have flush toilets, water tanks and internet. Some households have a pit toilet as well. The rates of phone and computer ownership are lower than the Cook Islands census averages of 73% and 75% respectively.

Table 6-7:   Other infrastructure owned by household.

Household infrastructure	Ivirua	Oneroa	Tamarua	Grand Total
Flush toilet	5 (100%)	18 (95%)	8 (89%)	31 (94%)
Water tank	4 (80%)	17 (89%)	9 (100%)	30 (91%)
Internet	3 (60%)	14 (74%)	7 (78%)	24 (73%)
Phone	4 (80%)	11 (58%)	6 (67%)	21 (64%)
Computer	1 (20%)	10 (53%)	5 (56%)	16 (48%)
Pit toilet	2 (40%)	3 (16%)	4 (44%)	9 (27%)
Vaka	0	4 (21%)	0	4 (12%)
Weedicide container	0	0	3 (33%)	3 (9%)
Outboard motorboat	0	3 (16%)	0	3 (9%)
Water-sealed toilet	0	1 (5%)	1 (11%)	2 (6%)
Dug well	0	0	0	0

The most common size for water tanks is between 5,000-10,000 litres. One household only has drums for storing water.

Table 6-8:   Water storage capacity.

Water storage capacity	Ivirua	Oneroa	Tamarua	Total
Drums to store water	0	1 (5%)	0	1 (3%)
<5,000L Storage Tank	0	4 (21%)	3 (33%)	7 (21%)
5,000L-10,500L Tank	2 (40%)	11 (58%)	4 (44%)	17 (52%)
10,500L-20,000L Tank	2 (40%)	4 (21%)	3 (33%)	9 (27%)
>20,500L Tank	1 (20%)	1 (5%)	0	2 (6%)

6.2.2   Section B: Livelihood & energy use

Most people (72%) said their life is better than it was five years ago. The remainder said it is the same. Nobody said their life is worse than it used to be.

Table 6-9:   Life satisfaction compared with 5 years ago.

Life satisfaction is:	Ivirua	Oneroa	Tamarua	Grand Total
Much better	2 (40%)	6 (32%)	4 (44%)	12 (36%)
A bit better	3 (60%)	8 (42%)	1 (11%)	12 (36%)
The same	0	5 (26%)	4 (44%)	9 (27%)
A bit worse	0	0	0	0
Much worse	0	0	0	0
Don't know	0	0	0	0
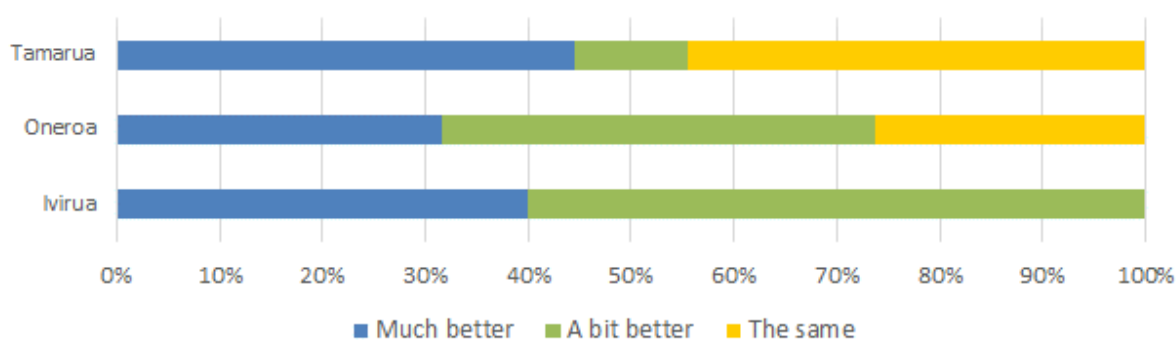
Figure 6-2:   Life satisfaction compared with 5 years ago.

Employment and spending

The majority (81%) of households have at least one person employed. There is a relatively even split between employed men and women.

Table 6-10:   Number of people employed.

Employed	Ivirua	Oneroa	Tamarua	Total
At least one person in household is employed	4 (80%)	17 (89%)	6 (67%)	27 (82%)
Employed men	2 (29%)	15 (75%)	5 (56%)	22 (61%)
Employed women	3 (43%)	11 (42%)	4 (31%)	18 (39%)

Many households have other income sources, including crops, seafood and crafts. The other category includes family businesses selling furniture, food, and tours.

Table 6-11:   Other income sources.

Other income sources	Ivirua	Oneroa	Tamarua	Total
Crops	1	6	2	9
Fish and seafood	1	5	1	7
Handicrafts	0	2	1	3
Shop	0	1	0	1
Remittances	0	0	0	0
Other	0	3	4	7

Household spending was the highest ranking category for spending, followed by church, children, education and then community. Tamarua participants appear to spend more on children and less on church than the other two villages.

Table 6-12:   Average rank of spending categories, by amount.

Spending category	Ivirua	Oneroa	Tamarua	Total
Household	1.6	2.0	1.8	1.9
Church	2.2	2.2	3.7	2.6
Children	4.2	3.7	2.4	3.4
Education	3.6	3.2	3.7	3.4
Community	3.4	3.9	3.4	3.7

Most households in all three villages own dogs, cats, pigs, and/or chickens.

Table 6-13:   Animals and livestock owned.

Type of animal owned	Ivirua	Oneroa	Tamarua	Total
Dogs/cats	3 (60%)	15 (79%)	7 (78%)	25 (76%)
Pigs	5 (100%)	13 (68%)	7 (78%)	25 (76%)
Chickens	2 (40%)	13 (68%)	4 (44%)	19 (58%)

Subsistence

Half of the participants said they harvest for subsistence, this involves fishing and collecting water regularly.

Energy use

Every household uses gas for cooking, with firewood as a backup. Half of the households said they use fuel for gardening, farming equipment and/or boats. One household has a diesel generator.

6.2.3   Section C: Awareness of environment

The majority of people (76%) agreed that climate change is happening, and the remainder said they did not know. Most people in Oneroa attributed climate change to loss of trees, while most people in Tamarua thought it is due to population growth.

Table 6-14:   Perceived causes of climate change.

Climate change causes	Ivirua	Oneroa	Tamarua	Total
Human activity that led to the emission of dangerous greenhouse gases	1 (20%)	3 (16%)	1 (11%)	5 (15%)
Population growth	2 (40%)	3 (16%)	4 (44%)	9 (27%)
Loss of trees	1 (20%)	10 (53%)	1 (11%)	12 (36%)
A hole in a protective layer of gas that covers the planet called ozone layer	3 (60%)	1 (5%)	0	4 (12%)
Forces of nature	0	0	0	0
Migration	2 (40%)	1 (5%)	0	3 (9%)
Don't know	0	2 (11%)	3 (33%)	5 (15%)

Most people have noticed environmental changes over the past ten years. Most people think the number of trees, animals and birds, and insects/pests have increased a lot. Perceptions of aquatic life are mixed, with a relatively even split between increased and decreased. Fish die-off seems to have decreased, although many people did not know. Most people think rainfall, flooding and storm surges have decreased, and temperature increased a bit. Some people think the beach and lagoon areas have decreased in size.
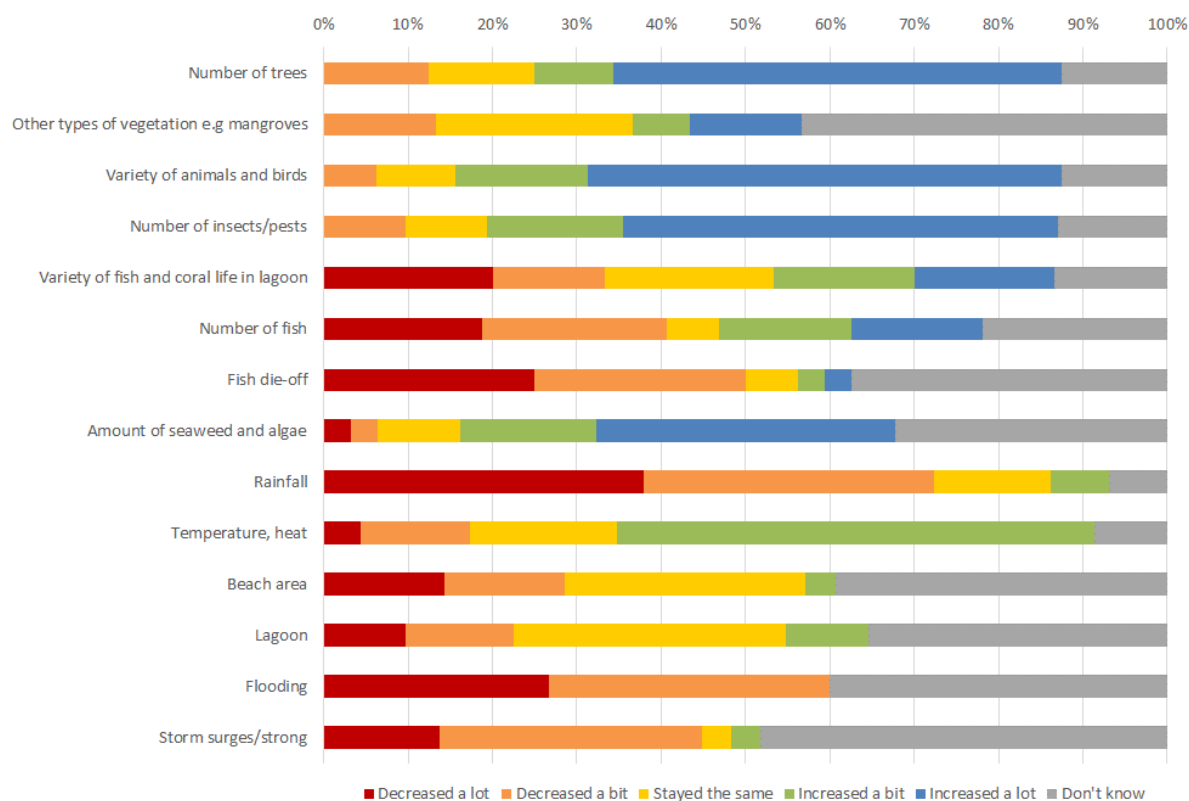
Figure 6-3:   Environmental changes over the past 10 years.

6.2.4   Section D: Sanitation

Few people said they had ever received information regarding the maintenance and proper care of their household rainwater system and septic tank.

Four people said they received the information from a sanitation officer visiting their house, two heard information at a community meeting, and two from the media. Most of the people who received information were in Tamarua, which may be due to the SRIC project.

Table 6-15:   Sources of sanitation information.

Source of information	Ivirua	Oneroa	Tamarua	Total
A sanitation aid officer visited my house	0	1 (5%)	3 (33%)	4 (12%)
It was discussed at a community meeting	0	1 (5%)	1 (11%)	2 (6%)
My church group discussed it	0	0	0	0
Heard from the media	1 (20%)	1 (5%)	0	2 (6%)
None	4 (80%)	16 (84%)	5 (56%)	25 (76%)

More than half of the participants said they had never cleaned their rainwater collection roof, gutters and water tank. The mapping of water systems showed that many tanks were installed in Tamarua between 2015 and 2019, implying water tanks have been used for several years without being cleaned. The ages of water tanks in Ivirua and Oneroa are unknown.

Table 6-16:   Frequency of cleaning roof, gutters and tank.

Frequency	Ivirua	Oneroa	Tamarua	Total
Every year	1 (20%)	6 (32%)	2 (22%)	9 (27%)
Every two years	0	1 (5%)	1 (11%)	2 (6%)
We have never cleaned it	4 (80%)	12 (63%)	6 (67%)	22 (67%)

Of the 30 participants who have sceptic systems, 19 have never had them pumped out or cleaned. Reasons for never cleaning the system include lack of awareness that it needs cleaning, lack of knowledge of how to do it, and the unpleasantness of the task. The focus groups revealed that villages have no equipment to pump out sceptic systems.

Table 6-17:   How long since sceptic tank was last pumped out and cleaned.

Sceptic tank was last pumped out and cleaned:	Ivirua	Oneroa	Tamarua	Total
1 year ago	0	0	2 (22%)	2 (6%)
Less than 5 years ago	0	4 (21%)	1 (11%)	5 (15%)
Less than 10 years ago	0	3 (16%)	0	3 (9%)
More than 10 years ago	1 (20%)	0	0	1 (3%)
Septic system never been cleaned	4 (80%)	10 (53%)	5 (56%)	19 (58%)
No septic system	0	2 (11%)	1 (11%)	3 (9%)

Every person said their toilet is functional, and all but one person said they always have soap available.

Food safety

More than half of participants said they had received information regarding the safe handling, preparation and storage of raw meat. Most people (13) received information through the media, while five received a visit from the Ministry of Health and two gathered information at a community meeting.

Table 6-18: **Sources of information regarding the safe handling, preparation and storage of raw meat.**

Information source	Ivirua	Oneroa	Tamarua	Total
Visit from the Health Ministry	0	3 (16%)	2 (22%)	5 (15%)
A community meeting	0	2 (11%)	0	2 (6%)
Through the media	1 (20%)	10 (53%)	2 (22%)	13 (39%)
Not received any information	4 (80%)	4 (21%)	3 (33%)	11 (33%)

A large proportion of people (72%) said they freeze raw meat and have difficulty keeping it frozen. 78% agreed with the statement that they prepare raw meat with separate equipment to minimise contamination.

Communicable disease

Only four people said anyone in their family suffered from an incidence of diarrhoea and/or vomiting within the last year, and three of these reported it to a health clinic. People who reported an incident said they received good information in response, although one person said the response was slow. Most people said they would only report an incident if it were very serious.

Table 6-19: **Communicable disease incidence.**

Did anyone in the family suffered from an incidence of diarrhoea and/or vomiting within the last year	Ivirua	Oneroa	Tamarua	Total
No	5 (100%)	16 (84%)	7 (78%)	28 (85%)
Yes, but we did not report it to the nurse practitioner at the health clinic	0	1 (5%)	0	1 (3%)
Yes, we reported it to the nurse practitioner at the health clinic	0	2 (11%)	1 (11%)	3 (9%)

Solid waste

Most participants said they either bury or put solid waste in a pit. Four people said their waste goes to the sea or beachfront. Three people, all in Tamarua, said they often have overflowing waste. People in every village have problems with flies and rats around the disposal area.

Table 6-20: **Solid waste responses.**

Solid waste	Ivirua	Oneroa	Tamarua	Total
Waste is thrown to the sea/ beachfront	2 (40%)	1 (5%)	1 (11%)	4 (12%)
Waste is put in a dug pit	2 (40%)	11 (58%)	8 (89%)	21 (64%)
Bury and/or burn our waste regularly	0	7 (37%)	0	7 (21%)
Often have solid waste overflowing prior to disposal	0	0	3 (33%)	3 (9%)
Problems with flies and rats around the disposal area	3 (60%)	2 (11%)	4 (44%)	9 (27%)

Standing water

Only seven people said they have sources of standing water near their homes. Two had uncovered water tanks, two had poor drainage, and three were other sources. Most people said they empty containers of water.

6.2.5   Section E: Risk and preparedness

Most of the people said they feel the risk to their community during extreme weather events is low or non-existent. People in Tamarua had the highest perceived risk, with four people (50%) responding "medium".

Table 6-21:   Perceived risk to community during extreme weather events.

Perceived risk level	Ivirua	Oneroa	Tamarua	Total
None	1 (20%)	7 (37%)	1 (11%)	9 (27%)
Low	1 (20%)	7 (37%)	3 (33%)	11 (33%)
Medium	0	1 (5%)	4 (44%)	5 (15%)
High	0	1 (5%)	0	1 (3%)
Don't know	3 (60%)	2 (11%)	1 (11%)	6 (18%)

Most people said they were prepared or very prepared for a drought or cyclone. Only one person (in Oneroa) said they feel not very prepared. The average perceived preparedness is slightly lower on Oneroa.

Table 6-22:   Preparedness of household.

Preparedness	Ivirua	Oneroa	Tamarua	Total
Very prepared	2 (40%)	5 (26%)	3 (33%)	10 (30%)
Prepared	1 (20%)	4 (21%)	3 (33%)	8 (24%)
Quite prepared	2 (40%)	9 (47%)	3 (33%)	14 (42%)
Not very prepared	0	1 (5%)	0	1 (3%)
Not prepared	0	0	0	0
Not at all prepared	0	0	0	0

There appears to be little correction between risk and preparedness, and the most prepared people have mixed perception of risk**.**
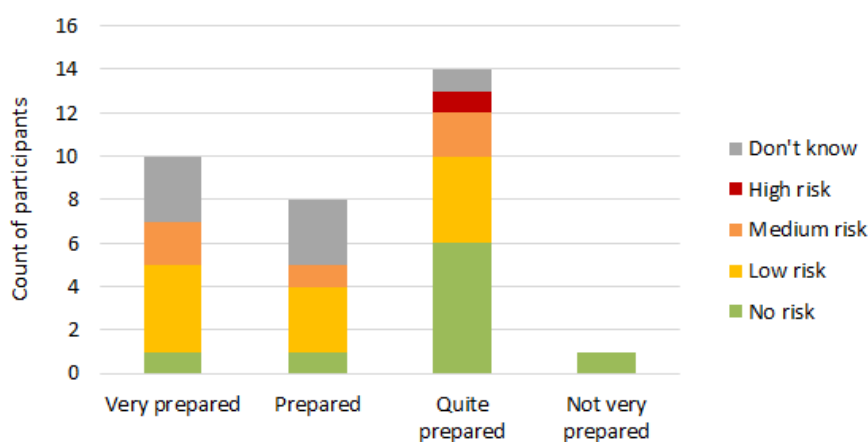
Figure 6-4:   Risk perception versus preparedness.

The majority of people said they would take multiple actions following an extreme event warning. The most common action (78%) was to stock emergency supplies. Risk perception and preparedness do not appear to be significantly correlated with willingness to take action.

Table 6-23:   Actions people would take following a drought/cyclone/tsunami warning.

| Actions	Ivirua	Oneroa	Tamarua	Grand Total
Raise alarm	1 (20%)	11 (58%)	4 (44%)	16 (48%)
Keep on top of weather reports	2 (40%)	15 (79%)	3 (33%)	20 (61%)
Follow emergency plan	3 (60%)	14 (74%)	3 (33%)	20 (61%)
Evacuate to safe place	3 (60%)	15 (79%)	2 (22%)	20 (61%)
Have emergency supplies	4 (80%)	17 (89%)	5 (56%)	26 (79%)
Pray to God	2 (40%)	13 (68%)	4 (44%)	19 (58%)
Don't know	0	0	1 (11%)	1 (3%)

Half of respondents said they know their community evacuation plan. Similarly, only half know who they should contact to let them know they are safe. Several people said they would contact overseas family, the police, or community leaders.

Regarding future actions that people might take to deal with extreme events, most people said they were very likely to make temporary or permanent adjustments, have a plan, store water, learn first aid, listen to the forecast, and stock up on food. Few people said they would learn to swim, although it is unclear whether this is because they already know how to swim.
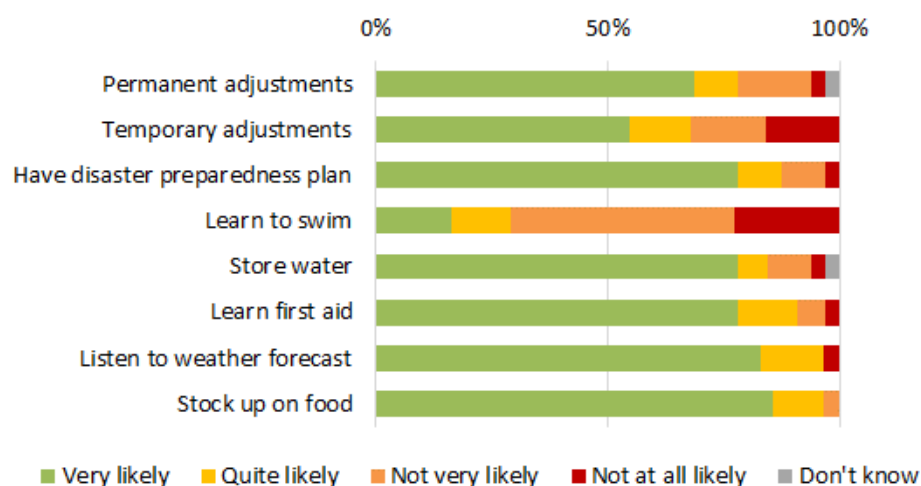
Figure 6-5:   Likelihood of taking future actions.

6.3   Focus groups

6.3.1   Water and sanitation focus groups

Six focus groups about water and sanitation were conducted in Tamarua in November 2021. Ages ranged from 17 to over 70, with a total of sample size of 56 participants. The goal was to assess:

- The impact of the water system improvement on community wellbeing.

- How far the adaptation project has impacted health and livelihood outcomes.

- How far adaptation project has contributed towards healthier lifestyles.

- Under which circumstances the adaptation project has achieved outcomes and impacts.

- What are some of the main barriers to achieving outcomes.

In-depth interviews were conducted with one participant selected from each group to gather further details about the Adaptation Assessment. The participant was selected for an in-depth interview, if they shared particularly interesting and/or revealing answers in the Focus Group sessions that seemed likely to provide further insights into the impacts the project has for that household in a more personal discussion. The stated purpose of the in-depth interview was to gather key demographic and socio-economic characteristics of the household and get a more in-depth understanding of how the Tamarua water adaptation project has impacted on the participant's household.

There was also one focus group held with traditional leaders in Tamarua and the GCCA + SUPA team to discuss water and sanitation.

Results
Responses from the six general population focus groups were consistent between groups. Most people said they use the treated village drinking water stations weekly or more often. Some people, particularly teenagers, also use the school drinking water station.

Every participant had a water tank, with many having two or more. Total tank capacity ranged from 1200 to 6000 litres. Very few people said they had received information regarding care or maintenance of their rainwater collection system, and many never cleaned it. Water is untreated and most people said they boil water for drinking. A few suffered from an incidence of diarrhoea and/or vomiting in the past year.

Most households have both pit and flush toilets with sceptic systems. People said they never pumped out or cleaned their sceptic system, because they discharge to a soak pit and do not get full. Participants also said they have no access to pumping equipment. Some people said they have problems with sewerage after heavy rain. Most participants think that both rainfall and flooding have decreased in the past 10 years.

The focus groups did not include questions that specifically asked whether people thought the project objective (a more secure water supply) had been achieved, or whether it had affected health and wellbeing. However, since everybody said they use the village water and no issues with supply were noted, it might be inferred that it was successful.

During the traditional leaders meeting, the GCCA + SUPA project team raised some issues with the water intake infrastructure. Specifically, animals wandering around the intake, the need for regular maintenance, and the fact that the filtration system is not yet operational and there has been no water testing. The traditional leaders said that the water tanks needed to be more secure, fenced, and surrounding trees trimmed. There is a problem with silt and sedimentation. They said the water is too coloured for drinking, but it is used for toilets and cleaning. They think that overflow should be stored and used by plant growers. It is unclear whether this coloured water is the same water referred to as "treated village drinking water" in the general focus group questions.

The lack of filtration and stock exclusion appear to be barriers to achieving the best possible health and wellbeing outcomes.

6.3.2   Marine focus groups

Six focus groups about the marine environment were conducted in Oneroa in November 2021. Ages ranged from 15 to over 70, with a total of total of 57 participants. The goal was to assess:

- The impact of Kei'ā Rā'ui on community wellbeing.

- How far the adaptation project has impacted health and livelihood outcomes.

- How far adaptation project has contributed towards healthier lifestyles.

- Under which circumstances the adaptation projects/programmes has achieved outcomes and impacts.

- What are some of the main barriers to achieving outcomes.

Similar to the water security focus groups, an in-depth interview was conducted with one participant from each group.

Results

Almost every person said people in their household go fishing, and commonly everyone in the household is involved. The most common stated purpose of fishing was for household consumption or sharing with community. Several people mentioned fishing was also a means to raise money either for the household or community. A variety of fishing techniques are used including lines, rods, nets and spearfishing. The most common method mentioned, especially by women, was prising clams, paua and tuber worms off the reef with a screwdriver. People in two groups mentioned ora fishing, which involves poisoning the water with plant root.

Every person knew what rā'ui is, and had received public information from community meetings, public signs, or local television. Everybody was aware that rā'ui are set up by traditional leaders (chiefs) end enforced by chiefs and sub-chiefs. People agreed that the rules are well communicated; however, in four focus groups, participants mentioned that some people ignore the rules. Most participants said they fished as much as possible when the rā'ui opened, tide and weather allowing.

Almost every participant agreed that having a healthy ocean and lagoon is important and linked to the health of family. In five out of six focus groups, people said that the number of fish in the lagoon had decreased in the past 10 years. There were mixed responses to a question about the variety of fish and coral life, with some saying it has decreased and some increased. Some said it has increased in the rā'ui area. Most people think the amount of seaweed and algae have decreased. There were mixed responses about the amount of coral bleaching – some people think it has decreased due to there being fewer crown-of-thorns (a starfish that preys on coral), while others noticed an increase in coral bleaching during hot weather.

In the focus group with traditional leaders, the GCCA + SUPA project team said that the rā'ui area looks to be in good condition with no rubbish or pollution and plenty of normal marine life. The project team would like to see more frequent monitoring and to get the community involved, particularly to check for changes such as coral bleaching.

The traditional leaders said that enforcing the rā'ui is very difficult and they do not get help from police. They said that it is difficult to punish someone when everyone is close or related, and leaders want to be giving and kind. They can only try to convince law-breakers of the importance of the rā'ui, and try to educate children. One leader suggested public naming and shaming would be better than punishment. The leaders also raised the issue that there is no gate or sign to the rā'ui area, so people have to already know the rā'ui boundaries. The leaders said that ora fishing (poisoning) is no longer practiced and they were surprised people in the focus groups mentioned this practice.

A Mangaia nearshore marine assessment (Ministry of Marine Resources, 2018) said that the rā'ui is effective at allowing species to recover between harvests, despite a few people breaking the rules. The Kei'ā rā'ui therefore appears to have achieved its stated objective.

The focus groups did not ask people about the personal impact of not being able to fish in rā'ui areas. Areas outside rā'ui could conceivably be less suitable or more difficult to access for fishing. However, in just one focus group someone said their life was not as good as it used to be (no reason given) so presumably the rā'ui has not had a significant negative effect on peoples' livelihoods.

6.4   Correlations and regressions

Data provided in the household surveys were analysed for correlations between household characteristics, satisfaction, risk, preparedness, and environmental changes. The small sample sizes mean that any correlations should be cautiously interpreted and they are not necessarily statistically significant. The correlation plot (Figure 6-6) shows correlation between the different future actions, meaning that if someone is willing to take one action they are also willing to take other actions. People in Tamarua believe their risk level to be slightly higher than the other villages. People in Oneroa are slightly more likely to agree to future actions.

The correlation plot (Figure 6-6) shows whether the correlation between each pair of variables is positive (blue) or negative (red). Statistical significance of the pairwise relationship is indicated by the size of each circle. A large circle indicates a p-value less than 0.01, medium is 0.05 to 0.01, small is 0.1 to 0.05, and no circle means the relationship is not significant.
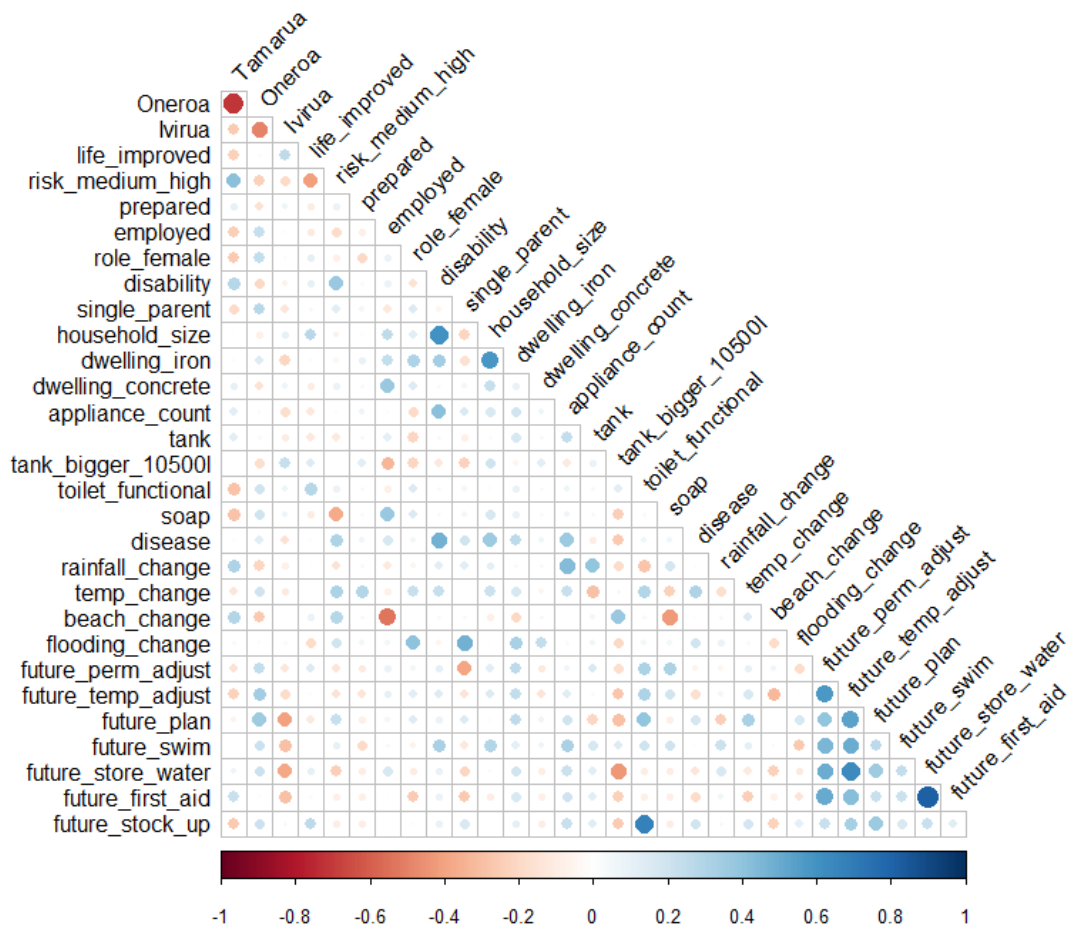
Figure 6-6: **Correlation plot of household, risk, preparedness and environmental change variables.**

The ordered logit regression coefficients presented in Table 6-24 indicate whether the variable is associated with improved (a positive coefficient) or worse life satisfaction (a negative coefficient) after controlling for the other variables. Larger coefficients in absolute terms indicate a stronger effect. The standard error indicates how different the population mean is likely to be from the sample mean, assuming the sample is representative and unbiased. The t value is the coefficient divided by standard error and is a measure of the precision of the coefficient. The p value is the probability that the true coefficient is zero (i.e., the variable has no effect on s83atisfaction). A low p value indicates that the association is unlikely to have been observed by chance. The threshold for statistical significance is a p value less than 0.05.

Few effects are statistically significant, despite having a good overall fit[4]. The lack of significance is probably due to multi-collinearity between variables and the small sample size. Owning chickens has a positive impact, as does a large rainwater tank, although the latter parameter did not quite achieve 5% statistical significance. Owning a boat has a negative significant effect, although this counter-intuitive result could be an anomaly due to the small number of boat owners. The dummy parameters for Ivirua and Oneroa were not significant. There is no parameter for Tamarua because that is the base case against which the dummies were compared.

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[4] McFadden pseudo r-squared = 0.26

Table 6-24: Ordinal logit regression estimates for life satisfaction compared with 5 years ago.

Variable	Value	Std. Error	t value	p value
Ivirua	-0.195	1.605	-0.12147	0.45
Oneroa	-0.549	1.577	-0.34817	0.36
Employed	0.750	1.921	0.390728	0.35
Tertiary education	-0.929	1.442	-0.64426	0.26
Female respondent	0.005	0.983	0.004633	0.50
Dwelling concrete	-7.400	39.981	-0.18509	0.43
Dwelling iron	0.369	1.979	0.186708	0.43
Appliance count	-0.641	1.804	-0.35519	0.36
Has computer	-0.431	0.927	-0.46525	0.32
Has a boat	-4.419	2.439	-1.81217	0.03*
Has chickens	2.987	1.423	2.098958	0.02*
Has pigs	-1.049	1.638	-0.63997	0.26
Tank > 10,500L	3.022	1.947	1.55261	0.06
Disability	6.461	74.796	0.086377	0.47
Single_parent	-0.595	1.643	-0.36194	0.36
Household size	0.083	0.289	0.285685	0.39
Disease incident	3.221	1.976	1.630488	0.05
Flies or rats problem	-0.083	1.063	-0.07794	0.47
Sewerage problem	-1.819	2.683	-0.67787	0.25

*indicates 5% significance.

6.5   Cook Islands conclusions

The lack of a control group or pre-intervention data means that it is not possible to formally test hypotheses about intervention impact. People in all three villages said their life is the same or better than it used to be, so the response cannot be linked to a specific intervention.

Regarding water and sanitation, all three villages have very similar infrastructure and no significant differences in terms of communicable disease or disaster preparedness. Since the water project involved repairing Tamarua infrastructure to a similar state to the infrastructure of the other villages, the lack of a significant difference between villages could be considered evidence the project was successful. The focus group with traditional leaders revealed that a lack of filtration and stock exclusion is a barrier to achieving the best possible outcome. Whether the other villages also have these problems is unclear.

Regarding marine conservation, there are multiple marine rā'ui areas around Mangaia, so all three villages are affected. The nearshore assessment (Ministry of Marine Resources, 2018) stated that the rā'ui are effective for the purposes of conservation. The focus groups revealed that some people still ignore the rā'ui, which may reduce its effectiveness. The focus groups did not specifically ask if the rā'ui affects peoples' livelihoods (by limiting opportunities to fish) but no-one volunteered any such information either. We can conclude that the overall impact is either positive, or at least not negative enough to make people think their lives are worse than they were 5 years ago.

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An implication for development of a database is that it should have fields to record the existence and details of barriers to achieving best possible outcomes. The database should also have a field to record whether communities were specifically asked about the impacts of the intervention, and, if so, what those impacts were.

7 Combined correlations and regressions

The household surveys data were pooled to assess whether relationships are significant after controlling for country-specific factors that were not measured. There are several significant country-specific correlations in the data (Figure 7-1). Similarly to the previous correlation plots, a positive relationship is indicated by red and negative by blue. Statistical significance of the pairwise relationship is indicated by the size of each circle. A large circle indicates a p-value less than 0.01, medium is 0.05 to 0.01, small is 0.1 to 0.05, and no circle means the relationship is not significant.

Respondents in Tonga have higher average satisfaction, perceived risk, preparedness, more appliances, less frequent subsistence activities, and have noticed a greater increase in rainfall. FSM respondents perceive more risk, feel less prepared, have more problems with flies and rats, do subsistence activities more frequently, and feel they are less likely to take future personal actions for adaptation. Cook Islands respondents perceive lower risk, have fewer appliances, and larger water tanks. Palau respondents have fewer tanks and have noticed an increase in beach area. The correlations between satisfaction, risk and preparedness are low after controlling for country-specific differences.
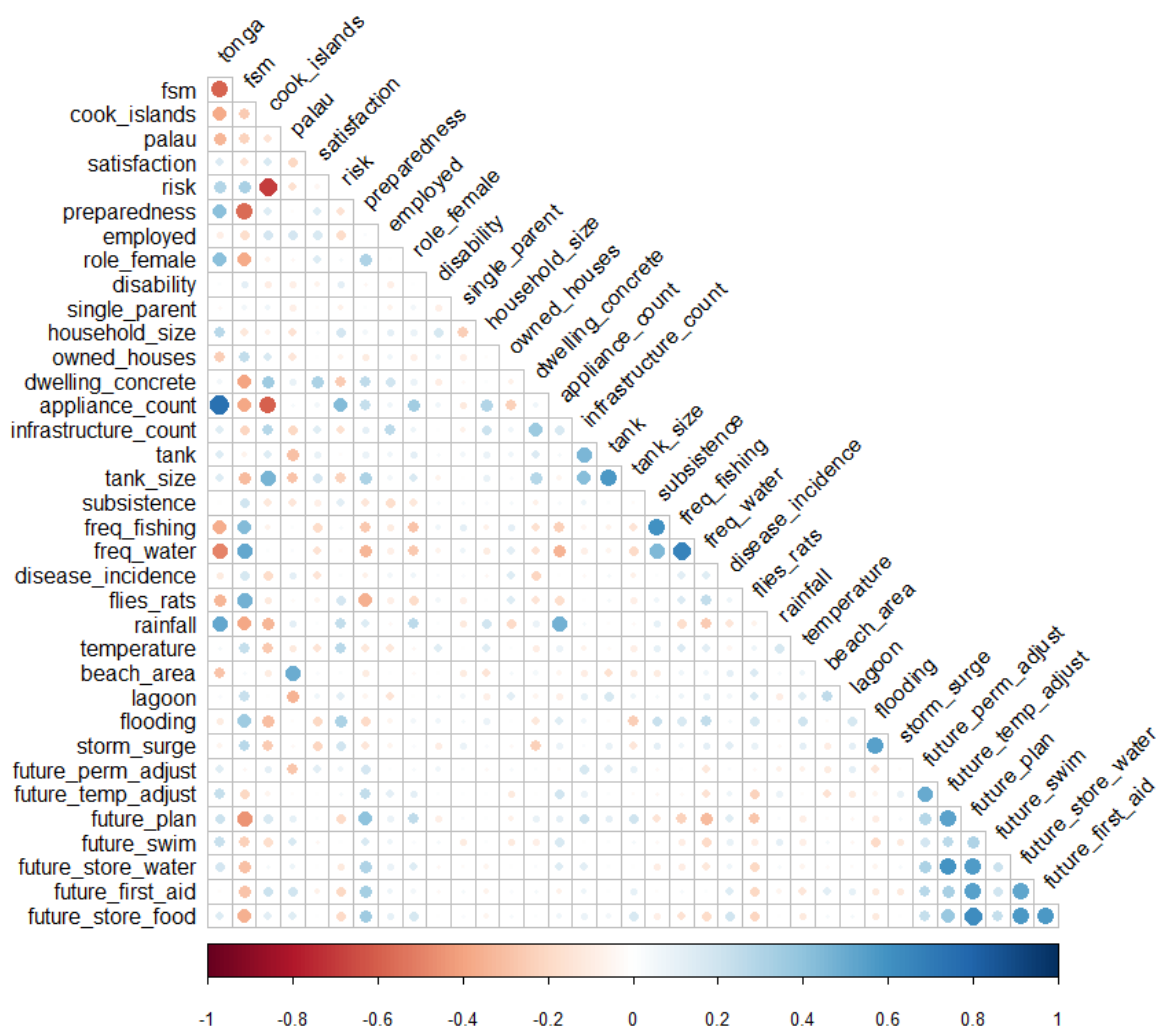

Figure 7-1:   Correlations for all four countries.

The multiple-country ordered logit regression coefficients presented in Table 7-1 indicate whether the variable is associated with improved (a positive coefficient) or worse life satisfaction (a negative coefficient) after controlling for the other variables. Larger coefficients in absolute terms indicate a stronger effect. The standard error indicates how different the population mean is likely to be from the sample mean, assuming the sample is representative and unbiased. The t value is the coefficient divided by standard error and is a measure of the precision of the coefficient. The p value is the probability that the true coefficient is zero (i.e., the variable has no effect on satisfaction). A low p value indicates that the association is unlikely to have been observed by chance. The threshold for statistical significance is a p value less than 0.05.

Employment, concrete dwellings, and increased beach area are associated with improved satisfaction. Increased temperature has a negative effect on satisfaction. There is also statistically significant negative relationship between satisfaction and Palau, implying some factor in Angaur or Babeldaob Islands has affected satisfaction but is not captured by the data. There is no country-specific variable for Tonga because Tonga is the base against which other countries are prepared.

Table 7-1: **Ordered logit for change in life satisfaction across all four countries.** Overall model fit = 0.146

Variable	Value	Std. Error	t value	p value
FSM	0.510	0.314	1.625	0.104
Cook Islands	0.717	0.317	2.261	0.024*
Palau	0.013	0.750	0.017	0.986
Female respondent	-0.856	0.998	-0.857	0.391
Employed in household	-2.934	0.666	-4.407	0.000*
Education high school/college	0.423	0.418	1.012	0.311
Education tertiary	-0.368	0.482	-0.764	0.445
Disability in household	-0.309	0.439	-0.704	0.481
Single parent household	0.047	0.598	0.078	0.938
Owned houses	0.060	0.187	0.321	0.748
Household size	0.003	0.044	0.069	0.945
Dwelling concrete	1.185	0.331	3.581	0.000*
Appliance count	-0.019	0.107	-0.180	0.857
Computer	0.187	0.390	0.480	0.631
Internet	0.305	0.384	0.795	0.427
Tank	-0.271	0.390	-0.694	0.488
Tank size	0.023	0.048	0.475	0.635
Subsistence	0.374	0.386	0.969	0.332
Frequency of water collection	-0.013	0.100	-0.131	0.896
Frequency of fishing	-0.111	0.108	-1.027	0.305
Disease incidence	-0.463	0.307	-1.510	0.131
Problem with flies or rats	0.251	0.319	0.787	0.431
Change in number of trees	-0.011	0.117	-0.098	0.922
Change in lagoon life	-0.013	0.117	-0.113	0.910
Change in rainfall	-0.121	0.144	-0.838	0.402
Change in temperature	-0.345	0.171	-2.017	0.044*
Change in beach area	0.424	0.130	3.262	0.001*
Change in flooding	-0.345	0.143	-2.405	0.016*

Variable	Value	Std. Error	t value	p value
Much worse|A bit worse	-4.909	1.148	-4.277	0.000*
A bit worse|The same	-2.373	0.930	-2.550	0.011*
The same|A bit better	-0.231	0.904	-0.255	0.798
A bit better|Much better	2.768	0.927	2.986	0.003*

denotes 5% significance

An ordered logit regression of preparedness reveals that respondents with internet and larger water tanks feel more prepared. Respondents in FSM feel less prepared, for reasons not explained by the data.

Table 7-2: **Ordered logit for preparedness.** Overall model fit = 0.104

Variable	Value	Std. Error	t value	p value
FSM	-1.667	0.753	-2.215	0.027*
Cook Islands	0.047	0.959	0.049	0.961
Palau	-0.365	0.746	-0.489	0.625
Female respondent	0.257	0.307	0.839	0.401
Employed in household	-0.045	0.310	-0.146	0.884
Education high school/college	0.307	0.416	0.738	0.460
Education tertiary	-0.477	0.446	-1.071	0.284
Disability in household	0.481	0.492	0.979	0.328
Single parent household	-0.107	0.555	-0.193	0.847
Owned houses	-0.010	0.186	-0.052	0.959
Household size	-0.057	0.046	-1.258	0.208
Dwelling concrete	0.319	0.329	0.968	0.333
Appliance count	0.112	0.102	1.093	0.274
Infrastructure count	-0.340	0.172	-1.976	0.048*
Computer	0.470	0.437	1.075	0.283
Internet	0.874	0.444	1.968	0.049*
Tank	-0.295	0.403	-0.733	0.464
Tank size	0.130	0.046	2.790	0.005*
Subsistence	0.029	0.397	0.073	0.942
Frequency of water collection	0.079	0.095	0.829	0.407
Frequency of fishing	-0.005	0.109	-0.043	0.966
Disease incidence	0.177	0.305	0.581	0.561
Problem with flies or rats	-0.283	0.314	-0.901	0.367
Perceived risk	-0.076	0.188	-0.406	0.685
Change in rainfall	-0.138	0.133	-1.033	0.302
Change in temperature	-0.112	0.161	-0.695	0.487
Change in beach area	-0.082	0.143	-0.571	0.568
Change in lagoon area	0.145	0.161	0.895	0.371
Change in flooding	-0.010	0.167	-0.059	0.953
Change in storm surges	0.297	0.169	1.761	0.078
Not prepared|Not very prepared	-3.805	1.036	-3.671	<0.001*
Not very prepared|Prepared	-1.799	0.989	-1.818	0.069
Prepared|Quite prepared	-0.271	0.979	-0.277	0.782
Quite prepared|Very prepared	0.823	0.984	0.836	0.403

An ordered logit regression of risk reveals that tertiary education and incidence of communicable disease are associated with higher perceived risk. Risk is perceived to be higher in FSM and lower in the Cook Islands and Palau when compared with Tonga.

Table 7-3:   **Ordered logit regression of perceived risk level.**   Overall model fit = 0.387.

Variable	Value	Std. Error	t value	p value
FSM	2.435	0.919	2.650	0.008*
Cook Islands	-1.538	0.337	-4.566	<0.001*
Palau	-1.784	0.897	-1.988	0.047*
Female respondent	0.386	0.403	0.956	0.339
Employed in household	0.095	0.381	0.249	0.803
Education high school/college	-0.100	0.592	-0.168	0.866
Education tertiary	-1.201	0.547	-2.194	0.028*
Disability in household	-0.393	0.531	-0.740	0.459
Single parent household	-0.146	0.762	-0.192	0.848
Owned houses	-0.152	0.269	-0.563	0.573
Household size	0.071	0.056	1.267	0.205
Dwelling concrete	0.087	0.384	0.226	0.821
Appliance count	0.163	0.128	1.273	0.203
Infrastructure count	0.121	0.237	0.511	0.609
Computer	-0.076	0.568	-0.133	0.894
Internet	-0.308	0.537	-0.573	0.567
Tank	0.349	0.568	0.615	0.539
Tank size	-0.025	0.072	-0.350	0.726
Subsistence	-0.043	0.472	-0.091	0.927
Frequency of water collection	-0.047	0.125	-0.379	0.705
Frequency of fishing	-0.039	0.130	-0.301	0.763
Disease incidence	-1.029	0.377	-2.729	0.006*
Problem with flies or rats	0.370	0.400	0.924	0.355
Change in rainfall	0.296	0.183	1.617	0.106
Change in temperature	0.051	0.217	0.237	0.813
Change in beach area	0.126	0.176	0.714	0.475
Change in lagoon area	-0.071	0.199	-0.354	0.723
Change in flooding	0.182	0.204	0.892	0.373
Change in storm surges	-0.174	0.195	-0.893	0.372
no risk|low risk	-2.270	1.210	-1.876	0.061
low risk|medium risk	-0.921	1.171	-0.786	0.432
medium risk|high risk	1.588	1.165	1.364	0.173

8   Recommendations

Based on the stated objectives of the household surveys and issues identified with the data, a number of recommendations for future impact assessments are suggested. These changes would enable more direct assessment of impacts and allow the surveys to better achieve the objectives of gauging awareness and determining whether an adaptation intervention is improving livelihoods and resilience to climate change. There are recommendations for sampling, data cleaning, additional questions, removing questions, and focus groups.

8.1   Sample selection

The sampling strategy should be documented. If it is intended to be representative of a particular community or group, this should be stated. When thinking about sample selection it would be useful to consider whether there is a community or group that could serve as a control for the intervention. An ideal control group would have a similar environment and socio-demographic characteristics but not have the adaptation intervention. For example, if a project installed tanks then a good control group might be a community on the same island that has no tanks.

8.2   Data cleaning

Some of the data would have benefited from data checking for consistency and notes to clarify anomalies. For example, the lack of beds in FSM and the situation where respondents said they were the father of their household but also that their household had no men.

8.3   Additional questions

8.3.1   Direct questions about adaptation interventions

We recommend including questions specifically about the adaptation intervention. These would ask:

- Whether the person was living in the area before the intervention?

- Whether they are aware of any climate change adaptation projects?

  - If yes, what they think the purpose was?

- Whether they think the intervention achieved the stated purpose?

- Whether they have noticed any changes caused by the intervention?

These questions were included in the Palau household survey and the answers revealed useful information.

8.3.2   Follow-up question for key indicators

Questions that are intended to be used as key indicators of impact would benefit from a follow-up question to ask why the respondent answered as they did. For example, the satisfaction follow-up question that was added to the Palau survey revealed that the most common reason given for a change in life satisfaction was income and family. None of the respondents mentioned the water tanks, though it is possible they might if they had time to experience a drought post-implementation.

8.3.3   Measure preparedness objectively

The preparedness question would also benefit from a follow-up question to ask what respondents had already done to prepare. This would enable more objective measurement of preparedness and would allow better interpretation of the responses to future action questions. For example, do people say they are unlikely to learn to swim because they can already swim?

8.3.4   Separate questions for different types of risk

The intervention sectors of coastal protection, water security, resilient agriculture, and marine resources, target different risks. Water tanks might reduce drought impacts but if people were thinking about floods when they answered the risk question, the impact of improved water security will not be apparent in the results. It would be useful, therefore, to have separate questions for the risk relating to each sector.

Similarly, people would take different actions for different types of risk. The question about actions could be separated for different event types because evacuation, for example, seems less relevant to a drought than a cyclone.

8.3.5   Add a question about elderly household members

The household survey measured vulnerability in terms of disability. Asking whether the household has any elderly members would also be useful for assessing impact to vulnerable groups.

8.4   Remove unnecessary questions

The additional questions would make the survey longer, but some pre-existing questions could be removed because they seem less useful for impact measurement. For example, the question about ranking of household spending does not seem useful when the income of the household is unknown. Questions about who collects firewood, or who goes fishing, or how much fuel of each type is used also seem less relevant. Question D9 about raw meat is double-barrelled and responses could either mean the person has no freezer or has no problems with their freezer so the question should either be removed or replaced with two questions.

8.5   Focussing the focus groups

Focus groups ideally should provide more context around the most important questions in the household survey. It is better to have a small number of questions or leading topics and record in detail any discussion about these matters. Some of the focus groups provided detailed information about implementation problems and barriers, for example with the Cook Islands Kei'ā Rā'ui project. The Tonga focus group results appeared to be more structured. They provided some additional information about beach use, but it would have been useful to learn more detail about the positive and negative impacts of the coastal adaptation project. We recommend that household survey results should be analysed before running focus groups, if possible, so that focus group questions can be targeted more precisely.

9   Conclusion and implications for impact assessment

The preliminary findings of the household surveys highlight that it is difficult to attribute life satisfaction, feelings of preparedness, or perceived risk to any specific adaptation intervention. When assessing the impact on community attributes it is important to have both baseline and post-implementation data for the same variables.

Because there can be other events or changes over time that affect responses (e.g., a cyclone or pandemic) it is also useful to have a control community that is as similar as possible to the community receiving the intervention. The best quality evidence is provided by randomised controlled trials, where half the community receives the intervention and half receives it later, after impact has been assessed. However, a randomised controlled trial may not be useful if the intervention potentially benefits the wider community beyond households involved in the trial.

In the absence of baseline and control data it is necessary to ask very targeted questions about the adaptation intervention. The additional questions included in the Palau survey made it possible to verify that respondents were aware of the project to improve water security, and some were already experiencing benefit.

The implication for the impact database design is that it should allow for inclusion of baseline and control data. The database should include a field to record any issues with sample representativeness, such as an over-representation of small households or more highly educated people. The database should also include fields for qualitative responses to questions such as perceived effects of the intervention, and any factors identified as reducing the impact of the intervention (e.g., incompleteness, or the problems faced by dry piggery farmers). It may also be useful to have a field to describe whether any notable events occurred following the baseline survey that might affect post-implementation measurements (e.g., a cyclone).

10 References

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