Pacific Community
Communauté du Pacifique

Small Islands Food and Water Project SIFWaP

Preparatory study on water security and hydrology

IFAD

GEM
Geoscience, Energy and Maritime Division

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Preparatory study on water security and hydrology

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Cover photo credit: Anesh Kumar (Atafu atoll, Tokelau)

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Suva, Fiji

January 2021

Original text: English

Prepared for publication at SPC's Suva Regional Office, Private Mail Bag, Suva, Fiji, 2021

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Contents

List of acronyms

FAO	Food and Agriculture Organisation
FPIC	Free Prior and Informed Consent
FSM	Federated States of Micronesia
GAFSP	Global Agriculture and Food Security Programme
GEF	Global Environment Facility
GESI	Gender Equity and Social Inclusion
GRM	Grievance Redress Mechanism
IFAD	International Fund for Agricultural Development
IHP	Intergovernmental Hydrological Programme
MISE	Ministry of Infrastructure and Sustainable Energy
NDMO	National Disaster and Management Office
NGO	Non-Governmental Organisation
PWD	Public Works Department
RMI	Republic of Marshall Islands
SDG	Sustainable Development Goals
SIDS	Small Island Developing States
SIFWaP	Small Islands Food and Water project
SPC	The Pacific Community
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization

Conversion factors - imperial to metric units

feet to metres	0.3048
metres to feet	3.2808
inches to millimetres	25.4
millimetres to inches	0.03937
miles to kilometres	1.6093
US gallons to litres	3.7854
US gallons per day per foot to meter squared per day	0.01242

1. Introduction

1.1 Project background

The Global Agriculture and Food Security Program (GAFSP) is a leading global financing instrument dedicated to fighting hunger, malnutrition, and poverty in the world's poorest countries, by strengthening agriculture and food systems, to improve the lives of smallholder farmers and their families. Customisation of approaches to meet the needs and interests of small holder farmers and their families is a hall mark of GAFSP.

The countries of Federated States of Micronesia, Kiribati, the Republic of the Marshall Islands and Tuvalu comprised mainly of coral atolls, and amongst the smallest, most isolated and fragile of Small Islands Developing States. The proposed Small Islands Food and Water Project (SIFWaP) recognizes the specific challenges of these countries and proposes a hub-and-spoke project management structure for the multi country initiative comprising a centralised Project Management Unit with a National Delivery Unit in each country.

The project objective is to improve food, nutrition and water security and livelihood opportunities in the small island communities of these countries. This objective will be achieved through three components:

- Investments to improve water, food, and nutrition security,
- Enabling communities to address food and water problems,
- Development of policy framework to address water and food security at national and community scale.

Total project costs will amount to USD $19.59M, with total GAFSP financing amounting to USD $15.04M, comprising USD $14.69M for project implementation (including contingencies) and USD $0.35M for project preparation. In kind contributions from governments and beneficiaries alike are expected to contribute USD $4.5M, mainly under Component 1.

IFAD has partnered with the Pacific Community (SPC) to draw upon their long history of technical support and recent experience in the design and implementation of a range of water security projects across the Pacific to help guide the design of the proposed water security intervention and implementation approaches. Specifically, IFAD has engaged SPC to undertake a Preparatory Study on Water Security and Hydrology for Federated States of Micronesia (FSM) Kiribati, Republic of Marshall Islands (RMI) and Tuvalu to support the design of the SIFWaP. The Terms of Reference for this study is found in Annex 1.

The most vulnerable communities are those with limited options for water and food resource diversification. These more vulnerable parts of the population include the rural communities who inhabit the low carbonate islands or atolls, and do not have access to the resources and facilities of the larger volcanic islands and or urbanised communities. This study will focus on these at most risk and more vulnerable populations of these island nations, being the non-urban communities of the low-lying islands. The approach to address the specific tasks identified will be to draw upon the existing reports, census data, technical and spatial data, and the significant experience that exists within the project team and in collaboration with leading regional water resource and water management specialists.

1.2 Background literature

A significant amount of investigation and reporting exists for each of the nominated countries. Information available from these existing reports and more recent census data will be used to identify

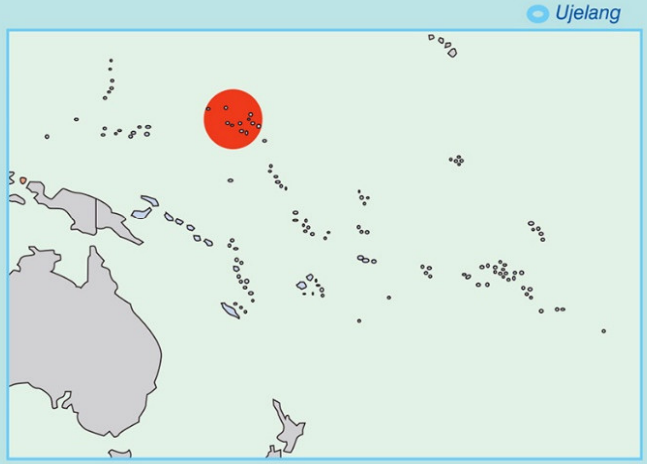
the targeted communities with actions which will address some of the underlying causes of water insecurity. A comprehensive listing of reference material is provided in Annex 5 as background information on water resource options and consideration in atoll environments.

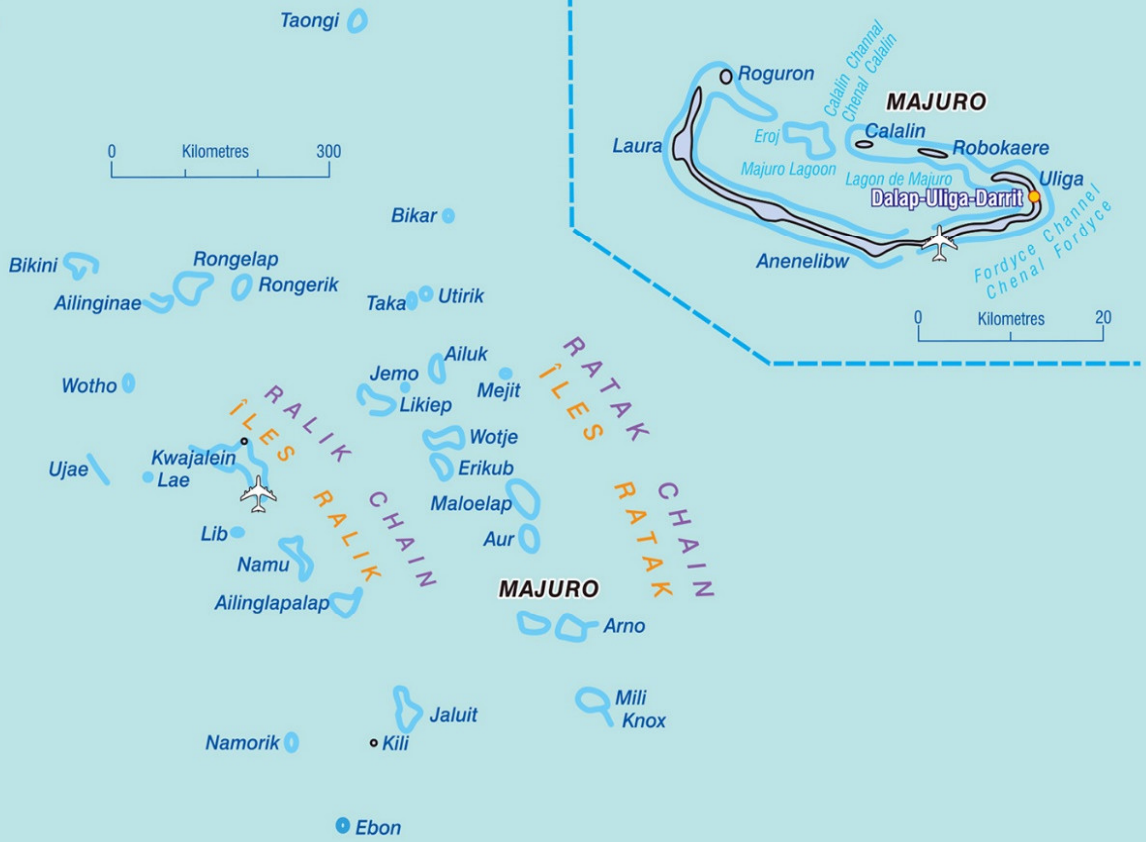
2. Background of project countries

2.1 Geography

Figure 1. Pacific Small islands developing states.

Marshall Islands

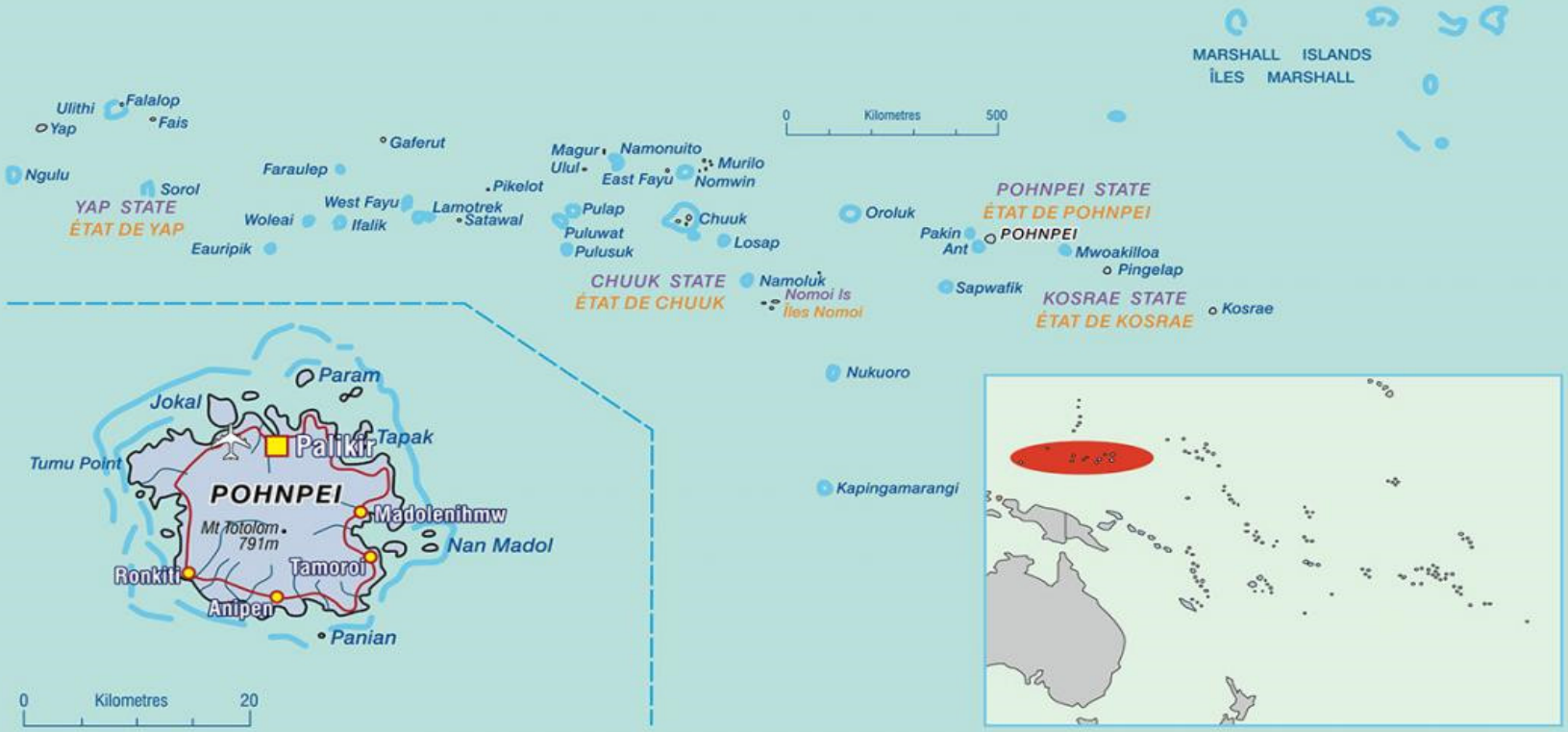


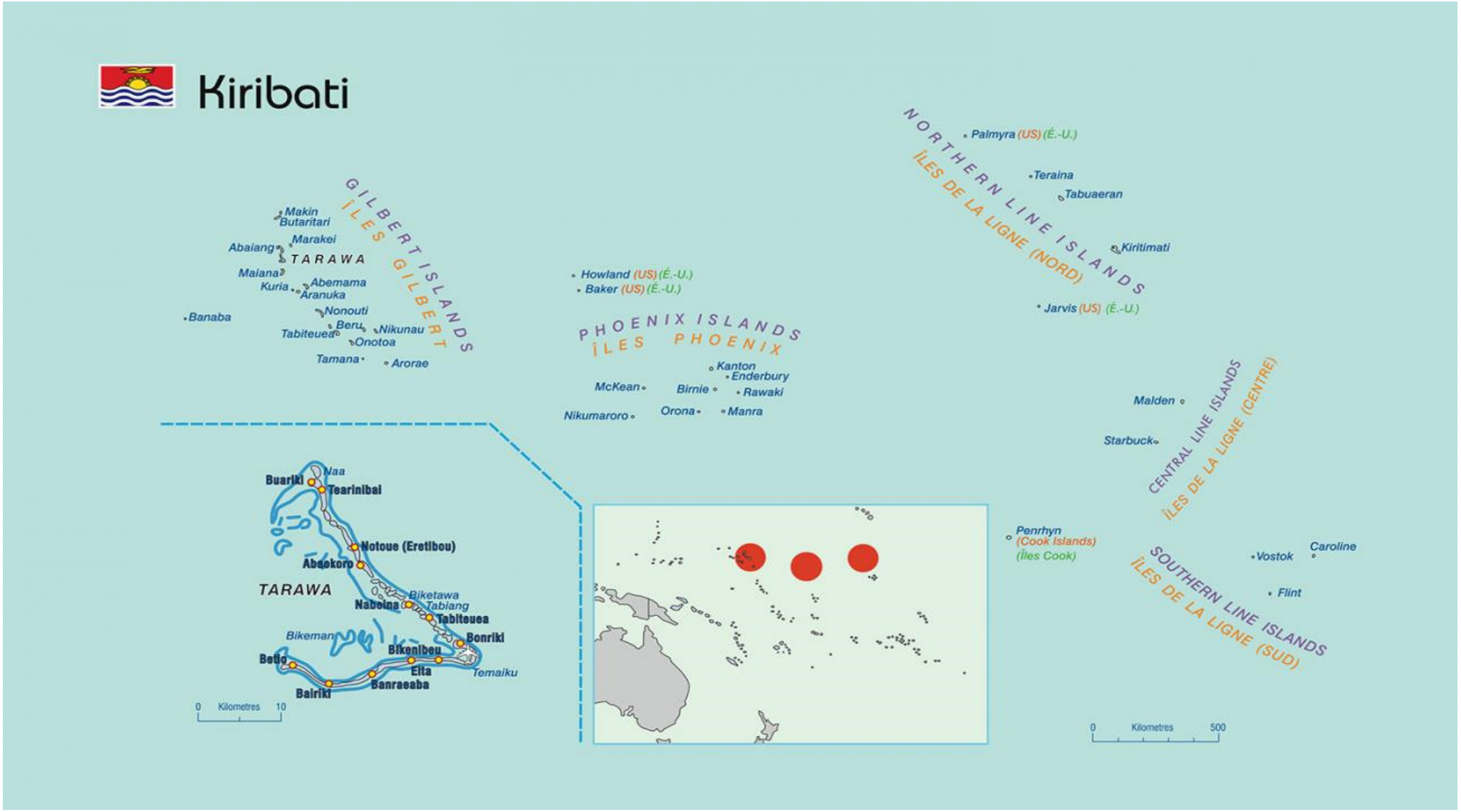


Tuvalu

Nanumea
Niutao
Nanumanga
Nui
Vaitupu
Nukufetau
FUNAFUTI
Nukulaelae
Niulakita
0 Kilometres 200

Federated States of Micronesia
États fédérés de Micronésie




Kiribati
GILBERT ISLANDS
ÎLES GILBERT
Makin
Butaritari
Marakei
Abaiang
TARAWA
Maiana
Kuria
Abemama
Aranuka
Nonouti
Banaba
Beru
Tabiteuea
Nikunau
Onotoa
Tamana
Arorae
Howland (US) (É.-U.)
Baker (US) (É.-U.)
PHOENIX ISLANDS
ÎLES PHOENIX
Kanton
Enderbury
McKean
Birnie
Rawaki
Nikumaroro
Orona
Manra
NORTHERN LINE ISLANDS
ÎLES DE LA LIGNE (NORD)
Palmyra (US) (É.-U.)
Teraina
Tabuaeran
Kiritimati
Jarvis (US) (É.-U.)
CENTRAL LINE ISLANDS
ÎLES DE LA LIGNE (CENTRE)
Malden
Starbuck
Penrhyn
(Cook Islands)
(Îles Cook)
SOUTHERN LINE ISLANDS
ÎLES DE LA LIGNE (SUD)
Vostok
Caroline
Flint
0 Kilometres 500
Buariki
Naa
Tearinibai
Notoue (Eretibou)
Abaokoro
TARAWA
Biketawa
Tabiang
Nabeina
Tabiteuea
Bikeman
Bonriki
Bikenibeu
Betio
Eita
Temaiku
Banraeaba
Bairiki
0 Kilometres 10

2.2 Climate

2.2.1 FSM

Because of its position in the north-western Pacific, FSM's climate is largely influenced by the occasional northward shift of the Intertropical Convergence Zone, the periodic contribution from the western monsoon and interannual rainfall variations driven by El Niño-South Oscillation conditions, be it El Niño or La Niña (*Fig 2*) (Australia's Bureau of Meteorology and CSIRO 2011). Fletcher and Richmond (2010) documented that the wet season in FSM occurs from May to September when the Intertropical Convergence Zone is strongest and farthest north, and where additional rain is also brought by the West Pacific Monsoon affecting FSM's western states. Very high rainfall periods are always experienced during La Niña periods, which usually result in flooding and storm surges around low-lying areas. The dry months are between November and April, with an increasing trend in temperature observed in western areas.

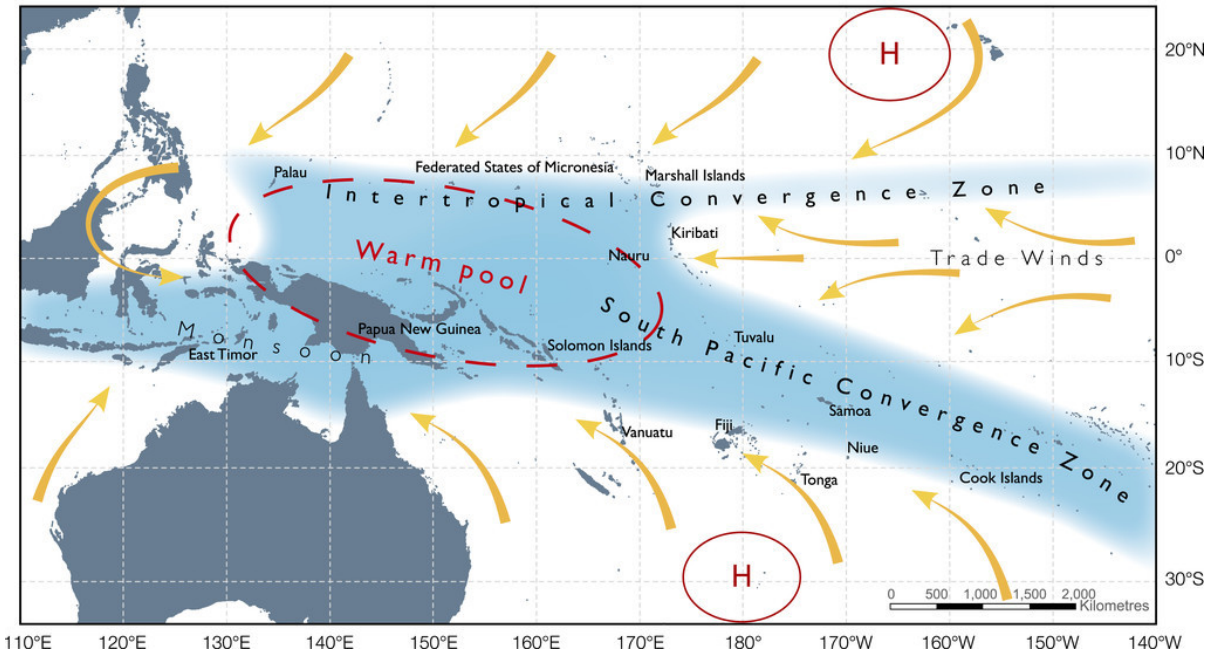


Figure 2. Features that influence the climate in the Federated States of Micronesia climate. Source: BOM and CSIRO 2011.

2.2.2 Kiribati

Kiribati's climate is dominated by hot, humid tropical conditions and varies considerably from year to year due to the El Niño Southern Oscillation, particularly El Niño and La Niña. Across Kiribati, El Niño events tend to bring wetter and warmer conditions than normal. La Niña events on the other hand bring dry and cool conditions resulting in some of the most severe droughts on record.

Rainfall patterns are strongly influenced by the movement of the South Pacific Convergence Zone and the Intertropical Convergence Zone that extend across the South Pacific Ocean from the Solomon Islands to east of the Cook Islands. Average annual rainfall in Kiribati is approximately 2100 mm with just over 900 mm received between May and October. In the capital South Tarawa, in the west, the driest period begins in June and the lowest mean rainfall is generally observed in October. In Kiritimati, 2000 km to the east, the wet season is from January to June. In the wettest years, Kiribati has recorded more than 4000 mm/year, while in the driest years as little as 150 mm of rain.

2.2.3 Tuvalu

Tuvalu has two distinct climatic seasons – a wet season from November to April and a dry season from May to October, having an average annual rainfall range of 2700 - 3500 mm over the nine atolls. Similar

to Kiribati, historical climatic patterns in Tuvalu are dictated by the El Niño Southern Oscillation with rainfall patterns strongly influenced by the proximity of the island nations to the West Pacific Warm Pool, where thunderstorm activity occurs year-round. Further, Tuvalu's close location to the South Pacific Convergence Zone makes it vulnerable to spring tides and tropical cyclones as frequently experienced in some of the atolls, especially Funafuti. These events are usually associated with high winds and rainfall, coupled with storm surges and swells and causing flooding-induced agricultural losses, particularly of taro crops and damage to buildings and roads along the coast.

2.2.4 RMI

Rainfall varies greatly from north to south in RMI. The northern atolls receive less than 1250 mm of rain annually, and experience significant droughts during the dry season. The southern atolls receive more than 2500 mm of rain annually. The difference between the wet and dry season is more pronounced in the northern atolls. RMI is particularly affected by intense El Niño-induced droughts and the associated depletion of rainwater storage and the thinning of freshwater lenses. Rainfall variability throughout the years is high, with the wettest years bringing up to twice as much rain as the driest years. Droughts generally occur in the first four to six months of the year following an El Niño event. During severe El Niño events, rainfall can be suppressed by as much as 80% (ABM and CSIRO 2011).

2.3 Population and water demand

Population data were obtained from the more recent national census surveys conducted in the four project countries. The projected 2030 populations and the annual change as a proportion of island and national population were estimated for each island based on the linear trend derived from previous year's population data.

Projected changes in population are generally a good proxy to estimate projected changes in water demand. There are of course more factors that can contribute to changes in water demand, such as climatic factors (e.g. increase in temperature) and socio-economic factors (e.g. improved access to water). Assuming that the daily water requirements per capita do not change then changes in water demand become directly proportional to changes in population.

In RMI, population and thus water demand are expected to increase in the two main urban centres located on Majuro and Kwajalein atolls. Majuro's population is expected to grow at a rate of 1.3% (or 0.67% of the national population) reaching an estimate of 34,500 by 2030. Ebeye's population on Kwajalein atoll is expected to grow at an annual rate of 0.9% (or 0.19% of the national population). The rest of the outer islands illustrate a mix of increasing (mostly) and decreasing population trends with some of these changes being significant in terms of the island population.

In Kiribati, population and water demand is expected to increase in South Tarawa, the capital and main urban center of Kiribati. South Tarawa's population is expected to grow at a rate of 2.5% (or 1.26% of the national population) reaching an estimate of 77,160 by 2030. The population on North Tarawa and Kiritimati is expected to grow at an annual rate of 2.2% (or 0.13% of the national population) and 2.7% (or 0.16% of the national population), respectively. The rest of the outer islands illustrate a mix of increasing and decreasing population trends with some of these changes being significant in terms of the island population.

In Tuvalu, population and water demand are expected to increase with an annual rate of 1.7% in the capital Funafuti and reaching an estimate of 7736 people by the year 2030. Small changes are expected to happen in the outer islands although the population of Vaitupu recorded a substantial decrease between the 2012 and 2017 census surveys, probably related to the school population normally present

on the island. It is possible that the boarding school population, which is roughly 500 students, was not included in the 2017 census.

In FSM, the population trends were analysed by State. Chuuk Lagoon islands in Chuuk State are expected to record an annual decrease of 0.9% of their population with total population expected to drop to 29,300 people in 2030. In the outer islands on the other hand, population is expected to increase with an annual growth rate of 0.4% (0.11% of total state population). The opposite pattern is expected for Yap State with population on Yap Proper expected to grow at an annual rate of 0.4% (0.25% of State's population) while population on the outer islands expected to decrease at an annual rate of 0.4% (0.14% of State's population). Pohnpei State is expected to exhibit a similar pattern with increasing population in Pohnpei Proper (0.6% annual growth rate) and decreasing population in the outer islands (-3.2% annual growth rate). Finally, all the islands of Kosrae State are expected to exhibit population decrease with an average annual rate of 0.6%.

Table 1. RMI population per island with 2030 projection and % annual change.

Atoll/island	1988	1999	2011	2030 projection	annual change (% of island population)	annual change (% of national population)
Ailinglaplap	1,715	1,959	1,725	1,804	0.2%	0.01%
Ailuk	488	513	339	244	-1.5%	-0.01%
Arno	1,656	2,069	1,794	2,010	0.6%	0.02%
Aur	438	537	499	570	0.7%	0.01%
Bikini	10	13	9	9	0.1%	0.00%
Ebon	741	902	704	726	0.2%	0.00%
Enewetak	715	853	664	670	0.0%	0.00%
Jabat	112	95	84	60	-1.5%	0.00%
Jaluit	1,709	1,669	1,788	1,830	0.1%	0.00%
Kili	602	774	548	562	0.1%	0.00%
Kwajalein	9,311	10,902	11,408	13,314	0.9%	0.19%
Lae	319	322	347	367	0.3%	0.00%
Lib	115	147	155	192	1.3%	0.00%
Likiep	482	527	401	359	-0.6%	0.00%
Majuro	19,664	23,676	27,797	34,552	1.3%	0.67%
Maloelap	796	856	682	622	-0.5%	-0.01%
Mejit	445	416	348	273	-1.1%	-0.01%
Mili	854	1032	738	711	-0.2%	0.00%
Namorik	814	772	508	286	-2.3%	-0.02%
Namu	801	903	780	796	0.1%	0.00%
Rongelap	0	19	79	139	4.0%	0.01%
Ujae	448	440	364	304	-0.9%	-0.01%
Utrik	409	433	435	460	0.3%	0.00%
Wotho	90	145	97	118	1.1%	0.00%
Wotje	646	866	859	1,070	1.3%	0.02%

Table 2. Kiribati population per island with 2030 projection and % annual change.

Atoll/island	1995	2000	2005	2010	2015	2030 projection	annual change (% of island population)	annual change (% of national population)
Banaba	339	276	301	295	268	234	-0.8%	0.00%
Makin	1,830	1,691	2,385	1,798	1,990	2,152	0.5%	0.01%
Abaiang	6,020	5,794	5,502	5,502	5,568	5,079	-0.6%	-0.03%
Maiana	2,184	2,048	1,908	2,027	1,982	1,817	-0.6%	-0.01%
Abemama	3,442	3,142	3,404	3,213	3,262	3,148	-0.2%	-0.01%
Kuria	971	961	1,082	980	1,046	1,093	0.3%	0.00%
Aranuka	1,015	966	1,158	1,057	1,125	1,220	0.6%	0.01%
Nonouti	3,042	3,176	3,179	2,683	2,743	2,419	-0.8%	-0.02%
Tabiteuea.Nth	3,383	3,365	3,600	3,689	3,955	4,332	0.6%	0.02%
Tabiteuea.Sth	1,404	1,217	1,298	1,290	1,306	1,242	-0.3%	0.00%
Beru	2,784	2,732	2,169	2,099	2,051	1,318	-2.4%	-0.04%
Nikunau	2,009	1,733	1,912	1,907	1,789	1,737	-0.2%	0.00%
Onotoa	1,918	1,668	1,644	1,519	1,393	1,029	-1.7%	-0.02%
Arorae	1,248	1,225	1,256	1,279	1,011	994	-0.1%	0.00%
Tamana	1,181	962	875	951	1,104	932	-1.0%	-0.01%
Butaritari	3,909	3,464	3,280	4,346	3,224	3,401	0.4%	0.01%
Tarawa.Nth	4,004	4,477	5,678	6,102	6,629	8,816	2.2%	0.13%
Kanton	83	61	41	31	20	-	-16.9%	0.00%
Teeraina	978	1,087	1,155	1,690	1,712	2,360	2.5%	0.04%
Marakei	2,724	2,544	2,741	2,872	2,799	2,975	0.4%	0.01%
Tabuaeran	1,615	1,757	2,539	1,960	2,315	2,839	1.5%	0.03%
Tarawa.Sth	28,350	36,717	40,311	50,182	56,388	77,160	2.5%	1.26%
Kiritimati	3,225	3,431	5,115	5,586	6,456	9,071	2.7%	0.16%

Table 3. Tuvalu population per island with 2030 projection and % annual change.

Atoll/island	2002	2012	2017	2030 projection	annual change (% of island population)	annual change (% of national population)
Nanumaga	589	551	491	423	-1.1%	-0.05%
Nanumea	664	612	512	411	-1.5%	-0.07%
Funafuti	4,492	5,436	6,320	7,736	1.7%	1.04%
Nukufetau	586	666	597	651	0.7%	0.04%
Nukulaelae	393	364	300	240	-1.5%	-0.04%
Nui	548	729	610	750	1.8%	0.10%
Niulakita	35	46	34	40	1.4%	0.00%
Niutao	663	694	582	564	-0.2%	-0.01%
Vaitupu	1,591	1,542	1,061	789	-2.0%	-0.20%

Table 4. Federated States of Micronesia, Chuuk State population per island and island group (in bold) with 2030 projection and % annual change.

Islands / island groups	1994	2000	2010	2030 projection	annual change (% of island population)	annual change (% of state population)
Lagoon	**41,662**	**40,465**	**36,158**	**29,313**	**-0.9%**	**-0.70%**
N. Namonea	**17,093**	**14,722**	**14,620**	**11,470**	**-1.1%**	**-0.32%**
Weno	16,121	13,802	13,856	10,965	-1.0%	-0.30%
Piis-Paneu	490	523	388	263	-1.6%	-0.01%
Fono	482	397	376	242	-1.8%	-0.01%
S. Namonea	**11,898**	**11,694**	**10,233**	**8,169**	**-1.0%**	**-0.21%**
Tonoas/Etten	3,949	3,910	3,517	2,982	-0.8%	-0.05%
Fefen	4,042	4,062	3,471	2,767	-1.0%	-0.07%
Siis	476	490	349	193	-2.2%	-0.02%
Uman	3,056	2,847	2,554	1,926	-1.2%	-0.06%
Parem	375	385	342	302	-0.6%	0.00%
Faichuk	**12,671**	**14,049**	**11,305**	**9,675**	**-0.7%**	**-0.17%**
Eot	361	382	266	150	-2.2%	-0.01%
Udot	1,598	1,774	1,680	1,788	0.3%	0.01%
Romanum	711	1,011	865	1,067	1.2%	0.02%
Fanapanges	606	681	672	757	0.6%	0.01%
Wonei	1,434	1,271	638	-	-7.8%	-0.10%
Paata	1,825	1,950	1,107	226	-4.0%	-0.09%
Tol	4,816	5,129	4,579	4,299	-0.3%	-0.03%
Polle	1,320	1,851	1,498	1,739	0.8%	0.02%
Outer Islands	**11,657**	**13,130**	**12,496**	**13,592**	**0.4%**	**0.11%**
Mortlocks	**6,471**	**6,911**	**5,677**	**4,715**	**-0.8%**	**-0.10%**
Nama	881	995	676	428	-1.8%	-0.03%
Losap	455	448	248	-	-5.2%	-0.03%
Piis-Emwar	448	427	258	23	-4.6%	-0.02%
Namoluk	402	407	355	297	-0.8%	-0.01%
Ettal	356	267	672	1,059	2.9%	0.04%
Lekinioch	802	927	848	910	0.4%	0.01%
Oneop	550	505	400	213	-2.3%	-0.02%
Satowan	823	955	692	536	-1.1%	-0.02%
Kuttu	633	873	323	-	-5.8%	-0.04%
Moch	837	854	932	1,050	0.6%	0.01%
Ta	284	253	273	258	-0.3%	0.00%
Pattiw	**2,171**	**2,736**	**3,522**	**5,213**	**2.4%**	**0.17%**
Houk	494	451	1,116	1,882	3.4%	0.08%
Polowat	688	1,015	745	829	0.6%	0.01%
Pollap	710	905	1,168	1,741	2.5%	0.06%
Tamatam	279	365	493	761	2.7%	0.03%
Namonuito	**1,001**	**1,341**	**1,384**	**1,871**	**1.8%**	**0.05%**
Makur	151	156	159	169	0.3%	0.00%
Onoun	436	580	633	882	2.0%	0.03%

Onou	118	182	172	241	2.0%	0.01%
Unanu	131	178	193	271	2.0%	0.01%
Piherarh	165	245	227	307	1.8%	0.01%
Halls	**2,014**	**2,142**	**1,913**	**1,794**	**-0.3%**	**-0.01%**
Nomwin	746	711	763	783	0.1%	0.00%
Fananu	320	355	580	902	2.8%	0.03%
Ruo	397	469	241	51	-3.9%	-0.02%
Murillo	551	607	329	57	-4.1%	-0.03%

Table 5. Federated States of Micronesia, Yap State population per island and island group (in bold) with 2030 projection and % annual change.

Islands / island groups	1994	2000	2010	2030 projection	annual change (% of island population)	annual change (% of state population)
Yap Proper	**6,919**	**7,391**	**7,371**	**7,948**	**0.4%**	**0.25%**
Rumung	143	126	58	-	-9.1%	-0.05%
Maap	547	592	621	714	0.8%	0.04%
Gagil	716	734	863	1,045	1.1%	0.08%
Tomil	897	1,023	1,231	1,649	1.7%	0.18%
Fanif	462	547	509	571	0.6%	0.03%
Weloy	1,188	1,197	1,031	838	-0.9%	-0.09%
Rull	1,973	2,019	2,095	2,248	0.4%	0.07%
Gilman	204	233	252	312	1.2%	0.03%
Kanifay	245	275	314	400	1.4%	0.04%
Dalipebinaw	544	645	397	220	-2.2%	-0.08%
Outer Islands	**4,259**	**3,850**	**4,006**	**3,677**	**-0.4%**	**-0.14%**
Ulithi	1,016	773	847	628	-1.3%	-0.10%
Fais	301	215	294	282	-0.2%	-0.01%
Ngulu	38	26	6	-	-33.3%	-0.02%
Woleai	844	975	1,039	1,285	1.2%	0.11%
Eauripik	118	113	114	109	-0.2%	0.00%
Ifalik	653	561	578	482	-0.8%	-0.04%
Faraulap	223	221	193	156	-1.0%	-0.02%
Elato	121	96	105	84	-1.0%	-0.01%
Lamotrek	385	339	329	258	-1.1%	-0.03%
Satawal	560	531	501	427	-0.7%	-0.03%

Table 6. Federated States of Micronesia, Pohnpei State population per island and island group (in bold) with 2030 projection and % annual change.

Islands / island groups	1994	2000	2010	2030 projection	annual change (% of island population)	annual change (% of state population)
Pohnpei Proper	**31,540**	**32,178**	**34,789**	**38,827**	**0.6%**	**0.56%**
Madolenihmw	4,951	5,420	5,767	6,794	0.9%	0.14%
U	3,001	2,685	3,192	3,415	0.3%	0.03%
Nett	5,977	6,158	6,639	7,464	0.6%	0.11%
Sokehs	5,773	6,227	6,647	7,745	0.8%	0.15%

Kitti	5,178	6,007	6,470	8,099	1.3%	0.23%
Kolonia	6,660	5,681	6,074	5,311	-0.6%	-0.11%
Outer Islands	**2,152**	**2,308**	**1,407**	**494**	**-3.2%**	**-0.13%**
Mwoakilloa	209	177	133	38	-3.6%	-0.01%
Pingelap	518	438	258	-	-6.3%	-0.04%
Sapwuahfik	603	857	456	285	-1.9%	-0.02%
Nukuoro	349	362	210	39	-4.1%	-0.02%
Kapingamarangi	473	474	350	198	-2.2%	-0.02%

Table 7. Federated States of Micronesia, Kosrae State population per island and island group (in bold) with 2030 projection and % annual change.

Islands / island groups	1994	2000	2010	2030 projection	annual change (% of island population)	annual change (% of state population)
Lelu	2,404	2,591	2,160	1,866	-0.7%	-0.22%
Malem	1,430	1,571	1,300	1,145	-0.6%	-0.12%
Utwe	1,056	1,067	983	893	-0.5%	-0.07%
Tafunsak	2,427	2,457	2,173	1,861	-0.7%	-0.24%

3. Lessons learned from previous work

3.1 Previous work

The project should build on findings and lessons learned from previous projects undertaken in the region over the last decade which have been gradually establishing the way towards achieving sustainable management of water resources. The intention should be to replicate good practices that have worked in the past and to integrate approaches towards inclusion of rainwater/ groundwater management into applicable national water policies and IWRM plans.

The WMO-funded Pacific HYCOS project (2007-2010) executed by the South Pacific Applied Geoscience Commission (SOPAC) first gave the opportunity to trial and observe different delivery modes used to assess and monitor water resources in 14 Pacific island countries. The most relevant and valuable modalities were identified and were consequently replicated during follow-up work in other similar settings.

The EU funded Pacific Integrated Water Resources Management project (2008-2012), and the GEF funded Pacific IWRM project have respectively provided support through the development of water and sanitation policy to address legislative reform allowing implementation of applicable and effective Integrated Water Resources Management (IWRM) and Water Use Efficiency (WUE) plans to improve cross sectoral coordination of water resources management and water use efficiency to help balance overuse and conflicting uses of scarce freshwater resources.

The EU-funded Global Climate Change Alliance: Pacific Small Island States (GCCA: PSIS) Project (2011-2016), executed by SPC, supported the Governments of Pacific Island Countries, including the four countries targeted under this project, with their efforts to tackle the adverse effects of climate change. The purpose of the project was to promote long-term strategies and approaches to adaptation planning and to pave the way for more effective and coordinated aid delivery to address climate change at the national and regional level.

The EU-funded KIRIWATSAN project (2011-2018), executed by SPC, employed novel assessment techniques to identify and quantify fresh groundwater resources in the islands of Kiribati which were consequently developed through the installation of suitable infrastructure (infiltration galleries) to improve the availability of safe drinking water and reduce water, sanitation, and hygiene related diseases. Water resources monitoring capacities were developed and monitoring mechanisms were strengthened through the development of guidelines for continuous collection of data and information necessary for water resources management.

The high risks associated with groundwater availability and natural/anthropogenic pollution in low-lying SIDS were also identified by the Global Environment Facility (GEF) funded Transboundary Waters Assessment Programme (UNESCO-IHP and UNEP, 2016). The global assessment performed for the groundwater systems in SIDS highlighted how these risks are particularly exacerbated when human groundwater dependence for its potable and domestic freshwater needs is high, as this is the case in many Pacific low-lying SIDS, including the three project countries.

The Australian-funded "Bonriki Inundation Vulnerability Assessment (BIVA)" (2013-2015) and the EU-funded "Climate and Abstraction Impacts in Atoll Environments (CAIA)" (2015-2017), both executed by SPC, demonstrated for the national groundwater reserve of South Tarawa, the capital of Kiribati, the value and integral role of water resources monitoring in aquifer management. Through the development of a numerical model which facilitated understanding the aquifer's response to external influences such as rainfall and groundwater abstraction, aquifer management options linked to regular monitoring of groundwater quality (salinity) were demonstrated to the Government of Kiribati as an adaptation technique to increase water security.

The New Zealand-funded "Strengthening Water Security of Vulnerable Island States" project (2014-2019), executed by SPC, built on the lessons learnt to support the atoll countries of Cook Islands, Kiribati, Marshall Islands, Tokelau and Tuvalu in building the skills, systems, and basic infrastructure to better anticipate, respond to, and withstand the impacts of drought. Water security management options were identified through the combined involvement of three key sectors - disaster management, water utilities, and weather services.

The EU-funded "North Pacific - Readiness for El Niño (RENI)" project (2017-2020), executed by SPC, focused on securing food and water resources for vulnerable communities in the outer islands of FSM, RMI, and Palau. The project implemented local area structural measures to support El Niño resilience with special attention to the rights of women and vulnerable groups, and national measures - institutional, planning, and technical – to support readiness for future El Niño events.

The EU-funded Global Climate Change Alliance Plus – Scaling up Pacific Adaptation (GCCA+ SUPA) project (2019-2023), executed by SPC, is aiming at scaling up climate change adaptation measures in specific sectors, including water security, supported by knowledge management and capacity building. The project is working with the Governments of Pacific Island Countries including RMI, Tuvalu, FSM, and Kiribati.

3.2 Lessons learned from recent outer island programmes

In working with remote island communities, the proposed programme will likely face a set of difficult and intersecting challenges and should consider the barriers encountered by similar past projects, as well as identified factors of success. Some of the key challenges and factors of success experienced by past SPC projects in outer island atoll environments are outlined below.

3.2.1 Embracing the demonstration role of outer island programmes

Access to clean drinking water and safe sanitation are critical development needs for the Pacific's remote atoll communities. Given the scale of the issue, individual Projects can at best aim to support a portion of the population to take meaningful steps towards addressing these needs. Despite the efforts of multiple government and development programmes, many remote communities continue to struggle to establish the improved infrastructure and practices to meet the SDG6 target of universal access to clean drinking water and safe sanitation facilities. In this regard, development projects working with selected communities can play an important demonstration role for Pacific governments, communities, and development partners. This demonstration role extends to the demonstration of appropriate and sustainable technologies and capacity development, as well as the demonstration of effective project modalities.

3.2.2 Managing the geographic reach of activities

An overly large and broad geographic spread of target communities is likely to present a significant challenge to project delivery. SPC and other development partners have in the past experienced challenges in the implementation of projects that covered a large number of widely disbursed communities Such an approach can spread resources thinly, making it more difficult to deliver the focus needed to fully support community needs while also attending to urgent and unexpected issues arising. In choosing target communities, it will be important to fully consider the impacts of scale and reach on project outcomes at the design stage, in order that all parties fully understand the constraints in delivering projects across multiple remote-island locations.

A multi-island scope and broad geographical coverage can significantly limit the depth and continuity of community engagement possible, and careful consideration is required of the coverage and reach of the project in order to manage expectations, reduce operational risks, and maximize the potential for demonstrating transformational change that can be replicated in other communities by subsequent programmes. Focus at a single-island level is recommended, as this can provide opportunities for deeper and more sustained community engagement and provide a better platform for the collection of the health, environmental and demographic data needed to support the establishment of baselines and to measure impacts.

3.2.3 Managing complex procurement and supply chains

Pacific outer-island projects routinely experience significant logistical delays in the procurement and transport of required materials and equipment. This can impact on community interest, motivation, and commitment - in some cases resulting in flow-on delays in the completion of facilities. SPC has also experienced projects that faced multiple challenges in ensuring the safe storage of materials and equipment on-island, particularly where competing priorities existed on island for scarce building materials, and consideration will need to be made for security and safe storage by local communities.

Procurement processes can be constrained by the relatively small pool of local businesses and vendors, requiring additional time to identify and secure appropriate contractors. Wherever possible, procurement processes should be fit-for-purpose and encourage the participation of local vendors, which may require a level of flexibility to cater to local circumstances and constraints.

The project should also be aware of the elevated risk of natural disasters on Pacific supply chains, whereby disasters outside of a target country can have a profound impact on the availability of goods and services. As an example, the surge in construction in Fiji to address the impacts of Tropical Cyclones

Winston (2016) and Keni (2017) resulted in a shortage of building materials in neighboring countries such as Tuvalu and Kiribati, and a situation where major suppliers prioritized the allocation of materials to domestic needs, necessitating the negotiation of alternative shipping arrangements for existing outer-island projects and significantly impacting on project schedules.

3.2.4 Enabling necessary community engagement

Effective and sustained community engagement is of course critical to the success of projects involving outer-island communities, and the project will be well served to engage the support of local community liaison officers (or positions that can effectively incorporate this important role). The establishment of such roles can assist with the community mediation and consultation required during planning and implementation, and strengthen community ownership and engagement, including through periods of change (such as changes in island leadership roles). In SPC's experience, local project coordinators are not always equipped and resourced to undertake this critical role alongside their competing project management duties, and there is significant benefit in engaging the services of dedicated liaison officers.

Consultations with outer-island communities can take significantly longer than envisaged by project implementing agencies, often due to challenges in securing the availability of local stakeholders and in securing infrequent flights and shipping services. Communications difficulties and the unavailability of important groups such as women and youth, and key Ministry staff with competing schedules and commitments, can also delay necessary community engagement activities. If prolonged, the time between initial consultations and project implementation may enable shifts in community engagement to occur and in some cases individual and communal commitments to weaken. Maintaining consistent levels of engagement requires sustained focus and support that can be made difficult given the significant geographic, communications and logistical constraints.

Communication and awareness activities can be critical to supporting project outcomes through engaging local communities and strengthening links between local and national efforts. Collaboration will likely be required with a range of Ministries (such as the Ministry of Health), and the utilization of global event dates (such as World Water Day) as a platform to improve information sharing to target behavior change. Project support can empower participating Island Councils and schools to plan their own awareness activities, and engaging children in these events can enable almost all members of the community to be reached, as children are often the agents of change and encourage the involvement of parents, teachers, government officers and youths. In SPC's experience, there is a clear demand by Island Councils and schools for project support to engage in such awareness activities.

3.2.5 Ensuring adequate technical and administrative support at all levels

Central project-level leadership, guidance and backstopping will be required from design to completion, as well as specific technical support where required. Central assistance may also be required to support procurement and general administrative functions such as recruitment of staff through human resources, organizing travels for staff and consultants, freighting of cargo and equipment, publishing reports, finances, and IT support to ensure the activities were delivered by the remotely based team in a timely fashion.

The support and guidance of relevant Government agencies over the life of a project is always critical, but particularly to programmes targeting remote outer-island communities. Critical Government support includes the provision high-level guidance to navigate the project through the numerous

hurdles and challenges likely to be encountered, and the integration of project activities with strategic plans and policies to ensure the ongoing ownership of Government. Having project resources located within relevant local agencies can enable stronger co-operation and commitment and help enable the close technical collaboration necessary to support remote outer-island activities. In SPC's experience working in atoll countries, the recruitment of local technical staff can experience delays due to the limited availability of locally based specialists, who are usually in high demand.

For infrastructure interventions, dedicated local construction supervisors are essential to provide the technical oversight required throughout construction. For outer-island work, SPC recommends at least one supervisor be engaged per island, as Government counterparts are often not resourced to provide technical expertise during construction. The identification of appropriate local expertise will require early and active attention, as suitably trained specialists with relevant on-ground expertise are often in very high demand. If project schedules permit, SPC recommends considering a model of mentorship of junior construction managers to help build the capacity of local engineers, which can help longer term capacity by ensuring that local Ministries are equipped with trained construction supervisors to support future project implementation.

The programme will need to recognize the integral role of Island Councils as key partners to achieving and sustaining project outcomes. There is always a risk that the communities, despite being trained and equipped, will not fully carry out their agreed role to maintain the facilities, and it is therefore important for outer island initiatives to work closely with the Island Councils, being the key governing institutions on-island. Given the right support, Island Councils can continue beyond a project to work closely with communities to support the sustainability of the facilities. The programme should be aware of roles and responsibilities that already exist within the Island Council that are able to support the oversight and monitoring of facilities, and it is important that these roles are adequately considered in planning and decision making.

3.2.6 Support to local capacity and systems

Behavioral change is important but also difficult to achieve overnight and a longer timeframe and sustained efforts are needed to instill the required change. There is a risk that despite construction of drinking water facilities, acceptance, use and maintenance by the community will be limited. As such, individual projects need to operate in support of longer-term programmatic efforts by national Governments to strengthen local capacities.

As time progresses, commitments made by communities can change and levels of ownership can diminish, and there will be a continuing role for Government in supporting the efforts of local communities and technicians in sustaining community engagement in the maintenance and operation of facilities. This role should be supported wherever possible by the project through the development of local capacity and systems, including through the establishment of clear and ongoing roles and responsibilities, the identification of sustainable supply chains for parts, and the securing of robust warranty and service arrangements. Having a robust asset management system in place on-island can assist in ensuring the availability of the small fittings regularly required for maintenance works, and sustainability of facilities will be significantly strengthened by ensuring routine checks and the availability of necessary spares parts such as taps, tap fittings, pumps, and controllers.

There may also be a need for strengthened laws and regulations to safeguard the facilities, either through revision of current policies or development of new legislation at the national level. Village by-

laws created by island-communities often vary in their effectiveness and could benefit from expert local guidance and direction. By example, improved mechanisms to raise and manage funds at the island level could assist Island Councils to establish a pool of funds that can be easily accessed for the ongoing maintenance of fittings and tools when required.

3.2.7 Establishing benchmarks and tracking targets

A challenge common to the Pacific, and in particular to outer-island locations, is the identification of available data to project baselines and targets. Relevant WASH data such as those obtained from health statistics are often aggregated at an island rather than a community level, as health centers are usually shared between multiple villages. Timely attention is needed to ensure that appropriate datasets are made available, including through the engagement of agencies that may not directly involved in project implementation. There is also a challenge inherent to all outer-island WASH programmes in accurately attributing impacts on health in data-poor environments, as these impacts can be difficult to isolate from other factors and often manifest themselves in the years after programme closure. In these cases, consideration should be given to the identification and use of alternative surrogate indicators.

3.3 Ongoing relevant programmes

Table 8 presents a non-exhaustive list of relevant projects and programmes taking place in the four SIFWaP countries. The relevant activities are identified for each project to support the planning of water interventions that will be conducted under SIFWaP.

Table 8. Ongoing relevant projects/programmes in the SIFWaP countries.

Project/ Programme	Donor	Countries	Water sector interventions	Implementation period
Water Scarcity Programme (SPC)	New Zealand's Ministry of Foreign Affairs and Trade (NZ-MFAT)	RMI, Tuvalu, Kiribati	Installation of drought-resilient water supply systems (rainwater/ groundwater) in outer islands. Improvement of skills and capacity, and institutional arrangements to enhance water security.	2020-2024
Managing Coastal Aquifers Project MCAP (SPC)	Global Environmental Facility (GEF)	RMI, Tuvalu	Water resources assessments in outer islands and installation of groundwater supply infrastructure. Strengthening of institutional arrangements and improved community-based water resources monitoring and management.	2020 - 2024
Global Climate Change Alliance Plus Scaling Up Pacific Adaptation GCCA+ SUPA (SPC)	European Union (EU)	RMI, Tuvalu, Kiribati, FSM	Strengthen sector-based climate change and disaster-risk-management strategies and plans through improved coordination and integration in implementing organisations and utilising a gender-sensitive/rights-based approach and involving all stakeholders.	2019-2023
Enhancing Climate Information and Knowledge Services for resilience in 5 island countries of the Pacific Ocean	GCF	RMI, Tuvalu	Appropriate adaptation interventions to address climate change threats, require tailored climate information and people-centred multi-hazard early warning services covering oceans and islands for all sectors. This programme will build capacity to provide such services for 5 vulnerable Pacific Island Countries by using a multi-country approach	

5 Addressing Climate Vulnerability in the Water Sector (ACWA)	GCF	RMI	Increase the resilience of water resources for drinking and hygiene through the improvement of household and community rainwater harvesting and storage structures, securing groundwater resources from seawater intrusion, strengthen the technical capacities of national and subnational institutions and key stakeholders to integrate climate change risks into water governance processes.	2020-2027
Chuuk Water Supply and Sanitation	ADB	FSM	Improve water and sanitation in Chuuk through (i) increasing the number of registered households with access to uninterrupted, safe, and climate and disaster resilient water supplies; (ii) provision of effective, efficient, and safe sanitation services to the residents of Chuuk; (iii) enhanced and sustained awareness and behaviour of hygiene and water conservation to raise residents' awareness of water issues and willingness to pay, and sustainably improve their hygiene behaviour; and (iv) continued strengthening of Chuuk Public Utility Corporation's financial, technical, and operational sustainability.	2020 - 2023
Climate Early Warning Systems in PICs (SSC) - Bonriki-Kiribati	India government funding	Kiribati	Installation of near-real time salinity and flow meters on all Bonriki gallery wells and water treatment plant to optimise groundwater abstraction by the Public Utilities Board for the residents of South Tarawa, Kiribati, particularly during drought periods.	2020
Funafuti Water and Sanitation Improvement	ADB	Tuvalu	Improvement of water supply and sanitation infrastructure and service to all households in Funafuti, and enhancement and sustained hygiene awareness and behaviour and water conservation.	2020-2023
IWRM - Water and Sanitation Governance Improvement (SPC)	NZ MFAT	Tuvalu	Finalise Water and Sanitation Policy and Drought Response Plan in Funafuti and adapt the implementation of these policies/plans in the outer islands.	2021-2023
Kiritimati Water Supply Project (SPC)	EU	Kiribati	Improved operation and management of water supply and sanitation scheme in Kiritimati Island and nearby outer islands through strengthened economic dialogue on Public Financial Management (PFM) reforms, improved access to safe and sustainable drinking water; strengthened the provision of adequate and equitable sanitation and hygiene facilities; and improved Community and household resilience	2020-2024
South Tarawa Water Supply Project	World Bank with co-financing from Asian Development Bank (ADB) and Green Climate Fund (GCF)	Kiribati	Improvement of South Tarawa water supply through (1) Improvement of water supply services to increase resilience of the services to climate change. (2) Institutional strengthening and implementation support that contributes to the sustainability of water-related investments funded in 1 and to help improve the operational efficiency and financial viability of Public Utilities Board. (3) support the formulation and implementation of a comprehensive and intensive 5-year Water, Sanitation and Hygiene (WASH) Awareness program	2020-2027

Vaitupu Island Water Supply Project (SPC)	NZ-MFAT	Tuvalu	Construction of a groundwater supply in Vaitupu island and improved operation and sustainability through community-driven management structures	2021-2022

4. Review of SIFWaP proposal

In the proposed project framework, the problem of water security is tackled through 3 parallel components addressing needs in hard investments, community planning and awareness raising, and in the policy environment at the national level. The suggested implementation modality identified in the SIFWaP project proposal is a hub-and-spoke project management structure. That is a centralized Project Management unit based in Fiji to support National Delivery Units based in each of the four countries, who in turn will manage the implementation undertaken by NGOs, competitively selected, and engaged under performance based contractual arrangements. The proposal indicates up to 10,000 households could benefit.

Component 1: Investments in water security

Component 1 accounts for up to 50% of the total project costs and proposes the implementation of 500 private good investments aimed at benefiting private individuals and 250 public good investments aimed at benefiting an entire community. The water supply interventions identified in component 1, would be implemented under the public good investments. The available funds for the nominal 250 public good investments (1 per island) under component 1.2, USD 4M, equates to an average unit cost, of USD 18,000 per public good investment, including the community contribution.

It is suggested that the current proposed approach, of implementing a large number of low-cost interventions, will considerably limit the type and impact of water security interventions, especially when considering logistics and transportation costs in the region. Also, the management of the large number of individual agreements with communities (250), and review of interventions required at each community, will increase the complexity, making the task of managing the individual implementations, and evaluating the success of the implementation, extremely challenging, increasing the risk of failing at achieving the proposed indicators and ongoing sustainability.

Existing NGOs in the selected countries may also be challenged in the delivery of the planned intervention, given the difficulties of working in remote locations with small communities, and the complex logistics of shipping materials and equipment. Additionally, it may be difficult for the project to meet its internal procurement and capacity assessment requirements for some of the individual NGO's, given the limited market of capacity and skillsets available in each country, thereby reducing the competitiveness of the selection of implementation partners. To improve the access to suitable partners, it is recommended that consideration is given to extending the list of potential service delivery partners to both the private and public sector, including commercial construction companies and contractors, and government departments, such as Public Works Department (PWD), Tuvalu, who have experience in the construction aspects of water supply systems at different scales and with remote island communities.

As mentioned earlier, it is recommended to fully consider the impacts of scale and reach on project outcomes in order to maximize their potential. This can be achieved by embracing the demonstration role of this project and associated interventions and promote their replicability potential across multiple outer island locations. In context of the proposed implementation modality, and the challenges of working in remote and small communities, it is highly recommended to re-think the approach and consider implementing a smaller number of public investments, allowing more investment of time and resources to achieve a larger impact locally at addressing the problem of water security. Maintaining a

project focus on a large number of small investments is expected to increase the complexity and reduce the overall effectiveness of achieving the objective of improved water security in these locations.

For the selection of project areas/islands and communities to be engaged, it is recommended that the initial selection criteria are based on the regional water security assessment conducted under this preparatory study and presented in Chapter 6 which can be used to obtain a preliminary prioritization. It is highly recommended to further discuss with the relevant national and local government bodies, island councils and community groups to confirm the preliminary prioritization results and to consider additional socio-economic factors which were not captured during this first-pass objective assessment.

As demonstrated in the regional water security assessment, rainwater harvesting may not always be the highest impact intervention. In many cases groundwater and/or desalination may be more impactful, where rainfall analysis indicates that rainfall is insufficient to cover household water needs at specific islands. Groundwater interventions while expected to be more costly in the initial setup, have greater cost benefit returns and resilience compared to desalination or rainwater harvesting infrastructure.

Component 2: Community engagement

Effective and sustained community engagement is critical to the success of projects involving outer-island communities, and the project will be well served to engage the support of local Island facilitators and of community field officers. The role of these community liaison officers goes well beyond the identification of priorities and the raising of awareness to encourage the acceptance of innovative practices. Their role is critical in strengthening community engagement and ownership of project interventions, strengthening the links between local and national efforts and ultimately ensuring the long-term sustainability of project outputs and outcomes.

With regards to community engagement and planning it is recommended that during the project preparation phase or alternatively in the early stages of project implementation, a suitable project-level Grievance Redress Mechanism will be established at the project sites to receive and address concerns about the impact of project interventions on external stakeholders. These GRMs will build on existing mechanisms already present within the local government structures and will follow the local decision-making processes through a GESI-sensitive lens to ensure participation of all groups. It is recommended that the establishment and communication of GRMs to the communities is accompanied by socio-cultural surveys and community consultations to obtain Free Prior and Inform Consent (FPIC) on the proposed project interventions.

After review of national legislations in the four project countries, it is likely that the criteria for defining the peoples concerned in the project's Social, Environmental and Climate Assessment Procedures as "indigenous" are met. As such, during the community consultations prior to any infrastructure developments, a FPIC should be sought to ensure that all peoples concerned have the right to freely pursue their economic, social, and cultural development and to ensure Indigenous Peoples' rights to lands, territories, and natural resources.

Preliminary consultations with communities and landowners should be conducted during the project preparation phase to ensure that loss of land access will not lead to resettlement, or a displacement of people or livelihoods. It is recommended that community consultations and national design meetings are conducted with communities living in the outer islands and not only with outer island representatives living in the capital. This will improve the commitment and long-term sustainability of project interventions at the local level. It is expected that these consultations will also reveal that public understanding surrounding the "ownership" of groundwater, which varies from country to country,

island to island and community to community, can be a sensitive subject given the common customary belief that people who own the land also own what lies beneath it, even if this position is not supported in state policy. As such, the project should ensure that all land access and use issues are addressed prior to any project intervention and allow sufficient time for consultation and permission processes to occur. Prior to any construction activities, consultations using established island practices, as well as GESI strategies to extend the reach of consultations, should be undertaken. The consultations should specifically include the detailed proposed construction activities, the identification of the land proposed for development, and the limitations on land use activities post construction. In practice, consultations will include details on the process of land clearing compensation, or other areas of compensation, as well as the process for securing land use. Informed consent through the established island council processes should be sought. If concerns arise during implementations consultations, there should be scope in the project design for alternate sites to be selected and the selection of new sites should include a GESI-sensitive participatory consultation with all stakeholders.

During the community consultations, land tenure arrangements for the proposed sites should be identified and discussed, being guided by existing national legislation and any relevant island by-laws. Land tenure arrangements will follow the "Falekaupule Act 1997", the "Crown Acquisition of Lands Act 2008", and the "Water Supply Act 1967" for Tuvalu, the "Land Acquisition Act 1986" and the "Planning and Zoning Act 1987" for RMI, the "Local Government Act 1984", "Native Lands Ordinance 1956", and the "Land Planning Ordinance 1977" for Kiribati.

Component 3: Enabling policy framework

Component 3 focuses on drafting and updating national policies and strategies for sustainable water security through the formation and support of inter-agency task forces. The four project countries have made varying levels of progress towards the endorsement of national water policies and strategies. In RMI the National Water and Sanitation Policy and Proposed Action Plan was approved in 2014 and it is currently being reviewed for update. In Tuvalu the Sustainable and Integrated Water and Sanitation Policy 2012-2021 was drafted in support of the key planning document, the National Strategy for Sustainable Development. Although the policy was formally approved, the relevant implementation plan was only drafted in 2020 and has not been approved yet. The policy is also currently being reviewed for update. Kiribati has endorsed a National Water Resources Policy and a National Sanitation Policy. Both policies are currently being reviewed for update.

With regards to the proposed efforts on enabling policy environment on water security at the national level, it is recommended working towards the development of technical guidance documents in support of updating national policies and strategies. The drafting of updated water sector policies and strategies may be realistic within the project's timeframe but the actual endorsement of these policies and strategies by Government, may take longer and is beyond the control of project partners. It is therefore suggested not having outcome indicators which depend on document endorsement by national governments and ministries. Where possible, it is recommended linking into existing national water and sanitation committees to ensure the long-term continuity and sustainability of these efforts, given their longer timeframe.

Table 9. Status of national water and sanitation policies and plans.

Country	National water and sanitation policies and plans
Kiribati	Policy and plan exist and have been formally approved – policy currently being reviewed
RMI	Policy and plan exist and have been formally approved – policy currently being reviewed
Tuvalu	Policy has been formally approved but expires in 2021 – policy currently being reviewed for approval by the end of 2022 – national action plan exists in draft version but has not

	been approved – individual water and sanitation plans and drought response plans to be drafted and approved for outer islands by the end of 2022
FSM	Policy formally approved – no plan exists

5. Water supply options

The proposed project implementation strategy is to utilize existing private construction contractors and NGOs for the implementation of water security investments, through performance-based contracts, managed by the National Delivery Units. This approach, while having the benefit of ensuring that the work is undertaken locally can be restrictive in that interventions that are complicated, unfamiliar, or require specific skill sets may not be suitable or available for that community or the location.

The approach recommended to identify, implement, and monitor appropriate interventions is suggested below.

1. Assessment of needs. Water resource assessment of each village/community in each targeted island. While guidance on which islands are more vulnerable to water security can be objectively identified using evidence-based methods (see Chapter 6) it is critical that onsite meetings are held with each community for the targeted islands to identify specific interventions and manage community expectations. Engagement strategies with communities should be considered prior to deployment.
2. Determination of intervention types. Identifying which interventions will be most appropriate and their significance for water security should be a starting point for discussions with communities, from which community preferences are then considered. Benefits/costs for proposed intervention is a useful approach to assist with the decisions made by communities.
3. Construction costs. Costs and availability of labour in each village/community based on a standard award. Increasingly there is a need to recognise that communities, despite directly benefiting from the proposed intervention, have an expectation that their labourers will be financially rewarded for their services. This should be negotiated during the early stages of the proposed intervention and can be used as criteria to help identify type and location of proposed intervention.
4. Accessibility considerations. Land being limited in the Pacific is of course a very sensitive issue. In general, throughout the Pacific, land can neither be bought nor sold, requiring a negotiation with the traditional owner(s) for its long-term access, being especially true when considering development of infrastructure. Certain legal instruments such as formal lease arrangements and Memorandums of Understanding are recommended to be negotiated and established with the traditional owner(s) as soon as possible after the site, for the proposed works, has been identified. Ongoing access to the infrastructure and the water supplied by the different parts of the community should be incorporated into the formal agreements to provide greater certainty on the investment. As noted above this can be used as criteria to help identify type and location of proposed intervention and should be negotiated during the early stages of the proposed intervention once the site is known.
5. Governance assessment. Given the individual communities and households will be responsible for the ongoing operation and maintenance of the water supply systems it is important that an assessment of the existing mechanisms for ongoing operation, management and maintenance of any water supply infrastructure is considered prior to a decision to invest in any specific intervention. This should consider existing island community governance mechanisms, including the structure/membership and operation of any “water user group’ (WUG) or water

and sanitation committee, and the inclusivity of the WUG to all aspects of the community, recognizing, that women are generally responsible for a household's water needs, and should form part of the WUG. Other considerations include the capacity and approach of the WUG to raise funds when needed to undertake operation and maintenance of a water supply system. As noted above this can be used as criteria to help identify type and location of proposed intervention and should be negotiated during the early stages of the proposed intervention.

Throughout the pacific generally, there is an established sense of fairness, the “Pacific Way”, whereby there is a tendency for the sharing of available resources which contributes to harmony and resilience within and between communities. An appreciation of this becomes important when considering the implementation of project activities to ensure that each individual community is both recognised and treated equitably or fairly, and that each community has access to the same communication, interactions and similar valued interventions. Within remote island settings there is a connectedness and interaction between individual communities which should be considered in designing project interventions. It is recommended that each individual community/village be consulted and assessed for its potential consideration in any proposed interventions, and that established social and cultural norms within and between communities are identified and respected. For example, it is common for two communities to be geographically linked however consider themselves as separate entities with separate approaches to shared issues.

The following interventions are considered to be suitable for implementation by existing private construction contractors, government entities, and NGOs with limited additional training. More complex interventions may require additional steps, such as water resource assessments and desalination installations, requiring additional technical support to ensure they can be successfully implemented.

Experience suggests that while the individual communities recognize the need to be self-reliant in the operation and management of their water supplies, they will continue to be guided by the national government on recommended approaches for water security, and availability and cost of materials for ongoing operation. The guidance by national governments includes standardization of water supply infrastructure, water quality standards, preferences for different water sources, and recommendations for water management approaches.

It is therefore recommended that designs and approaches link where possible to existing designs and standards which are endorsed by government and communities alike. Building on these existing approaches where possible will strengthen the sustainability and operation of the interventions.

The use of commonly available and quality materials is recommended to improve the sustainability. Polyethylene piping and tanks is recommended over PVC, as is standard sized materials and fittings. Annex 4 provides examples of the type of water supply interventions suggested.

Table 10. Material costs for recommended intervention types.

Water Source	Intervention Type	Estimated Costs $USD (materials only)	Application
1. Rainwater Harvesting	1.1. Community RWH cistern: construction of a community storage to an existing building such as a church or community hall (24 m * 12 m), includes construction of concrete cistern 12 m * 2 m * 2 m, installation of fascia boards, guttering, downpipes and transmission pipes, a handpump and a tap stand. It does not include replacement of metal roof.	$18,000	Community RWH systems are preferable as they allow management of water supply for community and are more accessible during times of need. Low roofs require construction of concrete cisterns, Kiribati. Cisterns if well-constructed is often more sympathetic with village architecture. If poorly constructed, can result in leaks
	1.2. Community RWH sheltered rain tank: improvements to an existing building (assuming 24 m * 12 m dimension) includes the installation of 5.7 m * 3.3 m tank shed and 2 * 10,000 L tank, with a fenced tap stand. Does not include replacement of metal roof on the existing building.	$21,000	Established governance mechanism on the access and use of these facilities should be a pre-requisite prior to intervention. Applicable in most village settings with established communal governance
	1.3. Community RWH cistern and sheltered rain tank: Suitable where rainfall is sufficient with RWH improvements to existing communal buildings (assuming 24 m * 12 m dimension); includes the construction and installation of 5.7 m * 3.3 m tank shed and 2 * 10,000 L tank that has a separate tap stand overflowing onto 12 m * 2 m * 2 m cistern, that will be accessed using a hand pump to a fenced tap stand.	$26,000	Intervention is a hybrid of 1.1, and 1.2 intervention types and would be applicable where sufficient rainfall, with higher variability, increased frequency would be expected. Intervention considers an increase to the available storage, with overflow from the main PE tanks into a cistern, which is available for use during extended dry periods
	1.4. Standalone RWH system: a purpose-built structure is constructed for water supply. Includes construction of new tank shed (10.4 m * 6.6 m), 4 * 10,000 L PE rainwater tanks, guttering, fascia boards,	$20,500	Standalone RWH systems provide additional communal storage, but in the past have suffered from poor governance on the ownership, access, use, and responsibility for operation and maintenance of the infrastructure and water,

	downpipes and metal roofing materials, and tap stand.		limiting their effectiveness and sustainability. Land acquisition and any compensation agreement needs to be formalized prior to intervention.
2. Groundwater	**2.1. Infiltration gallery supply system**: construction of horizontal wells 30 m each side (galleries) to a centralised well with solar submersible pump to header tank and distribution to 10 standpipes in the village. Includes solar shed, submersible pump, header tank (10 KL), pipe work, 10 standpipe locations.	$100,500	Suitable for communities of up to 500 people, in a village setting. Formal arrangements for long term access required, and some land clearance required. Established governance mechanism on the access, use operation and maintenance of these facilities required. Suitable for potable and secondary purposes. Machinery for excavation and installation of gallery and burying pipework required
	2.2. Communal groundwater supply system: includes the identification of a suitable groundwater resource through geophysical survey, construction of horizontal wells up to 6 m in length, either direction, solar shed, solar panel, low yield submersible pumps, flow meter, non-return valve, gate valve, tank stand and a 1 KL tank, fencing, distribution lines, 5 tap stands per village.	$32,000	Groundwater supply for up to 10 households. Suitable for potable and secondary purposes. Formal arrangements for long term access required, land clearance required. Established governance mechanism on the access and use of these facilities required. Suitable for potable and secondary purposes. More appropriate for lower density communities, use of machinery for excavation and installation recommended
	2.3. Individual groundwater supply system: standard well design without gallery arms. Access is via a bucket and well is located away from known contamination sources but within household area. Water is abstracted using a bucket.	$3,500	Individual well – suitable for secondary water supply purposes, e.g. washing, cleaning, agriculture, generally not suitable for potable purposes. Often is able to be constructed by the village. Recommend the sue of crane truck for installation of concrete rings
3. Desalination	**3.1. Small sized desalination unit:** 250 L/hour capacity	25,000	Useful for emergency water supply purposes. Requires consideration to ongoing operation and maintenance costs, estimated to be $3/m^3. Estimate is for standard electricity and not diesel costs, and doesn't include depreciation, maintenance costs, cost of delivery trucks and personnel costs so is a minimum cost.
4. Distillation	**4.1. Solar still:** up to 22 L/day capacity Solar Water Distiller | Water Distillation Kit | H2o Labs	3,100	Requires sunny conditions. Limited to emergency purposes at household level only given the small volume of water delivered. Application in the Pacific has been low. Suitable for individual household.

Table 11. Shipping costs.

Country	Capital – Island (Charter or std shipping)	Estimated Costs $USD	Comments
Kiribati	South Tarawa – Outer islands	89,000	Estimate from KIRIWATSAN II project. Charter cost inclusive of shipping all building materials for a number of sites, also includes shipping of trucks, machinery, and fuel to the island.
RMI	Majuro – Outer islands	35,000	Charter costs for shipping of building materials only. Does not include truck and plant, and fuel shipping costs.
FSM	Pohnpei - Kapingamarangi	35,000	Charter costs for shipping of building materials only. Does not include truck and plant, and fuel shipping costs.
Tuvalu	Funafuti – outer islands	30,000	Estimate (R2R Tuvalu 2017) – charter costs for shipping of equipment, personnel, and fuel for survey.
Fiji - Kiribati		5,500	Per container, port fees not included
Fiji - Tuvalu		5,000	Per container, port fees not included

Table 12. Labor and travel costs (estimates).

Personnel	FSM $USD/day	Kiribati $USD/day	Tuvalu $USD/day	RMI $USD/day
Construction lead	$50	$40	$45	$100
Carpenter/bricklayer	$28	$35	$40	$85
Plumber	$92	$35	$40	$85
Labourer	$23	$25	$30	$50
Assume $80/day perdiem/pax and $200/return travel/pax per island				

Table 13. Labor and plant costs for each water supply intervention (estimates).

Intervention Type	Time requirement (estimate of days)	Estimated Costs $USD (construction team and plant)				Comments
		FSM	Ki	Tv	RMI	
Community RWH cistern: requires excavation of 12 m * 2 m * 1 m cistern construction (cement blocks, cement/waterproofing), fascia board/gutter installation, plumbing, tap stand	10 days	2900	2450	2850	5550	All constructions require a construction team consisting of: Lead (1) Carpenter/bricklayer (2) Plumber (1) Labourers (4) Access to truck with crane, excavator if available, slab required
	Excavator $700/day - 2 days Crane Truck $200/day - 10 days	1400 2000				
Community RWH sheltered rain tank: tank stand construction, fascia board/gutter installation, plumbing, tap stand	6 days	1740	1470	1710	3330	
	Crane Truck $200/day - 6 days	1200				
Community RWH cistern and sheltered rain tank: requires, tank stand construction, excavation of 12 m * 2 m * 1 m cistern construction (cement blocks, cement/waterproofing), fascia board/gutter installation, plumbing, tap stand	14 days	4060	3430	3990	7770	
	Excavator $700/day - 2 days Crane Truck $200/day - 14 days	1400 2800				
Standalone RWH system: requires, tank stand construction, roofing, fascia board/gutter installation, plumbing, tap stand	6 days	1740	1470	1710	3330	
	Crane Truck $200/day - 6 days	1200				
Infiltration gallery supply system: excavation of horizontal wells 30 m each side (galleries), solar shed, submersible pump, header tank (1 KL), pipe work, 5 standpipe locations.	14 days	4060	3430	3990	7770	All constructions require a construction team consisting of: Lead (1) Carpenter/bricklayer (2) Plumber (1) Labourers (4) Access to crane truck and excavator required
	Excavator $700/day - 8 days Crane Truck $200/day - 14 days	5,600 2,800				
Communal groundwater supply system: excavation of horizontal wells 6 m in length, either direction. solar shed, solar panel, low yield submersible pumps, flow meter, non-	10 days	2900	2450	2850	5550	
	Excavator $700 - 6 days Crane Truck $200/day - 10 days	4,200 2,000				

return valve, gate valve, tank stand and a 1 KL tank, fencing, distribution lines, 5 tap stands					
Individual groundwater supply system: excavation and plumbing	2 days	580	490	570	1110
	Crane Truck $200/day - 2 days	$400			

Sustainability risks

Presented below are the key concerns/risks associated with the introduction of water supply and sanitation systems and suggested mitigation options to be used alongside the implementation of the proposed systems designs. While these have been specifically identified during previous work in Kiribati (Sinclair et al. 2015), they are considered relevant for all project countries.

Table 14. Key concerns/risks and suggested mitigation options.

Key concern/risk	Suggested mitigation options
1. No statutory basis for island council to control and administer water, or to impose and collect charges for the supply of water services in the outer islands.	It is proposed adopting community-based solutions and make use of village by-laws and existing social structures to administer and control water. It is recommended developing Water Supply Plans with village communities detailing implementation, operation, and maintenance of water supply. Two separate legislations may be required for urban and outer island settings respectively. It is recommended delivering water and sanitation infrastructure to the community free of charge. Agreements are then made with the community, signed by each household and potentially strengthened by a Cabinet paper.
2. Legal protection of water source areas and reserves.	All land in outer islands is privately owned. In many cases existing Government Acts permit the declaration of water reserves over private land at specified locations but these do not usually extend to outer islands. Custom law generally identifies the landowner as owning the water reserve. Sourcing public village water supplies from private lands may require lengthy negotiations. Communities prefer accessing water from a supply that is located close to their village, of which they have greater ownership and control over using existing by-laws. Land ownership and accessibility issues are generally not expected when the landowner(s) is a community resident. To minimise issues with multiple landowners and to increase security of supply with distributed systems, it is recommended constructing multiple small scale water supply points, at various locations that are more socially and technically acceptable.
3. Lack of ownership and engagement.	Past water supply projects have been unsustainable due to minimal or no local participation during the assessment, design, construction, and management of water security interventions. Discussions with communities have suggested that using a water source close to the village will promote 'ownership' with greater self-governance and control, increasing their responsibility to the infrastructure and the supply. This can be achieved through the development of a Water Supply Plan detailing the responsibilities and funding mechanisms for repairs and replacement of infrastructure.
4. Capacity to pay for the use of communal water supply systems and water technicians.	Outer island households are cash poor. Village councils indicate that mechanisms already exist within the village social systems such as by-laws and 'fund raising' which can be used to raise money for water supply and sanitation systems. These funding mechanisms, which may be different between communities, should be identified at the community level and the appropriate and agreed funding mechanism for operation and maintenance be included in the Water Supply Plan.

6. Regional water security assessment

A regional water security assessment was conducted for the purposes of this study as an opportunity to identify disparities between water demand and current water availability across the project countries, using expert analysis of available information incorporating rainfall, census and physical data. The assessment allows for the comparison of expert derived water vulnerability indicators across different scales. It is an attempt to consolidate the existing data into a spatial platform which allows non expert users to navigate from regional to island scale to prioritise where, and the type of interventions, which will have most impact for water security.

An island prioritization approach for water security was conducted considering the different types of water sources available on each atoll, and their resilience with respect to population demands. This information was used to objectively indicate the types of specific interventions that would be of most benefit in addressing the needs of water scarcity for that community, islet, atoll, country, and sub regionally. Of course, water vulnerability is not just a function of available storage and rainfall, but includes social, cultural, economic and capacity considerations to guide decisions on where, and the type of interventions required. This evidence based objective approach was however a useful first pass to help identify where interventions are needed and what type of interventions are likely to be most effective, on which an overlay of country identified social, cultural and economic considerations can guide project design and implementation.

National census data and project information on population, number of households, water source reliance, roof areas, and proportion of roof guttering were used in combination with rainfall probability at the island level to prioritize islands in terms of drought vulnerability and identify which islands are better off investing in rainwater harvesting interventions and which ones should also look at alternative water sources such as groundwater and desalination.

The results were used to create a climatic, socio-economic, and investment suitability overview of water security in the four project countries. This overview is presented by means of three interactive thematic maps hosted on ArcGIS Online and presented through the ArcGIS StoryMaps feature to communicate the message in a simple and targeted manner. The maps can be accessed at https://arcg.is/1umqGG1. The detailed methodology and island prioritization results in tabular format are presented in Annex 2.

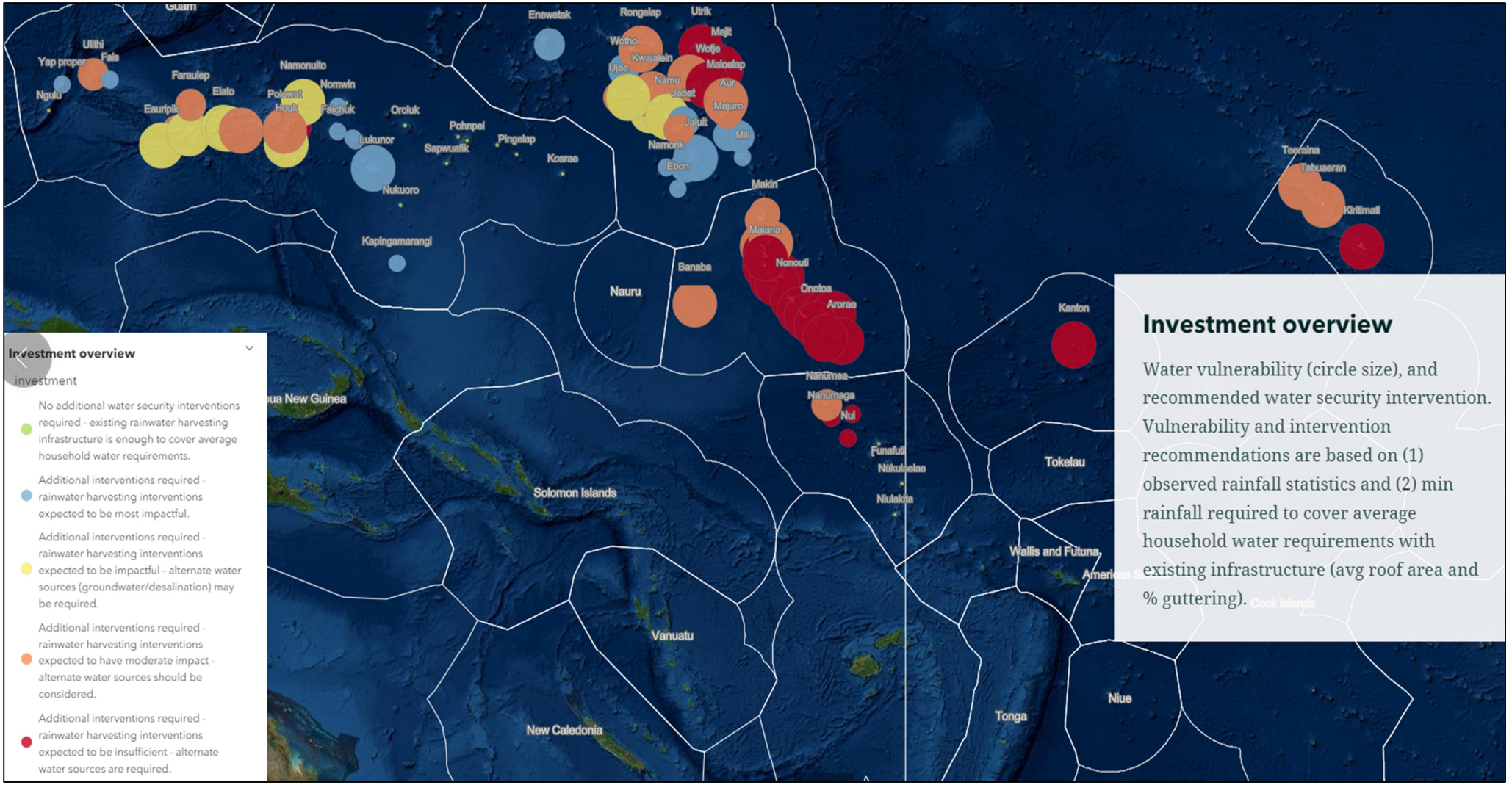


Figure 3. Investment overview Arc GIS Online StoryMap (https://arcg.is/1umqGG1).

7. Implementation considerations

7.1 Country implementation arrangements

A review of key government and non-governmental arrangements in the four countries was undertaken in terms of their current responsibilities and capacities in delivering specific roles within the water sectors. This is shown in Annex 3 and special attention should be placed on the responsibilities and capacity of service directed to the outer island communities. While there are similarities in how government ministries are organized to target, support and govern various aspects of hydrology such as the role of the weather services, National Disaster Management Offices (NDMO), water supply and public utilities, it is clear that the roles of local contractors and the empowerment of communities particularly in the rural and/or remote setting will be vital in the timely implementation and construction of the proposed water supply interventions as well as the sustainable operation and maintenance of these infrastructural investments.

7.2 Environmental sustainability review and policy considerations

With respect to the environmental sustainability of the project, an early environmental assessment should be carried out to ensure that the project implementation is not (temporarily or on longer term) impacting critical habitats, endangered species or nearby biodiversity. Preliminary environmental impact assessments should be conducted following the national legislation in the project countries and more specifically the "EIA Regulations 2014" for Tuvalu, the "EIA Regulations 1994" for RMI, the "Environment Act 1999" for Kiribati and the "Environmental Impact Assessment Regulations" of the FSM Environmental Protection Act. The project should follow the Pacific Waigani convention which the project countries have all ratified, aiming at prohibiting dumping of hazardous waste and ensuring availability of adequate treatment and disposal facilities for its management. A disposal plan, which should be built in collaboration with local project stakeholders and existing waste management technical partners, will ensure all materials imported in the countries required for the proposed installations will be disposed appropriately. Finally, it is recommended that all travel-related CO_2 emissions will be offset through appropriate compensation mechanisms.

7.2.1 Tuvalu

According to the Environmental Impact Assessment Regulations 2014, the procedures for undertaking environment impact assessment include a preliminary environmental assessment report; and a full environment impact assessment. The developer must notify the Department of Environment of the proposed activity and apply for a development consent under these regulations ($500 fee). The Preliminary Environmental Assessment Report must contain a brief description of the development proposal; a brief description of the area to be affected and the nature of the proposed change to the area (including a location map and site plan); a brief justification for the development proposal; an assessment of all reasonably foreseeable adverse and positive impacts, including long-term and short-term, primary and secondary consequences; an indication of possible alternatives to mitigate any identified adverse impacts; and an indication of measures that the proponent intends to take to mitigate or avoid identified adverse impacts.

The Minister may give approval to any development activity based upon a preliminary report which the Department has confirmed will not cause any significant adverse impact to the environment. An approval given under this regulation shall be in writing under the hand of the Minister or the Director (acting on the authority of the Minister) and may impose conditions determined by the Department to minimise any adverse impacts to the environment.

With regards to land acquisition, according to the Falekaupule Act 1997, a Kaupule may, for the purposes of performing its statutory functions or those of the Falekaupule, acquire by purchase, lease, gift or exchange, any land either within or outside the Falekaupule area. Functions of the Falekaupule relevant to water resources management are to provide, erect and maintain a public water supply, and impose water rates in accordance with the Water Supply Act; to establish, maintain and control public wells, springs, bathing places, wash houses and swimming pools.

In determining the amount of compensation to be awarded for land acquired under the Crown Acquisition of Lands Act 2008, the High Court shall take into consideration:

1. the market value of the land at the date of the notice of intention to take such land;
2. the damage sustained by the person interested, by reason of the taking of any standing crops or trees which may be on the land at the time of taking possession thereof;
3. the damage, if any, sustained by the person interested, at the time of taking possession of the land, by reason of severing such land from his other land;
4. the damage, if any, sustained by the person interested at the time of taking possession of the land, by reason of the acquisition injuriously affecting his other property, movable or immovable, in any other manner, or his earnings;
5. if, in consequence of the acquisition of the land, the person interested is compelled to change his residence or place of business, the reasonable expenses, if any, incidental to such change.

Tuvalu has a special act to make provision for water supplies and relevant matters (Water Supply Act 1967). According to this Act, an Authority appointed by the Minister shall have power to make and construct cuts, channels, feeders, catch-drains, reservoirs, aqueducts, tunnels, pipes, pipe tracks, conduits, filters, trenches, mounds, engines, works and machinery as he/she may think necessary, proper or convenient for conducting adequate supplies of water, together with such reservoirs and other works as the Authority shall think necessary for securing regularity in the said supplies of water, and to clean, uphold and repair the said works and machinery in all times ensuing, and for any and every such purpose to enter upon, take and use any lands required to be entered, taken or used for such purpose.

The Authority may for the purpose of this Act enter into and upon any land or premises other than a dwelling-house and inspect, survey and take levels of the same and set out and ascertain such parts thereof as he shall think necessary and proper for making or erecting any works or machinery authorised by this Act, and may also bore, dig, cut, trench, get, remove, take and convey away and lay earth, clay, stone, rubbish and beds of gravel or sand for making works which may be got in carrying on the said works.

Where the Minister considers it necessary for the protection or conservation of any water catchment area, or otherwise to secure to Tuvalu or any part thereof adequate and pure supplies of water, he may by notice declare any area to be a water reserve.

7.2.2 RMI

According to the Environmental Impact Assessment (EIA) Regulations 1994 the proponent of each and every proposed development activity shall prepare and submit to the General Manager of the Environmental Protection Authority a Preliminary Proposal at the inception of the proposed development activity. The inception of a proposed development activity is the stage at which the proponent has a development goal and is actively preparing to make a decision on one or more alternative means of accomplishing that goal and the effects can be meaningfully evaluated.

The Preliminary Proposal shall be submitted on forms supplied by the Authority and shall contain at a minimum the following particulars:

1. Identification and contact information regarding the project proponent and beneficiaries;
2. A brief description of the proposed development activity;
3. A brief description of the methods, materials, and techniques used to accomplish the proposed development activity;
4. A brief description of the area to be affected and the nature of the proposed change to the area;
5. A statement of the commencement and completion dates for the proposed development activity;
6. A brief justification of the purpose and need for the proposed development activity;
7. An assessment of the cost of the proposed development activity;
8. A brief statement of possible adverse impacts to the environment, and possible alternatives to mitigate those impacts.

If a determination is made that the proposed development activity may have a significant effect on the environment, the General Manager shall notify the proponent in writing that an Environmental Impact Assessment is required.

The Land Acquisition Act 1986 makes provision for the acquisition of lands and servitudes for public use for payment of just compensation. In assessing compensation, the following is considered:

1. Where any land or servitude is taken, the amount of compensation shall include reasonably equivalent land rights for all interest holders or the means to obtain the subsistence and benefits that such land rights provide.
2. Whenever the taking of land or servitude forces those who are dispossessed to live in circumstances reasonably requiring a higher level of support, that fact shall be considered in assessing whether the compensation provided is just.
3. In determining whether compensation for land rights is just, the High Court shall refer the matter to the Traditional Rights Court and shall give substantial weight to the opinion of the Traditional Rights Court.
4. In construing this Section the High Court shall have due regard for the unique place of land rights in the life and law of the Republic.
5. In the event of a dispute to ownership among the persons interested in the land, the High Court shall adjudicate and determine the ownership of the property as part of the proceedings and determine the apportionment of compensation among the persons interested.

The Planning and Zoning Act 1987 provides for planning of inland water use (among others). The National Government Chief Planner may act in his capacity as advisor:

1. to formulate and submit physical development plans to the national government in relation to areas;
2. to formulate land and water use policy in Majuro and other atolls;
3. to advise all local government Councils:
    (i) in setting environmental standards and preparation of schemes for environmental improvement in municipal areas;
    (ii) in the formulation of and the execution of housing schemes in such areas;
    (iii) in the demarcation of zones and areas for better planning, environmental protection and landscaping; and

(iv) in technical planning services;

4. to advise on physical planning projects or schemes prepared by any local government Council or any statutory authority.

The local government Council may take into consideration in its planning and implementation program the necessity to establish and maintain catchment areas and water reserves for the collection and supply of water. The National Government may acquire land for the local government Council and the use of such land by the local government Council shall be deemed to be a public use under the Land Acquisition Act 1986

7.2.3 Kiribati

According to the Local Government Act 1984, Local Government Councils have an important role and may enact by-laws for the control, conservation and management of the environment and natural resources, including water, sanitation and pollution, and land management.

At the national level, the protection, improvement and conservation of the environment is provided by the Environment Act 1999 (amended in 2007). The Act aims at providing integrated systems of development control, environmental impact assessment and pollution control, preventing pollution, regulating discharge of pollutants, and protecting the natural resources threatened by human activities.

The procedure required to conduct an Environmental Impact Assessment is described under Part III of the Environment Act 1999. The procedure follows a two-staged approach. An initial environment evaluation report is first conducted and, depending on the decision made by the Minister acting in accordance with the advice of the Cabinet, a full environmental impact statement may be required. All the costs and expenses incurred for monitoring the impacts of a prescribed development should be covered by the developer.

For environmental management to be effective, it is important to abide with customary land tenure and land planning arrangements and co-operate with the landowners. According to the Native Lands Ordinance 1956 (amended in 2013), native land owned by a native cannot be alienated, whether by sale, gift, lease or otherwise, to a person who is not native. The Act however does not restrict alienation of native land to the Crown, a Local Government Council, the Housing Corporation, a society registered under the Co-operative Societies Ordinance or the National Loans Board. Development and land use control is provided by the Land Planning Ordinance 1977 (amended in 2000) and the Central and Local Land Planning Boards.

7.2.4 FSM

Prior to taking or funding any major action that may significantly affect the quality of the human environment an environmental impact assessment statement must be prepared according to the Environmental Impact Assessment Regulations. An Initial Assessment is first required to evaluate routine projects or projects for which it is uncertain whether there is potential for significant impacts. It also acts as an initial screening and scoping process for major projects.

The Initial Assessment shall be submitted to the Secretary for review. The determination of whether a project may have a significant impact on the environment calls for careful judgment on the part of the project proponent, based to the extent possible on scientific and factual data. Significance of an activity may vary with the setting. Where there is a difference of opinion on whether a particular impact should be considered significant, the Secretary shall determine whether the impact is sufficiently significant to require a comprehensive EIA.

With regards to water, the following potential changes/alterations resulting from project interventions need to be addressed in the Initial Assessment:

1. Changes in currents, or the course or direction of water movements, in either marine or fresh waters.
2. Changes in absorption rates, drainage patterns, or the amount of surface runoff
3. Alterations to the course or flow of flood waters.
4. Discharge into surface waters or any alteration of surface water quality including but not limited to temperature, dissolved oxygen, bacteria, or turbidity.
5. Contamination of ground waters or wells, either from saltwater intrusion or surface activities
6. Change in the quantity of ground waters, either through direct additions or withdrawal, or through interception of an aquifer by cuts or excavations.
7. Substantial reduction in the amount or quality of water otherwise available for public water supplies.

If the project proponent or Secretary finds after an initial assessment that a project may have a significant impact on the environment, the project proponent shall conduct or cause to be conducted a comprehensive environmental impact assessment and prepare or cause to be prepared an EIA Statement. An EIA Statement shall be prepared whenever it can be fairly argued on the basis of substantial evidence that the project may have a significant impact on the environment, or when there is serious public controversy concerning potential environmental impacts of a project. Controversy not related to an environmental issue does not require the preparation of an EIA Statement.

When an EIA Statement has been prepared for a project, agencies having authority for its funding or approval shall not approve the project as proposed if the agency or agencies finds any practicable alternative or practicable mitigation measures, within its powers or the powers of the project proponent, that would substantially lessen any significant impact the project would have on the environment to an acceptable level.

All phases of the proposed project shall be considered when evaluating its impact on the environment, including, but not limited to, planning, acquisition, development, and operation. The discussion shall include direct and indirect significant impacts of the proposed project on the environment, including relevant specifics of the areas the resources involved, physical changes, alterations to ecological systems and changes induced in population, the human uses of the land, and other aspects of the resource base including, but not limited to, scenic quality and public utilities (power, water, sewer, roads, etc.).

With regards to water, a project is considered as having a significant impact on the environment if it will:

1. Substantially degrade water quality
2. Contaminate a public water supply.
3. Substantially degrade or deplete ground water resources.
4. Interfere substantially with ground water recharge.
5. Encourage activities which result in the use of large amounts of fuel, water, or energy.

The Constitution establishes three levels of government for Micronesia: national, state (Chuuk, Kosrae, Pohnpei, Yap) and local governments. Each state has its own constitution with special provisions to customary law and management of natural resources.

7.3 Gender Equity and Social Inclusion

The project should mainstream Gender Equity and Social Inclusion (GESI) by ensuring women's needs and views are fully considered and incorporated at regional, national and community level. Gender transformation will be supported by ensuring women, youth, and vulnerable groups actively participate in the project's decision-making processes, through the provision of training in non-traditional gender occupations, and by reducing women's work burden. By taking on more public roles in community/island water planning processes, this exposure could lead to women's increased engagement in broader political processes over time. Social inclusion will be promoted by ensuring that youth are included in water education, conservation and monitoring efforts. In this way, they will become more knowledgeable about water resource management, the impacts of climate change and how to safeguard this resource for future generations. The project should also support the inclusion of people with disabilities to ensure their rights and needs are understood and addressed while enhancing disability inclusive disaster risk reduction efforts at island level and community level.

The following recommendations are based on literature review findings, national and community level consultation results and best practice guidelines for effective GESI work in the Pacific Islands. These measures will ensure that women, youth, and disadvantaged and vulnerable households participate in decision-making and are able to benefit from improved water security.

1. Provide GESI technical support to National Management Teams, Island Facilitators, Community Field Officer and other project personnel and implementing agencies through the engagement of a Social Development/Gender Specialist.
2. Ensure the Project Coordinator of the National Delivery Units visits the project sites during project design to review findings from previous consultations/assessments; upcoming project activities and timeframes; land use requirements and permission process; traditional knowledge and practices; island/community planning and decision-making processes; project expectations, including GESI participation, labour contribution, maintenance, etc.
3. Ensure all policy updates, strategies and investment plans for food security will capture the views of women, men, youth and people with disabilities.
4. Ensure women, men and youth are equitably represented on project planning and monitoring committees at national, island and community level. Whenever possible the project should work through existing mechanisms including local government structures, water, disaster or health committees and women/youth organisations rather than setting up new arrangements. Where existing committees are not gender balanced, the project should seek advice from community leaders about how to address this issue. One option is for committee members to hold wider consultation meetings with under-represented groups such as women, youth and people with disabilities;
5. Ensure opportunities are provided to all members of the community to participate in project activities to learn more about water security and conservation. Students from island schools should also be given opportunities to assist with project activities and citizen science approaches should be strongly supported.
6. Keep community leaders informed of project activities, timelines and assessment results through suitable communications to ensure transparency and knowledge sharing.
7. Hold community meetings at a time and place convenient to all stakeholders and avoid "consultation fatigue".
8. Provide "Water for Women" learning opportunities and ensure all trainings supported by the project include equal representation of women and men. This will serve to build local capacity and create sustainability in operations and maintenance of community water systems; enhance

local monitoring capabilities; and increase women's engagement in non-traditional occupations, and their employability, all the while developing the next generation of female and male water specialists;

9. Ensure people with disabilities are involved in project planning, implementation and monitoring at both national and local level. To do this effectively project staff should liaise with each national disability people's organisations and government agencies responsible for disability work;
10. Develop gender-sensitive community and student-friendly education and awareness materials to assist local leaders and committees implement their water security and disaster plans.
11. Ensure that project monitoring and evaluation includes GESI indicators and targets.
12. Keep national gender and disability organisations/networks informed of key GESI issues, outcomes and lessons learned arising from project activities;
13. Model gender equity in project staffing and management arrangements (including the Project Board), develop and enforce a staff Code of Conduct and provide GESI training to all project, implementing and partner agency staff to build competence and confidence with the goal of ensuring adequate understanding, knowledge and skill to successfully implement this Action Plan.

GESI-sensitive Communication Guidelines

1. Ensure project communications are accessible to all stakeholders by considering technology, cost and other factors;
2. Ensure project communication is user friendly by considering literacy levels, language preferences, audio/visual appeal, etc.;
3. Identify suitable modes of communications for specific target groups such as social media, popular theatre, radio broadcasts;
4. Recognize the achievements of women, people with disabilities and other vulnerable groups connected to the project and the work of women, youth and disability organizations that contribute to the achievement of project goals;
5. Ensure project communication highlights beneficiaries in non-traditional gender roles - including leadership positions - and does not reinforce gender/disability stereotypes;
6. Emphasize that achieving gender equality and social inclusion outcomes is a shared responsibility of government, civil society, the private sector, communities and citizens; and
7. Use project communication to demonstrate commitment to regional and national GESI awareness and advocacy efforts.

GESI-sensitive Human Resource Guidelines

1. Include explicit GESI responsibilities in the Terms of Reference of all project staff;
2. Ensure GESI mainstreaming is included in staff performance monitoring;
3. Provide high quality in-country GESI expertise to train, mentor and support staff and stakeholders throughout project implementation;
4. Engage staff who are committed to GESI principles and practices and provide them with adequate time and resources to achieve GESI outcomes;
5. Engage staff in non-traditional gender roles whenever possible to serve as role models;
6. Ensure management teams have equitable representation from men and women; and
7. Ensure expectations regarding staff behaviour are clearly stated in the project Code of Conduct when working with women, children and other vulnerable groups.

GESI-sensitive Governance Guidelines

1. Appoint men, women and people with disabilities on project governance bodies;

2. Engage women and disability organisations in advisory roles;
3. Ensure governance bodies review and endorse project Gender Action Plans including strategies, targets and performance indicators;
4. Provide regular reports to Project Boards on GESI achievements, constraints, lessons and M&E results; and
5. Share case studies that feature vulnerable groups in project activities.

Annex 1 – Terms of Reference

FSM, Kiribati, RMI and Tuvalu

Small Islands Food and Water Project (SIFWaP)

Terms of Reference for a Preparatory Study on Water Security and Hydrology

I. Background

1. On 12th December 2019 the Global Agriculture and Food Security Program (GAFSP) informed the governments of Federated States of Micronesia (FSM), Kiribati, Republic of Marshall Islands (RMI), and Tuvalu, that it had approved a grant of USD 12.0 million to finance a new project, called the Small Islands Food and Water Project (SIFWaP). A detailed design report will now be prepared with further support from IFAD and FAO as the two supervising entities. To inform this process in certain key areas, GAFSP has also agreed that up to USD 350,000 of the grant amount may be used to undertake detailed preparatory work, including studies on:
   - Farmer and community organisations and how these should be engaged;
   - Water availability and hydrology assessments;
   - Environmental and social management plans (EMSP/SECAP) and frameworks including public consultations; and
   - Market studies, in countries that not covered by such studies in 2019.
2. The present ToRs cover the water availability and hydrology assessments.

II. Preparatory Study Context

Water supply has always been a problem on the atolls of the Pacific, accentuated by climate change, population growth and the concentration of population on one or two main islands in each country. Despite generally high rainfall, the availability and quality of water are both problematic with implications for public health and food production.

The problem is most acute on the densely populated atoll islands such as Tarawa (Kiribati), Majuro and Ebeye (RMI) and Funafuti (Tuvalu). These communities traditionally obtained their water from shallow wells, but growing population, rising sea levels and recurrent droughts have placed the groundwater resource under severe pressure. Some of the most vulnerable are populated islands that rely mostly on rainwater harvesting such as Funafuti, which has no potable groundwater due to its geomorphology.

Water insecurity is a key element of the fragility of the atoll nations and will therefore be addressed in all three components of SIFWaP. Component 1 will focus on the investments to improve water security, along with food and nutrition security; Component 2 will focus on sensitising and enabling communities to address food and water security problems; and Component 3 will support the development of an enabling policy framework for food and water security. All components will be focussed on non-urban island communities.

Under the process of community consultation that is the core of the SIFWaP approach, it is expected that water supply systems will be a popular choice including wells, rainwater catchment, solar distillation and desalination schemes. Most public good investments under Sub-Component 1.2 are expected to be in water supply – for both domestic use and food gardens. The detailed design of SIFWaP will also look into water, greywater, wastewater and marginal water reuse in order to optimize local water use efficiency levels.

The options for improving water security vary between islands depending on total rainfall, rainfall seasonality and variability, hydrogeology and population density. In most cases rainwater harvesting and storage is an available option but can be unreliable during dry seasons, droughts and with large households. On some islands careful management of the groundwater resources is still feasible, although they are at risk from pollution and salinisation due to over-extraction, extreme ENSO events and possibly rising mean sea level in the longer term.

A preparatory study of water availability and hydrology has therefore been recommended in order to inform the detailed design of SIFWaP. The study will enable the design team to identify the best options for addressing the water problem in the participating communities and to prepare indicative cost estimates for the proposed interventions.

III. Objective and Broader Aspects of the Preparatory Study

The overall objective of this assignment is to inform the water-related activities under all three components of the SIFWaP detailed design, particularly in relation to improved water security.

Taking into account the general comments received from the GAFSP Steering Committee and further guidance from IFAD and FAO, the preparatory study will also contribute to two broader aspects of the project design: 1) how inclusiveness and empowerment for women, youth and disadvantaged and vulnerable households will be incorporated in the implementation of activities; and 2) how the project will address governance issues, limited human resources, insufficient financing and limited implementation capacity in all four countries and particularly on outer islands.

IV. Specific Tasks

The Consultant will be expected to:

1. Review background information on water security in atoll environments of the Pacific region generally (see Attachment 1 for a preliminary list of sources), and in the four participating countries.
2. Where possible and in general terms, identify the recharge rate to groundwater based on rainfall, evaporation and land use and identify any known locations where -inappropriate groundwater extraction methods or over-extraction may occur.
3. Identify key issues, and lessons learned that may inform the design of SIFWaP.
4. Evaluate the general approach to the problem of water security in the SIFWaP proposal and recommend ways in which it can be improved or strengthened within the environmental, climatic, social and cultural, and institutional context of the participating countries and communities.
5. Undertake a structured problem analysis to identify the underlying causes of water insecurity, covering both water availability and quality, in the target households and communities and recommend different approaches or strategies for addressing these in different hydrological and socio-economic circumstances. The target households and communities are those outside urban areas on capital/main islands and those on outer islands.
6. Where information is available at island scale about population projections and other contributing factors, estimate increases in water demands by the year 2030.
7. Assess the available technical and management options and capacities for improving the availability and quality of water in the target households and communities, referring to lessons learned, and outline tailored solutions suited to local conditions and cultures, including possibilities such as rainwater harvesting, improved groundwater management, solar distillation, desalination and others.

8. Formulate a set of household and community water supply and management models and indicative cost estimates for consideration by the beneficiaries (households and community institutions including schools, hospitals and clinics), local/island councils and national or state government agencies so that they can make informed choices about which options to select and the investment and operating costs to be financed.
9. Propose measures to ensure that women, youth, and disadvantaged and vulnerable households participate in decision-making and are able to benefit from improved water security.
10. Identify any environmental or sustainability risks associated with the various options and recommend mitigation measures.
11. Recommend management arrangements for the design, operation and maintenance of water supply schemes in participating communities including the role of Water User Groups or other community organisations and/or local/island councils and national or state government agencies.
12. Assess the policy and institutional context for water security and sustainable management of water resources in each country, identify any shortcomings and recommend capacity-building measures to overcome these.

V. Methodology and Schedule of Work

The Consultant(s) will draw mostly on secondary sources for qualitative and quantitative information and data, which may be supplemented with short key informant interviews via telephone or by email.

The Consultant(s) will work, in collaboration with, and under the supervision of, the IFAD and FAO teams. One week into the assignment, the Consultant(s) will be expected to share an annotated outline of the report for comments and further fine-tuning. The Consultant(s) will produce a draft report, which will, to the extent possible, take into account any technical comments received before being finalised.

Attachment 1: Selected References on Water Issues in the Pacific Island Atolls

Falkland A.C. (1993) e and Water Management on Small Tropical Islands. Hydrology of Warm Humid Regions: Proceedings of Yokohama Symposium. IAHS Publ. No 216.

Gale A and de Brum H (2017) Water Challenges in the Marshall Islands: Managing Drought in a High Rainfall Country. Water e-Journal, Volume 2, No 2.

Oberle F.K.J, Swarzenski P.W, and Storlazzi C.D (2017). Atoll Groundwater Movement and its Response to Climatic and Sea Level Fluctuations. MDPI Water Journal 9, 650.

Pacific Partnership for Atoll Water Security
https://sustainabledevelopment.un.org/partnership/?p=7699

South Pacific Applied Geoscience Commission and Asian Development Bank (2003). Pacific Regional Action Plan on Sustainable Water Management.

Weber E (2016). Water in the Pacific Islands: Case Studies from Fiji and Kiribati. In Water: A Source of Conflict or Cooperation, Grover V.I. (ed) (2016).

White I, Falkland A, Perez P, Dray A, Metutera T, Metai E and Overmars M (2007). Challenges in Freshwater Management in Low Coral Atolls. Journal of Cleaner Production 15, 1,522-1,528.

Annex 2 – Regional water security assessment methodology

A regional water security assessment was conducted for the purposes of this study as an opportunity to identify disparities between water demand and current water availability across selected atoll countries, using expert analysis of available information incorporating rainfall, census and physical data. The assessment allows for the comparison of expert derived water vulnerability indicators across different scales. It is an attempt to consolidate the existing data into a spatial platform which allows non expert users to navigate from regional to island scale to prioritise where, and the type of interventions, which will have most impact for water security.

An island prioritization approach for water security was conducted considering the different types of water sources available on each atoll, and their resilience with respect to population demands. This information was used to objectively indicate the types of specific interventions that would be of most benefit in addressing the needs of water scarcity for that community, islet, atoll, country, and sub regionally. Of course, water vulnerability is not just function of available storage and rainfall, but includes social, cultural, economic and capacity considerations to guide decisions on where, and the type of interventions required. This evidence based objective approach was however a useful first pass to help identify where interventions are needed and what type of interventions are likely to be most effective, on which an overlay of country identified social, cultural and economic considerations can guide project design and implementation.

The main objective was to develop a suite of indicators which identify and guide an evidence-based prioritisation of the most impactful interventions to address the water security needs of Pacific Island countries.

In order to rank the islands in terms of their vulnerability to droughts and to identify which type of interventions may be more impactful, the following assumptions were made.

- Rainwater is the preferred source for potable purposes meaning that, if abundant to cover the average household water needs, then rainwater harvesting interventions are recommended.
- Daily water requirements per person: 50 L/day (currently uniform for all islands and countries).
- If data on roof catchment areas, effective roof catchment, and % guttering are unavailable, it is assumed that:
    - Current effective roof area per household: 50 m^2 (50% guttering)
    - Potential effective roof area per household: 100 m^2 (100% guttering)
- Calculations consider the average number of persons per household at the atoll/island level. They do not account for individual households.
- With regards to the residence time of captured rainwater in existing rainwater storages, a 3-month period is used as an appropriate planning timeframe to consider vulnerability of captured rainwater. That is, it can be expected that the rainfall amount over 3 consecutive months will have an impact on the storages and consecutively on the community. It is assumed that communities' current resilience to droughts can accommodate rainfall deficits of less than 3 months. There will of course be individual households for whom this assumption is not true and who will need to draw from other water sources over this period. The premise is that considering historical rainfall amounts at selected rainfall deficits (10^{th}, 25^{th} and 40^{th} percentiles), over a 3-month period, will give a realistic indication of the expected impacts on most of the community during a rainfall deficit.
- Houses have roofs which allow rainwater harvesting unless expert knowledge/census data advises otherwise (i.e. thatched roofing).

Datasets

Water security parameters were calculated using the following types of datasets.

- Monthly rainfall data for available stations (min 30 years continuous data)
- Census household data by island enumeration area
- Project specific data/knowledge – water storages, roof catchments, guttering, water resources assessments
- Expert advice/opinion and local/traditional knowledge

Calculated parameters

- 3-monthly average household water requirements (based on 50 L/p/d for the average persons per household, by island/atoll)
- Minimum 3-monthly rainfall (mm) required to cover the 3-monthly average household water requirements ("*min 3-month* R_{req}"). If data is available, the parameter is calculated using the **median** of the household catchment roof areas available on each island and the **average** of the % of guttering per household. If no data is available, it is assumed that catchment roof area is 100 m^2 and % of guttering is 50 % (i.e. 50 m^2 of effective roof area).
- 10^{th}, 25^{th} and 40^{th} percentile of total rainfall observed over 3 consecutive months throughout the entire rainfall dataset ("*min 3-month R*"). A multilevel b-spline interpolation was conducted to populate all atolls.
- Coefficient of variation (CV) of rainfall over 3 consecutive months for each atoll (multilevel b-spline interpolation conducted to populate all atolls).

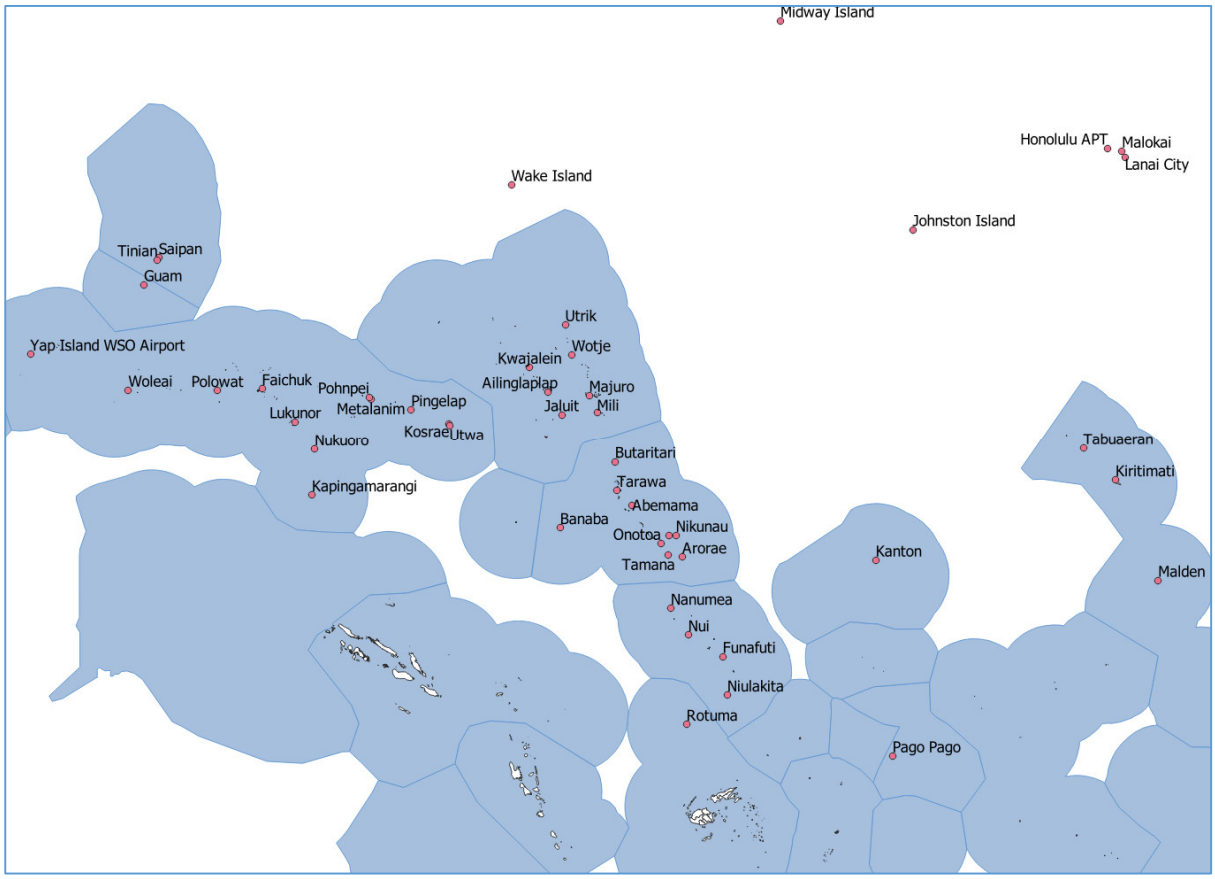


Figure 4. Rain stations used in the interpolation to populate all islands/atolls of FSM, RMI, Kiribati, and Tuvalu.

The water vulnerability of each island was estimated based on the following:

- If *min 3-month* R_{req} > 40th percentile of *min 3-month R*: Extreme vulnerability
- If 40th percentile > *min 3-month* R_{req} > 25th percentile: High vulnerability
- If 25th percentile > *min 3-month* R_{req} > 10th percentile: Moderate vulnerability
- If *min 3-month* R_{req} < 10th percentile: Low vulnerability

For instance, the minimum 3-monthly rainfall required to cover the 3-monthly average household water requirements in Nanumea atoll in Tuvalu falls between the 25th and 40th percentile of total rainfall observed over 3 consecutive months. The water vulnerability of Nanumea was therefore characterized as "high".

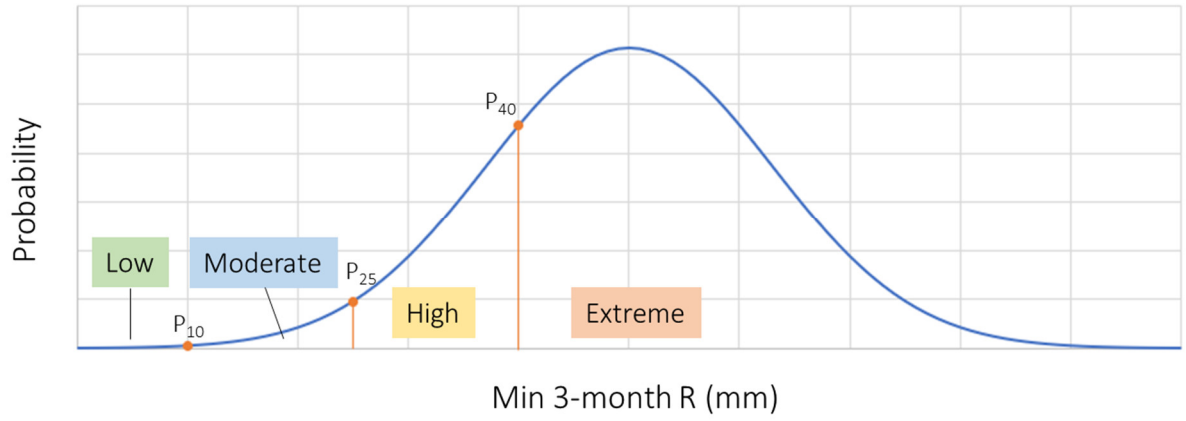


Figure 5. Estimation of water vulnerability.

Water vulnerability was then re-calculated for each island/atoll using the **median** of catchment roof areas assuming 100 % guttering, or 100 m^2 of effective roof area if no data is available. The suitable type of water security intervention is then deduced based on the following rules:

- If water vulnerability becomes "low": Rainwater harvesting interventions are expected to be most impactful and no alternate water sources are expected to be required (indicated as **class 1** in national water security summary Tables).
- If water vulnerability decreases by two units (but does not become "low"): Rainwater harvesting interventions are expected to be impactful but alternate water sources may additionally be required (indicated as **class 2** in national water security summary Tables).
- If water vulnerability decreases by one unit (but does not become "low"): rainwater harvesting interventions are expected to have moderate impact and it is recommended to additionally consider alternate water sources (indicated as **class 3** in national water security summary Tables).
- If water vulnerability does not decrease: rainwater harvesting interventions are expected to be insufficient and it is recommended investigating alternate water sources such as groundwater and desalination (indicated as **class 4** in national water security summary Tables). The availability and suitability of groundwater supplies for development should of course be investigated on site.
- If water vulnerability was estimated as "low" with the existing roof areas and guttering then it is suggested that no additional water security interventions are required (indicated as **class 0** in national water security summary Tables).

For instance, if all guttering is fixed in Nanumea to allow for maximum capture of rainwater through the existing roof areas, the minimum 3-monthly rainfall required to cover the average 3-monthly household water requirements would fall between the 10th and 25th percentile of total rainfall observed over 3 consecutive months. The water vulnerability of Nanumea would thus decrease from "high" to "moderate" indicating that rainwater harvesting interventions are expected to have moderate impact and it is recommended to also consider alternate water sources.

Additional recommendations are given on the type of suitable rainwater intervention by comparing the monthly household water requirements with the total storage per household currently available on the atoll (where data is available).

- If monthly household water requirements > existing storage per household: it is recommended to invest on additional storage (tanks) and in additional rainwater capture (guttering/roof areas).
- If monthly household water requirements < existing storage per household: it is recommended to invest in additional rainwater capture (guttering/roof area) only.

Water source reliance

This parameter indicates the percentage of households that utilise rainwater and groundwater as a water source for any of their water needs, either for potable or secondary water needs. This draws upon the traditional knowledge that the particular water source has been used in the past and could still be used to meet water needs. This is a surrogate guide to indicate useful groundwater supplies are available and that assessment and development of groundwater may be an appropriate intervention. Where groundwater is not relied upon, this may suggest that community perception towards its use is undesirable, or that groundwater quality is unsuitable. The variability of groundwater occurrence in atolls is based on parameters which require specific investigation, precluding a simple analysis using existing data, such as island width, annual rainfall, or islet location relative to wind direction.

Groundwater recharge

Recharge cannot be expected to be uniform across an island and will vary due to the presence of reef rock, variations in vegetation densities and type, minor variations in topography, land use, and variations on where and how much rain falls. However, to assist with determining the groundwater development potential, it is useful to determine an average recharge for subsequent estimations of available water volumes for abstraction. In the absence of specific recharge studies, a conservative estimate of recharge can be based on empirical studies. According to Falkland (1992), data from islands with similar conditions can be used to derive a general relationship. Falkland derived an empirical relationship between mean annual rainfall and calculated mean annual recharge for a number of low-lying coralline islands where there are no orographic influences and where the geology is relatively homogeneous (Fig 6). The polynomial relationship was used to roughly estimate the average annual groundwater recharge expected on each island (included in the national water security summary Tables).

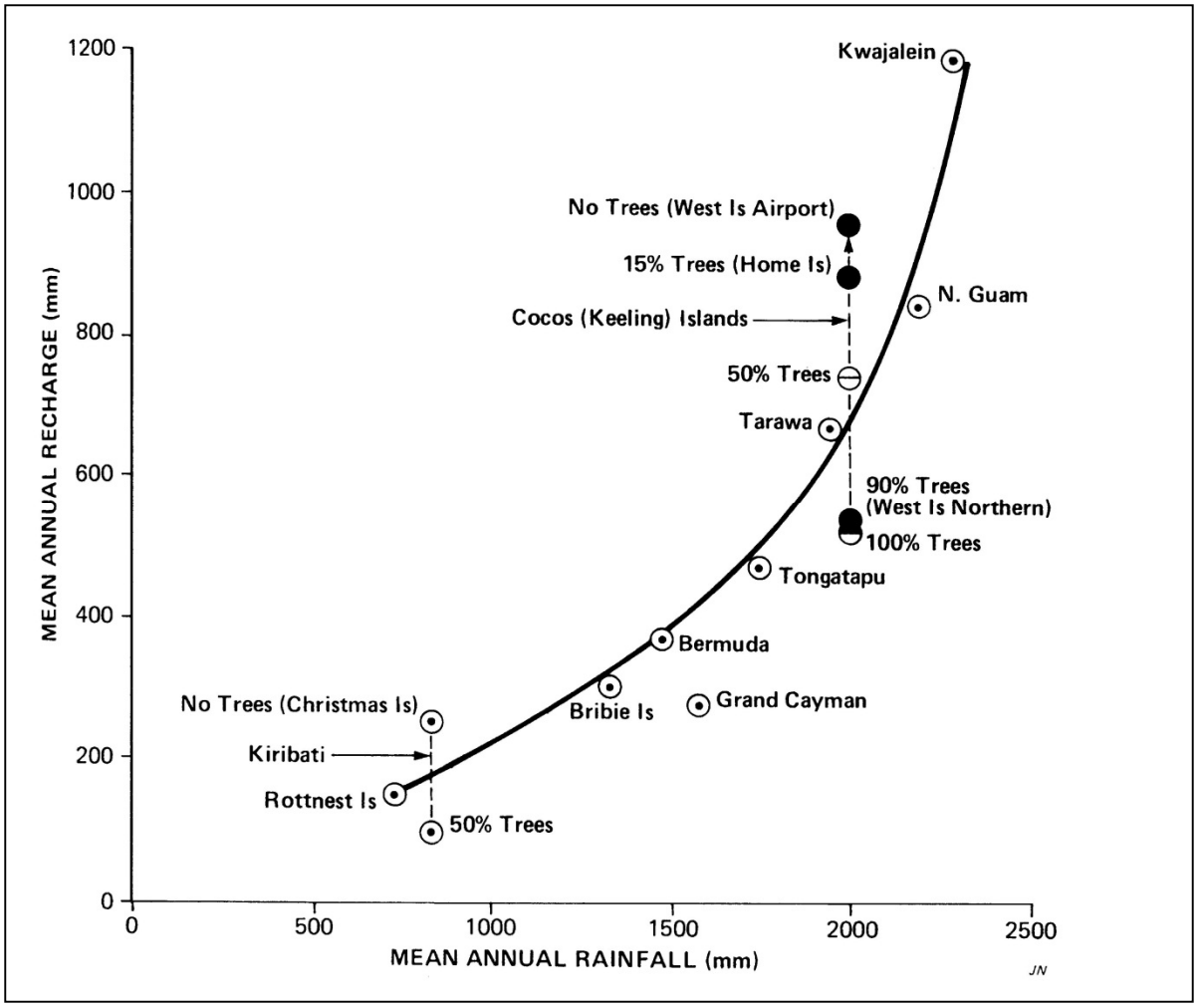


Figure 6. Relationship between average annual rainfall and average annual recharge for a number of low-lying islands.

Assessment results

The results were used to create a climatic, socio-economic, and investment suitability overview of water security in the four project countries. This overview is presented by means of three interactive thematic maps hosted on ArcGIS Online and presented through the ArcGIS StoryMaps feature to communicate the message in a simple and targeted manner. The maps can be accessed at https://arcg.is/1umqGG1.

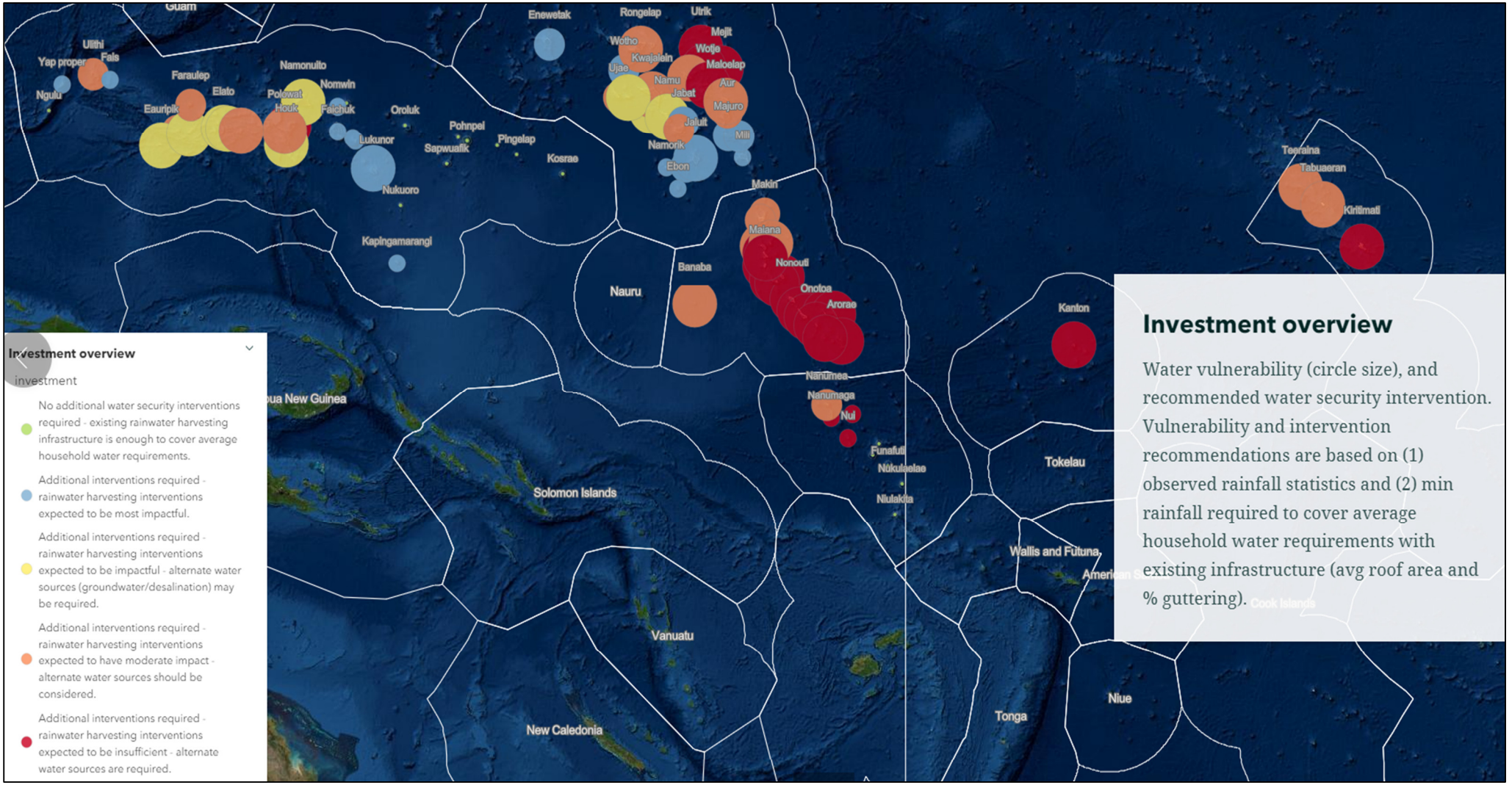


Figure 7. Investment overview Arc GIS Online StoryMap (https://arcg.is/1umqGG1).

Table 15. RMI water security summary.

Atoll name	Total population	Total households	Average annual rainfall (mm)	Average annual groundwater recharge (mm)	Rainfall variability	Rainwater reliance (%)	Groundwater reliance (%)	Water vulnerability	Recommended water security intervention
Utrik	435	69	1514	403	high	100	0	extreme	4
Mejit	348	57	2316	944	high	62	35	extreme	4
Lib	155	18	2651	1256	low	100	0	extreme	2
Rongelap	79	12	1861	602	moderate	-	-	extreme	3
Ailuk	339	63	2053	735	high	100	0	extreme	4
Jaluit	1788	252	3070	1716	low	98	1	extreme	1
Kwajalein	11408	1371	2520	1128	moderate	49	0	extreme	3
Lae	347	48	2575	1181	low	71	28	extreme	2
Likiep	401	74	2229	872	moderate	66	33	extreme	3
Namu	780	131	2626	1231	moderate	94	4	extreme	2
Wotje	859	132	1502	397	high	99	0	extreme	4
Maloelap	682	124	3418	2158	moderate	72	27	extreme	3
Ujae	364	52	2669	1274	low	69	30	high	3
Wotho	97	22	2093	765	moderate	68	31	high	1
Kili	548	89	3203	1879	low	86	13	high	1
Enewetak	664	106	1422	359	moderate	92	6	high	1
Jabat	84	19	2794	1404	moderate	78	21	high	1
Ailinglaplap	1725	286	2801	1412	low	92	7	high	3
Majuro	27797	4092	3346	2062	low	81	8	high	1
Arno	1794	261	3428	2172	low	87	11	high	1
Aur	499	95	3393	2125	moderate	84	12	high	3
Namorik	508	97	3252	1941	low	91	8	moderate	1
Mili	738	143	2970	1599	low	73	26	moderate	1
Ebon	704	135	3159	1824	moderate	60	32	moderate	1
Bikini	9		1565	428	moderate	-	-	low	0

Table 16. Tuvalu water security summary.

Atoll name	Total population (2017)	Total households (2017)	Average annual rainfall (mm)	Average annual groundwater recharge (mm)	Rainfall variability	Rainwater reliance (%)	Groundwater reliance (%)	Water vulnerability	Recommended water security intervention
Nanumea	512	105	2754	1362	moderate	68	32	high	3
Nanumaga	491	93	2772	1381	moderate	92	0	moderate	4
Niutao	582	116	2739	1346	moderate	67	38	moderate	4
Nui	610	97	3054	1697	moderate	48	36	moderate	4
Vaitupu	1061	187	3122	1779	moderate	61	27	low	0
Funafuti	6320	849	3519	2297	low	100	0	low	0
Nukufetau	597	112	3246	1933	low	79	20	low	0
Nukulaelae	300	57	3302	2005	low	-	-	low	0
Niulakita	34	10	3257	1947	low	-	-	low	0

Table 17. Kiribati water security summary.

Atoll name	Total population	Total households	Average annual rainfall (mm)	Average annual groundwater recharge (mm)	Rainfall variability	Rainwater reliance (%)	Groundwater reliance (%)	Water vulnerability	Recommended water security intervention
Banaba	268	77	1948	660	extreme	98	1	extreme	3
Abaiang	5568	996	2323	950	high	8	89	extreme	3
Maiana	1982	399	1894	623	high	11	88	extreme	4
Abemama	3262	602	1497	394	extreme	19	80	extreme	4
Kuria	1046	217	1801	563	extreme	23	76	extreme	4
Aranuka	1125	237	1749	532	extreme	7	92	extreme	4
Nonouti	2743	532	1628	462	extreme	3	95	extreme	4
Tabiteuea.Nth	3955	706	1583	438	extreme	6	88	extreme	4
Tabiteuea.Sth	1306	253	1538	415	extreme	6	89	extreme	4
Beru	2051	458	1414	355	extreme	4	86	extreme	4
Nikunau	1789	356	1184	263	extreme	5	93	extreme	4
Onotoa	1393	323	1307	309	extreme	8	90	extreme	4
Arorae	1011	217	1686	495	high	15	84	extreme	4
Tamana	1104	187	1391	345	extreme	7	91	extreme	4

Butaritari	3224	624	3067	1713	moderate	15	83	extreme	3
Nth.Tarawa	6629	1128	2112	779	high	16	83	extreme	4
Kanton	20	6	914	186	extreme	58	41	extreme	4
Teeraina	1712	292	2168	823	high	16	82	extreme	3
Marakei	2799	499	2348	972	high	64	83	extreme	3
Tabuaeran	2315	418	2081	756	high	20	79	extreme	3
Sth.Tarawa	56388	7877	2026	715	high	26	73	extreme	4
Kiritimati	6456	1017	921	187	extreme	19	79	extreme	4
Makin	1990	351	3018	1655	moderate	22	77	high	3

Table 18. FSM water security summary.

Atoll name	Total population	Total households	Average annual rainfall (mm)	Average annual groundwater recharge (mm)	Rainfall variability	Rainwater reliance (%)	Groundwater reliance (%)	Water vulnerability	Recommended water security intervention
Pulap	1661	63	2584	1190	moderate	61	38	extreme	4
Namonuito	1384	194	2693	1299	moderate	47	44	extreme	2
Houk	1116	146	2669	1274	moderate	53	45	extreme	2
Polowat	745	83	2330	956	moderate	53	46	extreme	3
Etal	672	69	3519	2297	low	52	47	extreme	1
Eauripik	114	16	3073	1720	low	56	43	extreme	2
Ifalik	578	83	3005	1640	low	57	16	extreme	2
Elato	105	16	2733	1340	moderate	56	43	extreme	2
Lamotrek	329	49	2694	1300	moderate	50	24	extreme	2
Satawal	501	59	2617	1222	moderate	99	0	extreme	3
Lukunor	1254	159	3477	2239	low	50	45	high	1
Satawan	2220	282	3547	2336	low	56	41	high	1
Woleai	1039	163	2825	1438	low	57	40	high	3
Faraulep	193	37	2843	1457	moderate	54	41	high	3
Ulithi	847	140	2688	1293	moderate	76	22	high	3
Losap	506	91	3605	2418	low	63	35	moderate	1
Nomwin	1343	203	3356	2076	low	48	48	moderate	1

Nema	676	108	3618	2437	low	95	4	moderate	1
Namoluk	355	56	3512	2287	low	59	35	moderate	1
Fais	294	65	2672	1277	moderate	100	0	moderate	1
Faichuk	36152	5445	3569		low	41	29	moderate	1
Kapingamarangi	346	74	3188	1860	low	82	12	moderate	1
Yap proper	7371	1680	3083		low	18	56	moderate	1
Murillo	570	125	3448	2199	low	52	47	low	0
Kosrae	6616	1143	4959		low	30	26	low	0
Nukuoro	210	52	4054	3106	low	71	27	low	0
Pingelap	258	71	3731	2602	low	96	3	low	0
Sapwuafik	456	91	4514	3905	low	79	20	low	0
Mwokilloa	133	30	3243	1929	low	100	0	low	0
Ngulu	6	3	3013	1649	low	100	0	low	0
Pakin	100	19	4807	4463	low	-	-	low	0
Pohnpei	34789	5970	4744		low	3	37	low	0
Oroluk	10	2	4027	3063	low	-	-	low	0

Annex 3 – Review of key authorities' responsibilities and capacities

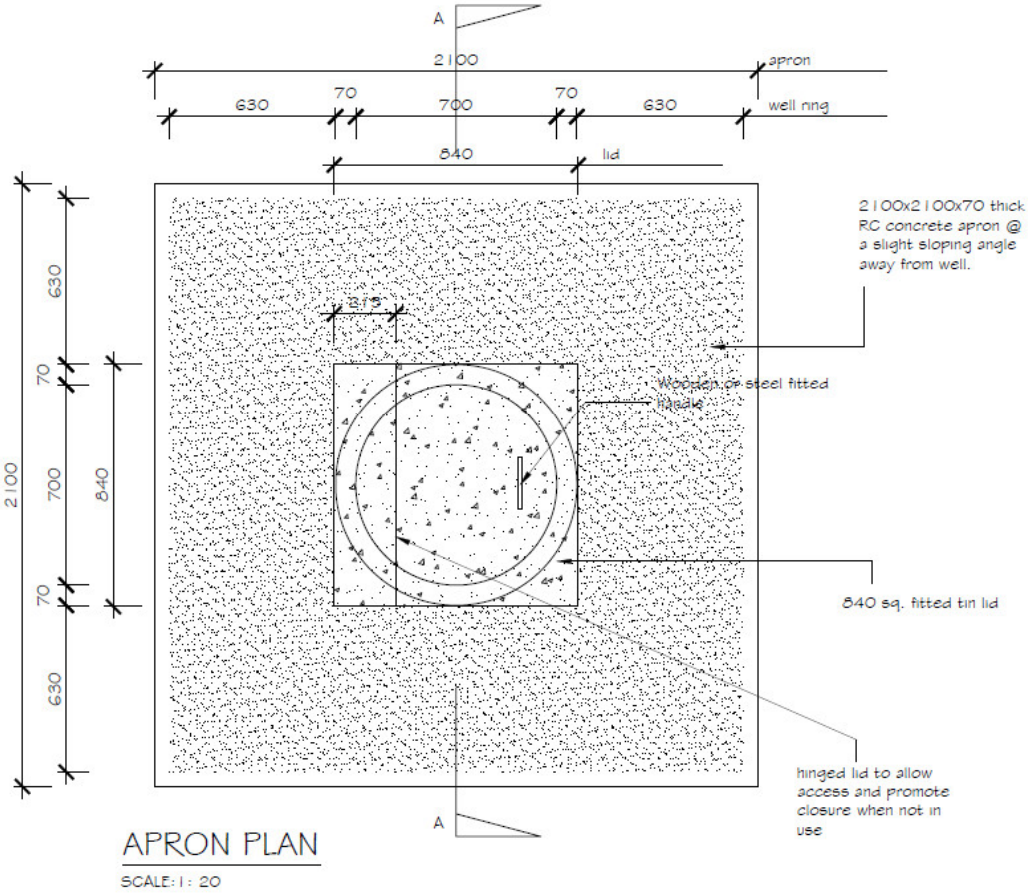
Country	Agency	Responsibilities	Capacity
KIRIBATI	Ministry of Infrastructure and Sustainable Energy (Water and Sanitation Engineering Unit – WSEU)	Assessment and periodical monitoring of Bonriki water reserve	Adequate capacity to deliver these roles.
		Assessment of outer islands water resources and groundwater potential	
		Supervise the construction of outer islands water supply infrastructures.	
		Monitoring of groundwater resources in the outer islands through the outer islands water technicians	
	Public Utilities Board	Operation and management of South Tarawa water supply (both form the BWR and newly installed desalination plants) and sanitation services.	Adequate capacity to deliver these roles.
	Ministry of Line and Phoenix	Operation and management of water supply scheme in Kiritimati Island and nearby outer islands	Adequate capacity to deliver these roles.
	Ministry of Health and Medical Services	Routine water quality monitoring and surveillance for groundwater and selected rainwater storages in South Tarawa and outer islands	Adequate capacity to deliver these roles
	Ministry of Environment, Lands and Agricultural Development	Provide small-scale irrigation support in Tarawa and in the outer islands.	Adequate capacity to deliver these roles.
	National Disaster Management Office (NDMO)	Lead national water committee and coordinates drought management responses through water rationing in South Tarawa and other water supply interventions in the outer islands.	Adequate capacity to deliver these roles.
	Kiribati Meteorological Services	Provision of rainfall data and weather forecasts to all key water stakeholders	Staffs are trained to deliver these roles.
	Ministry of Internal Affairs	Oversee outer islands development and governance, including the operation and maintenance of community water supply systems.	Adequate capacity within Island Council and leadership to deliver these roles.
	Ministry of Education	Manage water supply systems in all government schools in Tarawa and outer islands.	Adequate capacity to manage infrastructure given that proper support is given by WSEU on the operation and maintenance of these systems.
	Local Contractors	Construction of water supply infrastructures in South Tarawa and outer islands	Adequate capacity provided that stringent supervision and QA/QC measures as per Government construction standards
	Communities	Management of both communal and private rainwater systems and groundwater wells	Adequate capacity may exist within communities and church to operate water supply systems, but the establishment of a community water committee is IMPERATIVE for the sustainable management and maintenance of water supply infrastructures.
TUVALU	Public Works Department	Operation and management of public water supply (incl community rainwater harvesting	Adequate capacity to deliver these roles.

		storages and desalination) and sanitation in Funafuti.	
		Design, construction, and maintenance of water supply infrastructures around the outer islands	
	Ministry of Local Government and Agriculture	Oversee outer islands development and governance, including the operation and maintenance of community water supply systems. Note that Kaupule or Island government implements water rationing during prolonged dry periods.	Adequate capacity within Kaupule to deliver these roles.
	Ministry of Health, Social Affairs and Gender	Routine water quality monitoring and surveillance for groundwater and selected rainwater storages in Funafuti and in the outer islands	Adequate staff capacity and laboratory equipment to deliver these roles.
	NDMO	Lead national water committee and coordinates drought management responses through water rationing and other water supply interventions around the country.	Adequate capacity to deliver these roles.
	Tuvalu Meteorological Services	Provision of rainfall data and weather forecasts to all key water stakeholders	Trained staffs to deliver these roles.
	Local Contractors	Construction of water supply infrastructures in South Tarawa and outer islands	Adequate capacity provided that stringent supervision and QA/QC measures as per Government construction standards
	Communities	Management of both communal and private rainwater systems and groundwater wells	Adequate capacity may exist within communities and church to operate water supply systems, but the establishment of a community water committee would ensure the sustainable management and maintenance of water supply infrastructures.
RMI	Majuro Water and Sewer Company	Operation and management of water supply infrastructures in Majuro and outer islands	Adequate capacity in terms of staff training and infrastructures to support these roles.
		Coordinates the deployment and operation of desalination equipment to the outer islands during drought periods.	
	Ministry of Health and Human Services	Water quality monitoring and surveillance	Adequate capacity in terms of staff training and laboratory conditions.
	Environmental Protection Authority	Monitoring of groundwater quality in Majuro, including Laura lens, and outer islands	Adequate capacity to undertake this role.
	Weather Service Office	Provision of rainfall data and weather forecasts to all key water stakeholders	Staffs are adequately trained to deliver these roles.
	NDMO	Lead the dissemination of national disaster warning and response including water rationing and other water supply interventions around the country.	Staffs are adequately trained, and most weather offices are well equipped to deliver these roles.
	Ministry of Culture and Internal Affairs	Oversee outer islands development and governance, including the operation and maintenance of community water supply systems.	Adequate capacity
	Local Contractors	Construction of water supply infrastructures in South Tarawa and outer islands	Adequate capacity provided that stringent supervision and QA/QC measures as per Government construction standards

	Communities	Management of both communal and private rainwater systems and groundwater wells	Adequate capacity may exist within communities and church to operate water supply systems, but the establishment of a community water committee is IMPERATIVE for the sustainable management and maintenance of water supply infrastructures.
FSM	State-owned Water authorities	Operation, management and maintenance of water supply utilities in the main islands such as Yap, and Pohnpei	Adequate capacity
	NDMO	Lead the dissemination of national disaster warning and response including water rationing and other water supply interventions around the country.	Adequate capacity to provide disaster support.
	Weather Services Office	Provision of rainfall data and weather forecasts to all key water stakeholders	Staffs are adequately trained, and most offices are well equipped to deliver these roles.
	Municipal water authorities	Operation, management and maintenance of water supply schemes in rural communities and outer islands	Adequate capacity may exist to operate water supply systems but on-going support from state government is required to manage and maintain these infrastructures. Disaster periods usually necessitate urgent support.
	Department of Health and Social Affairs	Water quality monitoring and surveillance	Adequate capacity in terms of staff training and laboratory conditions.
	Local Contractors	Construction of water supply infrastructures in South Tarawa and outer islands	Adequate capacity provided that stringent supervision and QA/QC measures as per Government construction standards
	Communities	Management of both communal and private rainwater systems and groundwater wells	Adequate capacity may exist within communities and church to operate water supply systems, but the establishment of a community water committee is IMPERATIVE for the sustainable management and maintenance of water supply infrastructures.

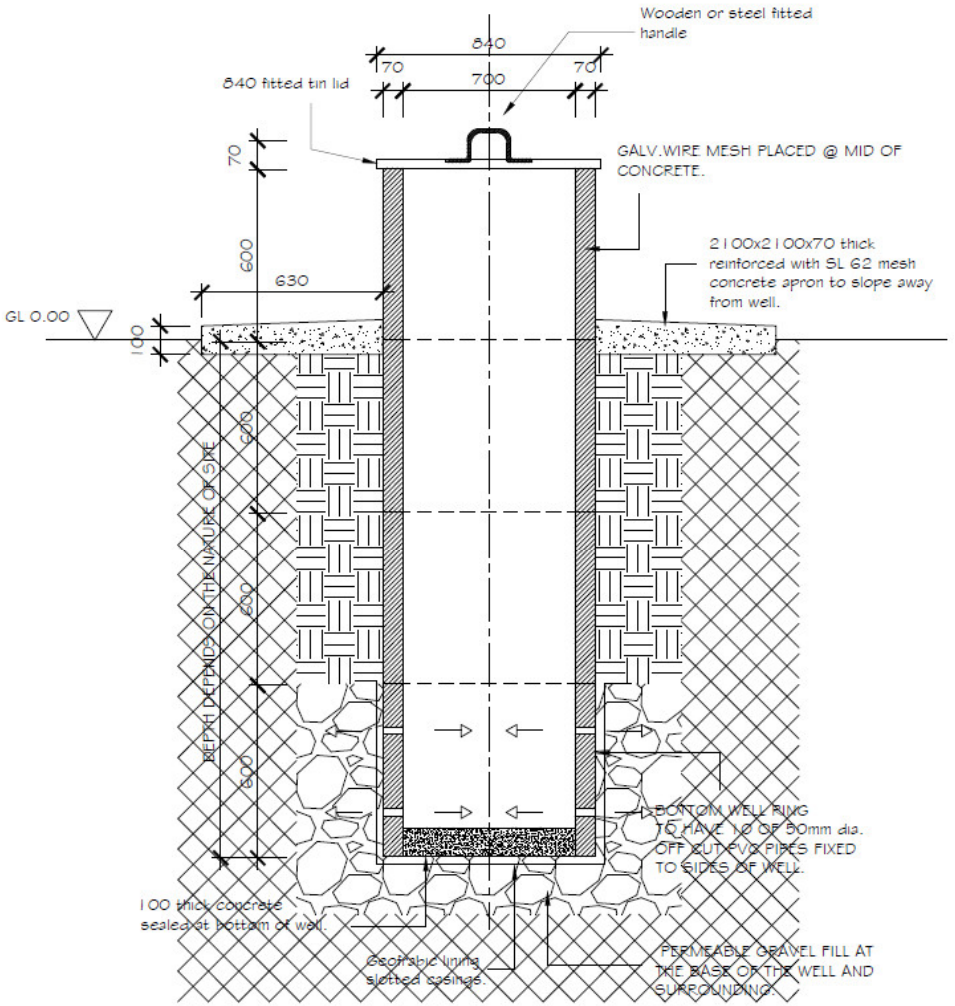
Annex 4 – Examples of water supply intervention types (after KIRIWATSAN I)

Individual Groundwater well



APRON PLAN

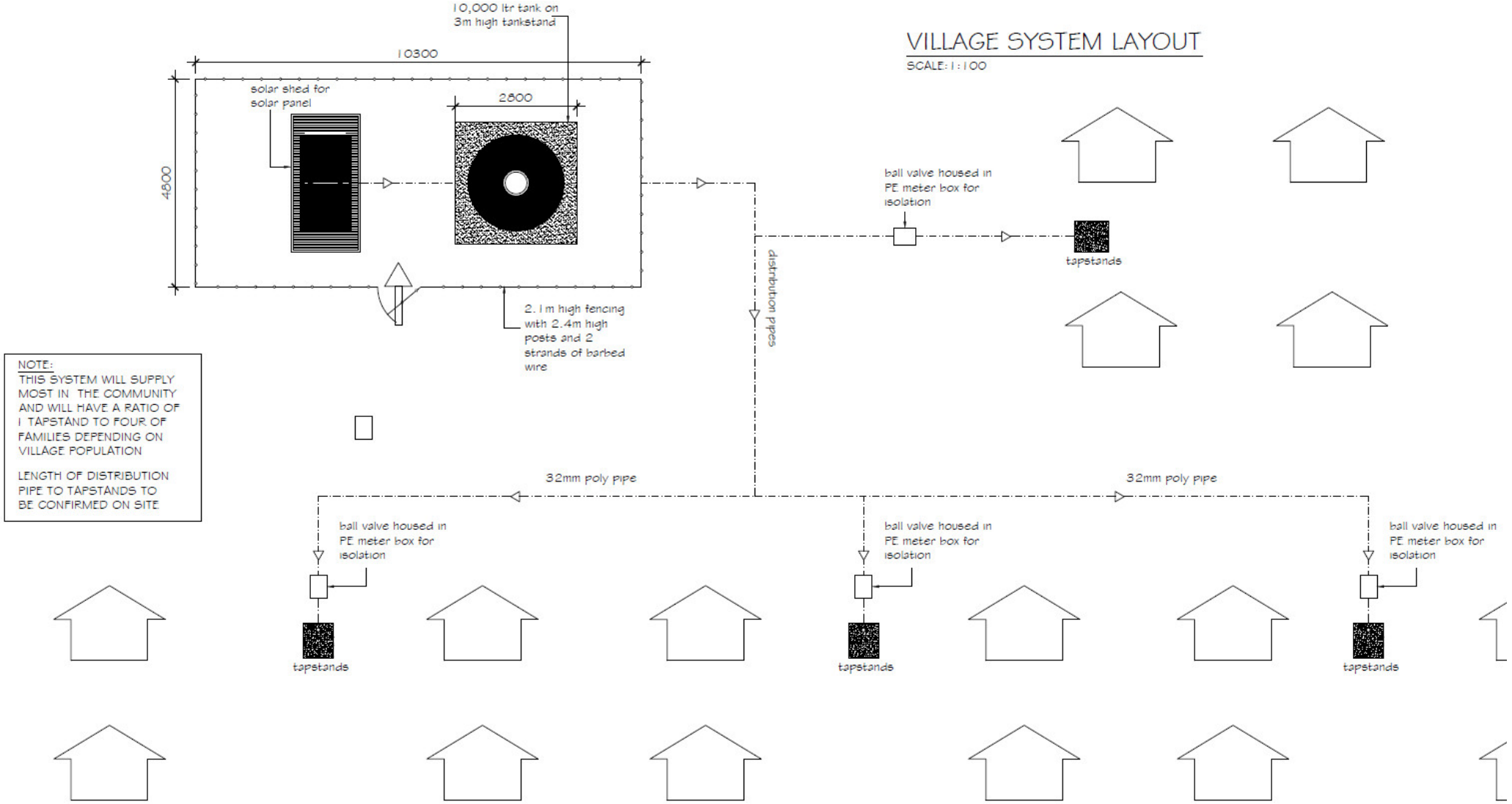
SCALE: 1 : 20

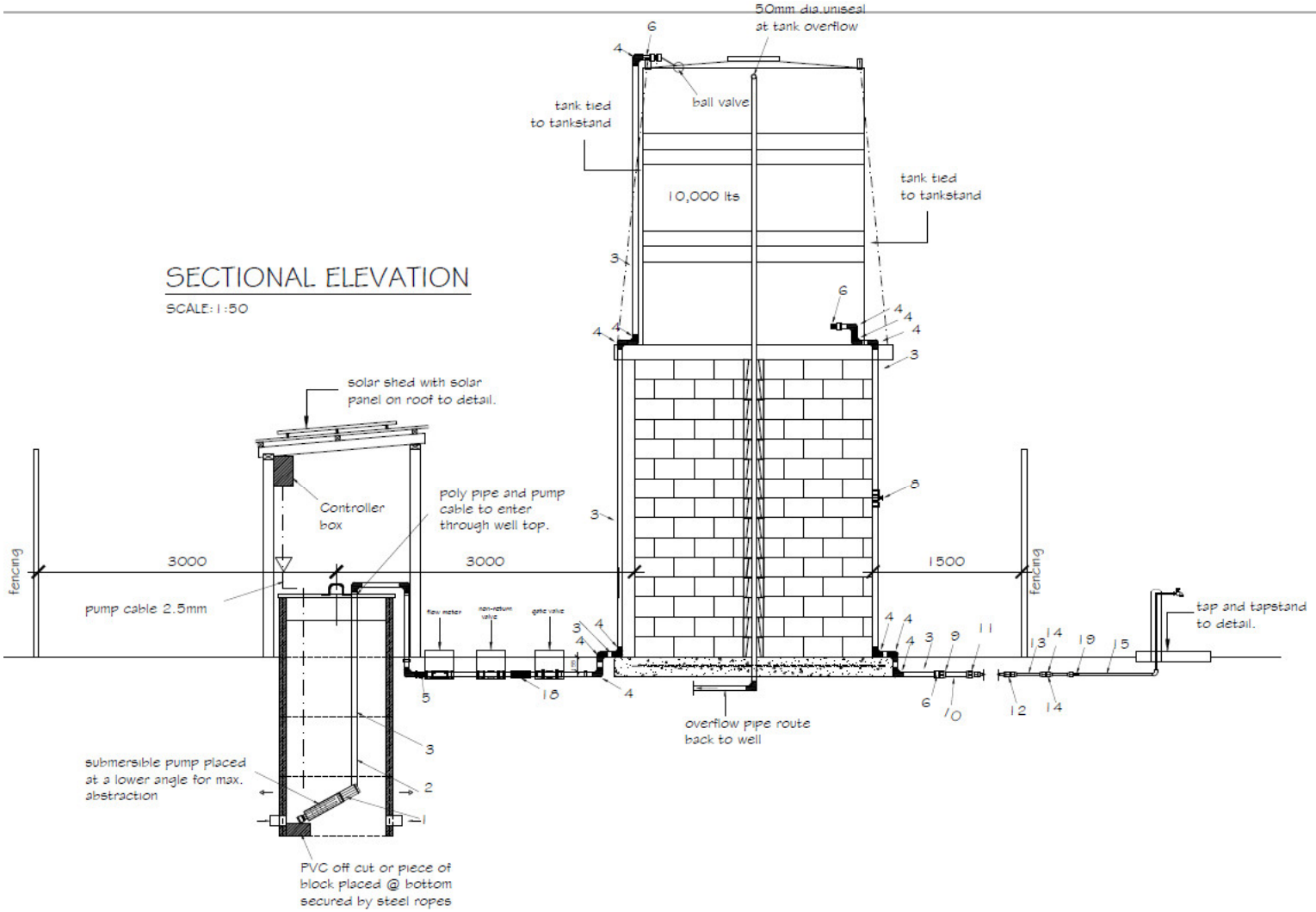


SECTION A - A

SCALE: 1 : 20

Infiltration Gallery and Communal groundwater supply system

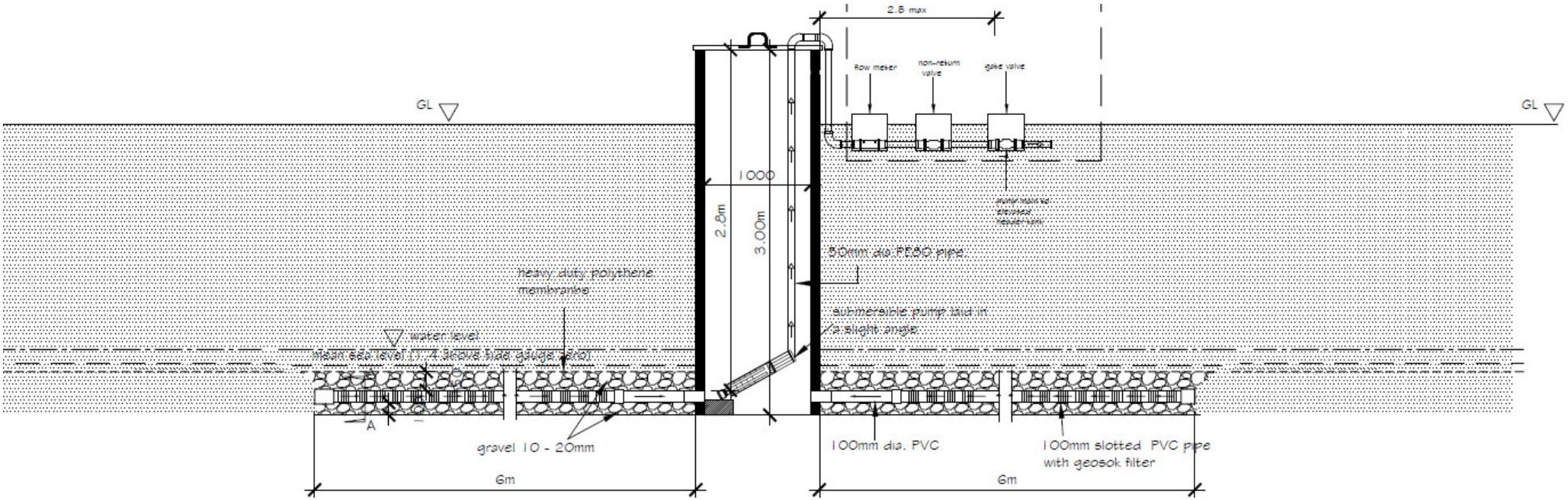




Legends.

1. Solar pump 12/24volt
2. pvc male adaptor 50x40mm
3. pvc pipe 50mm
4. pvc elbow 50mm
5. pvc union 50mm
6. float valve 50mm
7. pvc male adaptor 50x40mm
8. brass gate valve 50mm
9. poly female adaptor 50mm
10. poly pipe 50mm
11. poly reduce coupling 50x32mm
12. poly pipe 32mm
13. poly reduce coupling 32x25mm
14. poly pipe 25mm
15. poly reduce coupling 25x16mm
16. pvc pipe 15mm
17. pvc socket elbow 15mm
18. non return valve with fittings for 50mm poly pipe
19. ball valve

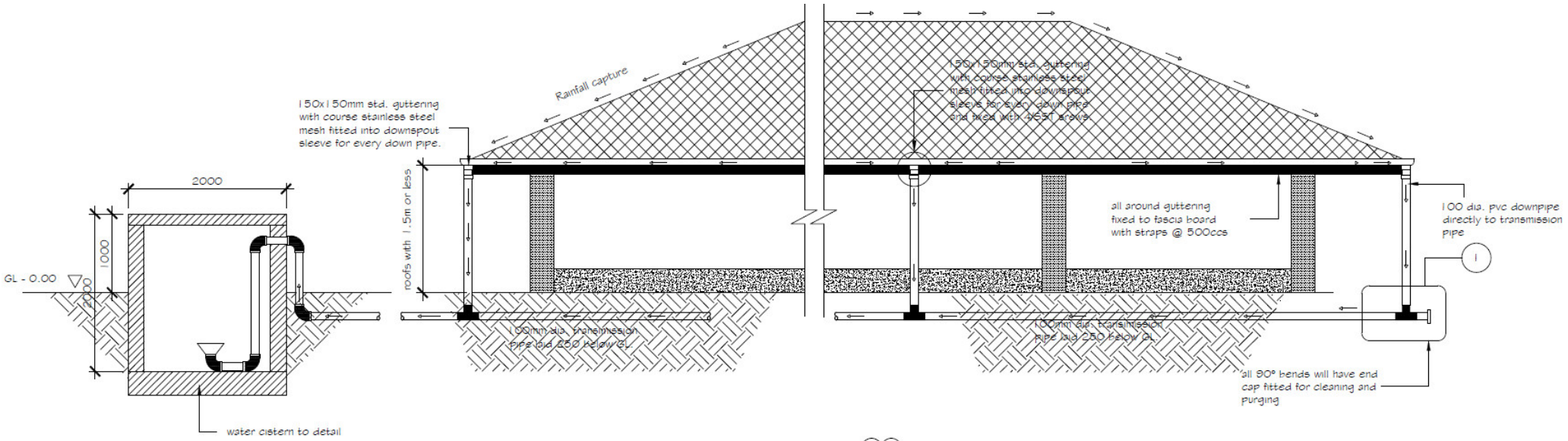
Infiltration Gallery and Communal groundwater supply system

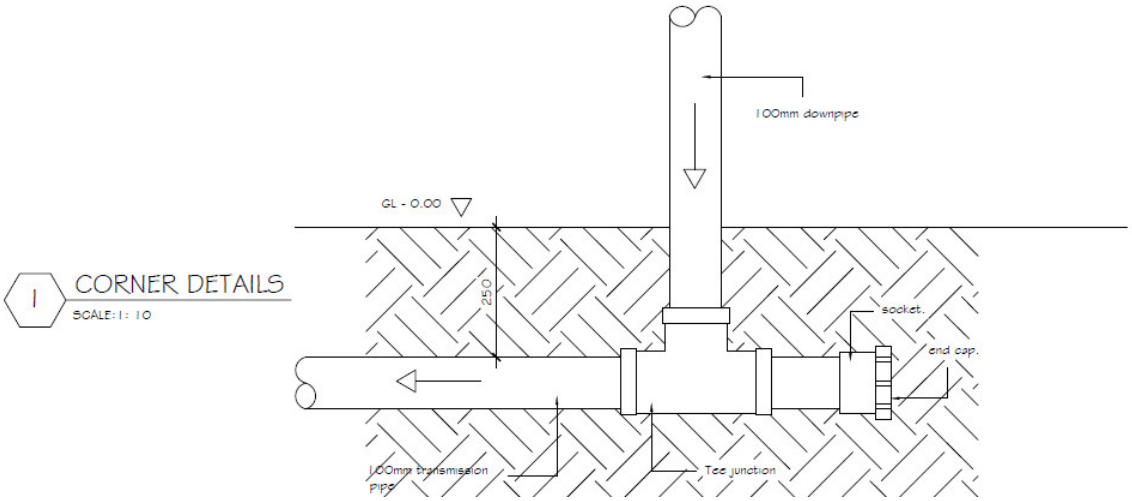


SECTION ELEVATION

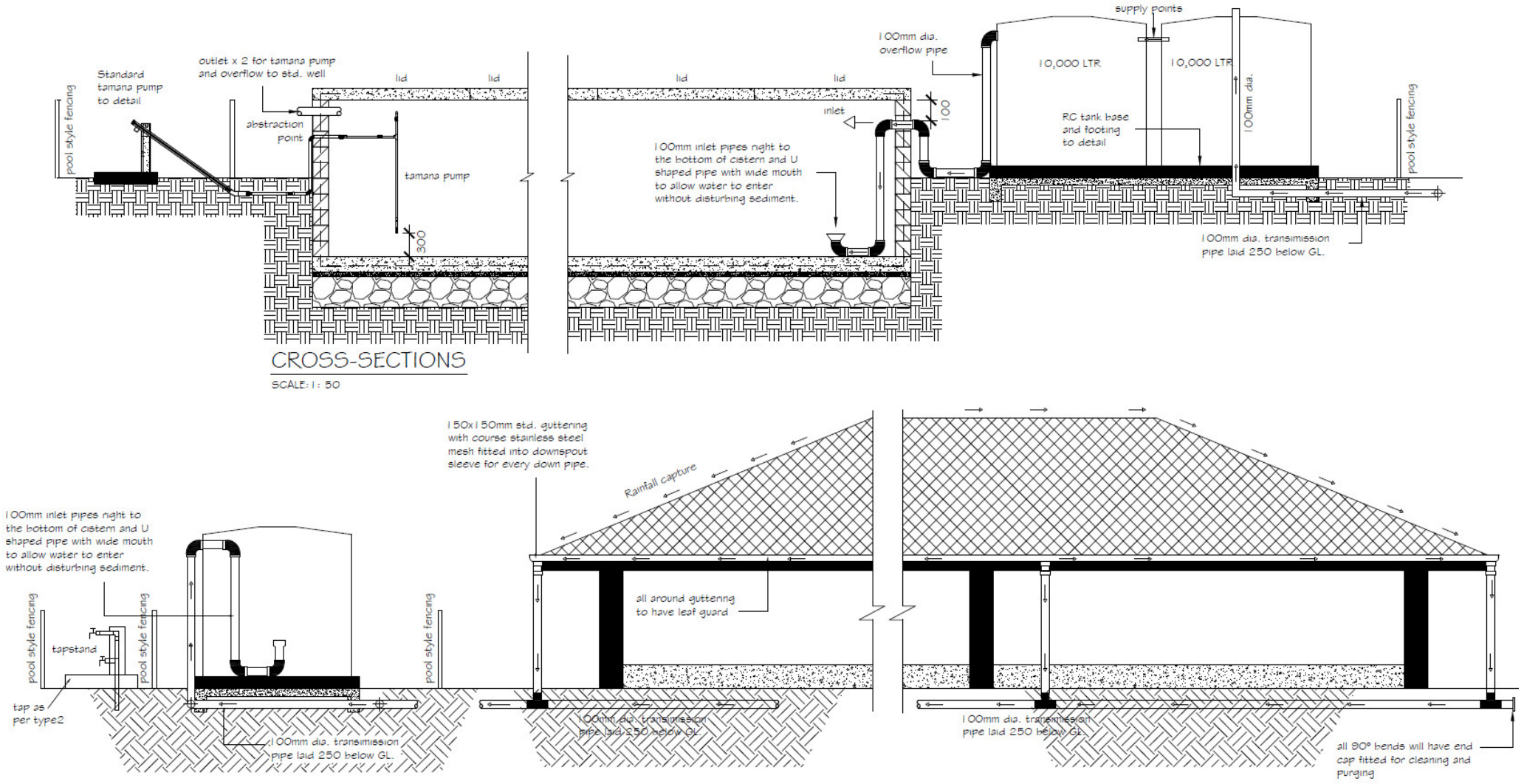
SCALE: 1 : 40

Community Rainwater Harvesting system





Rainwater Harvesting systems



Annex 5 – Background literature

References regarding water security and hydrology assessments in four Pacific countries with only or mainly atoll islands

The references below are listed according to:

- General (covering the 4 atoll countries below and other Pacific island countries)
- Federated States of Micronesia (FSM)
- Kiribati
- Republic of Marshall Islands (RMI)
- Tuvalu

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