Initial Environmental Examination

August 2019

Tuvalu: Increasing Access to Renewable Energy

Prepared by Tuvalu Electricity Corporation for the Asian Development Bank

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ABBREVIATIONS

AC	Alternating current
ADB	Asian Development Bank
BSAP	Biodiversity Strategy and Action Plan
BESS	Battery Energy Storage System
CCP	Communications and consultation plan (for the project)
CEMP	Construction Environmental Management Plan
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DC	Direct current
DoE	Department of Environment
DDR	Due diligence report
EEZ	Exclusive Economic Zone
EHSG	Environmental, Health, and Safety Guidelines (of the World Bank Group)
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ENSO	El Niño Southern Oscillation
EPA	Environmental Protection Authority
ESCR	Environmental and Social Complaints Register
GDP	Gross Domestic Product
GFP	Grievance Focal Point
GHG	Greenhouse gas
GoT	Government of Tuvalu
GRC	Grievance Redress Committee
GRM	Grievance Redress Mechanism
ha	Hectare
IBA	Important Bird and Biodiversity Areas
IEE	Initial Environmental Examination
IUCN	International Union for Conservation of Nature
kW	Kilowatt
kWp	Kilowatt peak
MFED	Ministry of Finance and Economic Development (Executing Agency)
MPUI	Ministry of Public Utilities and Infrastructure
MW	Megawatt
MWp	Megawatt peak
OHS	Occupational health and safety
PPE	Personal Protective Equipment
PREIF	Pacific Renewable Energy Investment Facility
PV	Photovoltaic
SPS	Safeguard Policy Statement 2009 (of ADB)
SPREP	Secretariat of the Pacific Regional Environment Programme
TEC	Tuvalu Electricity Corporation (Implementing Agency)
UNESCO	United Nations Educational, Scientific and Cultural Organization

CURRENCY EQUIVALENTS

Tuvalu uses the Australia dollar (AUD$) - as at January 2019

AU$1.00 = US$0.716

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US$1.00	=	AU$1.397

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EXECUTIVE SUMMARY

The project. The Pacific Renewable Energy Investment Facility (PREIF) will administer a grant from the Asian Development Bank (ADB) for Tuvalu: Increasing Access to Renewable Energy (the project). The project will include subprojects on Nukulaelae, Nukufetau, Nui and Funafuti to continue the PREIF's aim of transitioning electricity generation from diesel to sustainable renewable energy generation sources.

Hybrid power systems were installed on Nukulaelae, Nukufetau and Nui in 2015 via a European Union (EU) funded project. The subprojects identified as part of this project will expand the existing hybrid power stations by installing additional solar capacity, thereby increasing the renewable energy contribution from approximately 60 - 70% to more than 90%. The subprojects will also increase flood resilience by replacing the existing diesel powerhouse on Nukulaelae and upgrading distribution system pillar boxes on all outer islands as well as improving power system monitoring and communication.

The subprojects on Funafuti will install additional solar and a new battery energy storage system (BESS) to increase the renewable energy contribution. The renewable energy contribution is expected to increase from approximately 16% to 32% as a result of these subprojects. The Funafuti subprojects also include a control system to better manage power system and allow greater renewable energy penetration as well as improved communications between distributed generation sources.

The subprojects will assist Tuvalu meet the objectives of its *National Energy Policy* (2009) as well as its goal of achieving 100% renewable energy by 2025 as articulated in the "Enetise Tutumau" - the *Master Plan for Renewable Electricity and Energy Efficiency in Tuvalu*.

Implementation arrangements. The Ministry of Finance and Economic Development (MFED) will be the executing agency for the project and the Tuvalu Electricity Corporation (TEC) will be the implementing agency reporting to the Ministry of Public Utilities and Infrastructure (MPUI).

Screening and categorisation. The project will create site-specific impacts which can be readily avoided or managed/mitigated and has been classified as Category B for environment following the ADB's Safeguard Policy Statement 2009 (SPS). A Category B project requires an environmental assessment commensurate with its level of impact, and this draft initial environmental examination (IEE) including a draft environmental management plan (EMP) has been prepared. The IEE also meets the requirements of an environmental assessment under Tuvalu's Environmental Protection Act. The IEE will be updated based on the detailed designs and will be (i) submitted to the Department of Environment (DOE) as part of the approvals process under the Environmental Protection Act; and (ii) integrated into the bid and contract documents.

Potential Impacts. There are not expected to be any significant negative environmental impacts associated with any of the subprojects. With the exception of Nukufetau, all subprojects either involve upgrade/replacement of existing infrastructure or are located on land that is already modified. Construction of the subprojects will involve the clearance of up to 800m^2 of vegetation that is dominated by introduced ground cover. No trees will be cleared. The additional solar photovoltaic (PV) array on Nukufetau is proposed to be located on the tidal flat (adjacent to the existing array) however, the area of disturbance (approximately 420m^2 or up to approximately 1000m^2 including the existing array) is small compared to the area of available habitat in Nukufetau (1.7% of the available tidal flat on the southern side of Savave for new array and a total of approximately 4% of available tidal flat habitat including the existing array). The subproject is not expected to have a negative impact on any species that utilises the tidal flat habitat.

The subprojects will not significantly impact any species listed as critically endangered, endangered or vulnerable under the International Union for Conservation of Nature (IUCN)

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Red List nor any critical habitat as defined under the ADB's SPS. Two migratory bird species, the bristle-thighed curlew (*Numenius tahitiensis*) and bar-tailed godwit (*Limosa lapponica*), listed as vulnerable and near threatened respectively, are likely to occasionally utilise the tidal flat habitat that will be disturbed for the Nukufetau subproject. However, as noted above, the area of tidal flat to be affected by the project is only a small area of the available habitat and the subproject is not anticipated to have a negative impact on either species.

Environmental Management Plan. Potential pre-construction, construction and operation impacts will be managed and likely reduced to acceptable levels through the implementation of the measures identified in the EMP. The IEE and EMP will be updated based on subprojects detailed designs. The recommended environmental mitigation measures will be incorporated into the design of the subprojects. The IEE and EMP will be included in technical specifications and bidding documents. Prior to construction works commencing, the successful construction contractor will prepare a construction EMP (CEMP) based on their methodology and construction approach that will be reviewed and approved by the Project Management Unit (PMU) (or a specialist consultant engaged on their behalf).

Consultation, participation and disclosure. Stakeholders have been consulted during the design of the project including government agencies, Kaupule and landowners. Consultations will continue throughout project implementation as per the project's communication and consultation plan (CCP).

Grievance redress mechanism. At the start of project implementation, a grievance redress mechanism (GRM) will be established for the project and will be implemented through pre-construction, construction and operation. The community will participate in the design of the mechanism to ensure it is appropriate and incorporates traditional methods of/approaches to conflict resolution and will be informed of the GRM through the consultation programme and by prominent display of the GRM process at the subproject sites and in TEC's office prior to the commencement of onsite works. There will be full and free access to the grievance focal point in TEC. The contractor will be responsible for implementing relevant elements of the GRM and this will be reflected in their CEMP.

Monitoring and reporting. Monitoring requirements are incorporated into the EMP. Monitoring will be carried out through all phases of the project development to ensure that the environmental mitigation measures are effective and that actual environmental impacts accord with predicted impacts and comply with environmental approval issued by the DoE and ADB safeguard requirements.

Safeguard implementation and compliance will be reported in contractor's monthly reports to TEC, quarterly progress reports prepared by TEC for MOF and ADB, and semi-annual safeguards monitoring reports prepared by TEC and submitted to the MOF and ADB. ADB will disclose the monitoring reports.

Conclusion. This IEE has identified potential environmental impacts associated with the proposed subprojects as identified in the *Tuvalu Feasibility Report TA9242 REG: Pacific Renewable Energy Investment Facility: Tuvalu*. Measures required to mitigate or minimise impacts have been summarised in an EMP. Provided the mitigation measures outlined in the IEE and EMP are appropriately implemented, the subprojects are not be expected to have any significant environmental impacts.

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1. INTRODUCTION

A. Project Background

1. Tuvalu is a Polynesian country located in the west Pacific, situated 4,000 kilometres (km) northeast of Australia, south of Hawaii and east of Papua New Guinea, as shown in Figure 1.1. Tuvalu is one of the smallest and most remote member countries of the Asian Development Bank (ADB); it has a total land area of 26 square kilometres (km^2) and an oceanic area of 900,000 km^2. Tuvalu is made up of nine island groups, the capital is Funafuti.

2. Tuvalu, like many Pacific Nations, has traditionally relied on imported fossil fuels for electricity generation. However, the impacts of high and often variable cost of imported fuels on economic growth has led to the development of policies aimed at reducing reliance of fossil fuels thereby reducing costs and increasing security of supply. In Tuvalu, this articulated in the 2009 *National Energy Policy* that has the goal of promoting the use of renewable energy resources and cost-effective, equitable, reliable, accessible, affordable, secure and environmentally sustainable energy systems to improve the well-being of the people of Tuvalu. In addition, the Government of Tuvalu (GoT) launched the "Enetise Tutumau" - the *Master Plan for Renewable Electricity and Energy Efficiency in Tuvalu* in 2012. This plan aims to generate 100% renewable energy by 2020 and to increase energy efficiency in Funafuti by 30%. The GoT has recently extended the target date for achieving 100% renewable energy from 2020 to 2025.

3. Tuvalu currently has approximately 16% renewable energy generation and 98% of households have access to electricity. The focus of the GoT to date has been to increase the renewable energy penetration on the outer islands of Tuvalu to 100% to be followed by Funafuti. Approximately 7-10% of GDP is spent on imported fuel (depending on oil prices), making energy the costliest sector of the Tuvalu economy.

4. The Pacific Renewable Energy Investment Facility (PREIF), approved by Asian Development Bank (ADB) in May 2017, has been set up to support 11 small Pacific island countries, including Tuvalu, transition electricity generation from diesel to sustainable renewable energy generation sources. The PREIF will benefit economies through (i) improved balance of trade by reducing fossil fuel imports, (ii) improved energy security, (iii) downward pressure on tariffs, and (iv) reduced greenhouse emissions. The ongoing facility will support regional approaches to energy sector reform, private sector development and capacity building, and will finance projects with an overall estimated cost of $750 million.

5. The PREIF will finance the Increasing Access to Renewable Energy Project (the Project) in Tuvalu [1] which will administer a grant from the ADB to undertake a feasibility assessment (including safeguards due diligence), prepare procurement documents and implement subprojects on Nui, Nukufetau, Nukulaelae and Funafuti aimed at increasing the capacity of renewable energy generation.

6. **Implementation arrangements**. The Ministry of Finance (MoF) will be the executing agency for the project and the Tuvalu Electricity Corporation (TEC) will be the implementing agency within the Ministry of Public Utilities and Infrastructure. A GoT Task Force has been established that is responsible for providing Government oversight of the project and

[1] ADB (2018) *TA-9242 REG: Pacific Renewable Energy Investment Facility (formerly Pacific Renewable Energy Investment Program) - Tuv01 QCBS-Tuvalu (49450-001)*

reporting to Cabinet. A Project Management Unit (PMU) will be established under the direction of TEC and will report to the MoF Task Force and TEC as required.

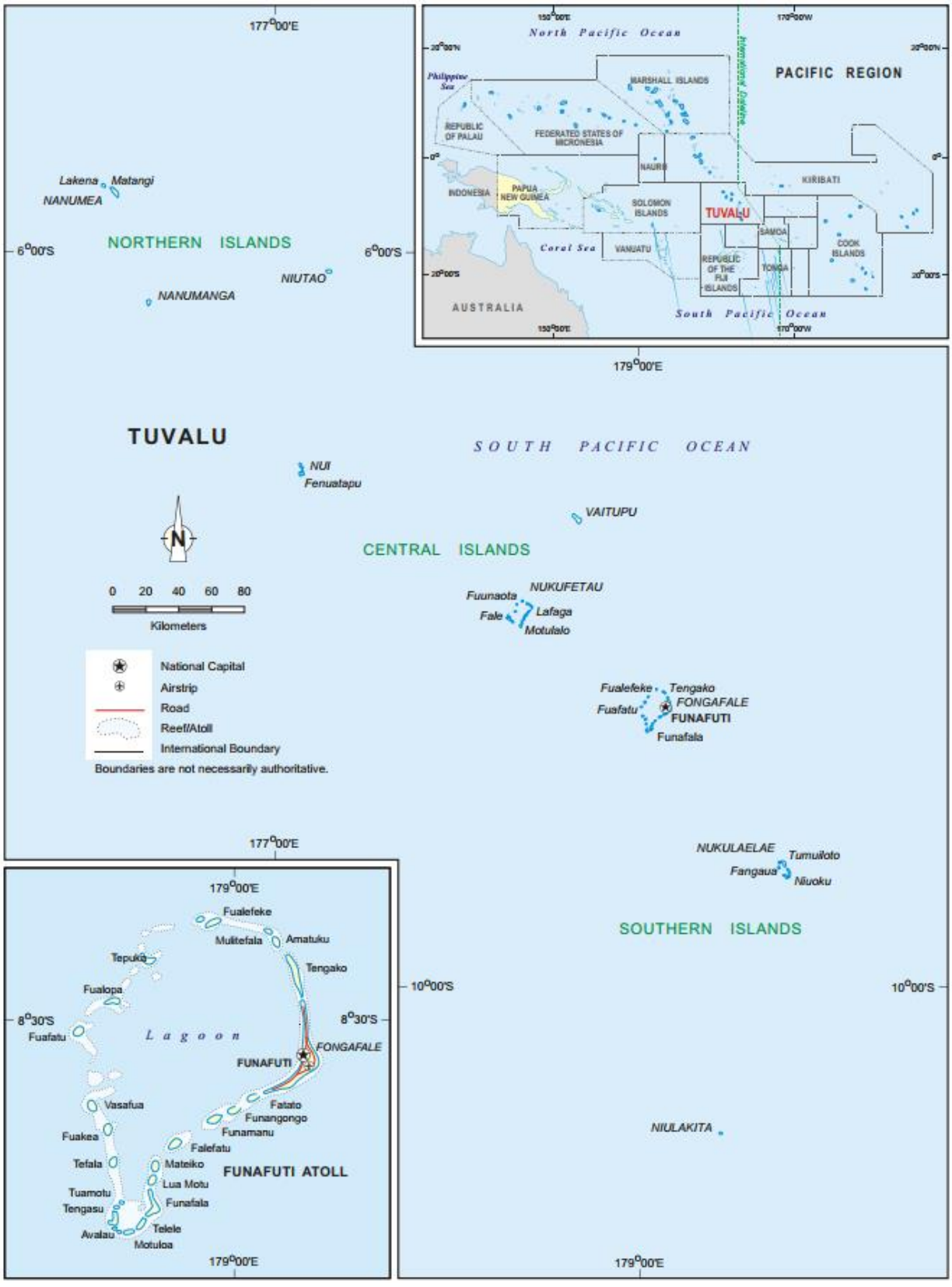

Figure 1.1: Map showing the location of Tuvalu its islands

B. Objectives and Scope of IEE

7. This document provides an initial environmental examination (IEE) of the project. The IEE has been prepared following the requirements of the ADB's Safeguard Policy Statement 2009 (SPS)[2] and the laws of Tuvalu.

8. The overall objective of the assessment process is to identify impacts associated with the project and measures to avoid, minimise/mitigate or compensate for them. The objectives of the IEE are to:

- Identify and describe the existing environmental conditions—physical, biological and socio-economic—in the subproject areas including the identification of critical habitat (as defined in SPS) potentially impacted by the project.
- Assess the proposed location, design, construction, and operation activities to identify and evaluate their potential impacts (positive and negative), and determine their significance.
- Propose appropriate mitigation and monitoring measures that are incorporated into an environmental management plan (EMP) that will avoid or minimise adverse impacts so that residual impacts are reduced to acceptable levels.
- Consult with stakeholders on the potential impacts and understand the issues and concerns about the impacts and how they might be affected.
- Ensure that all statutory requirements for the project such as applicable legislation and regulations, permits required (if any) and policies have been identified.

9. The scope of the IEE includes the construction footprint of the subprojects as well as the potential area of influence of the subprojects such as potential materials sourcing, haulage routes etc to ensure that secondary or indirect impacts can be identified and managed.

10. The IEE is based on primary sources of information derived through field observations and consultations during site visits and secondary sources of information available in relevant reports and databases.

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[2] ADB. 2009, Safeguard Policy Statement (Manila, Philippines)

2. LEGAL AND POLICY FRAMEWORK

A. Legal and Policy Framework of Tuvalu

11. **Institutional arrangements for environmental protection**. The Tuvalu Department of Environment (DoE), which is based in Funafuti, is overseen by the Director. It has a staff of four, including an EIA specialist, two environmental officers, and a librarian. It does not have offices or personnel in the outer islands. There will be limited capacity to provide environmental compliance monitoring of the projects on the outer islands during the construction phase.

12. Environmental management and the requirement for an environmental impact assessment are controlled by the *Environment Protection Act 2008*. The Tuvalu DoE administers the Act and Regulations. Specifically, Part 5 of the Act (sections 17 and 18) sets out the process and procedures for the undertaking of an Environmental Impact Assessment (EIA).

13. The *Environmental Protection (Environmental Impact Assessment) Regulations 2014* (amended in 2017) provides the regulatory management of EIA in the Tuvalu. It provides for the undertaking of preliminary environmental assessment report (PEAR) or EIA. All projects must comply with the legislation and regulations. Under Regulation 4, the Minister determines whether projects require either a PEAR or EIA.

14. **Policy framework.** Government policy on environmental protection is expressed in the National Environmental Management Strategy (NEMS)[3] which presents a long-term approach to dealing with environmental management issues to assist in efforts to achieve sustainable development. The key objectives of NEMS are to ensure sustainability of development by i) integrating environmental considerations into economic development, ii) improving environmental awareness and education, iii) balanced development and planned urbanization, iv) improving waste management and pollution control, v) protecting natural resources and vi) environmental monitoring. This sets the framework for the requirement of projects to undergo an environmental assessment process prior to approval and to commencement of any development.

15. **Legal framework.** The principal law governing the protection and management of the environment is the *Environmental Protection Act 2008*, and specifically, Part V – Environmental Impact Assessment, outlines the requirements and provisions for an Environmental Impact Assessment and monitoring of environmental impacts. This legislation was further strengthened with the *Environment Protection (Environment Impact Assessment) Regulation 2014* (amended in 2017) made under Section 39 of the *Environment Protection Act 2008*, which sets out the process for undertaking environmental impact assessments.

16. The DoE is responsible for the administration and enforcement of the *Environmental Protection Act 2008* and the *Environment Protection (Environment Impact Assessment) Regulation 2014.*

17. The DoE is a department under the Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour. Prior to 2011, it was part of the Ministry of Natural Resources. The DoE has the responsibility under the legislation for reviewing, assessing and monitoring projects.

18. The procedures for undertaking environment impact assessment under the *Environment Protection (Environment Impact Assessment) Regulation 2012* include a preliminary environmental assessment report (PEAR) be prepared for all development projects

in accordance with Regulation 8, and a full environment impact assessment (EIA) be prepared for activities with significant impacts as identified in the PEAR.

19. The PEAR includes an assessment of all reasonably foreseeable adverse and positive impacts, including long-term and short-term, primary and secondary consequences and an indication of measures that the proponent will take to mitigate or avoid identified adverse impacts. DoE will review the PEAR and prepare a report for the Minister. The Minister will consider the preliminary report and the recommendations provided by the Director of DoE.

20. If DoE confirms that a project will not cause any significant adverse impact to the environment and has complied with the requirements of Regulation 8, the Minister may give written approval to the project based on the preliminary report. The DoE and a proponent can also agree that an EIA is required for a major project at any time prior to or during the preparation of a preliminary report. If, after a review of the preliminary report, DoE confirms the project will cause significant adverse impacts to the environment, then the Minister may give notice in writing to the proponent that an EIA is required.

21. All EIA reports are submitted to the Director of DoE who arranges for a review of the report to be undertaken by DoE, or by an external reviewer in accordance with Regulation 15 if DoE does not have the necessary specialist skills to appropriately review a full EIA or any specific parts of an EIA. All EIA together with the report of the review by the DoE and a report of public consultations (if any) shall be referred to the Environmental Assessment Task Force for consideration.

22. The Minister may give written approval to any project based upon a full EIA which has complied with the requirements of Part IV, and which the Task Force has reviewed in accordance with Part V. The Task Force may also recommend to the Minister that a proposed major project is refused permission to commence or continue due to the unacceptable environmental impacts of the potential or existing project.

23. **Other relevant legislation**. Under the ***Foreshore and Land Reclamation Act 1969*** the State owns the foreshore and seabed. This is subject to public rights of navigation, fishing and passing over the foreshore, as well as any private rights which may exist. Section 3 (2) of the Act also gives authority to the Kaupule (council of elders) on each island specifically for licensing people who wish to remove anything from the foreshore. No person shall remove from the foreshore of any part of Tuvalu any sand, gravel, reef mud, coral or other like substances without having first obtained from the Kaupule in whose area of authority such foreshore lies, a license for that purpose.

24. The ***Conservation Areas Act 2008*** makes provision for the declaration and management of conservation areas. The Minister may declare any part of the territory of Tuvalu as a conservation area upon the request of a Kaupule and after due consultation with the Kaupule recommending the establishment of a conservation area. The objective of the conservation area is to protect the coastal, marine and terrestrial environment and preserve the biodiversity.

25. The ***Marine Resources Act 2006*** is the main law dealing with fisheries in Tuvalu and makes provisions for the promotion and regulation to ensure the long-term conservation and sustainable use of the living marine resources for the benefit of the people of Tuvalu. *The Marine Resources Amendment Act 2012* implements changes to the principal act which are intended to ensure that Tuvalu's international, regional and national rights and responsibilities in relation to fisheries conservation, management and development are accommodated. The Amendment significantly increased the level of penalties for various types of offence under the Act.

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26. Each inhabited island has a council of elders, or falekaupule, who are responsible for running the affairs of the island. The falekaupule cooperates with the national government on matters relating to the island and on matters of custom. The ***Falekaupule Act 1997*** (revised 2000) empowers Kaupule to provide for the improvement and control of fishing and related industries in accordance with the Fisheries Act and to prohibit, restrict or regulate the hunting, capture, killing or sale of animals, reptiles, birds or fish in accordance with the Wildlife Conservation Act.

27. **International agreements and conventions**. Tuvalu has ratified numerous environment- related international and regional commitments and remains in general compliance with the spirit of such commitments (Table 2.1).

Table 2.1: International Conventions and Treaties

Year	Convention or Treaty
1972	Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention)
1973	All IMO conventions and protocols relating to the prevention of pollution from ships
1982	United Nations Convention on the Law of the Sea (UNCLOS)
1982	Cooperation in the Management of Fisheries of Common Interest (Nauru Agreement)
1985	South Pacific Nuclear Free Zone Treaty (Rarotonga Treaty)
1985	Vienna Convention for the Protection of the Ozone Layer
1986	Protection of Natural Resources and Environment of the South Pacific Region and Related Protocols
1987	United States Multilateral Fisheries Treaty (as amended)
1987	Montreal Protocol for the Vienna Convention
1989	Basel Convention - Control of Transboundary Movements of Hazardous Wastes and Their Disposal
1989	Convention on the Prohibition of Fishing with Long Drift Nets in the South Pacific
1990	London Amendment to the Vienna Convention
1992	Rio Declaration on Environment and Development
1992	United Nations Framework Convention on Climate Change (UNFCCC)
1992	United Nations Convention on Biological Diversity (CBD)
1992	Copenhagen Amendment to the Vienna Convention
1993	Niue Treaty in Fisheries Surveillance and Law Enforcement
1993	United Nations Chemical Weapons Convention
1994	United Nations Convention to Combat Desertification
1995	Waigani Convention – banning importation, controlling and managing hazardous and radioactive waste within the South Pacific Region
1995	Amendment to the Basel Convention
1997	Kyoto Protocol to the UNFCCC
1999	Basel Protocol on Liability and Compensation for Damage to the Basel Convention
2000	Cartagena Protocol on Biosafety to the CBD
2001	Stockholm Convention on Persistent Organic Pollutants (POPs)
2004	Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (Tuna Convention)

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Year	Convention or Treaty
2016	Paris Agreement to the UNFCCC

B. ADB Safeguard Policy Statement

28. The goal of the ADB's SPS is to promote the sustainability of project outcomes by protecting the environment and people from any potential adverse impacts of the project.

29. The objectives of the SPS are to: (i) avoid adverse impacts of projects on the environment and affected people, where possible; (ii) minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible; (iii) help borrowers/clients to strengthen their safeguard systems and develop the capacity to manage environmental and social risks.

30. The SPS contains three safeguard requirements; SR1: environment, SR2: involuntary resettlement and SR3: indigenous peoples. Each of the safeguard requirements comprises an objective, scope and triggers, and a set of policy principles that must be met. Each of the safeguard requirements follows a due diligence process of screening, categorization, scoping, consultation, impact assessment, management, and monitoring and reporting. Documentation of the due diligence is subject to disclosure as per the requirements of the Public Communications Policy 2011.

31. ADB will not finance projects that do not comply with the SPS and the host country's social and environmental laws and regulations, including those laws implementing host country obligations under international law. The SPS also contains a prohibited activities list identifying specific activities that ADB will not finance.

32. As per SR1, the project has been screened as Category B i.e. its potential adverse environmental impacts are less adverse than those of Category A projects. These impacts are site-specific, few if any of them are irreversible, and in most cases mitigation measures can be designed more readily than for Category A projects. This IEE identifies as far as practicable the various components of the project and assesses the potential adverse environmental impacts and identifies the measures required to mitigate or minimize them and includes these in the EMP.

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3. PROJECT DESCRIPTION

A. Rationale

33. The energy sector in Tuvalu is managed by the Department of Energy within the Ministry of Public Utilities while the state-owned TEC is responsible for managing and operating the power system, which supplies 98% of the 11,000 population over eight islands. Like many other small Pacific islands, Tuvalu's electricity production has historically relied on diesel generation. In 2006, TEC consumed ~60% of all fuel (diesel, lubricant, oil and petrol) imported into Tuvalu, costing Tuvalu AUD 2.3 million[3]. As of September 2017, over 72% of electricity in Tuvalu was still generated using imported diesel fuel. Reducing Tuvalu's dependence on imported diesel fuel will also reduce their exposure to oil price shocks, such as the one that severely affected the region in 2008.

34. In terms of per-capita greenhouse gas emissions, Tuvalu registers in the upper half of Pacific island countries, ranked above Tonga, Samoa, Fiji, Tokelau, Kiribati, Vanuatu, Papua New Guinea (PNG) and the Solomon Islands In addition, Tuvalu has one on the highest electricity tariffs for residents in the Pacific region, with this tariff only covering half of TEC's operational costs in 2006[3].

35. Tuvalu has a large potential for renewable energy, notably from solar photovoltaic (PV) and wind power. However, financial, technical and other barriers have constrained the development of renewable energies. In response, a National Energy Policy was endorsed in 2009 with the goal of promoting the use of renewable energy resources and cost-effective, equitable, reliable, accessible, affordable, secure and environmentally sustainable energy systems to improve the well-being of the people of Tuvalu. In 2012, the Government of Tuvalu (GoT) launched the "Enetise Tutumau" - the *Master Plan for Renewable Electricity and Energy Efficiency in Tuvalu*. This plan had the goals to generate 100% renewable energy by 2020 and to increase energy efficiency in Funafuti by 30%. This 100% renewable target is also supported by "Te Kaniva 2012" (Tuvalu's Climate Change Policy). As of September 2017, Tuvalu had achieved around 28% renewable energy penetration. More recently the GoT revised the date to achieve the 100% renewable target to 2025.

36. Over the last 10 years, the European Union, United Arab Emirates, Japan International Cooperation Agency (JICA), World Bank and the New Zealand Ministry of Foreign Affairs and Trade (along with other donor agencies) have invested in a number of energy sector projects. These projects have helped Tuvalu increase its renewable energy generation through solar PV installations on Funafuti Island and hybrid solar PV-diesel-battery mini-grids on the outer islands. In addition, further projects are planned for Funafuti that will introduce wind power, add more solar PV and energy storage, and improved control systems.

37. In particular, there is a World Bank project currently procuring additional renewable energy options for Funafuti, including:

- 700 kW of solar PV to be installed at the northern end of Funafuti over the top of the waste disposal area
- 1 MW/1 MWh of battery energy storage system (BESS) to be installed in the TEC compound on Funafuti
- 200 kW of wind power installed to the north of the waste disposal area.

[3] Pacific Islands Applied Geosicience Commission (SOPAC) (2007) *Review of Tuvalu Electricity Corporation Base Tariff – Final Report*. Report prepared by Ridgeway Capital Projects, NZ.

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38. For Tuvalu to achieve its targets of 100% renewable energy by 2025, further investment is required. More specifically, for Funafuti to increase its renewable energy contribution further renewable energy generation is required whilst to increase its renewable energy penetration into the power system, additional energy storage is required to provide load shifting and to provide support to the grid when the solar production fluctuates. For the Outer Islands, the introduction of reliable 24 hour power supply has seen increased demand and in turn increased fossil fuel usage. The Outer Islands now require additional renewable energy generation to meet the renewable energy targets.

39. The current focus of the GoT is to raise the renewable energy contribution of the Outer Islands to as close to 100% renewable energy first, followed by increased renewable energy contribution on Funafuti. Based on data for the Outer Islands provided by TEC for the 2017, the annual renewable energy penetration for Nukulaelae, Nukufetau and Nui is 60-70% while the northern islands of Tuvalu are achieving in excess of 90%.

40. The subprojects proposed as part of the project will assist Tuvalu in meeting its 2025 renewable energy targets by increasing the renewable energy capacity of the Outer Islands of Nukulaelae, Nukufetau and Nui from 60-70% to greater than 90% and adding additional Solar PVs and storage on Funafuti. Thus, boosting renewable energy generation to approximately 39% (25 year average) on Tuvalu, from the estimated 16% currently and 29% following completion of the World Bank project[4].

B. Proposed Works and Activities

41. The project consists of ten subprojects located on three outer islands (Nukulaelae, Nukufetau and Nui) and Funafuti (see Figure 3.1 for location of subproject islands within Tuvalu).

Outer Islands

- *Outer Islands Subproject 1a-c*: expansion of the existing solar PV arrays on Nukulaelae, Nukufetau and Nui as outlined in Table 3.1.

Table 3.1: Solar expansion on Nukulaelae, Nukufetau and Nui (subprojects 1a to 1c)

Item	Nukulaelae (1a)	Nukufetau (1b)	Nui (1c)
Additional solar PV capacity (kWp)	44.8	78.4	100.8
Module capacity (W)	280	280	280
Additional module quantity	160	240	280
Additional PV Array area (m^2)	240	360	420
Additional 10kW inverter quantity	4	6	7
Additional PV Array 'blocks' (40 modules, 10m x 6m)	4	6	7

This subproject is an extension of a previous EU funded project for the outer islands of Nui, Nukufetau and Nukulaelae.

[4] Entura (2019) Tuvalu Draft Feasibility Report TA9242 REG: Pacific Renewable Energy Investment Facility: Tuvalu.

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- *Outer Islands Subproject 1d*: minor remedial works to the Nukufetau solar PV array.
- *Outer Islands Subproject 2*: replacement of the diesel powerhouse on Nukulaelae.
- *Outer Islands Subproject 3*: distribution system upgrades.
- *Outer Islands Subproject 4*: upgrade of ancillary, control and communication systems on Nukulaelae, Nukufetau and Nui.

Funafuti

- *Funafuti Subproject 1*: installation of 500 kWp of roof top solar PV on existing buildings.
- *Funafuti Subproject 2*: Installation of a 1MW / 2MWh BESS at the TEC Power Station.
- *Funafuti Subproject 3:* Upgrade of control and communication systems.

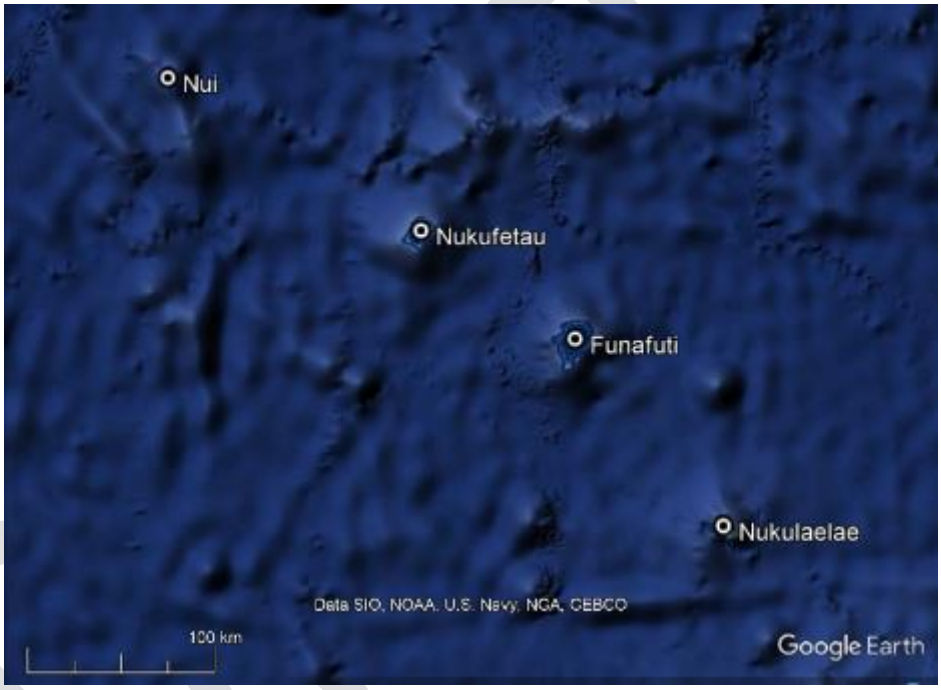

Figure 3.1: Proposed project sites in Tuvalu

42. **Outer Islands Subproject 1a**. The proposed solar PV expansion on Nukulaelae (Figure 3.2) will install an additional 44.8 kWp of capacity in a single row of four array 'blocks' each approximately 10 m x 6 m, totaling 240 m^2. The available space within the lease area at Nukulaelae is adequate for the proposed solar PV array extension as per indications provided by the lease area overlay on site imagery in Figure 3.3. The proposed extension will mirror the existing array. The expansion area has already been cleared of vegetation and will not impact the adjoining properties (Plate 3.1). Solar PV modules will be modern, high quality panels with a temperature / loss co-efficient suitable for the climate of Tuvalu. The solar PV array will be installed on a pre-manufactured solar PV array mounting system constructed of stainless steel, anodised aluminium and/or galvanised steel mounted on concrete blocks (pre-cast or cast on site) or piles. The new solar PV array will be connected to the solar powerhouse by a new buried DC cable (likely in the same cable trench or adjacent to the existing solar array connection). The subproject also includes the installation of additional equipment (inverters, distribution boards) within the existing solar powerhouse.

Figure 3.2: Location of project site in Nukulaelae

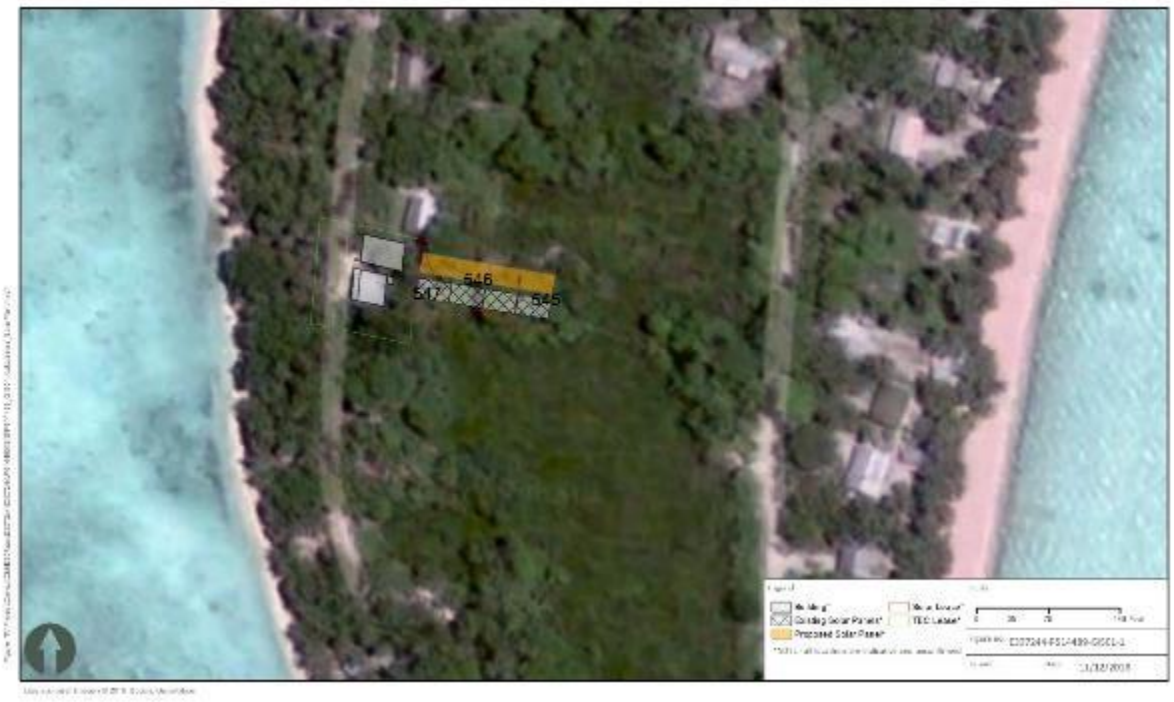

Figure 3.3: Nukulaelae site overview

Plate 3.1: Nukulaelae existing PV array showing planned area for expansion

Outer Islands Subproject 1b. The expansion of the solar PV array on Nukufetau (Figure 3.4) will install an additional 78.4 kWp in two rows of three array 'blocks' each approximately 10 m x 6 m, totaling 360 m^2. Nukufetau Island's existing solar PV array is located on the tidal flat adjacent to the power station as seen in Figure 3.5. The proposed new array will mirror the existing array and will also be located on the tidal flat. The solar PV array will be installed on a pre-manufactured solar PV array mounting system constructed of stainless steel, anodised aluminum and/or galvanised steel mounted on a frame specified by the contractor. The new solar PV array will be connected to the solar powerhouse by a new buried DC cable (likely in the same cable trench or adjacent to the existing solar array connection). The subproject also includes the installation of additional equipment (inverters, distribution boards) within the existing solar powerhouse.

Figure 3.4: Location of project site in Nukufetau

Figure 3.5: Nukufetau site overview

43. **Outer Islands Subproject 1c.** The expansion of the solar PV array on Nui (Figure 3.6) will install an additional 100.8 kWp in seven array 'blocks' each approximately 10 m x 6 m, totaling 420 m^2. The proposed solar PV expansion and layout area for Nui is shown in Figure 3.7. The Nui lease area overlaid in Figure 3.7 indicates that only limited space is available within the current lease agreements for additional solar capacity directly adjacent to the power station. The proposed areas are clear of vegetation, relatively flat and are set back from vegetation to the north. The 'block' arrangement from the existing array is repeated for ease of construction and uniformity of design. Solar PV modules will be modern, high quality panels with a temperature / loss co-efficient suitable for the climate of Tuvalu. The solar PV array will be installed on a pre-manufactured solar PV array mounting system constructed of stainless steel, anodised aluminium and/or galvanised steel mounted on concrete blocks (pre-cast or cast on site) or piles. The new solar PV array will be connected to the solar power house by a new buried DC cable (likely in the same cable trench or adjacent to the existing solar array connection). The subproject also includes the installation of additional equipment (inverters, distribution boards) within the existing solar powerhouse.

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Figure 3.6: Location of project site in Nui

Figure 3.7: Nui site overview

44. **Outer Islands Subproject 1d.** Minor remedial works to the Nukufetau solar PV array have been included to extend its operational life due. These shall include:

- Additional bracing brackets connecting the horizontal module support batons (rails) to the main framing rafters (existing speed bracing shows signs of corrosion and metal is dissimilar to module framing.

- Replacement of existing DC Isolators with IP66 rated isolators/ glands/ couplings/ conduits, sealing of conduit ends for PV connection tails with glands and installation of breather valves on isolators. (some existing isolators have failed, been replaced or otherwise modified by operators to release ingressed water)
- Installation of rounded strip footing to prevent further scouring around foundations of existing array, or other minor remedial works to be specified.
- Repainting wooden framing structure and fixings

45. **Outer Islands Subproject 2.** The existing diesel powerhouse on Nukulaelae was installed in 2000, and the floor is lower relative to sea level than the new battery house that was built in 2015. As evident when Cyclone Pam occurred in 2015, the diesel powerhouse is prone to flooding which presents a risk to the reliability of supply. This subproject includes replacement of this structure with a new building raised to at least the height of the new battery house. Required sizing has been estimated at 100 m^2. A 10 m x 10 m structure would provide adequate space for the existing diesel generator, include room for an operator office and the existing AC switchboards. The first distribution pillar equipment will also be relocated to within this structure, further increasing the reliability and robustness of the system. The proposed sizing fits within the extent of the existing TEC power house lease area.

46. **Outer Islands Subproject 3.** To mitigate future distribution risks of flooding impact from tropical cyclones, minor adjustments are proposed to the distribution system pillar design on all three outer islands. The updated design includes shifting fusing and metering equipment to the top half of the pillar enclosures. The flood resistant pillar design represents a low cost risk mitigation to improve the distribution system reliability and resistance to extreme weather events.

47. **Outer Islands Subproject 4.** Unlike the northern islands of Tuvalu, currently none of the power systems for the three islands within this project have control systems communications operating to provide remote support and monitoring by TEC or automation of system reporting. Thus, the subproject scope will include device and system upgrades to provide the additional functionality to support local operators, provide remote technical support and enable remote monitoring by TEC. This also will provide TEC with a complete long-term data set for future reference including meteorological data.

48. The control system upgrade will collect metering/status indication information from all devices, providing fault information and enabling remote diagnostics for support. This will include:

- Basic meteorological equipment; pyranometer (GHI), sonic wind sensor, ambient temperature & module temperature.
- Local data logging of major system parameters
- A Local HMI with an overview of the current power system status, trending of relevant power system parameters, status indication and alarms.
- Local island communications network upgrades may be required to enable an internet connection[5].
- Router, firewall and modem shall be utilised to provide secure remote access into the island systems from TEC offices in Funafuti.

[5] Full coverage options are proposed by the World Bank Project, Telecommunications and ICT Development Project (P159395), http://documents.worldbank.org/curated/en/324591500447035974/pdf/ITM00184-P159395-07-19-2017-1500447033526.pdf.

- Removal of the Sunny Webbox's (functionality superseded by above additions)
- Replacement of Sunny Island Inverter remote displays where faulty and provision of spares (25%).
- Operator desk with connected HMI laptop set up in either spare/replacement diesel powerhouse room or inverter hall.

49. **Funafuti Subproject 1.** Adding rooftop solar is likely to present the lowest cost solution to increase the renewable energy contribution on the Funafuti Island. Rooftops including the hospital, waste sorting building, civil services building and government office carparks have been identified for the installation of approximately 500kWp of roof top solar PV arrays (Figure 3.8). All buildings are owned by the GoT and all are either recently constructed or have been assessed for structural integrity and are suitable for the installation of solar arrays.

Figure 3.8: Rooftop solar and BESS locations

50. **Funafuti Subproject 2**. A 1 MW / 2 MWh Battery Energy Storage System (BESS) is proposed to be installed at the TEC Power Station compound on Funafuti (Figure 3.8). The BESS is likely to be containerised, utilise lithium ion batteries and be connected to the existing power station by a buried cable run through existing spare conduit.

51. **Funafuti Subproject 3.** As for the Outer Islands, the Funafuti project scope will include device and system upgrades to provide the additional functionality to support local operators, provide technical support and enable monitoring by TEC.

52. **Existing infrastructure**. Local infrastructure including roads and wharfs will be used for the subprojects. Roads and wharfs were inspected during the site visits and found to be suitable for use during the construction of the subprojects. It is noted that the ADB Tuvalu Outer Islands Maritime Infrastructure Project is installing a new wharf on Nukulaelae which, if complete, will facilitate the construction of the subprojects on Nukulaelae.

53. **Project construction**. Construction of ground mounted solar (*Outer Island Subprojects 1a-c*) will generally include:

- Clearing of existing vegetation.
- Spreading of fill material, compaction and levelling.
- Installation of site drainage, erosion and runoff controls where required.
- Trenching and installation of underground cables and conduit.
- Installation of solar PV mounting system.
- Installation of solar PV panels on mounting system.
- Site stabilisation planting low growing vegetation (e.g. grasses) beneath the solar PV modules to help stabilise the site and prevent erosion (ground mounted systems).
- Commissioning (load testing) of all equipment.

54. Replacement of Nukulaelae power station (*Outer Islands Subproject 2*) will generally include:

- Removal of existing generator and ancillary infrastructure from the diesel power house.
- Demolition of the existing diesel power house.
- Construction of the new diesel power house.
- Reinstatement of diesel generator and ancillary infrastructure.
- Commissioning of all equipment.

55. Upgrade of the new distribution pillars (*Outer Islands Subproject 3*) will generally include:

- Installation of redesigned pillar arrangement.

56. Construction of roof top solar (*Funafuti Subproject 1*) will generally include:

- Installation of solar PV mounting system on existing rooftops.
- Installation of solar PV panels on mounting system.
- Installation of cabling, ancillary electrical infrastructure and connection to the existing distribution line.

57. Little or no construction is anticipated for outer island subproject 1d and 4 and Funafuti Subprojects 2 and 3 and will be undertake by the same contractor team engaged to undertake the solar PV installations.

58. It is anticipated that up to eleven construction workers would be involved in the construction of each subproject (see Table 3.2). Where possible local workers will be employed under guidance from TEC. It is anticipated that the Outer Island subprojects will take approximately 12 weeks to construct including all ancillary projects (i.e. upgrade of communication and control systems, and distribution pillars; replacement of Nukulaelae power station). The Funafuti subprojects will take approximately 18 weeks to construct.

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Table 3.2: Estimated contractor team size and timeframe for each site

Island	Contractor team size (estimated)	Estimated total contractors	Duration
Nukulealea (inc. building replacement and upgrade of communication and control systems, and distribution pillar)	1 engineer, 1 electrician, 3 labourers	5	6 weeks
Nukufetau (inc. upgrade of communication and control systems, and distribution pillar)	1 engineer, 1 electrician, 3 labourers	5	3 weeks
Nui (inc. upgrade of communication and control systems, and distribution pillar)	1 engineer, 1 electrician, 3 labourers	5	3 weeks
Funafuti – BESS and system upgrades	1 engineer, 1 electricians, 4 labourers	6	6 weeks
Funafuti – Rooftop PV	1 engineer, 2 electricians, 8 labourers	11	12 weeks

59. **Project operation**. The subprojects will boost renewable energy generation. The existing and upgraded control systems will ensure grid stability by controlling the source of electricity into the grid as the solar PV systems fluctuate and load changes. The existing and new solar PV arrays, BESS and existing diesel generators will be combined and the control system used to manage operation to minimise diesel consumption while ensuring reliability of customer electricity supply.

60. **Project decommissioning**. The subprojects are expected to have a lifespan of approximately 25 years. It is likely that the system will be replaced with similar equipment and solar PV modules, batteries, inverters and other electronics and metal will be collected for recycling in the Tuvalu (where facilities exist) or transported to another country.

61. **Implementation schedule**. The proposed implementation schedule for the project is shown in Table **3.3**.

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Table 3.3: Proposed project schedule for implementation of projects for Outer Islands and Funafuti

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Activity	Q3 2019	Q4 2019	Q1 2020	Q2 2020	Q3 2020	Q4 2020	Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022
Award contract											
Submission of designs											
Design review											
Final design											
Place orders for PV and BESS											
Manufacturing of equipment											
Transportation to site											
Site preparation works											
Contractor mobilizes to Funafuti											
Output 1 – Outer Islands											
Site(s) handover to Contractor											
Contractor mobilization											
Site works Island 1											
Commissioning Island 1											
Site works Island 2											
Commissioning Island 2											
Site works Island 3											
Commissioning Island 3											
Initial O&M period											
Output 2 - Funafuti											
Site(s) handover to Contractor											
Contractor mobilization											
Rooftop solar PV installation											
Other solar PV											
BESS											

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Commissioning				[redacted]							
Initial O&M period				[redacted]							
Output 3 – Capacity Building											
Training of TEC operators											
Handover of manuals											

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4. BASELINE INFORMATION

A. Physical Resources

62. Tuvalu consists of six coralline (or true) atolls (Nanumea, Nui, Nukufetau, Funafuti, Nukulaelae, Vaitupu), and three table reef islands (Nanumaga, Niutao, Niulakita) with a total land mass of ~ 26 km^2 within an economic zone of 757,000 km^2.

63. **Nui**, consisting of 21 islets, is located~ 260 km north-west of Funafuti. It consists of eleven main islets separated by passages through which the sea passes freely from ocean to lagoon at high tide (Figure 4.1). The biggest, most southern and most eastern island is Fenua Tapu (area 1.38 km^2), which is followed by Telikiai, the most western islet. At low tide people can walk from islet to islet. Most people live on the western end of Fenua Tapu in a village that includes the settlements of Alamoni - Maiaki and Manutalake - Meang (Tanrake). The coral reef that links the islets is about 200 metres wide. The biggest opening in it is about 2 km long, stretching from Tabontebike to Tehikiai on the western side of the island. Nui has a total land area of 3.37 km^2. Nui's lagoon is comparatively small compared with the other atolls.

64. **Nukufetau** (35 islets) is a rectangular atoll located~ 100 km to the north-west of Funafuti. The biggest island is Motulalo (Figure 4.1). The total land area is about 3 km^2, making it the third largest island of Tuvalu. In the late 19th century, after the coming of the missionaries, the people of Nukufetau lived on Fale islet before shifting to Savave which is on the lagoon side of the Fale settlement. The lagoon is approximately 13 x 7 km with deep-water passages through the reef located on the northwest side to large ships to enter and anchor in the lagoon.

65. **Nukulaelae** meaning the 'land of sands' and consisting of 19 islets, is located ~ 130 km to the south-east of Funafuti. The atoll, with a total land area of 2 km^2, is characterised by a large central lagoon and fringing ponding lagoon that is approximately 10 x 4 km wide (Figure 4.1). There are two main villages, Pepesela and Nukualofa, both of which are located on Fagaua on the eastern side of the atoll.

66. The lagoon is completely surrounded by reef, without any passages to the sea. Although there are a number of natural shallow passages from the lagoon system to the ocean, the water level at low tide inside the lagoon is some 50 cm higher than the surrounding ocean. Most islets are bordered with sandy beaches on the lagoon side.

67. **Funafuti.** is the largest atoll on which the capital of Tuvalu is located. It is comprised of 33 islets around a central lagoon that is ~ 25 km by ~18 km (Figure 4.1). On the atoll, an annular reef rim surrounds the lagoon with several natural reef channels. The average depth in the lagoon is ~35 m, with a surface area of 275 km (making it the largest lagoon in Tuvalu). At the narrow "neck" area of the lagoon, the lagoon is very shallow and the surrounding islets are known for their unspoiled beauty and sandy beaches. The total land area of the 33 islets aggregates to 2.4 km^2, less than one percent of the total area of the atoll. The largest island of Funafuti is Fogafale on the eastern side of the atoll. There are nine main villages on Funafuti, seven on Fogafale (including the capital, Vaiaku) and one each on Amatuku and Funafala. Most of the government offices are located in Vaiaku. Cargo ships can enter Funafuti's lagoon and dock at the port facilities on Fongafale. The airport is also located on Fongafale islet in the village of Vaiaku on the eastern side of the atoll. The.

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68. **Topography and geology**[6] Tuvalu is a roughly linear archipelago and part of the Ellice-Gilbert-Marshall chain. It is the surface expression of thick carbonate carapaces draped over extinct volcanic mounds. The islands of Tuvalu are very low-lying with an average height of 1-2 m above sea level and maximum height of ~5 m[7], making them vulnerable to cyclones, tsunamis, king tides and other extreme tidal or weather events. This makes Tuvalu one of the most vulnerable countries to sea-level rise and climate change. There are no surface freshwater rivers or lakes in Tuvalu.

69. The Islands developed as a result of ocean tectonic activities. As the Pacific plate moved atop a stationary hotspot, massive successive eruptions resulted in the formation of a linear chain of nine Islands called Tuvalu, meaning 'eight standing together'. The ocean basaltic mountain foundations of Tuvalu then allowed the attachment and upward growth of coral polyps to the sea level surface. Thus, the Islands of Tuvalu are coralline with ocean basaltic mountain foundations.

70. The coral platform attached on top of the ocean basaltic mountain foundations emerged above sea level approximately 3,000 years ago, thus exposing it to erosion and degradation by natural forces. The erosion and the degradation of the coral platform resulted in the accumulation of unconsolidated sand on the reef-top. Soil development commenced after the arrival and by the activities of pioneer plants species, where, litter from these plants increased the humus content and richness of the soil, thus allowing it to support the growth of higher plants. +

71. Mineral deposits in Tuvalu are virtually non-existent, however phosphate (guano) deposits were mined in the late 1800s. While earth materials (sand, gravel and stone) can be obtained, it is at the expense of the environment as obtaining them results in precious land area being made essentially unusable (such as the borrow pits on Funafuti)[8]. In addition, extraction from foreshore areas can lead to increased erosion and susceptibility to storm surges.

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[6] Tuvalu Climate Change response Office (2002) *National Report to the United Nations Convention to Combat Desertification Tuvalu*. Draft UNCCD Report.

[7] Rodgers, K.A., 1992. Occurrences of phosphatic rocks and associated soils in Tuvalu, Central Pacific. *Atoll Res. Bull*. **360**: 1-31.

[8] Lane, J. (1993) *Tuvalu State of the Environment Report*. Report for the South Pacific Regional Environment Programme (SPREP) as documentation in support ofthe Tuvalu National Environmental Management Strategy (NEMS).

Figure 4.1: Satellite (Google Earth) images of Nui, Nukufetau, Nukulaelae and Funafuti

72. **Soils**[9]. As the islands of Tuvalu are all low atolls they are free of any major deposits of volcanic materials. Much of Tuvalu is composed of sand and silt-sized particles of limestone composed of calcium carbonate and a small proportion of magnesium carbonate. The coarse-textured, poorly developed calcareous soils tend to be 250 - 1,000 mm in depth, consisting of a variable layer of organic material, coral sand and rock fragments over a limestone formation. Levels of organic matter can be relatively high in undisturbed areas, however they decrease dramatically in disturbed areas. There is some accumulation of clays near the centre of the islets. The soils are also highly alkaline which locks up nutrients in the soil, and the activity of soil micro-organisms is limited.

[9] Lane, J. (1993) *Tuvalu State of the Environment Report*. Report for the South Pacific Regional Environment Programme (SPREP) as documentation in support ofthe Tuvalu National Environmental Management Strategy (NEMS).

73. Scattered throughout Tuvalu there are areas of phosphate rich soils and phosphate deposits which have originated from guano deposits that have accumulated over long periods of time. In some low lying areas, there are also poorly developed, but relatively fertile, wet soils.

74. Thus, the soils of Tuvalu are among the most infertile in the world. They typically have limited potential for agriculture production as they are deficient in key nutrients required for plant growth e.g. nitrogen, potassium and micronutrients such as iron, manganese, copper and zinc. The soil is also very porous and allows water to seep down to the bottom of the coral bed and float on a freshwater lens.

75. **Seismicity**[10]. Tuvalu is situated in a relatively quiet seismic area but is surrounded by the Pacific "ring of fire," which aligns with the boundaries of the tectonic plates. These tectonic plate boundaries are extremely active seismic zones capable of generating large earthquakes and, in some cases, major tsunamis that can travel great distances. No significant earthquakes have been observed in recent history. However, in 1899, a large earthquake off the eastern coast of New Ireland, Papua New Guinea generated a large tsunami that resulted in destructive waves at Nukufetau atoll. and a significant historic seismic event was a magnitude 7.0 earthquake recorded in 1907. Based on modelling undertaken for the World Bank, Tuvalu has a 40% chance in the next 50 years of experiencing, at least once, extremely weak levels of ground shaking. However, these levels of shaking are not expected to cause damage to well-engineered buildings and infrastructure assets.

76. **Tides and wave climate**[11, 12]. Tidal variations in Tuvalu based on tidal data for Funafuti and Vaitupu Atolls is generally small, with a mean spring tidal range (MLWS to MHWS) of ~1.9 m. Due to the small tides, tidal currents are expected to be small with the governing currents on the reefs are expected to be driven by waves[13]. The 2019 tidal range for Funafuti – Tuvalu is set out in Table 4.1. The tidal range for Nui and Nukufetau is expected to be similar to Vaitupu atoll (~0.03 – 0.15 m higher than Funafuti)[14]. Nukulaelae is expected to be similar to slightly lower that Funafuti.

Table 4.1: Tidal Range (2019) for Funafuti, Tuvalu

Tidal Plane	Water Level (m above tide datum)	Water Level (m to MSL)
Highest Astronomical Tide (HAT)	3.303	1.255
Mean High Water Spring (MHWS)	3.006	0.958
Mean High Water Neap (MHWN)	2.320	0.272
Mean Sea Level (MSL)	2.048	0
Mean Low Water Neap (MLWN)	1.760	-0.288

[10] World Bank (2011) *Pacific Catastrophe Risk Assessment and Financing Initiative - Country Risk Profile: Tuvalu*
[11] BOM (2019) *Tuvalu - Funafuti 2019 Tide Predictions Calendar. Climate and Oceans Support Program in the Pacific.* A Pacific Islands Program supported by the Australian Government.
[12] Australian Government (2015) *Current and Future Climate of Tuvalu*. Report for the Pacific-Australia Climate Change Science and Adaptation Planning Program.
[13] ADB (2018) *Tuvalu: Outer Island Maritime Infrastructure Project – Additional Financing: Initial Environmental Examination*
[14] BOM (2019) *Tuvalu - Vaitupu 2019 Tide Predictions Calendar. Climate and Oceans Support Program in the Pacific.* A Pacific Islands Program supported by the Australian Government.

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Mean Low Water Spring (MLWS)	1.130	-0.918
Lowest Astronomical Tide	0.888	-1.16

77. Tuvalu lies within the trade wind zone but on the edge of the South-west Pacific equatorial doldrum zone. From May to October the prevailing winds are from the east/south east and are generally light. Gale force winds (>33 knots) are relatively rare and mostly occur as west to north westerly winds during the cyclone season (November to April).

78. Wind driven waves around Tuvalu do not vary significantly in height during the year. Seasonally, waves are influenced by the trade winds, extra-tropical storms and cyclones. From year to year they vary with the El Niño–Southern Oscillation and the strength and location of the South Pacific Convergence Zone. At Funafuti maximum wave height occurs during June to September, with the wave direction south-easterly to east from May to October and north-easterly from December to March, associated with variability of the south-east trade winds and long period south-westerly swell waves from the Southern Ocean (Figure 4.2).

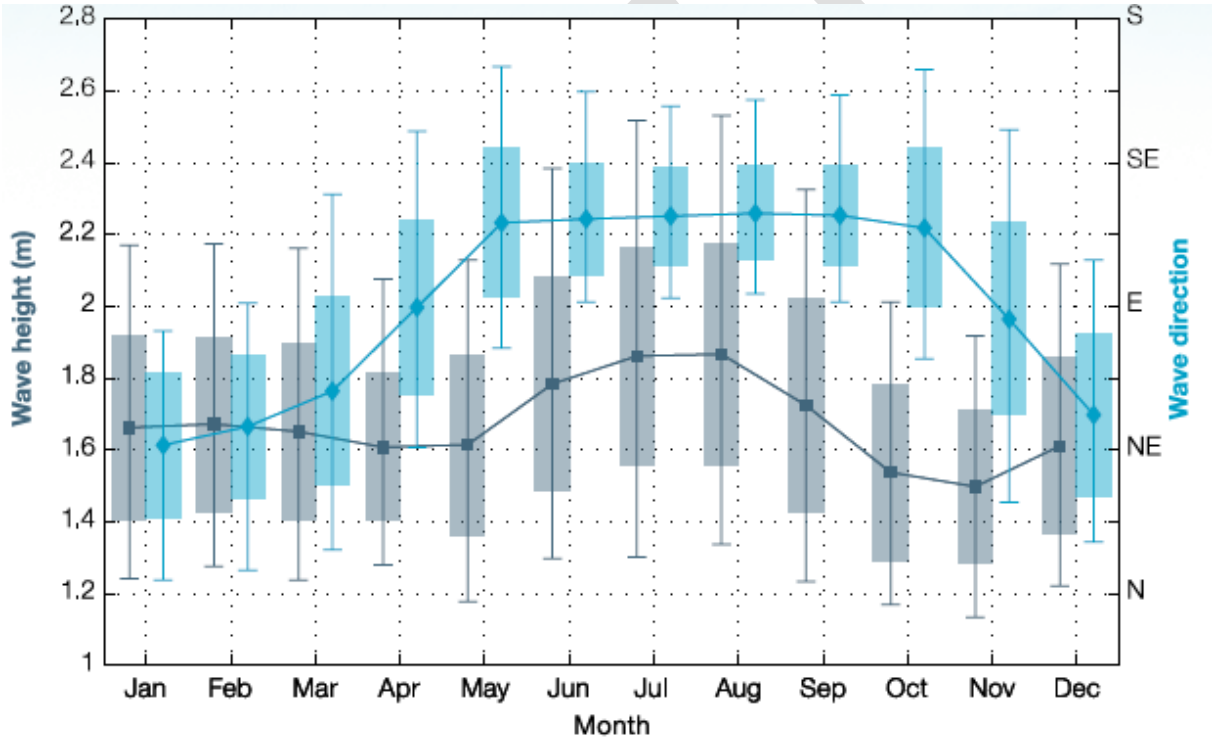

Figure 4.2: Mean annual cycle of wave height (grey) and wave direction (blue) at Funafuti. (Source**:** Australian Government (2015) *Current and Future Climate of Tuvalu*. Report for the Pacific-Australia Climate Change Science and Adaptation Planning Program**).**

79. **Coastal processes**. The coastal landscape of Tuvalu is inherently dynamic, with erosion and accretion of sands and sediments along the coastal margin a common feature, especially during tropical cyclones associated with high seas and storm surges. Coastal erosion processes in Tuvalu are most severe on the western side of islands or atolls where the sediment size is generally smaller (Figure 4.3)[15].

[15] Ministry of Natural Resources, Environment, Agriculture and Lands (2007) *Tuvalu's National Adaptation Programme of Action*.

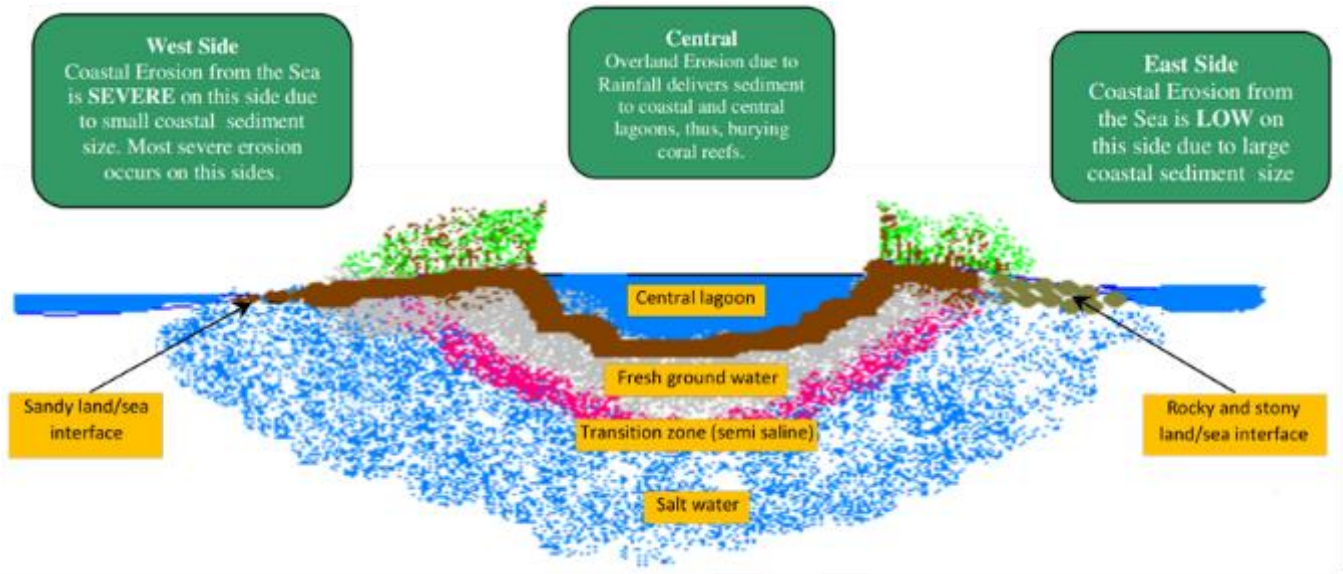

Figure 4.3: Cross-section of an atoll in Tuvalu showing common coastal erosional processes (Source: Ministry of Natural Resources, Environment, Agriculture and Lands (2007) *Tuvalu's National Adaptation Programme of Action*)**.**

80. Coastal erosional and accretion processes of Tuvalu archipelago can be influence by[16]:

- Shifts in the incident wave climate which reconfigures depositional nodes on reef surfaces. However, analysis of the 30-year wave hindcast data from the Tuvalu region shows no appreciable change in wave climate since 1979.
- Rising sea levels which can allow a greater transfer of wave energy across reef surfaces, thus enhancing remobilisation of island shorelines and sediment transfer. There is compelling evidence to indicate that this process has exerted an influence on atoll rim islands throughout the archipelago, expressed as ocean shoreline erosion and lagoon shoreline accretion. In many instances, such migration responses have also been accompanied by island expansion.
- Storm wave processes, including periodic cyclone events mostly occur from the west to north west that generate wave heights >3 m, which influence island morphology and size, although erosion or accretion trajectories vary depending on storm magnitude and the grade of material comprising islands.
- Maintenance of an active linkage between the reef sediment production regime and transfer to islands. On most windward reef sites such linkages are modulated by storm-driven wave deposition of new materials and subsequent reef recovery, whereas at leeward locations, where sand islands may prevail, supply is likely to be characterised by a more consistent incremental addition of sediments from reef flat surfaces.

81. Since 1971, the total land area of Tuvalu has expanded by 73.5 ha (2.9%)[16]. Nui, Nukufetau, Nukulaelae and Funafuti atolls have all expanded (Table 4.2), with the greatest expansion associated with Nukufetau and Nukulaelae.

[16] Kench, P.S., Ford, M.R. and Owen, S.D. (2018). Patterns of Island change and persistence offer alternate adaptation pathways for atoll nations. *Nature Communications* **9**: article 605.

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Table 4.2: Changes in land area from 1971-2014 for Nui, Nukufetau, Nukulaelae and Funafuti[16]

Atoll	No Islands	Land area	Change in land area 1971-2014		No. of Islands		Inhabited islands	
		(ha)	(ha)	(%)	Accreting	Eroding	No.	Area (km2)
Nui	13	342.8	7.61	2.22	13	—	1	1.34
Nukufetau	26	314.4	19.40	6.17	15	11	1	0.19
Nukulaelae	19	176.4	10.00	5.67	16	3	1	0.22
Funafuti	29	261.2	10.06	3.85	19	10	1	1.59

82. **Climate[17, 18]**. Tuvalu has a tropical marine climate with little variation in temperature throughout the year. In Funafuti, the maximum temperature is between 31–32°C and the minimum temperature between 25–26°C all year round (Figure 4.4). Air temperatures are strongly tied to the ocean temperatures surrounding the islands and atolls of the country.

83. The country has two distinct seasons: a wet season from November to April and a dry season from May to October (Figure 4.4). During the wet season, the monthly average rainfall in Funafuti is >300 mm compared to <250 mm in the dry season. The generally high average monthly rainfall (i.e. ≥200 mm) is due to the location of Tuvalu near the West Pacific Warm Pool (Figure 4.5), where thunderstorm activity occurs year round. The average annual rainfall for the period 1942–2005 was 2875 mm but rainfall can exceed 4000 mm per annum at times. However, rainfall varies from 3500 mm per annum in the southern islands to 2700 mm per annum in the northern islands. Tuvalu also frequently experiences droughts because of its location near the Pacific equatorial dry zone.

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[17] Australian Government (2015) *Current and Future Climate of Tuvalu*. Report for the Pacific-Australia Climate Change Science and Adaptation Planning Program.

[18] Australian Government (2011) *Climate Change in the Pacific: Scientific Assessment and New Research | Volume 2: Country Reports – Chapter 15 Tuvalu*. Report for the Pacific-Australia Climate Change Science and Adaptation Planning Program.

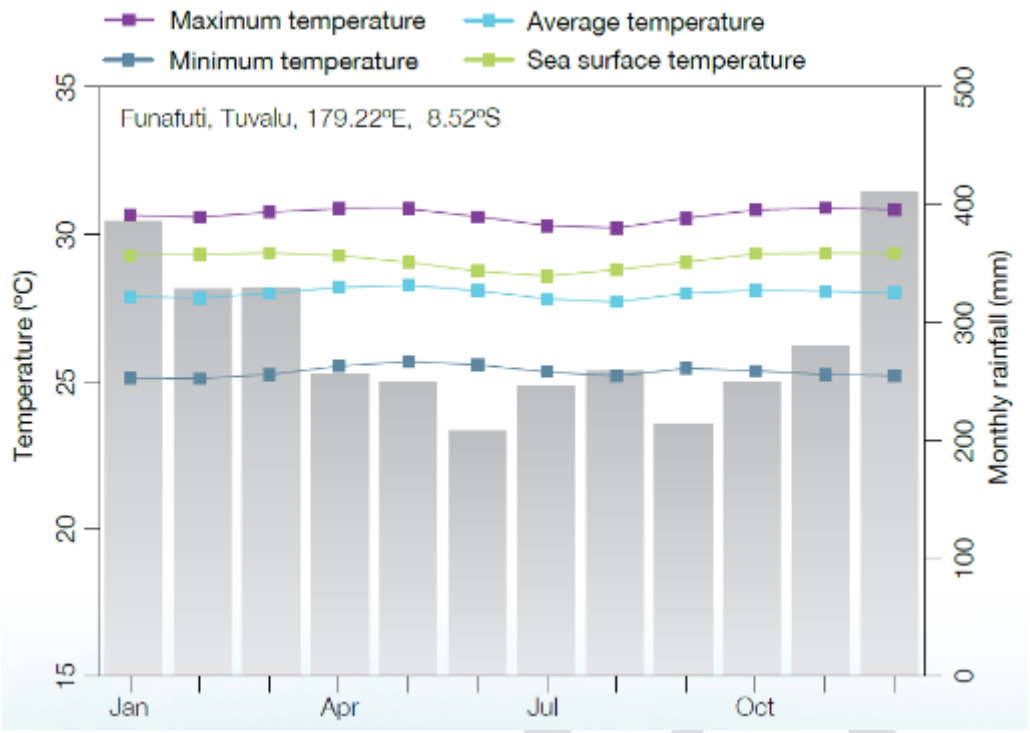

Figure 4.4: Seasonal rainfall and temperature in Funafuti

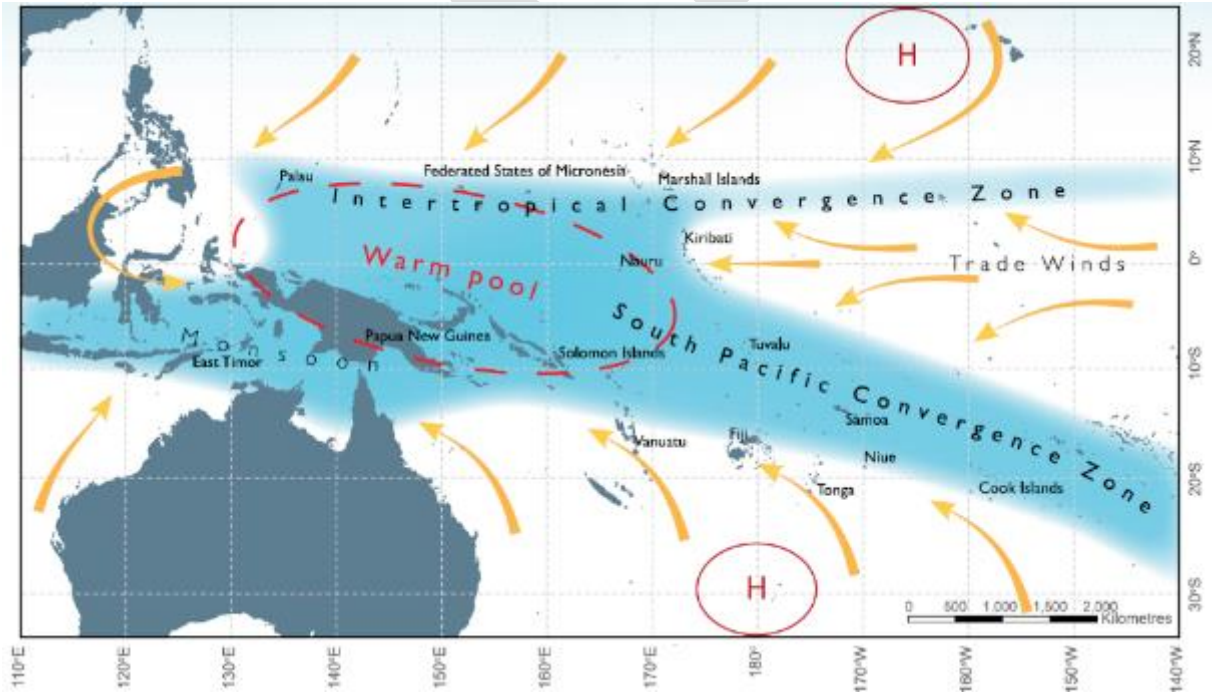

Figure 4.5: Average positions of major climate features during Tuvalu's wet season (November to April) (Source: Australian Government (2015) *Current and Future Climate of Tuvalu*. Report for the Pacific-Australia Climate Change Science and Adaptation Planning Program)

84. Tuvalu's wet season is affected by the movement and strength of the South Pacific Convergence Zone (Figure 4.5). This band of heavy rainfall is caused by air rising over warm water where winds converge, resulting in thunderstorm activity. It extends across the South Pacific Ocean from the Solomon Islands to the Cook Islands and is most intense during Tuvalu's wet season. The West Pacific Monsoon can also bring heavy rainfall to Tuvalu

during the wet season. The Monsoon is driven by large differences in temperature between the land and the ocean, and its arrival usually brings a switch from very dry to very wet conditions.

85. Tuvalu's climate also varies considerably from year to year due to the El Niño-Southern Oscillation. In Funafuti, El Niño events tend to bring wetter, warmer conditions than normal, while La Niña events usually bring drier, cooler than normal conditions. This is likely due to the warmer ocean temperatures around Tuvalu in El Niño years.

86. Spring tides and tropical cyclones are among the main extreme events that affect Funafuti. As well as high winds and rainfall, tropical cyclones also cause storm surges and swells. Tropical cyclones tend to affect Tuvalu between November and April. In the period between the 1969 and 2010 seasons, the centre of 35 tropical cyclones developed in or crossed onto the Tuvalu Exclusive Economic Zone i.e. passed within ~400 km of Funafuti (Figure 4.6).

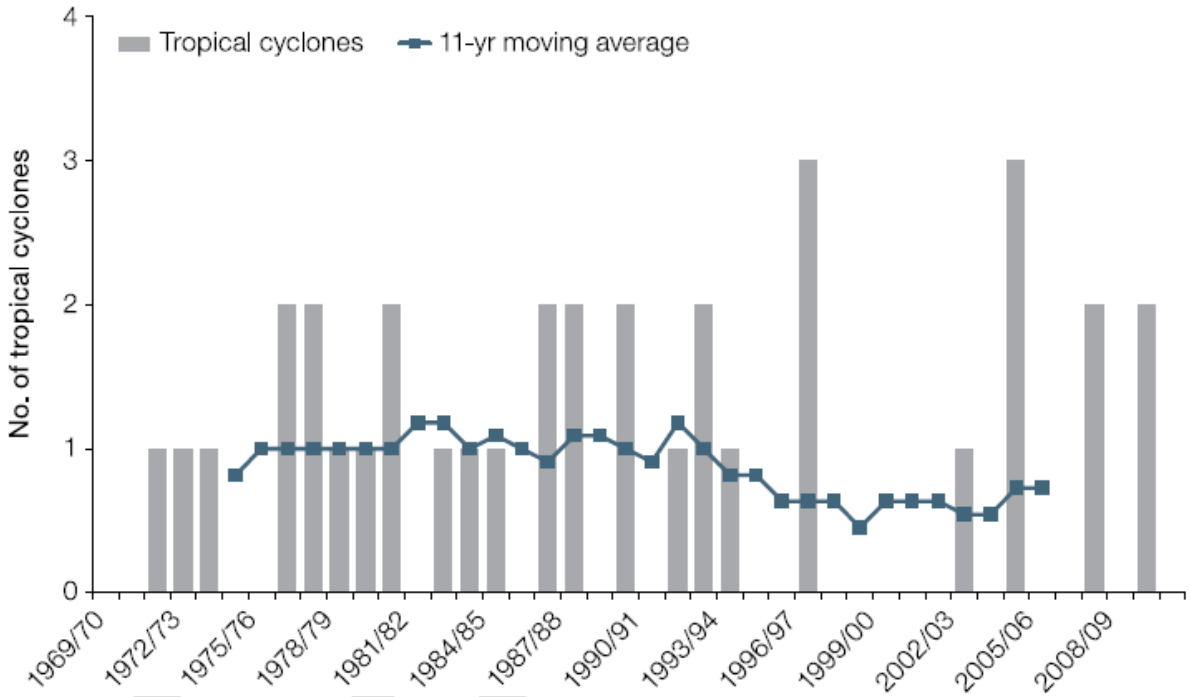

Figure 4.6: Occurrence of tropical cyclones that developed within or crossed the Tuvalu Exclusive Economic Zone per season between 1969 - 2010. A 11-year moving average is shown by the blue line.

87. Tropical cyclones were most frequent in El Niño years (12 cyclones per decade) and least frequent in La Niña years (four cyclones per decade). The ENSO-neutral season averaged six cyclones per decade. The interannual variability in the number of tropical cyclones in the vicinity of Funafuti is large, ranging from zero in some seasons to three in the 1997/98 season.

88. Several severe tropicalcyclones have caused devastating damage to Tuvalu in recent years, including:

- 1972 - Cyclone Bebe (Category 3): reportedly caused six fatalities and knocked down 90% of the houses on Funafuti and resulted in flooding due to seawater coming up through the coral to a depth of 1.5 m
- 1990 - Cyclone Ofa (Category 4): destroyed crops across Tuvalu and homes on Niutao, Nui and Nukulaelae. On Funafuti sea waves flattened the Hurricane Bebe

bank at the southern end of the airstrip, which caused sea flooding and prompted the evacuation of several families from their homes.

- 1992 – Cyclone Joni (Category 3): caused gale to storm force winds on the Tuvaluan island of Niulakita and minor damage to most of the Tuvaluan islands.
- 1996-97 - Cyclone Gavin, Hina and Keli (Category 3): Cyclone Gavin was the first of three Category 3 tropical cyclones to affect Tuvalu during the 1996-97 cyclone season, with Cyclones Hina and Keli affecting the islands later in the season. Cyclone Keli struck the islands of Tuvalu on June 12 and 13, with extensive damage reported throughout the Islands with trees uprooted by wind and waves. On Nivalakita, all buildings except for the church were flattened
- 2015 - Cyclone Pam (Category 5): Cyclone Pam resulted in 3-5 m waves causing significant damage to agriculture and infrastructure on most of the islands in Tuvalu, affecting 40% of Tuvalu's population. The atolls of Nanumea, Nanumanga, Niutao, Nui, Nukufetau, Nukulaelae, and Vaitupu were most affected.
- 2016 - Cyclone Ula (Category 4): affected Tuvalu in early 2016 with 3-4 m waves affecting all the islands. Ula produced winds up to 100 km/h across Tuvalu, uprooting trees and leaving 40 homes and ten businesses damaged, some beyond repair. Thirty families required evacuation.

89. Storm surges associated with cyclonic disturbances combined with high tides can result in waves washing over low sections of the atolls. As well as disrupting road access, increasing soil salinity, contaminating groundwater and enhancing coastal erosion processes, the resulting flooding causes agricultural losses and damage to buildings.

90. **Climate change**[19]. Tuvalu is listed as one of several island groups most likely to disappear beneath the sea in the 21st century due to climate change effects. For the period to 2100, the Pacific-Australia Climate Change Science and Adaptation Planning Program predicts:

- Annual mean surface air and sea surface temperatures and extremely high daily surface air temperatures will continue to rise.
  - By 2030, under a very high emissions scenario, the increase in surface air temperature is projected to be in the range of 0.5–1.0°C (the same range is also predicted under a low emissions scenario).
  - Increases in average surface air temperatures will also result in a rise in the number of hot days and warm nights, and a decline in cooler weather.
- It is not clear whether mean annual rainfall will increase or decrease, the model average indicating little change, with more extreme rain events.
  - Wet and dry years will still occur in response to natural variability.
  - Extreme rainfall days are likely to occur more often and be more intense.
  - Incidence of drought is projected to decrease slightly by the end of the century y.
- Tropical cyclones are projected to be less frequent but more intense.
  - likely to be an increase in the average maximum wind speed of cyclones by 2 - 11 % and an increase in rainfall intensity of ~20 % within 100 km of the cyclone centre.

[19] Australian Government (2015) *Current and Future Climate of Tuvalu*. Report for the Pacific-Australia Climate Change Science and Adaptation Planning Program.

- December–March wave heights and periods will decrease slightly.
- Sea level will continue to rise.
    - By 2030, under a very high emissions scenario, the rise in sea level is projected to be in the range of 7–18 cm.
    - The sea-level rise combined with natural year-to-year changes will increase the impact of storm surges and coastal flooding.
- Ocean acidification is expected to continue.

91. **Water resources**[20, 21]. There are no freshwater rivers or streams in Tuvalu, but freshwater does exists underground as a lens floating on seawater (see Figure 4.3). Atoll and reef islands greater than about 1.5 ha in size contain a permanent lens of freshwater surrounded by saltwater, with the volume of the lens roughly proportional to the surface area of the islet or island. These lens are derived from the infiltration of rainwater into the water table below the ground. The lenses form where the island/atoll is sufficiently wide enough to reduce the outward flow of the accumulated underground lens. The location and degree of development of the groundwater lens influences the health of the vegetation and associated wildlife, as well as the location of village wells and excavated taro pits. Significant groundwater occurs on Nanumea, Nanumaga, Niutao, Vaitupu and Nukufetau Atolls, where it has been estimated that the thicknesses of freshwater lens ranges from 3.2 to 7.9 m. On Funafuti the freshwater lens is most extensive and highly developed on the largest islet, Fogafale, although the freshwater resources are extremely limited in relation to the population size.

92. These freshwater lenses are extremely vulnerable to environmental influences, including pollution from inappropriate sanitation systems and animal waste (especially pigs). King tides and storm surges from cyclones also increase the frequency and duration of inundation, causing the fresh groundwater lenses to become salinised. Water quality measurements on the islands indicate that groundwater is heavily polluted with a high bacteria counts.

93. The majority of islands have groundwater wells with some wells just holes dug down to the groundwater lens and not protected from contamination and pollution. However within villages, most wells are protected by coral stone walls, capped and provided with hand pumps (diaphragm type). Thus, groundwater is only used as a secondary source for non-potable water where salinity levels are not too high and, in the outer islands, as an emergency supply for domestic needs during droughts. On Funafuti, groundwater is only used for feeding pigs, washing pig pens and flushing toilets. During droughts, its use is extended to washing clothes and bathing.

94. Due to the pollution levels and salinity of groundwater sources, all islands rely primarily on to stored household and communal rainwater from buildings and houses with iron roofs, with the rainwater a stored in concrete or plastic tanks above and below ground. Most households have their own water storage with few households having to rely solely on the community supply or someone else for their primary drinking water source. Communal sources include storages held by schools, churches and maneapas, and excludes hospitals and agricultural (fisheries) storages. Desalination plants have also been installed on Funafuti, Vaitupu and Nanumaga after Tuvalu experienced drought in 1999.

[20] GWP Consultants (2007) *Integrated Water Resources Management in Pacific Island Countries: A Synopsis*. Report compiled in conjunction with the Pacific Islands Applied Geoscience Commission, Fiji.

[21] Marsden Jacob Associates (2014) *Pacific Adaptation (Costs and Benefits) Scenarios: Water Security in Tuvalu*. Final Technical Report prepared for Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) Program.

95. This reliance on rainwater means that Tuvalu is highly vulnerable to changes in rainfall patterns, sea level, and associated extreme weather events that affect the quality and quantity of accessible, potable water. Availability of water resources is an ongoing challenge that is exacerbated by climate change, with water shortages frequent. In October 2011, a severe water shortage drove Tuvalu into declaring a state of emergency on Funafuti and Nukulaelae in which residents were rationed 25-45 litres of water a day per household. The governments of Australia and New Zealand responded to the freshwater crisis by supplying temporary desalination plants and assisting in the repair of the existing desalination unit on Funafuti that was donated by Japan in 2006.

96. **Physical coastal resources**[22, 23]. Tuvalu's shallow marine environments consist predominantly of fringing and patch reefs, with reef flats and intertidal rocky/sandy shores. Water depths increase very rapidly from the shoreline to over 1000 m within a few kilometres from the shoreline or outer reefs (Sauni 1998). There is no continental shelf seaward of any of the islands and the only substantial areas of shoal water are found within the internal lagoons. These atolls and low coral islands are generally subject to constant change through continuing growth of living corals and erosion and accretion as a result of wave action.

97. The people of Tuvalu are heavily reliant on the sea (in and off shore) for their subsistence needs and marine resources are regarded as Tuvalu's foremost asset for long-term economic development. All atolls and islands of Tuvalu have an open-access system where everyone has equal access to coastal and sea resources. At the same time, the State owns everything up to and including the coastal highest-water mark. This form of ownership extends to living (fish and invertebrates) and non-living (e.g. minerals, sand and rubbles, gravels, etc.) resources, below and above the seabed. The management of the resources therefore rests primarily with the State.

98. In Tuvalu, the only source of construction materials (e.g. sand, gravel, rocks and other aggregates) is reef-derived sands, reef rock and reef itself. Thus, mining for these materials has brought about irreversible damage to the coastal fringe of all islands and atolls, including shoreline modifications. Consequently, the removal of beach gravels and sands is now limited only for the construction of houses for personal use. Any project-scale removal of gravels and sand is not permitted. Thus, infrastructure projects are now required to import suitable aggregate, mainly from Fiji, adding considerably to the costs of construction[24].

99. **Unexploded ordnance**[24]. Tuvalu was used as an important staging base for US aerial attacks in the Battle of Tarawa in Kiribati during World War II. Bomber bases were established on Funafuti, Nanumea, and Nukufetau, being the only islands big enough to accommodate them, with the latter two being considerable closer to Tarawa. Funafuti, Nanumea and Nui were the only islands to be bombed during this operation. The U.S. Department of State provided assistance for the removal of World War II-era unexploded ordnance (UXO) on Funafuti, Nukufetau and Nanumea Atolls in 2015, with a range of small arms ammunition found and disposed of. There are no recorded unexploded ordnance (UXO) on Nukulaelae.

[22] Sauni, S. (2000) The status of the coral reefs of Tuvalu. pp. 331–349. In: *ICRI Regional Symposium: Coral Reefs in the Pacific: Status and monitoring; resources and management, 22–24 May 2000, Noumea, New Caledonia*. International Coral Reef Initiative/Institut de recherche pour le développement, Noumea, New Caledonia.

[23] Sauni, S., Kronen, M., Pinca, S., Sauni, L., Friedman, K., Chapman L. and Magron, F. (2005) *Tuvalu Country Report: Profiles and Results From Survey Work at Funafuti, Nukufetau, Vaitupu and Niutao (October–November 2004 and March–April 2005)*. Report to Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C/CoFish) / Secretariat of the Pacific Community.

[24] ADB (2018) *Tuvalu: Outer Island Maritime Infrastructure Project – Additional Financing: Initial Environmental Examination*

B. Terrestrial Biological Resources

100. **Terrestrial vegetation/habitat types**[25]. From the ocean to the lagoon side of a typical atoll islet there is normally distinctive zonation of substrates and associated vegetation. Despite severe habitat degradation, selective removal and harvesting of high-value trees and plants and increasing numbers of introduced species, there remains a significant amount of indigenous vegetation in various stages of disturbance, particularly in small stands of inland and coastal forest or mangroves and more extensive areas of scrub or shrub land where indigenous species remain dominant. On uninhabited reef islets and areas away from the main settlements, indigenous species are still largely the dominant species, although impoverished by selective removal of some species and the planting of coconut palms.

101. From the most 'natural' to the most highly modified or disturbed vegetation, the main vegetation types on Tuvalu are:

- *Inland broadleaf forest and woodland*: Relatively undisturbed areas of this vegetation type are mainly found in small stands or as scattered trees on uninhabited reef islets. Relatively undisturbed areas of this vegetation type are rare on Funafuti, being only found in the central portions of atolls islets and limited in area or represented by scattered remnant trees. Dominant species include puka vai (*Pisonia grandis*) and puka vaka (*Hernandia nymphaeifolia*), both of which form small stands on some atolls. Important understory species include the ferns laukatafa (*Asplenium nidus*), sulufe (*Nephrolepis acutifolia*) and maile (*Microsorum grossum*); the sedge, mouku milimili taliga (*Fimbristylis cymosa*); and the grasses *Lepturus repens*, *Stenotaphrum micranthum* and *Thuarea involuta*, all known generally as mouku.
- *Coastal littoral forest and scrub*: Least disturbed areas of this vegetation type are associated with uninhabited islets along both exposed ocean and more protected lagoon coasts and on coastlines bordering passes between the ocean and lagoon. Dominant species include the shrubs gasu (*Scaevola taccada*) and gie (*Pemphis acidula*). The dominant tree is tausunu (*Tournefortia argentea*), which is often seen as a wind- and salt-effected, stunted shrub. Other important trees include kanava (*Cordia subcordata*), pua (*Guettarda speciosa*) and talie (*Terminalia samoensis*).

  Important species that are under various levels of threat include important multi-purpose coastal species, such as kanava (*Cordia subcordata*), milo (*Thespesia populnea*), fetau (*Calophyllum inophyllum*), puka vaka (*Hernandia nymphaeifolia*), puka vai (*Pisonia grandis*) and tausunu (*Tournefortia argentea*), all of which are ecologically and culturally important species.
- *Mangroves and wetlands*: Although limited in extent, mangroves and limited areas of swampy wetlands are found on all of Tuvalu's atolls except Nukulaelae, along protected intertidal lagoon flats or in back-beach basins. The only two true mangrove species present in Tuvalu are the common mangrove, togo (*Rhizophora stylosa*), which is found on all atolls except Nukulaelae, and the red-flowered mangrove, sagale or hagale (*Lumnitzera littorea*), which is currently reported present only on Nanumaga, Niutao, Nui, and Vaitupu. On Funafuti, togo (*Rhizophora stylosa*) is locally abundant and forms dense thickets to the northeast of the airfield where it surrounds the lagoon or the back-beach intertidal basin landward of the ocean-coast coral rubble and shingle rampart along the east coast of Fogafale Islet.

[25] Thaman, R.R. (2016) The Flora of Tuvalu: Lakau Mo Mouku o Tuvalu. *Atoll Research Bulletin* **611**: 1-129.

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Species of considered to be under threat within this vegetation type include sagale (*Lumnitzera littorea*) and mangrove associated species surrounding mangroves, such as gie (*Pemphis acidula*), many of which are also found in coastal forest and scrub.

- *Coconut woodland and agroforest*: This is the most widespread vegetation type on Tuvalu. Agroforest includes agricultural lands dominated by deliberately planted or protected useful trees, in this case almost exclusively the coconut palm, niu (*Cocos nucifera*). Other useful indigenous trees are often protected and allowed to remain. Pandanus, breadfruit and other useful trees are occasionally planted as small tree groves in more favourable sites, usually near villages or residences. Important understory species, especially in more open sites, include the ferns laukatafa (*Asplenium nidus*), sulufe (*Nephrolepis acutifolia*) and maile (*Microsorum grossum*), the sedge, mouku milimili taliga (*Fimbristylis cymosa*), and the grasses *Lepturus repens*, *Stenotaphrum micranthum* and *Thuarea involute*. Also present in these areas, dependent on the level of disturbance, are a range of introduced weed species.
- *Excavated taro gardens*: Excavated taro pits (pela) are unique, specialized and highly modified communal garden areas found in the central parts of the larger atoll islets, normally near the main settlements. The pits have been excavated to the level of the freshwater lens through the limestone bedrock, to depths of 1.5–2 m. The artificial soils in these pits are fertile, swampy and rich in organic material and have been formed over many years by adding mulch or compost, known as kaiao, which is composed of leaves and other organic materials. On Funafuti, the only remaining extensive taro pit is located in Vaiaku, just north of the airport to the west of the runway.

  The main crop planted in the pela is giant swamp taro, pulaka (*Cyrtosperma chamissonis*). Common taro, talo (*Colocasia esculenta*), is also common and often planted in slightly raised beds bordering the pulaka. Bananas and plantains (*Musa cultivars*) are planted in contiguous stands bordering the pits. Other food plants such sugarcane, tolo (*Saccharum officiarum*), are also seen planted along the margins of these gardens. Occasional weeds include the sedge mouku filifou (*Mariscus javanicus*), the grass *Paspalum vaginatum,* and other herbaceous or subshrubby species, mouku solo (*Commelina diffusa*), lakau pula sega (*Ludwigia octovalvis*) and lita (*Rorippa sarmentosum*).
- *Village houseyard and urban gardens*: Due to increasing population and urbanization, houseyard and urban gardens are one of the most widespread vegetation types, especially on Fogafale Islet and in villages and government centres on the other atolls. Houseyard and urban gardens are a mixture of a wide range of deliberately planted indigenous and non-indigenous trees, shrubs, vines and other perennials and some short-term annual plants, plus many non-planted wild or weedy species.
- *Intensive vegetable and food gardens*: Intensive vegetable and food gardens, originally growing mainly non-traditional short-term seed crops and some other recently introduced perennial shrub and tree food plants, are increasingly important on Funafuti and on some other atolls, such as Vaitupu. This has been in response to a number of initiatives over the past 20+ years to improve nutrition and increase production and consumption of vitamin-rich vegetables and fruits.
- *Disturbed ruderal vegetation*: Increasing urbanization and the development of roads, airports and other facilities have created extensive areas of continually disturbed ruderal vegetation, especially on Fogafale Islet. These include roadsides, path sides, waste places, open lots, sports grounds, limited areas of

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lawns and grassy areas, unpaved areas around parking lots, airports and landing strips and other areas that are continually disturbed and/or not maintained or weeded. The dominant plants in these areas are a wide range of easily-dispersed, fast-growing herbaceous weedy species (grasses, sedges and other herbs, mostly referred to as mouku, the general term for small weeds) and some weedy shrubs. Some of these weeds, such as *Sphagneticola trilobata*, have become extremely invasive and constitute a threat to ecologically and cultural important indigenous species.

- Recently reclaimed, unvegetated areas infilled with lagoon sediment.

102. Estimates of land use or land cover types in Tuvalu in order of abundance are provided in Table 4.3. This shows that over 55% of the land area in Tuvalu is covered in coconut woodland or coconut and broadleaf woodland. Mangroves account for a further 17% of the land area and villages ~6%. Na

Table 4.3: Estimated areas of different land use/land cover types present in Tuvalu

Cover/Vegetation	Area (ha)	%
Coconut woodland	1,619	53.9
Mangroves	515	17.1
Scrub	419	13.9
Village, buildings	172	5.7
Broadleaf woodland	122	4.1
Pulaka pits & pulaka basins	65	2.2
Coconut and broadleaf woodland	51	1.7
Other (i.e. low ground cover)	33	1.1
Pandanus	10	0.3
Total	3, 006	100

Source: Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour Government of Tuvalu (2016) *Tuvalu National Biodiversity Strategy and Action Plan Fifth National Report to the Convention on Biological Diversity*.

103. **Flora**[26]. The indigenous terrestrial flora of Tuvalu is very poor, highly disturbed and dominated by introduced exotic species. This has been due to the selective removal of indigenous species and vegetation for growth of settlements, construction, boatbuilding, firewood, medicine, tools and handicrafts and other purposes as well as the deliberate and accidental introduction of a wide range of plants, some of which are important cultural plant and others invasive weeds.

104. A total of 368 vascular plant species have been recorded in Tuvalu, of which 65 (18%) are possibly indigenous (Table 4.4). The remaining 300 species (82%) are non-indigenous species that have been introduced by humans over time, with 14 thought to be aboriginal introductions that were brought to Tuvalu before European times by either Tuvaluans or other Pacific Islanders. The total recorded flora of Funafuti is about 356, with seven additional indigenous species having been reported on other atolls27.

105. Of the 65 possibly indigenous species, six are widespread pantropical or paleotropical ferns or fern allies and 59 are angiosperms or flowering plants (11 monocots, 48 dicots), with no indigenous gymnosperms (see ANNEX 1 for complete list of indigenous plant species). A further 14 species are considered to be of possible aboriginal origin.

[26] Thaman, R.R. (2016) The Flora of Tuvalu: Lakau Mo Mouku o Tuvalu. *Atoll Research Bulletin* **611**: 1-129.
[27] Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour Government of Tuvalu (2016) *Tuvalu National Biodiversity Strategy and Action Plan Fifth National Report to the Convention on Biological Diversity*.

Table 4.4: Approximate number (and % of total) of native and introduced flora species in Tuvalu

	Native (Indigenous)	Introduced (Aboriginal)	Introduced (recent)	Total
Ferns	6 (67%)	0 (0%)	3 (33%)	9 (100%)
Gymnosperms	0 (0%)	0 (0%)	2 (100%)	2 (100%)
Monocots	11 (11%)	8 (8%)	84 (82%)	103 (100%)
Dicots	48 (19%)	6 (2%)	200 (79%)	254 (100%)
Total	65 (18%)	14 (4%)	289 (79%)	368 (100%)

Source: Falanruw, M. (2002) *Terrestrial Biodiversity of the Federated States Of Micronesia*. Prepared for the FSM National Biodiversity Strategy and Action Plan Project

106. The low number of indigenous species is an indication of the lack of habitat diversity on atolls compared with larger high islands, the difficulty of cross-ocean dispersal by plants and the difficulty of long-term survival in the harsh atoll environment which is dominated by poor soils, high salinity and physiological drought.

107. The most common trees found on all islands are[28]: coconut (*Cocos nucifera*) stands which make up around 67% of the land cover area of the outer islands, casuarinas (*Casuarina equisetifolia*), breadfruit (*Artocarpus sp*), hibiscus (*Hibiscus sp*), papaya (*Carica papaya*), pandanus (*Pandanus tectorius*), flame tree (*Delonix regia*) salt bush (*Scaevola sericea*) and terminalia (*Terminalia sp*). These plants are widespread in the Pacific and tropical regions generally, though most are spread primarily by human cultivation. Papaya and flame tree originate from outside the Pacific region. Indigenous broad leaf species, including *Calophyllum inophyllum*, make up single trees or small stands around the coastal margin.

108. Plants are central to the rich culture of Tuvalu, with many indigenous and long-established introduced species used for multiple purposes such as building/construction materials, tools, musical instruments, food, medicines, traditional uses, dyes, fuel, brushes, soaps and oils. For example the coconut palm, niu (*Cocos nucifera*), is reported to have 125 different uses, while a range of other species have 20 or more reported uses: Hibis*cus tiliaceus* (fou fafine), *Pandanus tectorius* (fala), *Calophyllum inophyllum* (fetau), *Cordia subcordata* (kanava), *Guettarda speciosa* (pua), *Scaevola taccada* (gasu), *Pemphis acidula* (gie), *Thespesia populnea* (milo), *Rhizophora* spp. (togo), *Tournefortia argentea* (tausunu), *Casuarina equisetifolia* (lakau Kilisimasi), *Premna serratifolia* (valovalo), *Morinda citrifolia* (nonu), *Pipturus argenteus* (fou tagata), *Terminalia catappa* (kunikuni) and *Ficus tinctoria* (felo).

109. Almost all plants, even weeds, have a value, often for timber (laupapa), garlands (fou, ula or sisi), scenting coconut oil or perfume (sinu or sausau), medicine (vai lakau) or for mulch (kaiao). Unfortunately, many of Tuvalu's most important indigenous plants and many important traditional medicinal plants are uncommon or rare and in need of some form of protection or re-establishment if the next generation is to learn about them, protect them, and to continue to receive their many benefits.

110. A number of plants species are considered to be invasive species in Tuvalu, with wedelia or creeping daisy (*Sphagneticolaa trilobata*) considered to be the species of greatest concern. Wedelia is a plant native to the Caribbean that has spread throughout villages, along roadsides, into open lots and has colonised outer beach vegetation where it outcompetes important medicinal plants and other native species of cultural importance. Once established it is almost impossible to eradicate and is slowly replacing many of

[28] ADB (2018) *Tuvalu: Outer Island Maritime Infrastructure Project – Additional Financing: Initial Environmental Examination*

Tuvalu's most important low-growing herbaceous species along beaches and roadsides and inhibits the growth of seedlings of threatened trees and other plant. Other weed species of concern or potential concern are outlined in Table 4.5.

111. Invasive species are seen as a key threat to biodiversity in Tuvalu. In 2015, Tuvalu's Invasive Species Committee, coordinated by the Department of Environment, was established to help manage invasive pest, animals and plants. However, many of the most serious invasive species remain problematic and will require assistance from international partners.

Table 4.5: Known and potential invasive weed species in Tuvalu

Invasive Plant Species	Status	Current abundance	Comments
Sphagneticola trilobata (wedelia, creeping daisy or trailing daisy)	Recent introduction	Abundant	Provides habitat for rats First recorded in Tuvalu in 1993 Popular ornamental plant used for making traditional head garlands fou Very invasive in along roadsides, in coastal vegetation and near the excavated taro gardens Has become extremely invasive and constitute a threat to ecologically and cultural important indigenous species throughout much of Tuvalu Listed as one of the world's 100 worst invasive species
Cenchrus echinatus	Recent introduction	Common to locally abundant	Weedy grass with bur-like fruits that occurs in clusters or tufts in open and ruderal habitats
Mikania micrantha (mile-a-minute)	Recent introduction	Common and spreading	Widespread on Fogafale Islet Weed in open lots and on f ruderal sites A serious invasive weed in Fiji and other areas of the Pacific Has medicinal value
Sida rhombifolia (broomweed, Cuba jute, Paddy's lucerne)	Recent introduction	Common	Weed of roadsides, path sides, waste places and ruderal sites
Alternanthera sessilis (joyweed)	Recent introduction	Occasional	Weed in giant swamp taro (*Cyrtosperma*) pits at Vaiaku Reported present on Nui, Vaitupu and Nukulaelae
Lantana camara	Recent introduction	Occasional	Planted ornamental in houseyard gardens and landscaping Flowers used in head garlands (fou) or worn by females as sei over the ear or in the hair, often by young girls
Ricinus communis (castor bean, castor oil plant)	Recent introduction	Rare	Potentially an invasive weed that is invasive in Fiji and Tonga

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Invasive Plant Species	Status	Current abundance	Comments
Adenanthera pavonina (red-bead tree, false sandalwood)	Recent introduction	Rare or extirpated	Possibly introduced from Samoa or from Nauru where it is abundant and invasive
Piper aduncum (hooked pepper bush)	Recent introduction	Rare or extirpated	A potentially invasive weed that should be eradicated.

112. Rare, regionally significant or protected flora species. None of the indigenous plants of Tuvalu are considered to be endemic to Tuvalu with almost all of the indigenous plants being widespread, easily-dispersed coastal species that have the ability to cope successfully in environments with loose shifting sands, soil-less limestone and rock outcrops, high wave action, high salinity and sea spray, periodic flooding, strong sunlight, strong winds and drought; all conditions common on the atolls of Tuvalu. Nor are any of the Indigenous plants listed as threatened on the IUCN Red list.

113. Based on the outcomes of a survey of 19 respondent groups on Funafuti Atoll in November 2016, a number of plant species are considered to be of cultural significance in Tuvalu (see Table 4.6 for summary)[29]. Of these species, a number are considered threatened, rare (or in short supply) or extirpated by locals. In the survey, rare referred to species mentioned by at least 20% of respondents as being rare or extirpated. For these plants, land clearance, over use and climate changes were seen as key drivers of loss.

Table 4.6: Culturally important plant categories in Tuvalu

Category	Local name	Total Species	No. Threatened	No. rare or Extirpated
Mangrove trees and other associated plants	lakau lasi and nisi lakau I te vai ogo	20	16	6
Lagoonside trees and large plants	Lakau lasi i tafatai o te namo	20	16	4
Lagoonside small plants and vines	mouku foliki mo e lakau tolotolo i tafatai o te namo	21	10	3
Oceanside trees and large plants	lakau lasi fakaoga ki tu mo aganu kola e ola i tafatai o te tua fenua	17	13	5
Oceanside small plants/vines	a lakau foliki/ solo/mouku i tafatai o te tua fenua	21	15	2
Inland trees/large plants	lakau ote vao ite togavao ote fenua)	24	8	3

[29] Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour Government of Tuvalu (2016) *Tuvalu National Biodiversity Strategy and Action Plan Fifth National Report to the Convention on Biological Diversity.*

Category	Local name	Total Species	No. Threatened	No. rare or Extirpated
Inland Small plants/vines	lakau solo/mouku solo i manafa o tino ote fakai	28	12	3
Ferns	Vaega sulufe/maile	7	5	1
Cultivated food plants	Vaega lakau kaina	24	20	10
Coconut palm cultivars	Vaega niu	19	13	4
Pandanus cultivars	Vaega fala kai	19	12	3
Breadfruit cultivars	Vaega mei	12	11	5
Banana or plantain cultivars	Vaega futi	10	9	6
Giant swamp taro cultivars	Vaega pulaka	19	10	3
Taro cultivars	Vaega talo	15	11	4
Animal food/fodder	lakau mo fagia manu	19	12	5
Garland and body ornamentation	lakau manogi gali taua mo fai a fou/fau	28	17	4
Ornamental plants	lakau fakagaligali fale	29	19	6
Fence/hedge plants	lakau puipui matagi/pui	23	16	4
Medicinal plants	Lakau fait te vailakau	39	26	8
Animal Medicines	vailakau moo manu	11	8	3
Construction/housebuilding	fai te fale	16	11	5
Woodcarving/toolmaking	tofi mo nisi mea faigaluega	14	10	4
Canoe or boatbuilding	fai a vaka/ pooti	10	7	3
firewood	fafie	13	7	4
Weaving and handicrafts	laga	12	8	4
Cordage, string, rope	kolokolo	4	3	2
Fishing equipment	mea faika	13	8	3
Necklaces and beads	Mea tulima	9	8	4
Toys and games	mea taulima	8	6	4
Wrapping/parcelling	Saisai meakai	15	13	3
Perfumes/scenting coconut oil	Sinu manogi	23	15	5
Dye or paint	peeni	2	2	2
Fertilizer/mulching plants	kaiao	12	10	3
Magic/black magic plants	Vailakau fakaltaulaitu	10	8	3
Seabird nesting trees	Lakau fai ofaga i ei a manu	6	6	2

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114. **Fauna**[30]. The indigenous terrestrial vertebrate fauna of Tuvalu includes no indigenous land mammals, amphibians or freshwater fishes. There are, however, nine terrestrial reptiles (four geckos and five skinks), including Tuvalu's only recorded endemic vertebrate, the Tuvalu forest gecko (*Lepidodactylus tepukapili*). In addition, a total of 31 species of birds have been identified in Tuvalu, of which only one is introduced; the junglefowl (*Galllus gallus*).

115. There are three species of resident native terrestrial birds, pacific reef heron, buff-banded rail and Pacific imperial pigeon. There is also one migratory terrestrial bird, the long-tailed koel (*Urodynamis taitensis*), which is a non-breeding migrant from New Zealand that arrives in April and departs in September / October. The remaining 26 bird species are either shorebirds or seabirds including members of the families Sternidae, (eight species of terns and noddies), Scolopacidae (six species of migratory waders) and Procellariidae (five species of shearwaters and petrels). These three families account for 61% of the total number of bird species recorded. The six species of terns and noddies and the red-footed booby are breeding residents in Tuvalu (Table 4.8). The waders (tattler, godwits, curlews and plovers) are all non-breeding migrants from the northern hemisphere that overwinter in the southern hemisphere, including islands in the Pacific Ocean. The shearwaters and petrels are also visitors, and some of them are vagrants and do not breed in Tuvalu.

116. While there has been some work undertaken on the terrestrial invertebrates of the Tuvalu, there is a range of largely unassessed invertebrates. Notable terrestrial invertebrates include land or shore crabs such as paikea (*Cardisoma rotundum*), tupa (*Cardismoa carniflex*), kamakama (*Grapsus albolineatus*), a range of hermit crabs, uga (*Coenobita* spp) and the coconut crab, uu (*Birgus latro*). Of these at least seven are eaten, with most smaller crabs used as fish bait. The ghost crab, keviki (*Ocypode cerophthalmaa*) is also used as bait in bird traps. A range of land snails, misa (*Melampis* spp.) are also important as they are used to make shell leis (ula) and handicrafts. In addition, there are 22 species of butterfly and moth recorded from Tuvalu.

117. In addition to the indigenous fauna, there are a number of introduced and domestic species (including pigs, fowl, cats, rats and dogs, all of which were imported in the 19th century and now flourish on the islands) and invasive fauna species. The cane toad (*Rhinella marina*) has been recently introduced to Tuvalu and rats (*Rattus rattus* – black rat, *Rattus exulans* – Polynesian rat) are considered an invasive species of concern on Tuvalu. Rats are common on all Tuvalu's atolls, including many uninhabited offshore reef islets and are a major threat to bird species, particularly ground nesting seabird colonies, poultry and other important terrestrial species, including geckos, insects and culturally important plants. A full list of known invasive fauna species on Tuvalu is provided in Table based on the Global Invasive Species Database (GISD).

Table 4.7: Known invasive fauna species in Tuvalu

Scientific name	Common name	Notes
Achatina fulica	Giant African snail	*Achatina fulica* feeds on a wide variety of crop plants and may present a threat to local flora.
Aedes aegypti	Yellow fever mosquito	Very common in urban and suburban areas in the tropic and subtropic regions. It is adapted to close association with humans and the female feeds almost exclusively on human blood. A. aegypti is the domestic vector of the yellow fever virus, caused epidemics of yellow fever in the Americas (before the 1940's) and recently in West Africa,

[30] Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour Government of Tuvalu (2016) *Tuvalu National Biodiversity Strategy and Action Plan Fifth National Report to the Convention on Biological Diversity.*

		and is responsible for 'urban yellow fever' - direct transmission of the virus between humans. A. aegypti is also the most important carrier of the dengue virus, although it is not paticularly susceptible to viral infection compared with other mosquito species.
Bos taurus	Feral cattle	Feral cattle (*Bos taurus*) are escaped or released domestic animals. Unless well contained by adequate fences, they form feral herds and wander into native vegetation wherever suitable food is available. They can severely modify native vegetation by browsing, crushing and trampling. In native forests they invariably lay bare the forest floor and eliminate nearly all young trees, shrubs and ferns until only a few unpalatable or browse-resistant species remain
Mus musculus	House mouse	The house mouse can cause considerable damage to human activities by destroying crops and consuming and/or contaminating food supplies intended for human consumption. They are prolific breeders, sometimes erupting and reaching plague proportions.
Paratrechina longicornis	Crazy ant	*Paratrechina longicornis* (the crazy ant) is a tramp ant, which, by definition, is an ant that is widely dispersed through commerce and other human-assisted avenues. It is extremely easy to identify by observing its rapid and erratic movements. *Paratrechina longicornis* is highly adaptable to various environments and can be a major pest. It occurs in large numbers in homes or outdoors and is capable of displacing other ants and possibly other invertebrates. *Paratrechina longicornis* forages over long distances away from its nest, making the nest hard to find and the ants difficult to control
Pheidole megacephala	Big-headed ant, brown house-ant	*Pheidole megacephala* is one of the world's worst invasive ant species. Believed to be native to southern Africa, it is now found throughout the temperate and tropical zones of the world. It is a serious threat to biodiversity through the displacement of native invertebrate fauna and is a pest of agriculture as it harvests seeds and harbours phytophagous insects that reduce crop productivity. *Pheidole megacephala* are also known to chew on irrigation and telephone cabling as well as electrical wires.
Rattus exulans	Pacific rat	The Pacific rat is the smallest of the three rats closely associated with humans. The fur is brown and its tail length is only slightly longer or shorter than the combined head and body length. *Rattus exulans* is recognised as a predator of native insects, lizards and birds, a browser of native flora and an agricultural pest. There appears to be no island groups reached by the Polynesians that did not receive *Rattus exulans*, although not all islands in a group were necessarily colonised
Rattus norvegicus	Norway rat	The Norway rat (*Rattus norvegicus*) is globally widespread and costs primary industry hundreds of millions of dollars per year. It has caused or contributed to the extinction or range reduction of native mammals, birds, reptiles and invertebrates through predation and competition. It restricts the regeneration of many plant species by eating seeds and seedlings, eats food crops and spoils human food

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		stores by urinating and defecating in them. Additional economic damage is caused by chewing through power cables and spreading diseases.
Rattus rattus	Black rat	A native of the Indian sub-continent, the ship rat (*Rattus rattus*) has now spread throughout the world. It is widespread in forest and woodlands as well as being able to live in and around buildings. It will feed on and damage almost any edible thing. The ship rat is most frequently identified with catastrophic declines of birds on islands. It is very agile and often frequents tree tops searching for food and nesting there in bunches of leaves and twigs.
Rhinella marina (=Bufo marinus)	Cane toad	Cane toads were introduced to many countries as biological control agents for various insect pests of sugarcane and other crops. The cane toads have proved to be pests themselves. They will feed on almost any terrestrial animal and compete with native amphibians for food and breeding habitats. Their toxic secretions are known to cause illness and death in domestic animals that come into contact with them, such as dogs and cats, and wildlife, such as snakes and lizards. Human fatalities have been recorded following ingestion of the eggs or adults
Wasmannia auropunctata	Little fire ant	*Wasmannia auropunctata* (the little fire ant) is blamed for reducing species diversity, reducing overall abundance of flying and tree-dwelling insects, and eliminating arachnid populations. It is also known for its painful stings. On the Galapagos, it eats the hatchlings of tortoises and attacks the eyes and cloacae of the adult tortoises. It is considered to be perhaps the greatest ant species threat in the Pacific region.

118. **Rare, regionally significant or protected fauna species.** There are five threatened or near threatened fauna species known from Tuvalu (as listed on the IUCN Red List): four birds (Table 4.8),one reptile (Table 4.9) and one invertebrate (Table 4.10). In addition, there is one endemic vertebrate (Table 4.9) and six endemic invertebrates ((Table 4.10) known from Tuvalu:

Rare or threatened

- Steindachner's Emo skink (*Emoia adspersa*) is listed as endangered on the IUCN Red List and is a Central Pacific resident that is known from Funatui in Tuvalu. It is a terrestrial to semi-arboreal resident of heavily vegetated shorelines into the open coastal woodlands.
- The Phoenix petrel (*Pterodroma alba*) which is listed as endangered on the IUCN Red List has been recorded as a vagrant seabird in the region. This small gadfly petrel breeds on Phoenix and Line Islands in Kiribati to the north of western Polynesia, and Pitcairn Island to the east. It is unlikely to occur on Tuvalu.
- Three of the migratory wader species that overwinter on the islands of Tuvalu are listed as threatened or near threatened on the IUCN red list including:
    - The bristle-thighed curlew (*Numenius tahitiensis*) which is listed as vulnerable. Non-breeding migrant that occurs on tidal mudflats, fringing reefs, beaches and adjacent grasslands.

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- The bar-tailed godwit (*Limosa lapponica*) which is listed as near threatened. Non-breeding migrant that forages in tidal pools, rocky beaches and fringing reefs.
- The grey-tailed tattler (*Tringa brevipes*) which is listed as near threatened. Non-breeding migrant that occurs on tidal mudflats and sand banks.

- The ground dwelling snail, *Omphalotropis zelriolata*, is listed as near threatened. It is a detritivore recorded from lowland forests.

Endemic

- Tuvalu's only recorded endemic vertebrate, the Tuvalu forest gecko (*Lepidodactylus tepukapili*) is found on Tepuka Islet, Funafuti under loose bark and in crevices, 1-2 m from the ground on the trunks of living trees (*Calophyllum inophyllum* and coconut trees).
- There are four known endemic land snails and two jumping spiders: *Sinployea pseudovicaria*, *Sinployea* e*llicensis*, *Vatusila vaitupuensis* and *Thaumatodon decemplicata* (all land snails) and *Ascyltus audax* and *Ascyltus ferox* (jumping spiders). There is little documented on the habitat preferences for these species (see Table 4.10).

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Table 4.8: Migratory, non-migratory breeding birds and threatened birds of Tuvalu (source: Birdlife International, IUCN, Watling 2001)[31, 32, 33]

Common name	Scientific name	IUCN Category	Status	Habitat
Non-migratory species				
Phoenix petrel	*Pterodroma alba*	Endangered	Vagrant seabird.	Small petrel that breeds in the northern Pacific (Phoenix and Line Islands, Kiribati and Pitcairn Island to the east.
Pacific reef heron	*Egretta sacra*	Least concern	Breeding resident terrestrial bird	Occurs in all types of aquatic habitats on islands in the Pacific from coastal reefs to inland streams. Nests can be in trees, on cliff ledges and rock ledges.
Buff-banded rail	*Gallirallus philippensis*	Least concern	Breeding resident terrestrial bird	Widespread on land where it occurs in regrowth scrub, rank vegetation and village gardens. Builds a flimsy nest in dense vegetation.
Pacific imperial pigeon	*Ducula pacifica*	Least concern	Breeding resident terrestrial bird	Occurs in fringing dry coastal forest and coastal scrub. Nests in trees.
White-tailed tropic bird	*Phaethon lepturus*	Least concern	Breeding resident seabird	Nests in crevices in large trees or cliff faces.
Red-footed booby	*Sula sula*	Least concern	Breeding resident seabird	Colonial breeder that builds a frail nests in trees or shrubs, also nests on cliff ledges.
Black-naped tern	*Onychoprion anaethetus*	Least concern	Breeding resident seabird	Breeds in small loose colonies. Nest is is a depression in the sand or in gravel pockets on coral banks close to the high tide line.

[31] BirdLife International (2018) *Checklist of Birds for Tuvalu.*
[32] IUCN (2019) *International Union for Conservation of Nature's (IUCN) Red List of Threatened Species*. Accessed January 2019.
[33] Watling. D. (2001). Birds of Fiji and Western Polynesia: including American Samoa, Niue, Samoa, Tokelau, Tonga, Tuvalu

Common name	Scientific name	IUCN Category	Status	Habitat
Sooty tern	*Onychoprion fuscatus*	Least concern	Breeding resident seabird?	Breeds in large colonies. No currently active breeding colonies in Tuvalu although there are historic records.
Brown noddy	*Anous stolidus*	Least concern	Breeding resident seabird	Builds a bulky nest in the crowns of coconut palms or on cliffs on inhabited islands or on more remote uninhabited islands nests are in low shrubs, on the ground under cover.
Black noddy	*Anous minutus*	Least concern	Breeding resident seabird	A colonial breeder which builds a substantial nest in shrubs and trees on uninhabited islands.
White tern	*Gygis alba*	Least concern	Breeding resident seabird	Breeds in loose colonies on wooded islets or inland on larger forested islands. Lays a single egg on a rock or bare branch with no nesting material.
Migratory species				
Bristle-thighed curlew	*Numenius tahitiensis*	Vulnerable	A non-breeding migrant from its breeding grounds on the Artic coast.	Occurs on tidal mudflats, fringing reefs, beaches and adjacent grasslands and occasionally in coastal vegetation.
Bar-tailed godwit	*Limosa lapponica*	Near threatened	A non-breeding migrant from the northern hemisphere (Eurasia and Alaska).	Occurs on tidal pools, rocky beaches and fringing reefs.
Grey-tailed tattler	*Tringa brevipes*	Near threatened	A non-breeding migrant from Siberia. Vagrant visitor to Tuvalu.	Occurs on tidal mudflats and sand banks.
Long-tailed koel	*Urodynamis taitensis*	Least concern	Non-breeding migrant which arrives from its breeding grounds in New Zealand in April and departs in September / October.	Can occur across all terrestrial habitats but prefers forested areas.
Pacific golden-plover	*Pluvialis fulva*	Least concern	A non-breeding migrant from the northern hemisphere (Siberia and Alaska). Arrives in September departs in April.	Occurs across all coastal habitats and also found on short grasslands in near coastal situations. Can often be seen on rivers on the shore and on sandbanks..

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Common name	Scientific name	IUCN Category	Status	Habitat
Ruddy turnstone	*Arenaria interpres*	Least concern	A non-breeding migrant from the northern hemisphere.	Occurs on fringing reefs, rocky beaches, breakwaters and occasionally on mudflats.
Sanderling	*Calidris alba*	Least concern	A non-breeding migrant from its breeding grounds in the Artic.	Occurs on sandy beaches and sandbanks.
Semipalmated plover	*Charadrius semipalmatus*	Least concern	A non-breeding migrant from artic North America. Vagrant visitor to Tuvalu.	Occurs on coastal mudflats and beaches.
Wandering tattler	*Tringa incana*	Least concern	A non-breeding migrant from its breeding grounds in Alaska. Arrives in September departs in May.	Common visitor that occurs on all coastal habitats.
Whimbrel	*Numenius phaeopus*	Least concern	A non-breeding migrant from its breeding grounds in western Alaska.	Occurs on sandbanks and tidal mudflats and occasionally on beaches and reefs.

Table 4.9: Threatened and endemic reptiles of Tuvalu (source: IUCN) [34]

Common name	Scientific name	IUCN Category	Comments	Habitat
Steindachner's Emo skink	*Emoia adspersa*	Endangered	Central Pacific resident, living on Funafuti (Tuvalu), Nukunonu (Tokelau), Futuna, throughout the Samoan islands, and Niuafo'ou (Tonga)	Terrestrial to semi-arboreal resident of heavily vegetated shorelines into the open coastal woodlands This skink is terrestrial in littoral forest areas, including holes in coral sand substrate at the base of breadfruit trees. It will climb into the lower parts of trees. The species appears to be rare away from coastal areas
Tuvalu forest gecko	*Lepidodactylus tepukapili*		The first specimens were discovered on Tepuka island, Funafuti in 1998 Endemic to Tuvalu	Inhabits coconut woodland dominated by a variety of broad-leafed trees Found under loose bark and in the crevices, at 1-2 m from the ground on the trunks of living trees (*Calophyllum inophyllum* and coconut trees). Also found beneath bark on downed tree trunks.
Green Turtle	*Chelonia mydas*	Endangered	Like most sea turtles, green turtles are highly migratory and use a wide range of broadly separated	Marine waters Sandy beaches for nesting sites

[34] IUCN (2019) *International Union for Conservation of Nature's (IUCN) Red List of Threatened Species*. Accessed January 2019.

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Common name	Scientific name	IUCN Category	Comments	Habitat
			localities and habitats during their lifetimes Nesting sites for green seaturtle known within Funafuti Conservation Area.	
Leatherback Turtle	*Dermochelys coriacea*	Vulnerable	Leatherbacks make extensive migrations between different feeding areas at different seasons, and to and from nesting areas.	Marine waters Sandy beaches for nesting sites

Table 4.10: Endemic invertebrates of Tuvalu (source: IUCN)[34]

Common name	Scientific name	Category	Comments	Habitat
Land snail	*Omphalotropis zelriolata*	Near Threatened	This species is restricted to Fiji, Wallis and Futuna, and Tuvalu	Ground-dwelling detritivore, recorded from lowland forests.
Land snail	*Sinployea pseudovicaria*		Endemic to Tuvalu	Many Sinployea species are semiarboreal, ascending trees to 5m. Frequently found in leaf axils or attached to loose bark on stilt roots
Land snail	*Sinployea ellicensis*		Found on Nukulaelae and Funafuti Endemic to Tuvalu	
Land snail	*Vatusila vaitupuensis*		Found on Vaitupu, Tuvalu Endemic to Tuvalu	Unknown
Tuvaluan Thaumatodon Snail	*Thaumatodon decemplicata*		Known from Nukufetau and Vaitupu Endemic to Tuvalu	Lives in decaying wood
Jumping spider	*Ascyltus audax*		Known from Funafuti (found in 1897) Endemic to Tuvalu	Unknown
Jumping spider	*Ascyltus ferox*		Known from Funafuti (found in 1897) Endemic to Tuvalu	Unknown

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119. **Protected and areas of biodiversity significance areas**[35]. In 1999, the Tuvaluan Conservation Act was enacted, with the aim to:

- Protect the environment, including coastal, marine and terrestrial.
- Conserve living and non-living natural resources of island communities and provide for their sustainable use by present and future generations.
- Preserve the biological diversity of conservation areas, especially species that are endemic, threatened, or of special concern and the coastal and marine habitats upon which the survival of these species depend.

120. The Act states that no person shall hunt, kill or capture any turtle, birds, or fish in any designated conservation area. Only the Funafuti Conservation Area has been established under the Act with all other protected areas of Tuvalu established by local communities and are managed by traditional systems.

121. The Funafuti Conservation Area was originally established in 1996 as the first formal conservation area in Tuvalu by Funafuti local council and then listed under the Conservation Act in 1999. The conservation area supports community livelihoods and has high conservation value as a key habitat for threatened and near threatened species. Since the establishment of the Funafuti Conservation Area, Tuvalu has created nine other protected areas across its nine islands as part of its commitment to protect national biodiversity and livelihoods, covering a total area of 75.932 as of 2011 (Table 4.11).

122. The subproject sites on Nukufetau, Nui and Funafuti are all located outside of the listed protected areas of Tuvalu (Figure 4.7). The Nukulaelae project site is located within the boundary of the Nukulaelae Fisheries Reserve. However, as the Nukulaelae subproject involves expansion of the solar PV at the existing terrestrial site, the project will not impact the fishing reserve.

Table 4.11: Protected areas of Tuvalu as of 2011

Protected area	Comments	Management authority	Area (km^2)	Date	IUCN category
Funafuti Conservation Area	There are six uninhabited islets with native broadleaf forest and coral sand beaches located within the protected area. The islets are nesting sites for the green sea turtle (*Chelonia mydas*).	Kaupule(local government) / Fisheries	35.95	1996	VI*
Vaitupu Conservation Area		Kaupule(local government)	1.06	2003	-
Nukulaelae Fisheries Reserve	The lagoon surrounding the main settlement of Fagaua was declared “koga tapu” (a conservation area) over 20 years ago	Kaupule(local government)	1.46	2006	VI
Nanumea		Kaupule(local government)	2.52	2006	-

[35] Department of Environment (2011) *Action Plan for Implementing the Convention on Biological Diversity’s Programme of Work on Protected Areas*. Report Submitted to the Secretariat of the Convention on Biological Diversity October 6, 2011.

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Nukufetau		Kaupule(local government)	11.75	2006	VI
Nui		Kaupule(local government)	6.67	1997	-
Niutae		Kaupule(local government)	0.52	?	-
Niulakita		Kaupule(local government)	14.73	?	-
Nanumaga		Kaupule(local government)	0.02	?	-
Vaitupu		Kaupule(local government) / Ministry of Home Affairs	0.21	?	VI

* Protected area with sustainable use of natural resources

Source: UNEP-WCMC (2019). *Protected Area Profile for Tuvalu from the World Database of Protected Areas, February 2019*. Available at: www.protectedplanet.net.

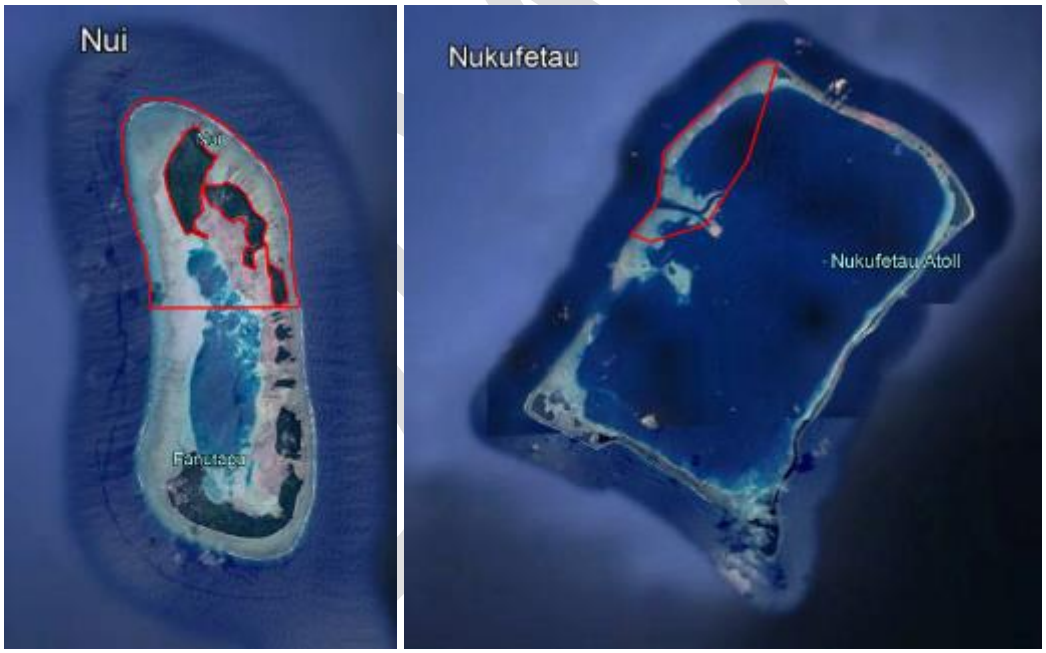

Figure 4.7: Location of protected areas (red line) on Nui, Nukufetau, Nukulaelae and Funafuti (Source: UNEP-WCMC (2019). *Protected Area Profile for Tuvalu from the World Database of Protected Areas, February 2019.* Available at: www.protectedplanet.net.)

123. **Subproject localities terrestrial biological resources**. A site assessment of the proposed location of the solar PV array at Nukulaelae (*outer island subproject 1a*) was completed in September 2018. The site was cleared in 2015 as part of the construction of the existing power system. It is now dominated by recently introduced species including sweet potato (*Ipomea batatas*), wire grass (*Eleusine indica*), yellow alder (*Turnera ulmifolia*), Jamaican vervain (*Stachytarpheta jamaicencis*) and graceful spurge (*Chamaesyce hypericifolia*). Regrowth of the indigenous tree species beach heliotrope (*Tournefortia argentea*) and beach saltbush (*Scaevola taccada*) was also observed (Refer Plate 3.1). A large beach mahogany (*Calophyllum inophyllum*) was located adjacent to the power station and would likely require pruning to prevent shading of a solar PV array if mounted on the roof of a new power diesel power house. No species listed as threatened under the IUCN Red List were observed. No fauna or fauna habitat was observed.

124. A site inspection of the proposed location of the solar PV array at Nui (*outer island subproject 1c*) was completed in May 2019. Aerial photography and anecdotal reports indicate that the site was also cleared in 2015 as part of the construction of the new power system. The site is dominated by introduced ground cover and is considered unlikely to contain any environmental values.

125. An onsite assessment of the location of the BESS on Funafuti (*Funafuti subproject 2*) has yet to be completed as the site of the BESS is yet to be determined. However, it is expected that the BESS would be located on cleared land close to the existing power station which is unlikely to contain any environmental values.

C. Marine Biological Resources of Nukufetau

126. A total of 1449 marine species have been recorded from Tuvalu, including 541 fish, 398 macroinvertebrates,379 cnidarians (sea anemones, corals, jellyfish), 59 algae, 41 seabirds, 21 marine mammals (whales, dolphins), four sponges, four turtles, three seasnakes and two species of mangroves. This section describes the known marine

biological resources of Nukufetau. The marine biological resources of Nukulaelae, Nui and Funafuti atolls have not been described as they will not be impacted by the proposed project.

127. **Marine habitats[36].** Tuvalu's highly diverse marine biodiversity is found to be strongly associated with its coral reef systems. Coral reefs not only provide a food source for Tuvaluans, but they also serve as a significant biological resource for medicines and other important traditional uses. Nukufetau atoll has a total area of 116.5 km^2, of which 22% is reef platform and 78% the enclosed lagoon). The bulk of the reef platform consists of bare reef flat (85%), vegetated islands and adjacent beaches. There are a few stands of mangrove, which are only found in certain coastal areas of the islets. The lagoon has two surface channels (*Te Ava Amua* and *Te Ava Lasi*) from the open sea and fills and drains across the reef flat and through subterranean passages. *Te Ava Amua* is the deepest channel and is very narrow. Only canoes and powered boats can move through both channels, with large boats only using *Te Ava Lasi*. It is also possible to access the lagoon via other parts of the barrier reef during high tides and good sea conditions.

128. The Nukufetau reef system spreads across 38.7 km^2 and consists of four reef types: Lagoon (back) reef (18.6 km^2), sheltered coastal reef (10.3 km^2) outer reef (9.7 km^2) and lagoon (intermediate) reef (0.1 km^2) (Figure 4.8, Table 4.12). These reef types form important habitat for finfishes and invertebrates, with the associated biomass increasing markedly from sheltered coastal reefs to the outer reef. The coastal-to-outer-reef trend is also reflected in the conditions of the benthic community, with an increase in live coral cover from sheltered coastal reefs to the outer-reef (Table 4.12). Sheltered coastal reef is the shallowest habitat (on average 2 m deep), compare to lagoon (intermediate) and outer reef which is on average 8 m deep. All reef habitat is composed of a range of substrate types including soft bottoms, rubble and boulders, hard bottoms, and live and soft coral. In all cases, hard bottoms is the dominant substrate, followed by live coral and/or soft bottoms.

Table 4.12: Reef habitat of Nukufetau[36]

Parameters	Habitat				
	Sheltered coastal reef	Lagoon (intermediate) reef	Lagoon (back)reef	Outer reef	All reef
Total habitat area (km^2)	10.3	0.05	18.6	9.7	38.7
Average depth (min-max) (m)	2 (1-5) (3)	8 (1-12) (3)	4 (1-10) (3)	8 (4-14) (3)	5 (1-14) (3)
Soft bottom (% cover)	17.6 ±3.7	13.2 ±7.0	16.4 ±3.0	0	12.6
Rubble & boulders (% cover)	6.8 ±3.5	3.3 ±1.5	12.4 ±7.5	0.7 ±0.3	7.9
Hard bottom (% cover)	62.0 ±4.2	68.3 ±4.0	53.2 ±5.4	66.1 ±3.5	58.8
Live coral (% cover)	13.5 ±2.7	15.2 ±4.5	17.8 ±2.7	33.0 ±3.3	20.5
Soft coral (% cover)	0.08 ±0.08	0	0	0.2 ±0.2	0.07
Biodiversity (species/transect)	28 ±5	44 ±10	41 ±5	41 ±3	38 ±3
Density (fish/m^2)	0.7 ±0.2	0.6 ±0.1	0.7 ±0.1	0.9 ±0.1	0.7
Biomass (g/m2)	104.7 ±37.8	175.7 ±74.8	191.4 ±57.3	222.8 ±75.9	176.2

[36] Sauni, S., Kronen, M., Pinca, S., Sauni, L., Friedman, K., Chapman L. and Magron, F. (2005) *Tuvalu Country Report: Profiles and Results From Survey Work at Funafuti, Nukufetau, Vaitupu and Niutao (October–November 2004 and March–April 2005)*. Report to Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C/CoFish) / Secretariat of the Pacific Community.

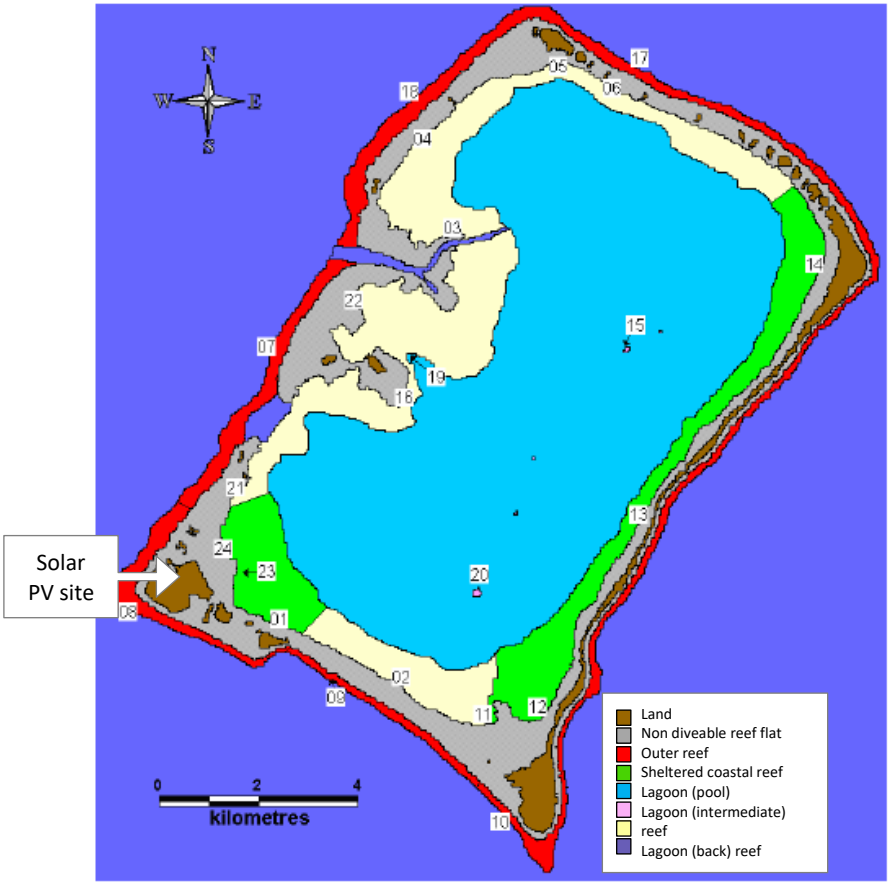

Figure 4.8: Marine habitat types of Nukufetau[36]

129. **Finfishes[36]**. Finfish surveys of Nukufetau in 2004 recorded a total of 154 species from 19 families. Based this study and previous studies, the overall fish assemblage in Nukufetau was shown to more closely resembled that recorded in sheltered coastal and lagoon (back) reef environments (75% of habitat) than that of an lagoon (intermediate) or outer reef environment (25% of habitat).

130. Dominant fish species recorded in sheltered coastal reef habitats were (in order of decreasing density): hump-nose big eye bream (*Monotaxis grandoculis*), lined bristle-tooth surgeonfish (*Ctenochaetus striatus*), humpback snapper (*Lutjanus gibbus*), flametail snapper (*L. fulvus*), bullet-head parrotfish (*Chlorurus sordidus*) and dark-capped parrotfish (*Scarus oviceps*). By comparison, the dominant species of the outer reef were: lined bristle-tooth (*Ctenochaetus striatus*), white-cheek surgeonfish (*Acanthurus nigricans*), striped surgeonfish (*Acanthurus lineatus*), orange-spine unicornifish (*Naso lituratus*), humpback snapper (*Lutjianus gibbus*), red snapper (*Lutjianus bohar*), black-and-white snapper (*Macolor macularis*), bullet-head parrotfish (*Chlorurus sordidus*), swarthy parrotfish (*Scarus niger*) and hump-nose big eye bream (*Monotaxis grandoculis*).

131. **Invertebrates[36]** Twenty-nine species or species groupings (groups of species within a genus) of invertebrates were recorded from Nukufetau by Saundi et al. (2005) including: five bivalves, nine gastropods, nine sea cucumbers, two urchins, two sea stars and a lobster. Invertebrates were primarily associated with the reef environment, with soft benthos habitats (e.g. shallow water lagoon areas) not containing beds of in ground resource species such as arc shells (*Anadara* spp.) or venus shells (*Gafrarium* spp.).

132. Key or important invertebrate species of Nukufetau include:

- Giant clams: Found on shallow reef habitat with the most suitable habitat concentrated along the western and southern edges, where water movement is the most dynamic. Two giant clam species have been recorded on Nukufetau: the elongate clam (*Tridacna maxima*) and fluted clam (*T. squamosal*). Neither of these species are listed on the IUCN Red List.
- Mother of pearl species - trochus and pearl oysters: Although reefs around Nukufetau could potentially support significant numbers of trochus, numbers of the grazing gastropods were general low, both inside the lagoon and on the outer. Pearl oysters were also low.
- Other gastropods and bivalves: a range of other gastropods and bivalves have been recorded from Nukufetau including Seba's spider conch (*Lambis truncate*), Strombus luhuanus, and Turbo, Chicoreus, Conus, and Cypraea species. The later three targeted by fishers as resource and handicraft species.
- Lobsters and crabs. Lobster and crabs are harvested by local fishers. Coconut crabs, a terrestrial hermit crab, are widely found on Nukufetau and Tuvalu.
- Sea cucumbers: sea cucumber species have been recorded associated with Nukufetau's reefs.
- Urchins and starfish: Urchins and starfish are both found in low densities in reef habitat.

133. **Reptiles**. Four species of marine turtles have been recorded from Tuvalu: loggerhead sea turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*) and leatherback turtle (*Dermochelys coriacea*). All species are listed as threatened or near threatened on the IUCN Red List.

134. **Marine resources[36].** On Nukufetau, fisheries are more important as a food source rather than as a source of income. Fisheries only provided complementary income sources for about half of all households. Catch records suggest that while most finfish were caught for subsistence needs, half of all invertebrates caught were sold and exported to Funafuti. Finfish fishing pressure is generally relatively low on Nukufetau, with the highest pressure on sheltered coastal reef environments. Key commercial invertebrate species include: cowrie (*Cypraea* spp.), giant clams (*Tridacna* spp.), lobster (*Panulirus penicillatus*), octopus, and giant spider conch (*Lambis truncate*); with cowrie and conch used for handicraft in Tuvalu.

135. **Subproject location and marine biological resources**. A site assessment of the proposed location of the solar PV array at Nukufetau (*outer island subproject 1b*) was completed in September 2018. The location of the Nukufetau solar PV site is between the islets of Fale and Savave, which is marked as land in the habitat map (Figure 4.8) as the site is intertidal and located on hard packed, sandy sediments that are exposed at low tide (Plates 4.1, 4.2 and 4.3). The site is located between sheltered coastal reef and outer reef habitat types and is a low wave energy environment. The substrate at the site is bare and sandy, with no reef habitat or rock pools present. At high tide, the water depth remains relatively shallow (< 1 m). As such, the site provides poor habitat for finfish and turtle species. Due to the shallowness of the area at high tide, larger marine species (e.g. sharks, dolphins, whales) are unlikely to use the area although smaller fish species may pass through the site when it is inundated. As proposed project area is inundated at high tide, it is not suitable nesting environment for turtles.

Plate 4.1 Location of proposed solar PV site on Nukufetau showing existing ray

Plate 4.2 Location of proposed solar PV site on Nukufetau showing proposed location of new array and sandy sediments exposed at low tide

Plate 4.3 Location of proposed solar PV site on Nukufetau showing incoming tide covering proposed location of the new array.

136. The tidal flats are likely to provide foraging habitat for bird species include migratory species. The only bird species observed utilising the lagoon during the inception mission was the Pacific Golden Plover (*Pluvialis fulva*) (Plate 4.4) however, Brown Noddy (*Anous stolidus*) and White Tern (*Gygis alba*) were observed overflying the site.

Plate 4.4: Pacific Golden Plover (*Pluvialis fulva*) observed near the site of the proposed solar PV array on Nukufetau

137. **Rare or threatened marine species.** Ninety eight marine species have been listed as threatened on the IUCN Red List including 14 fishes, seven sea cucumbers, 70 stony or hard coral species, two giant clam species, two whales and three turtles (Table 4.13). Of these, one is listed as critically endangered (hawksbill turtle) and eight as endangered (whale shark, giant wrasse, four sea cucumbers (black teatfish, golden sandfish, black teatfish, prickly redfish), blue whale and green turtle). The remaining 89 species are all listed as vulnerable. Of these species, none are expected to inhabit the proposed project site as:

- Fishes: listed species are all open ocean, deep water or reef species that may also inhabit seagrass beds.
- Invertebrate: listed species are not intertidal species unless located in rock pools (e.g. stony or hard corals) or if located intertidally, are only able to survive exposure briefly at low tide (e.g. sea cucumbers) and/or prefer reef/coral habitat (stony or hard corals, sea cucumbers, giant clams).
- Whales: listed species are open ocean species.

- Turtles: listed species are open ocean and neritic species that use sandy beaches above high tide for nesting.

138. A further 115 species are listed on the IUCN Red List as near threatened including ten fish, 103 invertebrates, one whale and one turtle.

139. Due to the intertidal nature of the site and poor habitat quality for finfish and turtle species it is not expected that any marine threatened species listed on the IUCN Red List would actively inhabit or use the site, although some fishes may pass through the site during high tide (Table 4.13).

Table 4.13: Threatened marine species of Tuvalu and their potential to occur at the proposed Nukufetau Solar PV project site (source: IUCN) [37]

Scientific name	Common name	Status	Habitat	Potential to occur
Fish				
Ground sharks				
Carcharhinus albimarginatus	Silvertip Shark	Vulnerable	Occurs on the continental shelf, offshore islands, coral reefs, and offshore banks, from surface waters to depths of 600-800 m. It is also found inside lagoons, near drop-offs, and offshore.	×
Carcharhinus longimanus	Whitetip Oceanic Shark	Vulnerable	This is one of the most widespread sharks, ranging across entire oceans in tropical and subtropical waters.	×
Mackerel sharks				
Alopias vulpinus	Atlantic thresher	Vulnerable	Virtually circumglobal in temperate oceans; penetrates into tropical waters.	×
Isurus oxyrinchus	Shortfin Mako	Vulnerable	Offshore littoral and epipelagic species, found in tropical and warm-temperate seas.	×
Carpet sharks				
Rhincodon typus	Whale Shark	Endangered	Whale sharks are found in both coastal and oceanic habitats. Whale sharks spend the majority of time in the epipelagic zone, but dive to at least 1,928 m in depth.	×
Ray-finned fish				
Cheilinus undulatus	Giant Wrasse	Endangered	Juveniles and adults live associated with reef or near-reef habitats of seagrass beds and mangrove areas, with juveniles typically inshore and the largest individuals found in deeper waters of outer reefs or lagoons They are usually found in association with well-developed coral reefs.	×
Makaira nigricans	Blue Marlin	Vulnerable	Epipelagic and oceanic species	×
Thunnus obesus	Bigeye Tuna	Vulnerable	Pelagic and oceanodromous species.	×
Hippocampus histrix	Longspine seahorse	Vulnerable	Usually found at depths between 10 and 40 m but may also be found deeper than this. This species is found on a variety of	×

[37] IUCN (2019) *International Union for Conservation of Nature's (IUCN) Red List of Threatened Species*. Accessed January 2019.

Scientific name	Common name	Status	Habitat	Potential to occur
			substrates including sponges, weedy rocky reefs, soft corals, and seagrass beds.	
Plectropomus areolatus	Polkadot Cod	Vulnerable	Inhabits lagoon and seaward reefs in areas with rich coral growth. It is most frequently encountered in channels along the reef front.	×
Epinephelus fuscoguttatus	Tiger Grouper	Vulnerable	Adults of this species inhabit lagoon pinnacles, patch reefs, channels and outer reef slopes in clearwater, coral-rich areas. Juveniles inhabit seagrass beds and estuarine or low salinity inshore areas.	×
Epinephelus polyphekadion	Camouflage Grouper	Vulnerable	This species prefers shallow coral-rich areas in lagoons and outer reefs and is more abundant around islands, particularly atolls.	×
Pufferfishes, triggerfishes, and relatives				
Mola mola	Giant Sunfish	Vulnerable	Oceanodromous, pelagic-oceanic species.	×
Oxymonacanthus longirostris	Beaked Leatherjacket	Vulnerable	Occurs in clear lagoon and seaward reefs. It nests near bases of dead corals, often on clumps of algae.	×
Invertebrates				
Sea cucumbers				
Holothuria nobilis	Black Teatfish	Endangered	This species is largely restricted to coral reef habitat. It occurs on reef flats and outer slopes and it is generally solitary. It can also be found in shallow seagrass beds where they have been reported to prefer sandy hard substrates.	×
Holothuria scabra	Golden Sandfish	Endangered	This species is distributed mainly in low energy environments behind fringing reefs or within protected bays and shores. Individuals prefer ordinary coastal areas to coral reefs, particularly intertidal seagrass beds close to mangroves, however they are also found along inner reef flats and lagoons. This species is attracted to muddy sand or mud habitats.	×
Holothuria whitmaei	Black Teatfish	Endangered	This species is found along slopes and passes within reef zones. This species can be found in reef flats, slopes and shallow seagrass beds between 0 and 20 m	×
Thelenota ananas	Prickly Redfish	Endangered	This species is found along slopes and passes within reef zones and along outer reef flats to depths of 35 m, but is more common in waters from 10-20 m. They are distributed mainly in shallow coral reef areas, on reef flats, reef slopes and near passes on sandy or hard bottoms with large rubble and coral patches. They prefer rubble and hard bottoms covered with a layer of coral sand.	×
Actinopyga echinites	Brownfish	Vulnerable	This species is found along outer reef flats, in the littoral zone, and in estuaries and	×

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Scientific name	Common name	Status	Habitat	Potential to occur
			lagoons. This species dwells in moderately shallow waters, mostly on reef flats of fringing and lagoon-islet reefs. It can be abundant in seagrass beds, on rubble flats, and compact flats.	
Actinopyga miliaris	Blackfish	Vulnerable	Prefers reef flats of fringing reefs and lagoon-islet reefs, rubble reefs and compact flats between 0-12 m.	×
Holothuria fuscogilva	White Teatfish	Vulnerable	This species is found from 0-40 m, but is mostly encountered between 15 and 30 m, and may occur occur in deeper waters. Inhabits outer barrier reefs and passes; it can also be found on shallow seagrass beds.	×
Stony or hard corals				
Montipora angulata		Vulnerable	This species occurs in shallow, tropical reef environments. It is commonly found on fringing reef flats, and also other reef habitats. This species is found from 1 m to at least 20 m.	×
Alveopora marionensis		Vulnerable	This species is only found in environments with moderate wave action, generally to depths of 30 m.	×
Pectinia lactuca	Lettuce Coral	Vulnerable	It is found in most reef environments, especially lower reef slopes and turbid water habitats.	×
Acropora paniculata		Vulnerable	This species occurs in shallow, tropical reef environments on upper reef slopes. It occurs just subtidally on reef edges and upper slopes as well as in sheltered lagoons.	×
Acropora kirstyae		Vulnerable	This species occurs in shallow, tropical reef environments. It is found in shallow water protected from wave action, only in protected, subtidal lagoons and protected reef slopes.	×
Porites attenuata		Vulnerable	This species is found in shallow, protected reef environments, generally to depths of 20 m.	×
Acropora retusa		Vulnerable	This species occurs in shallow, tropical reef environments. It is found on upper reef slopes and in tidal pools This species is found from 1-5 m.	×
Acropora abrolhosensis		Vulnerable	This species is found on shallow reefs. It is also found in lagoons or reef slopes protected from strong wave action. This species is restricted to enclosed lagoons and protected reef slope habitats. This species is found from 2-18 m.	×
Astreopora cucullata		Vulnerable	This species is found in shallow, tropical reef environments. This species is found from 5-15 m.	×

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Scientific name	Common name	Status	Habitat	Potential to occur
Leptoseris yabei		Vulnerable	It is usually found on lower slopes. Maximum size is over 1 m. This species is found from 6-20 m.	×
Turbinaria patula		Vulnerable	It is found on inshore reefs and shallow rocky foreshores of subtropical locations. They form plates of over 1 m in diameter. This species is found from 7-20 m.	×
Montipora calcarea		Vulnerable	This species occurs in shallow reef environments. It occurs on reef crests, outer reef flats and upper slopes. This species is found to at least 20 m.	×
Heliopora coerulea	Blue Coral	Vulnerable	This species occurs on shallow reef (generally less than 2 m), exposed reef locations, reef flats and intertidal zones (Richards, pers. comm.). Off the coast of Kenya, this species can occur in generally disturbed or marginal habitat (Hoeksma, pers. comm.).	×
Acropora donei		Vulnerable	This species occurs in shallow, tropical reef environments. It is restricted to shallow fringing reefs and upper reef slopes where Acropora spp. diversity is high and it is subtidal (Wallace 1999). This species is found from 5-20 m.	×
Acropora horrida		Vulnerable	This species occurs in shallow, tropical reef environments. It is found in turbid water around fringing reefs, and subtidally on protected deepwater flats, lagoons, and sandy slopes (Wallace 1999). This species is found from 5-20 m.	×
Acropora solitaryensis		Vulnerable	This species occurs in shallow, tropical reef environments. It is found in shallow reef environments and on rocky foreshores in subtropical locations. It occurs subtidally on reef slopes and walls and submerged reefs (Wallace 1999). This species is found from 5-25 m.	×
Cyphastrea ocellina		Vulnerable	This species occurs in shallow, tropical reef environments. It is found on upper reef slopes. This species is found in lagoons and can be found in the outer reef channel. This species is found to at least 20 m.	×
Acropora dendrum		Vulnerable	This species occurs in shallow, tropical reef environments, especially reef margins exposed to strong wave action. This species is found between 5-20 m.	×
Acropora speciosa		Vulnerable	This species occurs in shallow, tropical reef environments. It is found in protected reef environments with clear water and a high Acropora diversity. It occurs subtidally on walls and steep slopes, usually below 15 m, but occasionally shallower	×

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Scientific name	Common name	Status	Habitat	Potential to occur
			where shaded conditions exist (Wallace 1999). This species is found from 12-30 m.	
Galaxea astreata		Vulnerable	This species is found in reef environments protected from strong wave action. Sparse colonies of G. astreata are found from 3-15 m in the South China Sea and Gulf of Siam (Titlyanov and Titlyanova 2002). This species is considered to be a main reef-framework builder and is found at 20-30 m on the Chagos lagoon (Sheppard 1982). The maximum size is over 2 m.	×
Acropora microclados		Vulnerable	This species occurs in shallow, tropical reef environments. This species is found on upper reef slopes. It occurs just subtidally at reef edges (Wallace 1999). This species is found from 5-20 m.	×
Montastrea multipunctata		Vulnerable	This species is found in shallow, tropical reef environments. It forms sub-massive to massive colonies. This species is found on the back and foreslope of the reef and in lagoons. This species is found to 15 m. Species in this genus are usually most abundant at mid-depth. This genus is a common and extremely important reef-building coral in the western Atlantic (Wood 1983). It forms massive colonies that are usually rounded or lobed in shallow water and flattened or plate-like on deep reefs (Wood 1983).	×
Montipora corbettensis		Vulnerable	This species occurs in shallow reef environments, especially shallow to mid reef slopes. This species is found from 2 m to at least 20 m.	×
Montipora samarensis		Vulnerable	This species is found on shallow, protected reef slopes. It prefers tropical reef environments. This species is found to at least 15 m.	×
Acanthastrea bowerbanki		Vulnerable	This species is found in lower reef slopes protected from wave action. This species is found to 20 m.	×
Montipora capricornis		Vulnerable	This species occurs in shallow, tropical reef environments. It is found mostly in lagoons. This species is found to at least 20 m.	×
Acropora spicifera		Vulnerable	This species occurs in shallow, tropical reef environments. It is found on reef slopes. It occurs mostly intertidally on reef flats (Wallace 1999). This species is found from 2-10 m.	×
Montipora crassituberculata		Vulnerable	This species occurs in shallow, tropical reef environments. It is found on upper and lower reef slopes. This species is found to at least 20 m.	×

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Scientific name	Common name	Status	Habitat	Potential to occur
Montipora australiensis		Vulnerable	This species occurs in shallow, tropical reef environments. It is found in shallow reef environments exposed to strong wave action. This species is found from 2 m to at least 30 m.	×
Turbinaria peltata		Vulnerable	It occurs shallow on sandy reef flats and deep sandy reef bases. This species is found from 0.5-25 m.	×
Acropora anthocercis		Vulnerable	This species occurs on shallow reefs. It is found on upper reef slopes exposed to strong wave action. This species is found from 5 to ~10 m depth.	×
Lobophyllia diminuta		Vulnerable	This species is found on upper reef slopes and lagoons. This species is found to 10 m.	×
Montipora cebuensis		Vulnerable	This species occurs in shallow reef environments, especially lagoons. This species is found from 2 m to at least 20 m.	×
Acropora polystoma		Vulnerable	This species occurs in shallow, tropical reef environments. It is found on upper reef slopes exposed to strong wave action. This species appears to be confined to reef-edge habitats with good water circulation. This species is found from 3-10 m.	×
Acropora echinata		Vulnerable	This species occurs in shallow, tropical protected reef environments with clear water and a high species diversity, and is also found subtidally on protected sandy slopes and lagoon floors. This species is found from 8-25 m.	×
Caulastrea curvata		Vulnerable	This species occurs in shallow, tropical reef environments. It is found on slopes and flat substrates. This species is found in lagoons and inter-reef soft substrates. This species is found to at least 20 m.	×
Montipora altasepta		Vulnerable	This species occurs in shallow, tropical reef environments on protected reef slopes. This species is found to at least 10 m.	×
Pavona venosa		Vulnerable	This species occurs in shallow reef environments. This species is found from 2-20 m.	×
Acropora acuminata		Vulnerable	This species occurs on shallow reefs. It also is found in turbid or clear water on upper or lower reef slopes. It is found from 5-20 m depth.	×
Pectinia alcicornis		Vulnerable	It is found in turbid water, especially on horizontal substrates. Also found in clear water. This species is found to 25 m. Occurs in most reef habitats, both in shallow and deep areas.	×
Acropora listeri		Vulnerable	This species occurs in shallow, tropical reef environments. It is found on upper reef	×

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Scientific name	Common name	Status	Habitat	Potential to occur
			slopes, especially those exposed to strong wave action, also just subtidal shallow reef edges. This species is found from 3-15 m.	
Acropora vaughani		Vulnerable	This species occurs in shallow, tropical reef environments. It is found in turbid water around fringing reefs. It only occurs in protected subtidal habitats such as contained lagoons and sandy slopes. This species is found from 3-20 m.	×
Porites nigrescens		Vulnerable	This species is common on lower reef slopes and lagoons protected from wave action, generally to depths of 20 m.	×
Pavona decussata	Cactus Coral	Vulnerable	This species occurs in most reef environments. Commonly found from 3-11 m, rarely from 12-15 m.	×
Pocillopora elegans		Vulnerable	This species occurs in shallow reef environments. Occurs in all shallow water habitats on coral reefs and coral communities on rocky substrata, to at least 20 m depth, but is most common between 1-10 m depth.	×
Montipora lobulata		Vulnerable	This species occurs in shallow reef environments. This species is found to at least 20 m.	×
Acropora aspera		Vulnerable	This species occurs on shallow reef flats. It occurs on reef flats and shallow lagoons, also exposed upper reef slopes and deep water. It is found from 0-5 m.	×
Alveopora verrilliana		Vulnerable	This species is found in shallow reef environments, generally to a depth of 30 m.	×
Montipora caliculata		Vulnerable	This species occurs in most shallow, tropical reef environments. This species is found to at least 20 m.	×
Acropora lovelli		Vulnerable	This species occurs in shallow, tropical reef environments. It is found in shallow, protected lagoons, and lagoon entrances, found subtidally in lagoons and calm-water reef shoals. This species is found from 1-10 m.	×
Alveopora allingi		Vulnerable	This species is found in protected reef environments. This species is most commonly reported at depth between 5 and 10 m.	×
Pavona bipartita		Vulnerable	This species occur on reef slopes and vertical walls. This species may be found from 3-20 m.	×
Acanthastrea ishigakiensis		Vulnerable	This species is found in depths of 1-20 m in all sheltered reef areas away from high wave action.	×
Barabattoia laddi		Vulnerable	It has been recorded from shallow lagoons, foreslope, back slope, and reef flats. This species is found to at least 10 m.	×

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Scientific name	Common name	Status	Habitat	Potential to occur
Acropora globiceps		Vulnerable	This species occurs in shallow, tropical reef environments. It is found intertidally on upper reef slopes and reef flats. This species is found to 8 m depth.	×
Turbinaria stellulata		Vulnerable	It may form conspicuous dome-shaped colonies on upper reef slopes. This species is seldom found in turbid waters. This species is found from 2-15 m.	×
Anacropora puertogalerae		Vulnerable	This species occurs in shallow reef environments. This species is found from 5-20 m.	×
Pachyseris rugosa		Vulnerable	It may develop into large mound-shaped colonies in shallow water, but smaller colonies occur in a wide range of habitats including those exposed to strong wave action. This species can be found from 5-20 m.	×
Physogyra lichtensteini		Vulnerable	This species occurs in shallow, tropical reef environments. It is found more often in turbid reef environments but may be found in most reef habitats. This species can be found from 1-20 m.	×
Acropora aculeus		Vulnerable	This species is found on shallow reefs on upper reef slopes and lagoons. This species is found from 5-35 m depth	×
Porites horizontalata		Vulnerable	This species is found in shallow reef environments. This species is found from less than 10 m to greater than 20 m.	×
Alveopora fenestrata		Vulnerable	This species is found in shallow reef environments, generally to a depth of 30 m.	×
Acropora palmerae		Vulnerable	This species occurs in shallow, tropical reef environments on reef flats exposed to strong wave action and in lagoons, also intertidally or subtidally on shallow reef tops and edges, especially in areas of strong current. This species is found from 0-12 m.	×
Acropora verweyi		Vulnerable	This species occurs in shallow, tropical reef environments. It is found on upper reef slopes, especially those exposed to wave action or currents. It is found in shallow reef top and reef edge habitats often filling in spaces between other > species. This species is found from 2-15 m.	×
Leptoseris incrustans		Vulnerable	This species is found on reef slopes and on vertical walls. The maximum size is 20 cm. This species is found from 10-20 m.	×
Pavona cactus		Vulnerable	It is usually found in lagoons and on upper reef slopes, especially those of fringing reefs, and in turbid water protected from wave action. This species may be found from 3-20 m.	×

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Scientific name	Common name	Status	Habitat	Potential to occur
Euphyllia cristata		Vulnerable	This species can be found on all areas on a reef from depths of 1-35 m.	×
Turbinaria mesenterina		Vulnerable	It is common in shallow turbid environments. This species is found to 20 m.	×
Isopora cuneata		Vulnerable	This species occurs in all shallow, tropical reef environments, especially upper reef slopes and reef flats. It is found intertidally or just subtidally on reef flats, reef tops or submerged reefs. This species is found to 15 m depth.	×
Turbinaria reniformis		Vulnerable	It may form large stands on fringing reefs where the water is turbid. This species is found from 2-15 m.	×
Giant clams				
Tridacna derasa	Southern Giant Clam	Vulnerable	Found on the outer edges of reefs at depths of 4 to 10 m.	×
Tridacna gigas	Giant Clam	Vulnerable	Found on flat coral sand or broken coral and can be found at depths of as much as 20 m	×
Mammals				
Balaenoptera musculus	Blue Whale	Endangered	Open sea	×
Physeter macrocephalus	Sperm Whale	Vulnerable	Open sea	×
Reptiles				
Eretmochelys imbricata	Hawkesbill Turtle	Critically Endangered	Hawksbills nest on insular and mainland sandy beaches throughout the tropics and subtropics. They are highly migratory and use a wide range of broadly separated localities and habitats during their lifetimes Juveniles recruit into a neritic developmental foraging habitat that may comprise coral reefs or other hard bottom habitats, sea grass, algal beds, or mangrove bays and creeks. Once sexually mature, they undertake breeding migrations between foraging grounds and breeding areas at intervals of several years.	×
Chelonia mydas	Green Turtle	Endangered	After a number of years in the oceanic zone, these turtles recruit to neritic developmental areas rich in seagrass and/or marine algae where they forage and grow until maturity. Upon attaining sexual maturity green turtles commence breeding migrations between foraging grounds and nesting areas (sandy beaches) that are undertaken every few years During non-breeding periods adults reside at coastal neritic feeding areas that sometimes coincide with juvenile developmental habitats.	×

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Scientific name	Common name	Status	Habitat	Potential to occur
Dermochelys coriacea	Leatherback Turtle	Vulnerable	Oceanic, deep-diving marine turtle inhabiting tropical, subtropical, and subpolar seas. Leatherbacks make extensive migrations between different feeding areas at different seasons, and to and from nesting areas (sandy beaches).	×

×: Unlikely to inhabit the project site

D. Socio-economic Resources

140. **Demographics**[38]. The Tuvalu 2017 mini census recorded a total population of 10,645 which included residents (10,507) and short term visitors, tourists, and temporary contract workers (138). Since the previous census in 2012 the resident population of Tuvalu in 2017 has decreased by 131 (1.3 %), compare to an increase of 13.7% over the previous census period (2002 to 2012). Approximately half the population is male (51.4%) and half female (48.6%), similar to in 2012.

Within Tuvalu, there has been a general migration from the Outer Islands since 2012, with a decrease in population by 1,017 (-19.5%), and an increase in population on Funafuti (884, 16.3%) (Table 4.14). Of the Outer Islands, Vaitupu has the highest population (1,061) and Niulakita the lowest (34). Similarly, Funafuti has by far, the greatest population density (2,257 people/km^2) of all the atolls and islands of Tuvalu, with Niulakita the lowest (84). Of the Outer Islands, Nui has the second highest population (610) and density (218), while Nukufetau has the third (597; 199) and Nukulaelae the second lowest population (300) and third lowest density (167). Key villages (and their population size) on Nui, Nukufetau, Nukulaelae and Funafuti are shown in Table 4.14. Generally, the size of villages on the Outer Islands is smaller than on Funafuti.

141. Of Tuvalu resident population, less than half reside on their home island. While 90% of the Outer Islands population are residents of their home island (Nui 91%, Nukufetau 93%, Nukulaelae 94%) only 21% of Funafuti's population was born on the atoll. The majority of Funafuti residents are from the Outer Islands (77%), with the greatest proportion from Nanumea (17%), Vaitupu (14%), Nanumaga (12%), Niutao (12%) and Nukufetau (12%).

142. The population of Tuvalu is very homogeneous, with 10,193 (97%) being of Tuvaluan descent and 249 (2.4%) Tuvaluan/I-Kiribati or part Tuvaluan descent. Adult literacy rates are high, with 87% literate in English and 99.8% literate in Tuvaluan in 2012.

Table 4.14: Population of Tuvalu by Island

Island	Resident Population		Home island residents		Population of Funafuti by home island		Population change 2012-2017		Population density 2017 (people/km^2)	No. HHs
	2012	2017						%		
Funafuti	5,436	6320 (1)*	1309	21%	1,309	21%	884	16.3 %	2,257 (1)*	849

[38] Central Statistics Division, Ministry of Finance, Economic Planning and Industries (2018) *Tuvalu Population and Housing Mini Census 2017: Preliminary Report*.

Outer Islands	5,204	4,187	3765	*90%*	4,879	77%	-1,017	-19.5%	184	*777*
Nanumea	*612*	*512 (6)*	*475*	*93%*	*1,069*	*17%*	*-100*	*-16.3%*	*131 (8)*	*105*
Nanumaga	*551*	*491 (7)*	*444*	*90%*	*772*	*12%*	*-60*	*-10.9%*	*175 (6)*	*93*
Niutao	*694*	*582 (5)*	*541*	*93%*	*780*	*12%*	*-112*	*-16.1%*	*233 (2)*	*116*
Nui	*729*	*610 (3)*	*553*	*91%*	*448*	*7%*	*-119*	*-16.3%*	*218 (3)*	*97*
Vaitupu	*1,542*	*1,061 (2)*	*898*	*85%*	*915*	*14%*	*-481*	*-31.2%*	*189 (5)*	*187*
Nukufetau	*666*	*597 (4)*	*553*	*93%*	*730*	*12%*	*-69*	*-10.4%*	*199 (4)*	*112*
Nukulaelae	*364*	*300 (8)*	*283*	*94%*	*253*	*4%*	*-64*	*-17.6%*	*167 (7)*	*57*
Niulakita	*46*	*34 (9)*	*18*	*53%*	*12*	*0%*	*-12*	*-26.1%*	*85 (9)*	*10*
Other					82	*1%*				
Total	10,640	10,507	5,074							1,626
Male	5,424 (50.9%)	5,403 (51.4%)			3,307	52%				
Female	5,216 (49.0%)	5,104 (48.6%)			3,013	48%				

HH: households; *: number in brackets equals rank from highest to lowest

Source: www.citypopulation.de (2015) City population: Tuvalu. http://www.citypopulation.de/Tuvalu.html

Table 4.15 Resident population of villages >100 residents on Nui, Nukufetau, Nukulaelae and Funafuti

Village	**Atoll**	**Population**	
		2002	**2012**
Alamoni - Maiaki (Fenua Tapu islet)	Nui	281	321
Manutalake - Meang (Fenua Tapu islet		242	221
Aulotu (Savave islet)	Nukufetau	333	331
Maneapa (Savave islet)		249	191
Pepeysala (Fangaua islet)	Nukulaelae	NA	247
Alapi (Fongafale Islet)	Funafuti	1,002	1,029
Amatuku		52	128
Fakaifou (Fongafale Islet)		972	1,158

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Village	Atoll	Population	
		2002	2012
Lofeagai (Fongafale Islet)		385	627
Senala (yFongafale Islet)		574	1,207
Tekavaytoetoe (Fongafale Islet)		337	650
Teone (Fongafale Islet)		520	570
Vaiaku (Fongafale Islet)		498	638

Source: www.citypopulation.de (2015) City population: Tuvalu.
http://www.citypopulation.de/Tuvalu.html

143. **Social infrastructure and services**[39]**,** [40]. The government provides free primary education for all. By law, it is compulsory for everyone between the ages of 6 - 15 to attend school. All tuition, books and stationery along with infrastructure development and provision of teachers are funded by the government supported by development partners. Pre-school education (ages 3-5 yrs) is not compulsory and run by the Island Kaupule (local council) subsidised by the government. There is at least one pre-school on each atoll, with two on Nanumea and Vaitupu and nine on Funafuti.

144. Primary education consists of eight years of schooling (Classes 1 to 6 and Forms 1 and 2; ages 6-13 yrs). There are nine government primary schools, one on each island, and a Seventh Day Adventist primary school in Funafuti. Whilst primary education is officially free, schools ask parents to pay a 'school contribution' that ranged between $2 and $5 per term in 2013. Secondary education consists of four years of schooling, Forms 3 through 6 (ages 14-18). The government-run Motufoua Secondary School is a boarding school on Vaitupu, with fees of $50 per term in 2013. A private secondary school, Fetuvalu Secondary School, operates in Funafuti and charges an equal amount.

145. The Maritime Training Institute on Funafuti (founded in 1979) provides vocational and technical training for those seeking employment on ships and fishing boats and in-service training for serving seamen. The Technical Education Centre offers training in building trades, while Tuvalu is a partner in the regional University of the South Pacific, which has its main campus in Suva, Fiji, and a campus on Funafuti.

146. Tuvalu has one hospital (50 beds), the Princess Margaret Hospital (PMH)on Funafuti, which offers basic routine medical, surgical, obstetrics and gynaecology (O&G) services with anaesthesia supporting the surgical procedures. The PMH provides primary and secondary care services for patients from Funafuti and those referred from the outer rural islands. In the outer islands there are clinics manned by nurses who provide primary care and preventive services. Patients needing clinical care that cannot be offered at the PMH, are referred to bigger overseas hospitals through the Tuvalu Medical Treatment Scheme. Health services are all provided by the public service as there is no private sector.

147. Life expectancy for Tuvaluans is 61.7 years for males and 65.1 years for females. The leading causes of morbidity and mortality remain non-communicable diseases, with the majority of deaths caused by cardiac diseases. Other common causes of mortality include diabetes, hypertension and cancers (all types). In 2014, acute respiratory infections

[39] Ministry of Education and Sports and Ministry of Finance and Economic Development (2013) *Tuvalu - MDG Acceleration Framework: Improving Quality of Education.*
[40] Government of Tuvalu (2016) *Health Reform Strategy 2016-2019: Ministry of Health*.

dominated the outpatient morbidity data. Child health indicators have improved over the last two decades with child mortality rates dropping and immunization almost universal.

148. **Tuvaluan economy**[41]. Tuvalu is a small and highly vulnerable economy, strongly linked to external economic influences (Tuvalu uses the Australian dollar as its currency). Tuvalu is the 216th largest export economy in the world, exporting $4.02M and importing$35.6M of goods in 2017, resulting in a negative trade balance of $31.6M. In 2017 the GDP of Tuvalu was $39.7M, GDP per capita $3.92k and GNI (gross national income $4,970,which places Tuvalu in the upper middle income group.

149. Between 1996 and 2002, the Tuvalu economy grew at a real rate of 7.3% per annum or 6.1% per capita. However, the economy grew at a lower rate of 1.5% between 2001 and 2008. From 2008-2014 GDP annual growth fluctuated between -4.4 -7.5 % per annum (average 0.4 % per annum), with an annual growth rate of 1.3 % recorded in 2014.

150. In Tuvalu, the public sector dominates economic activity as Tuvalu has few natural resources, except for its fisheries. Tuvalu's main sources of revenue include:

- fishing licences include those for foreign tuna fishing vessels. Earnings from fish exports and fishing licenses for Tuvalu's territorial waters are a significant source of government revenue. In 2013, revenue from fishing licenses doubled and totalled more than 45% of GDP.
- remittances from overseas workers (especially seamen and those living in New Zealand). While remittances are a substantial source of income, the value of remittances has declined since the 2008-09 global financial crisis (currently stabilized at nearly $4 million per year). The 2012 census revealed that around 40 per cent of Tuvalu's households had received remittances over the previous year.
- export of goods. Agriculture (copra) and fisheries are the principal economic activities which together account for 60 per cent of Tuvalu's GDP
- sale of postage stamps and coins
- sale of passports
- resale of rights to international telephone codes (initially to the sex industry and subsequently for gambling).
- '.tv' internet domain. In August 1998 a North American company agreed to lease Tuvalu's internet domain '.tv'. In December 2001 another company took over the lease agreeing to pay the Tuvalu government US$2.2 million a year plus five per cent of revenue exceeding US$20 million per year for the right to market '.tv' until December 2016.

151. As a result, balance-of-payments deficits have been made up by income from the Tuvalu Trust Fund and bilateral aid. In 1987, the governments of Australia, New Zealand, UK, Japan and South Korea (and Tuvalu itself) acknowledged that the country needed financial support for the foreseeable future and each government agreed to contribute money to set up a Tuvalu Trust Fund. The fund is invested by commercial fund managers and income is drawn by the Tuvaluan government as required, so long as its current value is above its real value according to the Australian consumer price index. At its foundation, the fund totalled A$27.1 million, subsequent contributions – mainly by Tuvalu itself – have added a further A$38.6 million, with the fund valued in September 2012 at A$127 million.

[41] Commonwealth Secretariat (2019) *Tuvalu: Economy*. http://thecommonwealth.org/our-member-countries/tuvalu/economy

152. **Livelihoods and income**. Remoteness to markets, internationally and domestically, has led to a heavy dependence on subsistence for main livelihoods, exploiting extremely poor soils and/or abundant marine resources. This in turn, contributes to persistent levels of poverty, with the World Bank reporting that an estimated 26.6 per cent of the population was living below the national poverty line in 2010.

153. Households across Tuvalu have an average monthly income of $1,364 (including remittances and imputed rents), with the average income higher on Funafuti ($2,033) than in the Outer Islands ($853)[42]. Wages and salaries accounted for ~54% of household incomes in 2012, with income from subsistence activities (subsistence income + home produce consumed) accounting for ~35% (Table 4.16). In a typical Outer Island household, a greater proportion ($222 in 2010) of the household income is from home production (which is the most significant source of employment in the Outer Islands) than on Funafuti ($73)[42]. Livestock (mostly pigs) is the largest source of subsistence income for Tuvalu, followed by fishing, agriculture, small scale activities and finally handicrafts. Remittances also form an important part of Tuvaluan household incomes.

Table 4.16: Household income sources in Tuvalu

Sources/types of cash income	% of households	Average monthly income	
		Funafuti	Outer Island
Wages/salary	53.9	$819	$169
Remittances/Gifts	43.4	$256	$158
Land leases/rents	41.0	$193	$83
Investments	24.3	$93	$17
Handicraft sales	26.4	$24	$16
Small business	15.8	$181	$48
Subsistence/home production	11.0	$246	$299
Other	17.2	$221	$63

Source: Central Statistics Division, Ministry of Finance, Economic Planning and Industries (2018) *Tuvalu Population and Housing Census 2012: Volume 1*.

154. Worth AUD4 million and accounting for more than 15 per cent of GDP between 1998 and 2006, work in international shipping (seafaring) is a very important economic sector for Tuvalu, representing the main source of income (remittances) for about 30 per cent of households. Starting in the 1960's, 250 to 300 seafarers per year were recruited to work on foreign ships, peaking to a yearly amount of about 400 in the mid-2000's. This number has fallen to less than 100 per year, mostly because of the global financial crisis.

155. Tuvaluans on average spend $919 per month on goods, with a further $575 expended on gifts, investments, savings and imputed rents Table 4.17. The greatest expense is on food and non alcoholic beverages, followed by water/electricity/other fuels, furnishings/equipment/maintenance, and recreation/culture. The lowest expenditure is on health. On average, Tuvaluans spend $28 per month on alcohol and tobacco. Household expenditure on Funafuti is over twice that on the Outer Islands. While expenditure on food and non alcoholic beverages in the Outer Islands is 72% of expenditure in Funafuti and gifts 52%, all other expenditure is less than 46% of that on Funafuti. In particular, expenditure on education is only 11%, taxes 22%, recreation/culture 25% and investments/savings 28%.

Table 4.17: Household expenditure in Tuvalu

Sources/types of cash income	Average monthly expenditure		
	Tuvalu	Funafuti	Outer Island
Water, electricity and other fuels	$168	$282	$81

[42] Central Statistics Division, Tuvalu Government (2010) *Household Income and Expenditure Survey: Report*.

Food and non alcoholic beverages	$479	$571	$409
Alcohol and tobacco	$20	$28	$13
Health, transport and communication	$83	$133	$44
Education	$22	$45	$5
Recreation and culture	$39	$68	$17
Other consumer goods	$107	$205	$35
Gifts (including home produce)	$187	$256	$133
Taxes	$53	$95	$21
Investments and savings	$205	$348	$96
Imputed rents	$130	$193	$83
Total	**$1,493**	**$2,224**	**$937**

Source: Central Statistics Division, Ministry of Finance, Economic Planning and Industries (2018) *Tuvalu Population and Housing Census 2012: Volume 1*.

156. Imported food stuffs, including frozen foods, are important sources of food for the local inhabitants and relies heavily on the Government shipping service (see below). There are frequent delays and some lines of food are in very short supply or run out until the next service arrives.

157. Historically, the main means of communication between the islands of Tuvalu was via boats moving between the islands, especially the monthly passenger boats from Tuvalu. However, improvements in technology (radio, internet, television, telephones (land lines), mobile phones) as opened up communication between the islands[43]. Today, mobile phone users outnumber users of telephones and 41% of the population use a computer.

158. **Economic activities**. Extreme outer island isolation results in limited opportunities for viable economic activities for these communities. For example, exporting fisheries products from the Outer Islands is hardly done due to extreme distance to markets. At the same time, access to alterative livelihoods for outer island communities is limited due to limited inflow of outside information and materials.

159. Livestock is one of the major subsistence activities in Tuvalu and is one of the main sources of meat, especially pigs and poultry. Reef and lagoon fishing including collection of shellfish is also an important subsistence activity. Agriculture opportunities are very limited due to poor soil fertility and are predominantly centred on the traditional taro-like root crop; pulaka, coconut, breadfruit, bananas, and pandanus all of which are important traditional food crops and are cultivated by most outer island households. Handicrafts such as brooms and mats, usually made by women, are another source of cash income.

160. **Employment and unemployment**. The public sector in Tuvalu is large and the government owns most enterprises, many of which require subsidies or concessions, while the private sector is small and underdeveloped and business opportunities are limited. Thus employment opportunities are dominated by the public sector (approximately 2/3 of all those employed) with limited employment in Tuvalu's private sector.

161. The main source of private sector employment is through foreign Tuvaluan seafarers (between 10-15% of employed Tuvaluans) working overseas, particularly in Europe. Starting in the 1960's, 250 to 300 seafarers per year were recruited to work on ships, peaking to a yearly amount of about 400 in the mid-2000's. This number has fallen to less than 100 per year, mostly because of the global financial crisis.

[43] Aselu, B. (2015) *A Tuvaluan Concept of Well-being: Reflection on National Planning – Te kakeega II*. Master thesis submitted to Auckland University of Technology.

162. According to the 2017 mini census, the total labour force in Tuvalu in 2017 was 3,518, of which 2,517 were employed and 1,001 unemployed. Of those employed, 2,402 are in paid employment either as formal employees or through producing goods for sale. Unpaid workers (115) are involved in family work, producing goods for own consultation or voluntary work. Of those classified as unemployed, 782 are actively looking for work. While ~35% of the working age group (i.e. 15+ years old) is employed in Tuvalu, there are high levels of under-employment in the labour force.

163. Table 4.18 provides a breakdown of unemployment levels in 2012 for each atoll/island of Tuvalu. This shows that the unemployment level on Funafuti is considerable lower than on the Outer Islands, where unemployment accounts for over 50% of the population on all atolls except Nuilakita. Unemployment on Nui, Nukufetau and Nukulaelae ranges between 52.3 – 54.1%.

Table 4.18: Level of Unemployment in 2012

Island	No. of total unemployed (including those in the labour force and those that are not e.g. students, full time home duties, retires or inactive)			% of total population
	Total	Male	Female	
Nanumea	332	165	167	54.3
Nanumaga	279	140	139	50.6
Niutao	375	167	208	54.0
Nui	381	182	199	52.3
Vaitupu	912	418	494	59.1
Nukufetau	357	170	187	53.6
Funafuti	2114	1014	1100	38.9
Nukulaelae	197	96	101	54.1
Nuiliakita	19	12	7	41.3
Total	4966	2364	2602	46.7

Source: Central Statistics Division, Ministry of Finance, Economic Planning and Industries (2018) *Tuvalu Population and Housing Census 2012: Volume 1*.

164. **Land tenure, ownership and use[44].** Traditionally the major social institutions have been family based under the leadership of the *aliki* (chiefs). The selection of the *ulu aliki* (highest chief) for each island has been based on chiefly lineage. A woman has never held this position. In Tuvaluan society, the family, community and church are the primary institutions. The people's wealth is the land and seas that surround them, with Tuvaluans valuing land as much as non-Tuvaluans value cash. Today, over 80% of the land is still held in customary tenure for the use of family members.

165. In traditional time, land was not sold as it was held under customary tenure, however today there are various types of land ownership such as privately owned land (native lands), government leased land, crown land, communal land, village land and church land. As Tuvalu is a patrilineal culture, land ownership is under the jurisdiction of the men and passed on from generation to generation.

[44] Aselu, B. (2015) *A Tuvaluan Concept of Well-being: Reflection on National Planning – Te kakeega II*. Master thesis submitted to Auckland University of Technology.

166. The land tenure system is largely based on extended family ownership. Around 95% of the land is held in customary tenure with only 5% government or privately owned or alienated and less than 0.1% is held in freehold title.

167. **Transport[45].** Tuvalu, as a remote island nation, relies heavily on air transport to afford access to international destinations. Services are currently unreliable, and aviation infrastructure improvements are required if tourism and time-critical exports are to be increased. Tuvalu has only one international airport located on Funafuti. It consists of a 1,535 m long by 30 m wide asphalt runaway with two aprons, that was originally constructed using coral aggregate (from island borrow pits) in World War II. The sub-base layer is 8 cm thick coral gravel, surfaced with a 1-2 cm asphalt chip seal. The runway was recently resealed as part of a World Bank Project. The Department of Civil Aviation (DCA) within the Ministry of Transport and Communications is responsible for the airport.

168. Limited air services have been provided over the years to the Outer Island via seaplanes. Seaplanes did not prove sustainable as a means of transport to the Outer Islands because of low demand compared to the real cost of providing the service. At present there are no operational airstrips on the outer islands, although there are remains of WWII airstrips on several of the outer islands.

169. Most roads in Tuvalu were constructed when the funds from the dot.tv sale were released over 10 years ago. There are about 18 km of paved roads on the island of Funafuti which are in good condition, while the Outer Islands have no paved roads, with Kaupule having limited ability to maintain roads and no funds. As of 2015, nearly all of the 1,240 vehicles registered in Tuvalu are in Funafuti. In the outer islands, there are very few motor vehicles and scooters[46].

170. Maritime transport is managed by the Department of Marine and Port Services, which owns and operates the port in Funafuti and the two vessels that are used for inter-island and international shipping services. The other port at the island of Vaitupu (Nukufetau) is unable to handle containerized shipping and is owned, operated and maintained by the local government.

171. The main focus for shipping is domestic and international trade. The outer islands are reliant on delivery of cargo and passengers by sea from Funafuti, and this has suffered severely due to poor maintenance of facilities and vessels. As a result, large sums are expended just to keep the inter-island services afloat, without the capacity to address deferred maintenance problems. Fishing is seen as an important driver of future economic growth and will require improved ports and shipping services. Monthly sea transportation via Tuvalu's two passenger boats is the primary means of transport between the atolls/islands of Tuvalu[47].

172. **Energy**[48, 49]. The energy sector in Tuvalu was dominated by electricity generation using diesel-based generators. In Funafuti and some separate islets of the Funafuti atoll, there are still small inhabited areas that have no power or are served by solar home systems (Funafala Islet) or stand-alone diesel power (Amatuku Islet). The generation system on Funafuti comprises a recently installed (JICA 2007) power station comprising three 750kVA

[45] Government of Tuvalu (2012) *Tuvalu Infrastructure Strategy and Investment Plan.*

[46] Government of Tuvalu (2015) *Second National Communication of Tuvalu to the United Nations Framework Convention on Climate Change*.

[47] Aselu, B. (2015) *A Tuvaluan Concept of Well-being: Reflection on National Planning – Te kakeega II*. Master thesis submitted to Auckland University of Technology.

[48] Government of Tuvalu (2012) *Tuvalu Infrastructure Strategy and Investment Plan.*

.[49] Government of Tuvalu (2015) *Second National Communication of Tuvalu to the United Nations Framework Convention on Climate Change*.

diesel generators with 11kV operating voltage. Total power output is 1,800kW. This is backed up by the old generators that have remained offline (1920kW) but are still able to be used as necessary. Seven of the eight outer islands are powered by 48-80 kW diesel generators with a total generating capacity per island averaging 176kW, apart from Vaitupu with 208 kW and Nukulaelae with 144kW. Niulakita is powered by individual DC home solar systems. The diesel generators run for 12-18 hours per day to save fuel and maintenance.

173. In 2001, as part of a government initiative, the outer islands were connected to diesel grids (except for Niulakita where solar is used). Virtually all household lighting is by electricity, although there remains minor kerosene use in the islands where power is not provided 24 hours a day. About 92% of the total households are connected to the diesel electricity grid.

174. In 2010, Tuvalu developed a 10 year National Energy Master Plan (2010-2020) which aimed to achieve a 100% renewable energy target by the year 2020. Since 2012, there has been substantial donor investment in solar energy across the country. Starting in Funafuti, a 66 kWp grid-connected PV (funded by Japan) and a 9kWp solar PV standalone (funded by Australia, United Kingdom and United States) have been installed at the desalination plant. By 2015, solar PVs had been installed at the government building (130kWp), Tuvalu Media (49 kWp) and Princess Margaret Hospital (75 kWp) in Funafuti as well as on the outer islands (including Nui, Nukufetau and Nukulaelae). As of 2015, 13% of electricity generation was solar and 87% diesel. Solar generation as a percentage of total electricity generated is considerable higher on Funafuti (93%) compared to the Outer Islands (61%) (Table 4.19).

175. More recently the Government of Tuvalu revised the date to achieve the 100% renewable target to 2025. Currently there are several renewable energy projects underway in Tuvalu which are looking to increase the penetration of renewables and battery storage across the islands.

176. Tuvalu's electric power industry is under the supervision of the Ministry of Works and Energy, and the Tuvalu Electric Corporation (TEC) is the state-owned power utility which plans, operates and maintains the generation, distribution and sales of electric power on the archipelago's inhabited islands. Financial assistance from Japan is used to subsidise the cost of fuel for the operation of the diesel power plant.

Table 4.19: Electricity generation and diesel fuel consumption for Funafuti and Outer islands in 2015

	Funafuti		**Outer Islands**		**Total**	
Generated - Diesel (MWh)	4912.02	93%	641.32	61%	5553.34	87%
Generated – Solar (MWh)	394.04	7%	406.32	39%	800.36	13%
Total Electricity Generated (MWh)	5306.06	100 %	1047.65	100 %	6353.71	100 %
Fuel consumed (kl)	1402.07		238.80		1640.87	
Fuel efficiency (MWh/kl)	3.50		2.69		3.38	

177. Since 1996, the total amount of diesel imported into Tuvalu has tripled. As diesel fuel is used for generating electricity, predominantly in Funafuti, the rise in demand for diesel due to rapid urban growth. The increasing demand for imported diesel goes hand in hand with economic growth however, the existing heavy reliance on imported fuels makes Tuvalu vulnerable to fluctuations in the international fossil fuel markets.

178. For people living on the outer islands, energy is often the only hope for improving their standard of living. As a result, solar power is being widely used for household energy

requirements on the outer islands supplemented by diesel-generated electricity. For cooking, firewood is most commonly used on the outer islands. As urbanisation continues, there will be a greater demand for electricity. Investment in renewable energy is critical for Tuvalu to reduce reliance on fossil fuels and to achieve sustainable development.

179. **Water supply and sanitation[50].** There are two natural sources of water in Tuvalu. The first is the freshwater lens that forms under a typical coral island due to the lower density of freshwater relative to saltwater. The second is rainwater, collected and stored primarily at the household level.

180. Rainwater harvesting is the principal source of freshwater on Funafuti. Every household has been supplied with water tanks and associated plumbing fittings, although not all roof space is utilised for harvesting. Groundwater resources on Funafuti are now non-potable due to seawater inundation and pollution from septic tank effluent. A small number of household wells are used by their owners as a secondary water supply only. With water in short supply due to varying rainfall, government has renovated and expanded the system of water storage and catchment in recent years. Government and community storages supplement household storages during dry conditions and a desalination plant are utilised to refill the government storage when this storage falls below one third capacity. However, in times of prolonged dry periods, the desalinated water is also distributed to households and businesses. The 65 m^3 desalination plant can produce about 55 m^3 per day based on a 90% operational capacity. Real production has been closer to 40 m^3 per day. Government cisterns are replenished by both desalinated water and rainwater.

181. Regular access to safe drinking water also poses an ongoing challenge in the Outer Islands. Only three of seven outer islands possess fresh water lenses and Nukufetau, Vaitupu and Nanumea are considered the only islands with sustainable groundwater supplies. Rainwater collection is still the most efficient and sustainable source of fresh water throughout the outer islands with the existing storage in the outer islands estimated to be ~ 29,000 m^3 in 2012.

182. To try to minimize further degradation of groundwater quality, Tuvalu is piloting the use of composting toilets and trying to improve the treatment of sewage sludge from septic tanks. The current sludge truck on Funafuti is disabled, and septic tanks are leaking into groundwater and the ocean/lagoon. The composting toilet trials (20 units) by SOPAC have been a huge success, with a long list of households (42% of Funafuti) signing up for future toilets.

183. Sanitation is provided through septic tanks with septic tanks emptied by sludge truck (on Funafuti) or into nearby holes. In addition, many septic tanks leak. Thus the septic system of Tuvalu is an ongoing source pollution to the ground water system and ocean/lagoon environments and an alternative long term solution to dealing with septic waste in Tuvalu is needed. To try to minimize further degradation of groundwater quality, Tuvalu is piloting the use of composting toilets and trying to improve the treatment of sewage sludge from septic tanks. Composting toilet trials were a huge success, with a long list of households (42% of Funafuti) signing up for future toilets.

184. With climate variability and the effects of climate change, water security will continue to be an issue for Tuvalu. Adapting to the changing climatic conditions will involve a variety of measures that focus on both supply and demand for precious water resources. The Government of Tuvalu has adopted a sustainable and integrated water and sanitation policy (Fakanofonofoga Mo Vai Mote Tumaa) that covers the period 2012−21. This policy promotes measures to improve water security as well as to develop more sustainable sanitation systems.

[50] Government of Tuvalu (2012) *Tuvalu Infrastructure Strategy and Investment Plan.*

185. **Waste management.** Solid waste management has traditionally been delegated to the *Kaupule*. During the 1990‟s integrated waste management was also undertaken by the Department of Environment, often in parallel with the *Kaupule*. As one of the requirements under the *Waste Operation and Services Act 2009*, the existing waste management project became a department in 2010 within the Ministry of Home Affairs and was given a new name Solid Waste Agency of Tuvalu (SWAT).

186. Waste on Funafuti is collected weekly utilising two trucks (depending on maintenance). Previous projects facilitated the subsidised distribution of household wheelie bins and small commercial skip bins (although these are now in poor repair), which are lifted onto, or emptied into the trucks. After waste is collected it is driven to the north of the island for disposal. There are three dumpsites at the northern end of Funafuti. All are simply the borrow pits excavated during World War 2 to construct the runway. One site has been completely filled, compacted and closed (not sealed) with vegetation allowed to cover it. In 2000, a new dumpsite was established as the main recipient of waste in the northern large borrow pit. Although the waste was originally dumped within the pit and partially compacted, it is now neither compacted nor covered. As the pit has filled, trucks have been forced to dump along the roadway, and this is now piled up for over a 1km of road. The main dump has therefore been closed to allow operators to work on the site and a small borrow pit just to the south of the northern dumpsite has been opened to accept waste.

187. Communities in the outer islands produce significantly less non-recyclable waste than Funafuti. Their dump space requirements are minimal, and normally consist of a small pit that may have been used as source for earlier construction. Handling equipment is minimal and often in poor repair. The *Kaupule* on each island are responsible for managing waste overseen by SWAT.

188. The SWAT continues to implement the integrated solid waste plan developed in 2005, and is currently preparing a National Waste Policy for the 2017−26 period and an Integrated Waste Management Plan for the 2017−21 period[51]. Older landfills on Funafuti have been replaced with a new landfill under a project funded by the Government of New Zealand to repair the environmental damage associated with borrow pits, although this landfill has very little remaining capacity.

189. **Physical and cultural resources[52]**. Culture in Tuvalu underpins the ability of the people of Tuvalu to live and thrive in the island environment. Strong community-based cultural values support a traditional safety net, even with overseas communities, for resilient communities. Tuvalu is particularly rich in intangible cultural heritage including: Fatele (Tuvalu traditional performing arts), Alofa (presentation of performing arts and gifts in the forms of mats and handicrafts to visitors at the end of welcoming feasts), and traditional craftsmanship related to, for example, mat weaving, fan making, and shell necklace making. Traditional agriculture, such as Pulaka (giant swamp taro) pits, is a good example of sustainable farming. In addition, traditional community fishing practices are also important ICH elements that support sustainable livelihoods.

190. With regard to tangible cultural heritage, several archaeological sites have been identified in Tuvalu such as Punatau on Vaitupu Island, the ancient settlement of the people of Vaitupu. It also contains an important potential for underwater cultural heritage in the form of shipwrecks, sacred sites linked to its local communities and underwater cultural landscapes.

[51] Government of Tuvalu (2017) *Tuvalu Infrastructure Strategic and Investment Plan*.
[52] Government of Tuvalu (2018) *Tuvalu National Culture Policy: Strategic Plan 2018 – 2024*.

191. During WWII, the islands of Tuvalu formed a strategic location for the Allied forces since the nearby islands of Kiribati in the Pacific were occupied by the enemy[53]. There are several remains of this historically conflict around Tuvalu, such as old and disused military aircraft on the north eastern side of Nanumea, and other plane wrecks on the islet of Motulalo. Other remains and debris can be seen along the beaches of the island of Fongafale, and there is a well preserved underground bunker on the islet of Tepuka.

192. Examples of known tangible cultural heritage sites on Tuvalu are provided in Table 4.20.

193. **Subproject localities physical and cultural resources**. Consultation with the Kapule and Cultural Heritage Officer, GoT Office of Cultural Affairs indicates that there are no items of tangible cultural heritage associated with any of the subproject sites.

Table 4.20: Examples of tangible cultural heritage sites on Tuvalu

Name	Atoll/Island	Description	Relation to Project Sites
Punatau	Vaitupu Island	Punatau on Vaitupu Island, Tuvalu, is the ancient settlement of the people of Vaitupu including a traditional meeting house, the chief 's house, the clan meeting place, some dwellings and water wells.	Located on different atoll
WWII bunker	Tepuka	well-preserved underground bunker on the island, which was an American communications outpost built during the Pacific War, which was connected to the military airfield on Fongafale.	Located on different atoll
Fire Caves	Nanumanga	Remains of old settlements of the island was found. These remains include signs of fire which used to be lit on the rocks and coral reefs in ancient time by the inhabitants	Located on different atoll
WWII Plane Wreckage Sites	Nanumea, Motulalo	wreckage and remains of several war planes around different islands or atolls of Tuvalu like Nanumea, Motulalo	Located on different atoll
Landing ship, Tank	On ocean reef near entrance to Lagoon, Nanumea	300 foot ship on reef	Located on different atoll
WWII airstrips	Nanumea	Remains of two airstrips, with wreckage of a Douglas SBD-5 Dauntless dive bomber near one	Located on different atoll

[53] IExplore (2019) *Tuvalu - Attractions*. https://www.iexplore.com/articles/travel-guides/australia-and-south-pacific/tuvalu/attractions

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Name	Atoll/Island	Description	Relation to Project Sites
Borrow Pits	Funafuti	In order to provide fill for construction the WWII airport on Funafuti (now Tuvalu's international airport), huge quantities of coral were excavated at the north and south ends of the islands, creating deep and wide pits. These constituted convenient dumping areas for the morass of boiler tanks, vehicle chassis, spare part etc. no longer wanted by the US Forces when they withdrew. In 2015 a project commenced to fill borrow pits on Funafuti (http://tautai.com/borrow-pits-rehabilitation-in-tuvalu/).	Location of borrow pits on Funafuti 
WWII airstrip, Motulao	Nukufetau	Remains of airfield and B-24 Liberator bomber plus other wreckage	The airfield is located on Motulao islet, approximately 10 km south west of the proposed project site on Savave Islet.

Sources: Wikipedia (2019). *Tepuka*. Bartsch, W.H. (1973) Searching for war remains in the Gilbert and Ellice Islands. South Pacific Bulletin. Second quarter: 8-15

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5. ANTICIPATED IMPACTS AND MITIGATION MEASURES

A. Overview

194. This IEE provides an analysis of the anticipated environmental impacts associated with the subprojects recommended by the feasibility assessment. Environmental safeguard measures will be incorporated into the project as follows:

- *Pre-construction phase* – this IEE and EMP will be updated as the subprojects are further defined during detailed design. Environmental mitigation measures will be incorporated into project design. The updated IEE and EMP will be submitted as part of the approval process under the country safeguard system and included in technical specifications and bidding documents. Once the contract is awarded, the successful contractor may mobilise to site but not commence works (including site clearing) until a notice to proceed is issued. The contractor shall prepare a site-specific construction EMP (CEMP), including sub-plans as specified in this IEE and EMP, that will be reviewed and approved by the PMU. No physical works (including site clearance) will be undertaken before the CEMP is approved.
- *Construction phase* - the period from the time that the 'notice to proceed' is issued to the contractor to when the 'certificate of completion' is issued. The contractor will complete the project as per the design and technical specifications and implement the measures included in the approved CEMP. This process will be monitored and documented by PMU.
- *Operation and maintenance phase* - the period starting when the 'certificate of completion' has been issued until the end of the agreed lifetime of the project. The TEC will be responsible for implementing the measures identified in the operation phase of the EMP to mitigate post-construction impacts.

B. Design and Pre-construction Impacts

195. **Access to land**. The construction of Outer Islands Subprojects 1a-1c and 3 and Funafuti Subprojects 1 and 2 will require the use of land. It is critical that the subproject sites are acceptable to land owners and the wider island community. The Kaupule on Nukelaelae, Nukefeau and Funafuti have been consulted and indicated that the selected sites are acceptable. On Funatuti, the subprojects are located on land owned by the GoT.

196. A due diligence report (DDR) has been prepared and found that no subprojects will require involuntary land acquisition or resettlement. As such the subprojects are classed Category C for Involuntary Land Acquisition and Resettlement. The expansion of the solar arrays on Nukulaelae, Nukufetau and Nui and the upgrade of the distribution system will be within the lease area of the existing solar arrays or, if required, a new lease will be agreed (preliminary discussion with the Kaupule have indicated that this would be acceptable). The rooftop solar installations and BESS on Funafuti is on land owned by the GoT.

197. **Adaptation for climate change**. Tuvalu has a tropical marine environment and is subject to cyclones (the two most recent in 2015 and 2016 resulting in extensive damage). The frequency of cyclones is projected to decrease but cyclones will be more intense (increased wind speed and rainfall). Sea level is project to continue to increase with a rise in the range of 7-18 cm expected by 2030. Sea level rise will exacerbate flooding and caused by storm surges and tides. The design of the subprojects will consider the impacts of climate change.

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198. Solar PV arrays are susceptible to strong winds and the technical specifications will ensure that all subprojects are designed to relevant Australian or US standards to withstand extreme winds.

199. The proposed subproject on Nukulaelae and Nui may be subject to flooding. Ground mounting systems (including cabling) will be designed and installed to withstand inundation. In addition, the diesel powerhouse on Nukulaelae will be replaced (Outer Island Subproject 2) and the floor level raised to the same level as the solar powerhouse such that it is not inundated during extreme weather events. Distribution system upgrades on all three outer islands have similarly been designed to withstand inundation. The subproject on Nukufetau will be located in the tidal estuary and an increase in sea level will not impact the array as the site is already subject to inundation. The subprojects on Funafuti will be located on roof tops (solar PV array) or in the existing TEC power station (BESS, control upgrades) and will not be impacted by increased sea levels.

200. All components procured for the subprojects will be suitable for tropical marine and coastal environments (preferably be preassembled) and will be as resistant to corrosion as practicable (e.g. stainless or galvanized steel mounting systems). Components will meet international standards (e.g. IEC 61730 Photovoltaic (PV) module safety qualification).

201. **Hazardous materials management**. The existing power stations on all three outer islands do not have adequate storage for diesel, oil and other hazardous materials. Accidental spills of hazardous materials have the potential to cause localised soil and ground water contamination. The technical specifications for Outer Islands Subproject 2 will include the provision of an appropriately sized bunded area at the new Nukulaelae diesel power house to store hazardous materials.

202. There is potential for asbestos containing materials to be associated with rooftops on Funafuti where solar installations are proposed and, to a lesser extent, with the old power station building to be demolished on Nukulaelae. Asbestos is carcinogenic to humans and, if present and disturbed by the project, would be a serious health risk for both workers and the community. A pre-construction survey for asbestos will be undertaken on all material likely to be disturbed by the installation of rooftop solar on Funafuti and at the old power station on Nukulaelae. If found an appropriately qualified contractor, approved by the Tuvalu DoE, will be engaged to remove and dispose of asbestos containing material.

203. **EMP update, bid documents and national requirements**. The IEE and EMP will be updated following the preparation of detailed designs for the subprojects. The update will include consideration of potential environmental impacts of changes or modification to the design of the subprojects.

204. The updated IEE and EMP will be formatted as a PEAR or EIA to be submitted to the Tuvalu DoE in application for Development Approval of the project in accordance with the Tuvalu *Environmental Protection (Environmental Impact Assessment) Regulations 2014* (amended 2017).

205. The updated IEE and EMP, together with any conditions associated with development approval will be included in the technical specifications and bid documents. The successful contractor will prepare their construction EMP (CEMP) reflecting their approach to the work and construction methodology (detailed with sub-plans and work statements as required) including number of workers to be brought to the site, length of time they will be there, accommodation and water and food security/supply etc for the period. Prior to the contractor mobilising to each site the CEMP will be reviewed by the PMU and ADB and approved by the TEC and the supervision consultant. The CEMP will also detail how emergency situations and medical evacuations will be addressed.

206. **Visual impacts.** The installation of the subprojects has the potential to impact the visual amenity of the view shed in which they are constructed. The design of the subprojects will minimise visual impacts by:

- Specifying the use of antireflective panels or coatings to ensure reflected light from PV surfaces does not create a nuisance to any nearby residents.
- Specifying that cables connecting the solar PV arrays to the existing grid will be buried.
- Ensuring that the new diesel power house on Nukulaelae will be neutral coloured or coloured according to the wishes of local residents.

207. **Noise**. The subprojects do not contain any noise generating components that may impact the amenity of nearby residents. The subprojects are anticipated to result in a reduction in the use of existing diesel generators thereby reducing noise emission from the existing power stations on Funafuti and the outer islands.

208. **Local contractor engagement**. The construction of the subprojects is likely to lead to increased employment opportunities for local people, particularly on Funafuti. To ensure opportunities are made available to local people as workers (or contractors on Funafuti as the case may be) an item encouraging the engagement of local people by the selected contractor(s) will be included in the tender documentation.

209. **Pathogens and invasive species**. Invasive species, many recent introductions, are seen as a key threat to biodiversity in Tuvalu. Twenty three invasive species are listed on the IUCN Global Invasive Species Database (GISD) as potentially occurring in Tuvalu. In addition, a further six invasive flora species have been identified by Tuvalu's Invasive Species Committee. Species include terrestrial fauna (e.g. rats, mice, ants, snails) and flora (grasses, herbs, shrubs and climbers). No marine invasive species are listed in the GISD for the ocean surrounding Tuvalu.

210. Pathogens and invasive species may be carried on, or in, materials, equipment (including vessels used to transport materials, equipment or workers) and any workers brought to Tuvalu for the subprojects. This includes materials, equipment and workers bought from other countries or elsewhere in Tuvalu.

211. The subproject sites on Nukulaelae and Nui are dominated by recently introduced species. Whilst none of the species recorded at the subproject sites are considered species of concern or potential concern, they have potential to be spread by the construction of the subprojects at these locations e.g. through tracking of seeds on vehicles or machinery.

212. Mitigation measures to prevent the introduction or spread of invasive species and pathogens will include:

- The tendering documents will specify that the contractor must obtain all required biosecurity and phyto-sanitary clearances (e.g. permits) for any material or equipment imported onto Tuvalu.
- The contractor will comply with all measures stipulated in the *Biosecurity Act 2017* and obtain all permits and clearances for import of any materials and equipment to be used for the project as required by Department of Foreign Affairs and Trade and Department of Agriculture.
- Materials will be inspected and any equipment imported for project purposes will be steam-cleaned and certified under biosecurity and phyto-sanitary procedures in Funafuti prior to mobilization to the outer islands.

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- Immediately following clearing and construction, the subproject sites will be planted with low growing ground cover to help stabilise the site and minimise the establishment of weeds at each location. The species of ground cover will be selected in consultation with the Kaupule and Tuvalu DoE.
- Weed hygiene measures will be implemented to prevent introduction or spread of invasive species, including cleaning machinery before it enters and leaves the subproject sites.

C. Construction Impacts on Physical Resources

213. **Erosion and sedimentation control**. The course textured calcareous soils present at all subproject sites are generally highly erodible when disturbed. Clearing of existing ground cover and potential minor civil works (e.g. site levelling) for the construction of the solar arrays at Nukulaelae (*Outer Islands Subproject 1a*) and Nui (*Outer Islands Subproject 1c*) as well as the construction of the new diesel power station at Nukulaelae (*Outer Islands Subproject 2*) and installation of a BESS at Funafuti (*Funafuti Subproject 2*) have potential to result in erosion. In particular, erosion from the subproject sites on Nukulaelae has potential to impact taro patches located adjacent and downslope of the sites.

214. The Nukufetau subproject site (*Outer Islands Subproject 1b*) is located in a dynamic marine environment but is sheltered from wave and storm surge and is not subject to significant deposition or accretion of sand/sediment. Tidal movement may result in minor localised erosion or accretion around the pylons of the solar array (as evidenced at the existing array, see **Error! Reference source not found.**) but it is not expected to result in any wide scale erosion or changes to existing coastal processes.

215. Measures to minimise and mitigate erosion at the subproject sites will include:

- Erosion control works and measures will be installed to control surface water runoff and prevent the export of sediments from the site by ensuring;
  - discharge of storm water is to stable preferably vegetated land; and
  - erosion control measures closely follow land contours to reduce runoff velocity from exposed soils.
- All land disturbances will be confined to the minimum practicable working area to ensure that the minimum area of land is exposed to erosion for the shortest possible time;
- Existing drainage lines will be protected and diversion of drainage lines avoided;
- Sediment traps (e.g. silt fences) will be constructed across all drainage lines and erosion controls from site that are likely to receive runoff from exposed or disturbed soils;
- Sediment and erosion control measures will be monitored regularly to ensure their continued correct functioning;
- Cable trenches will remain open for the shortest duration possible to reduce erosion and where possible will not be open during periods of heavy rain or forecast weather events that may inundate the trench;
- Spoil from excavated trenches will be stored on the uphill side of the trench such that any sediment from the spoil is deposited in the trench;
- A shade tolerant low groundcover (e.g. grass) will be established as soon as practicable after site clearance. The species of groundcover will be selected in

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consultation with the Tuvalu DoE and subproject location Kaupule. The species selected will not shade the PV modules and;

- The pylon footings at Nukufetau will be designed to minimise potential for localised tidal erosion.

216. **Water resources and quality**. All subproject islands have limited freshwater resources. Freshwater on outer island subproject islands is sourced either from the groundwater lens or rainwater captured from roofs and other structures. Water supplies are supplemented by a desalination plant on Funafuti. Salinity and pollution of groundwater mean that rainwater is the primary source of potable water. The construction of the subprojects may require significant volumes of freshwater (e.g. for concreting) and the inappropriate use of water (e.g. over abstraction of groundwater, overuse of rainwater) has the potential to impact fresh and potable water supplies.

217. Water resources may also be negatively impacted by the subprojects through pollution (e.g. accidental spill of hazardous materials (refer Hazardous materials); or alteration of surface water flow across the subproject site leading to sedimentation of adjacent environments (e.g. taro patches) (refer Erosion Control).

218. Mitigation measures to manage water resources and quality include:

- Water required for construction will be sourced with agreement of the subproject island Kaupule and the Tuvalu DoE.
- Where feasible, construction techniques will be specified that minimise the need to alter the topography (e.g. piling of ground mounted solar arrays) and hence surface water drainage from the subproject sites.
- Implementation of hazardous material mitigation measures (see below).
- Provision of adequate sanitation facilities for construction workers (Refer Health and safety)

219. **Use of local materials.** The construction of the subprojects may involve the use of local materials such as fill and aggregate (sand or coralline) and water (refer above). The requirement for fill and aggregate will be dependent on the contractors preferred construction method but may be used to level solar PV sites on Nukulaelae and Nui as well as in concrete for solar PV anchors (if not pre-cast off site) and foundations for the diesel power house on Nukulaelae. If fill or aggregate is sourced locally there is potential to negatively impact the source site through clearing of vegetation, erosion and sedimentation, noise and over extraction impacting local projects. Mitigation measures will include: If required sources of fill and aggregate will be agreed with the subproject island Kaupule.

220. **Hazardous materials**. Hazardous materials (e.g. fuels, oils, chemicals) will be required for the construction of the subprojects. The inappropriate transport, storage and use of hazardous materials has the potential to negatively impact the marine, aquatic, groundwater and terrestrial environments of the subproject locations. Additionally, in the event of an accidental spill, failure to adequately contain and clean up the spill has the potential to negatively impact the surrounding environment. Mitigation measures will include:

- The contractor(s) will prepare a hazardous materials management plan that shall, at a minimum, include:
    - The type and quantity of hazardous materials the will be present on site.
    - Safety Data Sheets for all hazardous materials.
    - A spill response plan, including training, for staff in the use of spill kits.

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- Details of planned transport, storage and disposal of hazardous materials (including compliance with commitments contained within this IEE).

- The transport of hazardous materials will undertaken by an appropriately qualified, experienced and equipped contractor;
- Hazardous materials storage areas will be located at least 50 m from any marine environment.
- Hazardous materials will be stored in appropriate containers that are in good condition with adequate labelling.
- Hazardous materials (including fuel and oils) storage will be appropriately bunded (e.g. self bunded containers or a bund with a minimum of 110% capacity of the largest container).
- Refuelling will take place in a designated area and drip trays or containment devices will be used when refuelling equipment and machinery.
- Limit the amount of any marine paint to be used on the solar array pylons to no more than two litres at any one time contained within a larger volume drip tray.
- Spill kits and containment devices appropriate for the type and volume of hazardous materials on site will be located at the storage area(s), on site and on vehicles carrying hazardous materials.
- All personnel involved in the handling of hazardous materials will be trained in the handling, emergency procedures and storage requirements for the materials they are handling.

221. **Waste management**. The subprojects are not anticipated to produce a significant volume of waste. Wastes will predominately include packaging materials and general waste. There are expected to be few hazardous wastes generated during construction however, there are no facilities for the disposal of hazardous wastes on the outer islands. The inappropriate management of waste during construction of the subprojects has the potential to pollute surrounding water, groundwater and land. Waste management during all phases of the subprojects will seek to reduce, reuse and recycle waste as far as possible and dispose of waste in an appropriate way. Mitigation measures will include:

- Where practicable, all solid and inorganic waste will be removed from the outer islands for disposal in Funafuti. Where waste is planned to be disposed of on island, the method and location of waste disposal on the outer islands will be approved by the Kaupule and Tuvalu DoE.
- Hazardous waste (if generated) will be disposed of in accordance with the manufacturers requirements at a facility licenced to accept the type and quantity of waste (or approved by the Tuvalu DoE). If no such facility exists in Tuvalu hazardous waste will be shipped to an appropriately licenced facility.
- The construction contractor will consult with the Kaupule and TEC to identify opportunities to avoid and reduce the generation of waste and to recycle or re-use waste generated.
- If excess spoil is generated during site preparation it will be stored at an existing stockpile site for re-use.
- Bins for recycling and general rubbish will be provided at the project site and materials laydown area for the disposal of construction wastes and will be removed off-island at end of construction period.

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D. Construction Impacts on Biological Resources

222. **Removal of vegetation**. The construction of the solar arrays at Nukulaelae (*Outer Islands Subproject 1a*) and Nui (*Outer Islands Subproject 1c*) as well as the construction of the new diesel power station at Nukulaelae (*Outer Islands Subproject 2*) and installation of a BESS on Funafuti (*Funafuti Subproject 2*) will require the removal of approximately 600 m^2 of existing vegetation. The subproject locations at Nukulaelae and Nui have previously been cleared of vegetation for the installation of the existing solar arrays and power station and are dominated by introduced ground covers. The location for the BESS on Funafuti will be located within the TEC Power Station compound on land that has been previously cleared. No trees will be cleared for the subprojects. All subprojects site are surrounded by vegetation (predominantly coconut woodland) which has potential to be impacted by:

- unauthorised clearing outside the subprojects site boundary
- clearing elsewhere on the subproject island e.g. to store materials
- causing damage to surrounding vegetation through erosion (refer *Erosion control*)
- changes to surface drainage (refer *Water resources and quality*)
- introduction of invasive species (refer *Pathogens and invasive species*).

223. Mitigation measures include:

- The subproject site boundary will be clearing marked on a plan and approved by the Engineer/supervision consultant prior to the commencement of clearing. Trees and vegetation to be removed according to the plan will be physically marked with paint to tape. Only vegetation identified on the plan will be removed.
- Ensure vegetation clearance is restricted to within the subproject site boundary and is the minimum practically required for the proposed works, including allowance for shading. The proposed site boundary will be approved by the IA (or their representative) and the Kaupule prior to the commencement of clearing.
- Cleared vegetation will be removed for the subproject site and disposed of at a location approved of by the Kaupule and Tuvalu DoE (noting cleared vegetation includes weeds and potentially weed seeds). Vegetation will not be stockpiled on site or pushed into existing vegetation adjacent to the site.
- Machinery storage and materials lay down areas will be established in previously disturbed areas to avoid increasing the footprint of the project site.
- As far as is practicable, existing stockpiles of fill material will be used. If new fill material is required it will be sourced from locations approved by the Kaupule and Tuvalu DoE.

224. **Loss of tidal flat habitat.** The proposed solar array at Nukufetau is located on tidal flats between Savave and Fale. The tidal flat provides habitat for a variety of species including birds (foraging habitat), invertebrates, and when the tide is high, fish. The installation of the solar array will result in the potential loss of up to 420 m^2 of habitat. It is noted that this figure assumes the complete loss of habitat beneath the arrays whereas the actual physical disturbance will be restricted to the footprint of the pylons. It is likely that the area beneath the arrays will continue to provide suitable habitat for most species. The loss of 420 m^2 is approximately 1.7% of the available tidal flat on the southern side of Savave. A conservative cumulative estimate of 1000m^2 of lost habitat as a result of both the existing and new projects represents approximately 4% of available habitat on the southern side of Savave. However, there are also significant areas of tidal flat elsewhere on Nukufetau and in Tuvalu. The loss of a relatively small area of this widespread and common habitat type will not have a significant impact on any species that utilises the habitat.

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225. The construction of the project, including the use of equipment on the tidal flat, will not result in the permanent loss of any additional tidal flat habitat.

226. **Impacts to threatened and protected species and habitats**. There are no flora species in Tuvalu that are listed as threatened on the IUCN Red List. Of the indigenous flora species that occur none are considered endemic to Tuvalu. There are five threatened or near threatened terrestrial fauna species known from Tuvalu (as listed on the IUCN Red List): four birds, one reptile and one invertebrate.

227. Of the bird species one, the Phoenix petrel (*Pterodroma alba*) is a vagrant and will not be impacted by the subprojects. The other three birds, the bristle-thighed curlew (*Numenius tahitiensis*), bar-tailed godwit (*Limosa lapponica*) and grey-tailed tattler (*Tringa brevipes*) are all migratory wader species that overwinter on the islands of Tuvalu. The tidal mudflats where the Nukufetau subproject is located may provide foraging habitat on occasions for the bristle-thighed curlew and bar-tailed godwit. However, as noted above, the area of mudflat disturbed by the subproject is small compared to the available habitat (1.7%) and the subproject is unlikely to affect the available foraging habitat for these species. Further, both species are likely to avoid the subproject site during construction. Nonetheless, if possible construction of the Nukufeatu subproject will be completed between March and October to avoid the migratory period when both species may be present in Tuvalu. The grey-tailed tattler does not inhabit tidal mudflats.

228. Steindachner's Emo skink (*Emoia adspersa*) is known from Funafuti but is found in heavily vegetated coastal areas and is unlikely to be impacted by the subprojects which are located on previously cleared land. The ground dwelling snail, *Omphalotropis zelriolata*, is found in lowland forest and is unlikely to be disturbed by the subprojects which are located on previously cleared land.

229. There are 98 marine species in Tuvalu that have been listed as threatened on the IUCN Red List however, however, none of these species actively inhabit or use the intertidal habitat disturbed by the Nukufetau subproject site, although some fishes may pass through the site during high tide.

230. Protected areas have been established on the three subproject outer islands as well as on Funafuti (see Figure 4.7). The Kaupule are the management authority for the outer island protected area whilst the Kaupule in conjunction with the Fisheries Department manage the protected area in Funafuti. While the protected area on Nukulaelae surrounds Fagaua Island where the Nukulaelae subprojects are located, the protected area is a fisheries reserve that surrounds Fagaua and is not terrestrially based. For all the other subprojects, the project sites are located on islands external to the protected areas. Thus, none of the subproject sites are located within a protected area nor are likely to impact a protected area.

231. The subprojects are not expected to impact any threatened and protected species or habitats, critical habitat as defined by ADB SPS 2009 or any protected areas.

E. Construction Impacts on Socio-economic Resources

232. **Cultural heritage.** The Office of Cultural Affairs (OCA) were consulted during the inception mission. There is currently no register of culturally significant sites in Tuvalu however, it was recommended that representatives of the Kaupule of each of the outer islands be consulted to determine if culturally significant values were associated with potential subproject sites. The Kaupule on Nukulaelae and Nukufetau have been consulted and no cultural heritage values were identified at the subproject sites. The Kaupule on Funafuti will be consulted prior to the finalisation of the subproject locations.

233. If an artefact is discovered during site clearance that may be of cultural heritage significance work will cease immediately and the Kaupule contacted to determine significance of the find. The PMU will also be notified immediately. A chance finds protocol is included in the EMP and will be elaborated in the CEMP.

234. **Noise and vibration**. The construction of the subprojects will generate noise through the operation of machinery on the subproject sites and movement of vehicles and machinery transporting equipment and materials to subproject sites. All subproject sites on the Outer Islands are close (within 100 m) of sensitive receptors including residential houses. Several of the proposed rooftop solar installation sites on Funafuti are on buildings that are sensitive to noise disturbance. Construction noise impacts will be sporadic and are expected to be minor. Mitigation measures will include:

- Working hours will be between 8am and 5pm Monday to Friday unless otherwise agreed between the contractor, PMU and Kaupule (or operators of buildings on Funafuti). Where safety or technical reasons require work to be completed outside of these hours, noise levels will be kept to a minimum and subproject island Kaupule together with nearby residents will be informed.
- Noise generating activities will be carried out in the least sensitive time periods as determined in consultation with the Kaupule and building managers (roof top solar installations). Wherever possible works will be scheduled to avoid disruption to the normal use of buildings.
- Equipment and plant will be maintained in good order. Noise reduction components (e.g. mufflers) will be inspected prior to the commencement of works to ensure they are fully functional. Noise emissions from construction equipment will not exceed 75 dBA.

235. **Air quality and dust**. The construction of the subprojects has the potential to generate dust through earth moving associated with site clearance and levelling (if required), by the movement of vehicles and machinery and by exposed soil on cleared sites or in soil stockpiles. Exhaust emissions will also be generated from machinery and vehicles. Measures to mitigate impacts to air quality and the generation of dust will include:

- Vehicles and machinery will be maintained in good order.
- Vehicles will not be left idling when not in use.
- Vehicles carrying soil, sand, crushed aggregate or other fine materials to or from the subproject sites will be covered.
- The subproject sites, material stockpiles and access roads, including those from the wharf and material stockpile areas, will be wetted or stabilised if dust is generated.

236. **Influx of labour – impacts of foreigners and non-local workers.** The subprojects are likely to require foreign contractors and technical specialists for the duration of construction. It is anticipated that, dependent on the number of local workers employed, between approximately five and ten foreign workers would be present on the subproject island for the duration of construction which is expected to be approximately three months. There is potential for conflict between foreign workers and local communities. The size of the non-local workforce is expected to be relatively small, however, the population of the subproject islands is also small. Mitigation measures will include:

- A code of conduct will be agreed between the Kaupule and the contractor which will govern the conduct of all workers for the period they are working at each site. The protocols will govern workers' conduct while at work and in communities, behavior around women and children, restrictions on alcohol consumption,

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prohibitions (with sanctions for non-compliance) on workers hunting or fishing, implementation of awareness programs, implementation of the GRM and handling of complaints, hiring of local labor, and implementation of the health and safety plan (HSP).

- All non-local workers will receive an induction that outlines the social and cultural expectations when working in Tuvalu and on the subproject island and the code of conduct they must adhere to. Any worker not complying with the code of conduct will be expelled from the island and Tuvalu and repatriated at the contractor's expense.
- A grievance redress mechanism (GRM) has been established for the project (refer Section 8) and will be communicated through the engagement programme and by prominent display of the GRM process at the subproject sites prior to the commencement of onsite works.

237. **Health and safety – workers**. The construction of the subprojects will involve health and safety risks to contractors and TEC staff. Except by agreement with the TEC, the contractor will be responsible for access to the subproject sites during construction. The contractor shall be required to prepare a Health and Safety Plan that complies with the World Bank Group's *Environmental, Health, and Safety Guidelines (EHS Guidelines)*[54] that describes the safety measures that will be implemented to protect staff and contractors during construction. The HSP, as part of the CEMP, will at a minimum:

- Include measures and equipment required to protect workers and link to the emergency response plan and other plans as necessary.
- Identify responsibilities and authorities within the contractor's staff for adhering to occupational health and safety (OHS) requirements.
- Identify and provide required personal protection equipment (PPE) for staff and sub-contractors (before they start work).
- Install fencing on all areas of excavation greater than 1 m deep whether temporary or permanent.
- Define appropriate emergency and medical process including evacuation procedures.
- Prepare appropriate work method statements for each construction activity.
- Provide daily hazard identification checklists and risk assessments.
- Identify mandatory meeting requirements including toolbox sessions, to ensure all personnel understand the task before commencing work for the day.
- Set procedures for safe handling of toxic materials and other hazardous substances.
- Provide for installation of lights and cautionary signs in hazardous areas.
- Ensure operators of vehicles and equipment are properly licensed and trained.
- Ensure safety and inspection procedures are implemented, setting schedules for regular checking.
- Ensure movements of heavy vehicles is managed so as to minimise impacts to existing traffic and the wider community.

[54] https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/ehs-guidelines

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- Provide for the provision of adequate sanitation and potable water for staff and contractors for the duration of construction works.
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238. The construction of the subprojects will also involve health and safety risks to the local community on sub project islands. The contractor's HSP will also include measures to protect the community at a minimum including:

- Before construction commences the contractor/s will conduct training for all workers on environmental safety, environmental hygiene including delivery of the HIV/AIDS/STIs awareness and prevention training and the code of conduct.
- Child and/or trafficked labor will be strictly prohibited for any activities associated with the project.
- Children will be prohibited from entering the sites (including worker's accommodation, works area/construction zone) and prohibited from playing on any equipment or machinery.
- Access will be controlled to subproject sites for the duration of construction to prevent public access e.g. through the use of security fencing or restricting access to roof tops.
- Advisory signage warning of the dangers of unauthorised access will be placed where clearly visible on security fencing.
- All advisory and warning signage will be clear, secured on fences, gates and signboards and be posted in Tuvaluan, the language of the main nationality of workers and repeated in English.

239. **Unanticipated environmental impacts**. If unanticipated environmental impacts occur during construction phase, in consultation and agreement with the PMU, the Contractor will update the CEMP. The environmental protection measures will be designed to address the impacts.

F. Operation Impacts

240. **Waste and hazardous materials**. The operation of the subprojects will generate waste, including hazardous waste (e.g. inverters and batteries may require replacement during the life of the subprojects), which must be appropriately managed to prevent contamination. In addition, the existing power stations will continue to require hazardous materials (e.g. fuel, lubricant) and produce waste (e.g. used oil). Mitigation measures will include:

- Where possible batteries and inverters will be recycled. If recycling is not possible, they will be disposed of at a facility approved by the Tuvalu DoE or, if no facility is available, transported to an appropriately licenced facility outside of Tuvalu.
- No hazardous waste (e.g. used oils, batteries or inverters) will be disposed of on the subproject Island (except Funafuti). Waste will be sent for disposal at regular intervals and not allowed to accumulate at the power station.
- Inverters and batteries that are replaced during the operating lifetime of the power station will be removed, transported and disposed of by an appropriately experienced and equipped contractor.
- Waste oil and other hydrocarbons from generators will be stored in a bunded hydrocarbon storage area.

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- Washing of solar PV panels will only be undertaken on an 'as needs' basis to minimise the generation of wastewater. Disposal of wastewater will be agreed with Tuvalu DoE.
- All infrastructure containing hazardous materials (e.g. batteries, transformers) will be inspected regularly to ensure they function correctly and no hazardous materials are being discharged.

241. **Water resources**. Water will be required for washing solar PV modules during operation of the subproject. A source of water will be agreed with subproject island Kaupule and Tuvalu DoE prior to the commencement of operation.

242. **Erosion control**. If localised erosion is detected during operation of the subproject, effective mitigation measures will be installed such as:

- application of mulch
- covering with open weave jute matting and reseeding with ground cover
- protection with geotextile fabric
- localised flow dispersal and diversion structures.

243. **Fauna**. The subprojects do not provide habitat for any species of fauna however, some species, including birds, may pass through of overfly the sites. The collision risk of birds and solar panels (eg through glare) in generally considered to be low and the small size of the arrays would not prevent birds moving between preferred habitats. The subprojects will not result in a significant impact on any fauna species, including birds.

244. **Employment**. It is expected that existing employees will be retained to operate the new solar power systems. Training will be provided for TEC employees in the operation and maintenance of the new infrastructure.

245. **Emergency response**. TEC will prepare (or update) an operational emergency response plan. The plan will be included in the training provided to employees and be implemented during the operation of the power station.

G. Decommissioning impacts

246. **Decommissioning of solar PV array, batteries and WTE facility**. The subproject's solar PV modules are expected to have an economic life of at least 25 years. At this time it is expected that they will be replaced by new solar PV modules. The removal of the solar PV modules will be contracted to a specialist supplier.

247. The batteries installed are expected to have an economic life of between 10 and 20 years depending on the battery type selected. All equipment will be removed from the subproject sites (e.g. PV modules, batteries, invertors) and will be reused or recycled where possible. Equipment that cannot be reused or recycled will disposed of at a facility approved by Tuvalu DoE or, if no facility is available, transported to an appropriately licenced facility outside of Tuvalu.

248. **Hazardous materials**. The decommissioning contractor will be required to develop a hazardous materials management plan prior to the commencement of any works on site.

249. **Revegetation**. If the site is not reused it will be allowed to revegetated with species appropriate to the future land use of the site.

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6. ANALYSIS OF ALTERNATIVES

250. Through its *Master Plan for Renewable Electricity and Energy Efficiency in Tuvalu* Tuvalu is committed achieving a target of 100% renewable energy. In order to raise the current renewable energy generation on Nukulaelae, Nukufetau and Nui from 60-70% and Funafuti from 16% toward 100% more renewable energy or enabling technology is required. A 'do nothing' option was not considered as it will prevent the GoT meeting the goals contained in the master plan as well as its international commitments. A variety of subprojects were, and continue to be, considered at Nukufetau, Nukulaelae, Nui and Funafuti.

251. On Nukulaelae, Nukufetau and Nui options to increase the renewable energy contribution include additional generation capacity (solar) or additional storage capacity (batteries). System modelling assessed both options but found that the most cost effective (levelized cost of electricity (LCOE)) means of increasing renewable energy contribution to above 90% is the installation of additional solar capacity. Additional solar capacity is able to be easily integrated into the current power system. Other means of renewable generation (e.g. wind) were not assessed for the outer islands as the addition of an alternative means of generation would add cost and complexity to the subprojects. In addition, proven, reliable solar equipment is widely available and the addition of further solar, potentially of the same as the existing equipment, simplifies the operation and maintenance of the power system.

252. On Funafuti both increased storage and generation were also considered to increase renewable energy contribution. In conjunction with the planned World Bank installation of additional solar and BESS, analyses found that currently the most appropriate means of increasing renewable energy contribution was the installation of additional solar generation and battery storage together with a hybrid control system to manage the expanded system and allow for future expansion. A range of options for the increased solar generation were assessed including installation of additional rooftop solar at numerous locations, a floating solar system and raised road shade solar.

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7. CONSULTATION AND INFORMATION DISCLOSURE

A. Consultation

253. ADB requires projects to engage in and carefully document meaningful consultation with stakeholders. ADB defines 'meaningful consultation' as a process that:

- begins early in the project preparation stage and is carried out on an ongoing basis throughout the project cycle.
- provides timely disclosure of relevant and adequate information that is understandable and readily accessible to affected people.
- is undertaken in an atmosphere free of intimidation or coercion.
- is gender inclusive and responsive and tailored to the needs of disadvantaged and vulnerable groups.
- enables the incorporation of all relevant views of affected people and other stakeholders into decision making such as project design, mitigation measures, the sharing of development benefits and opportunities, and implementation issues (ADB SPS, p. i).

254. In carrying out the preliminary design and safeguards due diligence , all major stakeholders on Funafuti, Nukulaelae, Nui and Nukufetau have been consulted including staff and officers of TEC, the government (including the DoE and Office of Cultural Affairs), the national women's NGO, the Kaupule, affected landowners and residents of the subproject islands, and ADB.

255. More specifically, the consultations have included:

- group meetings with:
  - *Kaupule* and senior staff of Nukulaelae (January 2019)
  - *Kaupule* and senior staff of Nukufetau (January 2019)
  - *Kaupule* and senior staff and leading chiefs of Funafuti together with representatives of the Funafuti Native Lands Trust Board (January and March, 2019)
  - senior officers of GoT (September,2018, January and March 2019)
- individual households on the outer islands.

256. A summary of stakeholder meetings is provided in Table 7.1 whilst a full list of stakeholders and communities that have been consulted as part of this project is provided in ANNEX 3. All stakeholders consulted were found to support the project with the main interest of community stakeholders being that the new infrastructure will help reduce electricity rates. No other concerns were expressed during the consultations.

Table 7.1: Summary of stakeholder meetings

Date	Meeting place	Number of particpants (male / female)
07/09/2018	Department of Environment and Department of Cultural Affairs	3 (1/2)
08/09/2018	Nukulaelae Kapule	7 (6/1)
09/09/2018	Nukufetau Kapule	4 (4/0)

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12/09/2018	Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour	3 (3/0)
24/01/2019	Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour	3(0/3))
24/01/2019	Home Affairs	1 (1/0)
25/01/2019	Funafuti Kapule	5 (5/0)
27/01/2019	Tuvalu National Council of Women	2 (0/2)
28/01/2019	Minister of Natural Resources	1 (1/0)
25/03/2019	Department of Environment, Ridge to Reef and FassNet.	5 (3/2)
25/03/2019	Department of Environment	3 (0/3)
25/03/2019	Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour	2 (1/1)
25/03/2019	Gender Affairs and Culture Department	2 (0/2)
04/06/2019	Nui Kapule	2 (2/0)
11/06/2019	Funafuti Kapule	5 (5/0)

257. TEC are committed to undertaking further consultation with the wider community. A draft consultation framework for future phases of the project is outlined below.

258. ADB requires projects to engage in and carefully document meaningful consultation with stakeholders. ADB defines “meaningful consultation” as a process that:

- begins early in the project preparation stage and is carried out on an ongoing basis throughout the project cycle;
- provides timely disclosure of relevant and adequate information that is understandable and readily accessible to affected people;
- is undertaken in an atmosphere free of intimidation or coercion;
- is gender inclusive and responsive and tailored to the needs of disadvantaged and vulnerable groups; and
- enables the incorporation of all relevant views of affected people and other stakeholders into decision making such as project design, mitigation measures, the sharing of development benefits and opportunities, and implementation issues (ADB SPS, p. i).

259. TEC will meet initial consultation requirements for the project by calling a public information meeting on Fogafale and inviting Funafuti and outer island Kaupule and other members of target stakeholder groups along with institutional stakeholders and members of the general public. TEC will send emails and letters to invite key stakeholders and use its official web site to invite members of the public. TEC will also use its web site to post reports and other information about the project. TEC will advise and inform residents of the target outer islands through the local Kaupule.

260. TEC will post summary information and answer common questions on its web site and in person at the public meeting on Fogafale. TEC will explain in detail what effect, if any, continued development of renewable energy is expected to have on TEC electricity rates. This would require providing transparency to the public about TEC’s current operations and finances.

261. Depending on the outcome of (and any follow up to) the current review of the electricity tariff structure and rates, and depending on advice from GoT, public consultations could include important discussions with stakeholders regarding electricity rates and

subsidies. TEC would take stakeholder comments under consideration and modify rates and subsidies as appropriate.

262. ADB requires that stakeholder consultations be well documented. During project implementation TEC will ensure that meaningful public consultations will continue to be undertaken. ANNEX 4 provides a template that can be used to document meetings. Attendance sheets recording name, gender, and institution should be prepared and filed for all group meetings. For large group meetings, written documentation should be accompanied by one or more photographs to document the meeting, its venue, and its participants.

263. The project's communication and consultation plan (CCP) outlining the main project information, messages and mechanisms throughout the project cycle will guide the information to be provided to stakeholders and affected people and timing, along with general disclosure requirements (see below). The CCP will be updated early in implementation by the supervision consultant. The CCP will be implemented by the TEC with support from the supervision consultant. The contractor's CEMP will explain how the contractor will implement the elements of the CCP relevant to construction activities and will include in their monthly reports the consultation and disclosure activities undertaken.

B. Information Disclosure

264. All safeguard documents including the safeguards monitoring reports are subject to public disclosure, and therefore will be made available to the public. Following clearance of the IEE by ADB the document will be posted on government and ADB websites as per the Access to Information Policy (2018). Provided it does not contain any commercially sensitive information, the approved CEMP will also be disclosed.

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8. GRIEVANCE REDRESS MECHANISM

265. Every project should have a Grievance Redress Mechanism (GRM) to receive and facilitate resolution of any concerns or grievances that might arise during the course of project implementation. Since all the proposed project works would be carried out by or under the guidance and authority of TEC, and since project communities and their respective landowners, households, and businesses deal directly with TEC on a regular basis as customers, it would be best to use standard TEC channels for receiving and dealing with any project-related grievances relating to land acquisition and resettlement. Note here that "resettlement" impacts would include any temporary commercial, wage, or other income losses due to project works.

266. In serious cases, people would likely take grievances directly to the GM or perhaps to a relative that happens to hold a senior position in TEC, but a project-specific staff member acting as grievance focal point within TEC or the PMU will be designated once project implementation begins and will employ the following mechanism:

267. Any complaints or concerns about the project, including any environmental or social complaints will be received through the Grievance Focal Point (GFP), which will be a designated personnel from within TEC who will be responsible for receiving the complaints. TEC will record the complaint in the onsite Environmental and Social Complaints Register (ESCR) in the presence of the GFP. The contractor's CEMP will explain how the contractor will implement the elements of the GRM relevant to construction activities and will also maintain a grievance register.

268. The GFP will discuss the complaint with the Implementation Contractor and have it resolved. If the Contractor does not resolve the complaint within one week, then the GFP will bring the complaint to the attention of the designated pmu Safeguard Specialist. The PMU Safeguard Specialist will then be responsible for coordinating with the Contractor in solving the issue.

269. If the Complaint is not resolved within two weeks the GFP will present the complaint to the Grievance Redress Committee (GRC). The GRC will be comprised of designated officials from the following organizations: Contractor's Environment Specialist and/or Social Specialist, pmu Safeguard Specialist, GFP, Island Level Representative, and a representative from the Executing Agency.

270. The GRC will have to resolve the complaint within a period of two weeks and the resolved complaint will have to be communicated back to the community. The Contractor will then record the complaint as resolved and closed in the Environmental and Social Complaints Register.

271. In parallel to the ESCR with the Contractor, each GFP will maintain a record of the complaints received and will follow up on their rapid resolution. The Executing Agency through the Implementing Agency will also keep track of the status of all complaints through the Monthly Environmental and Social Monitoring Report submitted by the Contractor to the PMU and will ensure that they are resolved in a timely manner. Figure 9 shows that Grievance Redress Mechanism.

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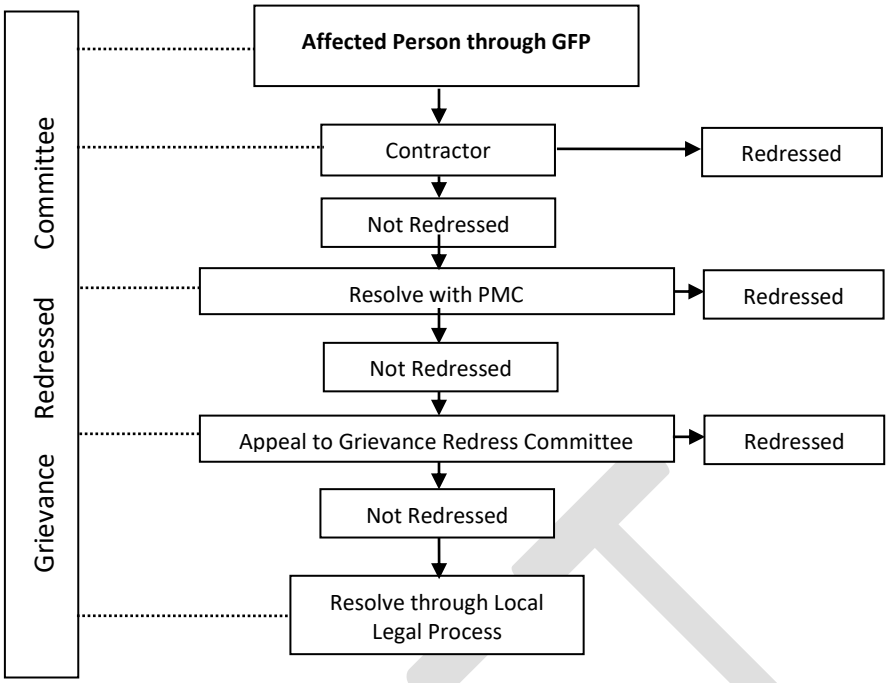

Figure 9: Flow chart of the GRM

272. In any case, the project's CCP will describe the GRM and how project information will be disseminated during implementation, and will also describe where and how to direct any grievances that might arise.

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9. ENVIRONMENTAL MANAGEMENT PLAN

A. Introduction

273. This EMP is intended to cover all phases of the Pacific Renewable Energy Investment Facility (PREIF) – Tuvalu Component (the project) implementation including design, construction, commissioning, operation and decommissioning. The EMP complies with ADBs SPS and includes the following information:

- Implementation arrangements including institutional roles and responsibilities for the EMP implementation throughout all phases of the project.
- Environmental management matrices including:
  - Potential environmental impacts at each stage of the project
  - Proposed mitigation measures to address each potential impact
  - Costs associated with implementation of the mitigation measure
  - Institutional responsibility for implementing proposed mitigation measures
  - Schedule of implementation of mitigation measures.
- Environmental monitoring plan including:
  - Aspects to be monitored to ensure mitigation measures have been implemented effectively
  - Schedule and frequency of monitoring
  - Costs associated with monitoring
  - Responsibility for implementing and supervising monitoring.

B. Implementation arrangement and responsibilities

274. The MoF will be the executing agency for the project and the TEC will be the implementing agency within the Ministry of Public Utilities and Infrastructure. The MoF will have overall responsibility for the project whilst the TEC, through its PMU supported by a supervision consultant, will be responsible for day to day implementation and management of the project including the project's compliance with environmental safeguard requirements. TEC will be responsible for implementing all environmental safeguards as per the SPS and country safeguard system. A GoT Task Force has been established that is responsible for providing Government oversight of the project and reporting to Cabinet. Organisational responsibilities for environmental management are summarised in Table9.1.

Table9.1: Organisational environmental responsibilities

Project Implementation Organisations	Environmental Management Roles and Responsibilities
Executing Agency (Ministry of Finance and Economic Development)	• General project oversight • Ensure overall compliance with the project grant agreement and covenants .Overall delivery of the project and reporting to Government • Ensure compliance with grant agreement covenants • Ensure the compilation and presentation of all reporting requirements under the project
Implementing Agency	• Submission of environmental documentation to Tuvalu DoE as required under the *Environment Protection Act 2008* and

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(Tuvalu Electricity Corporation / Ministry of Public Utilities and Infrastructure)	*Environmental Protection (Environmental Impact Assessment) Regulations 2014*. • Responsible for the overall implementation of the project • Ensure compliance with the provisions of the Grant and Project Agreements and government policies and guidelines • Responsible for procurement and services for the project • Issue contract change orders as appropriate • Establish and implement the project monitoring and evaluation framework
GoT Task Force	• Comprising of the CEOs of MPUI, MFED, MHARD and MFATTEL, GM of TEC and Directors of Departments of Energy and Environment • Chaired by CEO of MPUI • Responsible for providing Government oversight of project and reporting to DCC and Cabinet
Project Management Unit	• Responsible for oversight of the implementation of the project, under the direction of the IA, to ensure compliance of contractors with contracts, specifications and management plans. • Update the IEE including its EMP, as PEAR or EIA as required and assist the TEC prepare and submit the development approval application • Incorporation of updated IEE mitigation measures and EMP and any conditions on the development approval into bidding documents and technical specifications; • Provide inputs to the bid evaluation in respect of contractor's response to the EMP requirements • Prepare reports and supporting information for the EA, IA and GoT Task Force as required • Submission of quarterly progress reports and semi-annual monitoring reports • Ensure readiness of all project sites for contractor including surveyed and staked out sites, any required permits in place and secured lease agreements (if required) • Recruit PMU Supervision Consultant • Depending on the experience of the contractor, provide support in preparation of contractor's CEMP • Review and approve selected contractor(s) project specific CEMP and other plans as required by the EMP. • Revising the EMP and ensuring its integration along with other safeguards provisions into the bid and contract documents. • Prepare semi-annual safeguards monitoring reports to be submitted to EA and ADB. All safeguards monitoring reports to be disclosed as per ADB policies. • Ensure contractors are aware of any development application or other permit conditions and the implications for the implementation of the project. • Supervise, monitor and report on contractor's implementation of approved CEMP and all other contractual obligations • Enforce contractual requirements • Audit construction phase through environmental inspections and review monitoring reports and data

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Tuvalu Department of Environment	• Ensure compliance with government requirements • Review complicated issues, if any, arising from the project • Participate in monitoring
Construction contractor	• Preparation of the project CEMP and other plans as required prior to the commencement of any on site works. • Submit CEMP to PMU and CSC for review and approval (revising as necessary if required) • Prepare, in consultation with Kaupule, the Code of Conduct to be implemented and complied with by all workers • Compliance with the EMP • Identify materials and equipment sources and arrange necessary permits, consents and compliance certificates • Provide inductions prior to commencement of construction • Provide ongoing training, awareness and "tool box" sessions for workers. • Implement CEMP • Implement relevant aspects of GRM and CCP • Includer sections and updates on CEMP, CCP and GRM implementation in the monthly reports • Implementation of corrective actions as requested by the PMU or SC.
ADB	• Review all feasibility study documentation (incl. IEE) • Prepare documents package for Board review (incl. requirements and TOR in PAM and covenants in grant agreement) • Board approval of project • Undertake regular review missions • Review monitoring reports • Disclose project information as required

EA = Executing Agency, IA = Implementing Agency, ADB = Asian Development Bank, TEC = Tuvalu Electricity Corporation, MFED = Ministry of Finance and Economic Development, MPUI = Ministry of Public Utilities and Infrastructure, MHARD = Ministry of Home Affairs and Rural Development, MFATTEL = Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour, GoT = Government of Tuvalu, DCC = Development Coordination Committee

C. Mitigation Measures

275. Environmental mitigation measures have been designed to avoid potential impacts where possible and to mitigate impacts that cannot be avoided. Implementation of this EMP and mitigation measures will ensure compliance with obligations under the Tuvaluan Acts and Regulations, principally the *Environment Protection Act 2008* and *Environmental Protection (Environmental Impact Assessment) Regulations 2014* (amended in 2017). The EMP will also ensure ADB safeguard standards are met.

276. To ensure mitigation measures contained in the EMP are successfully implemented:

- The EMP will be updated based on detailed design and along with any conditions of the project approval issued by the DOE will be included in tender documentation.
- The contractor(s) shall prepare a site-specific construction EMP (CEMP) describing the project and measures that will be implemented to comply with the EMP. It is expected that the contractors CEMP will address specific environmental

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issues associated with the construction methods they propose and the subproject sites.

- The contractor(s) will submit its CEMP for each site to the TEC/PMU for approval prior to the commencement of any construction (including site preparation, clearing and grubbing activities).
- TEC will ensure there are sufficient resources to oversee the implementation of the approved CEMP at each project site.
- The updated IEE including EMP, CCP and GRM will be disclosed to the public in accordance with Access to Information Policy 2018.

277. An EMP describing the potential impacts and proposed mitigation measures and responsible agency has been prepared in a matrix form and presented in Table 9.2.

278. The EMP matrix (Table 9.2) provides an operational reference and a tool for environmental management during construction activities. It describes in general terms how the contractor will meet the specified contractual, regulatory and statutory requirements. The contractor will provide the detail in its response (the CEMP) which will set out method statements and site-specific plans as required.

279. This project, and all project activities to be financed by ADB and government, will be subject to ADB's SPS. The project is classified as Category B for environment.

D. Monitoring and reporting

280. **Monitoring**: Environmental monitoring will be carried out through all phases of the project to ensure that the environmental mitigation measures are effective and that actual environmental impacts accord with predicted impacts and are in compliance with *Environment Protection Act 2008* and ADB safeguards .

281. TEC will ensure appropriate monitoring is undertaken during construction in accordance with project progress.

282. Complaints received will be monitored and resolved in accordance with Grievance Redress Mechanism. If required, addition monitoring inspections will be undertaken.

283. An environmental monitoring plan is presented in Table 9.2 and outlines the parameters, frequency and responsibility for monitoring.

284. **Reporting**: In consultation with EA and ADB, the TEC will establish a system for preparing quarterly reports on safeguards performance monitoring, issues resolution, and corrective action plans. The quarterly report will include a summary of the contractor's monthly reports.

285. The EA will submit environmental monitoring reports on EMP implementation for ADB's review.

286. Contractors will prepare monthly reports which will describe the implementation of the CEMP including any non-compliances and corrective actions. The report will be submitted, reviewed and approved by the IA.

287. Throughout implementation of the project, ADB will monitor the implementation progress and impacts of the Project. Overall, the EMP will be implemented by the IA through project implementation. In consultation with the EA and ADB, the IA will establish a system

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for preparing quarterly reports on safeguards performance monitoring, issues resolution, and corrective action plans.

288. The EMP will be part of the overall project monitoring and supervision and will be implemented by the project management unit with oversight from the implementing agency. Progress on the preparation and implementation of an EMP will be included in the periodic project progress reports. Specific monitoring activities defined in the IEE and EMP will be carried out by the contractor and supervised and monitored by the IA. The EA will submit semi-annual environmental monitoring reports on EMP implementation for ADB's review.

289. In general, the overall extent of monitoring activities, including their scope and periodicity, should be commensurate with the project's risks and impacts. The IA is required to implement safeguard measures and relevant safeguard plans.

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Table 9.2: Environmental Management and Monitoring Plan

Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
Design and pre-construction phase						
Access to land	Subproject delays or future legal land challenges.	• Land ownership / lease arrangements validated and agreements made as set out in the Social Safeguards Due Diligence Report (DDR). • Social Safeguards DDR updated during detailed design.	Project Management Unit (PMU), PMU Supervision Consultant (SC), Kaupule	Verification of land access agreements	Once, visual inspection of agreements	PMU, Kaupule
Adaptation for climate change	Damage to subproject components due to inappropriate siting or design specification.	• Subprojects will be designed and sited to withstand flooding. • Components will meet international standards (e.g. IEC 61730 Photovoltaic (PV) module safety qualification). The subprojects will be designed to withstand extreme winds (e.g. cyclones) and temperatures.	PMU	Bidding and contract documents (BCD), detailed design	Once, visual inspection of BCD	PMU
	Premature failure of components	• All components procured for the subprojects will be suitable for tropical marine and coastal environments, preferably be preassembled and will be as resistant to corrosion as	PMU	Selection of appropriate components	Once, visual inspection detailed design	PMU

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
		practicable (e.g. stainless or galvanized steel mounting systems).				
Hazardous materials management	Spills of hazardous materials due to inappropriate storage	• Provision of an appropriately sized bunded area in the design of the Nukulaelae diesel powerhouse to store hazardous materials (e.g. diesel, oil)	PMU	Inclusion of bunded area in BCD and detailed design	Once, visual inspection of BCD and detailed design	PMU
	Distrubance of asbestos containing materials	• A pre-construction survey for asbestos will be undertaken on all material likely to be disturbed by the installation of rooftop solar on Funafuti and at the old power station on Nukulaelae. • If found an appropriately qualified contractor, approved by the Tuvalu DoE, will be engaged to remove and dispose of asbestos containing material.	Contractor	Asbestos survey report	Once, visual inspection of survey report	MoF, TEC, PMU
EMP update, bid documents and national requirements	Failure to identify and mitigate environmental risks, breach of national legal obligations.	• IEE updated based on detailed design, reformatted for submission to the Tuvalu Department of Environment (DoE) as either a PEAR or EIA (based on prior discussion with the DoE).	TEC, SC, Contractor	Bidding documents, Environmental Consent, CEMP.	Once, visual inspection bidding documents, environmental consent, CEMP	MoF, TEC, PMU.

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	**Institutional responsibility**	**Parameters**	**Frequency & verification**	**Institutional responsibility**
		• Updated IEE / EMP and conditions of environmental approval included in technical specifications and bid documents. • Bidding documents include requirement for contractor to prepare CEMP including required sub-plans, number workers and accommodation and food security arrangements. • The contractor is required to prepare a CEMP that at a minimum addresses the commitments contained in this IEE and EMP. • Approval of CEMP by TEC, PMU and SC				
Visual impact	The subprojects create an unacceptable visual impact on the existing landscape.	• Specify use of antireflective panels or coatings to ensure reflected light from PV surfaces does not create a nuisance to any nearby residents • Specify that cables connecting the solar PV arrays to the existing grid will be buried • Specify that the new diesel power house on Nukulaelae will be neutral coloured (or coloured according to the wishes of local residents)	PMU	Specifications included in BCD	Once, visual inspection of BCD	PMU
Local contractor engagement	Increased opportunity for local businesses and contractors	• A list of relevant local contractors available on each subproject island will be provided in tender documentation to facilitate the	PMU	Requirement included in BCD	Once, visual inspection of BCD	PMU

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
		engagement of local contractors by the selected contractor(s).				
Pathogens and invasive species	Introduction and/or spread of pathogens and invasive species to and within Tuvalu or the subproject island	• The tendering documents will specify that the contractor must obtain all required clearances (e.g. permits) for any material or equipment imported onto Tuvalu. • The contractor will comply with all measures stipulated in the *Biosecurity Act 2017* and obtain all permits and clearances for import of any materials and equipment to be used for the project as required by Department of Foreign Affairs and Trade and Department of Agriculture. • Materials will be inspected and any equipment imported for project purposes will be steam-cleaned and certified under biosecurity and phyto-sanitary procedures in Funafuti prior to mobilization to the outer islands. • Immediately following clearing the subproject sites will be planted with low growing ground cover to help stabilise the site and minimise the reestablishment of weeds currently at the subproject locations. The species of ground cover will be selected in consultation with the Kaupule and Tuvalu DoE.	Contractor	Pathogen and invasive species free status of all materials, equipment and workers.	Visual inspection of phyto-sanitary certificate for each shipment	PMU

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	**Institutional responsibility**	**Parameters**	**Frequency & verification**	**Institutional responsibility**
		• Weed hygiene measures (including cleaning machinery before it enters and leaves the subproject sites) will be implemented to prevent introduction or spread of invasive species.				
Construction phase – physical resources						
Erosion and sedimentation control	Erosion of subproject sites and sedimentation of surrounding environment	• Erosion control works and measures will be installed to control surface water runoff and prevent the export of sediments from the site by ensuring; ○ Discharge of storm water is to stable preferably vegetated land. ○ Erosion control measures closely follow land contours to reduce runoff velocity from exposed soils. • All land disturbances will be confined to the minimum practicable working area to ensure that the minimum area of land is exposed to erosion for the shortest possible time. • Existing drainage lines will be protected and diversion of drainage lines avoided. • Sediment traps (e.g. silt fences) will be constructed across all drainage lines and erosion controls from site that are likely to receive runoff from exposed or disturbed soils.	Contractor	Erosion on subproject site and sedimentation of adjacent land or water bodies. Site drainage, erosion and runoff controls in place and functioning correctly. Inspection records.	Daily, visual inspection of subproject sites during construction. Monthly, visual inspection of sites for 6 months post construction. Monthly inspection of records during construction	PMU, Contractor

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
		• Sediment and erosion control measures will be monitored regularly to ensure their continued correct functioning. • Cable trenches will remain open for the shortest duration possible to reduce erosion and where possible will not be open during periods of heavy rain or forecast weather events that may inundate the trench. • Spoil from excavated trenches will be stored on the uphill side of the trench such that any sediment from the spoil is deposited in the trench. • A shade tolerant low groundcover (e.g. grass) will be established as soon as practicable after site clearance. The species of groundcover will be selected in consultation with the Tuvalu DoE and subproject location Kaupule. The species selected will not shade the PV modules. • The pylon footings at Nukufetau will be designed to minimise potential for localised tidal erosion.				
Water resources and quality	Over use of subproject island water resources impacting local fresh	• Water required for construction will be sourced with the agreement of the subproject island Kaupule, PMU and the Tuvalu DoE.	PMU, Contractor, Kaupule, Tuvalu DoE	Agree water sources	Water source agreed with Kaupule and DoE.	PMU.

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
	and potable water supplies					
	Alteration of surface water flow across the subproject sites leading to sedimentation of adjacent environments	• Where feasible construction techniques will be specified that minimise the need to alter the topography (e.g. piling of ground mounted solar arrays) and hence surface water drainage on the site.	PMU, Contractor, Kaupule, Tuvalu DoE	Agree construction techniques	Construction technique agreed with PMU	PMU.
Use of local materials	Environmental or social impacts of sourcing local materials (e.g. fill).	• Local materials will be sourced with the agreement of the Kaupule.	Contractor, PMU, Kaupule	Agree sources of local materials with Kaupule.	Once, materials source agreed with Kaupule	PMU.
Hazardous materials	Spills of hazardous material with subsequent impacts to marine, aquatic, groundwater and terrestrial environments	• The contractor(s) will prepare a hazardous materials management plan that shall, at a minimum, include: ○ The type and quantity of hazardous materials the will be present on site. ○ Safety Data Sheets for all hazardous materials. ○ A spill response plan including training for staff in the use of spill kits. ○ Details of planned transport, storage and disposal of hazardous materials (including	Contractor	Hazardous materials management plan in place and implemented.	Once, visual inspection of hazardous materials plan, as required visual inspection of controls and mitigations during construction.	PMU.

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
		compliance with commitments contained within this IEE). • The transport of hazardous materials will undertaken by an appropriately qualified, experienced and equipped contractor. • Hazardous materials storage areas will be located at least 50 m from any marine environment. • Hazardous materials will be stored in appropriate containers that are in good condition with adequate labelling. • Hazardous materials (including fuel and oils) storage will be appropriately bunded (e.g. self bunded containers or a bund with a minimum of 110% capacity of largest container). • Refuelling will take place in a designated area and drip trays or containment devices will be used when refuelling equipment and machinery. • Limit the amount of any marine paint to be used on the solar array pylons to no more than two litres at any one time contained within a larger volume drip tray. • Spill kits and containment devices appropriate for the type and volume of hazardous materials on site will be located at the storage				

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
		area(s), on the site and on vehicles carrying hazardous materials. • All personnel involved in the handling of hazardous materials will be trained in the handling, emergency procedures and storage requirements for the materials they are handling.				
		•				
		•				
Waste management	Inappropriate storage, transport or disposal of waste resulting in contamination of surrounding water, groundwater and land	• Where practicable, all solid and inorganic waste will be removed from the outer islands for disposal in Funafuti. Where waste is planned to be disposed of on island, the method and location of waste disposal on the outer islands will be approved by the Kaupule and Tuvalu DoE. • Hazardous waste (if generated) will be disposed of in accordance with the manufacturers requirements at a facility licenced to accept the type and quantity of waste (or approved by the Tuvalu DoE). If no such facility exists in Tuvalu hazardous waste will be shipped to an appropriately licenced facility.	Contractor, Kaupule, TEC, SCPMU.	All hazardous waste appropriately managed	Daily visual check of waste disposal bins during construction, monthly check of waste disposal documentation.	PMU

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	**Institutional responsibility**	**Parameters**	**Frequency & verification**	**Institutional responsibility**
		• The construction contractor will consult with the Kaupule and TEC to identify opportunities to avoid and reduce the generation of waste and to recycle or re-use waste generated. • If excess spoil is generated during site preparation it will be stored at an existing stockpile site for re-use. • Bins for recycling and general rubbish will be provided at the project site and materials laydown area for the disposal of construction wastes.				
Construction phase - biological resources						
Removal of vegetation	Over clearing of subproject locations resulting in loss of vegetation.	• The subproject site boundary will be clearing marked prior to the commencement of clearing. • Ensure vegetation clearance is restricted to within the subproject site boundary and is the minimum practically required, including allowance for shading. The proposed site boundary will be approved by the PMU and CS and the Kaupule prior to the commencement of clearing). • Cleared vegetation will be removed and will not be stockpiled on site or pushed into existing vegetation adjacent to the site.	Contractor, PMU, SC.	No vegetation clearance outside subproject site boundary, no stockpiles of vegetation	As required during construction, at least verification of site boundary prior to clearance and verification of clearance during construction.	PMU

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	**Institutional responsibility**	**Parameters**	**Frequency & verification**	**Institutional responsibility**
		• Machinery storage and materials lay down areas will be established in previously disturbed areas to avoid increasing the footprint of the project site. • As far as is practicable existing stockpiles of fill material will be used. If new fill material is required it will be sourced from locations approved by the Kaupule and Tuvalu DoE.				
		•				
Impacts to threatened and protected species and habitats	Disturbance to migratory bird species	• If possible, construction of the Nukufeatu subproject will be completed between March and October to avoid the migratory period of the the bristle-thighed curlew (*Numenius tahitiensis*) and bar-tailed godwit (*Limosa lapponica*).	Contractor	Construction schedule	Once, visual inspection of construction schedule.	PMU
Construction phase – socio economic impacts						
Cultural heritage	Unexpected discovery of artefact(s) of cultural heritage significance	• If an artefact is discovered during site clearance that is suspected of being of cultural heritage significance work will cease immediately and the Kaupule contacted to determine significance of the find. The PMU will also be notified immediately. • The contractor shall include an unexpected discovery protocol as part of their CEMP.	Contractor, Kaupule	Unexpected find protocol	Once visual inspection of protocol	PMU

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
Noise and vibration	Noise and vibration impacts on local communities	• Working hours will be between 8am and 5pm Monday to Friday unless otherwise agreed between the contractor, PMU and Kaupule (or operators of buildings on Funafuti). Where safety or technical reasons require work to be completed outside of these hours, noise levels will be kept to a minimum and subproject island Kaupule together with nearby residents will be informed. • Noise generating activities will be carried out in the least sensitive time periods to be determined in consultation with the Kaupule and building manager (roof top solar installations). Where ever possible works will be scheduled to avoid disruption to the normal use of buildings. • Equipment and plant will be maintained in good order. Noise reduction components (e.g. mufflers) will be inspected prior to the commencement of works to ensure they are fully functional. Noise emissions from construction equipment will not exceed 75 dBA.	Contractor	Work carried out between agreed times, equipment in good order with appropriate noise reduction components	As required, daily visual inspection of all equipment	PMU
Air quality and dust	Creation of dust and air emissions by	• Vehicles and machinery will be maintained in good order. • Vehicles will not be left idling when not in use.	Contractor	Dust generated, complaints	As required, visual	PMU

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
	vehicles and machinery	• Vehicles carrying soil, sand, crushed aggregate or other fine materials to or from the subproject sites will be covered.		received via GRM		
	Excessive dust from project sites, stockpiles and access roads	• Subproject sites, material stockpiles and access roads, including those from the wharf and material stockpile areas, will be wetted or stabilised if dust is generated	Contractor	Dust generated, application mitigation measures, inspection records, complaints received via GRM	Daily visual inspection of subproject sites during construction	PMU
Influx of labour – impacts of foreigners and non-local workers	Presence of foreign workers caused conflict, social disruption and/or diseases in community	• A code of conduct will be agreed between the Kaupule and the contractor which will govern the conduct of all workers for the period they are working at each site. The protocols will govern workers' conduct while at work and in communities, behavior around women and children, restrictions on alcohol consumption, prohibitions (with sanctions for non-compliance) on workers hunting or fishing, implementation of awareness programs, implementation of the GRM and handling of complaints, hiring of local labor, and	Contractor, Kaupule	Code of conduct agreed, inductions carried out, GRM in place	As required, visual inspection of agreement and GRM as well as records of induction.	PMU.

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
		implementation of the health and safety plan (HSP). • All non-local workers will receive an induction that outlines the social and cultural expectations when working in Tuvalu and on the subproject island and the code of conduct they must adhere to. Any worker not complying with the code of conduct will be expelled from the island and Tuvalu and repatriated at the contractor's expense. • A grievance redress mechanism (GRM) has been established for the project and will be communicated through the engagement programme and by prominent display of the GRM process at the subproject sites prior to the commencement of onsite works.				
Health and safety – workers and community	Health and safety of workers and communities inadequate managed leading to injury of fatality.	• The contractor shall prepare a Health and Safety Management Plan that will at a minimum: ○ Cover measures and equipment required to protect workers and the community and link to the emergency response plan and other plans as necessary. ○ Before construction commences the contractor/s will conduct training for all workers on environmental safety,	Contractor	Health and Safety Management Plan in place, training completed	As required, visual inspection of Health and Safety Management Plan, health and safety controls, records of	PMU

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
		environmental hygiene including delivery of the HIV/AIDS/STIs awareness and prevention training and the code of conduct. ○ Identify responsibilities and authorities within the contractor's staff for adhering to occupational health and safety (OHS) requirements. ○ Identify and provide required personal protection equipment (PPE) for staff and sub-contractors (before they start work). ○ Install fencing on all areas of excavation greater than 1m deep whether temporary or permanent. ○ Define appropriate emergency and medical process including evacuation procedures. ○ Prepare appropriate work method statements for each construction activity. ○ Provide daily hazard identification checklists, risk assessments. ○ Identify mandatory meeting requirements including toolbox sessions, to ensure all personnel understand the task before commencing work for the day. ○ Set procedures for safe handling of toxic materials and other hazardous substances.			training and induction.	

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
		○ Provide for installation of lights and cautionary signs in hazardous areas. ○ Ensure operators of vehicles and equipment are properly licensed and trained. ○ Ensure safety and inspection procedures are implemented, setting schedules for regular checking. ○ Ensure movements of heavy vehicles is managed so as to minimise impacts to existing traffic and the wider community. ○ Provide for the provision of adequate sanitation and potable water for staff and contractors for the duration of construction works. ○ Child and/or trafficked labor will be strictly prohibited for any activities associated with the project. ○ Children will be prohibited from entering the sites (including worker's accommodation, works area/construction zone) and prohibited from playing on any equipment or machinery. ○ All advisory and warning signage will be clear, secured on fences, gates and signboards and be posted in Tuvaluan, the				

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	**Institutional responsibility**	**Parameters**	**Frequency & verification**	**Institutional responsibility**
		language of the main nationality of workers and repeated in English. ○ Access will be controlled to subproject sites (e.g. through the use of security fencing or restricting access to roof tops) for the duration of construction to prevent public access. ○ Advisory signage warning of the dangers of unauthorised access will be placed where clearly visible on security fencing.				
Unexpected environmental impacts	Unanticipated environmental impacts during construction	• If unanticipated environmental impacts occur during construction phase, the PMU will update the IEE/EMP and the Contractor will update the CEMP. The environmental protection measures will be designed to address the impacts.	Contractor, PMU	Update of IEE / EMP and CEMP as required	As required, visual inspection of updated IEE / EMP and CEMP	PMU
Operation phase						
Waste and hazardous materials	Inappropriate storage, transport or disposal of waste resulting in contamination	• Where possible batteries and inverters will be recycled. If recycling is not possible they will be disposed of at a facility approved by the Tuvalu DoE or, if no facility is available, transported to an appropriately licenced facility outside of Tuvalu. • No hazardous waste (e.g. used oils, batteries or inverters) will be disposed of on the	TEC	Appropriate disposal of wastes	As required, visual inspection of waste disposal certificates, operation of infrastructure containing	TEC

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	**Institutional responsibility**	**Parameters**	**Frequency & verification**	**Institutional responsibility**
		subproject Island (except Funafuti). Waste will be sent for disposal at regular intervals and not allowed to accumulate at the power station. • Inverters and batteries that have been replaced during the operating lifetime of the power station will be removed, transported and disposed of by an appropriately experienced and equipped contractor. • Waste oil and other hydrocarbons from generators will be stored in a bunded hydrocarbon storage area. • Washing of solar PV panels will only be undertaken on an 'as needs' basis to minimise the generation of waste water. Disposal of waste water will be agreed with Tuvalu DoE. • All infrastructure containing hazardous materials (e.g. batteries, transformers) will be inspected regularly to ensure they functioning correctly and no hazardous materials are being discharged.			hazardous materials	
Water resources	Over use of water impacting fresh and potable water supplies	• A source of water will be agreed with subproject island Kaupule and Tuvalu DoE prior to the commencement of operation.	TEC, Kaupule, Tuvalu DoE	Agreed water source	As required, visual inspection of agreement.	TEC

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
Erosion control	Erosion of project sites	• If localised erosion is detected during operation of the project effective mitigation measures such as application of mulch, covering with open weave jute matting and reseeding with ground cover, protection with geotextile fabric or localised flow dispersal and diversion structures will be installed.	TEC	Effective control of erosion	As required, visual inspection of erosion mitigation	TEC
Employment	Staff unable to operate new power systems	• Training to be provided for TEC employees in the operation and maintenance of the new infrastructure and power systems.	TEC	Provision of training	As required, evidence of training completed	TEC
Emergency Response	Emergency on site	• TEC will prepare an operational emergency response plan. The plan will be include in the training provided to employees and be implemented during the operation of the solar power system.	TEC	Emergency response plan prepared and training completed	As required, visual inspection of plan and training records	TEC

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Project activity	Potential impact	Management and mitigation		Monitoring		
		Proposed mitigation measure	Institutional responsibility	Parameters	Frequency & verification	Institutional responsibility
Decommissioning phase						
Decommissioning of solar PV array, batteries and WTE facility	Inappropriate disposal of waste	• All equipment will be removed from the subproject sites (e.g. PV modules, batteries, invertors, WTE facility) and will be reused or recycled where possible. • Equipment that cannot be reused or recycled will disposed of at a facility approved by Tuvalu DoE or, if no facility is available, transported to an appropriately licenced outside Tuvalu	TEC	Appropriate disposal of waste	As required, visual inspection of waste disposal during commissioning	TEC
Hazardous materials	Release of hazardous materials to the surrounding environment	• The decommissioning contractor will be required to develop a hazardous materials management plan prior to the commencement of any works on the subproject site.	Decommissioning contractor	Decommissioning plan completed	Once, visual inspection of plan prior to decommissioning	TEC
Revegetation	Erosion of project sites	• If the subproject site is not reused it will be revegetated with species appropriate to the future land use of the site.	TEC	Completion of revegetation	As required, visual inspection of revegetation.	TEC

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10. CONCLUSIONS

290. In order to meet the goals of the National Energy Policy and the Master Plan for Renewable Electricity and Energy Efficiency Tuvalu must increase both the contribution and penetration of renewable energy on Funafuti as well as the Outer Islands. The feasibility assessment undertaken as part of the project has identified a range of subprojects on Funafuti, Nukulaelae, Nukufetau and Nui that well increase the renewable energy contribution from 26% (including World Bank project) to 39% on Funafuti and from approximately 60 - 70% on the three Outer Islands to more than 90%.

291. Environmental assessments have not identified any significant negative environmental impacts associated with the construction or operation of any of the proposed subprojects. All subprojects are relatively small and, with the exception of the Nukufetau subproject, will utilise land that is already heavily modified to upgrade to existing infrastructure. The operation of the subprojects will not result in the generation of any air or noise emissions and wastes that may be generated (batteries and invertors) can be readily recycled.

292. The subprojects will are not expected to have a negative impact on any species listed as threatened on the IUCN Red List. Two migratory bird species, the bristle-thighed curlew (*Numenius tahitiensis*) and bar-tailed godwit (*Limosa lapponica*), listed as vulnerable and near threatened respectively, may potentially utilise the tidal flat habitat that will be disturbed the Nukufetau subproject (*Outer Islands Subproject 1b*). However, the area of habitat disturbed is small compared to the area of habitat available on Nukufetau and the subproject is not anticipated to have a significant impact on either species. There are also 98 marine species in Tuvalu that have been listed as threatened on the IUCN Red List however, none of these species are expected to actively inhabit or use the intertidal habitat disturbed by the Nukufetau subproject site, although some fishes may pass through the site during high tide. In addition, the subproject sites are not located within any protected areas on Tuvalu.

293. The subprojects are not expected to have any negative impacts on local communities, but instead are expected to provide employment opportunities for local contractors.

294. The subprojects will reduce the use of existing diesel generators for electricity generation thereby reducing greenhouse gas emissions and securing electricity supply by reducing reliance on diesel. The subprojects will also improve flood resilience of the existing power system by installing a new diesel power house on Nukulaelae and upgrading distribution pillars on all outer islands. Control and communications upgrades will allow accurate system modelling and remote support of the outer islands power systems from Funafuti.

295. The subprojects are still subject to feasibility assessment and this IEE and EMP will be updated as the subprojects are further defined.

296. Provided the mitigation measure outlined in this IEE and EMP are appropriately implemented then the project is not expected to have any widespread, irreversible or significant or long-term environmental impacts. As such, it is considered that a Category B level of assessment as per the ADB's SPS is appropriate to the scale and nature of the project.

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ANNEX 1: INDIGENOUS OR POSSIBLY INDIGENOUS PLANT SPECIES OF TUVALU[55]

Family	Species	Common name	Local name
Ferns and fern allies			
Aspleniaceae (spleenwort fern family)	*Asplenium nidus*	bird's-nest fern	katafa, laukatafa, laulū
Nephrolepidaceae (sword fern family)	*Nephrolepis acutifolia*	sword fern, fishtail fern	sulufe, hulufe, paka, laukimoa
	Nephrolepis hirsutula	sword fern, fishtail fern	sulufe
Polypodiaceae (common or polypody fern family)	*Microsorum grossum*	scented fern, lawai fern	maile
Psilotaceae (psilotum family)	*Psilotum nudum*	psilotum, reed fern	sai, pōatua, silotau, fulukimoa
Pteridaceae (bracken or brake fern family)	*Pteris tripartita*	lacy fern, giant bracken fern, sword brake	lautolo, lakau sauga
Monocots			
Arecaceae (palmae) (palm family)	*Cocos nucifera*	coconut palm	niu, niu Fiti
Cyperaceae (sedge family	*Eleocharis geniculata*	sedge	
	Fimbristylis cymosa	sedge, beach sedge	mouku milimili taliga
	Mariscus javanicus	sedge, marsh cypress	mouku filifou, mouku, lakau fai tika
Pandanaceae (pandanus family)	*Pandanus tectorius*	pandanus, screw pine	fala, fala vao, fala tinakaleve, kie, falaketi, fala kai
Poaceae or graminae (grass family)	*Ischaemum murinum*	ribbed muraina grass	mouku
	Lepturopetium kuniense		mouku
	Lepturus repens	bunchgrass, beach bunchgrass	mouku, mouku laululiki te titi o Kulu, mutia
	Paspalum vaginatum	knot grass, salt grass, knotweed, swamp couch grass	mouku
	Stenotaphrum micranthum		mouku, mouku laululiki te titi o Kulu
	Thuarea involuta	Tropical beachgrass, Kuroiwa grass	mouku solo, mouku tolo, mouku fau
Dicots			
Amaranthaceae (amaranth family)	*Achyranthes canescens*	native prickly chaff-flower	tamatama, lautamatama, sisi vau
Apocynaceae (dog-bane family)	*Neisosperma oppositifolium*		fao, paopao, paupau

[55] Thaman, R.R. (2016) The Flora of Tuvalu: Lakau Mo Mouku o Tuvalu. *Atoll Research Bulletin* **611**: 1-129.

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Family	Species	Common name	Local name
Asteraceae (aster, sunflower or composite family)	*Adenostemma lanceolatum Miq. ?*	Adenostema	mili, lipilipi, kisikisi?
	Wollastonia biflora	beach sunflower	ateate, lakau o galiga, lakau manogi
Barringtoniaceae or lecythidaceae (brazilnut family)	*Barringtonia asiatica*	fish-poison tree, barringtonia	futu, kafutu, kafuti, ulu
Boraginaceae (heliotrope family)	*Cordia subcordata*	sea trumpet, kou (Hawaii)	kānava
	Tournefortia argentea	beach heliotrope	tausunu, tauhunu
Clusiaceae or guttiferae (mangosteen family)	*Calophyllum inophyllum*	Portia tree, Alexandrian laurel, beach mahogany	fetau, itati
Combretaceae (terminalia family)	*Lumnitzera littorea*	red-flowered black mangrove	tokotū, sagale, hagale, tangali
	Terminalia samoensis	beach almond	talie, te ipe
Convolvulaceae (morning-glory family)	*Ipomoea macrantha*	wild moon flower, night blooming beach morning-glory	fue, fue kena, fue pula kena, fue, fue tolo
	Ipomoea pes-caprae	Sweet beach morning-glory, goat-foot morning-glory	fue, fue piniki, fue pula piniki
Euphorbiaceae (spurge family)	*Acalypha grandis*	Acalypha	ogoogo, kalakalāpuhi, kalakalāpuki, kakarapus
	Chamaesyce atoto	Croizat beach spurge	mouku toto, eveeve, pulutai
Fabaceae or leguminosae (bean, pea or legume family)	*Caesalpinia bonduc*	beach nicker, gray nicker, nicker bean	talatalāmoa
	Canavalia cathartica	Mauna Loa bean	saketa
	Mucuna gigantea	seabean, giant seabean, velvet bean	saketa
	Sophora tomentosa	Silverbush	
	Vigna marina	beach pea	saketa, saketa sama
Goodeniaceae (naupaka family)	*Scaevola taccada*	half-flower, beach saltbush	gasu, gahu
Hernandiaceae (hernandia family)	*Hernandia nymphaeifolia*	hernandia, lantern tree	puka, puka vaka, puka vai, puka faivaka

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Family	Species	Common name	Local name
Lauraceae (laurel family)	*Cassytha filiformis*	beach dodder, giant dodder, devil's twine	fetai
Lythraceae (loosestrife family)	*Pemphis acidula*	pemphis, ironwood	gie, giegie
Malvaceae (mallow family)	*Abutilon indicum*	Sweet Indian mallow	aka tā
	Hibiscus tiliaceus	beach hibiscus, hibiscus tree	fou, fou fafine, fau, fau tuu, fau tū
	Sida fallax	golden mallow	akatā, kai ‘uli, kaula
	Thespesia populnea	Thespian’s tree, milo	milo
Moraceae (mulberry family)	*Ficus tinctoria*	Dyer's fig, native fig	felo, felo lasi, felo fōliki, felo, felo Nanumaga, pelo
Nyctaginaceae (four-o'clock family)	*Boerhavia repens*	boerhavia, pigweed	mouku solo, mouku tolo, kalisi lisi, kisi
	Boerhavia tetrandra		kisikisi, kalihilihi, eveeve lauefa
	Pisonia grandis	Brown pisonia, lettuce tree, bird-catcher tree	puka, pukavai, puka fai kaiao
Olacaceae (olax family)	*Ximenia americana*		talatalāmoa, kanana
Portulacaceae (purslane family)	*Portulaca australis*	small-leaf portulaca	katuli, tuli
	Portulaca lutea	Purslane	katuli
Rhamnaceae (buckthorn family)	*Colubrina asiatica*	soapbush, hoop with/hoop-withe	lakau sopu, lakau hopu
Rhizophoraceae (mangrove family)	*Rhizophora stylosa*	spotted mangrove	togo, te tongo, pika
Rubiaceae (coffee family)	*Guettarda speciosa*	beach gardenia, sea randa, zebra wood	pua, pua vao, uli
	Hedyotis romanzoffiensis		
	Morinda citrifolia	beach mulberry, Indian mulberry	nonu, nonu Kilipati, te non
	Timonius polygamus		
Surianaceae (quassia family)	*Suriana maritima*	bay cedar	gie, gie cool, ngie
Tiliaceae (linden family)	*Triumfetta procumbens*	beach burr	tolotolo, kiaou
Urticaceae (nettle family)	*Laportea interrupta*	Hawaii woodnettle	aluna, luna
	Laportea ruderalis	weedy woodnettle	luna, luna lanu lau niu, luna lanu kula, aluna, pakisikisi

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Family	Species	Common name	Local name
	Pipturus argenteus	false stinger, white nettle, native mulberry, white mulberry	fou tagata, fau vau, te pau, fau, la fau, fau pa, pau pau
	Procris pedunculata	Procris	vauvau
Verbenaceae (verbena family)	*Clerodendrum inerme*	beach privet	inato
	Premna serratifolia	false elderberry, headache tree	valovalo, aloalo, te ango

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ANNEX 2: PLANTS OF POSSIBLE ABORIGINAL ORIGIN[56]

Family	Species	Common name	Local name
Monocots			
Araceae (arum family)	*Alocasia macrorrhiza*	giant taro, elephant ears	tāmū, kape
	Colocasia esculenta	taro	talo
	Cyrtosperma chamissonis	giant swamp taro	pulaka
Arecaceae (palmae) (palm family)	*Cocos nucifera*	coconut palm	niu, niu Fiti
Musaceae (banana family	*Musa*	cooking banana, plantain, bluggoe	pata
	Musa	cooking banana, plantain, blue Java	kefu
Pandanaceae (pandanus family)	*Pandanus tectorius*	pandanus, screw pine	fala, fala vao, fala tinakaleve, kie, falaketi, fala kai, teou, te to
Taccaceae (Polynesian arrowroot family)	*Tacca leontopetaloides*	Polynesian arrowroot	vatia, masoā, niu ‘a Naleau
Dicots			
Amaranthaceae (amaranth family)	*Achyranthes aspera*	prickly chaff flower	tamatama, titi vau, sisi vau
Apiaceae (parsley family)	*Centella asiatica*	Asiatic pennywort	
Combretaceae (terminalia family)	*Terminalia catappa*	Indian almond, Malabar almond, tropical almond	kunikuni
Moraceae (mulberry family)	*Artocarpus altilis*	breadfruit	mei
	Artocarpus mariannensis	Marianas breadfruit	mei, pokēkē, matua mei
Rubiaceae (coffee family)	*Gardenia taitensis*	Tahitian gardenia	tiare, siale

[56] Thaman, R.R. (2016) The Flora of Tuvalu: Lakau Mo Mouku o Tuvalu. *Atoll Research Bulletin* **611**: 1-129.

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ANNEX 3: LIST OF STAKEHOLDERS/COMMUNITIES CONSULTED

Name	Organisation	Role
Mr. Tine Leuelu	GOT	Secretary of Government
Hon. Dr. Puakena Boreham	GOT Ministry of Natural Resources	Minister
Mr. Nikolasi Apinelu	GOT Ministry of Natural Resources	CEO
Mr. Avafoa Irata	GOT Ministry of Public Utilities & Infrastructure	CEO
Ms. Siemai Apinelu	GOT Ministry of Public Utilities & Infrastructure	Assistant CEO
Mr. Talavai Iona	GOT Ministry of Finance & Economic Development	CEO
Mr. Niuatui Niuatui	GOT Ministry of Finance & Economic Development	Acting CEO and Director Planning, Budget and Aid Coordination
Ms. Palipa Lauti	GOT Ministry of Finance & Economic Development	Acting CEO
Ms. Simalua Enele	GOT Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour	Acting CEO
Mrs. Moira Simons-Avafoa	GOT Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour	Acting CEO & Senior Adviser Foreign Affairs
Mr. Iete Avanitele	GOT Ministry of Home Affairs	Acting CEO Home Affairs
Mr. Temetiu Maliga	GOT Ministry of Home Affairs	Acting CEO Home Affairs
Ms. Corinna Ituaso	GOT Office of the Attorney General	Acting Attorney General
Mr. Eli Lopati	GOT Office of the Auditor General	Auditor General
Mr. Fatasi Malologa	GOT Lands and Survey Department	Director
Mrs. Pasai Andrew	GOT Lands and Survey Department	Acting Director and Chief Registrar & Title Officer
Mr. Vakafa Lupe	GOT Lands and Survey Department	Land Information System Officer
Ane Talia	GOT Lands and Survey Department	Draftsman
Mr. Molipi Tausi	GOT Ministry of Public Utilities & Infrastructure	Director of Energy
Mr. Pua Malu	GOT Ministry of Public Utilities & Infrastructure	Petroleum Specialist

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Name	Organisation	Role
Ms. Sulufaiga Uota	GOT Ministry of Public Utilities & Infrastructure	Department of Energy - FASSNETT Project Manager
Mr. Ampelosa Manoa Tehulu	GOT Ministry of Public Utilities & Infrastructure	Director Public Works Department
Mr. Penivao Moealofa	GOT Ministry of Finance & Economic Development	Economic Adviser, Department of Planning, Budget and Aid Coordination
Mr. Frank Fiapati	GOT Ministry of Finance & Economic Development	Central Procurement Unit
Mr. Michael Nafatali	GOT Ministry of Finance & Economic Development	Central Procurement Unit
Mr. Sania Taumaheke	GOT Ministry of Finance & Economic Development	Central Procurement Unit
Mr. Vitolia Famasino	GOT Ministry of Finance & Economic Development	Central Procurement Unit
Mr. Reena Mataio	GOT Ministry of Finance & Economic Development	Central Procurement Unit
Mr. Soseala Tinilau	GOT Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour	Director of Environment
Ms. Tilia Tima	GOT Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour	Biodiversity Officer and Acting Deputy Director Department of Environment
Ms. Liliele Nafatali	GOT Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour	EIA Officer Department of Environment
Ms. Hilary Boyes	GOT Ministry of Foreign Affairs, Trade, Tourism, Environment and Labour	Environmental Advisor
Ms. Kate Morioka	GOT Department of Climate Change and Disaster Management	Technical Advisor
Lanuola Fasiai	GOT Gender Affairs Department	Director
Salesa Falesene	GOT Gender Affairs Department	Communication and campaign officer
Mr. Matini Vailopa	GOT Office of Cultural Affairs	Cultural Heritage Officer
Mr. Sapeta Talapai	GOT Central Statistics Division	Assistant Statistical Officer
Mr. Angus Amasone	GOT Central Statistics Division	Assistant Statistical Officer
Mr. Mafalu Lotlolua	TEC	General Manager

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Name	Organisation	Role
Mr. Fatonga Talama	TEC	Generation Manager
Mr. Polu Tanei	TEC	Renewable Energy Manager
Mr. Teafa Tautu	TEC	Distribution Manager
Ms. Alafou Silo	TEC	Finance Manager
Mr. Ted Wypych	TEC (funded by NZ MFAT)	Finance Manager
Taulogo Fakasega	TEC	Billing Supervisor
Mr. Paulo Ioapo	TEC	Account and Payroll Officer
Mr. Taumanu Sio	TEC	Supervisor, Nukulaelae Power Station
Mr. Falani Malua	TEC	Supervisor, Nukufetau Power Station
Mr. ‘Alo	TEC	Supervisor, Nui Power Station
Mr. Matio Aneteleni	TEC	Supervisor, Nanumaga Power Station
Mr. Tapu Pepeuga	TEC	Supervisor, Nanumea Power Station
Mr. Tuni Teititi	TEC	Supervisor, Niutao Power Station
Ms. Cindy Cisneros Tiangco	ADB	Senior Energy Analyst
Ms. Beth Saguan Carandang	ADB	Social Safeguards Officer
Mr. Taniela Faletau	ADB	Safeguards Officer
Ms. Jane Fantilanan	ADB	Project analyst
Mr Hussain Haider	ADB	Senior Infrastructure Specialist
Ms. Eun young So	ADB	Energy Specialist
Mr. Letasi Iulai	ADB/World Bank	Development Co-ordination Office
Mr. Vete Sakaio	Outer Islands Marine Project (World Bank and ADB)	PMU Project Director
Ms. Siulai Elisala	Outer Islands Marine Project (World Bank and ADB)	PMU Project Manager
Kaimalie	Outer Islands Marine Project (World Bank and ADB)	PMU Project Manager
Ms. Semolina Tavita	Nukulaelae Kaupule	President
Collin Namoliki	Nukulaelae Kaupule	Secretary
Saosaoa Liulau	Nukulaelae Kaupule	
Falanai Valoa	Nukulaelae Kaupule	

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Name	Organisation	Role
Terubuti Tinatali	Nukulaelae Kaupule	
Kelisiano	Nukulaelae Kaupule	
Aketi Alama	Nukulaelae Kaupule	
Fuli Toaga	Nukufetau Kaupule	Treasurer
Suetusi Sateko	Nukufetau Kaupule	
Kiutu Sateko	Nukufetau Kaupule	
Natano Lafita	Nukufetau Kaupule	
‘Enele Taloka	Nui Kaupule	Pulekaupule
Papua Uilisese	Nui Kaupule	Acting Secretary
Maryanne Vunisarati	Funafuti Office of Kaupule	Island Strategic Plan Manager
Karl Tili	Funafuti Falekaupule	Failautusi (Secretary)
Taualo Penivao	Funafuti Falekaupule	Failautusi (Secretary)
Seliga Kofe	Funafuti Kaupule	‘Ulufenua (High Chief)
Teleke Lauti	Funafuti Kaupule	Tokolua (Assistant to High Chief)
Semi Vine	Funafuti Kaupule	Pulekaupule (President or Mayor)
Simon Kofe	Tuvalu Parliament	Member from Funafuti
Pula Toafa	Coordinator	Tuvalu National Council of Women
Eseta Penitusi	Vice President	Tuvalu National Council of Women

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ANNEX 4: TEMPLATE FOR DOCUMENTATION OF PUBLIC CONSULTATIONS

Example of Meeting Minutes Documentation

Name of project:

Date:
Time:
Location:

MEETING AGENDA

1. Introduction ….

2. Presentation and key points….:

QUESTIONS / COMMENTS OF PARTICIPANTS AT MEETING

1.

2.

3.

4. etc.

REPLIES OF PRESENTORS

1.

2.

3.

4. etc.

PARTICIPANTS

Name, number, associated organization, gender (in tabular format).

The meeting was at XXX the same day. All participants agreed with the minutes of meeting.
Signed by person taking minutes:
Position:

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