Technology Needs Assessment Adaptation Report

Government of Tuvalu

TECHNOLOGY NEEDS ASSESSMENT ADAPTATION REPORT

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TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE ADAPTATION TECHNOLOGIES IN COASTAL, WATER AND AGRICULTURE SECTOR REPORT

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NATIONAL TNA COORDINATOR
Ms. Faatupu Simeti

NATIONAL TNA ASSISTANT COORDINATOR
Finikaso Consultancy Firm

NATIONAL TNA ADAPTATION CONSULTANT
Mr. Mataio Tekinene

Foreword

Talofa,

Tuvalu is amongst the most vulnerable countries in the world to adverse effects of climate change. The threat of climate change faced by Tuvalu is real and an ongoing phenomenon. Tuvalu struggles to save itself as a sovereign state for the future of its citizens. However, this cannot be achieved alone. Tuvalu perceives climate change as a shared responsibility which requires global and local actions, commitment and cooperation. The development of this Technology Needs Assessment project is very timely and priority for Tuvalu to provide remedial actions at the earliest opportunity.

Technology plays a collective role in addressing climate change, whether it relates to mitigating or reducing emissions of greenhouse gases into the atmosphere or adapting to the increasing impacts of climate change. There are no restrictions in these circumstances. Therefore, Tuvalu is bound by being part of the international community and fully aware that in its own jurisdictions it has to undertake action.

TNA is a set of nationally driven activities aimed at helping developing countries like Tuvalu to identify and analyze its adaptation and mitigation technology priorities. However, eenhancing technology transfer for the mitigation of greenhouse gas emissions (GHG) and adaptation to climate change through the TNA project is fundamental to the Tuvalu Government reaction to climate change.

It is paramount to highlight that our existing environmental and socio-economic challenges are serious and alarming. As a Least Developing Small Island State, funding and expertise are extremely limited. Tuvalu acknowledges the financial assistance through enabling activities, medium- and large-scale environment projects and will continue to request more of this funding arrangement to ensure Tuvalu achieves sustainable development. With regional and international assistance from executing agencies, Tuvalu has been able to progress further to fulfil its obligations as a party to the United Nations Framework Convention on Climate Change (UNFCCC).

This report shows the priority technologies of the three selected sectors to respond to the seriousness of the problems Tuvalu is encountering and if no concerted actions are taken, the situation will be worsen with time and Tuvalu cannot let this happen. Swift, sustainable and practical solutions through technology transfer are needed today, not tomorrow. There is an understanding that the resilience of the country is best supported by measures that ensure the integrity and sustainability of natural, economic and social ecosystems and resources, which underpin the very existence and the future of the country.

As Minister of Finance responsible for climate change, it gives me great pleasure to present this TNA report for proper consideration by the UNEP Climate Change Centre.

Hon. Seve Paeniu
Minister of Finance

Acknowledgement

The Climate Change Department through the TNA Project Coordinator, the Assistant Project Coordinator and the National TNA Consultant would like to acknowledge the contribution of all public and private stakeholders from different sectors who were involved in preparing and finalising this Technology Needs Assessment report for Tuvalu. Special thanks are due to members of the adaptation working groups of the three sectors – coastal, water and agriculture.

The report was compiled by the National TNA Consultant under good guidance of the TNA Team and in particular the guideline instructions prepared by UNEP DTU Partnership. It has been prepared for the Government of Tuvalu through the Climate Change Department coordination.

Lastly, enormous gratitude to the Global Environment Facility (GEF) for providing financial support and the UNEP Division of Technology, Industry and Economic for their technical support and guidance.

Acronyms

AIT	:	Asian Institute of Technology
BAEF	:	Barrier Analysis and Enabling Framework
CCD	:	Climate Change Department
CTCN	:	Climate Technology Centre and Network
DFAT	:	Department of Foreign Affairs and Trade
DOA	:	Department of Agriculture
DWM	:	Department of Waste and Management
EKT	:	Ekalesia Kelisiano o Tuvalu
ENSO	:	El Niño Southern Oscillation
EU	:	European Union
GCCA	:	Global Climate Change Alliance
GCF	:	Green Climate Fund
GDP	:	Gross Domestic Product
GEF	:	Global Environment Facility
GHG	:	Greenhouse gas
GoT	:	Government of Tuvalu
IPCC	:	Inter-governmental Panel on Climate Change
IWRM	:	Integrated Water Resource Management
JICA	:	Japan International Cooperation Agency
MCA	:	Multi-criteria Analysis
MOF	:	Ministry of Finance
MPWIELD	:	Ministry of Public Works, Infrastructure, Environment, Labour and Disaster
NACCC	:	National Advisory Council on Climate Change
NAPA	:	National Adaptation Program of Action
NBSAP	:	National Biodiversity Strategic Action Plan
NGOs	:	Non-Government Organizations
NSSD	:	National Strategy for Sustainable Development
NSSD	:	Nation Strategy for Sustainable Development
PSC	:	Project Steering Committee
PWD	:	Public Works Department
QE II Park	:	Queen Elizabeth II Park
R2R	:	Ridge to Reef Project
RCs	:	Regional Centers
SIDS	:	Small Island Developing States
SLR	:	Sea Level Rise
SNC	:	Second National Communication
SPREP	:	Secretariat of the Pacific Region Environment Programme
TANGO	:	Tuvalu Association of NGO
TAP	:	Technology Action Plan
TAP	:	Technology Action Plan
TC	:	Tropical Cyclone
TC	:	Tropical Cyclone
TCAP	:	Tuvalu Coastal Adaptation Project
TEC	:	Technology Executive Committee
TFS	:	Technology Factsheet
TISIP	:	Tuvalu Infrastructure Strategy and Investment Plan
TLAP	:	Tuvalu Long-term Adaptation Progrmme
TNA	:	Technology Needs Assessment
TNC	:	Third National Communication
TNCW	:	Tuvalu National Council of Women
TNEP	:	Tuvalu National Energy Policy
TPCC	:	Tomasi Puapua Convention Centre
TUCAN	:	Tuvalu Climate Change Action Plan
UDP	:	UNEP DTU Partnership
UNEP	:	United Nation Environment Programme

UNFCCC	:	United Nation Framework Convention on Climate Change
USP	:	University of the South Pacific

Executive Summary

This report presents Tuvalu Adaptation Technology Needs Assessment (TNA) and prioritisation processes along with the results for priority sectors and their identified technologies.

The main objective of the TNA project is to support Tuvalu in developing and prioritising possible technologies for adapting to climate change. Furthermore, to meet its obligations under the United Nations Framework Convention on Climate Change (UNFCCC). Selected sectors and associate technologies for the TNA process is the outcome of stakeholders' discussion through working groups from various government ministries, departments and non-government organisations delegates. These discussions were also informed by desk research undertaken by the TNA Adaptation Consultant taken into accounts respective development and climate change priorities.

Experiencing intense periods of droughts, increase of severe tropical cyclones, escalating coastal devastation, water and soil salinization, impact on agriculture with more detrimental impacts of climate change and climate variability; these are already being felt and ongoing in Tuvalu. As a result of these consequences, the working group on adaptation technology felt that the following 3 sectors which include: Coastal Sector, Water Sector and the Agriculture Sector are the most priority sectors for the TNA exercise.

In fact the identified sectors have been beforehand selected by the Climate Change Department (CCD). Then again, the Adaptation Working Group reinforced this selection through a Multi Criteria Analysis which reported in Chapter 1. However, the Adaptation Working Group (AWG) did not make any further analysis prioritizing the Sectors, however, just support the CCD recommendation. Except for the selection and prioritizing of the Technologies for each Sector, the AWG realises the long list of technologies and as a consequence, they agreed to select the most appropriate five technologies to become the long list, however, prioritise the most 3 top technologies for the purpose of this TNA report. Technology prioritization was conducted following the MCA tool provided, including other analysis tools provide for this TNA assessment. More details of the MCA tool prioritization are highlighted in the report content.

The report contains five key chapters.

Chapter 1: Introduction. This chapter highlight the overall process of the TNA, overview of the country and the selection sector process.

Chapter 2: Institutional arrangement. This chapter convey an overall arrangement for the TNA team and stakeholders' membership and their dedicated involvement in the TNA process.

Chapter 3: Technology prioritization for the Coastal Sector. This section elaborates further on the coastal sector vulnerabilities to climate change; overview of existing technologies and adaptation technologies; criteria process of technology prioritisation; and result of technology prioritisation.

Chapter 4: Technology prioritization for the Water Sector. Again, this section elaborates further on the water sector vulnerabilities to climate change; overview of existing technologies and adaptation technologies; criteria process of technology prioritisation; and result of technology prioritisation.

Chapter 5: Technology prioritization for the Agriculture Sector. Similar to above sections, this section once again elaborates further on the agriculture sector vulnerabilities to climate change; overview of existing technologies and adaptation technologies; criteria process of technology prioritisation; and result of technology prioritisation.

Chapter 6: Summary and conclusion.

Overall the three sectors and their top three respective technologies being identified consist of:

1. Coastal Sector.
   - Computer Monitoring Model/Tool to monitor coastal erosion and currents strengths.
   - Land reclamation – seawalls and sand bags.
   - Wave Breaker (lagoon and ocean sides).
2. Water Sector.
   - Solar Reverse Osmosis System (mobile).

- Water reticulation system (gravity process).
- Groundwater solar extraction.

3. Agriculture Sector.
    - Composting for tolerant varieties.
    - Horticultural technology through Beddings (concrete, wooden, etc).
    - Cultivator & Irrigation.

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Chapter 1 Introduction

1.1 About the TNA project

As highlighted in the Project TNA Guidance, TNA is a set of nationally driven activities aimed at helping developing countries to identify and analyze their adaptation and mitigation technology priorities. The main key features (as implemented under UDP guidance) includes:

- Country driven - implemented by national TNA teams;
- Stakeholder involvement;
- Capacity building;
- Align with national development objectives;
- Explore synergies with other national processes. e.g. Nationally Determined Contribution (NDC) and other related climate change policies.

The TNA project is implemented through the Tuvalu Third National Communications (TNC) funded by the Global Environment Facility (GEF) through United Nations Environment Programme (UNEP). The technical support for TNA was provided by UNEP Climate Change Centre in collaboration with the University of the South Pacific (USP) and the Asian Institute of Technology (AIT). The funding for technical support delivered by UDP was provided by Climate Technology Centre and Network (CTCN) and in-kind contributions were provided by the Tuvalu Climate Change Department through the Ministry of Finance.

In fact, the TNA process is based around three main activities. These are
a) To identify and prioritise mitigation and adaptation technologies for selected sectors;
b) To identify, analyse and address barriers hindering the arrangement and dissemination of the prioritised technologies, including the enabling framework for technologies;
c) To produce a Technology Action Plan (TAP). This can be medium or a long-term plan for the implementation of identified technologies.

Enhancing technology transfer for the mitigation of greenhouse gas emissions (GHG) and adaptation to climate change through the TNA project is fundamental to the Tuvalu Government reaction to climate change.

The Technology Needs Assessment Project is based at the Climate Change Department (CCD) in the Ministry of Finance. The Project Coordinator in the CCD through the Finikaso Consultant Firm is fully responsible to the overall implementation of the TNA project. The TNA team is the steering committee which includes two local experts; the Adaptation Consultant and the Mitigation Consultant. The team works with technical working groups in the selected sectors. The TNA team also consulted with relevant stakeholders in the whole process of the project.

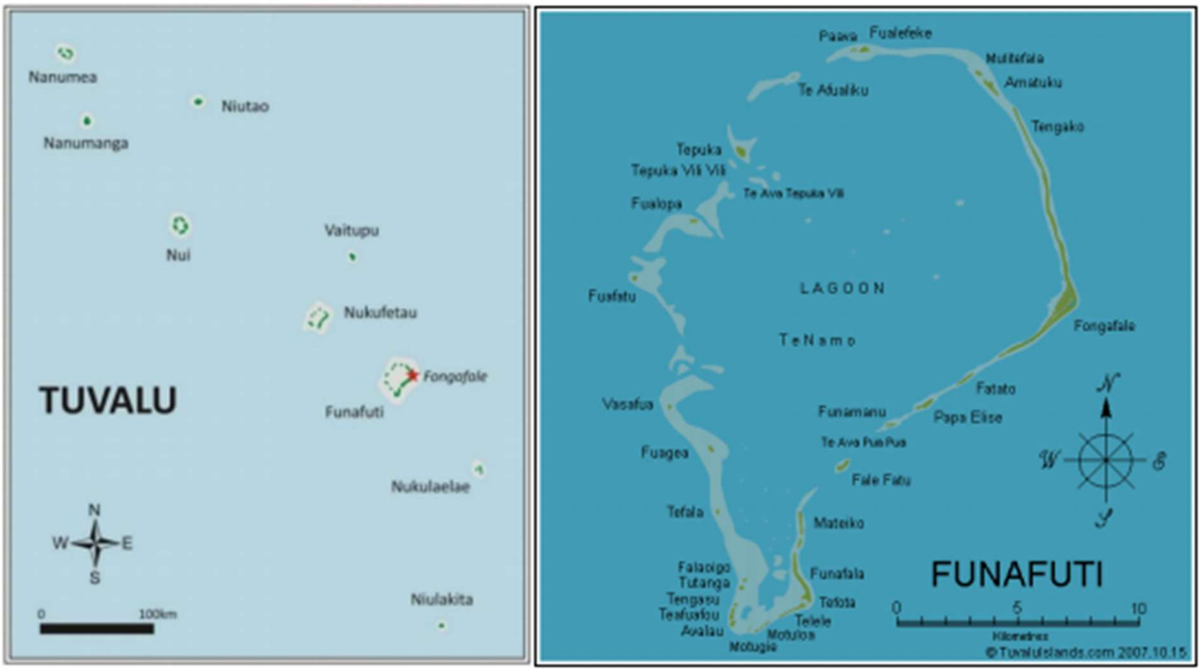
1.2 Existing national policies related to technological innovation, -adaptation to climate change and development priorities

National Circumstances

Geographic Setting

The archipelago of Tuvalu lies between latitude of 5^0 to 11^0 south and between longitude of 176^0 and 180^0 east of Greenwich. It is located approximately 1,100 kilometres (km) north of Fiji and 1,400 km south of the Republic of Kiribati. Tuvalu is situated in the South Pacific Ocean consisting of nine islands that stretch 579 km in length. The islands have a combined land area of 26 km^2 and are surrounded by 1.3 million km^2 of ocean, including an Exclusive Economic Zone of 719,174 km^2. The average height above sea level is less than 3 metres (m) with the highest point above sea level being 4.6 m in Niulakita (Government of Tuvalu, 2012). The islands are highly vulnerable to climate change impacts and their remoteness dispursed over a vast area of ocean, and limited inter-island transportation contribute to geographical isolation.

Figure 1.1: Map of Tuvalu showing the locations of the nine atolls from Nanumea in the northwest to Niulakita in the southeast (left) (Source: www.nowshoptime.com); and a map of Funafuti Atoll showing the central lagoon and the individual reef islets (motu), including Fogafale Islet, the largest and most populated islet and capitol of Tuvalu, along the eastern side of the Lagoon (right) (Source: TuvaluIslands.com)



Climate

Tuvalu has a tropical climate and it is characterized by two distinct seasons, a wet season from November to April and a dry season from May to October. This seasonal cycle is strongly influenced by the South Pacific Convergence Zone (Australian Bureau of Meteorology and CSIRO, 2011). The mean annual rainfall in the southern islands of Tuvalu is 3,400 mm while in the north is 2,900 mm Temperature ranges from 25 degrees Celsius (°C) to 30°C all year around (Australian Bureau of Meteorology and CSIRO, 2011).

The tropical cyclone season is from November to April. Tuvalu is particularly vulnerable to cyclone-generated winds, storm surges and swells. In March 2015, Tropical Cyclone Pam devastated the islands of Tuvalu, damaging houses, infrastructure, food gardens, graves and coastlines. Nearly half of the country’s population was temporarily displaced. Several islets in Funafuti also disappeared as a result of the cyclone (Government of Tuvalu, 2015). Nine months later in December 2015, Tropical Cyclone (TC) Ula affected the country with minor damages to residences, natural vegetation, agriculture and livestock. Again January 2020 TC Tino hit the country and destroyed a lot of food crops such as tree crops, root crops, agroforestry, vegetables gardens and livestock (GoT, 2020).

Global climate models indicate with high level of confidence that surface air temperature and sea-surface temperature are projected to increase over the course of the 21st Century (Australian Bureau of Meteorology and CSIRO, 2011). A slight increase in annual and seasonal mean temperature is projected by 2030 (<1°C) with a more significant increase projected for 2090 (2.5°C).

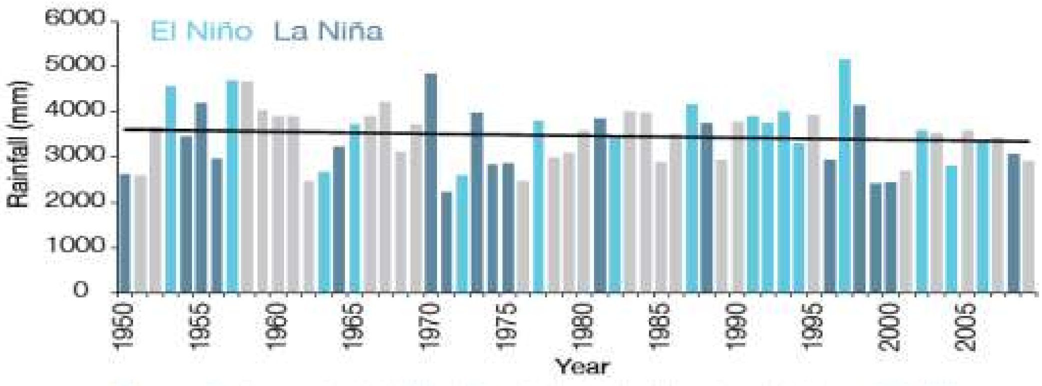
Figure 1.2: Annual Average Temperature: Funafuti, 1950-2005

Source: Australian Bureau of Meteorology and CSIRO, 2011
Note: Light blue bars indicate El Niño years; dark blue bars indicate La Nina years and
Grey bars indicate neutral years

Precipitation in the southern islands is high and constant throughout the year but less so in the northern islands. There is a significant relationship between rainfall and the El Niño Southern Oscillation (ENSO) Index, with less rainfall during the La Niña years. Prolonged periods of reduced rainfall are not uncommon, with the most recent drought occurring in 2011 when a state of emergency was declared due to severe shortage of water. In response, fresh water had to be flown and shipped into Tuvalu through international humanitarian assistance.

For Tuvalu, annual and seasonal mean rainfall is projected to increase in the future. The intensity and frequency of days of extreme rainfall are projected to rise while the incidence of drought is projected to decrease (Australian Bureau of Meteorology and CSIRO, 2011).

Figure 1.3: Annual Average Rainfall – Funafuti, 1950-2005



Source: Australian Bureau of Meteorology and CSIRO, 2011
Note: Light blue bars indicate El Niño years; dark blue bars indicate La Nina years and
Grey bars indicate neutral years

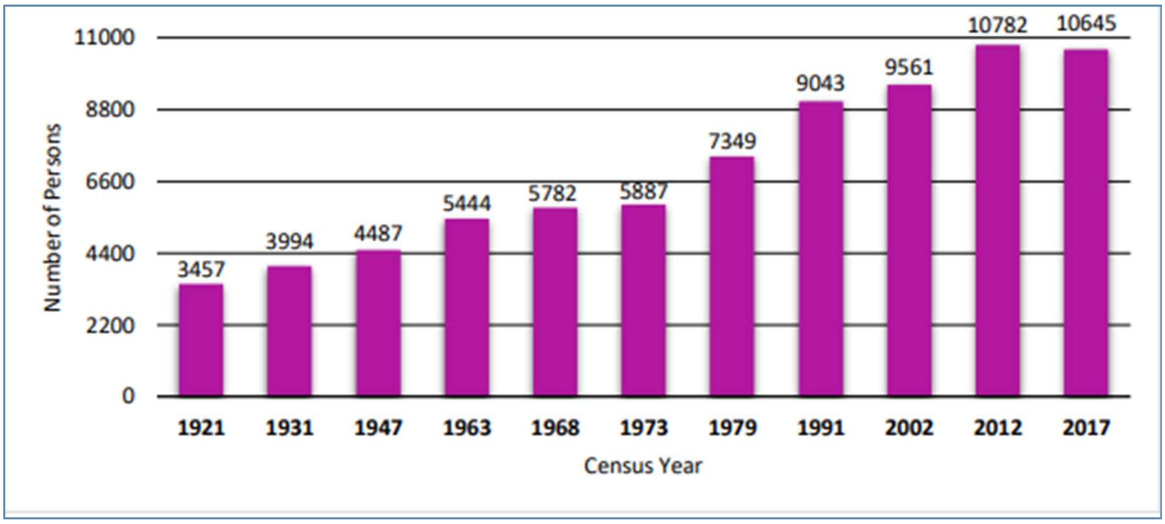
The main extreme event affecting Tuvalu is tropical cyclones. Between 1969/70 and 2006/07, total of 33 tropical cyclones passed within approximately 400 km of Funafuti which is equivalent to an average of eight cyclones per decade (Australian Bureau of Meteorology and CSIRO, 2011).

The last series ofcyclones passing Tuvalu; Tropical Cyclone Pam in March 2015, TC Ula in 2016 and TC Tino in 2020 have generate strong winds and storm surge, causing substantial damage to houses, essential infrastructure and agricultural crops. Apart from these impacts, the whole country community suffers a lot with financial constraints as families are still recovering at the intervals of each cyclone.

Demography

The total enumerated population for Tuvalu during the 2017 mini-census was 10,645 people (Figure 5), this sums up the 10,507 permanent residents and 138 visitors or the non-residents. Within the 5 years from 2012 to 2017, the total population has decreased by 137 people. The first decline experienced with the census population, and a straight decrease of -1.3%, making an annual average growth rate of -0.3% per annum.

Figure 1.4: Total population, 1921 – 2017.



Source: Mini census report 2017, Government of Tuvalu.

Economy

The dispersed nature of the islands, isolation from key international and regional markets, tiny land mass and small population, and narrow natural resource base are major constraints to economic development in Tuvalu. The national economy is reliant on donor aid with additional revenue being sourced from taxes, custom duties, postage stamp sales, fishing and dot TV domain licenses. Tuvalu's gross domestic product (GDP) was estimated at US$67 million in 2020 (GoT Fiscal Budget, 2020). As from 2014 to 2020 the overall fiscal ratios GDP for Tuvalu has been rising annually while 2019 to 2020 rises to 1% (Table 1.1 below).

Table 1.1: Fiscal ratios GDP for Tuvalu. Source from GoT Budget Report 2020.

FISCAL RATIOS – PRE BUDGET CEILINGS

	2014 Actual	2015 Actual	2016 Actual	2017 Actual	2018 Actual	2019 Actual	2020 Actual
Taxation	5,969,052.73	8,656,221.24	7,399,578.92	8,804,657.24	9,471,201.53	12,037,305.88	11,639,079.86
Recurrent Expenditure	36,676,349.82	46,852,463.42	57,748,670.52	51,681,639.77	54,386,078.29	55,522,993.45	60,019,291.76
Staffing	15,262,542.21	16,278,405.26	18,847,690.88	19,654,204.02	22,487,713.18	24,261,445.86	25,027,797.11
TMTS	2,993,034.06	4,286,668.10	4,606,926.05	6,146,689.16	4,933,115.40	5,286,251.41	6,767,390.97
Scholarship	1,979,359.26	3,693,125.76	4,442,818.08	4,699,944.95	4,673,132.38	4,543,533.22	6,163,735.52
Fiscal Balance	8,000,449.92	10,610,532.67	- 453,408.94	- 4,506,510.81	17,106,640.36	3,572,889.30	6,931,446.55
Capital spending	4,714,089.65	15,650,582.39	19,247,532.19	22,414,446.73	33,251,408.12	31,892,380.43	32,072,237.73
Fishing License	13,587,606.65	23,918,309.54	34,351,222.28	26,042,593.72	51,381,378.77	38,138,823.89	44,235,022.48
Domestic Revenue	**37,762,338.38**	**57,027,959.33**	**61,141,258.67**	**56,626,481.08**	**80,260,592.29**	**68,497,966.71**	**73,648,764.65**
GDP	**42,609,699.70**	**48,701,177.83**	**55,549,354.75**	**57,423,165.97**	**58,330,746.49**	**66,423,843.94**	**67,088,082.38**

National Strategies

National Planning Documents

The National Strategy for Sustainable Development (NSSD) *Te Kete* of Tuvalu is the overarching sustainable development policy that stipulates the broad national planning framework in which all subordinate island strategic plans, sector and corporate plans, annual plans and budgets will need to be aligned so they all follow the path towards achieving our national vision. Its overall vision embrace: ***"A Peaceful, Resilient and Prosperous Tuvalu"***

Peaceful - Tuvalu will remain a peaceful, loving and happy society, and rooted in our traditional cultural values and heritage.

Resilient – our security is well intact, our justice system brings lasting peace, our political process matures and stable, our sustainability is well managed accounting for our future generations and continued pristine environment and last but not the least our financial resources continue to thrive under a responsible hard working and honest work force.
Prosperous – we will strive for every Tuvaluan to have the opportunity to become well educated, healthy and attain higher standards of living.

Outcome 4 of NSSD focuses on climate change and disaster resilience and clearly summarizes the status of Tuvalu which is fragile and highly vulnerable atoll environment makes Tuvalu the first nation to disappear under the rising seas. Thus, seeking greater degree of security not only from climate change but also disaster by increasing adaptive capacity through increased level of financing from global climate funding sources and high-tech innovative development measures.
The Key Strategic Action required:

- Develop long-term national adaptation strategy, including a staged land reclamation programme, that takes into account a worse-case scenario of sea level in Tuvalu rising by one meter by year 2100.
- Secure increased funding from global climate financing facilities.
- Strengthen access to labour mobility schemes.
- Develop effective frameworks for disaster risk and resilience management.
- Implement a land rehabilitation and reclamation framework that is resilient to sea level rise and climate change impacts.

National Strategies, Policies and Actions Related to Climate Change

Tuvalu atoll islands are extremely vulnerable to the impacts of climate change, some of which include rising sea levels, extreme weather events, king tides, inundation and coral bleaching. The difficulties and worries over climate change had not been invisible nor unheard during climate action deliberations that been echoed clearly and decisively across the world for many years. Climate change is impacting the overall livelihood of communities with additional challenges to everyday living.

Currently there are a number of significant policies, strategies and frameworks that are relevant to the context of Tuvalu where climate change is concerned. These documents include:

Tuvalu National Climate Change Policy 2020-2030 (*Te Vaka Fenua oTuvalu*)

This National Climate Change Policy 2020-2030, *Te Vaka Fenua o Tuvalu*, has been developed to respond to the needs of Tuvaluans. The policy advances national priorities set out in the National Strategy for Sustainable Development 2021-2030 *Te Kete*, some of which contribute towards addressing regional and international commitments on climate change. The policy draws on evidence and findings from numerous assessments, including the review of the previous climate change policy and its strategic plan of action in 2016 and the nation-wide consultations on the initial framework for this policy in 2018. The National Advisory Council on Climate Change (NACCC) played an important role in both processes by providing strategic guidance and technical advice to the Climate Change Department (CCD). Island leaders and communities, including the Falekaupule, Kaupule, women, youth and people with disabilities, made valuable contributions and recommendations. This policy is an articulation of the voices, aspirations and actions of the people of Tuvalu.

The Policy vision is to have “a strong and resilient Tuvalu that protects the identity, culture and existence of the people and meets their commitment to environmental sustainability”.

The Policy Goal is “to protect Tuvalu from the impacts of climate change through bold and decisive actions that strengthen the resilience of our people and natural ecosystems to climate change risks by 2030”.

The Policy Outcomes covers three priority outcomes:

- Policy Outcome 1: Strengthened access to climate finance and strategic partnerships (2 objectives and 7 priority actions).

- Policy Outcome 2: Reduced vulnerability to climate change impacts through enhanced resilience (8 objectives and 26 priority actions); and
- Policy Outcome 3: Managed human mobility and protection of national sovereignty (2 objectives and 7 priority actions).

Tuvalu National Strategy for Sustainable Development 2021-2030 (*Te Kete*)

Te Kete is a high-level planning and result oriented (seai ko pati kae ko faiga - not words but deeds) strategic plan. Government and all stakeholders are truly committed to its execution to realise noble results. Success, however, is dependent on collective ownership of the plan and collaborative partnerships between the people, government, community leaders, businesses and civil society. Development partners will also need to ensure their programmes are aligned to the national vision, goals and policy objectives in this plan.

Vision:
"A Peaceful, Resilient and Prosperous Tuvalu"

It covers 5 Strategic Priority Areas (SPA):

- SPA 1: ENABLING ENVIROMENT
  GOAL: The required institutional, policy and regulatory enablers are imperative platforms which facilitate the effective achievements of our national vision and are rated priority in the overall execution of te Kete.
- SPA 2: ECONOMIC DEVELOPMENT
  GOAL: Sustainable economy where equitable distribution of wealth through comprehensive review and effective implementation of tariffs, taxes and traditional sharing norms, job creation and income generation opportunities are achieved.
- SPA 3: SOCIAL DEVELOPMENT
  GOAL: Achieving a healthy, educated, appropriately skilled, spiritual and cultural value-based society that is committed, proactive and innovative.
- SPA 4: ISLAND AND CULTURE DEVELOPMENT
  GOAL: Building vibrant and resilient island communities enhanced by the protection and promotion of our unique cultural heritage for sustainable livelihoods.
- SPA 5: INFRASTRUCTURE DEVELOPMENT
  GOAL: The physical infrastructure required to establish an enabling infrastructure that contributes to the resilience of our people from the impacts of climate change and natural disasters is established.

Tuvalu National Energy Policy 2009.

The Tuvalu National Energy Policy (TNEP) Framework sets out the Government's policies for the planning and management of the energy sector over the next 15 years. The framework defines the strategies that Government is taking to ensure that the objectives of the policies are fully realised. In developing the energy policy framework, Government is mindful of the critical role of the energy sector in the attainment of its overall socio-economic development goals of improving the livelihood of all its peoples.

Vision:
"By the year 2020 guided by the principles in the "Te Kakeega II" and the "Malefatunga Declaration", Tuvalu shall attain a prosperous living standard that is fostered through an energy policy that promotes the provision of socially, financially, economically, technically, politically and environmentally sustainable energy systems and within the framework of the Tuvalu Initial National Communication under the United Nations Framework on Climate Change".
Goal:
To improve the well-being of the Tuvalu people by promoting the use of its renewable energy resources and implementing cost effective, equitable, reliable, accessible, affordable, secure and environmentally sustainable energy systems.

TNEP is developed with six (6) guiding principles:
- sustainability,
- gender equity,
- environment compatibility,

- stakeholder participation,
- good governance, and
- cultural and traditional compatibility.

Tuvalu Second National Communication 2015

This Second National Communication (SNC) is an update on activities undertaken domestically since the initial communication covers the period from 2000 until 2015. It has a tendency in providing information on the progress made by Tuvalu in implementing the United Nations Framework Convention on Climate Change (UNFCCC),. In contrast with the initial national communication submitted in 1999, the SNC has achieved considerable progress in documenting Tuvalu's vulnerability assessment, adaptation measures and sector analyses of GHG emissions. The SNC consists of five main chapters:

1. National Circumstances
2. GHG Inventory
3. Vulnerability and Adaptation Assessment
4. Mitigation Analysis
5. Other Information including technology transfer, public awareness, capacity building, and data availability and gaps.

Pilot Gravel Beach Nourishment Against Coastal Disaster on Fongafale Island in Tuvalu 2013

Tuvalu Government requested the Government of Japan in 2008 to conduct a comprehensive study towards strengthening the resilience of the coastal area. In response, a coastal protection plan for Fongafale Island was established with substantial assistance from the Japan International Cooperation Agency (JICA) through the project titled "The Study for Assessment of Ecosystem, Coastal Erosion and Protection/ Rehabilitation of the Damaged Area in Tuvalu". Considering the environmental impacts and unique social customs of Tuvalu, JICA formulated the plan and proposed gravel nourishment as a countermeasure to reduce the disaster risks associated with overtopping and inundation. However, gravel nourishment has never been tried in Tuvalu.

National Adaptation Programme of Action (NAPA 1&2)

The NAPA 1 and 2 projects are substantially critical programmes for Tuvalu as they cover the three identified Technology Needs Assessment (TNAs) for this assignment. In the area of food security, the NAPA1 managed to develop a cemented pit catchment on top of the ground to avoid salt intrusion, for the growth of *pulaka* (giant swamp taro – *Cyrtosperma Chamissonis*). For coastal management, soft measures like planting of trees and plants on the shoreline was practiced while hard measures were recommended for future measures. The Ridge to Reef project for Tuvalu initiated the use of vetiver grasses which also recommended to be a successful mechanism for coastal protection. In terms of water security, the NAPA programme put emphasis on the awareness programme to ensure safe water through usage of water wisely couple with provisional of water supplies to communities.

Agriculture Policy Framework

The Department of Agriculture have since developed a framework to monitor and evaluate the implementation of the Tuvalu National Agriculture Sector Plan ('the Plan')[1]. The Plan identifies six distinct, but closely linked Goals, which each contribute to an overall End-of-Plan objective of 'increased domestic agriculture production (food + non-food)' and in turn a longer term impact 'To improve livelihoods of the Tuvaluan people through strengthening food security. Each Goal is comprised of one or more individual Outcomes (Table 1.2), which themselves comprise of one or more Strategies and Actions (not reflected in the table).

Table 1.2: Agriculture Sector Goals and Outcomes (from the Tuvalu National Agriculture Sector Plan 2014-2023)

[1] Department of Agriculture, 2014. Monitoring and Evaluation Framework for the Tuvalu National Agriculture Sector Plan 2014-2023.

GOALS	OUTCOMES
Goal 1: Strengthened enabling environment for the agriculture sector	• Policy, legislation and regulatory framework strengthened for the long term development of the agriculture sector. • Land use planning & utilization for agriculture development enhanced • Access to financing improved • Culture of community development strengthened
Goal 2: A strengthened and well-functioning Department of Agriculture	• Department of Agriculture has adequate capacity and means to implement the National Agriculture Sector Plan
Goal 3: Farmers have adopted more resilient, productive and environmentally sustainable farming practices and techniques.	• Increased domestic food production • Application of good environmental standards and good agricultural practices • Strengthened risk and disaster mitigation for the sector • Establishment of organic farming as a major mode of production
Goal 4: Demand for domestic agriculture products encouraged to grow	• Marketing systems for domestic agricultural produce strengthened • Markets for new & emerging domestic products developed & supported • Export potential of selected agricultural products investigated and developed where feasible.
Goal 5: Agriculture workforce increased, inclusive of landowners, women and youth	• Adequate long-term supply of labour force for agriculture sector development
Goal 6: Access to safe, affordable and nutritious food enhanced	• Improved health through consumption of healthy local foods. • Improved access to adequate and safe food supplies for the population.

1.3 Vulnerability assessments in the country

Groundwater is extremely limited. Poor soil and limited agricultural tools and expertise are common weakness status of the country. The present coastal area is already threatened with coastal disaster caused by high storm waves due to cyclone or atmospheric depression especially during high tide[2]. It is highly exposed to extreme weather events and the impacts of climate change are only going to exacerbate.

Ocean acidification and sea-level rise (SLR) are going to make life on all the islands more marginal. Rising temperatures and changing rainfall patterns are altering the growth of agricultural crops throughout the country and moreover imposing high social risks.

Vulnerability Assessments

There are several key documents highlighting Tuvalu's climate vulnerability. These includes: Vulnerability Assessment Reports of islands in Tuvalu provided by the USP EU Global Climate Change Alliance Project; the Climate Change Department assessment reports on island's vulnerability; Disaster Department reports on vulnerabilities encountered by islands during cyclone damages and other disasters phenomenon and a study conducted by the GCCA.

The USP EU Global Climate Change Alliance Project 2012

2 JICA, 2013. Pilot gravel beach nourishment against coastal disaster on Fogafale, Funafuti.

This study covers all islands and focus on Community Vulnerabilities on five sectors;

- Water resources and security.
- Health and Sanitation.
- Energy Resources and Information Communication Technology.
- Food Resources and Security and Natural Resources.
- Natural Resources (Terrestrial, Marine, Freshwater).

Each Sector were thoroughly discussed in groups to indicate the type of vulnerability that is of most priority, then further identify the problem/s of each vulnerability and the cause of the problem/s. Finally, adaptation solutions were formulated to meet the context of Tuvalu, meaning that are affordable and easy to be implemented.

1.4 Sector selection.

This section focus on how the priority sectors for adaptation to climate change are selected in the country, with analysis based on current environmental damages caused by climatic variations and climate induced phenomenon. Temperature, rainfall, tropical cyclones and sea level rise are the core analytical parameters perceived during the selection process. Given the vulnerability status of the country, sector selection is also highly dependent on the national development priorities as outlined in its Nation Strategy for Sustainable Development 2021-2030 (NSSD) and in other Sector Policies.

Tuvalu, like many Small Island Developing States (SIDS), is affected by climate change impacts and extremely vulnerable to climate change. The susceptibility of the country to climate change impacts is shaped by its geographic and socio-economic characteristics. Particularly, the small size and remoteness in conjunction with key infrastructure being located in particularly exposed areas exacerbate Tuvalu's vulnerability. Climatic and natural hazards impacts are demonstrably significant on climate sensitive sectors such as water, agriculture, coastal and infrastructure. Given the significance of agriculture, water and coastal area on livelihoods, these three sectors are the focus of this adaptation technologies prioritization exercise.

Overall, the Tuvalu Climate Change Department follows instructions provided by the UNEP Climate Change Centre selection process of the three important sectors for Tuvalu which include the Coastal, Water and Agriculture. The three sectors were highlighted and well discussed during the first TNA stakeholder consultation where approval was obtained and confirmed by stakeholders as priority sectors for Tuvalu. A follow up consultation with the TNA Adaptation Working Group was held to reconfirm the Sectors and to identify the priority technologies for each Sector. The sector selection through the MCA method and priority technologies are highlighted in later sections.

Water

Tuvalu is highly reliant on rainfall as the main source of fresh water. Groundwater resources are very limited and if available, are brackish and exposed to saltwater intrusion from flooding and rising sea level. It is also exposed to contamination from human and animal waste. In Funafuti groundwater is only used for feeding pigs, washing pig pens and flushing toilets. During drought, its use extends to washing clothes, bathing and flushing toilets. Adding to the problem on Funafuti only is the increase population growth due to urban drift to search for jobs. Census from 2012 and 2017 shows an increase of population in Funafuti. The issue is not very much an increase but it is already crowded. All these competing demands on already constrained water resources.

The vulnerabilities associated with water resources in Tuvalu include:

- Dependency on Rain Water (primary water resource);
- Lack storage capacity & vulnerability to droughts;
- Huge consumption of primary water (flush toilets);
- Absence of Water & Building policies, codes or legislation;
- Salinity of Ground Water due to sea water intrusion;
- Water-borne sanitation systems; and

- Lack expertise to test quality.

The Government's Public Works Department is responsible for water distribution in Tuvalu. Reverse osmosis desalination plants are already in place in Funafuti, this source was intended originally during emergency but is now used as a main water supply especially on Funafuti. It is a very expensive way to acquire freshwater. In response, the Integrated Water Resources Management (IWRM) Project is currently exploring more cost-efficient methods to meet public demand for water and to gradually reduce the dependence on desalinated water supply.

The drought extreme event in 2011 tremendously devastating the food crops such as tree crops, root crops, agroforestry, vegetables gardens and livestock. Water problems to households on all the islands were extremely low causing difficulty to the entire livelihood of the entire population. Although the Government with co-financing from the European Union distributed households across the country with water tanks of 10,000 litres in capacity successively from 2009-2013, water scarcity during long droughts still a problem.

Coastal

The need to address climate change impact in Tuvalu is the government's highest priority, as it seeks to develop infrastructure projects that will protect the country and the population against, particularly the significant flooding, which has already starting to occur. The large ongoing project—the Tuvalu Coastal Adaptation Project (TCAP)—financed by the Green Climate Fund (GCF) and approved in 2017 seeks to fortify the coastline against climate change impacts. The government is also looking beyond this important project to adapt to climate change. In this sense, the Government of the day has formulated a National Implementing Steering Committee (NISC), housed under the Country Project Management Office (CPMO) in the Ministry of Finance to look after all Multi-million Dollars Project for Tuvalu and to ensure their sustainability and ongoing progresses. The focus of the NISC beyond TCAP is to develop a multi-billion dollar project to accommodate new infrastructures (airport, residential area, industry area, parks, and other amenities). The proposed project is in design phase and under negotiation process with international stakeholders and financial supporters. This proposed project is labelled as the Tuvalu Long-term Adaptation Project (TLAP).

The National Adaptation and Reclamation Project scored highest on all prioritization criteria in the Tuvalu Infrastructure Strategy and Investment Plan (TISIP). It is considered the ultimate solution to climate adaptation, and would safeguard Tuvalu's territory, its economy, and its way of life. It envisages land reclamation and relocation to that land. The project would involve a massive investment estimated millions of dollars, many times Tuvalu's gross domestic product, making it challenging to justify in economic terms, although this cannot be the only measure of benefits. This is the current dream of the NISC to happen in the future.

The physical nature and limited natural resources of the country will remain and continue to be affected by the rising sea level. Persistence erosion of coastal areas, seawater intrusion and inundation, loss of land and food security will continue with other damaging factors. Adaptation measures to overcome these natural and physical circumstances are underway and need to be ongoing on a longer-term course of action. Clearly Tuvalu's survival depends on its natural resources and climatic condition. Without appropriate adaptation, climate change could have an extremely harmful impact on the sustainability of the development process with the coastal zone being most vulnerable.

Current activities completed in terms of coastal protection includes:

- Funafuti land reclamation and beach nourishment project were completed in August 2016. The reclamation of land in front of the government building in Vaiaku measures 275 metres in length, 4 metres in depth and 115,000 cubic metres in volume of sand fill. The sand was dredged from the lagoon. In October, the reclaimed land was opened for public use as a recreation area. Beach nourishment on the northerned end of the reclaimed land was also completed, measuring 500 metres in length, 10 metres in width and a total sand volume of 67,000 cubic metres.

- Along the Savave coast in Nukufetau, geo-textile sand bags have been placed to protect the 1,013 meter stretch of the shoreline. A total of 35,000 cubic metres of sand has been used for the Nukufetau Seawall Project.
- The Tuvalu Coastal Adaptation Project (TCAP) to build coastal resilience through strengthening of institutions and financing mechanisms, and the delivery of coastal protection measures in Funafuti, Nanumaga and Nanumea. The Funafuti reclamation has already started and is ongoing..

Agriculture
The Tuvalu Infrastructure Strategy and Investment Plan (TISIP) which was endorsed by the cabinet in December 2016, highlighted the government's investment priorities in social and economic infrastructure over 2016–2025. Agriculture is one of its priority area given the infertile sandy soil which limits agricultural development and food security. With weak productive capacity, limited agriculture, heavy reliance on one primary commodity (fish), the country is marginalized in global trade. Apart from the TISIP, the NSSD called *Te Kete* mentioned in its National Outcome 8 that agricultural productivity increase is very essential to address food security. Therefore, local food production including crops and livestock with small agri-businesses are key milestones for agriculture over the plan period of the TISIP.

The population is highly dependent on subsistence agriculture over the past years and still an ongoing process for Tuvaluans. However, climate change impacts pose a tremendous risk to the agriculture sector and food security. Agricultural activities are susceptible to climate change induced changes in precipitation patterns (as most cropping practices are rain-fed), extreme rain or drought events, salinization processes, increased in evapotranspiration, seasonal variations, and reduction in fresh-water availability. Droughts, on the other hand, cause added thermal stress on plants.

The impact of TC PAM in 2015 had devastated most of the food crops in the country, however, worse in Nanumaga and Nui where their main root crop vegetation (swamp taro) were totally damaged and ruined. According to the World Bank, the damage and loss caused by TC Pam to agriculture and infrastructure sectors alone amounted to AU$14million or just over 25% of the country's Gross Domestic Product. Additionally, the cost of damages to the fisheries sector was estimated to be AUD$108,000.

The International Fund for Agricultural Development (IFAD), in "Climate Change Impacts – Pacific Islands" has projected damages to water resources in the region of $1 billion if average atmospheric temperatures increase by 2-4°C (even long-term average temperature increases less than a 2°C are still likely to cause unpredictable disruptions to weather patterns). As in other PICs, Tuvalu agriculture will be adversely affected, as well Tuvalu fisheries if, as expected, tuna migratory patterns shift, or the health of Pacific tuna stocks decline as a result of rising average atmospheric and oceanic temperature increases.

1.4.1 An Overview of Expected Climate Change and its Impacts in Sectors Vulnerable to Climate Change

Tuvalu Second National Communication (SNC) highlights the fact that Tuvalu has a national policy framework that provides strategic guidance on climate-smart development, strengthening of the economy, identification of areas requiring research, investing in renewable energy, and introduction of better agriculture practices. In the area of vulnerability assessment, the SNC again highlighted that since the first National Communication, Tuvalu has placed considerable emphasis on addressing climate change vulnerabilities and implementing measures that enhance adaptive capacities by collaborating with different development partners in key sectors including coastal protection, water resources, biodiversity, agriculture, energy, waste management and human health.

From a study conducted by the Australian Bureau of Meteorology/CSIRO, the projected changes in climate aspects in Tuvalu was developed using the three scenarios known as:

1. Low, marked in blue;
2. Medium, marked in green;
3. High, marked in purple.

Projections are given for three 20-year periods centred on 2030 (2020–2039), 2055 (2046–2065) and 2090 (2080–2099) - relative to 1990 (1980–1999). Confidence level in the projections is also given. These projections also refer to an average change over the whole country based on projections for the region around Tuvalu Islands. The projections are based on IPCC assessments and simulations from up to 18 global climate models, which were combined for the three emissions scenarios as tabulated in Table 1.3 below.

Table 1.3: Projected changes in climate aspects in Tuvalu under three scenarios

Variable	Season	2030	2055	2090	Confidence
Surface air temperature (°C)	Annual	+0.7 ± 0.4 +0.8 ± 0.4 +0.7 ± 0.3	+1.1 ± 0.4 +1.5 ± 0.5 +1.4 ± 0.4	+1.5 ± 0.6 +2.3 ± 0.8 +2.7 ± 0.6	High
Maximum temperature (°C)	1-in-20-year event	N/A	+1.0 ± 0.6 +1.5 ± 0.6 +1.5 ± 0.5	+1.4 ± 0.7 +2.1 ± 1.1 +2.7 ± 1.3	Low
Minimum temperature (°C)	1-in-20-year event	N/A	+1.2 ± 1.8 +1.5 ± 2.0 +1.5 ± 1.8	+1.6 ± 1.8 +2.2 ± 2.0 +2.4 ± 1.9	Low
Total rainfall (%)*	Annual	+3 ± 8 +3 ± 8 +4 ± 8	+7 ± 11 +7 ± 10 +7 ± 12	+7 ± 12 +12 ± 14 +11 ± 18	Moderate
Wet season rainfall (%)*	November-April	+3 ± 10 +3 ± 9 +4 ± 8	+7 ± 9 +6 ± 11 +6 ± 10	+7 ± 11 +11 ± 14 +11 ± 16	Moderate
Dry season rainfall (%)*	May-October	+3 ± 10 +4 ± 11 +5 ± 13	+7 ± 16 +7 ± 16 +8 ± 19	+8 ± 18 +12 ± 23 +12 ± 26	Moderate
Sea-surface temperature (°C)	Annual	+0.6 ± 0.4 +0.7 ± 0.3 +0.7 ± 0.4	+1.0 ± 0.3 +1.3 ± 0.4 +1.3 ± 0.5	+1.3 ± 0.5 +2.1 ± 0.6 +2.5 ± 0.6	High
Aragonite saturation state (Ωar)	Annual maximum	+3.6 ± 0.1 +3.5 ± 0.2 +3.5 ± 0.2	+3.3 ± 0.1 +3.2 ± 0.2 +3.2 ± 0.1	+3.2 ± 0.2 +2.8 ± 0.2 +2.6 ± 0.2	Moderate
Mean sea level (cm)	Annual	+9 (4–14) +9 (5–14) +9 (4–14)	+17 (9–25) +19 (10–29) +19 (9–28)	+31 (16–45) +37 (19–56) +39 (19–58)	Moderate

Source: Australian Bureau of Meteorology/CSIRO – Volume 2.

These projections do not represent a value specific to any actual location, such as a town in Tuvalu. Instead, they refer to an average change over the broad geographic region encompassing the islands of Tuvalu and the surrounding ocean.

The following projected climatic parameters from the above study are proved as major contributing factors to sectors vulnerable to climate change.

Temperature

Surface air temperature and sea-surface temperature are projected to continue to increase over the course of the 21st century. There is very high confidence in this direction of change because warming is physically consistent with rising greenhouse gas concentrations as all CMIP3 models agree on this direction of change.

Rainfall

Wet season (November-April), dry season (May-October) and annual average rainfall are projected to increase over the course of the 21st century. There is high confidence in this direction of change because physical arguments indicate that rainfall will increase in the equatorial Pacific in a warmer climate (IPCC, 2007; Volume 1, Section 6.4.3); and almost all of the CMIP3 models agree on this direction of change by 2090.

Extremes

Temperature

The intensity and frequency of days of extreme heat are projected to increase over the course of the 21st century. There is very high confidence in this direction of change because an increase in the intensity and frequency of days of extreme heat is physically consistent with rising greenhouse gas concentrations and all CMIP3 models agree on the direction of change for both intensity and frequency.

Rainfall

The intensity and frequency of days of extreme rainfall are projected to increase over the course of the 21st century. There is high confidence in this direction of change because an increase in the frequency and intensity of extreme rainfall is consistent with larger-scale projections, based on the physical argument that the atmosphere is able to hold more water vapour in a warmer climate (Allen and Ingram, 2002; IPCC, 2007). Almost all of the CMIP3 models agree on this direction of change for both intensity and frequency.

Drought

The incidence of drought is projected to decrease over the course of the 21st century. There is moderate confidence in this direction of change because a decrease in drought is consistent with projections of increased rainfall and the majority of models agree on this direction of change for most drought categories.

Tropical Cyclones

Tropical cyclone numbers are projected to decline in the south-east Pacific Ocean basin (0–40ºS, 170ºE–130ºW) over the course of the 21st century. There is moderate confidence in this direction of change because many studies suggest a decline in tropical cyclone frequency globally (Knutson et al., 2010) and tropical cyclone numbers decline in the south-east Pacific Ocean in the majority assessment techniques.

Ocean Acidification

The acidification of the ocean will continue to increase over the course of the 21st century. There is very high confidence in this projection as the rate of ocean acidification is driven primarily by the increasing oceanic uptake of carbon dioxide, in response to rising atmospheric carbon dioxide concentrations.

Sea Level

Mean sea level is projected to continue to rise over the course of the 21st century. There is very high confidence in this direction of change because Sea-level rise is a physically consistent response to increasing ocean and atmospheric temperatures, due to thermal expansion of the water and the melting of glaciers and ice caps. Projections arising from all CMIP3 models agree on this direction of change.

The following Table 1.4 tend to illustrates sector level impacts against climate change phenomenon for the three selected sectors.

Table 1.4: Climate Change Impact at Sector Level

Sector	**Climate Sea and Air Temperature Rise Change Impacts**				
	Sea and Air Temperature Rise	Rainfall/ Sunshine Variation	Extreme Weather Events	Ocean Acidification	Sea Level Rise
Water	• Increased demand, compromised quality. • Economic loss.	• Drought, flooding, contamination, blockages. • Infrastructure stress,	• Water pollution, infrastructure damage. • Economic loss,	• Potential impact on cloud formation and water ph. • ph level will affect	• Increased salinity of freshwater table. • Reduce agriculture land and production

	• Strain on national budget.	economic loss, • Strain on national budget.	• Strain on national budget.	marine lives and water quality.	
Coastal	• Coral bleaching, algal blooms, coral disease. • Loss and reduction of species and food sources.	• Run-off nutrient and terrigenous sediments, increased debris to lagoons, lower salinity. • Economic loss and reduction of food sources.	• Wave damage to coastal infrastructure, erosion, increased sedimentation, changes to coastline features • Economic loss, strain on national budget	• Coral reef habitat and species degradation. • Economic and food loss	• Erosion, increased storm surges, damage to coastal infrastructure, receding coastline, • economic loss, • strain on national budget
Agriculture	• Increased prevalence of invasive species and disease. • Reduce production increase economic losses.	• Drought, flooding, sunburnt crops, invasive species and disease. • Reduced production increase economic losses.	• Damage to infrastructure, agricultural crops and economic losses • Time and labour intensive. • Strain on national budget	• Affects growth of shell-fish foods and fish. • Reduced food sources and income.	• Salt water intrusion of low-lying agriculture lands. • Inundation of planting areas. • Time and labour intensive cost

The predicted impacts of climate change in Tuvalu are of critical concern to the government and people. The government is committed to addressing these issues and has made climate adaptation its highest priority. Adaptation to climate change is highly essential for Tuvaluans to remain in the country and continue their unique culture and way of life.

1.4.2 Process and results of sector selection

The process and results of the selection of the TNA sectors for Tuvalu was conducted as follows.

Selection of Consultants and Sector Selection Confirmation

At the initial stage of the TNA project preparation, the TNA Team (Project Coordinator and Assistant Project Coordinator) convene meetings with the Consultants (Adaptation Consultant and Mitigation Consultant) several times to share a common understanding of the project. At this preparatory stage of meetings, deliberations focus on:

- Terms of Reference (TOR) which clearly define the works of the Consultant and the processes that are required to achieve the implementation of the TNA project.
- Orientation inception workshop – going through the project objectives, outputs and other requirements for the project implementation;
- Confirmation of sector's already identified in the project document and highlighted in the TOR of the Consultant;

- Consultant contract arrangement and signing.

As a result of the above deliberation, and having gone through the project document and TORs for both Consultants, a mutual agreement for both the Consultants and the TNA Team confirmed that the Sectors for the Adaptation TNA will be focused on the proposed sectors which include the Coastal, Water and Agriculture. Later subSections highlights stakeholder engagement and inception meetings to discuss national priorities and to confirm the selected sectors and identify the priority technologies.

In fact the above selection was based from desktop review and analysis of appropriate documents that are essential to ensure the facilitation of the TNAs selection for the three sectors, conducted by the National TNA Team under the CCD and approved by the UNEP Climate Change Centre. The followings are the national policies, plans and strategies that are used as basis to technologies selection:

- Te Kete – National Strategy for Sustainable Development 2021-2030.
- Te Vaka Fenua o Tuvalu - National Climate Change Policy 2021-2030.
- Second National Communication of Tuvalu to the UNFCCC 2015.
- Preparation of Tuvalu Third National Communication under UN Framework Convention on Climate Change (UNFCCC) 2020-2023.
- Tuvalu Priority Infrastructure Investment Plan 2020–2025.
- Tuvalu National Energy Policy 2009.
- Tuvalu's National Adaptation Programme of Action 2007.
- Tuvalu Coastal Adaptation Project (TCAP) 2017.
- Tuvalu Intended Nationally Determined Contributions 2015.
- Sustainable and Integrated Water and Sanitation Policy 2012-2021.
- National Biodiversity Strategic Action Plan (NBSAP).
- Tuvalu National Agriculture Sector Plan 2014-2023.

Sector Selection Confirmation by Stakeholders

Following to the above sector selection, a stakeholder consultation was convened in April 2022 at the TPCC for the purpose of:

- To reconfirm the selection of Sectors and their relevancy to national priorities.
- Introduce the TNA project and proper awareness to key stakeholders.
- Seek collaborative support and necessary feedbacks from stakeholders of their support.
- Identification of Technology priorities for each sector.

Stakeholders realises and were confident that the identified national policies were aligned with the priority sectors been identified. They agreed and support the selection been recommended by the TNA Team and the Climate Change Department that the 3 Sectors are highly priority for the nation. They also acknowledge their support to the project and take note of explanations about the project and it's most relevant to the current need of the nation in the face of climate change.

In May 2022 a follow up Adaptation Stakeholder Consultation was again convened at the same Government Convention Centre (TPCC) to identify the most priority Technologies for Tuvalu. The consultation objectives include:

- Group discussions to identify key TECHNOLOGY NEEDS under the 3 sectors'; Coastal Zone, Agriculture and Water sector.
- Technologies must be consistent to Tuvalu context.
    a. Existing technologies that are working efficiently/effectively.
    b. Consistent to national policies and sector plans.
    c. New technologies that are cheap and viable.

- Prioritization of the selected technologies.

The methodology used for the consultation comprises the following:
Step 1: Introductory remarks and presentation of the key objectives of the consultation.
Step 2: Power-point presentation highlighting the overall overview of the exercise to be conducted. Also presenting some technology examples and definitions to facilitate the deliberation.
Step 3: Group deliberation as the main key of the consultation which include:

- Identifying the most five appropriate technologies under each sector as a long list technology for each sector. The underlying perception to limit the long list to five technologies will provide quick-thinking in reprioritizing the most appropriate three technologies for each sector.
- To attain the 3 most appropriate technologies, it is essential that groups will provide rankings of the technologies with brief description per technology on their relevancy and least relevance for Tuvalu context.

Step 4: Presentation of group works.

- The three working groups presented their final deliberation as highlighted in Table 1.5 below.
- The list of the three groups is attached as Annex 2B.

Results generated from this Consultation are well highlighted in the later Chapters 3, 4 and 5. However, Table 1.5 below shows the result of the selected and ranked Technologies for the three sectors.

Table 1.5: Technologies selection for Coastal, Water and Agriculture Sectors.

Priority Ranking	Technology	Relevance/Importance for Adaptation	Barriers
Coastal Sector Technologies			
1	**Computer Monitoring Model/ Tool** to monitor coastal erosion and waves strengths.	• Technical data records availability for decision making. • Essentially provides available data to facilitate coastal development or technology to be adopted. • Coastal erosion in Tuvalu is alarmingly increased and so require proper monitoring.	• Low technical capacity: ○ Unskilled/untrained staff. ○ High staff turnover. ○ Limited training programmes. • High capital cost: ○ Low or few local suppliers. ○ Low demand for desalination. • Coordination limitation: ○ No designated unit for desalination. ○ Limited human resources. • No particular regulatory framework to govern coastal issues.
2	**Land reclamation** - seawalls, sand bags	• The current reclaim land - the QEII Park has set a supporting scenario as the best option for coastal protection in Tuvalu. • Again the existing reclamation under the TCAP project also strengthen significantly the relevance and value of the technology. • Constant and intense coastal erosion are obviously alarming	• Financial issues: ○ High capital cost. ○ Inadequate financial status of the government. • Low technical capacity: ○ Unskilled/untrained staff. ○ High staff turnover. • Coordination limitation:

		so land reclamation is highly recommended as a robust protection measure.	○ No designated unit for land reclamation.
3	**Wave Breakers** (lagoon and ocean)	• Proved to be most relevant in other countries, so can be applied in Tuvalu. • The application of wave breakers at the Tuvalu Deep Sea Wharf was confirmed extremely relevant and robust.	• Financial issue: ○ High capital cost. ○ Inadequate financial cost at the national level. ○ Require donor support. • Low technical capacity: ○ Unskilled staff. ○ Designing capacity is poor at the local level. • Coordination limitation: ○ No designated institution to oversee the technology. • No regulatory framework in place.
4	Beach Groin	• This can be trialled in a more robust technique. • Traditional methods using tree trunks like coconut been practiced years back. • Proved to be most relevant in other countries, so can be applied in Tuvalu.	• Financial issues: ○ High capital cost when implementing permanent structure. ○ Inadequate financial cost at national level. ○ No financial saving. ○ Durable methods designing and logistics are costly. • Donor supports to be sought. • Less durable as easily taken away during hurricanes or cyclones. • No coordination mechanism in place as which institution to oversee the approach.
5	Tree Planting	• Already practiced in Tuvalu and looks to be an ongoing protection measure.	• Cyclone intensity easily removed the trees. • Climate proof plants are required.
Water Sector Technologies			
1	**Solar Reverse Osmosis System** (Desalination Plant)	• Water shortages during drought seasons is serious. • Solar system is highly available and robust.	• Hardware Issues. • Unavailability of parts. • Lack expertise in Tuvalu. • Cost can be a concern, however, donor funding always available.
2	**Water reticulation system** (gravity pressure)	• Technology is viable and highly practised at household levels. • Non-existence at the community level. • A windmill water pump was installed in 1981 at Nukufetau under the SPC funding assistance was confirmed to be very useful. The system is water gravity distribution.	• Unavailability of parts for servicing and maintenance • The cost can be a concern at the local level. . • None institutional arrangement.
3	**Groundwater solar extraction**	• Underground water is available in outer islands. • Useful during drought periods. •	• Existence of groundwater acquifer/wells lack information. • Contamination of groundwater.

4	Plate type fresh water generator (solar powered)	• Not exist and so require trial.	• Maintenance issues. • Cost issues. • Limited access of information of the technology.
5	UV Filter system	• Few households use the technology utilizing their own water reservoirs. • Used as potable drinking water. • Few households use it and sell the water at very low cost for drinking only.	• Un-availability of parts. • Expensive to low income households. • Capacity limitation for maintenance.
Agriculture Sector Technology			
1	**Composting for tolerant varieties**	• Composting is common in Tuvalu. • Climate change impact on plants and crops is high and ongoing. • Tolerant varieties are most essential.	• Technical expert requirement is essential. • Procurement of tolerant varieties.
2	**Horticultural technology through Beddings** (concrete, wooden, etc)	• Concrete based cultivation is now practice in Tuvalu (eg: swamp taro cultivation). • Raising farming above the ground is very essential for Tuvalu given its status to salt water intrusion and heavy/frequent drought.	• Technical expert may be required on new technologies.
3	**Cultivator with Irrigation**	• The status of poor soil quality in Tuvalu couple with in-favourable temperature with prolonged drought periods, it is a requirement to cultivate and irrigate the soil very often.	• Technology is expensive and require technical expertise and equipment. • Seeking donor assistance.
4	Plow and Crop rotation	• Similar to above technology (3). However, deeper soil cultivation will be more essential to overcome worst drought periods.	• Also the technology is expensive. • Donor assistances are available.
5	Livestock Farming technology	• Tuvaluans are very keen in livestock farming. So appropriate technologies are highly recommended.	• Improve current status of farming with marketing capacity building.

Sector Selection and Technologies using the MCA tool

The Adaptation Working Group again manages to reconvene later-on in July 2023 to reconfirm the selection process of the Sectors using the MCA tool. In fact, enlightenment for using the tool was provided by the Adaptation Consultant and the TNA Project Coordinator. The result of the group analysis was attached in Annex III.

More than two hours was spent by the team discussing regarding the tool, including clarifications from the stakeholders and responses provided by the TNA Team. After all, stakeholders had a common understanding and agreed to use the selection criteria provided by the UNEP Climate Change Centre. With regard to the scoring rate, the Team agrees to use the following rating for the technologies (refer to the agreed arrangement below).

Score	***Cost threshold***
100	0 - 1 Million
75	1 Million – 25 Million
50	25 Million – 50 Million
25	50 Million – 75 Million
1	Over 75 Million

Sensitivity Analysis

The sensitivity analysis of the result in identifying the Sectors at this stage was not numerically assessed. However, it was based from the relevancy and importance of the Sector that voted for by the Working Group. As in the case of the coastal sector, coastal erosion due to climate change impacts is a number one priority for the nation. Currently, during this reporting period, coastal reclamation on the capital of Funafuti is ongoing and was confirmed as the main key adaptation measure for the livelihood of the nation. Similarly applies to the Water Sector for the need of a safe and hygienic water supply. From the Agriculture Sector food security is the key for the entire livelihood of the nation.

Chapter 2 Institutional arrangement for the TNA and the stakeholder involvement

National Institutional Arrangement

Climate Change Policy formulation and implementation is the full responsibility of the Climate Change Department (CCD) in the Ministry of Finance. Generally, the CCD oversee the overall implementation of the policy at both the international, regional and national level. At the national level, the CCD is responsible to the National Advisory Committee on Climate Change (NACCC) which comprised of technical members from various Departments/Institutions in the Government as well from NGOs.

Under the NACCC is the Technical Advisory Committee (TAC) that operates at the Departmental level to oversee all projects that operates under the CCD. This TAC is also involved in this TNA process.

Regional Institutional Arrangement

At the regional level, it is anticipated that all Regional Centres (RCs) in the Pacific including the USP, Secretariat of the Pacific Region Environment Programme (SPREP), Forum Secretariat, SPC and SOPAC and other centres will thus play a substantial role in providing technical support to the national TNA teams. The main responsibilities of the RCs and consultants include:

- Partner with UDP in the organization and facilitation of regional training workshops where participants from countries will be trained in the methodology for conducting the TNA;
- Provide technical and process support to the countries within the region during the whole project implementation;
- Provide participating countries with support through the help desk upon request from the countries throughout project implementation;
- Review country deliverables to help improve quality of reports and compile a synthesis report.

Global TNA support mechanism

1. UNEP DTU Partnership (UDP):

UDP is the Executing Agency for the project at the global level and is responsible for day-to-day management of the project, including financial management and project reporting. UDP works directly with participating countries, and facilitates the TNA process through several activities including, but not limited to:

- Guidance and assistance to the participating countries to set-up institutional structures for conducting the TNA process;
- Development and provision of methodologies;
- Training in methodological tools and methodologies through national and regional capacity building workshops.

2. UN Environment:

The project Implementing Agency is the UN Environment Climate Mitigation Unit. It is responsible to the GEF for the project’s oversight, the use of resources as written in the Project Document, or any amendments agreed to it by all donors.

3. UNFCCC Technology Mechanism:

UN Environment and UDP collaborate closely with the UNFCCC Secretariat's technology team and the CTCN team, and are members of the UNFCCC Technology Executive Committee (TEC) TNA Taskforce. These linkages and cooperation will continue to increase opportunities related to technical assistance, knowledge sharing and networking activities.

The two bodies of the UNFCCC Technology Mechanism, the TEC and the CTCN, will serve in an advisory role to the TNA project, since both are members of the Global TNA Project Steering Committee. Also, the TNA project will continue working closely with the CTCN in order for countries to receive support for taking their TNA results forward.

4. Global level Project Steering Committee (PSC):
The Steering Committee plays a central role in the implementation of the project by providing strategic guidance and advice on various issues related to the implementation of the TNA project at a global level, and suggests corrective measures or interaction with participating countries along project implementation. The Steering Committee will receive periodic reports on progress and will make recommendations to UN Environment and UDP concerning the need to revise any aspects of the implementation.

2.1 National TNA team

The main structure of the national institutional setup of the project is managed under the CCD in the Ministry of Finance (MOF). The core team members of the project comprises of the National TNA Coordinator, Assistant Coordinator (ie: Finikaso Consultant Firm), National Steering Committee, Consultant (Adaptation/Mitigation), Sector Working Groups and Stakeholders.

National Coordinator
The Climate Change Department with proper supervision of the Ministry of Finance designated Ms. Faatupu Simeti as the TNA co-coordinator. Ms Faatupu is involved in national reporting and coordination of the project. She is the focal point for the overall management and coordination of the TNA process. Also responsible for facilitating and managing the project, and communicate with national consultants, sectoral working groups, stakeholders, regional agencies and UDP.

Assistant Coordinator
The CCD engaged Finikaso Consultant Firm as an Assistant Coordinator to the project. Its main role is to assist the coordinator in the overall implementation, administrative tasks, facilitation of tasks that may be required from time to time by consultants and assist consultants on any requirement may requested by consultants.

National Steering Committee
The national steering committee is fundamental in providing guidance to the project. It provides high level and maximum guidance to the national TNA team and is responsible for policy making. Its role includes providing guidance to the national team and assisting in securing political acceptance for the TAP. It consists of members from relevant ministries, private sector and other key stakeholders.

Under this TNA preparation, the steering committee is labelled as the Technical Advisory Committee (TAC) for the TNA is established as a subcommittee under the National Advisory Committee on Climate Change (NACCC). There are two primary role(s) of the TAC which include:

1. Providing technical assistance and guidance on the development of the TNA report, updating and adding the relevant information that may be required to facilitate the diffusion of the technologies to the country.
2. Provide technical assistance and guidance in prioritizing the technologies and identifying barriers, development of Technology Action Plans and concept notes to attract funding.

This TAC will work closely with other project management units in order to achieve its primary roles. Composition of the TAC can be obtained from the Climate Change Department.

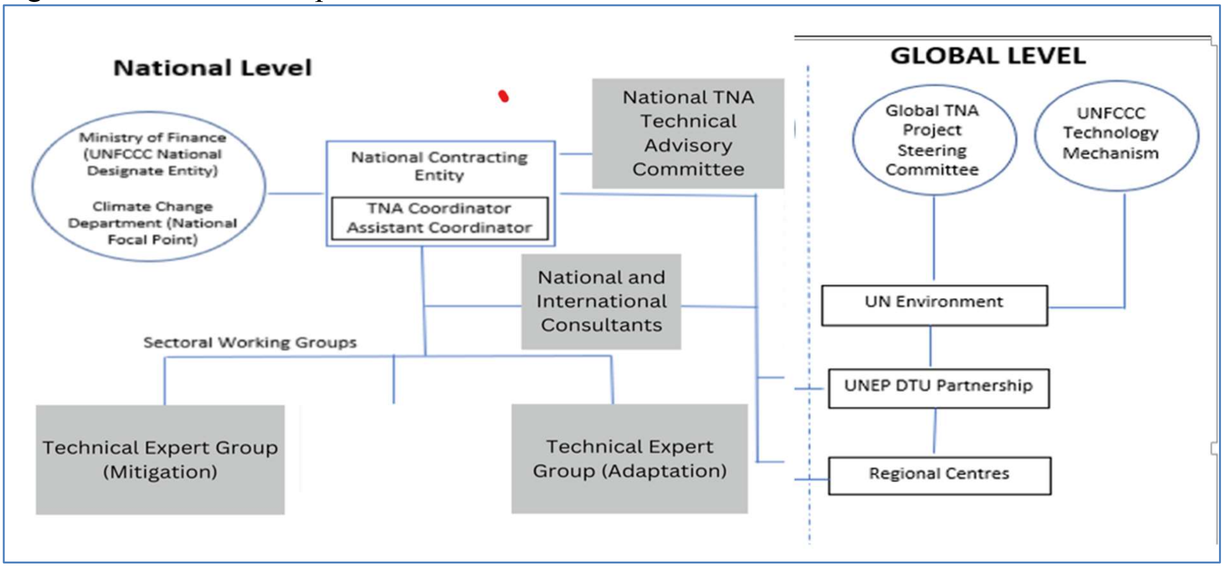
National Consultants
The lead national consultants were recruited by the CCD under the guidance of the MOF. CCD appointed Mr.Mataio Tekinene as TNA adaptation expert, and Mr. Lomiata Niuatui as the mitigation expert. The adaptation and mitigation experts are responsible for consulting relevant stakeholders; identifying and prioritising technologies for specific sectors under good guidance of stakeholders; leading the analysis process with stakeholders and sector working groups; participating in capacity-building workshops; working with the national coordinator and assistant coordinator, sector working groups, and stakeholders; and preparing the TNA, BAEF and TAP reports.

Sector working groups
The Climate Change Department, on the suggestion of the co-coordinators and national consultants and in line with UDP guideline for the project, established two working groups on the mitigation technologies for the transport and waste sectors, and two working groups on adaptation technologies for Coastal Protection, Agriculture and Water Security. The composition of the sectoral working group includes representatives from government ministries, private sector, academia, the area of climate change and civil society.

Stakeholders
Stakeholders include representatives of the government ministries, private sector, academia, climate change experts and civil society.

Figure 2.1 below is a schematic representation of the Tuvalu TNA institutional structure.

Figure 2.1: Schematic representation of the Tuvalu TNA institutional structure



2.2 Stakeholder Engagement Process followed in the TNA – Overall assessment

Initial Engagement and Stakeholder Consultation
Initially the Consultant for the TNA Adaptation awarded a contract in June 2021, followed on by participating in the TNA online workshop which facilitated by collaborating partners including the UN Environment Programme and DTU (UNEP DTU), Asian Institute of Technology (AIT) and the University of the South Pacific (USP). The main purpose of the workshop is to provide an overall overview of the TNA project and its implementation processes and stages. These technical and academia institutions will provide assistances and facilitation roles as may be required from time to time.

At the national level in April 2022 an inception workshop was conducted with key stakeholders to familiarize them about the project and to confirm their support and availability for the project.

It is an opportunity as well as the first step to discuss the project at the national level context. Sector selection and identification of some potential technologies are the highlights of the discussion. Then a timetable including interviews, desktop research, and further consultations of target groups was drawn up and confirmed as a starting point for implementation.

A follow up interviews through face to face and emails sharing was conducted by the Consultant by approaching firstly the Coastal Sector stakeholders including the Public Works Department (PWD) personnel; the Department of Environment personnel; Funafuti Kaupule Secretary; Tuvalu Non-Government Organisation (TANGO) staff; the Department of Local Government personnel; Tuvalu Coastal Adaptation Project (TCAP) Coordinator and the Fisheries Department Officer. From the Water Sector the Consultant managed to collect information from PWD; Funafuti Kaupule; Meteorology Department; community representatives from Lofeagai, Funafuti, Vaiaku and Tekavatoetoe districts. The final group data collection on the Agriculture Sector includes the Department of Agriculture (DOA) Director, the Department of Waste and Management (DWM), some local farmers and the Taiwanese Garden (Fatoaga Fiafia).

In May 2022, a follow up consultation with Adaptation Working Group Stakeholders was convened at the TPCC to identify and prioritised the most appropriate technologies that are viable, affordable, robusts and meet the need of the people at the national level. Refer to Annex II list of stakeholders consulted.

Stakeholder Analysis
The intention was to involve as broad a cross-section of the stakeholder group as possible. The following table illustrates the initial consideration of which stakeholders would be consulted in the development of the long-list of technologies, while taking into accounts the prioritised sectors.

Table 2.1 Stakeholder analysis

Sector	**Institution/Organisation**	**Relevance**
Government/Public	Climate Change Department	High. The lead department of the project.
	Department of Environment	High. Provide appropriate information on environmental aspects at certain extent.
	Department of Waste and Management	High. Provide necessary information on waste risk or pollution.
	Planning, Budget and Aid Coordination Department	High. Provide necessary data on funds and assist on financial advices.
	Department of Local Government	High. Provide local data from the community level.
	Department of Agriculture	High. Advise and provide most appropriate technologies in Agriculture
	Department of Energy	High. Essential energy data required and advises.
	Tuvalu Revenue and Customs Department	High. Provide data and advises with customs clearances.
	Gender Affairs Department	High. Gender is key to any project as they categorised vulnerable group.
	Public Works Department	High. Provisional of data on water and coastal sector.
	Department of Disaster Management	High. Given the impact of climate change in Tuvalu, DDM will provides

		assistances and required information.
	Funafuti Kaupule	High. Act on behalf of the indigenous people.
	Fisheries Department	High. Provisional of coastal fisheries data.
NGOs/Civil Society	Tuvalu Climate Action Network (TUCAN)	High. Its roles in climate change are relevance in the TNA process.
	Tuvalu National Council of Women	High. Representing the nation on behalf of women, the vulnerable group.
	Fuligafou Group (Youth group)	High. Representing the youth group and their involvement in the TNA MCA is vital.
Academia	University of the South Pacific	High. The only academic regional centre that provides necessary information on academic issues.

2.3 Consideration of Gender Aspects in the TNA process

Usually gender is a key component in all projects design and implementation. Given this status, gender becomes a significant consideration in project design and implementation in Tuvalu. The Government project management system called the Country Project Management Office (CPMO) housed under the Ministry of Finance (MoF) was led by a woman as a Director and most staffs are women. So, gender mainstreaming in policies, plans and working places is common in all Ministries and Departments in the Government. This applies as well to NGOs and civil society. The Gender Affairs Department has its own Gender Policy.

The Climate Change Department which is the leading agency for the TNA project was led by a woman as Director of Climate Change. The TNA team that comprise of the TNA Coordinator and Assistant Coordinator also led by a woman. The Assistant Coordinator which awarded to the Finikaso Consultant and Law Firm again led by a male and a female.

In the TNA process, it is crucial we ensured that the perspectives of both men and women were given equal opportunities and consideration during the engagement and prioritisation process. During the wider inception workshop in April 2022, there were 8 females and 13 males attending the consultation. However, the opportunity of deliberation was equally shared. In a follow up workshop of identifying technologies in May 2022, both females and males from the three sectors are given the opportunity to facilitate their group discussions as well presenting results of their group works. Gender considerations will be maintained as an important part of the design and implementation of the selected technologies, throughout implementation.

At the national level from traditional perspective, in fact gender sensitivity in project design is not as important as normally considered in formal project designs and implementation. However, for this exercise, gender sensitivity in prioritizing the Sectors and technologies is well considered. During the latest consultation to prioritize the Sectors and Technologies using the MCA tool, there were 32 participants and 11 of them are females. Despite that males take the majority to participate, however, female participation still significant.

Chapter 3 Technology prioritisation for the Coastal Sector

3.1 Key Climate Change Vulnerabilities in the Coastal Sector

In general, Tuvalu is a roughly linear archipelago of eight islands and of which the ninth island (Niulakita) is part of the main land of Niutao. They are very low-lying with an average height of 1-2 m above sea level and maximum height of approximately 5 meters, 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.

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. Its common characteristic of vulnerability to extreme weather events, sea-level rise and ocean acidification is rated high. The impact of these occurrences on coral will reduce the protection that the reefs and lagoons provide to the coastal zone. Coastal infrastructure and beach front properties will be more exposed to damage as storm events become more extreme.

Coastal erosional and accretion processes of Tuvalu archipelago can be influenced by:

- 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 (https://www.sciencedirect.com/science/article/pii/S0921818110001013).
- 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.

Tropical cyclones are the main extreme events affecting Tuvalu coastal zones. Between 1969/70 and 2006/07, total of 33 tropical cyclones passed within approximately 400 km of Funafuti which is equivalent to an average of eight cyclones per decade (Australian Bureau of Meteorology and CSIRO, 2011). Tropical Cyclone Pam in March 2015 is category 5 cyclone generated strong winds and storm surge, causing substantial damage to houses, essential infrastructure and agricultural crops. The northern islands of Nanumaga and Nanumea, and the central islands of Nui and Vaitupu were the hardest hit. A nation-wide state of emergency was declared with approximately 4,600 people – nearly half of the country's population – was directly affected by Cyclone Pam (Government of Tuvalu, 2015).

Late 2015 and mid-January 2016, Tropical Cyclone Ula, another powerful cyclone produced winds of up to 100km/h. The physical damage from the cyclone left many families in financial hardship as they were still recovering from the effects of TC Pam. A number of families from Nanumea to Nukulaelae were affected by the damage to their properties. Then, in January, 2020 storm surges caused by Tropical Cyclone Tino caused flooding and inundation in the country. People living along the western coastlines on all islands in Tuvalu moved inland, evacuating to safer areas.

3.2 Decision context in coastal protection

Tuvalu Government had several policy documents that highlighted the important of coastal protection as a cross-sectoral issue. The National Strategy for Sustainable Development (NSSD) or Te Kete - Outcome 4 on Climate Change and Disaster Resilience Increased highlighted the following key strategic actions:

- Develop long-term national adaptation strategy, including a staged land reclamation programme, that take into accounts a worse-case scenario of sea level in Tuvalu rising by one meter by year 2100.
- Secure increased funding from global climate financing facilities.
- Strengthen access to labour mobility schemes.
- Develop effective frameworks for disaster risk and resilience management.
- Implement a land rehabilitation and reclamation framework that is resilient to sea level rise and climate change impacts.

The Second National Communication has identified coastal protection as one of the priority areas for implementing climate change-related activities. The Tuvalu Priority Infrastructure Investment Plan 2020–2025 highlighted that Climate Change sector is priority, therefore the need to secure projects on National Adaptation and Reclamation is highly essential.

Tuvalu had benefitted from various programmes, projects and activities carried out by different institutions in terms of coastal protection. The government effort in the past decades, through the PWD has implemented coastal protection methods such as gabion basket and square blocks about 1 ft sizes that failed due to strong current movement couple with intense storms and tropical cyclones.

The Foram Sand Project (2009-2014) funded by the Government of Japan introduced ecotechnological measures to improve coastal environments while enhancing sand production and sedimentation, including foraminifera farming. Linking up to this eco-technology, the Government of Japan funded a project called the Pilot Gravel Beach Nourishment against Coastal Disaster on Fongafale Island – Funafuti. This was further builds on the findings of the Foram Sands Project. It was implemented in conjunction with the Tuvalu Government's Department of Environment. The purpose of the project is to assess the effectiveness and adequacy of the beach nourishment method for reducing coastal vulnerability to climate change risks. The project involves replenishing a 177 m section of the lagoon-side beach on Fongafale islet with locally-extracted gravel and sand from Papa Elise and Funamanu islets. Imported boulders and concrete blocks are used for the groins on either end of the pilot site.

On the outer islands of Nukufetau and Nanumea, coastal options and feasibility analysis were carried out in 2014. The findings recommended both soft and hard coastal protection measures which may include:

- Beach recharge (nourishment) and reef sediment recycling;
- Sand container revetment structures;
- Detached (semi submerged) breakwaters;
- Coral Gabion Structures;
- Mangrove / wetland habitat improvement (Green Buffers);
- Rock Revetment (Coral Blocks); and
- Coral Gravel Ridge Maintenance.

The NAPA project in conjunction with the Ridge to Reef (R2R) project trial the use of local salt tolerant trees planted alongside the coastal area. The approach did not work as anticipated as trees were uprooted and damaged by waves and cyclones prior maturity stages to withstand coastal protection. The R2R also piloted vetiver grasses to protect pollution leachate and beach erosion. This approach seems to work, however, the need to nurture and protect these grasses from uprooted is highly essential.

Recently an ongoing TCAP project under the Climate Change Department main objective is to conduct a reclamation land in addition to the existing QEII Park reclaimed land.

3.3 Overview of Existing Technologies in the Coastal Sector

Traditional technologies

One of the common technology used to protect beach or coastal erosion is the erection of beach groynes using tree trunks (eg: coconut trunks and other tree trunks that can be manually lifted). The trunks were securely erected into the beach sand in a straight line, starting from the high water-mark to the lowest water-mark. Such technology will interrupt sea water flow and limit the movement of sediment. Usually sand accretion is favourable in this type of protection measure.

A similar method is using tree trunks to establish a bunding type structure (*fakapae* in Tuvaluan) where tree trunks are erected adjacent to the beach in a rectangular shape and used as a dumping site. Usually coconut fronds and large garbage like tree trunks and branches, coconut husks and building debris were dumped at the site along with small trashes. Over time as beach sediment moves around by waves, these will fill up gaps in between the erected trunks, then penetrated into the trashes to fill up the rectangle shape bunding. Such method is more viable and durable on the lagoon side coastal area where wave strength and movement are minimal.

Coastal dumping is another practicable method, however, the disadvantage of it is that it provides pollution to the sea and coastal areas. Tree planting along the shoreline is also common in the past. Usually this method is more viable along with coastal dumping. At certain spots along the coast area where people used to dump their trashes, they also dump seedlings like coconut fruits or tree trunks where they propagated and fill the area as protection technology.

All the above traditional knowledge technologies can be categorised as soft measures for coastal protection. They often collapsed and deteriorated during cyclone events and strong current movements associated with strong wind and storms.

Technical technologies

Beach Nourishment

The pilot Gravel Beach Nourishment against Coastal Disaster on Fongafale Island - Funafuti, further builds on the findings of the Foram Sands Project. It was implemented in conjunction with the Tuvalu Government's Department of Environment to assess the effectiveness and adequacy of the beach nourishment method for reducing coastal vulnerability to climate change risks. This was constructed adjacent to the Funafuti Community hall. Technically , this technology is suitable at enclosed lagoon beaches where current strength is very little or none.

Gabion Baskets

The technology consists of mesh wire connected in rectangular or square shapes which then arranged along the coastal area and filled up with rocks. Once they are filled, they enclosed securely by the same mesh wire size to prevent rocks from dispersion. Such technology is not favourable at coastal areas with strong current movement or exposed areas to hurricane and tropical cyclone impacts.

Square Blocks

Similar to the gabion basket method, the concrete square blocks were arranged along the beach area. At some areas these blocks were dumped and arranged randomly. The technology seems to be more favourable than the gabion basket and the beach nourishment where wave actions are strong and intense. Despite this, the blocks are not resistant to cyclones with strong surges at all. At certain areas where these blocks have been piloted as in the case of Nanumaga Island. The piloted site is on the northern side of the island where their pulaka pit is situated. The site is well known as Te Utua where wave actions are very intense and damaging to shorelines. The effects on concrete blocks were de-shaped and eroded away. Some blocks found in round shapes of football sizes or smaller than that.

Land Reclamation – QEII Park

The Government reclamation project adjacent the Government building at Vaiaku area on Funafuti was proved to be a very successful tand a robust technology. The reclaimed land is currently called

Queen Elizabeth II Park (QEII Park) accommodating the main Government Conference Centre, the Government hall, the national entertainment stage and few bungalows with a small bar lounge. Further improvements were made like hard protection to prevent erosion such as boulders lay out in front of the Park and sand bags groins at both ends of the Park. The Park also used for storage of project materials for the Government and the nation.

A similar piloted reclamation effort was done in Nukufetau, but did not complete as anticipated. The reclamation although provide high protection to the coastal area, it is not robust as it is incomplete.

Tuvalu Coastal Adaption Project (TCAP).

The project is Government owned focusing on improving coastal protection in key locations on the islands of Funafuti, Nanumea and Nanumaga. The Funafuti site will be instigated from the northern end of the existing QEII Park towards north covering the whole coastal area resided by Funafuti people. While this reclamation technology will act as a buffer during storms, the project also strives to build the capacity of national and island governments and local communities in adapting to climate change in the longer term. The project has three key outputs:

1. *Strengthen institutions, human resources, awareness & knowledge for resilient coastal management*
    - Strengthen technical capacity, knowledge and awareness of monitoring, protecting and maintaining of coastal protection infrastructure.
    - Enhanced long-term national human resource capacity and awareness related to coastal resilience.
2. *Reduced vulnerability of key coastal infrastructure – including homes, schools, hospitals – to wave-induced damages*
    - Coastal assessments undertaken in all islands in a participatory manner.
    - Implementation of coastal protection measures in Funafuti, Nanumea and Nanumaga.
3. *Establishment of a sustainable financing mechanism for long-term adaptation efforts*
    - All islands Strategic Plans and annual budgets integrate island-specific climate risks through gender-sensitive, participatory processes.
    - Strengthen capacity of Kaupules, Falekaupules and community members in monitoring coastal adaptation investments.

Permanent Seawall

This technology is rare in Tuvalu given its technical status to be expensive and require an expert to supervise the construction. The Funafuti deep sea wharf coastal area was protected by a permanent seawall structure made with concrete and several wave breakers also made of concrete.

The Vaitupu community on Funafuti managed to obtain funding assistance from an NGO institution which they utilized to construct a permanent seawall alongside their community hall on the coastal area to the ocean side. The project is locally designed and implemented by the indigenous people of Vaitupu. It is the first kind of adaptation locally managed and implemented. The seawall will permanently protect the community hall from wave actions and provide a likely reclamation area for the community use for parking vehicles and other social amenities.

3.4 Adaptation Technology Options for the Coastal Sector and their main adaptation benefits

In general, the list of technologies was provided by the consultant based from a number of key documents and current climate challenges faced by the coastal sector. A number of technologies were identified, however the project guidance as stipulated highlighted to select 2 to 3 technologies for each sector. During the stakeholder consultation in May 2022, working groups agreed to identify 5 technologies per sector as clearly highlighted in Chapter 1.

These technologies were selected mainly to improve resilience and safety of communal infrastructures like households, community buildings (schools, hospital, church, hall), pulaka pits and roads. The 5 technology options were agreed by working group members.

Factsheets for the approved technologies were prepared and circulated to stakeholders for review and feedback. The fact sheets provided a description of the technology, its potential to contribute to adaptation to climate change and the status of the technology in Tuvalu. Estimated cost and benefits of the technology options was provided where available. Refer to Annex I for the fact sheets.

The time available for the process of Technology prioritisation was limited and as a result, there was no ability to enhance the available information of the 5 technologies. Consequently, a pre-screening was done in order to facilitate the writing of the fact sheets. About three criteria were identified as essential to developing the fact sheets for the Technology prioritisation.

- Information Availability: Reliance on available documents to search information is the only way to obtain technology information. Coastal technology information in Tuvalu is very limited.

- Technology Development: Development of a technology requires an expert and this is the limitation for Tuvalu.

- Technology Impact: Given the fact that there is very limited knowledge of technology development in the country, it is therefore impossible to identify the impact of a technology. However, at the current situation the level of education and knowledge on coastal sector is growing and ongoing.

Brief summaries of the technologies and their respective contributions to adaptation are provided below:

Table 3.1: Summary of technologies for the coastal sector.

Priority Ranking	Technology	Relevance/Importance for Adaptation	Barriers
Coastal Sector Technologies			
1	**Computer Monitoring Model/ Tool** to monitor coastal erosion and waves strengths.	• Technical data records availability for decision making. • Essentially provides available data to facilitate coastal development or technology to be adopted. • Coastal erosion in Tuvalu is alarmingly increased and so require proper monitoring.	• Low technical capacity: o Unskilled/untrained staff. o High staff turnover. o Limited training programmes. • High capital cost: o Low or few local suppliers. o Llimited availability of local experts to operate, maintain and service the Computer models/tools. Technology have high commercial requirement. • Coordination limitation: o No designated unit computer modelling exist in country. o Limited human resources. • No particular regulatory framework to govern coastal issues.

2	**Land reclamation** - seawalls, sand bags	• The current reclaim land - the QEII Park has set a supporting scenario as the best option for coastal protection in Tuvalu. • Again the existing reclamation under the TCAP project also strengthen significantly the relevance and value of the technology. • Constant and intense coastal erosion are obviously alarming so land reclamation is highly recommended as a robust protection measure.	• Financial issues: ○ High capital cost. ○ Inadequate financial status of the government. • Low technical capacity: ○ Unskilled/untrained staff. ○ High staff turnover. • Coordination limitation: ○ No designated unit for land reclamation.
3	**Wave Breakers** (lagoon and ocean)	• Proved to be most relevant in other countries, so can be applied in Tuvalu. • The application of wave breakers at the Tuvalu Deep Sea Wharf was confirmed extremely relevant and robust.	• Financial issue: ○ High capital cost. ○ Inadequate financial cost at the national level. ○ Require donor support. • Low technical capacity: ○ Unskilled staff. ○ Designing capacity is poor at the local level. • Coordination limitation: ○ No designated institution to oversee the technology. • No regulatory framework in place.
4	Beach Groin	• This can be trialled in a more robust technique. • Traditional methods using tree trunks like coconut been practiced years back. • Proved to be most relevant in other countries, so can be applied in Tuvalu.	• Financial issues: ○ High capital cost when implementing permanent structure. ○ Inadequate financial cost at national level. ○ No financial saving. ○ Durable methods designing and logistics are costly. • Donor supports to be sought. • Less durable as easily taken away during hurricanes or cyclones. • No coordination mechanism in place as which institution to oversee the approach.
5	Tree Planting	• Already practiced in Tuvalu and looks to be an ongoing protection measure.	• Cyclone intensity easily removed the trees. • Climate proof plants are required.

3.5 Criteria and process of technology prioritisation

On 8th April 2022 during the first awareness workshop, key stakeholders for the Adaptation Working Group discuss and prioritize the most three appropriate Technologies from the long list of technologies for the Coastal Sector. A follow up workshop in May 2022 feedback reveals that the prioritized technologies are applicable and relevant for the country. However, given the fact that, the Technology Fact Sheets (TFS) and the MCA tool were not considered during this prioritization, it was recommended that another round for prioritization was required. So, the working group reconvened after the BAEF workshop in July 2023. During this consultation, the

Adaptation WG reviewed the TFS and go through the MCA exercise. As a result, they agreed to the TFS as well to the development of the MCA. It is appropriate to note that the selected criteria for prioritization were based on expert opinions and experience of individual stakeholders. Table 3.2 shows the criteria and processes used by stakeholders to prioritize the technologies.

Table 3.2: Selected criteria for the coastal sector

Category		Criteria
Costs		Cost to set up and operate.
		Cost of maintenance
Benefits	Economic	Improving livelihood and income opportunity.
		Job creation
		Trigger private investment.
	Social	Poverty reduction potential.
		Gender Equality, Diversity, and Social Inclusion (GEDSI).
	Environment	Protect and sustain ecosystem services.
	Climate Related	Improvement of resilience to CC.
Others	Institutional and Implementation	Ease of implementation.
		Replicability.
	Political	Coherence with national development, policies and priority

The above criteria are well defined with their potential relevancy so that they are not overlapping and they are locally recognised as meaningful in assessing the priority of the Technology. These criteria are listed in the MCA tool used for technologies prioritization.

Following the above criteria selection, stakeholders conveyed their endorsement on the relevance and appropriateness of the technologies in contrast with the identified criteria. Then based on expert opinions and stakeholders' experience, the following prioritisation on the sector criteria, indicators and scoring scale was developed. Table 3.3 below shows the criteria, indicators and scoring scale used for prioritization. Also refer to the MCA in Annex III.

Table 3.3: List of criteria, indicators and scoring scale used for prioritisation of the technologies

Criteria	Indicators	Scoring Scale
Cost	Set up and operation costs	0 = Very high cost 100+ = Very low cost
Maintenance cost	Cost of maintenance	0 = Very high cost 100+ Very low cost
Improving livelihood and income opportunity	Opportunity to obtain better livelihood and income from technology.	0 = Very low 100+ = Very high
Job Creation	People employed by the technology.	0 = Very low 100+ = Very high
Trigger private investment	Private opportunity inevstment	0 = Very low 100+ = Very high
Poverty reduction potential	None poverty community exist	0 = Very low 100+ = Very high
Gender Equality, Diversity, and Social Inclusion	Gender balance in decision making and development engagement.	0 = Very low 100+ = Very high
Protect and sustain ecosystem services.	Better ecosystems and benefits are obtained.	0 = Very low 100+ = Very high

Improvement of resilience to CC.	Improve protection opportunities to climate change.	0 = Very difficult 100+ = Very easy
Ease of implementation.	The technology is viable and implementable.	0 = Very difficult 100+ = Very easy
Replicability.	Easy to replicate the technology.	0 = Very difficult 100+ = Very easy
Coherence with national development, policies and priority.	The technology is inline with national priorities and policies.	0 = Very difficult 100+ = Very easy

Establishing the weightings for each indicator, stakeholders used the MCA analysis (Annex III) and came up with the following weighted score and criterion weight sensitivity as shown in Table 3.4 below.

Table 3.4: Result of weightings used for different criteria for the prioritisation and sensitivity analysis

Criteria	Criterion Weight	Criterion Weight & Sensitivity
Cost	11	11
Maintenance cost	0	0
Improving livelihood and income opportunity	10	10
Job Creation	0	0
Trigger private investment	8	6
Poverty reduction potential	16	20
Gender Equality, Diversity, and Social Inclusion	0	0
Protect and sustain ecosystem services.	17	15
Improvement of resilience to CC.	19	17
Ease of implementation.	8	10
Replicability.	6	6
Coherence with national development, policies and priority.	5	5
Total	100	100

3.6 Results of technology prioritisation

The prioritisation through MCA the Computer Monitoring Model/Tool to monitor coastal erosion with current strengths, etc was ranked as number one technology. Land reclamation (seawalls, sandbags and boulders) ranked as number two technology and Wave breakers as number three.

Furthermore, emphasis was given to technologies with the potential to contribute to adaptation to the extreme events, prolonged dry periods and salinization. Much discussion also revolved around the cost implications of a technology and whether implementing a technology will contribute to broad development or sector development objectives such as poverty reduction and gender mainstreaming.

Computer Monitoring Model/Tool
A computer monitoring tool or model is a complex technical equipment required to monitor the behaviour of coastal areas as a result of natural disasters (cyclones, hurricanes, waves, storm surges) and anthropogenic behaviours (removal of sand and gravel). Coastal erosion is an ongoing phenomenon in Tuvalu that exacerbated by climate change variation and its impacts. So, through

computer monitoring tools, data on coastal behaviour will be collected and collated to inform decision making that will facilitate the selection and designing of an appropriate technology for coastal protection. Currently, the exposure of community facilities to the impact of coastal erosion is high and therefore the need for their protection via coastal protection is a high priority.

Land Reclamation
Land reclamation is an integral approach that has been proven and exist in Tuvalu as the most appropriate technology that not only limit to coastal protection, however, provides a central area of land addition for public use. A clear example of this is the QEII Park reclaimed land. The Tuvalu Coastal Adaptation Project conducting a similar approach will further provide additional land for public use. Potential limitation of land in Tuvalu will obtain great benefit of additional land through this technology.

Wave Breakers
Given the fact that coastal erosion been exacerbated due to wave actions coupled with the intense of cyclones, it is therefore vital that this technology is applied to slow down wave flows and catastrophic actions. Wave breakers have been trialled in other parts of the world in which they been confirmed to be robust in slowing down current movement and forceful actions. So, the introduction of this technology will surely provide less coastal erosion and may increase accretion which is highly recommended.

Chapter 4: Technology prioritisation for the Water Sector

4.1 Key Climate Change Vulnerabilities in the Water Sector

Water vulnerability is a serious issue for Tuvalu, the serious impacts of the 2011 drought will not be forgotten, and now is the time to put in place practical measures to secure safe drinking water and sanitation for all Tuvaluans. This year 2022 in which this assignment is conducted is another challenging year for the country as it hit another prolong drought.

Rainwater is the only possible water supply that the whole population relies on. Therefore, in the case of prolong drought, the whole nation suffers from safe water for consumption including other domestic usage. Domestic animals, home gardens and other food crops, together with the entire terrestrial and fauna survivals will be potentially affected. During wet and rainy seasons, it is essential that water harvesting is prudently practiced. Given that rainwater is the only water resource that is essentially free, safe, and delivered by nature directly to the consumer. Nevertheless, there are times in Tuvalu when there is a need to supplement rainwater supplies with other sources.

While more information is needed about the extent and sustainability of our potable groundwater resources, it is a limited but nonetheless important resource on many of Tuvalu's outer islands. Groundwater is also used for non-potable uses throughout Tuvalu, and is therefore an important factor in reducing the pressure on drinking water supplies.

The first Reverse Osmosis was installed on Funafuti in 1992 and later on Nanumaga and Vaitupu where local conditions necessitate that a reliable back up supply be in place. The number of desalination units has recently increased through partner supports, and in response to a number of drought conditions. This year 2022 drought prompt more actions to procure more desalination plants though partnership support and distributed to other islands to overcome the drought crisis.

On the mainland of Funafuti, the only urban centre of Tuvalu suffered mostly from this 2022 drought as the population is high with limited rainwater storage facilities. Given this situation, the Public Works Department (PWD) provides water supplies stations, where 10,000 litres water tanks are filled with desalinated water and rationed to nearby households with six buckets of rainwater daily. It is the responsibility of a household to utilize its water ration wisely.

4.2 Decision context

The Government's Public Works Department is responsible for water distribution in Tuvalu. Reverse osmosis desalination plants are already in place in Funafuti, this source was intended originally during emergency but is now used as a main water supply especially on Funafuti. It is a very expensive way to acquire freshwater. In response, the Integrated Water Resources Management (IWRM) Project is currently exploring more cost-efficient methods to meet public demand for water and to gradually reduce the dependence on desalinated water supply.

From 2009-13, the Tuvalu Government with co-financing from the European Union distributed households across the country with water tanks of 10,000 litres in capacity. The Pacific Adaptation to Climate Change (PACC) also focused on improving communal water infrastructure as a drought mitigation measure. The community of Lofeagai on Fongafale Islet, a community of 637 people in 97 households, was selected as a pilot site for the project. The community did not have any 32 communal water reserves and during shortages people had to carry water in buckets from as far as 15 km away. In 2012, a 700,000 litres community cistern was installed by the PACC project in Lofeagai, which was officially opened in January 2013. As a result, 90% of the Lofeagai population now have access to the minimum water supply of 40 litres per household per day during extreme dry periods. Following the success of the first pilot, it was decided to replicate the project in the community of Tekavatoetoe, on the southern side of Fongafale Islet. Installation of a 288,000 litres concrete cistern was constructed and it provides emergency water reserve for the community.

The Sustainable and Integrated Water and Sanitation Policy 2012-2021 is a response to the 2011 drought and it sets out the policy framework to plan for and manage water crisis in the future. The mission statement of the policy is to ensure "Tuvalu will have a safe, reliable, affordable and sustainable water supply; with proper and improved eco-sanitation to fulfil island communities' basic needs as well as meeting the sustainable development needs of the country" by the year 2021.

Similar to many other Pacific Island Countries, Tuvalu faces pressures of growing populations, limited water resources and storage capacity, and poor sanitation infrastructure. Inadequate institutional capacity, intermittently spread of human resources, and irregular funding sources further challenge the public ability to effectively respond to water and sanitation issues.

Tuvalu vulnerability was dramatically illustrated in 1999 and 2011, when the country experienced a prolonged period of drought, for which a state of emergency was declared and drinking water supplies in some communities were pushed to the point of exhaustion. High year-to-year variability in rainfall is largely due to the impact of the El Niño Southern Oscillation (ENSO), a natural climate pattern that occurs across the tropical Pacific Ocean, playing a significant great role in the severity and incidence of droughts and extreme weather events.

Tuvalu is making steady progress in the management of its water resources through applying Integrated Water Resources Management (IWRM) and traditional water management methods. The IWRM approach acknowledges that water is everybody's business, from individuals to community and to government, and it is on this basis that Tuvalu developed its Water and Sanitation Policy which include seven goals as follows:

1. To provide a safe, reliable, affordable and sustainable water supply;
2. To manage and conserve scarce water supplies;
3. To establish and maintain effective early warning and response systems;
4. To enable effective, equitable and integrated governance of water and sanitation;
5. To increase community awareness and participation in the management of water and sanitation;
6. To improve access to reliable, affordable and environmentally sustainable technologies; and
7. To improve the affordability of water and sanitation services and increase access to sustainable sources of finance.

4.3 Overview of Existing Technologies in the Water Sector

Preliminary literature research on water adaptation technologies was undertaken as part of this assignment to come up with a pre-selection list from which the prioritization process will be based on. The assessment was done to determine which technologies are currently in use, economically reasonable for Tuvalu context and have the potential to be applied in Tuvalu. Following this and as highlighted in above chapters, a working group was formed to conduct a proper screening and prioritisation process which resulted in identifying 5 technologies (refer to Table 4.1) with the first three technologies ranked as most priority and appropriate for the purpose of this assignment. The following Table 10 tabulate the identified technologies and their status in Tuvalu.

Table 4.1: Selected technologies with their status in the country.

Priority Ranking	Technology	Relevance/Importance for Adaptation	Barriers
Water Sector Technologies			
1	Solar Reverse Osmosis System (Desalination Plant)	• Water shortages during drought seasons is serious. • Solar system is highly available and robust.	• Hardware Issues. • Unavailability of parts. • Lack expertise in Tuvalu. • Cost can be a concern, however, donor funding always available.
2	Water reticulation system (gravity pressure)	• Technology is viable and highly practised at household levels. • Non-existence at the community level. • A windmill water pump was installed in 1981 at Nukufetau under the SPC funding assistance was confirmed to be very useful. The system is water gravity distribution.	• Unavailability of parts for servicing and maintenance • The cost can be a concern at the local level. . • None institutional arrangement.
3	Groundwater solar extraction	• Underground water is available in outer islands. • Useful during drought periods. •	• Existence of groundwater acquifer/wells lack information. • Contamination of groundwater.
4	Plate type fresh water generator (solar powered)	• Not exist and so require trial.	• Maintenance issues. • Cost issues. • Limited access of information of the technology.
5	UV Filter system	• Few households use the technology utilizing their own water reservoirs. • Used as potable drinking water. • Few households use it and sell the water at very low cost for drinking only.	• Un-availability of parts. • Expensive to low income households. • Capacity limitation for maintenance.

4.4 Adaptation Technology Options for the Water Sector and their main adaptation benefits

In general, as agreed by the working groups of the three selected sectors, the long list of technologies for each sector has been trimmed down to five technologies. The selection, once again was drawn from a number of key documents and current climatic challenges faced by the water sector at present. These five technologies were prioritised using the MCA approach to select the most top three technologies that will certainly improve resilience and safety of domestic water supply and improvement of household livelihoods.

Following the guideline provided, the factsheets for the approved technologies were prepared with emphasis on the basic information about the technology options, including brief description of the technology, application potential in the country, costs (capital and operation), technical aspects (geographical applicability range, maturity), and the environmental, social, and economic impacts/benefits of their application in the country. These factsheets were circulated to stakeholders for review and feedback.

Brief summaries of the technologies and their respective contributions to adaptation are provided below:

Reverse Osmosis or Desalination is the elimination of sodium chloride and other dissolved elements from seawater, brackish waters, or contaminated freshwater. This technology support climate change adaptation, primarily through modification of water supply and resilience to water quality degradation. Modification of water supply can provide alternate or supplementary sources of water when current water resources are inadequate in quantity or quality.

Water reticulation system is the approach of transporting safe water supply from a source through a pipeline to reach households at various destinations or sites. It can be transported through gravity process or using a pressure pump on long distance locations. Pipelines are critical in this technology as damages may occur anytime. So proper connection and sizes selection of pipes at various points is crucial to avoid very slow of water flow.

Groundwater solar extraction refer to the extraction of underground water using solar energy pump to extract underground water efficiently and in a very sustainable process. It is essential that the technology allows the utilization of groundwater which is not easily affected by rainfall inconsistency, also supports mitigation benefits as well where there are offsets in greenhouse gas emissions.

Plate type fresh water generator refers to a system mainly consists of evaporating, condensing chamber, ejector equipped to achieve vacuum, freshwater pump for delivering distilled water to storage tanks. Similar to the reverse osmosis plant that desalinate seawater for the purpose of drinking water or other domestic used.

UV filter system refers to the use of ultraviolet light for water disinfection. The method is based on the natural disinfection action of the sun's rays. UV system provides the same ultraviolet germicidal rays through its UV lamps, just thousands of times stronger. No bacteria, viruses, molds or spores are able to withstand the water treatment path.

4.5 Criteria and process of technology prioritisation

On 8th April 2022 during the first awareness workshop, key stakeholders for the Adaptation Working Group discuss and prioritize the most three appropriate Technologies from the long list of technologies for the Coastal Sector. A follow up workshop in May 2022 feedback reveals that the prioritized technologies are applicable and relevant for the country. However, given the fact that, the Technology Fact Sheets (TFS) and the MCA tool were not considered during this prioritization, it was recommended that another round for prioritization was required. So, the working group reconvened after the BAEF workshop in July 2023. During this consultation, the Adaptation WG reviewed the TFS and go through the MCA exercise. As a result, they agreed to the TFS as well to the development of the MCA. It is appropriate to note that the selected criteria for prioritization were based on expert opinions and experience of individual stakeholders. Table 4.2 shows the criteria and processes used by stakeholders to prioritize the technologies.

Table 4.2: Selected criteria for the water sector

Category		Criteria
Costs		Cost to set up and operate.
		Cost of maintenance
Benefits	Economic	Improving livelihood and income opportunity.
		Job creation
		Trigger private investment.
	Social	Poverty reduction potential.
		Gender Equality, Diversity, and Social Inclusion (GEDSI).
	Environment	Protect and sustain ecosystem services.
	Climate Related	Improvement of resilience to CC.
Others	Institutional and Implementation	Ease of implementation.
		Replicability.
	Political	Coherence with national development, policies and priority

The above criteria are well defined with their potential relevancy so that they are not overlapping and they are locally recognised as meaningful in assessing the priority of the Technology. These criteria are listed in the MCA tool used for technologies prioritization.

Similarly to the Coastal Sector (above) criteria selection, stakeholders conveyed their endorsement on the relevance and appropriateness of the technologies in contrast with the identified criteria. Then based on expert opinions and stakeholders' experience, the following prioritisation on the sector criteria, indicators and scoring scale was developed. Table 4.3 below shows the criteria, indicators and scoring scale used for prioritization. Also refer to the MCA in Annex III.

Table 4.3: List of criteria, indicators and scoring scale used for prioritisation of the technologies

Criteria	Indicators	Scoring Scale
Cost	Set up and operation costs	0 = Very high cost 100+ = Very low cost
Maintenance cost	Cost of maintenance	0 = Very high cost 100+ Very low cost
Improving livelihood and income opportunity	Opportunity to obtain better livelihood and income from technology.	0 = Very low 100+ = Very high
Job Creation	People employed by the technology.	0 = Very low 100+ = Very high
Trigger private investment	Private opportunity inevstment	0 = Very low 100+ = Very high
Poverty reduction potential	None poverty community exist	0 = Very low 100+ = Very high
Gender Equality, Diversity, and Social Inclusion	Gender balance in decision making and development engagement.	0 = Very low 100+ = Very high
Protect and sustain ecosystem services.	Better ecosystems and benefits are obtained.	0 = Very low 100+ = Very high
Improvement of resilience to CC.	Improve protection opportunities to climate change.	0 = Very difficult 100+ = Very easy
Ease of implementation.	The technology is viable and implementable.	0 = Very difficult 100+ = Very easy
Replicability.	Easy to replicate the technology.	0 = Very difficult 100+ = Very easy
Coherence with national development, policies and priority.	The technology is inline with national priorities and policies.	0 = Very difficult 100+ = Very easy

Establishing the weightings for each indicator, stakeholders used the MCA analysis (Annex III) and came up with the following weighted score and criterion weight sensitivity as shown in Table 4.4 below.

Table 4.4: Result of weightings used for different criteria for the prioritisation and sensitivity analysis

Criteria	Criterion Weight	Criterion Weight & Sensitivity
Cost	11	11
Maintenance cost	0	0
Improving livelihood and income opportunity	10	10
Job Creation	0	0
Trigger private investment	8	6
Poverty reduction potential	16	20
Gender Equality, Diversity, and Social Inclusion	0	0
Protect and sustain ecosystem services.	17	15
Improvement of resilience to CC.	19	17
Ease of implementation.	8	10
Replicability.	6	6
Coherence with national development, policies and priority.	5	5
Total	100	100

4.6 Results of technology prioritization

Technically the Working Group prioritisation resulted in Solar Reverse Osmosis System (mobile) ranked as the most priority technology for the water sector. Followed by the Water Reticulation System (gravity process) ranked as number two priority; and the Groundwater Solar Extraction ranked as the third option technology.

Furthermore, emphasis was given to technologies with the potential to contribute to adaptation to the extreme events, prolonged dry periods and salinization. Much discussion also revolved around the cost implications of a technology and whether implementing a technology will contribute to broad development or sector development objectives such as poverty reduction and gender mainstreaming.

Solar Reverse Osmosis System

This is a technology in which salt water elements like sodium chloride and other salt components are removed from seawater using efficient solar pump to obtain safe drinking water. The technology pushed seawater through a reverse osmosis (RO) membrane to remove salt and other elements while filtering safe water for human use. It is highly used in arid areas and proved to be very crucial to areas or countries with very limited rainfall or frequently experiencing long drought periods.

The technology is definitely confirmed to be viable and cost effective in the context of Tuvalu. The Public Works Department (PWD) under the Ministry of Public Works, Infrastructure, Environment, Labour and Disaster (MPWIELD) had installed this type of technology in Funafuti that is currently servicing the communities with desalinated water. These machineries were also distributed to the outer islands to support water shortages during long drought periods. The value of the technology in its relevance to reducing vulnerability to cyclones, prolonged dry periods and salinization manifestation is the main observation of the Working Group in selecting this technology as the highest priority.

The performance of the technology was highly considered and discussed by the Working Group that resulted to be ranked as the first priority. Sensitivity analysis was also undertaken, with respects to, ensuring gender considerations were adequately considered. Refer to Table 4.4 above (depicted from the MCA result – Annex 3) shows the criterion weighting and sensitivity analysis.

Water Reticulation System (gravity process)
This is the water distribution network that exist within every advanced societal framework. An infrastructural layer, an essential gridwork of pipes and fittings. Usually transporting safe water from a source to an end point or to a consumer through gravity pressure. A tank is elevated at an appropriate height that can distribute water through gravity pressure in a pipeline network. Normally reticulation systems are common at household level and there is no communal reticulation system.

The technology is common in advanced societies which is likely to be viable and sustainable in the context of Tuvalu. Normally households connected to this technology network have fixed meters that monitor and display the amount of water usage per household. Water charges or bills are usually reasonable and in this case it must be affordable for Tuvaluans.

The Working Group as they rank this technology, they take into accounts the performance that the technology will provide to the public in general. They also consider the fact that water being reticulated is not exposed and always safe and easy to monitor their safety in terms of quality wise.

Groundwater Solar Extraction
Groundwater as highlighted in above sections is available on the outer islands. Therefore, its extraction to be utilized during drought periods is highly essential. The technology required at this point is the extraction of the water using a solar pump with high technology of self-efficiency by means of discontinue pumping at certain level of water in the overhead tank. It is crucial to monitor the pumping to avoid wasting water from overflow of the overhead tank. From the overhead tank, the water will be distributed in a network pipeline to households with gravity flow. This technology has been used in Tuvalu which was found viable and helpful for the benefit of the community.

Given the fact that the technology performance is more likely similar to the above ranked technologies, the Working Group therefore consider it priority that it is a must to be used for the underground water extraction. However, high level of monitoring the system is very crucial to avoid excessive use but keep the freshwater lense sustainable.

Considering the use of this technology, the Working Group feels that it is very essential to limit the use of the technology by not opening the system for the whole day. It has to be rationed out to the public within a schedule of opening hours. Through this plan, the freshwater lense will be anticipated to be highly sustainable.

Chapter 5: Technology prioritisation for the Agriculture Sector

5.1 Key Climate Change Vulnerabilities in the Agriculture Sector

Agriculture is the primary production that the whole population of Tuvalu being dependent on at a subsistence level. Subsistence agriculture plays a pivotal role in the livelihoods of communities and individual families. Conversely, the impacts of climate variability and climate change pose a serious risk to the agriculture sector and the entire food security for Tuvalu. Similar to other Pacific Island countries, agriculture activities are highly vulnerable to climate change induced changes in temperature and precipitation patterns, given the fact that all cropping practices relies mostly from rain water. Extreme rainfall and drought events, coupled with salinization processes, seasonal variations and reduction in freshwater availability contribute tremendously to impact the whole sector.

During severe rainfall, pulaka pits (giant swamp taro – the main root crop and staple food in Tuvalu) were inundated causing destruction to seedlings and encourage conditions that will support the existence of diseases and pests. Planted crops on ground surface also impacted and destroyed. Alternatively, drought contribute to dry up the soil, increase the temperature that added thermal stress on plants that finally decline crop yields. As climate change intensifies these incidences, crop growth will be impeded while land available for crop production will be decreasing.

Salt water inundation is another common phenomenon that impacted pulaka pits and ground level farming mostly during king tides associated with hurricanes and storm surges. The island of Nui and Nanumaga pulaka pits were devastated during TC Pam in 2015. Again Nui pulaka pits experienced similar devastation in later tropical cyclones, TC Ula and TC Tino.

5.2 Decision context

Food security is one sector of concern in relation to climate change in Tuvalu, in particular agriculture and fisheries. Coastal flooding and erosion are expected to exacerbate the existing situation, with traditional crop like pulaka (giant swamp taro) already becoming difficult to grow as a result of saltwater intrusion into the pulaka pits. Introduction of salt tolerant species is necessary as salinization will undermine food security of the country. The Department of Agriculture (DOA) has already developed a programme to address food security through the assistance of the SPC. The DOA efforts include, the introduction of pulaka tolerant species, banana species and other crops and facilitate home gardening for households at the community level.

Agricultural production (and market activity) is highly exposed and vulnerable to drought and cyclone impacts in particular. With projections for more intense or regular climatic impacts, there is also the associated increasing disaster risk outlook on agriculture and food security in general.

Health nutrition programmes supported food security improvement and encourage households to make backyards garden to grow green vegetables and fruit trees. The live-n-learn project supporting the health nutrition programme provides individual households on selected sites with home gardening tubs to grow vegetables and root crops.

In June 2018, Biofilta installed 200 of its Foodwall wicking garden beds across various sites including home gardens, the Hospital, University of South Pacific and schools. Installation was undertaken as an Australian Aid initiative implemented by Biofilta on behalf of the Australian Government Department of Foreign Affairs and Trade (DFAT). Biofilta also partnered with NGO, Growing Tall located in Funafuti.

The Taiwan Fatoaga Fiafia established in Funafuti and Vaitupu are key providers of vegetables and fruits on these two islands. Where there is excess at the Vaitupu garden, these were transhipped to Funafuti. Organic farming approach is the main method practiced in these gardens.

With climate change likely to make climatic conditions more unpredictable, combined with the growth of the cash economy and access to global markets, the Tuvaluan diet will continue to shift from traditional and locally harvested food to one that is based on imported food products. This is a major concern to population health and nutrition over the years to come.

5.3 Overview of Existing Technologies in Agriculture

A similar approach was adopted from the other two sectors in preparing an overview of existing technologies in the agriculture sector. Preliminary literature research on agricultural adaptation technologies was undertaken to come up with a pre-selection list from which the prioritization process will based on. The assessment was simply done to determine which technologies are currently in use, economically reasonable for Tuvalu context and have the potential to be applied in Tuvalu. Following this and as highlighted in above chapters, a working group was formed to conduct a proper screening and prioritisation process which resulted in identifying 5 technologies with the first three technologies ranked as most priority and appropriate for the purpose of this assignment. The following Table 5.1 tabulated the identified technologies and their status in Tuvalu.

Table 5.1: Selected technologies with their status in the country.

Priority Ranking	Technology	Relevance/Importance for Adaptation	Barriers
Agriculture Sector Technology			
1	Composting with tolerant varieties	• Composting is common in Tuvalu. • Climate change impact on plants and crops is high and ongoing. • Tolerant varieties are most essential.	• Technical expert requirement is essential. • Procurement of tolerant varieties.
2	Horticultural technology through Beddings (concrete, wooden, etc)	• Concrete based cultivation is now practice in Tuvalu (eg: swamp taro cultivation). • Raising farming above the ground is very essential for Tuvalu given its status to salt water intrusion and heavy/frequent drought.	• Technical expert may be required on new technologies.
3	Cultivator with Irrigation	• The status of poor soil quality in Tuvalu couple with in-favourable temperature with prolonged drought periods, it is a requirement to cultivate and irrigate the soil very often.	• Technology is expensive and require technical expertise and equipment. • Seeking donor assistance.
4	Plow and Crop rotation	• Similar to above technology (3). However, deeper soil cultivation will be more essential to overcome worst drought periods.	• Also the technology is expensive. • Donor assistances are available.
5	Livestock Farming technology	• Tuvaluans are very keen in livestock farming. So appropriate technologies are highly recommended.	• Improve current status of farming with marketing capacity building.

5.4 Adaptation Technology Options for the Agriculture Sector and their main adaptation benefits

Similar to other sectors, it was agreed by the working groups of the three selected sectors that the long list of technologies for each sector has been trimmed down to five technologies. The selection, once again was drawn from a number of key documents and current climatic challenges faced by the Agriculture Sector at the present situations. These five technologies were prioritised using the MCA approach to select the most top three technologies that will certainly improve resilience and safety of the agriculture sector and food security for the betterment of household livelihoods.

Following the guideline provided, the factsheets for the approved technologies were prepared with emphasis on the basic information about the technology options, including brief description of the technology, application potential in the country, costs (capital and operation), technical aspects (geographical applicability range, maturity), and the environmental, social, and economic impacts/benefits of their application in the country. These factsheets were circulated to stakeholders for review and feedback.

5.5 Criteria and process of technology prioritisation

On 8th April 2022 during the first awareness workshop, key stakeholders for the Adaptation Working Group discuss and prioritize the most three appropriate Technologies from the long list of technologies for the Coastal Sector. A follow up workshop in May 2022 feedback reveals that the prioritized technologies are applicable and relevant for the country. However, given the fact that, the Technology Fact Sheets (TFS) and the MCA tool were not considered during this prioritization, it was recommended that another round for prioritization was required. So, the working group reconvened after the BAEF workshop in July 2023. During this consultation, the Adaptation WG reviewed the TFS and go through the MCA exercise. As a result, they agreed to the TFS as well to the development of the MCA. It is appropriate to note that the selected criteria for prioritization were based on expert opinions and experience of individual stakeholders. Table 5.2 shows the criteria and processes used by stakeholders to prioritize the technologies.

Table 5.2: Selected criteria for the water sector

Category		Criteria
Costs		Cost to set up and operate.
		Cost of maintenance
Benefits	Economic	Improving livelihood and income opportunity.
		Job creation
		Trigger private investment.
	Social	Poverty reduction potential.
		Gender Equality, Diversity, and Social Inclusion (GEDSI).
	Environment	Protect and sustain ecosystem services.
	Climate Related	Improvement of resilience to CC.
Others	Institutional and Implementation	Ease of implementation.
		Replicability.
	Political	Coherence with national development, policies and priority

The above criteria are well defined with their potential relevancy so that they are not overlapping and they are locally recognised as meaningful in assessing the priority of the Technology. These criteria are listed in the MCA tool used for technologies prioritization.

Similarly to the Coastal Sector (above) criteria selection, stakeholders conveyed their endorsement on the relevance and appropriateness of the technologies in contrast with the identified criteria. Then based on expert opinions and stakeholders' experience, the following prioritisation on the sector criteria, indicators and scoring scale was developed. Table 5.3 below shows the criteria, indicators and scoring scale used for prioritization. Also refer to the MCA in Annex III.

Table 5.3: List of criteria, indicators and scoring scale used for prioritisation of the technologies

Criteria	Indicators	Scoring Scale
Cost	Set up and operation costs	0 = Very high cost 100+ = Very low cost
Maintenance cost	Cost of maintenance	0 = Very high cost 100+ Very low cost
Improving livelihood and income opportunity	Opportunity to obtain better livelihood and income from technology.	0 = Very low 100+ = Very high
Job Creation	People employed by the technology.	0 = Very low 100+ = Very high

Trigger private investment	Private opportunity inevstment	0 = Very low 100+ = Very high
Poverty reduction potential	None poverty community exist	0 = Very low 100+ = Very high
Gender Equality, Diversity, and Social Inclusion	Gender balance in decision making and development engagement.	0 = Very low 100+ = Very high
Protect and sustain ecosystem services.	Better ecosystems and benefits are obtained.	0 = Very low 100+ = Very high
Improvement of resilience to CC.	Improve protection opportunities to climate change.	0 = Very difficult 100+ = Very easy
Ease of implementation.	The technology is viable and implementable.	0 = Very difficult 100+ = Very easy
Replicability.	Easy to replicate the technology.	0 = Very difficult 100+ = Very easy
Coherence with national development, policies and priority.	The technology is inline with national priorities and policies.	0 = Very difficult 100+ = Very easy

Establishing the weightings for each indicator, stakeholders used the MCA analysis (Annex III) and came up with the following weighted score and criterion weight sensitivity as shown in Table 5.4 below.

Table 5.4: Result of weightings used for different criteria for the prioritisation and sensitivity analysis

Criteria	Criterion Weight	Criterion Weight & Sensitivity
Cost	11	11
Maintenance cost	0	0
Improving livelihood and income opportunity	10	10
Job Creation	0	0
Trigger private investment	8	6
Poverty reduction potential	16	20
Gender Equality, Diversity, and Social Inclusion	0	0
Protect and sustain ecosystem services.	17	15
Improvement of resilience to CC.	19	17
Ease of implementation.	8	10
Replicability.	6	6
Coherence with national development, policies and priority.	5	5
Total	100	100

5.6 Results of technology prioritisation

Technically the Working Group prioritisation resulted in Composting and tolerant varieties to be ranked as the most priority technology for the agriculture sector. Followed by the Horticultural technology through Beddings (concrete, wooden, etc) ranked as number two priority; and Cultivator & Irrigation ranked as the third option technology.

Furthermore, emphasis was given to technologies with the potential to contribute to adaptation to the extreme events, prolonged dry periods and salinization. Much discussion also revolved around the cost implications of a technology and whether implementing a technology will contribute to broad development or sector development objectives such as poverty reduction and gender mainstreaming.

Composting with tolerant varieties

Composting is a mixture of ingredients used as plant fertilizer and improve soil physical, chemical and biological properties. Given the fact that it is commonly practiced throughout Tuvalu by individual farmers, coupled with the fact that the Department of Agriculture had introduced new tolerant varieties of pulaka and banana, it is therefore highly recommended to aid benefits for the entire community of Tuvalu.

At the current situation, farmers had received both pulaka and banana varieties which have been planted and provides additional foods to communities.

Horticultural technology through Beddings (concrete, wooden, etc)

Horticulture is the science and art of the development, sustainable production, marketing and use of high value, intensively cultivated food and ornamental plants. These include crops that are diverse like annual and perennial species, fruits and vegetables and decorative indoor plants. Given the fact that poor soil is very common in Tuvalu, it is therefore recommended that raised beddings to grow these crops and plants is highly essential. The technology is now being practiced at household levels through individual initiatives or small projects initiatives. The Taiwan Fatoaga Fiafia Garden in Funafuti, Vaitupu and now extended to Papaelise and Funafala small communities, and even to outer islands is promoting such technology that had resulted in providing good amount of vegetables and fruits for the benefit of communities. The technology was proven to promote adaptation by avoiding soil salinity, salt intrusion and inundation which are the key climate impacts throughout Tuvalu.

Cultivator with Irrigation

Cultivator is a farm machine that designed to stir the soil around a crop to promote growth and destroy weeds. Also used for mixing soil that's already been broken up, such as when compost or fertilizer added after tilling and before planting. In the context of Tuvalu, this has not been practiced otherwise farmers used spades to stir soil in pulaka pits, nourished the soil with compost to plant pulaka. Given the very poor soil status in Tuvalu, it is essential to adopt this technology with the application of irrigation to improve soil productiveness. Simple irrigation technology can support farmers to adapt to climate change by providing efficient use of water supply. The use of bucket drip irrigation which been trialled in past years by the Agriculture Department is one of the essential technology. There are households with sufficient water storage capacity that can be used for basic home garden irrigation and grey water could be used too.

Chapter 6: Summary and Conclusions

Over-all, the main process undertaken in the development of this TNA report include desktop review, multi-stakeholder consultations and working groups exercises, couple with the expertise knowledge and processes provided by the Consultant and the TNA team. The key result required in this undertaking is to prioritize adaptation sectors limited to three sectors with their priority technologies of both the long list and the top three priorities. The result as mutually agreed in the overall process is tabulated in Table 16 below.

Table 6.1: The priority sectors and their technologies.

Sectors	Priority Technologies	Ranks
Coastal	• Computer Monitoring Model/Tool to monitor coastal erosion and currents strengths, etc.	1
	• Land reclamation - seawalls, sand bags.	2
	• Wave Breaker (lagoon and ocean)	3

	• Beach Groin	4
	• Tree Planting	5
Water	• Solar Reverse Osmosis System (Desalination Plant)	1
	• Water reticulation system (gravity process)	2
	• Groundwater solar extraction	3
	• Plate type fresh water generator	4
	• UV Filter system	5
Agriculture	• Composting with tolerant varieties	1
	• Horticultural technology through Beddings (concrete, wooden, etc)	2
	• Cultivator & Irrigation	3
	• Plow and Crop rotation	4
	• Livestock Farming technology	5

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Annex I: Technology Factsheets for selected technologies

Technology Fact Sheets for Coastal, Water and Agriculture Sectors

Coastal Sector Factsheets

Factsheet One: Computer monitoring model or tool.

Introduction	Computer monitoring model or tool is an essential device that will provide appropriate information to inform decision making and the selection of the most appropriate coastal protection technology. Given the current devastated status of coastal erosion in Tuvalu due to climate variation and changes, it is therefore fundamental to assess root causes of the problem so that counteractive measures can be appropriately identified, designed and implemented effectively. Should this model or tool provide efficient data, the effort on selecting and designing the most appropriate technology to protect coastal erosion will be easy and simply cost effective in the long run.
Technology	Computer Monitoring Model/Tool to monitor coastal erosion and currents strengths.
Country specific applicability and potential	**Capacity:** Technical capacity exists in the Public Works Department, Lands & Survey Department, as well in the Meteorological Services which surely can roll out this technology. Given the fact that the technology may comprise of different components and operational system, it is recommended that these institutions are provided with proper capacity building in order to operate the technology successfully. Expanding the knowledge to NGO actors and private sectors is highly recommended. **Scale of application:** Should cover the entire community under appropriate guidance provided by the National Government through the PWD and other potential Departments within government. **Time horizon – Short/Medium/Long Term:** A long-term application of the technology is recommended. However, monitoring throughout implementation is crucial and priority.
Status of technology in country	**Availability of Technology:** Technically this is not existing nor available anywhere in Tuvalu. However, the traditional knowledge applied by ancestors in terms of coastal protection methods, indicate that the technology is existing but never been documented nor robust. It looks like that it is a matter of passing on the knowledge through practical or transferrable skills. This proposed technology is anticipated to be a permanent tool that can used over years for data collection as anticipated.
Climate change adaptation benefits	The community-based monitoring model contributes to climate change adaptation and risk reduction by fostering the competency of communities to identify and select appropriate methodologies in response to observed impacts of climate variability on coastal impacts.
Benefits	**Economic development:** Provide employment through project implementation activities and support coastal coastline activities that produces economic incentives. **Social development:**

	Provisional of communities, individual families, men and women protection from sea water intervention. Building capacity of coastal communities. **Environment development:** Provide protection to coastal terrestrial and fauna species and the entire coastal ecosystem.
Financial Requirements and Costs	The overall cost of the technology will depend on the parameters that appropriately used in the technology along with the maintenance cost. The technology may cost over AUD5M.
Capital, operating costs	The overall operating cost is fundamental as it may takes several months or years to complete data collection cycle. So may be another AUD800K is required for the overall operation.

Factsheet Two: Land reclamation (seawalls, sandbags, etc)

Introduction	Land reclamation, usually known as reclamation, and also known as land fill (not to be confused with a waste landfill), is the process of creating new land from oceans, seas, riverbeds or lake beds. The land reclaimed is known as reclamation ground or land fill. The technology is new to Tuvalu given lack of working machineries and inadequate skills existing in-country. The piloted land reclamation in Funafuti which is now called Queen Elizabeth II Park (QEII Park) has been proved that the technology is highly important to protect the country from climate impacts to coastal areas and on the other hand, provides additional land for Tuvalu. This area is now the central area for Government main buildings to host national conventions or meetings and other national entertainment activities. Proper engineering designs and completion works turns robust and retain the reclaimed land area safe and secure from cyclones and other climate change influences. It is one of the first kind adaptation activity against coastal erosion as the result of the impact of climate change confirmed to be robust and favourable in the context of Tuvalu.
Technology	Land reclamation - seawalls, boulders and sand bags.
Country specific applicability and potential	**Capacity** Certainly, there is potential technical capacity of local experts that can be utilized whenever requires. However, further trainings and skills upgrading still a need to local experts. Partnership and donor assistances are considerably recommended. **Scale of application** The application of this technology in all coastal areas of Tuvalu is highly essential and feasible. However, proper in-depth assessment is highly recommended, particularly at sites where tides movements are vigorous and more damaging. **Time horizon – Short/Medium/Long Term** A long-term application of the technology is recommended. However, monitoring throughout implementation and after implementation is crucial and priority.
Status of technology in country	**Availability of Technology** The technology has been piloted in Funafuti (QEII Park) and confirmed feasible and relevant to the context of Tuvalu.
Climate change adaptation benefits	The technology provides adaptation benefits through a robust coastal protection and security to community residences as well coastal foods security and the entire livelihoods of people in Tuvalu.
Benefits	**Economic development**

	In the long-run the technology will provide an opportunity for economic incentives in terms of coastal development like small scale commercial farming and fishing. Protection of existing small industries around the area will be securely protected from coastal inundation and storm surges that will lead to advance industries. **Social development** From the social point of view, all communities around the area will be benefitted through gaining high social profit in terms of food security, economic incentives and better livelihoods. **Environment development** From the environment point of view, high security of terrestrial and marine species will gain better protection that will lead to a sustainable environment.
Financial Requirements and Costs	The technology requires funding availability that should be sourced from outside to meet the costs of heavy equipment, transportation and expert proficiency. AUD$10B may suffice to initiate a piloted programme. Can be piloted first in Funafuti as the main capital of the country.
Capital, operating costs	Overall operation cost is fundamental as long-term operation is considerable to sustain the technology. So a budget of AUD$3M annually may sustain the overall operation cost.

Factsheet Three: Wave Breakers.

Introduction	This technology is applied to slow down wave flows and catastrophic actions. Wave breakers have been trialled in other parts of the world in which they were confirmed to be robust in slowing down current movement and forceful actions. So, the introduction of this technology will surely provide less coastal erosion and may increase accretion which is highly recommended. Man-made wave breakers from concrete and reinforced rods in the form of tetrapod shapes are recommended for this approach. Other designs are also recommended if their status have been proved to be robust and withstand the context of Tuvalu current movement. Its adaptation contribution during cyclones and intense weather events associated with storm surges is obvious in protecting coastal areas from extreme erosion.
Technology	Wave Breakers
Country specific applicability and potential	**Capacity** The Public Works Department has the capacity and better knowledge in designing and conduct piloted mechanisms using the technology. Where there are gaps or lack of knowledge that may be required, donor and expert partnership is always available and tenderable. Current national projects like the Boat Harbour Project initiated in Nukulaelae has set up a scenario of such kind that can be imitated and improved for this technology. **Scale of application** The technology is applicable on every part of the coastal areas in the country. **Time horizon – Short/Medium/Long Term** A long-term measure is recommended given the high vulnerability of the whole country from the impacts of climate variability and changes.
Status of technology in country	**Availability of Technology** The technology is available upon request. However, a very similar technology was applied at the deep-sea wharf in Funafuti for the purpose of protecting the seawall erected at the wharf. Another successful scenario

	that has been realized is the wave breakers installed for the Nukulaelae Boat Harbour Project.
Climate change adaptation benefits	The technology provides adaptation benefits through a robust coastal protection and security to community residences as well coastal foods security and the entire livelihoods of people in Tuvalu.
Benefits	**Economic development** The technology in the long-run will provide a new excellent ecosystem for coastal marine species that can transform these resources into economic incentives. **Social development** In terms of food provisions, the technology is highly feasible to harbour and provide marine coastal resources for the entire population of Tuvalu. **Environment development** In the long-run, the technology will provide an entire protection mechanism to prevent coastal erosion and support the whole coastal ecosystem.
Financial Requirements and Costs	An appropriate amount of funds is required for the development of the technology and its implementation. Approximately AUD$50M will be adequate for a piloted system.
Capital, operating costs	Seeking donor funding support of around AUD$5M annually may suffice to initiate the operation of the technology while slowly absorbing the operation cost under the relevant Ministry.

Water Sector Factsheets

Factsheet One: Solar Reverse Osmosis (Desalination Plant)

Introduction	The technology comprises of the removal of salt water elements like sodium chloride and other salt components from seawater using efficient solar pump to acquire safe drinking water. Seawater is pushed through a reverse osmosis (RO) membrane to remove salt and other elements while filtering safe water for human use. Highly used in arid areas and in countries with very limited rainfall or frequently experiencing long drought periods like Tuvalu. So, it is very essential to the context of Tuvalu. The Public Works Department (PWD) under the Ministry of Public Works, Infrastructure, Environment, Labour and Disaster (MPWIELD) had install this type of technology in Funafuti that currently servicing the communities with desalinated water during dry seasons. This technology was also distributed to the outer islands. The value of the technology in its relevance to reducing vulnerability to cyclones, prolonged dry periods and salinization manifestation is the main observation of the Working Group in selecting this technology as high priority. It is considered as an excellent adaptation technology that can be used during prolonged droughts and dry seasons.
Technology	Solar Reverse Osmosis (Desalination Plant)
Country specific applicability and potential	**Capacity** PWD and Tuvalu Electricity Corporation (TEC) had sufficient capacity to install and operate the technology. PWD will focus on the technology itself while TEC assist in the installation of the solar system. It's more-less a combine effort. **Scale of application** The technology is expected to cover the whole country, so individual islands will receive one appropriate unit for servicing communities. **Time horizon – Short/Medium/Long Term**

	Require a long-term system with high consideration of maintenance and operation costs.
Status of technology in country	**Availability of Technology** The technology already exists but powered by diesel electricity. Solar power will be used at this stage.
Climate change adaptation benefits	The technology provides adaptation benefits through securing water supply for the communities on each island. Moreover, the use of solar power to organize the entire functioning of the system highly contribute to the adaptation and mitigation approaches due to climate change.
Benefits	**Economic development** The water extracted from the technology will generate a small income to support operational and maintenance costs. **Social development** Communities at large will benefit a lot from the technology. Also support individuals through small income generation in terms of labour cost by distributing the water to customers. **Environment development** The technology provide support to the terrestrial ecosystem through reserving underground water.
Financial Requirements and Costs	Financial requirement highly depends on the size of the technology that needed to cater for the community. If the community is large as in the case of Funafuti, then a bigger system is required. Perhaps funding support can be sought from a donor around AUD$500M to procure a machine.
Capital, operating costs	The overall operation and maintenance cost must be around AUD$10M to kick off the project while absorbing it slowly into the PWD.

Factsheet Two: Water Reticulation System (gravity process)

Introduction	The technology can be described as a distribution network, an infrastructural layer or an essential gridwork of pipes and fittings that transport safe water from a source to an end point or to a consumer through gravity pressure. A tank is elevated at an appropriate height that can distribute water through gravity pressure. The system is preferred to be a communal reticulation system. Households connected to this technology network will have fixed meters that monitor and display the amount of water usage per household. Water charges or bills will be provided to households according to the amount of water utilization. Even though households are connected to this system, they still have the opportunity to enjoy using their own water supply.
Technology	Water Reticulation System (gravity process)
Country specific applicability and potential	**Capacity** The PWD has the capacity in installing, maintaining and oversee the overall operation of the technology. There are also private companies with skills to execute the implementation of the technology. On outer islands, Kaupule (local government) will be responsible to the technology. **Scale of application** The technology is anticipated to provide benefits to the entire communities on each island as well existing institutions like schools, hospital, etc. **Time horizon – Short/Medium/Long Term** A long-term technology system is recommended. So, funding support for operation and maintenance is very essential.

Status of technology in country	**Availability of Technology** There is no public reticulation system in existence, however, individual households have their own reticulation systems using their own water storage tanks and cisterns.
Climate change adaptation benefits	The technology provides adaptation benefits in terms of rationing water during long periods of drought.
Benefits	**Economic development** The reticulation system will operate sustainably through income generated from water charges. **Social development** All households will be benefit from this technology by obtaining water supply from the grid, as long as they are connected. **Environment development** Perhaps the technology may not provide direct benefits for the environment, however, the service it performed will support the environment in some other aspects.
Financial Requirements and Costs	The project requires sufficient funding, so seeking for donor assistance is crucial. The only expenses to be considered include costs of pipes and fittings, overhead water tanks, water meters and other small essential items. So the overall cost is estimated for AUD$20M for a pilot system in Funafuti.
Capital, operating costs	The overall operation and maintenance cost for a start is estimated around AUD$5M.

Factsheet Three: Groundwater Solar Extraction

Introduction	The extraction of underground water using solar energy pump to extract underground water is an attempt to draw water efficiently and in a very sustainable process. The technology allows the utilization of groundwater which is not easily affected by rainfall inconsistency, also supports mitigation benefits as well where there are offsets in greenhouse gas emissions. Groundwater is another source in Tuvalu that may be sufficient for public use during prolong droughts. So, the extraction of the supply wisely is crucial with high technology consideration. There is a piloted project in past years using wind power energy to extract the water on the island of Nukufetau, which is perfectly working as anticipated. So, a similar technology using the solar energy system is recommended. Niutao Island has used the same technology
Technology	*Groundwater Solar Extraction*
Country specific applicability and potential	**Capacity** PWD and other private contractors has the capacity to implement the technology. **Scale of application** The technology is potentially providing an excellent service to the public at large, including institutions like schools and businesses. So the application of the technology will actually benefits all the islands communities. **Time horizon – Short/Medium/Long Term** A long-term technology system is highly recommended for the whole country. However, the national and local government are urged to consider the technology and to maintain it sustainably.
Status of technology in country	**Availability of Technology**

	At the current status, there is no existing technology as the piloted one in Nukufetau is no longer operational, while the pipe network is assumed to be existing.
Climate change adaptation benefits	Similar to above technologies, this one will provide water supply to communities during drought periods.
Benefits	**Economic development** Certainly, the technology will generate a small income through water supply consumption charges/bills as well creating jobs on the overall operation of the technology. **Social development** Small income generation and job creation will support individuals and communities in general. **Environment development** Although there might be no direct benefit realized, however, it does provide support from other viewpoints such as the use of water for proper sanitation. This approach supports the theme of learning to avoid wasting water. Meaning that using waste water for sanitation purposes.
Financial Requirements and Costs	The overall financial requirement includes cost of pipes, fittings, water meters, solar pump, solar PVs and fittings, other small items as may necessarily requires. An estimation of AUD$50M for a piloted project is recommended.
Capital, operating costs	The overall operational and maintenance cost for a start is estimated to AUD$10M.

Agriculture Sector Factsheets

Factsheet One: Composting with tolerant varieties

Introduction	Composting is a mixture of ingredients used as plant fertilizer and improve soil physical, chemical and biological properties. Commonly prepared by decomposing plant leaves, food waste, recycling organic materials and manure. The technology is commonly used by Tuvaluan forefathers to cultivate their pulaka (giant swamp taro) pits. The technology comprises of rotten leaves (coconut fronds, breadfruit and pandanus leaves and other tree leaves) that are highly decomposable by putting them around the pulaka and cover it with muddy soil to accelerate decomposition and nourishing the pulaka. This technology provides naturally man-made soil nutrients that will increase crop productivity and preserve soil productivity for the root crop (pulaka). It also had positive effects on the pulaka during drought conditions and depletion of nutrient stocks. It is recommended that through using this technology and the introduction of drought tolerant varieties of pulaka and taro with other crops and fruit trees, certainly will probably overcome the impact of drought and poor soil nutrient capacity. At present, the Taiwanese Fatoaga Fiafia do use the technology through organic farming. Likewise, the Department of Waste is employing the technology through shredding green leaves for composting purposes that also generate a minimal income activity through selling compost publicly for AUD$2 per garbage bin.
Technology	Composting and tolerant varieties
Country specific applicability and potential	**Capacity** The technology is existing nationally and commonly used on daily basis by farmers and individual households. The Department of Waste is employing the technology and sell out compost manure for AUD$2. The Taiwan Fatoaga Fiafia also used composting technique to grow vegetables and fruit trees.

	Scale of application Given that current practices of the technology is existing in the country, it is crucial to strengthen it with support from the Department of Agriculture and other relevant institutions. **Time horizon – Short/Medium/Long Term** A long-term technology approach is recommended.
Status of technology in country	**Availability of Technology** As highlighted above, the technology is existing in the country through individual farming as well employed by institutions like the Department of Waste and the Taiwan Fatoaga Fiafia.
Climate change adaptation benefits	The technology is anticipated to alleviate stresses on crops and food trees as a result of climate change impact.
Benefits	**Economic development** Small income generation and job creation can be realized through using the technology. **Social development** From the social point of view, the public at large will obtain and maintain the sustainability food crops and trees. **Environment development** The technology in general will support the entire environment in maintaining it naturally through using compost to enrich the soil for plant growth.
Financial Requirements and Costs	Seeking financial support from donors is very essential to meet the technology cost. Cost of equipment, labour and land lease are the core expenses for consideration. It is estimated to secure AUD$50M to initiate the technology.
Capital, operating costs	Operation and maintenance cost is estimated to AUD$10M for a start.

Factsheet Two: Horticultural technology through Beddings (concrete, wooden, etc)

Introduction	Horticulture is the science and art of the development, sustainable production, marketing and use of high value, intensively cultivated food and ornamental plants. These include crops that are diverse like annual and perennial species, fruits and vegetables and decorative indoor plants. Given the fact that poor soil is very common in Tuvalu, it is therefore recommended that raised beddings to grow these crops and plants is highly essential. The technology is currently practiced at household levels through individual initiatives or small projects initiatives. The Taiwan Fatoaga Fiafia Garden in Funafuti, Vaitupu and now extended to Papaelise and Funafala small communities, and even to outer islands is promoting such technology that had resulted in providing good amount of vegetables and fruits for the benefit of communities. The technology was proven to promote adaptation by avoiding soil salinity, salt intrusion and inundation which are the key climate impacts throughout Tuvalu.
Technology	Horticulture technology through Beddings.
Country specific applicability and potential	**Capacity** Household levels have learned the approach from the Taiwan Fatoaga Fiafia, coupled with capacity build from previous food nutrition programmes conducted by the Department of Health and the Department of Agriculture. **Scale of application** The technology is anticipated to apply to the whole community of Tuvalu. **Time horizon – Short/Medium/Long Term**

	The timeframe recommended for the technology is to be a long-term approach system. So, sustainability cost is essentially required for consideration.
Status of technology in country	**Availability of Technology** As highlighted above, the technology is existing at the household level and at the Taiwan Fatoaga Fiafia.
Climate change adaptation benefits	Soil salinity and salt water inundation and intrusion is continuously experienced throughout Tuvalu. The technology will assist crops stresses from the impact of climate variability and changes.
Benefits	**Economic development** Small income generation and job creation will be realized using the technology. **Social development** Benefits gained by communities and individual families will be huge as they can use the technology sustainably without worrying about the impact of climate variation and changes. **Environment development** In fact, the technology provides adaptation approaches by avoiding unconditional of environmental situations like soil salinity and intrusion.
Financial Requirements and Costs	Similar to other technologies, financial requirement will be focusing on the farming approach that will be used and the type of bedding required. Currently there are pvc tubs or concrete made tubs that can be used to grow vegies and other reliable crops like taro. Wooden beddings are commonly used at household levels. So, the estimated cost is around AUD$100M to initiate the programme.
Capital, operating costs	Perhaps the overall operation and maintenance cost is estimated to AUD$20M.

Factsheet Three: Cultivator with Irrigation

Introduction	Cultivator is a farm machine that designed to stir the soil around a crop to promote growth and destroy weeds. Also used for mixing soil that's already been broken up, such as when compost or fertilizer added after tilling and before planting. In the context of Tuvalu, this has not been practiced otherwise farmers used spades to stir soil in pulaka pits, nourished the soil with compost to plant pulaka. Given the very poor soil status in Tuvalu, it is essential to adopt this technology with the application of irrigation to improve soil productiveness. Simple irrigation technology can support farmers to adapt to climate change by providing efficient use of water supply. Particularly in the case of Tuvalu which highly subject to climate change impacts such as seasonal droughts, couple with water evaporation losses (as evaporation increases at higher temperatures).
Technology	Cultivation technology with Irrigation
Country specific applicability and potential	**Capacity** The Department of Agriculture has the capacity and knowledge in employing the technology. However, the procuring of required machines and essential equipment is substantial for this technology. **Scale of application** The technology is anticipated to be applied at all household levels on the islands of Tuvalu. **Time horizon – Short/Medium/Long Term** A long-term approach of the technology is required.
Status of technology in country	**Availability of Technology** The Department of Agriculture had already employed the technology in the past in its demo-farm in Elisefou, Vaitupu Island. It is essential that the

	technology is revisited for implementation. Currently the Taiwan Fatoaga Fiafia in Vaitupu is repeating the technology.
Climate change adaptation benefits	The key adaptation benefit of the technology is the reconditioning of poor soil due to climate variation and changes and cater for the nourishment of crops and plant growth.
Benefits	**Economic development** The technology may create small income generation through sales of food crops obtained from the technology. **Social development** The capacity of individual farmers will be improved in terms of knowledge in farming. **Environment development** The entire environment will obtain benefit from the technology through sustainable soil that will support the growth of food crops, plants and trees.
Financial Requirements and Costs	Based from the nature of the technology, financial requirements will focus on costs of the cultivator, the tractor, irrigation system and other essential items required for the technology. The estimated cost is around AUD$100M. Seeking donor support is crucial.
Capital, operating costs	Operation and maintenance cost is estimated around AUD$20M.

Annex II: List of stakeholders involved and their contacts

A: List of adaptation stakeholders consulted – Inception consultation

Tuvalu government agencies			
Participant		***Position/ Organisation***	***E-mail***
1.	Mr. Sitia Maheu	GCCA Project Officer, CCD.	*cdia.army@gmail.com*
2.	Mr. Alamoana Tofuola	WSP Project Coordinator, CCD.	*alamoanat@gmail.com*
3.	Ms. Vaiaoga V Lameko	Readiness Project Coordinator, CCD.	*vaiaogal@gmail.com*
4.	Mr. Simeti Lopati	Readiness Project Consultant, CCD.	*simeti@gmail.com*
5.	Mr. Taukelina Finikaso	TNA Project – Assistant Coordinator, CCD.	*finikaso@gmail.com*
6.	Mr. Lomiata Niuatui	TNA Project – Mitigation Consultant, CCD.	*lomiatan@gmail.com*
7.	Mr. Patuki Faletiute	Technical and Finance Officer (IASP), Dept of Environment.	*faletiute7@gmail.com*
8.	Mr. Taaku Sekielu	Distribution Manager, TEC.	*taaku.sekielu@gmail.com*
9.	Mr. Mataio Tekinene	TNA Project – Adaptation Consultant, CCD.	*mtekinene@gmail.com*
10.	Ms. Faailo Pasekfika Eliesa	Waste Operation Officer, Dept. of Waste Management	*fpasefika@gmail.com*
11.	Mr. Lae Peleti	Snr Statistician, Central Statistics Dept.	*lpeleti@gov.tv*
12.	Mr. Saeala Pisi	EIA Officer, DoE.	*saealapisi2010@gmail.com*
13.	Mr. Alan Resture	TCAP Project Manager, CCD.	*alan.resture@undp.org*
14.	Ms. Pepetua E Latasi	Director, CCD.	*platasi@gov.tv*
15.	Mr. Jamie U Ovia	Mitigation Officer, CCD.	*jovia@gov.tv*
16.	Ms. Faatupu Simeti	TNA Project – Coordinator CCD.	*4tupu.s@gmail.com*
17.	Mr. Talake F Teo	Sector Economist, Planning, Budget & Aid Coordination Dept.	*tfteo@gov.tv*
18.	Ms. Galivaka T Niko	Director, Dept. of Local Government	*takeisi@gmail.com*
19.	Ms. Toeaso Tulaga	Snr Extension Officer, DoA.	*asora.tulaga@gmail.com*
20.	Mr. Iosia Taomia	Energy Information Specialist, Dept of Energy.	*itaomia@gov.tv* *jnrjohn257@gmail.com*
21.	Mr. Lono Leneuoti	MCAP Project Coordinator, CCD.	*lleneuoti@gmail.com*
22.	Ms. Taloline T Afega	Snr Tax Officer, Revenue and Customs Dept.	*ttakuo@gov.tv*
23.	Mr. Sokotia Kulene	Director, Gender Affairs Dept.	*skulene@gov.tv*
24.	Mr. Sailoto Leauma	Water Division, Public Works Dept.	*shsaioflife11@gmail.com*
25.	Mr. Luka Selu	Director, Dept. of Disaster Management	*lukaselu1@gmail.com*

26.	Ms. Enileta George	Secretary Funafuti Kaupule, Local Government.	
27.	Mr. Semi Vine	Pule Kaupule, Funafuti Kaupule, Local Government	
Non-government organisations			
Participant		***Position, Organisation***	***E-mail***
1.	Mr. Talua Nivaga	Chairman, Fuligafou Group	*Tnivaga92@gmail.co*
2.	Ms. Vasa Saitala	SUPA Project Coordinator, USP.	*v_saitala@yahoo.com*
3.	Ms. Teimana Avanitele	Member, Tuvalu National Council of Women	*teiavanitele@gmail.com*
4.	Mr. Richard Gokrun	Director, Tuvalu Climate Action Network (TuCAN)	*director@tuvalucan.tv*
5.	Ms. Tamala Pita	Climate Action Officer, Tuvalu Red Cross Society	*tamalafele@gmail.com*

Abbreviations:

GCCA	Global Climate Change Alliance		
WSP	Water Safety Project		
TNA	Technology Needs Assessment		
EIA	Environmental Impact Assessment		
TCAP	Tuvalu Coastal Adaptation Project		
MCAP	Managing Coastal Aquifer Project		

B: List of Stakeholders Working Groups

SECTORS	RESPONSIBLE PERSON	CONTACT (email/phone)
WATER SECTOR		
Water Security Project	Alamoana Tofuola	alamoanat@gmail.com
MCAP	Lono Leneuoti	lleneuoti@gmail.com
Water and Sanitation Project	Sitia Maheu	cdia.army@gmail.com
Water Sector – PWD	Sailoto Taliu	shsaioflife@gmail.com
Funafuti Kaupule	Tutonu Bruce	tutonu.bruce@gmail.com
Local Government Department	Suiti Faavae	suitifaavae2019@gmail.com
Department of Disaster Management	Luka Selu	lukaselu1@gmail.com
Public Health	Vine Lei	vine.sosene@gmail.com
Tuvalu Red Cross	Tagifoe Taomia	tagifoe@gmail.com
AGRICULTURE SECTOR		
Agriculture department	Selotia Tausi	sltausigeorge@gmail.com
Department of Waste Management	Epu Falenga	licaepu@gmail.com
Climate Security Project	Saamu Tui	mataakapau@gmail.com
Tuvalu National Women's Council	Pula Toafa	pula_toafa@yahoo.com
Department of Environment	Alitaake Alefaio	allyalefaio@gmail.com
National Disaster Management Officer	Talafou Esekia	talafouesekia68@gmail.com
TNA - Climate Change Department	Lomiata Niuatui	lomiatan@gmail.com
IASP – Environment Department	Patuki Faletiute	faletiute7@gmail.com
COASTAL SECTOR		
Coastal Unit – Fisheries	Sam Finikaso	samfinikaso70@gmail.com
Tuvalu Coastal Adaptation Project	Alan Resture	aresture@gmail.com
Invasive Species project	Sam Panapa	sampanapa@gmail.com
Department of Environment	Tilia Asau	tilia.tima@gmail.com
Climate Change Department	Pepetua Latasi	pepetua@gmail.com
Fuligafou Association	Talua Nivaga	tnivaga92@gmail.com
Gender Affairs	Salesa Falesene	sfalesenesalesa@gov.tv
Tuvalu Climate Action Network	Richard Gorkrun	richardgorkrun@gmail.com
Tuvalu PROP Project	Reena Mataio	reenam@tuvalufisheries.tv

Annex III: Multi Criteria Analysis (MCA) Result

Scoring Matrix

#	Sector	Technology	Costs			Benefits										Other			
			Costs			Economic			Social			Environmental			Climate related	Institutional/Implementation		Political	
	Sector	Technology	Cost to set up and operate the technology per beneficiary /year	Cost of maintenance		Improving livelihood and income opportunity	Job creation	Trigger private investment	Poverty reduction potential and improve livelihood	Imnational GEDSI				Contribution of the technology to protect and sustain ecosystem services	Improvement of Resilience to Climate Change (i.e. to what extent the technology will contribute to reduce vulnerability to climate change impacts)	Ease of implementation	Replicability	Coherence with national development policies and priority	
1	Coastal	*Computer monitoring model or tool to monitor coastal erosion*	75	75		20	10	10	10	50				100	100	50	80	100	
2	Coastal	*Land reclamation to protect land erosion and adding land area for safe livelihood*	0	75		100	80	70	100	100				70	100	50	80	100	
3	Coastal	*Wave breakers to protect land from erosion*	25	75		80	40	10	80	100				80	100	50	50	100	
4	Water	*Solar reverse osmosis system*	0	75		80	20	10	80	50				65	80	65	75	100	
5	Water	*Water reticulation system (gravity pressure)*	75	75		75	50	20	75	80				30	40	35	40	100	
6	Water	*Ground water extraction using solar pumps*	25	75		60	30	10	60	50				20	60	45	30	100	
														0					
7	Agriculture	*Composting for tolerant varieties*	25	75		100	60	10	80	100				90	40	50	100	100	
8	Agriculture	*Horticultursl technology through beddings*	0	75		60	45	10	60	70				40	80	45	100	100	
9	Agriculture	*Cultivator and Irrigation*	0	75		100	25	20	25	100				85	85	50	60	35	
		Scoring scale	0=very high cost --> 100=very low cost			0= Very low --> 100= Very high		0= Very low --> 100= Very high	0= Very low --> 100= Very high					0= Very low --> 100= Very high	0=Very Difficult -->100=Very Easy	0=Very Difficult -->100=Very Easy	0=Very Difficult -->100=Very Easy	0= Very low --> 100= Very high	
		Criterion weight	11			10		8	16					17	19	8	6	5	100
		Criterion weight, sensitivity	11			10		6	20					15	17	10	6	5	100 should add to 100

Decision Matrix: Weighted Scores

#	Technology	Costs			Benefits										Other				
		Costs			Economic			Social			Environmental			Climate related	Institutional/Implementation		Political		
		Cost to set up and operate the technology per beneficiary /year	Cost of maintenance	0	Improving livelihood and income opportunity	Job creation	Trigger private investment	Poverty reduction potential and improve livelihood	Imnational GEDSI	0	0	0	Contribution of the technology to protect and sustain ecosystem services	Improvement of Resilience to Climate Change (i.e. to what extent the technology will contribute to reduce vulnerability to climate change impacts)	Ease of implementation	Replicability	Coherence with national development policies and priority	Total Benefit	Technology Rank
1	*Computer monitoring model or tool to monitor coastal erosion*	825	0	0	200	0	60	200	0	0	0	0	1500	1700	500	480	500	5965	1
2	*Land reclamation to protect land erosion and adding land area for safe livelihood*	0	0	0	1000	0	420	2000	0	0	0	0	1050	1700	500	480	500	7650	2
3	*Wave breakers to protect land from erosion*	275	0	0	800	0	60	1600	0	0	0	0	1200	1700	500	300	500	6935	3
4	*Solar reverse osmosis system*	0	0	0	800	0	60	1600	0	0	0	0	975	1360	650	450	500	6395	4
5	*Water reticulation system (gravity pressure)*	825	0	0	750	0	120	1500	0	0	0	0	450	680	350	240	500	5415	5
6	*Ground water extraction using solar pumps*	275	0	0	600	0	60	1200	0	0	0	0	300	1020	450	180	500	4585	6
7	*Composting for tolerant varieties*	275	0	0	1000	0	60	1600	0	0	0	0	1350	680	500	600	500	6565	7
8	*Horticultursl technology through beddings*	0	0	0	600	0	60	1200	0	0	0	0	600	1360	450	600	500	5370	8
9	*Cultivator and Irrigation*	0	0	0	1000	0	120	500	0	0	0	0	1275	1445	500	360	175	5375	9
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Criterion weight	11	0	0	10	0	6	20	0	0	0	0	15	17	10	6	5	100	

Step 1: Add your criteria: D7 - M7

Step 2: Add your options: A7 - A16

Step 3: Add criteria weights: B18 - M18

Step 4: Rate how well the options contribute to each criterion: B7 - M16

Step 5: View weighted results and total benefit results in second table, 'Weighted Scores': B24 - M33

Note: You may need more or less rows for technology options or columns for criteria. Just add/delete them within the framework provided.