NAURU

TECHNOLOGY NEEDS ASSESSMENT
FOR
CLIMATE CHANGE ADAPTATION

Barrier Analysis and Enabling Framework

JUNE 2021
BARRIER ANALYSIS AND ENABLING FRAMEWORK FOR CLIMATE CHANGE ADAPTATION TECHNOLOGIES

REPORT II

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This document is an output of the Technology Needs Assessment (TNA) project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Program (UNEP) and the UNEP DTU Partnership (UDP) in collaboration with the University of the South Pacific (USP). The present report is the output of a fully country-led process and the views and information contained herein is a product of the TNA team, led by the Department of Climate Change and National Resilience, Republic of Nauru.
Forward

“The lessons of the past are clear not only for Nauruans but for the rest of the world as well. Waste not this precious planet, or you shall want. Squander non-renewable resources at your risk. Destroy land, and you destroy human culture. Devastate the forest, and you will lose the coral reef as well, for the forest and the reef are like husband and wife. (extract from Nauru's Plenary Address to the "United Nations Global Conference on the Sustainable Development of Small Island Developing States", Bridgetown, Barbados, 1994)

The Republic of Nauru’s high vulnerability to adverse impacts of climate change, in particular extreme climatic events, sea level rise and water scarcity on the Island means that the country is in dire need of innovative adaptation technologies to lessen damage to life, property, natural eco-systems, and its economy. I am confident that the Technology Needs Assessment (TNA) process initiated by the Department of Climate Change and National Resilience (DCCNR) in partnership with the United Nations Environment Program (UNEP), University of the South Pacific (USP) and UNEP DTU Partnership will play an effective role in increasing resilience against climate change vulnerabilities through transfer and diffusion of prioritized technologies in prioritised sectors including water, coastal area vegetation restoration and removing barriers in their adoption. I am pleased to note that the entire process to set preliminary targets for transfer and diffusion of technologies, identify barriers and suggest an enabling framework for overcoming the barriers in this phase-II of the TNA project has been country-driven despite of the impact of the current covid 19 pandemic. Being highly consultative, it involved a number of stakeholders and experts from the government, private sector, and non-government organisations. I strongly believe that the implementation of adaptation technologies prioritized in TNA Adaptation Report Phase-II will help the country in building resilience to the impacts of climate change. I would like to thank the members of the TNA National Team and my colleagues in the Department and experts of the Adaptation Working Group for their invaluable contributions to the preparation of this Report. I also thankfully acknowledge the contributions of Dr. Michael Otoara Ha’apio, Adaptation national consultant, Abraham Aremwa, Mitigation national consultant and other experts of USP, United UNEP, UNEP-DTU Partnership and the Asian Institute for Technology (AIT) for their constant support and guidance for implementation of the TNA project.

Mr Reagan Moses,
Secretary for Climate Change and National Resilience
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<th>Full Form</th>
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<td>AEWG</td>
<td>Adaptation Expert Working Group</td>
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<tr>
<td>AIT</td>
<td>Asian Institute for Technology,</td>
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<tr>
<td>CBO</td>
<td>Community Based Organisation,</td>
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<tr>
<td>CED</td>
<td>Climate Change and Environment division,</td>
</tr>
<tr>
<td>DCIE</td>
<td>Departments of Commerce, Industry and Employment,</td>
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<tr>
<td>DCNR</td>
<td>Department of Climate Change and National Resilience</td>
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<tr>
<td>DoE</td>
<td>Department of Education (DoE),</td>
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<tr>
<td>DTU</td>
<td>Technical University of Denmark,</td>
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<tr>
<td>GCF</td>
<td>Green Climate Fund</td>
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<tr>
<td>GEF</td>
<td>Global Environment Facility</td>
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<tr>
<td>LMMA</td>
<td>Locally Managed Marine Area,</td>
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<tr>
<td>NFMRA</td>
<td>Nauru Fisheries and Marine resource authority,</td>
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<tr>
<td>NGO</td>
<td>None Government Organisation,</td>
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<tr>
<td>NSDS</td>
<td>National Sustainable Development Strategy,</td>
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<tr>
<td>NUC</td>
<td>Nauru Utility corporation,</td>
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<tr>
<td>NWSHIP</td>
<td>National Water, Sanitation and Hygiene Implementation Plan,</td>
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<tr>
<td>NWSPH</td>
<td>National Water, Sanitation and Hygiene Policy,</td>
</tr>
<tr>
<td>RO</td>
<td>Reverse Osmosis,</td>
</tr>
<tr>
<td>RoNAdat</td>
<td>Republic of Nauru Framework for climate Change and Disaster Risk Reduction.</td>
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<tr>
<td>RT RWHT</td>
<td>Rooftop Rainwater Harvesting Technology,</td>
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<td>RTRWH</td>
<td>Rooftop Rainwater Harvesting,</td>
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<tr>
<td>TNA</td>
<td>Technological Need Assessment,</td>
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<tr>
<td>UNEP</td>
<td>United Nation Environment Program,</td>
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<tr>
<td>USP</td>
<td>University of the South Pacific</td>
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<tr>
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Executive Summary

Nauru is a small island developing state (SIDS) with a land area of 21 km². The population of just over 10,000 people is mostly settled on the coastal perimeter of the island, in a thin strip between the reef and the elevated interior. Most of the island’s raised interior has been mined for phosphorous over several decades, with the result that the land surface is severely degraded. Phosphate rock has provided Nauru’s main export income, and although primary mining is winding up there are plans to continue secondary mining (removing rock pillars at the surface followed by extraction of deeper phosphates). At one stage mining created a wealthy society, during which the government provided most basic services such as – housing, electricity, water – free of charge to its population. However, mining revenues are now in decline, and so too is the government’s ability to provide or maintain infrastructure around the island (Connell, 2006). This situation is enhanced by Nauru’s need to import most of its necessities to support its growing population. With virtually no agriculture, almost all food is imported apart from fish. Similarly, with virtually no renewable energy capacity all energy resources are imported in the form of fossil fuels, including those needed to run the power station. Consequently, Nauru is highly vulnerable to external market shocks which raise the price of food or fuel. Prior to 1995, drinking water was also imported. Since then, however, a succession of five (5) desalination plants have provided treated water, which is delivered, on request, to household tanks by trucks. The other main sources of water are rainfall captured in household or small community tanks and in some areas brackish groundwater which has become increasingly contaminated and is not suitable for drinking.

Technology Needs assessment (TNA) is a country-driven participatory process which aims to identify and prioritize environmentally viable technologies in the sectors of water, coastal adaptation, renewable energy, and waste management in Nauru. The purpose is to increase the coping capacity of individuals and communities across the island to better prepare for the potential negative consequences of the impacts of climate change. During the first phase of TNA, through stakeholders’ consultation meetings, Nauru has selected and prioritized eight (8) technologies (combined) under water and coastal area management sectors and a further 8 technologies (combined) under renewable energy and waste

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2 One large evaporative desalination plant and four small RO desalination plants.
management, respectively. In water sector, the four technologies selected include: *Roof top rainwater harvesting, water reticulation system, non-potable water access,* and *tanker truck technologies.* While in coastal area management the following technologies are selected: *Coastal vegetation restoration, locally managed marine area, policy formulation* (over coastal area and resource management) and *sea wall construction.*

This report is the output of the second phase of the TNA process which covers barrier analysis on transfer and diffusion of the prioritised adaptation technologies in the selected two sectors across the country. In addition, the report also outlines the enabling framework and measures to overcoming identified barriers. For example, for each of the 8 technologies identified for water and coastal area sectors, a systematic approach of describing and analysing technological barriers and identification measures and enabling framework is also outlined, discussed, and adopted. The process included:

1. Identification of preliminary targets for the technology development and diffusion sectoral scale.
2. Describe each technology properties and potential adaptation benefits, categorize technology either as market or a public good and briefly elaborate on its current status in the country.
3. Identify important barriers to diffusion of technologies through expert opinions, literature reviews, consultation meetings with important stakeholders, development of barrier analysis tools including problem and objective trees and marketing mapping tools. The report also categorises the barriers into financial and non-financial barriers.
4. The last process includes, identifying the measures for overcoming the barriers, possible linkages between different technology barriers within a sector and outline a technology enabling framework that would help to overcome barriers and create a supporting environment for the development and successful diffusion of the selected technologies.

The whole process of technology barrier identification was drawn from various literature reviews, stakeholder meetings, stakeholder bilateral meetings, Adaptation expert working group and respective technology experts. Adaptation consultant also seek reference to the TNA barrier analysis guideline, resources, information, and templates provided by specialists UNEP-DTU and USP partnership during and after regional capacity building workshops.

**Technology barriers and measures in water and coastal area management sectors (Adaptation).**
Each of the four adaptation technologies in the water sector, namely *rooftop rainwater harvesting*, *water reticulation system*, *non-potable water access* and *tanker water technologies* were all categorised as public goods or non-market good which requires public sector support for its development and successful replication at different implementation scales at local levels. From literatures and stakeholders’ discussions with reviews of barriers it was noted that economic and financial barriers were closely associated with high cost of development of technologies which were due to the lack of incentives and assistance offered to individuals and communities, due to high cost of construction materials, unavailability to technological expertise and labour at the local levels. The Table 1 below summarizes the sectors and barriers identified with measures taken overcome respective barriers.

**Table 1: Identified barriers and measures taken to overcome respective barriers.**

<table>
<thead>
<tr>
<th>Key Sectors</th>
<th>Identified Barriers</th>
<th>Measures taken to overcome barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Sector</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Rooftop rainwater harvesting</td>
<td>Economic barrier</td>
<td>Subsidy by government</td>
</tr>
<tr>
<td>2) Water system Reticulation</td>
<td>High Capital Cost</td>
<td>Government offering incentives, i.e., import duty free.</td>
</tr>
<tr>
<td>3) None-potable water access</td>
<td>Water contamination/</td>
<td>Improved alternate clean water access sources</td>
</tr>
<tr>
<td>4) Tanker water</td>
<td>High Establishment Cost</td>
<td>Increased fleet reduced usage</td>
</tr>
<tr>
<td><strong>Coastal Sector</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Coastal Vegetation restoration</td>
<td>Under capacity</td>
<td>Training and awareness</td>
</tr>
<tr>
<td>2) LMMA</td>
<td>Land tenure ship</td>
<td>Policy to regulate access</td>
</tr>
<tr>
<td>3) Policy &amp; guideline formulation</td>
<td>Lack of skills</td>
<td>Training of locals</td>
</tr>
<tr>
<td>4) Construction of seawall</td>
<td>No capacity to formulated guideline</td>
<td>Training of locals/ Hiring of consultancy</td>
</tr>
<tr>
<td></td>
<td>Cost of capital</td>
<td>Government subsidy and regulation, Import subsidy</td>
</tr>
</tbody>
</table>

Source: In country consultation, 2020

The nonfinancial barriers include lack of ineffective policy on water sectors (was developed but no political-will) to effectively implement components of the water policy. Moreover, there was not a policy regarding the coastal area and resource management in the country. In absence of such a policy framework that oversees the coastal area and resource management
with effective water sector resource in the country will also fail to adopt an effective coastal area and resource management to ensure that not only the current but future generations also benefit from the scarce resources on the island.

Nevertheless, the barriers in the water and coastal area resource management can be overcome by putting in place appropriate financial and technical resources for the development and diffusion of these technologies at the local levels. The non-financial barriers can be tackled through formulating and approving a coastal area resource management and enforcement of the current integrated water policy in the country. It is critical that any policy of this nature must be agreed to by the stakeholders, individuals, and communities across the country.
Chapter 1: Water Sector

1.1 Preliminary targets for technology transfer and diffusion in Water Sector

The National Water, Sanitation and Hygiene Implementation Plan (NWSHIP) is a fifteen-year plan to implement the Republic of Nauru’s 2011 National Water, Sanitation and Hygiene Policy (NWSHP), which sets out the visions, goals, and objectives of the Government of the Republic of Nauru for water and sanitation. Despite this well-designed initiative, the country continues to experience water challenges as it faces multi-dimensional factors from impacts of climate change and extreme events. According to NWSHIP (2012)\textsuperscript{3} the existing water resources in Republic of Nauru (RoN) are under substantial stress due to the growing population, fast rate of urbanization and subsequent unplanned land use changes. The document outlines a multi-level of challenges that need to be addressed to achieve a reliable, safe, affordable, secure, efficient, and sustainable water supply on the islands. This is in line with the Nauru National Sustainable Development Strategy’s (NSDS) (2005-2025)\textsuperscript{4} goal to achieve better standard of living to all Nauruan. However, this objective will not be easily achieved as it also has its own constraints and challenges. One of the identified constraints factors to achieve better standard of living in Nauru is the poor quality and expensive water cost on the island. As matter of fact, the Nauru’s water supplies are vulnerable to fluctuations in rainfall, embedded with the effects of climate change on temperatures, humidity, rainfall, and weather extremes are affecting the quality and quantity of water resources available on the Islands. This increases the risks for Nauruan households to depend on the expensive RO water supplied by Nauru Utility Corporation (NUC) for sustenance and livelihoods.

Additionally, the island nation continues to face challenges in the water sector includes: No water quality standards, high rate of diarrhoea and health impacts from poor quality water especially from groundwater resources, groundwater contaminated by sewage, oil, waste pits and other contaminants, reliance on energy intensive desalinated water (up to 1/3 of Nauru

\textsuperscript{3} The National Water, Sanitation and Hygiene Implementation Plan (NWSHIP) a blue print document of fifteen-year plan to implement the Republic of Nauru’s 2011 National Water, Sanitation and Hygiene Policy (NWSHP),

power production), lack of storage at both household and national levels, maintenance of infrastructure (includes existing water tanks, tanker trucks, RO equipment’s) and delivery capacity for Reverse Osmosis (RO) water, RO production capacity of desalinated water is insufficient in major droughts, unaccounted for water and water loss up to 85 percent of RO production, effective strategy needed for water delivery to priority users such as schools, the hospital and dialysis unit, public and household rainwater harvesting and storage is insufficient, and is poorly maintained and inefficient, and list goes on.

With the above backdrop, the technological development and innovation in water sector could play a critical role to achieve food and water security targets of the country considering uncertain climatic conditions cast by climate change, sea level rise and other extreme events. Republic of Nauru NSDS (2005-2025) vision as a focal policy roadmap document for the country, stresses on investing in proven methods and technologies to minimize wastage of water and to promote its conservation to achieve its goal of water security by the year 2025 (NSDS2005). Below we will explain in brief two major impacts of climate change events on water across the Island.

Sea Level Rise – Sea level rise is a climatic event, which sees change in sea level could affect people through flooding (Neumann, et al, 2015)\(^5\), when water in rivers cannot flow into the ocean because the sea is too high and when seawater surges onto the land during storms. On the Island nation, sea level rises contaminate ground water wells and destroy coastal vegetations. Thus, investing in roof top rainwater harvesting technology would be beneficial to coastal communities.

Frequent precipitation - global warming increase in the intensity and frequency of heavy precipitation events. This heavy precipitation on the Island pollutes the ground water available for usage by households and business houses.

Moreover at the first phase of Technology Needs Assessment (TNA) in the country, with consensus from CC Adaptation Expert Working Group (AEWG) members and other important stakeholders, a set of eight adaptation technologies were identified in areas of water and coastal area management sectors and finally four technologies were prioritized through multi-criteria assessment process based on their importance in reducing vulnerability of communities and individuals to the severe impacts of climate change.

The prioritized technologies were as follow:

1. Roof top rainwater harvesting technology
2. Water reticulation system
3. Non potable water access
4. Tanker Truck

**Current Level of Experience – Prioritised Technologies**

In terms of experience, the Republic of Nauru have some levels of experience with all the above short-listed technologies (4) which are available and are also in use at various levels across the country. From observation, the major challenge lies with the cost relating to the establishment and construction of the prioritized technologies to ensure that those technologies can be implemented and sustained across the country.

To ensure sustainability of these technologies, the TNA project during this second phase of barrier analysis and enabling framework sets some preliminary targets for the transfer and diffusion of these above-mentioned technologies in water sector which are as below:

1. To construct 50 community-run rainwater harvesting facilities at selected sites around the island each with a capacity between 15,000- 50,000 m³ by 2026.
2. Modernize and upgrade water storage infrastructures by 2026,
3. To construct infrastructure that assist to providing water reticulation system on parts of the Island by 2023.

To achieve these preliminary targets of transfer and diffusion of technologies in water sector the relevant stakeholders and players must get involved and play active role in the successful implementation of the identified technologies. The important stakeholders include water related policy makers, experts, relevant authorities such as Departments of Climate Change and National Resilience (DCCNR), Nauru Utility corporation (NUC), provider of water and electricity, Nauru Fisheries and Marine resource authority (NFMRA), Department of Education (DoE) and Department of Industries, Employment and Environment. Other players include technology dealers, technicians, and experts in water sector. The implementers include Non-Government Organisations (NGOs) and Community based organisations.
(CBOs) focusing on water issues, advocacy groups of women, youth and community leaders active at local and national levels.

Figure 1: Different stages of TNA project implementation followed in Nauru

<table>
<thead>
<tr>
<th>Phase I</th>
<th>Phase II</th>
<th>Phase III</th>
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</table>
| Main elements:  
  • Sector Identification and prioritisation  
  • Technology Identification and prioritisation in each sector | Main elements:  
  • Barrier analysis for each technology and enablers addressing the barriers – Enabling framework. | Main elements:  
  • Action Plan for each of the prioritised technology  
  • Cross cutting issues  
  • Specific project ideas in each prioritised sector. |

Source: Adapted from UNEP Risco Centre Flyer (March 2014). What are the technology needs of developing countries?

1.2 Methodology

This report is the output of the Second Phase of the TNA process for Adaptation for the Republic of Nauru. The report covers mainly barriers analysis on transfer diffusion, enabling framework and key measures identified to overcoming the barriers. For each of the prioritised technologies identified for adaptation (water and coastal management sectors), a systematic approach of describing and analysing each technology barrier, and identification of measures and enabling framework was adopted. The following steps were taken as part of the process:

1. Identifying the preliminary targets for the technology development and diffusion at sectoral scale.
2. Description of the technologies identified. Provision of its potential adaptation benefits. Determine and categorise whether such technology is market or public goods with some description of its status in the country.
3. Identification of key measures for overcoming the barriers, possible linkage between different technology barriers within a sector and device a technology enabling
framework would help overcome potential barriers while creating a supporting environment for the development and successful diffusion of the selected technologies.

Since the closure of the borders, the adaptation consultant undertook most of its review and analysis work off country while the mitigation consultant has undertaken its role mainly in country. Most of the work were collated through desktop review especially from adaptation sector and validated through the process of in-country bilateral meetings and group discussions by the mitigation expert. The purpose of the validation process is to ensure that the views and ideas of the stakeholders on the ground are correctly reflected in the report.

1.2.1 Desktop Reviews

The consultant undertook extensive literature review of reports and articles in the areas of water and coastal sector management (Adaptation) across the country. According to Lurie et al, (2013) desktop review is critical to understanding any topic under research. Thus, we undertook literature review to understand the context of water and coastal area management in Nauru. The reports we study include the National Water, Sanitation and Hygiene Implementation Plan, the national water sanitation and hygiene policy of Nauru, The National Sustainable Development Strategy (2005-2025), Climate Change and Water Security in Nauru (SPC report), Expanding water national storage capacity for Nauru Report and the Phase I TNA report (2020). This process helped to formulate and draft the Second Phase of the TNA report.

1.2.2 Validation Consultation meetings.

After the desktop review process, a series of bilateral and group meetings were held by consultants through the adaptation expert. The validation consultations and meetings were critical to ensure that the ideas that were captured through the desktop review and first round of consultation meetings are correctly interpreted and applied according to the local context.

Figure 3: Methods followed in conducting TNA barriers analysis and enabling frameworks.

<table>
<thead>
<tr>
<th>Main Stages of Analysis</th>
<th>Methods and Tools</th>
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9
1. Identification of Stake holders
   This was done during the Phase I of the TNA

2. Identification of potential barriers
   Extensive Literature Review, consultation meetings and brainstorming

3. Analysis of barriers
   Use of logic thinking, problem tree design, expert consultations, and bilateral meetings

4. Measures development to overcome barriers
   Translating barriers into measures using logical solution tree during consultation meetings

5. Screening and validation of important barriers and measures
   Validation through extensive consultation during Stakeholders/experts meetings

   TNA Adaptation & Mitigation consultants drafted the report

7. Final BAEF Report
   First DTU/USP experts reviewed and then DCIE officials reviewed/approved the report.

1.2.3 The Department of Commerce, Industry and Employment

The Climate Change Department (CCD) and stakeholders through national consultation at the TNA inception workshop had agreed on the sectors for the TNA process to concentrate. After the sector identification, then at the Phase I consultation, the stakeholders then have selected and prioritised the technologies under each sector. Also, at this stage the government through the Department of Commerce, Industry and Employment (DCIE) ensure that the sectors selected are in line with the national sustainable development strategy of the country (NSDS 2005-2025).

1.3 Barrier analysis and possible enabling measures for rooftop rainwater harvesting technology (RTRWHT)

1.3.1 General description of rooftop rainwater harvesting technology.

Nauru currently relies on desalinated water, rainwater harvesting, and poor-quality groundwater for its water needs (Freshwater et al, 2011)\(^6\). There is no whole of country

reticulation distribution system across the Island. Desalinated water is trucked to households on request and with relatively high cost. According to key informant, “a hand full of households across the Island could have access to rooftop rainwater facility but it’s not a facility that could be easily accessible within the communities because of financial constraints”. (Personal Interview May 2019). Rooftop rainwater harvesting (RTRWH) is the collection and storage of rain, rather than allowing it to run off. Rainwater is collected from a roof-like surface and redirected to a tank, cistern, deep pit (well, shaft, or borehole), aquifer or a reservoir with percolation. According to Lee et al (2010)\(^7\) for more than three centuries, rooftop catchments and storage of water facility have been used by households and communities around the world at diverse locations especially the areas with no natural safe ground water or streams for consumption. Rainwater collected from the rooftop is typically used for both potable and non-potable purposes, including domestic uses and drinking. There are three main types of rainwater harvesting system: direct pumped, indirect pumped, and indirect gravity. In certain situations, it may be possible to have a purely gravity system, though such occasions are rare in the country.

**Direct-Pumped (Submersible/underground tank)**

This is the most common type of semiprofessional rainwater harvesting system, particularly for domestic properties, and is generally the easiest to install (Casolco, 2007)\(^8\). The pump is located underground, and harvested water is simply pumped directly to the water tank or other appliances. If the tank should be in danger of running dry, a small amount of mains water is fed to it to maintain supply. For commercial projects, such systems tend to be dual pump arrangements (duty standby).

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Figure 4: Direct pump or underground pump water tank system

According to Pederson (1965) this system has a pump and control system inside a building or enclosures rather than inside the water tank itself. This makes maintenance of the pump and filters easier rather than a system which has the pump inside the tank. This also use a mains water back up so as not to run dry.

**Indirect Gravity**

This type of system differs in that the harvested water is first pumped to a high-level tank (header tank), then allowed to supply the outlets by gravity alone. With this arrangement, the pump only must work when the header tank needs filling. Also, the mains water is fed directly to the header tank, as it can only be filled from the main harvesting tank.

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10 They use hand pumps to pump water up to a higher storage tank before using gravity to distribute water for usage in the house.
**Figure 5: Indirect gravity rainwater harvesting system**

Source: Total Water system (2020).

**Indirect Pumped**

This arrangement is similar to the indirect gravity system as earlier described, with the exception that the internal tank can be at any level in the building, as it does not rely on gravity to supply the outlets. Instead, a booster pump set is used to provide a pressurized supply. This system employs the benefit of not having to feed mains back-up water to the underground tank, whilst also offering great flexibility as the booster pumps can be tailored to suit the flow and pressure requirements of the building.

**Figure 6: Indirect pump water harvesting system**

Source: Gurung, Thuli Ram, Sharma, Ashok (2014)

**Gravity Only**

In some situations, it may be possible to have a system that functions purely through gravity, requiring no pump and therefore no energy use. With this arrangement, rainwater is collected
from a part of the roof which has gutters above the filter and collection tank which are in turn above all the outlets. This arrangement is only ever possible where the storage tank can be located below the level of the gutters, yet higher that the outlets that it will supply. Only the power of gravity is needed to feed collected and filtered water to various parts of the home for use, so it is an ultra-energy efficient option.

Figure 7: Gravity only rooftop rainwater harvesting system

Source: Total Water services (2020)

This RTRW technology with various products described above offers many benefits during seasonal dry periods and droughts especially in the face of climate change that is projected to increase long term drought and dry season in the long run. Roof top rainwater collection helps to stabilize the depleting groundwater level while the storage infrastructure can reduce land erosion and flood inflow in the sea. In Sub-Sahara, this technology acts as a convenient source of stored water that could enhance agricultural productivity, decrease travel time for rural women to remote water resources that would result in better health and time for social activities (Rosen & Vincent, 1999)¹¹.

1.3.1.1 Technology status in Nauru

RTRWH is widely practiced across the country during the late 80’s and 90’s, the periods which were regarded as the prosperous days of the country (Personal Interviews, May 2019)¹².


This is because many family units can afford this type of water collection system around the country. Nowadays, household units in Nauru can take advantage of rainwater system installed on some roofs of domestic and commercial buildings. A structure of tubes or gutters direct rain towards a small tank in which household units could store water, which can later be used for drinking, cooking, and other domestic purposes.

**Figure 8: Rooftop rainwater harvesting system**

*Source:* Total water system (2020).

**Ground water** - However, between rainy seasons groundwater is the major source of water on the island. Unfortunately, the low water quality in Nauru means that groundwater is contaminated or unsafe for human consumption. According to key informants\(^\text{13}\), groundwater quality in Nauru is affected by wastewater disposal from houses, shops, commercial buildings and the refugee camp. In addition, some zones have an increasing salinity rate, which makes the water inadequate for human usage. To resolve this problem, Nauru government has launched an expansion of the national water storage capacity in order to improve the water supply. The project consists of installation of more water tanks which will prevent water shortage during periods of drought. Thus, if this technology is to be supported and sustained, donor partners should invest money to support the government’s initiative to provide clean and quality water to its citizens. The solution from this technology will also protect the environment since the desalination plants are energy-intensive and use fossil fuels for power.

\(^{13}\text{Key informants- Senior People who worked in the water sector in the country for the past 20 to 30 years.}\)
The use of rooftop water harvesting technology may reduce the energy required to produce the same litters of water on the Island.

1.3.1.2. **Technology category and market characteristics**

The Rooftop rainwater harvesting technology can be categorized as a non-market public good when established at a community level and requires state level support to develop and manage the system. The technology option in this report is community or State-managed Rooftop rainwater harvesting system and thus considered as a non-market public good. But if it is to be provided by the Nauru Utility Corporation (NUC) as the primary provider of desalinated water across the country, then to some extend it would be a market product. In this context, the RTRWHT may have to be classified as private or market product.

1.3.2 **Identification of barriers for rooftop rainwater harvesting technology.**

A desktop-review was carried out by the adaptation consultant on some important policy papers and documents on rooftop and rainwater harvesting in general in the country. This process was supplemented by interviews, group discussions with water experts, key stakeholders and workshop brainstorming on the Island. A list of potential barriers to the development, transfer, and diffusion of RTRWH technology was identified, prepared, and categorized into two broad main categories of economic and financial barriers, and non-financial barriers. The non-financial barriers were further segregated down into policy, legal and regulatory barriers, technical barriers, institutional and organizational capacity barriers, social, cultural, and behavioural barriers, information and awareness barriers. In random order, the identified barriers included the following:

i. High cost of capital,

ii. Insufficient legal and regulatory framework for rainwater harvesting systems,

iii. Poor inter-departmental interaction and coordination,

iv. Lack of incentives for community ownership and participation,

v. Uncertain frequency of rain falls and irregular water flows over the country,

vi. Low or no preference to research and training,

vii. Inadequate information on societal benefits of technology,

viii. Limited institutional capacity and management skills of government departments,

ix. Health issues arising from water – bone vectors.

**Screening and Prioritization of identified barriers**
After the compilation of the potential barriers list, it was presented to the participants of the technology barrier analysis workshop to screen the list and to identify the essential barriers that need to be addressed for technology transfer and diffusion to occur – as well as the non-essential barriers that were to be ignored (See annex 3). The barrier analysis tools such as the starter problem and solution trees were used to expedite process of prioritization of barriers. Through consensus among participants, the final list of barriers was achieved and briefly discussed below.

### 1.3.2.1 Economic and financial barriers

**a) Capital and Maintenance cost** - As the technology is classified as a public good, so its development, operation and maintenance would also remain under the same public domain. Having said that, this is one of the technologies which the relevant Department or government authority dealing with water resource sector within the country should provide public fund to support. But as from the feedback at the consultation, it is something the government would really want to invest-in but does not have the financial capacity to support. In terms of the maintenance cost would be minimal as it involves only in cleaning of the gutters.

**b) Capital cost.**

As you could see from the Table 2 below, the cost of producing a single household rooftop rainwater harvesting system is estimated about AUD$7,000. This is relatively costly for households and individuals on the Islands. Direct cost for installation of 50 units across the Island would cost AUD$350,000.

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**Table 2: Expenses related to building a single rooftop water harvesting system.**

<table>
<thead>
<tr>
<th>Activities</th>
<th>Details</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofing</td>
<td>Not included – Pre-installed</td>
<td>0</td>
</tr>
<tr>
<td>Guttering</td>
<td>$10 meter @ 46 m for above roofing area.</td>
<td>$460</td>
</tr>
<tr>
<td>Down pipes</td>
<td>$5 meter @ approx. 30 m</td>
<td>$150</td>
</tr>
<tr>
<td>Water catchment</td>
<td>Storage system</td>
<td>$6,000</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------</td>
<td>--------</td>
</tr>
<tr>
<td>Additional costs</td>
<td></td>
<td>390</td>
</tr>
<tr>
<td><strong>Total cost estimated</strong></td>
<td></td>
<td><strong>$7,000</strong></td>
</tr>
</tbody>
</table>

Table 3: Cost of water to consumers both domestic and commercial

<table>
<thead>
<tr>
<th>Details</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average cost to produce a litre of water is</td>
<td>0.0206</td>
</tr>
<tr>
<td>Domestic rate –</td>
<td>$0.0084/l</td>
</tr>
<tr>
<td>Commercial rate –</td>
<td>$0.0118/l</td>
</tr>
<tr>
<td>Government rate –</td>
<td>$0.01533/l</td>
</tr>
<tr>
<td>Domestic delivery rate</td>
<td>– $5 ≤ 5kl</td>
</tr>
<tr>
<td>Commercial delivery rate</td>
<td>– $263 per truck load (any capacity)</td>
</tr>
<tr>
<td>Government delivery rate –</td>
<td>$165 per truck load (any capacity)</td>
</tr>
</tbody>
</table>

c) *Inherited Risk of the RTRWHT* – This cost relates to maintenance and repairs which the household and communities will inherit from taking ownership to the technologies into the future. Nevertheless, as you can see from the Table 3 above, providing rooftop rainwater harvesting system to households will ease their budget from meeting expensive cost of water delivery across the Island. On average a household would require one truck delivery per month, this would cost about AUD$3,156 while cost of installing one Unit of RTRWHT would be only AUD$7,000. Investing in the RTRWHT would see the money invested would have return just over 2 years.

### 1.3.2.2 Non-financial barriers

*Policy, Legal and Regulatory*

a) *Ineffective water policy - (The National Water, Sanitation and Hygiene Policy)* – This is the policy that oversees the water, sanitation, and hygiene in the country. This policy outlines how water is managed in the country, but it lacks the government’s strong support to ensure its people achieve quality levels of safe and clean water at very minimum cost. The support refers to include implementation and monitoring of the types of rooftop rainwater system that households implement at their homes.
b) *Lack of understanding of existing rights and rules on water* – Since there is no running river on the Island, there seems to be lack of knowledge of indigenous people’s rights and rules on access to water. During the prosperous years of the Island nation water is freely supplied and thus there no intension to promote effective rooftop rainwater harvesting technology.

c) *Inequitable distribution of water among water users* – There is unequal distribution of water among users. This is because water is being commercially distributed by NUC authority across the Island. Households and business houses must pay for their water usage on the island.

*Water Contamination* – There is high level of ground water contamination at the local levels. Thus, in order to address this contamination issue, use of rooftop rainwater technology could be seen as an option aims at achieving cleaner water.

**Technical Level**

a) *Limited local capacity*: The technology may sometime require some technical skills to construct the infrastructure of such system. The government must train locals to start installing these technologies across the island.

**Social, cultural and behaviour**

a) *Land tenure* – Most of the land around the Island are customary or privately owned. Thus, community members often dispute where such communal structures to be built. But if the technology is built on existing community halls or buildings, there wouldn’t be dispute. Ideally, these RTRWHT should be built on individual households across the Island.

b) *Ownership Question* – There is a limitation in communal properties or structures for public uses. Often such assets not well looked after and sustain in the long run. To counter such situation, there would be bylaws formulated and enforced surrounding the operations of communal RTRWHT.

c) *Perception of such Technology* - General perception about such technology acquired under project or donor assistance, it’s only for short term and won’t last for that long.

**Information and awareness**

a) *Potential benefits of such Technology* – There is limited knowledge and awareness of the potential benefits from Rooftop Rainwater Harvesting Technology at community levels.
b) *Limited awareness of climate change* and disasters—Although there might be some awareness but little seriousness about the impact of climate change and its impact on the water sector across the country.

c) *Need for community cooperation through communal participation.* There is little awareness of the need for community engagement and participation to embrace community harmony in such a public good.

**1.3.3 Identified measures.**

This part of the document attempts to discuss the measures needed to overcome the identified barriers to possible implementation of RTRWHT in Nauru. The principal methodology engaged for the identification of appropriate measures was the development of problem and tree solution or fish bone approach through stakeholder’s consultation and participation. Besides, there was also a detail analysis of the current national practices in the relevant sectors. The series of discussions during the face-to-face consultation led to the identification of some of the key measures necessary to overcome and eliminate the identified barriers above (Refer to annex 3 for participant list).

**1.3.3.1 Economic and financial measures**

a) *High Initial and capital cost* – To offset the high capital cost the Republic of Nauru may consider waiving tax and duties on materials imported to build this technology should there is potential for the donor aid partners invest in this technology on the Island.

b) *High maintenance cost* – The communities may meet some of the maintenance and running cost of maintaining the technology. This means they will have to clean the gutters and tanks frequently.

c) *Inherited Risk* – In the event of no or little rain on the Island, the government will leverage any economic implication on the community to ensure there is safe and clean water available or accessible to the households.

**1.3.3.2 Non–financial measures**

In almost all the Small Islands Developing States (SIDS) or even other poor and developing countries the existing non-financial technology management practices are predominantly reactional due to the limited understanding of technological, socio- economic, and institutional aspects of the implementation of technology management and diffusion. For
instance, non-financial barriers to the implementation of technology, the following measures need to be taken:

**Policy, legal and regulatory**

a) *Ineffective water Policy* (The National Water, Sanitation and Hygiene Policy) – This is the base line policy to implement effective strategies on water resource management in the country. The government must financially support such initiative to be effective across the country.

b) *Poor understanding of existing rights and rules on water* – There must be awareness and civic education to increase the knowledge of indigenous people’s rights and rules on access to water. Safe and clean water is often seen as a foreign product because, mainly its either imported or brought in through some other means.

c) *Inequitable distribution of water among water users* – When the Technology is implemented there must be equal distribution or access to this public good technology.

d) *Water Contamination* – There must be effective implementation and monitoring of the current national water, sanitation and hygiene policy to include how to build sewage facilities and disposal of the same (sewage) in the country to prevent even ground water contamination. In the event of drought, the communities have no alternative but resort to ground water resources.

**Technical Level**

a) *Weak Research Capacity* – The government must collaborate with regional organisations such as the South Pacific Applied Geoscience Commission (SOPAC), South Pacific Commission (SPC) which have undertaken several studies in the past on the types of RTRWHT is viable and could withstand extreme weather events across the Pacific, mainly the low-lying islands.

b) *Limited local capacity* – According to respondents, there is a need for the government to assist local business entrepreneurs to invest in this technology. The investment would include locals acting as dealers or agents to importing and distributing of RTRWHT parts across the Island. In addition, the entrepreneur must be able to recruit and train locals that would be able to assemble and install the system at houses whenever the demand arises.

**Social, cultural and behaviour**
a) **Ownership** – There must be a high level of community education and awareness about the benefit of such infrastructure to the community if it is installed and used communally by all. Additionally, those who have installed the technology on their private homes must be able to learn the basic skills to clean and take care of such investment for the long term.

b) **Perception of such Technology** - Community training and capacity awareness will be able to change the mind-set of the community members’ perception about such technology acquired under project or donor assistance. This is for the good of such technology to impact the livelihoods of the people.

**Information and awareness**

a) **Potential benefits of such technology** – There is a need to take this awareness strategy to the rural communities across the Islands. Such awareness of the potential benefits from rooftop rainwater harvesting technology at community levels will increase the support and ownership of such investment.

b) **Limited awareness of climate change** – The relevant government stakeholders must increase the climate change awareness and its impact on the community. Only by this increase of knowledge and civic education by where villagers will support this communal technology structure.

1.4 **Barrier analysis and possible enabling measures for water reticulation technology.**

1.4.1 **General description of a water reticulation technology**

Water reticulation system is a series of pipes that are connected to help transfer water from its original source to consumers. It is an efficient and vital structure by where water is distributed within a house or community. According to Conradie et al, (2018), water reticulation system saves more than 30% of energy in a study undertaking to reconfigure mine water reticulation system in South Africa. In Nauru, the construction of water reticulation system is aimed to distribute RO water from selective water reservoirs around the Islands and distribute to hospitals, schools, hotels, and households at the same with minimal costs.
Republic of Nauru lacks the national capacity to store potable water (Climate Change Adaptation in Nauru, 2015).\textsuperscript{14} Presently, both business and private household units rely on rainwater harvesting as the primary source, desalination as secondary and groundwater (poor quality) for its water needs. Having said that, there is no country-wide reticulated system available to distribute water to essential services such as schools and hospital (Personal Observation, May 2019)\textsuperscript{15}. Desalinated water is trucked to consumers on request.

Nauru’s secondary source of water which is the desalination water has four desalination plants throughout the island. However, the desalination plants require high quantities of energy to power and operate. The desalination process is also expensive and affects the beach environment (Nauru Environmental law planning and Assessment 1976)\textsuperscript{16}. In 2014, water quality in Nauru took a remarkable turn with the development of a project by the Nauruan government to install a solar PV system and desalination plant. It was projected that this project could produce 100 cubic meters of safe water per day. In addition, the PV system would generate 1.3 percent of the energy demand in the island, doubling the then existing energy production of solar energy.

Regardless of this noble intension, there is no country-wide safe drinking water reticulation system across the Island nation. Although at a certain location of the Island there was a project which was implemented to provide an alternate source of water for non-potable uses in that locality, thus saving precious potable water for other domestic uses. Reticulation water technology although would be seen as a public good, it would be sustainable if it is managed by the Nauru Utility Corporation.

\subsection{1.4.1.1 Water reticulation system status in Nauru}

There is no country-wide water reticulation system in operation across the Island, beside pumping of some brackish water from the coastal area to the hilltop at a certain location. The main sources of water across the Islands are rainwater, imported water, shallow unconfirmed ground water and desalination water. Regardless of this statement, water reticulation system

\begin{itemize}
\item \textsuperscript{14} Climate Change Adaptation in Nauru (2015)- A report on Expanding national water storage capacity and improving water security in Nauru by EU, GCCA, SPC and Government of Nauru.
\item \textsuperscript{15} CCA national consultant observation trip in May (2019)
\item \textsuperscript{16} Environmental Law Planning and Assessment (1976)
\end{itemize}
is not a new concept as part of the Island once experienced such technology in the past 20 to 30 years (Oral history, May 2019).

According to key informants, there were some parts of the Island which experienced the service of a water reticulation system during the prosperous years of the island nation. There is still an existing infrastructure to support that key informant’s claim. There is a tank right at peak of the hilltop of the Island, where water was used to be pumped from the shipping lines. From that storage tank then water is being reticulated to other parts of the Islands and then to the nearby households. The system mainly supported the senior executive management members of the Phosphate Mining company and some members of the diplomatic communities. Now the system is inoperative as there is no financial investment to support such technology.

Support for this technology

Over the past decades the Republic of Nauru was seeking financial assistance from donor aid partners to revisit and support the concept of water reticulation technology again across the Islands nation. Although this may be seeing as expensive and capital intensive it would be an effective way of fulfilling one of the obligations that the government owes to its citizens, to provide them with clean and safe drinking water. The intention is that the government through NUC – Water authority to continue to produce desalination water as it is currently doing. It then pumps those desalinated water into central tank facilities at the hilltop and reticulate the water through the technology from the storage to essential services such as hospital, schools and other services including, police force, fire department and then to households and business houses. According to an insider one of the reasons, the aid donors are reluctant to support such initiative is they do not want to invest in a sector which the national government should take the leading role in provision of funds for and furthermore, there need to be high level of accountability and transparency for projects of that scale in the country (Key informant, 2020)\(^\text{17}\).

1.4.1.2. Technology category and market characteristics

The water reticulation system (WRS) could be categorized as a non-market public good when established at a community level and requires state level support to develop and manage

\(^{17}\) The view does not represent that of the government nor the real reason but is only of her/his opinion.
the system. The technology option in this report is community or State-managed water reticulation system and thus considered as a non-market public good. But the water that runs through the pipe or the system will be provided by the Nauru Utility Corporation (NUC) as the primary provider of desalinated water across the country, then to some extent the water will be a market product. In this context, reticulation system (pipelines) is a public good while it will be used by the NUC to sell a private good which is the water (as commodity).

1.4.2 Identification of barriers for water reticulation technology

   i. High capital cost,
   ii. Aged (old) infrastructure for water reticulation system,
   iii. No natural water source availability on the Island,
   iv. Contamination of ground water,
   v. Poor governance.
   vi. Weak coordination amongst among public departments
   vii. Land ownership issues,
   viii. Impact of Climate Change
   ix. Lack of land use and planning policy
   x. Lack of technical expertise

Screening and Prioritization of identification barriers

After the compilation of the potential barriers list, it was presented to the participants of the technology barrier analysis workshop to screen the list and to identify the essential barriers that need to be addressed for technology transfer and diffusion to occur – as well as the non-essential barriers that were to be ignored. The barrier analysis tools such as the starter problem and solution trees were used to expedite process of prioritization of barriers. Through consensus among participants the final list of barriers was achieved and briefly discussed below.

1.4.2.1 Economic and financial barriers

   a) High capital cost – From a cost perspective, the technology would cost about AUD$2.5M to AUD$3.5 M. The cost includes refurbishment and improvement of some existing structures already in place. The project would be used to replace old pipes and build new structure from the NUC, the desalination plant to selected essential service sites.
From a structural viewpoint the good is identified as a non-market public
good. Thus, if such good is constructed it will be initially a public good, owned and
operated by the government before it could be finally corporatized or transferred to a
relevant authority to manage and sustain it into the long term. But as it stands now, it
must remain a public good and as such the Department responsible for water
management resources will initially take charge over the operation of the technology.
Usually, it requires high capital cost for establishment.

b) Project continuity - In case of donor funding, where international funding institutions
such as the World Bank or Global Climate Fund (GCF) are providing funding for such
project, there is always a cloud of uncertainty over the continuity and long-term
success of such investments when the project duration lapses. This calls for some level
of institutional ownership from either the community or governmental level.

1.4.2.2 Non-financial barriers

Policy, legal and regulatory

a) The National Water, Sanitation and Hygiene Policy – This is a policy on Water
Sanitation and Hygiene. Although its objective is noble, the government must take
substantive action to fulfilling its mandate under this policy framework.

b) Poor understanding of existing rights and rules on water – The general public at large
(Nauruan) need to know that basic things as health, clean and safe drinking water are
their rights which the government must provide opportunities communities to access
to.

c) Water distribution – There must be better policy on how water is been distributed
around the island nation.

Social, cultural and behavioural

a) This technology will be owned collectively by the people within the community. –
There is likely an attitude problem towards community ownership of such large-scale
investment.

Technical

a) This will be a large investment done at the community level. The question is whether
there is an adequate level of expertise to run such technology effectively.
b) Poor knowledge about the reticulation system and how it operates at community level. The last time, part of the island nation has experienced having a water reticulation system was more than 30 years ago during the phosphate days.

**Information and awareness**

a) There is limited information on the cost-effective of such a large-scale infrastructure development.

b) *Climate change and disaster* – there is limited meaningful data on climate change and how will it affect the community, in terms of water security.

c) Need to know the benefit from such technology to the essential service providers, such as hospital, school (education), police and fire department.

1.4.3 **Identified measures.**

The following measures were considered important to overcome the barriers.

1.4.3.1 **Economic and financial measures**

a) The government through the relevant Department should allocate budget for better design and development, construction and subsequent operation and maintenance of the reticulation technology infrastructure in the country. As stated above, the system would cost within the range of AUD$2.5 to AUD$3.5M. This is a huge capital investment for the country, this will ensure that water is reticulated across all areas of the island nation. To meet maintain and repairs in the long term, both private and commercial demands, users will have to pay for their water bills through a body like the NUC.

b) The government should explore and develop bankable projects with this technology and compete for donor funding opportunities particularly from international climate adaptation financing for the diffusion and transfer of green reticulation infrastructure system.

c) There must be incentive provided by the national government to potential authority who would manage and take over the operation and management of the reticulation system in the long term.

1.4.3.2 **Non–financial measures**

*Policy and regulatory*
a) There should be a specific policy design explicitly around the implementation of the water reticulation in the country. This will include the ownership, operational issues, technology and long-term management and future direction of such entity.

b) Increase coordination and cooperation among various districts around the island nation over this national infrastructure system.

c) Prepare and implement standard operational procedures for the operation of the reticulation system.

Technical

a) The government should strengthen its skill development at national level to ensure that water engineers are well equipped and prepare to manage the system in the long run.

b) The government should start negotiation and collaborating with the NUC management for possible take-over and collaboration of management over the reticulation system.

c) The government should promote and support public and private partnership collaboration to ensure investments of such magnitude (water reticulation system) is established and effectively implemented on the ground. This means giving incentives such as duty exemptions and other benefits to companies importing parts into the country.

1.5 Barrier analysis and possible enabling measures for non-potable water access technology.

1.5.1 General description of non-potable water access technology

Most of the potable water supply comes from domestic rainwater harvesting (mainly rooftops), and desalinated seawater produced by reverse osmosis (RO) system. The non-potable water supply comes from groundwater and the ocean. Groundwater in Nauru is not potable due to salination and pollution. Almost every household in Nauru have access to non-potable water, either from ground water or saltwater along the coast. Non-potable water is used mainly by households for toilet flushing and other domestic and commercial uses. The difficulty is finding an affordable system that could be used to pump or extract non-potable water supply into the houses from the seashore. Although this technology is ranked 3rd of the prioritized technologies there are literatures indicated that use of non-potable water such as salt water to flush toilets is not favourable because the high salinity that kills micro-organisms
needed to breakdown wastes. Furthermore, the use of salinity content water for washing increases rusting and damage household and kitchen items. The only reason, it was selected as one of the priorities is to ease the pressure on household to use potable water due to climate change for both drinking and other household uses such as washing and toilet flushing. Having access to such water source may ensure that households utilize their limited potable water access and other resources to build resilience against impact of climate change.

1.5.1.1 Technology status in Nauru

Non-potable water is abundantly found around the island. This is either sourced from ground water or saltwater at the coastal areas. The difficulty of this technology is the ability to source them together through a reticulation system and distribute to homes and business houses for usage. A specific area of the Island uses this technology, plumbing mainly brackish water from the coastal area up the hilltop for usage especially.

1.5.1.2 Technology category and market characteristics

The non-potable water harvesting could be categorised as a non-market public good when established at national wide across the island. It however will require government support to sustain such investment in the long term. The technology option in this report is a community or government–managed non-potable water supply system across the districts and communities thus considered as non-market public good.

1.5.2 Identification of barriers for non-potable water access technology

Preliminary barrier Identification:

Like other technologies, the initial step was we performed a desk top study of important policy papers and other relevant documents was conducted, supplemented by interviews with experts, key stakeholders and workshop brainstorming. As part of the study, a list of potential barriers to the development, transfer and diffusion of NPWA technology in the country was identified. The list was prepared and categorized into two broad main categories of economic and financial barriers and non-financial barriers. The non-financial barriers were further segregated down into policy, legal and regulatory barriers, technical barriers, institutional and organizational capacity barriers, social, cultural and behaviour barriers, information and awareness barriers. In random order, the identified barriers included the following:

i. High capital cost,

ii. Poor infrastructure for water access,
iii. No natural water source availability on the Island
iv. Contamination of ground water
v. Poor governance
vi. Land ownership issues
vii. Climate Change and disasters
viii. Lack or inadequate access to financial resources.
ix. Consumer preferences and social biases
x. Lack of social acceptance due to water quality consideration

**Screening and prioritization of identified barriers**

After the compilation of the list, it was presented to the participants of the technology barriers analysis workshop to screen the list and identify the essential barriers – that need to be addressed for technology transfer and diffusion to occur. This was done alongside the non-essential barriers that were then ignored. The barrier analysis tools such as starter problem and solution trees were used to determine the process of prioritization of barriers. Through consensus among participants, the final list of barriers was achieved and briefly discussed below:

1.5.2.1 **Economic and financial barriers**

a) As the technology is identified as public good, so its development and operational maintenance and running costs will remain under the public sector domain. The ministry responsible for water and utility may access finance to support such investment. This however may not be that feasible as access to funding may be difficult for the government to secure and support such a service to its people.

1.5.2.2 **Non-financial barriers**

*Policy, Legal, and Regulatory*

a) Republic of Nauru has a general Policy on Water and Sanitation, but it does not have a specific policy on water distribution on the Island nation. This water distribution policy should include both potable and non–potable water technology system. Like other related water technologies, the policy should include the rights, the rules and specifically the non-potable water distribution on the Island. This provide a good compressive a ray of strategies to on how to handle this technology throughout the country.
Technical

b) High labour and capital cost to construct such a structure of magnitude would be technically a challenge. This would be similar concept of a potable water reticulation technology system, but the difference is its non-potable water distribution.

c) Like reticulation of potable water, such technology would require high capacity of communities, in terms of know-how and material resources to sustainably maintain and manage the technology beyond the project duration.

Social, cultural and behaviour

a) Land is privately owned either by individual or family groups. Thus, the government will have to acquire some of the land for public assets or structural construction. Often people don’t want to allow their private property for a communal purpose.

b) Government must acquire or lease the privately-owned properties for public benefits.

c) Communities must aware of the need to have access even to non-potable water at district level across the Island.

Information and awareness

a) Limited knowledge and awareness about the potential benefits of Non-potable water access technology at community level is limited.

b) Limited awareness of the impact of climate change and this identified technology solution at community level.

1.5.3 Identified measures

This section outlines the measures needed to overcome the barriers to implementation of Access to non-potable water technology on the island nation. Like the other earlier types of technologies discussed, the methodology we engaged to arrive at this stage was the development of a problem and solution trees and through stakeholder participation we narrowed the down the identified barriers with potential strategies in overcoming them.

1.5.3.1 Economic and financial measures

a) To compensate the projected high initial cost of construction of a structural infrastructure needed to build such a technology government should again reduce or apply tax remission for imported material required for construction of the structure by the contractor.
b) The central government should provide through its development annual budget money to support such investment at the local levels.

c) The international donor grants may be used for subsidizing the initial construction of large structural infrastructure to supply water through the reticulation of non-potable water system.

**Policy, Legal, and Regulatory**

a) Republic of Nauru to approve and implement a specific policy on water distribution on the Island nation. This water distribution policy must include both potable and non-potable water technology system. Like other related water technologies, the policy must include the rights, the rules and specifically the none-potable water distribution on the Island. This provide a good compressive a ray of strategies to on how to handle this technology throughout the country.

**Technical**

a) Train locals to participate to construct such a structure of magnitude would a technically a challenge. This would be similar concept of a potable water reticulation technology system, but the difference is its non-potable water distribution.

b) Train women and young girls to participate in construction of structures at local level to distribute potable water across the country.

**Social, cultural and behaviour**

a) Understand the local context of the community and design a technology that will be useful to the community. The land and social cultural context must be carefully addressed for long sustainability.

b) Government must acquire or lease the privately-owned properties for public benefits.

**Information and awareness**

a) Awareness program need to be promoted at local level to increase knowledge and potential benefits of Non-potable water access technology at community level is limited.

b) Run awareness campaign to increase knowledge about the impact of climate change and this identified technology solution at community level.
1.6 Barrier analysis and possible enabling measures for Tanker Truck Water Distribution technology.

1.6.1 General description of Tanker Truck Water Distribution technology (TTWDT)

Tanker trucks are fitted with a cistern or storage tank to transport and distribute water from a point of supply to the point of use, particularly to areas not served by a piped supply. If water is not supplied from a central treatment facility, it is usually extracted from the closest natural source (canals, reservoirs, or groundwater sources) and transported by the trucks to the point of use. Water thus transported may be pumped into a storage cistern, dispensed directly into household or other containers, or discharged into a small-scale treatment facility for centralized distribution. The tanks on the trucks are usually manufactured locally, and some trucks are equipped to carry potable pumps to extract the water from its source. In Nauru, desalinated water is stored at a storage facility at the Utility compound and is trucked to the customers both private and business houses upon request or order. Although rooftop rainwater harvesting is said to be the primary source of potable water on the Island, due to the impact of Climate change, there is reduced number of rainfalls or prolong dry spells therefore making people more dependent on Nauru Utility for Potable water.

1.6.1.1 Technology status in Nauru

There are currently about 5 Tanker Trucks water distribution technology (TTWDT) in operation on the Island nation. These are of course need regular maintenance and repair of the pumps, pipes, fittings and periodic upgrading of the facilities. Problems with water leaks, pumps, and storage facilities, mechanical defaults to the truck require immediate attention in order to avoid interruption of services.

Maintenance of this distribution system includes servicing the pumps and other treatment plant components, inspecting the diversion systems and pipelines, repairing leaks, and replacing electrical motors and other moving parts. Several problems were encountered in the operation and maintenance of a distribution system in the island. The level of skill needed to operate these systems is medium to high and involves some technical training of the operators. Currently, the Nauru Utility Corporation is the body which is responsible for distribution of water from the storage facility to consumers. It is done on a commercial basis.
1.6.1.2 Technology category and market characteristics

The current TTWD technologies which are up in running in the country are owned by the NUC, a corporation owned by the government. It sells water upon request to private and business consumers at a subsidized rate. Therefore, we can say is partially a market product. The NUC is currently charging money from the consumers to cover cost of maintenance and administration of the technology. This was in operation for more than three (3) decades.

Market characteristics for tanker truck water technology systems are identified as:

i. Usually are relatively big trucks and have the capacity to hold thousands of litters of water at same time,

ii. Usually imported from overseas, but can be modified with pumps and other parts at local level or in country to suit level context,

iii. Awareness raising about the usefulness of this technology needs to be undertaken mainly by relevant institutions and supported by the government.

iv. It is a current technology, thus there are some levels of awareness about the technology in the community but just need remind users of its usefulness in the community.

1.6.2 Identification of barriers for tanker truck water distribution technology

The barrier identification process for the diffusion of tanker truck water technology is done through literature review and by interviews with the NUC expert staff, consultation, brainstorming sessions with stakeholders including NGO representatives, employees of the NUC and household representatives. The number of barriers were identified and summarized into two major categories- economic/financial barriers and non-economic/financial barriers. Non-economic/financial barriers are further divided into other sub-categories: policies/regulatory, technical, social, cultural, and behavioural barriers. The other sub-categories include, institutional capacity barriers, information and awareness barriers, human skills barriers, environment barrier and market failure barriers.

Listed below is a list of generalized potential barriers to diffusion and transfer of higher efficiency tanker truck water distribution technology:

i. High cost of set up additional fleet,

ii. High maintenance and operational cost,

iii. Poor infrastructure, bridges etc. for such technology to be operative,

iv. Lack of financial resources- Repairs to older tanker trucks,
v. Water prices are increased because of the expense of transporting relatively small quantities by road.

vi. There is a lack of quality control over transported water,

vii. Water distribution is costly and slow,

viii. Adequate roads are required to transport water from one area to another,

ix. High Operational costs to ensure all of most of the tanker trucks are in operation,

x. There should be storage facilities build across the island nation as reservoir.

1.6.2.1 Economic and financial barriers

a) There is a high initial investment required to acquire additional tankers truck for water distribution across the island nation. Although, it is an existing technology, half of the fleet (three (3) out of six (6) tankers) are inoperative due to mechanical reasons. Thus having the ability to fix and maintain the existing fleet with spare parts is just as important as getting the new additional tankers.

b) Furthermore, since additional tankers are needed more for dry spells their utilisation is low other and therefore become more expensive.

1.6.2.2 Non-economic / financial barriers

The non-economic / financial barriers identified are grouped under different categories as described below:

Market failure and imperfection

a) Since it is a market good, the TTWDT faces a ray of market challenges that are major obstacles in the deployment and successful replication of the technology across the country. But since the technology is already in operation in the country for more than three decades, there are a lot of lesson learned that this technology could learn from to ensure successful implementation. Currently, there are 3 tankers truck in operation by the NUC, the additional fleet should subsidize the cost of water to consumers both household and businesses.

b) In the case where the fleet is owned and run by another body, it will promote competition and thus drop the prices of water loads which the consumers will greatly benefit from such development.

Policy, legal and regulatory
a) Absence of approved designed water distribution policy across the island. This to
protect household and business consumers.
b) Current pricing of water distribution business in the country is not that conducive, thus
itself is a barrier to further expansion.
c) Water and Property rights conflict over of constructing water storage tanks or
reservoirs strategically at locations around the Island nation.

Technical

a) Require special mechanics to service the tanker truck on regular basis
b) Limited repair and maintenance technical know-how on the Islands
c) Lack of Scientific data or proper socio-economic analysis of the current technology at
the national level
d) Limited research on quantifying the real water saving from using this technology
compared to another technology. For example, the new reticulation technology
e) Need for well-trained local mechanics and water engineers to support the technology.
f) Need a proper road and bridge infrastructure to support this technology around the
country.

Social, cultural and behavioural barriers

a) Resistance of households from using current rainwater harvesting system and ground
water with this new and added fleet of Tanker truck water distribution technology.
b) Preference of other households and business consumers from changing their means of
water source (ground water or rainwater harvesting system) to this tankers truck water
distribution technology.
c) Fear of water shortage during periods which there is no fuel or energy to power the
RO into water to distribute to households.
d) If there is a disaster and there is no water reserve at the distribution facility base for
distribution to households and business houses

Institutional capacity barriers

a) The NUC must have the capacity to store water at various strategic locations around
the Islands. This would be useful if there is disaster and disruption to the road and
bridge infrastructure.
b) Limited good knowledge and practical experience which is necessary to coordinate
such tanker truck water distribution technology around the Island.
Information and awareness barriers

a) Absence of communication between producers of spare parts and the operators (NUC) of the current technology.

b) Inadequate access to training and service and information by operators.

1.6.3 Identified Measures.

This part of the section identifies and discusses measures needed to overcome the barriers identified in earlier section to implement effective Tankers Truck Water Distribution Technology in Nauru. The main methodology engaged for the identification of appropriate measures is the development of problem and solution trees through the stakeholders’ participation. Additionally, there is a detail analysis of current national practice by way of interview with the NUC, who’s role as the primary entity responsible for distribution of desalinated water around the Island country. Finally, these discussion during a stakeholders’ workshop conducted by the mitigation team with experts in water sector on the island.

1.7 Linkages of the barriers identified.

This section discusses the different barriers common to rooftop rainwater harvesting system, water reticulation system, non-potable water access and tanker truck technologies. These four prioritized technologies in water sector serve the common goal for communities to have access to potable and non-potable water. Non potable water access seemed to be oldest technology of harvesting on the island nation, then followed by roof top rainwater harvesting technology, tanker truck and ideally the water reticulation system.

The country once had a reticulation system on certain part of the Island, but it was abandoned after the scaling down and closure of the phosphate in the early 90’s. Now the island country depends largely on desalination water and distribution by way of tanker trucks, but this technology is expensive and often inconvenient to consumers. Currently, the government through the NUC is strategically working towards construction of some form of water reticulation system for essential services such as hospital, schools, police, and utility corporations, although sustainability of technology selected is questionable.
All prioritized four technologies share many common barriers in the context of similarity in the development and use, therefore it is only imperative to take a holistic approach towards finding linkages in order to find potentially more efficient approaches and opportunities to address their combined effect. Refer to Table 4 that shows the key common barriers identified for the four technologies in water sector in Nauru.

Table 4: Common barriers identified in different prioritised technologies in water sector

<table>
<thead>
<tr>
<th>Barrier Category</th>
<th>Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic &amp; Financial</td>
<td>High capital and maintenance cost</td>
</tr>
<tr>
<td></td>
<td>Limited financial allocation by national government</td>
</tr>
<tr>
<td></td>
<td>Inadequate loan and donor funding</td>
</tr>
<tr>
<td>Policy, legal and regulatory</td>
<td>Lack of sound and robust cross-sectorial policies – resource protection, development, and management.</td>
</tr>
<tr>
<td></td>
<td>When there are policies, they are ineffective and meaningless.</td>
</tr>
<tr>
<td>Information &amp; Awareness</td>
<td>Lack of public information and awareness about the existence and usefulness of the technology.</td>
</tr>
<tr>
<td></td>
<td>When there is information, they are insufficient and ineffective.</td>
</tr>
<tr>
<td>Institutional &amp; organizational capacity</td>
<td>Limited institutional capacities specially at national level in integrating climate change risks in development planning.</td>
</tr>
<tr>
<td></td>
<td>Limited human skills and maintenance specially at local level</td>
</tr>
</tbody>
</table>

1.8 Enabling framework for overcoming the barriers in the water sector.

A key component of the enabling framework for overcoming the barriers to the diffusion of prioritized technologies in the water sector is operationalization of the existing Republic of Nauru Framework for climate Change and Disaster Risk Reduction (RoNAdapt) policy and its implementation framework recommendations. The next step should include the increased budgetary allocation for increasing the resilience of the vulnerable communities from the impact of climate change on water resources. So that the diffusion of above-mentioned prioritized technologies can be facilitated through the mobilization of external donor agencies and getting access to international climate finance funds specifically GCF and adaptation fund. For that to happen we may need to devise effective technology-based adaptation projects.
that would promise to deliver the potential benefits of these technologies to the resource managers, users and other beneficiaries alike.

The next important component of sustainable water sector management in Nauru is the need to ensure that social, economic and environmental aspects of water are integrated into the across-cutting themes of water access, equity and hazards.

Based on this theme, the prioritized technologies implementing strategy needs to be focusing on prioritised water resources, such as rooftop rainwater harvesting system, water reticulation system, potable water access or distribution and tanker truck technologies.

In the category, we easily can place institutional capacities enhancement, strengthening laws, and regulations, ensuring climate change informed decision making and planning, promoting research and technology awareness, and implementing pilot demonstration projects on the islands. In addition, ensuring the required investment will continue to be the fundamental enabling factors all water sector technologies implementation.

Based on the above discussion, barriers and measure may cover broad issues:

1. Ensuring appropriate financial mechanism to support implementation,
2. Mainstreaming of climate change considerations into relevant sectoral policies, plans and strategies,
3. Strengthening research, training and technology awareness – rising among stakeholders,
4. Strengthening institutional capacities at national and sub-national levels,
5. Designing and implementing practical pilot demonstration projects.

A brief account of important enabling measures needed to diffuse water sector prioritized technologies is given in Table 5 below.

Table 5: Key measures identified for three technologies in water sector.

<table>
<thead>
<tr>
<th>Key measures identified</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economic &amp; financial</strong></td>
</tr>
<tr>
<td>a. Ensure the availability of enough local development funding from national government as well as international funding sources for the diffusion of water technology.</td>
</tr>
<tr>
<td><strong>Policy, legal and regulatory</strong></td>
</tr>
</tbody>
</table>
a. Strengthen the current water policy with special attention to effective and coordinated national water management and framework for government to take the lead in an area of vital national concern.

b. Define administrative boundary of saltwater desalination and authorize a single distributor across the country (currently the Nauru Utility Corporation).

c. Resolve ownership right to water and land property rights through improved policy coordination.

<table>
<thead>
<tr>
<th>Information and awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Prepare extensive information and awareness material about the existence and usefulness of water sector technologies and disseminate them improved right to water and land property rights through workshops and training sessions.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technical –Institution and organisation capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Invest in technology capacity building of R &amp; D and governmental institutions.</td>
</tr>
<tr>
<td>b. Ensure the local training and availability of resources and maintenance staff.</td>
</tr>
</tbody>
</table>

**Key water sector measures and enabling framework.**

The key enabling measures needed to ensure diffusion of above-mentioned prioritized water sector technologies and to achieve the preliminary technology transfer and diffusion targets are as follow:

a) **Financing:** High capital cost is a key issue in all four water sector technologies. So, we need to ensure that the national development planning process give required priority to the diffusion of these technologies in the country. Furthermore, as national development funds are limited ‘Department of Finance -Nauru’ should made every effort to obtain project specific grants /soft loans from international donor agencies particularly from international climate financing mechanism such as ‘Adaptation Fund’, ‘Green Climate Fund’ etc. The government must subsidise the cost of these technologies at the local levels across the country.

b) **Skills & Institutional capacity development:** Need to ensure that sufficient financial resources are allocated in annual budget towards skill & Institution capacity development to enhance their technical skills dealing with respective technologies. So, they can undertake feasibilities studies to select most suitable sites for surface rainwater harvesting (non-potable water), groundwater recharge based on hydro-geological conditions. Further, for designing the most appropriate urban storm water
drainage system based on future climate projection also require skills and institutional capacity development.

c) Operation and maintenance capacity: To ensure the sustainability of all four water sector technologies enough financial resources needed to make available for enhancing the technical capacity of R&D and other line departments. Further, special training programs be undertaken to train local technicians in operation and maintenance of these technologies.
Chapter 2: Coastal Sector

2.1 Preliminary targets for technology transfer and diffusion

Nauru is a single, raised coralline island with a land area of only 21 sq. km. but with an EEZ which extends over more than 431 000 sq. km. The island lies 41 km south of the equator. The island nation was formerly rich in phosphate, which has been the country’s principal source of income for many years. Phosphate resources are now depleting, and the country needs to develop alternate sources of income to replace the declining mining revenues. With porous soils and uncertain rainfall, Nauru offers limited opportunity for agricultural production, while fisheries development is a major economic prospect for the future. Although the island nation possessed only a very shallow lagoon, much of which dries at low tide, and a narrow fringing reef, the food produced by fishing in these inshore areas is very important in the Nauru diet. Nauru’s open ocean areas are frequented by an abundance of tuna and other pelagic species. The harvests of tuna in Nauru waters is substantial, but the vast majority of the catch is taken by overseas-based industrial fishing vessels. The access fees paid by those vessels form a large portion of the government revenue.

The Island nation has a fertile coastal strip of only 150 to 300m, and people are settled around the narrow coastal belt where coconut palms flourish and is continually under pressure from sea level rise, coastal flooding, and impact of climate change. According to Kopp et al, (2014) Nauru records one of the highest sea level rise in the world. Following the initial TNA consultation on the Island in 2019, both the government and private stakeholders have agreed that alongside with water sector, the TNA process would also focus on Coastal Area resource management in its endeavour to safeguard the Island nation coastal resources.

During the TNA phase 1, participants have discussed and selected with ranks, 4 potential technologies which the TNA process would have to pursue and prioritise under its process. The focus on these selected technologies is deemed necessary to arrest the increasing impact of sea level rise, destruction of coastal beaches and removal of corals and other resources along the decreasing strips of narrow beach, around the Island nation. Below is the list of technologies which the TNA process has selected by listing them in their ranked order.

Prioritised coastal areas Technologies:
a) Coastal vegetation restoration,
b) Locally Managed Marine area (LMMA).
c) Policy Formulation over coastal area and resource Management
d) Sea Wall Construction

2.2 Barrier analysis and possible enabling measures for coastal vegetation restoration technology.

2.2.1 General description of coastal vegetation restoration technology (CVRT)

The only fertile land areas in Nauru are the narrow coastal belt, where there are coconut palms, pandanus trees and indigenous hardwoods such as the tomano tree (Fa’anunu, 2012). Thaman, et al, (1994) in an earlier study also found that the land surrounding Buada lagoon, where bananas, pineapples and some vegetables are grown are also fertile. Furthermore, some secondary vegetation grows over the coral pinnacles at various locations around the Island.

Sea level rise

Below the belt of land as described above (also refer to Figure 9 below), the coastal vegetation protects coastal areas from saltwater inundation as result of sea level rise, saltwater intrusion and costal erosion or washing away of beaches and soil into the ocean. According to PCCSP 2014, Satellite data indicates the sea level has risen near Nauru by about 5 mm per year since 1993. This is larger than the global average of 2.8–3.6 mm per year. This higher rate of rise may be related to natural fluctuations that take place year to year or decade to decade caused by phenomena such as the El Niño-Southern Oscillation. Sea level rise mainly destroys and washes away vegetation along the beaches (Kopp et al, 2014).

20 PCCSP (2014), Pacific Climate Change Science Program for Nauru,
Coastal Flooding

More frequent coastal flooding is a direct impact of global warming and subsequent sea-level rise (IPCC 2012). Based on the global tides and surge reanalysis by Muis et al., (2016)\(^1\), it is estimated that the extreme coastal water level could increase from 0.2 – 2.8m over the mean level. While in extreme cases like China and the Netherlands it could experience 5-10m of extreme sea levels. Henceforth, the coastal local flood level is added on top of the projected SLR. Because of the above projection, the country is expected to experience the impact of sea level rise, especially along the coast lines.

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**2.2.1.1 Technology status in Nauru**

The coastal vegetation restoration technology is not a new concept on the island nation. Communities around the island nation now realised the importance to plant trees and replenish the vegetation between the beaches and identified fertile land inland to prevent coastal flooding and beach erosion. While some random actions of the communities in this space are not well coordinated, literature found that some of the main drivers to soil erosion mainly in the shore zones areas are mainly cause by human activities, such as sand extraction through beach mining for construction and reclamation purposes always result in long term depletion of the sand resources on the beach (Gillie, R. D. (1997)) Thus, it significantly reduces the natural protection that the beach provides to the coastal communities. For replenishment of vegetation to hold, communities must learn from past mistakes and committed to this initiative.

**2.2.1.2 Technology category and market characteristics**

The Coastal vegetation restoration technology can be categorized as a non-market public good as when established at a community level requires state and community level support to develop and implement such technology at the local level. The technology option in this report is a community or State-coordinated coastal vegetation restoration technology and thus considered as a non-market public good. The government, land owning groups and district administrators must collaborate in this endeavour to ensure long term sustainability.

**2.2.3 Identification of barriers for Coastal Vegetation Restoration technology**

*Preliminary barrier identification*

The barrier identification process for the diffusion of Coastal vegetation restoration technology is done through literature review and by interviews with government officials, consultation, brain storming sessions with stakeholders including NGO representatives and community leaders. The number of barriers were identified and summarized into two major categories- economic/financial barriers and non-economic/financial barriers. Non-economic/financial barriers are further divided into other sub-categories: policies/regulatory, technical, social, cultural, and behavioural barriers. The other sub-categories include,

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institutional capacity barriers, information and awareness barriers, human skills barriers, environment barrier and market failure barriers.

Listed below is a list of generalized potential barriers to diffusion and transfer of coastal vegetation restoration technology:

i. Land tenure system  
ii. Financial constraints  
iii. Awareness – attitude problem  
iv. Climate Change and Disasters  
v. Introduction of new types of trees to be planted at the coastal sites.  
vi. Coastal Flooding  
vii. Coastal area development is not national government priority areas.  
viii. Local government politics  
ix. No policy on coastal vegetation destruction

Screening and prioritization of identified barriers

After the compilation of the list, it was presented to the participants of the technology barrier analysis workshop to screen the list and to identify the essential barriers – that need to be addressed for technology transfer and diffusion to occur. Also, at this stage, the participants decided to ignore the non-essential barriers to the technology as identified in the process. Through consultation and consensus among participants, the final list of barriers was accepted as discussed below in brief.

2.2.2.1 Economic and financial barriers

a) Economic hardship – Coastal area land owning groups see this opportunity of beach mining and extraction for economic purpose as source of income. Thus, land owning groups will always be negatively induced to allow their beaches to be removed in bulk for other development purposes and in the process deforesting the coastal vegetation.  
b) Financing barrier – The cost of individual investing in coastal vegetation replenishment program may be expensive for land owning group to sponsor by themselves.  
c) Types of Vegetation to plant at the coastal areas- The types of vegetation and how to grow them is also important. They are expensive to collect them or import them to Nauru. To address the concern, the project may do a nursery to raise them in, multiply them. Additionally, cost of sands, soils, nursery bags, distribution, planting tools are also costly.
2.2.2.2 Non-financial barriers

The non-economic / financial barriers identified are grouped under different categories as described below:

a) Land Tenure system – The coastal land areas are owned by individuals or family units. Often the people who owns these coastal areas have authority over the activities that take place within their boundaries.

b) Awareness – Landowning group and general public may not understand the importance of growing the coastal area vegetation to the community.

c) Policy – There is no national policy on how communities should be managing and extracting resources within this designated boundary – coastal area.

d) Not priority area – Coastal area management is not priority area of the government and communities to invest funding into. Unlike schools, hospitals and law and order.

Technical

This technology was a simpler one and does not require a high level of technical expert to lead the revegetation process. Nevertheless, it requires the technical knowledge of what to plant, what to rehabilitate and what to protect at the coastal areas. Knowing what, where and how to plant are some of the essential skills that are critical for this technology. Furthermore, it requires government and community support to ensure that such technology is planned, accepted and well implemented at the community levels.

Social, cultural and behaviour

Land owning groups must recognise the need to allow their land plots to be revegetated at the coastal areas to protect the Island from experiencing coastal flooding and beach erosion. Culturally, it is the prerogative right of landowners to have control over their land and boundaries along the coast lines but some of those rights must be forgone for the public good of all.

Information and Awareness

a) There is limited knowledge about revegetation if native trees along the beach to prevent soil erosion and flooding.

b) There is limited knowledge at the local level that such vegetation may project the coastal land areas from sea level rise.
2.3 Barrier analysis and possible enabling measures for locally managed marine area (LMMA)

2.3.1 General description of LMMA

A Locally Managed Marine Area (LMMA) is an area of nearshore waters and its associated coastal and marine resources that is largely or wholly managed at a local level by the coastal communities, land-owning groups, partner organizations, and/or collaborative government representatives who reside or are based in the designated area (Kawaka, et al, 2017). Community-based management and co-management are mainstream approaches to marine conservation and sustainable resource management. In the tropical Pacific, these approaches have proliferated through the spread of locally managed marine areas. LMMA have garnered support because they can be adapted to different contexts and focus on locally identified objectives, negotiated and implemented by the people involved. While LMMA managers may be knowledgeable about their specific sites, broader understanding of objectives, management actions and outcomes of local management efforts remain limited. According to Key Informants, the Ridge to Reef information on the Island is limited. Despite this limitation some communities along the coastline are keen to participate in the LMMA purposively to conserve the marine resources but at the same time renourish the coastal beaches to grow and rebuild against sea level rise and coastal erosion including man made removal of beaches along the coast lines.

2.3.1.1 LMMA status in Nauru

There is not much data available on this technology across the Islands. Although there was recently an outreach by the Ridge to Reef program on this concept, but still yet to be aggressively pursued. According to key informants, some communities on the Islands intend to rigorously pursue this concept because it is seen as the only chance to conserve and rehabilitate their coastal areas. The LMMA is common across most Pacific Island countries. This is because LMMA across the region are developed at national levels are built on a unique feature of the region, customary tenure and resource access, and make use of, in most cases, existing community strengths in traditional knowledge and governance, combined with a local awareness of the need for action, resulting in what have been most aptly termed LMMA. The

main driver in most cases, is a community desire to maintain or improve livelihoods, often related to perceived threats to food security or local economic revenue and prevent coastal erosions from impacts of climate change.

2.3.1.2 Technology category and market characteristics

The Locally Managed Marine Area technology could be categorised as a non-market public good when it’s established at the community level. This is because although it will be established within the private area of some landowning group on the Island, but it will need state assistance to support and implement such technology.

2.3.2 Identification of barriers for Locally Managed Marine Area technology

As a first step, the consultation team with relevant stakeholders including members from some NGOs and land owning groups have identified a list of potential barriers to diffusion of LMMA technology in Nauru with addition of literature. (It must be noted that literature is not helpful at all as there is little data available about the LMMA in the public domain). Regardless of hurdles, this is the list of barriers as identified:

i. Lack of coastal area development policy document,
ii. Land ownership at coastal area decision making,
iii. Limited funding to support such initiative,
iv. Awareness by communities of importance of LMMA
v. Enforcement issues
vi. Livelihood needs vs need to conserve the resources,
vii. Low institutional capacity
viii. Coastal flooding
ix. Low capacity

Screening and prioritization

The final screening and prioritization of the above barriers to diffusion of this technology were undertaken through extensive consultation and brainstorming led by the National Mitigation expert while on the Island. The need to be addressed for technology transfer and diffusion to occur – as well as the non-essential barriers that were to be ignored. The barrier analysis tools such as starter problem and solution trees were used to expedite process of prioritization of barriers. Through consensus among participants, the final list of barriers was achieved and discussed as below in brief.
2.3.2.1 Economic and financial barriers

As the technology is identified as public good, so its base line study where to establish LMMA, surveillance, operations including enforcement, monitoring of shoreline areas as well other related costs will be met by the state or government. There is a lot of information needed to create a baseline and make an assessment on what and where to be considered as an LMMA. These surveys include marine and terrestrials, thus this is also costly if there is no local capacity to do. These will be expensive exercise for the government to go down this part. Below are some descriptions of the economic barriers are detailed as follows:

a) Baseline study – Before deciding on the actual locations for establishment of the LMMA, the government through relevant stakeholders must participate in a study determine what resources or species to conservation and the type of conversation that is applicable to that community.

b) Surveillance – It will be costly to land owning groups and communities who participate in this technology to run such initiatives by themselves. Thus, it is preferable that the government under the responsible Department funds such technology.

c) Enforcement and Monitoring costs - enforcement and monitoring of vast offshore areas will be proven expensive to local land-owning groups and community residences. It will be effective if the government invest into the monitoring and enforcement.

d) Staffing costs - This will be a burden on to the communities or land-owning groups if they decide to establish this technology. In the past, there were some similar technologies to this LMMA established but due to economic reasons, communities and land-owning groups discontinue those good intensions. The government must absorb this cost into its recurrent expenses to ensure the long-term sustainability of this technology on the ground.

2.3.5.2 Non-financial barriers

On the other hand, there were some non-financial barriers which were identified and needs specific attention to either absorb or minimise these barriers. The barriers are categorised under Policy, Legal, and regulatory.

a) Policy – There is no clear policy to provide guidance on development of the coastal area to link with the policy on marine protected areas or even locally managed marine
areas. In absence of this, communities wanting to venture into this technology are usually left with no direction.

b) **Legal and regulatory** – The government has to establish a legal framework purposively to protect the locally managed marine areas in the country. Without such instrument or regulation, the communities will not effectively adopt and implement such noble intension- to conserve the environment across the country.

c) **Land ownership issues** – This is also an area which needs to be addressed at both the national and district levels across the country. From past experiences, land ownership issues amongst tribal groups and communities’ distrusts and discontinue such noble investments.

**Technical**

a) Establishing a LMMA on the Island could also be challenging. For example, it may require scientifically based, comprehensive nationally designed model of MPA representing diverse, marine ecosystems, and the Nation's natural and cultural resources. Often there are few locals who has the capacity to design such technology.

**Social, cultural and behavioural**

b) Coastal area including the sea areas around the Island are very much part of how people live and go about their livelihoods across the Island. They depend on the sea for food and other recreational purposes. Allocating a specific area for conservation will test how community members behave and manage their resources.

c) Community members must accept that conserving the environment or marine resource is a critical for long term sustainability of future generations.

**Information and awareness**

a) Develop and maintain the database on Ridge to Reef matters in the country. This is important to ensure that people know the importance of locally managed marine resources. On the short term is to protect their coastline areas but in the long term ensuring that there are marine resources conserve for future generations.
2.4 Barrier analysis and possible enabling measures for Policy and Guideline formulation over Coastal Resource Management

2.4.1 General description of Policy and Guideline formulation over coastal resource management

Policy is a deliberate system of principles to guide decisions and achieve rational outcomes. Policies are generally adopted by a governance body within an organization or country. Policies can assist in both subjective and objective decision making. For example, in Nauru there are various policies which are put in place for the government to operate within to achieve long and sustainable development to all Nauruan (National Development Strategy 2005-2025). Additionally, the Integrated Water Resource Management Policy (IWRM) of Nauru which provide guiding principles on how to manage the scarce water resources in the country. This policy and guideline formulation as technology is aimed to develop set of rules and guidelines surrounding the extraction of resource alone the coast lines including extraction of vegetation and sand beaches.

The benefit of having such a technology is to provide some level of control and oversight over the extraction and removal of sand beach which could lead to further coastal erosion and washing away of beaches.

2.4.2 Technology category and market characteristics

Policy and Guideline formulation over coastal resource management technology is categorised as a non-market and publicly provided good. This means, the national government will have to allocate the relevant expertise and resources to design this technology for the good of society and country.

2.4.2 Identification of barriers for Policy and guideline formulation

Screening and Prioritization process.

The screening and prioritization process for this technology has not much complications compared to other technologies. This is mainly because there aren’t a lot of barriers identified during the consultation and workshop process regarding this specific technology. Nevertheless, it went through the process for potential barriers to the diffusion and transfer of policy guideline formulation over resource technology. The barriers identified were as follows:
i. No capacity to engage legal experts,

ii. No prioritized funding from the state

iii. Cultural issues

iv. Government support

v. Enforcement issues

The key identified barriers are discussed below:

2.4.2.1 Economic and financial barriers

b) Legal Cost – Usually it will cost the Nauruan government or state, thousands of dollars to hire a legal counsel to design and develop such policy. The participants urged as part of this process if this technology could be developed to ensure engagement of a legal counsel to lead in formulation and development of policy over coastal resource management.

c) Economic benefits – There is perception that coastal area resources are owned by land owning groups or individuals. Thus, any economic or authority regulating this process, rests on land owning groups and not the state.

d) Enforcement cost – When such policy is formulated there must be an authority who has the resources and capacity (laws and institutional) available to enforce such instrument.

2.4.2.2 Non-financial barriers

a) Political will – The government must support this initiative. The technology was overwhelmingly supported during the consultation and workshop but, it must have the political will by the government of the day.

b) Land ownership – Development of any technology to safe guard the extraction and harvesting of resources at the national level will face some barriers or views of some sort by the land owning groups and individuals.

c) Enforcement issues - There will be clash between land owners and government official over enforcement issues if proper awareness and education is not done at the local levels.

d) Regulatory – The government must take ownership to such technology establish a regulatory body to regulate the design, development, adoption and implementation of such policy.
Social and Cultural

a) **Community support** – The communities including landowners should promote development of such important technology.

Technical

b) As this is a new area across the country, there is little or no technical expert available to design, formulate or lead in drafting such technology (coastal resource management policy).

c) Poor knowledge in coastal resource management design or formulation in the face of climate change.

Information and Awareness

a) There is limited information on the need to have such a technology over resource management in the country.

b) Absence of data and information on the negative impact consequences of climate change at the national level to support the call for such policy technology formulation.

c) Need to inform the general public on the potential benefit of having such a technology in the country.

2.5 **Barrier analysis and possible enabling measures for Seawall Construction technology**

2.5.1 **General description of Seawall Construction technology**

A seawall (or sea wall) is a form of coastal defence constructed where the sea, and associated coastal processes, impact directly upon the landforms of the coast. The purpose of a sea wall is to protect areas of human habitation, conservation and leisure activities from the action of tides, waves, sea level rise or tsunamis. In some Small Pacific Island countries a few governments resort to sea walls as temporary measures against the increasing sea level rise, storm surges and coastal erosion. In Nauru a new seawall in the district of Anetan will help alleviate sand erosion and the effects of king tides on the community. The Government of India donated AUD 500,000 to its Nauru counterpart to help construct the 200-metre seawall on the north side of the island. According to Key respondents on the Island, the barrier helps the community to build resilience against King tides and provides them with some comfort of hope that their community will not immediately be washed away by the looming impact of climate change.
The downside of this technology is that, it is costly and capital intensive. Furthermore, it could also have some environmental impact on the beaches if not properly planned and constructed. For example, in the neighbouring Island country of Kiribati at the Aonebuka community, the villagers have banned construction of sea wall because, they believed that building a seawall is not best for their community, so they setup a community agreement, that nobody, no family, or no clan is allowed to build a seawall on the coastline. The sea wall rearranges the flows of waves and currents around the Island.

According to a key informant, Seawalls can sometimes increase the rate of erosion in front of the seawall due to wave reflection and at the ends of the structure caused by wave focussing. When all available sediment has been removed in front of the wall, down drift areas will no longer receive sediment and erosion may be accelerated as a result of building the wall.

2.5.2.1 Technology category and market characteristics

Depending on scale and who is formulating the application, Seawall construction technology in this context is a non-market public good. This is because the applicant is the government and most likely general public will benefit from such technology and the state will meet the cost of such infrastructure. Thus, in our discussion, the on the technology barrier, it is considered as a public good.

2.5.3 Identification of barriers for Seawall Construction technology

Preliminary barrier identification.

As an initial step, a desk top review was made on various key documents and policy papers to determine any immediate major barrier to sea wall construction technology in the country. Such exercise was supplemented by interviews with experts, key stakeholders and brainstorming. During the process a list of potential barriers to development, transfer and diffusion of seawall construction technology in the country was prepared and categorised into two broad main categories. These were economic and financial barriers and non-financial barriers. The non-financial barriers were then further divided down into policy, legal, and regulatory barriers, technical barriers, institutional and organisational capacity barriers, social barriers, informational and barriers. These barriers were discussed in detail below.

i. High capital cost,

ii. Funding allocation by government,
iii. Land ownership issues,
iv. Material Intensive,
v. Technical expertise,
vi. Community perception,

**Screening and Prioritization of identified barriers**

After the compilation of the list (barriers), it was then presented to the stakeholders during a technology analysis workshop. The list was further scrutinised and reduced to identify the essential barriers – that need to be addressed for technology transfer and diffusion to occur while the non-financial barriers identified and were ignored from the same process. As most of the barriers above, a barrier analysis tool such as starter problem and solution tree were used to speed up prioritization of barriers. Through consensus among stakeholders and expert participants the final list of barriers was achieved and discussed in brief below:

2.5.2.1 Economic and financial barriers

a) **High capital cost** – The cost to build a seawall is relatively expensive at the local level. For example, the total project cost of the recent sea wall donated by Government of India was AUD$500,000, this is including imported materials such as cements, reinforce wires to construct the technology. Additionally, it requires transportation of rocks and from the mining.

b) **Funding Allocation** – There is no government budgetary allocations into this sea wall construction around the Island. And with such limited funding opportunities, sea walls are prioritised by the government of the day.

c) **Donor Funding** – Donors could be approached to fund one of the TNA projects in the country.

2.5.2.2 Non-financial barriers

a) **Policy** – There is no policy on how and where to construct seawall technology across the Island nation.

b) **Legal** – The Island nation like many others through the region don’t have the legal framework that guides communities and individuals on how to build sea walls at their own areas.
c) **Regulatory** – In absence of policy around construction of sea wall, there isn’t a requirement such as Environment Impact Assessment (EIA) and Cost Benefit Analysis (CBA) as approval process for construction of these structures.

### 2.6 Linkages of the barriers identified.

This section looks at different barriers that are common to; roof top – rainwater harvesting, water reticulation system, non-potable water access and tanker-truck technologies under water sector. Likewise, it also looks at linkages which coastal vegetation restoration, locally managed marine area, policy formulation over coastal area and resource management and sea walls construction technologies may have in common at the local level.

For the water sector; the identified four technologies are geared towards enabling the individuals and communities having access to both potable and non-potable water improving the health and livelihood of the communities. The barriers identified are similar, with all the technologies, and that they are all expensive and costly to establish. This implies that individual households and communities may find it difficult to privately acquire these technologies.

### 2.7 Enabling framework for overcoming the barriers in the coastal sectors

A key component of the enabling framework for overcoming the barriers to diffusion of prioritised technologies in the coastal sectors is the operationalizing of existing national climate change policy and its implementation framework recommendations related to the coastal area management. The next step should include the increase budgetary support allocation for increasing the resilience of the vulnerable communities from impact of climate change on coastal areas. Thus, the diffusion of above-mentioned prioritised technologies can be facilitated through the mobilization of external donor agencies and getting access to international climate finance funds especially Green Climate Fund (GCF), Global Environment Facility (GEF) and Adaptation Fund (AF). For that to happen, the country needs to devise effective technology-based adaptation projects that would promise to deliver the potential benefits of these technologies to the resource’s owners, managers, users, and other beneficiaries alike.

Similarly, the next important component of sustainable coastal area resource management in the country is needed to ensure that social, economic and environmental aspects of coastal
Area management are integrated into sectoral policies and plans of the government and communities across the country. Since communities across the country are settled mostly along the coastal areas, any plans and programs should be taking guidance from the cross-cutting themes of coastal protection, water equity and hazards.

Based on the above themes, the prioritised technologies’ implementing strategy, need to focus on ensuring that there is effective design and implementation of the eventually approved and funded technologies that are aimed at benefit households and communities at large. Furthermore, though several measures are proposed to improve diffusion of coastal sector prioritised technologies, it is important to address the most fundamental, practical urgent ones first.

At this stage, we could potentially link institutional capacities’ enhancement, strengthening laws and regulations, ensuring climate informed decision making and planning, promoting research and technology awareness, and implementing pilot demonstration projects at various locations across the country. In addition, ensuring the required investment will continue to be the fundamental enabling factors across all water and coastal sectors technologies implementations at national and local levels.

Based on the above themes, discussions, barriers and measures may cover these 5 broad issues for both water and coastal sectors:

1. The national government must ensure that there is appropriate financial mechanism to support any implementation.
2. The appropriate authority to mainstream climate change considerations into relevant sectorial policies, plans and strategies.
3. There is need to strengthen institutional research, training, and technology awareness –raising among stakeholders
4. There is need for strengthening institutional capacities at national and sub-national levels
5. Prior to full implementation, there must be proper designing and implementing practical pilot demonstration projects at the local levels.

A brief account of important enabling measures needed to diffuse water and coastal area sectors prioritised technologies is given in the Table 6.
Table 6: Key measures identified for the four technologies in coastal area resource management

<table>
<thead>
<tr>
<th>Key Measured Identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic &amp; financial</td>
</tr>
<tr>
<td>a. Ensure availability of fund of sufficient local development funding from National as well as international funding sources for diffusion technologies.</td>
</tr>
<tr>
<td>Policy, legal, and regulatory</td>
</tr>
<tr>
<td>b. Formulate a coastal area resource management policy with special attention to conserve the coastal areas from soil mining and extraction by human activities.</td>
</tr>
<tr>
<td>c. Define administrative boundary for landowners with restriction on what they could do and what they shouldn’t do even in their own areas along the coastline zones.</td>
</tr>
<tr>
<td>d. Recognise the role and authority of land-owning groups along the coastlines but must setup process on how they could still have access to their coastal area without any damage or disturbances to the land.</td>
</tr>
<tr>
<td>Information and awareness</td>
</tr>
<tr>
<td>e. Prepare extensive information, and awareness material about the importance of keeping or conservation coastal area (land) vegetation intact, pretending soil erosion and impact of climate change.</td>
</tr>
<tr>
<td>Technical – Institutional and organisational capacity</td>
</tr>
<tr>
<td>f. Invest in technical capacity building of R &amp; D and local government institutions</td>
</tr>
<tr>
<td>g. Ensure the local training and availability of local experts to maintain coastal areas and resources.</td>
</tr>
</tbody>
</table>

Key coastal area measures and enabling framework.

The key enabling measures needed to ensure diffusion of the above mentioned prioritised coastal sector technologies and achieve the preliminary technology transfer and diffusion targets includes the following:

a) **Financing:** High capital cost is a key issue in all of the identified technologies in the coastal area sector management. Because of this we need to ensure that the national development planning process provides the maximum required priority to the diffusion of these technologies into the country. Additionally, since the funds since there is limited development fund available to fund these investments the Department of Finance must seek external climate financing mechanism such as Adaptation Fund and Green Climate Fund etc. to fund developments.
b) **R & D institutional capacity:** There will be some research and institutional capacity training especially in the area of LMMA and conservation. Besides, building of sea wall must be done with proper research on the sea and wave current and etc. thus enough budgetary support should always be available to support such technologies.

c) **Operational and maintenance:** To ensure sustainability with the identified technologies, there must be always enough funding and budgetary support available for operational and maintenance of the identified technologies.
List of References


### Annex 1: Water Sector - Market mapping, problem/solution trees

#### 1.1 Rooftop Rainwater Harvesting Technology

**1.1.1 Market Mapping** – *Rooftop Rainwater Harvesting Technology*

<table>
<thead>
<tr>
<th>BUSINESS ENVIRONMENT</th>
<th>MARKET ACTORS</th>
<th>SERVICE PROVIDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Support for production</td>
<td>2. NGOs, CSOs and Communities</td>
<td>2. Technical Support</td>
</tr>
<tr>
<td>3. Trade and Quality standard</td>
<td>3. Local Importers</td>
<td>3. Quality control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Market Information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Awareness</td>
</tr>
</tbody>
</table>
1.1.2 Problem Tree – Rooftop Rainwater Harvesting Technology

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>CAUSES</th>
<th>EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved livelihood</td>
<td>Livelihood Improved</td>
<td>Local expertise capacity building</td>
</tr>
<tr>
<td>Sustainable livelihood</td>
<td>Stability in Food security</td>
<td>Wider use of technology</td>
</tr>
<tr>
<td>Stability in Food security</td>
<td>Improved community health</td>
<td>Accessible water by essential services such as schools and hospital</td>
</tr>
<tr>
<td>Local dealers in parts</td>
<td>Improved hygienic levels of communities</td>
<td>Stability in Food security</td>
</tr>
<tr>
<td>Improved community harmony</td>
<td>Improved vegetation beautification</td>
<td>Local ownership</td>
</tr>
<tr>
<td>Improved community health</td>
<td>Local dealers in parts</td>
<td>Information sharing</td>
</tr>
</tbody>
</table>

Accessible water by communities

- Strengthen Institutional Capacity
- Increased opportunity to participate in back yard gardening
- Increased water access to households
- Access to information and technical know how
- Access to management and capacity development
- Potential benefit knowledge of technology
- Accessible water by communities
- Improved community health
- Effective community coordination
- Capacity development
- Improved vegetation replenishment
1.1.3 Solution Tree – Rooftop Rainwater Harvesting Technology

Water Policy and regulation
Improved Technology Design
Vegetation replenishment
Capacity Training
More awareness

Customized Technology design
Community ownership
Use of modern and quality of roofing irons
Community training and capacity building
More inter-governmental department cooperation

Increased water access
Information Dissemination
Access to clean water
Community harmony
Effective water harvesting policy

Availability of donor funding

More Financial options
Could be easily installed
Green environment
Acquired Skills
More awareness about the technology

Government Subsidy
Improved Community Ownership
Improved Livelihoods
Improved Information on the benefits of the technology
High level of cooperation

Access to high technology
Communal cooperation
Improved community harmony
Effective coordination
Effective policy and regulation on rainwater harvesting
### 1.2 Water Reticulation Technology

#### 1.2.1 Market Mapping – Water Reticulation Technology

<table>
<thead>
<tr>
<th>BUSINESS ENVIRONMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Government Scheme for Subsidy/Loan</td>
</tr>
<tr>
<td>2. Support for production</td>
</tr>
<tr>
<td>3. Skilled workers</td>
</tr>
<tr>
<td>4. Political environments</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MARKET ACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nauru Utility Corporation</td>
</tr>
<tr>
<td>2. Household units</td>
</tr>
<tr>
<td>3. NGOs and Private Sectors</td>
</tr>
<tr>
<td>4. Importers of materials</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SERVICE PROVIDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Financial Support Services</td>
</tr>
<tr>
<td>2. Technical Support</td>
</tr>
<tr>
<td>3. Quality control</td>
</tr>
<tr>
<td>4. Training and capacity Building</td>
</tr>
<tr>
<td>5. Market Information</td>
</tr>
<tr>
<td>6. Awareness</td>
</tr>
</tbody>
</table>
1.2.2 Problem Tree – Water Reticulation Technology

Reduced Quality Water for competing uses

Water Scarcity

Unsustainable Livelihoods

Poor performances

poor water infrastructure support

Poor Technologies

unsustainable livelihood

Food insecurity

land ownership issues

In access to basic water services

Poor feasibility studies

Poor Community Health

Contaminated ground water

Community disharmony

Poverty driven community

High capital cost

ECONOMIC/FINANCE

SOCIAL

ENVIRONMENT

HUMAN CAPACITY

INSTITUTIONAL

High capital cost

Land ownership issues

Impact of Climate Change

Unskilled workers

Poor governance

Land ownership issues

Contamination of ground water

No surface water in the country

Lack of land use and planning policy

Weak coordination

High Interest rate

Weak coordination

Aged infrastructure

Non cooperative community

Poor information sharing
1.2.3 **Solution Tree** – *Water Reticulation Technology*

- **Water Policy and regulation**
  - Increased livelihood levels
  - Access to clean water
  - Capacity building
  - Better land use planning policy

- **Access to Financial support**
  - Increased ownership
  - Effective water distribution method
  - Increased Local expertise
  - increased governance

- **Increased water access**
  - Information dissemination
  - Use for Agricultural production
  - Increased local ownership
  - Improved coordination

---

**Community having access to clean and safe water**

- **Improved water policy and regulation**
  - Community ownership
  - Use of modern infrastructures
  - Increased labor skills
  - Capacity building trainings

- **Improved Financial options**
  - Better use planning policy
  - Environment fertilization
  - Increased capacity to support community management of the technology
  - information sharing

- **Improved technology design**
  - Better understanding of project initiatives
  - Improved community health
  - Community participation
  - Effective coordination

- **High financial options**
  - Community support
  - Increase positive perception of the project
  - Community harmony
  - Good governance
1.3 **Non-potable Water Access Technology**

### 1.3.1 Market Mapping – *Non-potable Water Access Technology*

<table>
<thead>
<tr>
<th>BUSINESS ENVIRONMENT</th>
<th>MARKET ACTORS</th>
<th>SERVICE PROVIDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Trade and Quality standard</td>
<td>3. NGOs and Private Sectors</td>
<td>3. Quality control</td>
</tr>
</tbody>
</table>

5. Market Information

6. Awareness
1.3.2 Problem Tree – Non-potable Water Access Technology

- Reduced water availability for competing uses
- Water Security
- unsustainable livelihoods
- Poor workmanship
- Poor governance

- Poor technologies
- Poor Health
- Food security
- Fault in infrastructure
- Poor Service

- Under performance
- Unsustainable livelihood
- Vector bone diseases
- poor design
- Health effects

High cost of Capital

- ECONOMIC/FINANCE
  - High Capital Cost
  - Limited Financial Access
  - High Interest rate

- SOCIAL
  - Land ownership issues
  - Information dissemination
  - Weak Coordination

- ENVIRONMENT
  - Unhealthy family units
  - Unhealthy communities
  - Contaminated underground water

- HUMAN CAPACITY
  - Under capacity
  - Unskilled laborers
  - Poor human capital

- INSTITUTIONAL
  - Poor coordination
  - Weak Management
  - Information sharing
1.3.3 **Solution Tree** – *Non-potable Water Access Technology*

**Government subsidy**  
Improved Land use planning policy  
Improved health of family units  
Capacity Training  
Effective coordination

Better policy on water  
More awareness and improved community health  
Skilled workers  
Strong management

Financial Access options  
Strong coordination  
Have access to better water  
increase water experts  
More information sharing and awareness

---

Government support through budgetary and aid coordination

**STATER PROBLEM**

Government Subsidy  
Land use planning policy  
Healthy families  
Superior Work experts  
Team commitments

Water Policy and regulation  
High level of department cooperation  
Healthy communities  
High performance  
Knowledge management and learning

---

**RESULTS**
## 1.4 Water Tanker Truck

### 1.4.1 Market Mapping – Water Tanker Truck Technology

<table>
<thead>
<tr>
<th>BUSINESS ENVIRONMENT</th>
<th>MARKET ACTORS</th>
<th>SERVICE PROVIDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Support for production</td>
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<td>2. Technical Support</td>
</tr>
<tr>
<td>3. Trade and Quality standard</td>
<td>3. Local Importers</td>
<td>3. Quality control</td>
</tr>
<tr>
<td></td>
<td>5. Maintenance Providers</td>
<td>5. Market Information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Awareness</td>
</tr>
</tbody>
</table>
1.4.2 Problem Tree – Water Tanker Truck Technology

Expensive to purchase  Little knowledge of benefit of water tanker technology  Fluctuating rain fall  Limited local capacity to deal with water distribution  Poor water management and distributions systems

Expensive to maintain  No community ownership  Poor infrastructure to support technology  No local importers of parts  Ineffective water distribution policy

Required experts - engineers to maintain  Requires promotion at schools for importance of water  Deteriorating state of road and bridge  Low support by community  Weak governance

Required specialized trained expert to run or operation

ECONOMIC/FINANCE
- High Capital cost

SOCIAL
- Low awareness
- Little option for water harvesting

ENVIRONMENT
- Limited existing services
- Impact of climate change

HUMAN CAPACITY
- Weak regulatory system
- Week access to high technology

INSTITUTIONAL
- Limited Institutional Research
- Limited

CAUSES
- High Research Investment
- More expensive than traditional water collection

EFFECTS
- High Maintenances cost
- Perception of benefits from technology
- Other priorities
- Low community awareness
- Quality control
1.4.3 Solution Tree – Water Tanker Truck Technology

Livelihood Improved
Sustainable livelihood
Stability in Food security
Local expertise capacity building
Wider use of technology

Improved community health
Accessible water by essential services such as schools and hospital
Stability in Food security
Local dealers in parts
Information sharing

Improved community harmony
Improved hygienic levels of communities
Vegetation beautification
Increased community support
Increased community awareness

Accessible water by communities

Strengthen Institutional Capacity
Increased opportunity to participate in back yard gardening
Improved vegetation replenishment
Accessible to information and technical know how
Access to management and capacity development

External funding is affordable
 Increased water access to households
Healthy community
Increased local experts
Effective communication

Reduced Tax through Subsidy and tax
Sustainable livelihoods
Community in harmony
Increased knowledge sharing
Increased governance

Improved community health

Stability in Food security

Information sharing
Annex 2: Market mapping, problem/solution trees for Coastal Sector Technologies

2.1 Coastal Vegetation Restoration

2.1.1 Market Mapping – Coastal Vegetation Restoration Technology

| BUSINESS ENVIRONMENT                  | 1. Government Scheme for Loan subsidy  
|                                       | 2. Policy formulation for coastal area  
|                                       | 3. Technical Skills  
|                                       | 4. Local Politics  
| MARKET ACTORS                          | 1. NGOs, CBOs, and associations  
|                                       | 2. Land owning groups  
|                                       | 3. Household units  
|                                       | 4. Consumer trends  
| SERVICE PROVIDERS                     | 1. Financial support  
|                                       | 2. Technical Support  
|                                       | 3. Market information  
|                                       | 4. Training and capacity building  
|                                       | 5. Awareness |
2.1.2 Problem Tree – Coastal Vegetation Restoration Technology

Sea level rise
- Over extraction of resources
- Sand dune mining
- Knowledge Gap about resource management
- Department working in silos

Saltwater intrusion
- unwanted removal of vegetation’s
- Extraction for economic purposes
- Limited skills for planting of trees
- Noncooperative environment

Coastal erosion
- Human induced activities
- Removal of vegetation’s for coastal development

Extraction of corals and sand beach along the coastlines

<table>
<thead>
<tr>
<th>CAUSES</th>
<th>EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECONOMIC/FINANCE</td>
<td>SOCIAL</td>
</tr>
<tr>
<td>High capital cost</td>
<td>Land owning groups right to resources</td>
</tr>
<tr>
<td>No funding alternatives</td>
<td>Insufficient Policy and regulation</td>
</tr>
<tr>
<td>Low local skills</td>
<td>Attitude problems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ENVIRONMENT</th>
<th>HUMAN CAPACITY</th>
<th>INSTITUTIONAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact of Climate Change</td>
<td>Limited awareness about over extraction</td>
<td>Ineffective coordination of relevant Departments</td>
</tr>
<tr>
<td>Increased storm surges</td>
<td>Little knowledge about vegetation replenishment</td>
<td>Information sharing &amp; awareness</td>
</tr>
<tr>
<td>Sea level rise</td>
<td>Capacity training building</td>
<td>Policy Formulation</td>
</tr>
</tbody>
</table>
2.1.3 Solution Tree – Coastal Vegetation Restoration Technology

- Reduced coastal erosion
- Controlled usage over resources
- Vegetation prevents further erosion
- Improved level of awareness
- Increased awareness

- Prevent saltwater intrusion
- Better policy over resources
- Vegetation protects the coastline areas
- Increased technical know how’s
- Increased coordination

- Improved vegetation
- Awareness and understanding
- Vegetation provide barriers against saltwater intrusion
- Ownership of the technology
- contained malpractices

Restoration of coastal vegetation prevents coastal erosion

- Clear government policy on coastal area management
- Understand the importance to regrow vegetation
- Replenishment of vegetation
- Mass awareness
- Policy and Regulation design

- Community ownership of conservation activities
- Improved vegetation growth at the shorelines
- Improved beach barriers
- Climate Change trainings
- Public awareness

- Community skills training
- Lessen picnics and activities that will destroy vegetation’s
- Minimized saltwater intrusions
- Basic training skills
- Policy Coordination

- Awareness of Coastal vegetation
- Cooperative attitude
- Soil replenishment
- Community ownership
- Effective communication
## 2.2 LMMA Technology

### 2.2.1 Market Mapping – LMMA Technology

<table>
<thead>
<tr>
<th>BUSINESS ENVIRONMENT</th>
<th>MARKET ACTORS</th>
<th>SERVICE PROVIDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Limited funding to support LMMA</td>
<td>2. Land owning Groups</td>
<td>2. Technical Support</td>
</tr>
</tbody>
</table>
2.2.2 Problem Tree – LMMA Technology

High extraction of resources

Reduced coastal area for public uses

Unsustainable environmental harvesting

Unsustainable livelihood

Poor coordination

Unsustainable Livelihoods

Reduced area for fishing

Weak environment planning

Local incapacity

Weak government policy

Financial Access in capacity

Reduced area for recreational purposes

short term environment benefits

Reduced resource access

No local government regulation

There is not incentive to conserve coastal area resources

ECONOMIC/FINANCE

SOCIAL

ENVIRONMENT

HUMAN CAPACITY

INSTITUTIONAL

Food insecurity

Resort to illegal fishing technique

High exploitation of environment and coastal resources

Poor resource planning

Insufficient policy

Financial insecurity

travelled long distance for fishing

Limited awareness about potential benefits

Poor Coordination

Weak Surveillance

Fast cash return

land ownership issues

Importance of environment to communities

poor knowledge about climate change

Poor coordination
2.2.3 Solution Tree – LMMA Technology

**Results**

- Improved governance surrounding harvesting resources
- Reduced over harvesting of fish
- Vulnerable coastal communities restored
- Increased local knowledge
- Stable in food security

Focus on the long-term benefit of conservation

- Reduced over exploitation of resources
- Exposures to storm surges reduced
- Improved coordination
- Better coastal resource management

Increase fish catch

- Reduced land disputes
- Exposure to sea level rises managed
- Improved information sharing
- Better coordination

Locally managed marine areas help to conserve marine resource from extractions etc

**Measures**

- More financial options
- Designated area for fishing
- Preservation of the coastal environments
- Community participation
- Clear government policy

- Increased community ownership
- Approved fishing technique
- Replenishment of coastal vegetation
- Landowning group awareness
- Improved social & cultural acceptability

- Increased subsidy
- Improved social and cultural access to resources
- Reduced exposure to sea level rise
- Household participation
- Increased local government participation
## 2.3 Policy Formulation Technology

### 2.3.1 Market Mapping

<table>
<thead>
<tr>
<th>BUSINESS ENVIRONMENT</th>
<th>MARKET ACTORS</th>
<th>SERVICE PROVIDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Government Priorities</td>
<td>1. NGOs, CSO, and associations</td>
<td>1. Financial Services</td>
</tr>
<tr>
<td>4. Local Politics</td>
<td></td>
<td>4. Training and capacity building</td>
</tr>
<tr>
<td>5. Donor Aid partners</td>
<td></td>
<td>5. Public awareness</td>
</tr>
</tbody>
</table>


2.3.2 Problem Tree – Policy Formulation Technology

Not a government Priority to formulate coastal area resources

**PROBLEM**

**ECONOMIC/FINANCE**  **SOCIAL**  **ENVIRONMENT**  **HUMAN CAPACITY**  **INSTITUTIONAL**

- High legal fees
- Limited capacity
- No government Policy

**CAUSES**

- Low level of community support
- Low level of capacity to understand climate change
- Low involvement by land owning groups

- High extraction level of resources
- Lander ownership’s right
- Short economic benefit

- Little support
- No incentives
- No perception of future benefits

- Poor government Priority
- Weak Government Departments’ awareness and support
- Policy inefficiency

**EFFECTS**

- No funding support
- Increasing poverty line
- Not locally prioritized

- No government Priority
- Increasing impact of climate change
- Increased in sea level rise

- Unstainable livelihood
- Local incapacity
- Competing objectives at community level

- Conflicting priorities
- Increasing community exposures
- Increased in saltwater intrusion

- Weak information sharing
- Weak governance
- Weak government

**Not a government Priority to formulate coastal area resources**
2.3.3 **Solution Tree** – *Policy Formulation Technology*

**RESULTS**

- Increased awareness
- Increased community resilience
- Controlled resource management
- Increased Livelihood awareness
- Increased Coordination
- Increased Policy coordination
- Community support
- Proper Planning
- Clear policy drafting
- Effective planning
- Increased community participation
- Livelihood sustainability
- Long-term focus over resources
- Community harmony
- Good governance

**Policy formulation will control over extraction of resources**

**STARTER PROBLEM**

- Information sharing
- Training capacity
- Conservation of environment
- Community participation
- Increased Awareness
- Community training
- Local exposure
- Awareness of the need to support policy formulation
- Local government Support
- Effective coordination
- Financial Support
- Government support
- All of resource owners' views
- Local support
- Effective Surveillance
- Regional Support
- Donor aid partners support
- Community awareness
- Increased Information sharing
- Strong perception of benefits
### 2.4 Seawall Technology

#### 2.4.1 Market Mapping – Seawall Technology

<table>
<thead>
<tr>
<th>BUSINESS ENVIRONMENT</th>
<th>MARKET ACTORS</th>
<th>SERVICE PROVIDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Government Scheme for Loan subsidy</td>
<td>1. NGOs, CSO, and associations</td>
<td>1. Financial Services</td>
</tr>
<tr>
<td>5. Donor Aid partners</td>
<td></td>
<td>5. Public awareness</td>
</tr>
</tbody>
</table>
### 2.4.2 Problem Tree – Seawall Technology

<table>
<thead>
<tr>
<th>Impact of Sea level Rise</th>
<th>Coastal land ownership issues</th>
<th>Unsustainable communities</th>
<th>Poor local skills</th>
<th>Poor Management skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costal Erosion</td>
<td>Community perception</td>
<td>Landownership attitudes</td>
<td>Poor capacity</td>
<td>Poor idea sharing</td>
</tr>
<tr>
<td>Storm Surges</td>
<td>Material incentive</td>
<td>Extraction for social or economic gains</td>
<td>Poor coordination</td>
<td>No cooperation between local government &amp; national government</td>
</tr>
</tbody>
</table>

**Community perception of sea wall benefits**

<table>
<thead>
<tr>
<th>ECONOMIC/FINANCE</th>
<th>SOCIAL</th>
<th>ENVIRONMENT</th>
<th>HUMAN CAPACITY</th>
<th>INSTITUTIONAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>High capital cost</td>
<td>Regulatory Requirement</td>
<td>Destruction of natural environment</td>
<td>Low local skills</td>
<td>little knowledge of role to play</td>
</tr>
<tr>
<td>Low financial capacity of the community</td>
<td>Community awareness</td>
<td>Redirection of sea current</td>
<td>Low local capacity to support</td>
<td>No direction</td>
</tr>
<tr>
<td>Unsustainable coastal management</td>
<td>Priority of coastal communities</td>
<td>Proper R &amp; D</td>
<td>High Initial support</td>
<td>No collaboration of stakeholders</td>
</tr>
</tbody>
</table>
2.4.3 Solution Tree – Seawall Technology

- Increased Sustainable communities
- Increased community awareness
- Coastal community’s livelihood sustained
- Local capacity developed
- Sustainable communities

- Increased resilience by coastal communities
- Increased local government ownership
- Sea level rise controlled
- Community awareness
- Resilient to sea level rise

- Increased level of adaptation
- Increased government participation
- Reduced coastal erosion
- Local government support
- Better coordination

Sea wall must be supported by proper EIA and Cost Benefit Analysis

- International donor’s support
- Community planning
- Environment Impact Assessments
- Local capacity training
- Policy on coastal resource management

- Increased Financial options
- Local government participation
- Coastal community awareness
- Community skills training
- Better collaboration with aid donor partners

- Increased community ownership
- Household ownership
- Long term sustainability
- Local business support trainings
- Community support
Annex 3: Technology Experts Consulted

3.1 Water Sector Working Group

i. Reagan Moses Secretary for Climate Change & National Resilience, GoN
ii. Jayden Agir Water Strategy Manager, Dept. CC&NR, GoN
iii. Mark Hiram Water Services Manager, NUC
iv. Abraham Aremwa TNA Mitigation Consultant

3.2 Coastal Sector Working Group

i. Reagan Moses Sec. for Climate Change & National Resilience, GoN
ii. Bryan Star Director for Environment, Dept. CIE, GoN
iii. Frankie Ribauw Director for Coastal (Seawall), Dept. CIE, GoN
iv. Abraham Aremwa TNA Mitigation Consultant