Government of Tuvalu

BARRIER ANALYSIS AND ENABLING FRAMEWORK OF DAPTATION TECHNOLOGIES

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Foreword

Climate change poses significant challenges to the small island nation of Tuvalu, particularly in the sectors of coastal management, water resources, and agriculture. As we strive to adapt to these changes, it is crucial to identify and overcome the barriers that hinder our progress and to establish an enabling framework that supports the implementation of prioritised technologies.

This Barrier Analysis and Enabling Framework report focuses on three critical sectors:

1. **Coastal Areas**: Tuvalu's low-lying atolls are highly vulnerable to sea-level rise, coastal erosion, and extreme weather events. Enhancing the resilience of our coastal areas through innovative technologies and sustainable practices is essential to protect our communities and ecosystems.
2. **Water Resources**: Freshwater availability is a pressing concern in Tuvalu, exacerbated by saltwater intrusion and changing precipitation patterns. Prioritizing technologies that improve water conservation, storage, and desalination will be vital in ensuring a reliable supply of clean water for all.
3. **Agriculture**: The impacts of climate change on agriculture threaten food security and livelihoods. Introducing salt-tolerant crop varieties, improving soil management, and adopting climate-smart agricultural practices are key to sustaining and enhancing agricultural productivity.

This report aims to provide a comprehensive assessment of the barriers to technology adoption in these sectors and to propose actionable strategies to create an enabling environment for their implementation. By addressing these challenges, we can build a more resilient and sustainable future for Tuvalu.

As Minister responsible for the climate change concerns, it gives me great pleasure to present this TNA report for proper consideration by the UNEP Copenhagen Climate Center.

Dr. Maina Vakafua Talia
Minister for Home Affairs, Climate Change, and Environment

List of Abbreviations

BAEF	:	Barrier Analysis and Enabling Framework
BES	:	Biodiversity and Ecosystem Services
CBO	:	Community Based Organization
CSO	:	Civil Society Organization
CTCN	:	Climate Technology Centre and Network
DOA	:	Department of Agriculture
IPCC	:	Inter-governmental Panel on Climate Change
JICA	:	Japan International Cooperation Agency
MPWIELD Disaster	:	Ministry of Public Works, Infrastructure, Environment, Labour and
NAPA	:	National Adaptation Program of Action
NGO	:	Non-Government Organization
ODA	:	Overseas Development Assistance
PACE	:	Protection Against Coastal Erosion
PWD	:	Public Works Department
QE II Park	:	Queen Elizabeth II Park
SNC	:	Second National Communication
SPC	:	Secretariat of the Pacific Community
TCAP	:	Tuvalu Coastal Adaptation Project
TIVA	:	Tuvalu Integrated Vulnerability Assessment
TNA	:	Technology Needs Assessment
UDP	:	UNEP DTU Partnership
UNEP	:	United Nation Environment Programme
UNFCCC	:	United Nation Framework Convention on Climate Change
USP	:	University of the South Pacific

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Executive Summary

Tuvalu is a small island state located in the Central Pacific, between 5° and 11°S latitude and 176° and 180°E longitude of Greenwich. It comprises of nine atolls and low islands: Nanumea, Nanumaga, Niutao, Nui, Vaitupu, Nukufetau, Funafuti, Nukulaelae, and Niulakita, with a total land area of only 26 sq km. The average height above sea level is less than 3 meters, with the highest point being 4.6 meters in Niulakita. There are no rivers on the islands, and groundwater is extremely limited. Currently, the coast of Tuvalu is already threatened by coastal disasters caused by high storm waves due to cyclones or atmospheric depressions, especially during high tide. Food security is the main concern throughout the country, as the agriculture sector is highly susceptible to drought periods and saltwater intrusion during king tide seasons.

Technology Needs Assessment (TNA) is a country-driven participatory process that aims to identify and prioritize environmentally viable technologies in the sectors of coastal areas, water, and agriculture in Tuvalu. The purpose is to increase the coping capacity of individuals and communities across the country to better prepare for the potential negative consequences of climate change impacts. During the preparation of the TNA, through stakeholders' consultation meetings, Tuvalu has selected and prioritized nine (9) technologies, with three technologies each under the selected sectors of coastal areas, water, and agriculture.

In the coastal sector, the three technologies include:

- Computer Monitoring Model/Tool to monitor coastal erosion and wave strengths.
- Land reclamation (seawalls, sandbags).
- Wave Breakers (lagoon and ocean).

For the water sector, the technologies are:

- Solar Reverse Osmosis System (Desalination Plant).
- Water reticulation system (gravity pressure).
- Groundwater solar extraction.

For the agriculture sector, the technologies are:

- Composting for tolerant varieties.
- Horticulture, and
- Cultivator with irrigation.

This report is the outcome of the TNA process, which covers barrier analysis on the transfer and diffusion of the prioritized adaptation technologies in the selected three sectors across the country. The report also summaries the enabling framework and measures to overcome identified barriers. For example, for each of the nine technologies identified for the three sectors, a systematic

approach of describing and analysing technological barriers, identification measures, and enabling framework is outlined, discussed, and adopted. The process included:

- Identification of preliminary targets for technology development and diffusion at the sectoral scale.
- Describing each technology's properties and potential adaptation benefits, categorizing the technology either as a market or a public good, and briefly elaborating on its current status in the country.
- Identifying important barriers to the diffusion of technologies through expert opinions, literature reviews, consultation meetings with important stakeholders, and the development of barrier analysis tools, including problem and objective trees and market mapping tools. The report also categorizes the barriers into financial and non-financial barriers.
- Identifying the measures for overcoming the barriers, possible linkages between different technology barriers within a sector, and outlining a technology enabling framework that would help to overcome barriers and create a supportive environment for the development and successful diffusion of the selected technologies.

The whole process is fully guided through the barrier analysis guideline and other available resources provided by specialist from UNEP and USP partners. Literature reviews, stakeholder consultations and bilateral meetings are also part of the process in developing this BAEF. The Table 1 below summarizes the sectors and the identified barriers with measures to be taken to overcome the respective barriers.

Table 1: Identified sectors with their barriers and measures to overcome respective barriers

Key Sectors Technology	Identified barriers	Measures to be taken to overcome barriers
Coastal		
Computer monitoring tool	High capital cost and lack of skills	Government subsidy and community investment.
Reclamation	High capital cost and limited skills	Seek funding sources through project proposal.
Wave breakers	Capital cost	Seeking funding sources through project proposals
Water		
Solar reverse osmosis system	High capital cost	Government and community investment
Water reticulation	High capital cost	Government subsidy and community support
Groundwater solar reticulation	High capital cost	Seeking funding sources through project proposals
Agriculture		

Composting	High capital cost and limited skills	Government subsidy through the Department Waste Management and the Agriculture Department.
Horticulture	Capital cost and limited skills	Government investment through the Department of Agriculture.
Cultivator	Capital cost and limited skills	Government investment through the Department of Agriculture.

The technologies looks to have common barriers due to be costly to the Government and the nation in general. Limited skills and lack of equipment are other hindrances for the transfer and diffusion of the technologies. However, skills upgrading, subsidies and investment for the technologies including financial request through project proposals are the best approaches to overcome the barriers in the diffusion of these identified technologies.

Chapter 1 Coastal Sector

This section starts with preliminary targets for technology transfer and diffusion. Then the barriers for the selected technologies and the possible measures to overcome these barriers are identified and analysed in sections 1.2, 1.3, and 1.4. Based on the analysis on the linkages of the barriers and possible solutions to them, Section 1.5 offers some suggestions on how the barriers can be addressed, and what are the resource requirements, strengths and weaknesses of each solution.. An overall strategy for overcoming the barriers for each sector and how to achieve specific technology transfer, diffusion, and deployment targets in the Coastal Sector is formulated and described in section 1.6. If the preliminary target set in the beginning of this chapter is found too ambitious or too conservative based on the barrier analysis and enabling framework formulation process, the final strategy may have a different technology transfer and diffusion target, which should be specified.

1.1 Introduction for preliminary targets for technology transfer and diffusion

During the first stage of preparing the Technology Needs Assessment (TNA) for Tuvalu, with consensus from the Adaptation Technical Working Group members and other important stakeholders, a set of 5 adaptation technologies of the Coastal Sector were identified. Then finally, 3 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 include:

Chapter 1 Computer Monitoring Model/Tool to monitor coastal erosion and waves strengths, etc.
Chapter 2 Land Reclamation - seawalls, sand bags.
Chapter 3 Wave Breaker (lagoon and ocean)

From the above 3 technologies, technology 2 – land reclamation has been piloted and confirmed as a robust technology highly favorable for Tuvalu. However, the reclaimed land requires further high technology protection mechanism like aligning of huge boulders and polythene sand bags as in the case of the QEII Park in Funafuti. The other two technologies although were not available in country, however, they were used in other countries which surely appropriate for Tuvalu.

To ensure sustainability of these technologies, the coastal expert working group through exhaustive deliberation sets some preliminary targets based on the country's necessities for the transfer and diffusion of these above-mentioned technologies in the coastal sector. Though, the availability of sufficient funds for implementation of such activities and targets is very crucial.

On the other hand, achieving these preliminary targets of transfer and diffusion of technologies in the coastal sector, it is important that the relevant stakeholders and players have to get involved and play active role in the successful implementation of technologies. The important stakeholders include coastal sector policy makers, experts, relevant ministries like the Ministry of Home Affairs and Education for Research purposes, Public Works Department, Climate Change and its

connecting counterparts at the national level. Other players include technology dealers, technicians, and experts in coastal protection sector. The implementers include NGOs and Community-Based Organizations (CBOs) focusing on coastal issues, advocacy groups of women, youth and community leaders active at local and national levels. Lastly and not the least, it is crucial that the Government and Island Communities in general provide supports and ownership of the technologies to ensure sustainability.

Key preliminary targets of the technologies:

Computer Monitoring Tool for Coastal Erosion:
Target: To develop a computer model or monitoring tool to predict changes in the coastline of 9 atolls and islands in Tuvalu by 2030, utilizing satellite imagery, GIS (Geographic Information System), and remote sensing technologies to monitor and assess coastal erosion over time.

Implementation: This could involve the use of satellite imagery, GIS (Geographic Information System), and remote sensing technologies to monitor changes in the coastline over time. The data collected can help in understanding the impact of sea level rise and coastal erosion, aiding in planning and decision-making.

Land Reclamation:
Target: To reclaim 50 hectares of land from the sea in Funafuti, Tuvalu by 2030, utilizing sediment deposition and engineering solutions such as constructing sea walls and barriers to counteract the effects of sea-level rise and create additional space for development.

Implementation: A similar engineering and implementation plan and strategy that was applied to the Queen Elizabeth II Park in Funafuti will be continually applied to implement this technology.

Wave Breakers to Protect the Coastal:
Target: To implement wave breakers along the coastline of Funafuti, Tuvalu, covering an area of 10 kilometers by 2030. These wave breakers will protect approximately 500 households and 5,000 residents from the impacts of wave action and storm surges, thereby reducing coastal erosion and flooding. The wave breakers will be constructed using a combination of natural structures like reefs and engineered barriers made of concrete and other durable materials.

Implementation: Wave breakers, also known as breakwaters, can be built offshore to dissipate the energy of incoming waves. They can be natural structures like reefs or constructed barriers made of concrete or other materials. They help protect the coastline by reducing the impact of waves.

For Tuvalu, where the impacts of climate change, including sea-level rise, are significant, these technologies reflect a focus on adaptation and resilience. By monitoring coastal erosion, reclaiming land, and implementing wave breakers, Tuvalu aims to address the immediate challenges posed by changing environmental conditions.

It is essential for Tuvalu to consider the environmental impact and sustainability of these technologies, as well as potential social and economic implications. Local community involvement

and collaboration with international partners for expertise and resources may also play a crucial role in the successful implementation of these initiatives.

1.2 Barrier analysis and possible enabling measures for Computer Monitoring Model/Tool to monitor coastal erosion

1.2.1 General description of the technology on Computer Monitoring Model/Tool to monitor coastal erosion and waves strengths

Computer monitoring model or tool is an essential device that will collect and provide appropriate information to inform decision making and the selection of the most appropriate coastal protection technology. Given the current devastated state of coastal erosion in Tuvalu due to climate variation and changes, it is therefore fundamental to assess root causes of the problem so that counteractive measures can be appropriately identified, designed and implemented effectively.

Should this model or tool provide efficient data, the effort on selecting and designing the most appropriate technology to protect coastal erosion will be easy and simply cost effective in the long run.

The Tuvalu Meteorological Department has a technology or model that collect data pertaining sea level movement that finally produce an output of a tide calendar predictions for Tuvalu. The tool will strengthen the capacity of the Meteorological Department to do prediction of beach erosion rate and strength of wave actions. The tool will aid in decision making process and will not be used at a household level as a consumer like solar panels, mini irrigation system and so on which are classified as consumer market goods.

The technology category and market characteristics in the country although never been applied, the technology can be categorized as the non-market good and hardware technology given its tangible component as a machinery or equipment. Its non-market characteristics may include:

- Coastal erosion and wave movement detecting equipment for data collection.
- Availability in the market.
- Affordability and practicability in the context of Tuvalu.
- Easy for implementation by local experts.

1.2.2 Identification of barriers of the technology on Computer Monitoring Model/Tool to monitor coastal erosion and waves strength

Using the method described in the guideline, the adaptation stakeholders (refer to annex 2 and identify which are coastal stakeholders, also state during the national stakeholder consultation was gender considered during consultation) on coastal sector identified four key barriers that hinder accelerated implementation of computer monitoring model or tools to monitor coastal erosion and surge movement strengths. These barriers were categorized as economic/financial and non-financial (Table 1.1).

Table 1.1: Barriers in implementing the Computer Monitoring Model/Tool to monitor coastal erosion and wave strength

Barrier Category	Barriers	Measures
Economic and Financial	*Inadequate investment into computer monitoring model/tool to monitor coastal erosion and waves strengths.*	• *Seeking for funding from necessary donors.* • *Engage in island community savings through local government.*
Non-financial	*Limited technical skills of existing experts in the country.*	*Expanded mentorship of frontline staffs at the Meteorological Department and the Public Works Department in computer modelling.*
	Poor access to information and communication.	*Enhance capacity to collect, interpret, and internalize on-line data and information about computer monitoring models to monitor coastal erosion.*
	Gender inequality	*Transform gender relations through providing incentives and participatory education and training oriented specifically to women*

1.2.2.1 Economic and financial barriers

Inadequate investment into computer monitoring model/tool to monitor coastal erosion and waves strengths.

Given the overall financial status of the country that highly dependent on foreign aides, it is unlikely that adequate funding will be available for the technology implementation. However, Tuvalu has benefitted from donor funding to implement a similar technology for sea-level movement which is an ongoing project now. A similar approach to acquire funding for the technology is recommended and perhaps to be blended into other existing project like the one existing now to monitor sea-level movement in the Tuvalu Meteorological Department. On the other hand, the Tuvalu Coastal Adaptation Project (TCAP) is focusing on reclamation technology for Funafuti and protection of coastal erosion in Nanumea and Nanumaga. Such approach provides opportunity for investment to the technology however, through project appraisal.

Recent research on wave transformation across atoll reefs has focused on wave overtopping [Hoeke et al., 2013; Merrifield et al., 2014; Quataert et al., 2015], without considering the processes that promote wave activity on the beach face. Sea level, tidal oscillations, setup, IG waves, and SS waves combine to determine reef flat water level and the point of maximum runup at the shoreline [Merrifield et al., 2014]. In turn, reef flat water level and runup influence the temporal window for geomorphic activity on sedimentary islands. Therefore, it is necessary to investigate wave transformation in the context of the processes that impact shoreline water level in order to understand the key drivers of geomorphic change on atoll landforms.

1.2.2.2 Non-financial barriers

Limited technical skills of existing experts in the country.

In fact, the technology is based on acquiring a computer monitoring model or a tool which is not existing in the country nor can be developed nationally. The computer model is a foreign tool which is technical in nature. Therefore, it is highly recommended to invite technical experts to train and build skills of local experts on how to use the technology. The new era and present generation is proven to have the capacity potentially in learning and imitating new innovation. One good example of this kind of model which is in operation at the national level, is the tide gauge model that operates under the meteorological department.

Poor access to information and communication.

Information sharing, internet connection and telecommunication status in Tuvalu is poor compared to other developing countries. Outer islands telecommunication is still in a poor stage and therefore accessing information that are mostly required remains a challenge that will contribute to poor extension and outreach coverage that will prevent the transfer and widespread diffusion of the technology.

Gender in-equality

Gender continues as a significant barrier to the adoption of the technology by women; stemming largely from customary gender roles. This is irrespective of their significant contribution to the technology at the technical operational level. Gender biases in institutions where women have limitations often reproduce assumptions that it is men who should operate such technology. This type of assumption resulted in the limitation of women participation in technology advancement and operation.

1.2.3 Identified measures

The following identified measures were based from the stakeholder consultations as a group as well individual interviews and dialogue. However, these identified measures arises from the identified barriers following the Barriers Analysis Guideline.

1.2.3.1 Economic and financial measures

Tap for financial support through project proposal

On the contrary that the country economic and financial status is very poor and cannot afford such technology immediately, it is highly essential that Government provides project proposals through an appropriate Ministry or Institution to acquire the technology and procure services to enable the diffusion of the technology.

As highlighted in previous sections, it was assumed that such technology is anticipated to be similar to the current model operated under the Meteorological Department that monitor the movement of the tide. However, for this model, it is acquired to measure coastal erosion rate and strength of waves damaging the beaches.

At the community level, seeking for funding support through Kaupule or Island Council savings is recommended. There is a national fund called the Falekaupule Trust Fund (FTF) and other funding sources that were normally distributed to Island Kaupule each year for community development. These available funds be able to be used to support the diffusion of the technology.

1.2.3.2 Non-financial measures

Limited technical skills in country

Proper technical skills of the technology is implicitly a concern in those institutions (eg: PWD, Environment Department, Meteorological Department, etc) that are anticipated to implement the technology. So, building capacity of these workers in terms of proper training of using the equipment (or any other capable person) on the technical aspects of the technology will enable them to adequately facilitate the widespread adoption of the technology with appropriate diffusion as anticipated. Overall, capacity building enhancement will speed up the technology transfer and diffusion.

Poor access to information and communication

Access to appropriate information and communication support is critical to enable local workers build their knowledge to access the technology for proper diffusion and operational services. Information comes in many different forms of varying relevance, accessibility and quality. So, such information necessitated to be assessed, synthesized, translated, and simplified for the ordinary workers to easily understand and use it. Presenting the information in a Tuvaluan language using appropriate mode of communication would enhance assimilation and use of the information for appropriate decision-making at a community as well at the national level. The media and other entities, such as community organizations (women groups, old men groups, local government officials and CSOs can play this critical role.

Gender transformative programmes and awareness raising through the media and Workshops

The element of gender inequality in most project or development at the national level is always a priority to prevent hindrance and diffusion of the technology. Therefore, the gender roles, identities and expectations are socially, culturally and politically constructed to ensure gender transformative

approaches and awareness raising are in place to overcome gender inequality that hence promoting the transfer and diffusion of the technology. From project definitions, through this exercise guideline, clearly indicated that gender transformative approaches and programmes, including interventions that create opportunities for individuals to actively challenge gender norms and promote positions of social and political influence for women in communities, and address power inequalities between persons of different genders.

1.3 Barrier analysis and possible enabling measures for Land Reclamation (seawalls, sand bags).

1.3.1 General Description of the Technology

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

The technology category and market characteristics in the country can be categorized as a public good provided the technology is a large investment that will provide services for the public. Simply a hardware as well an orgware technology given its tangible component of machinery and equipment that will be utilized by a Contractor for implementation.

In fact the technology has been proved to be appropriate and provide robust coastal protections for the country through a pilot project called the Tuvalu Coastal Adaptation Project. It is a million dollars project which has been identified and endorsed by the Government to be continued in several phases. This TCAP is now ongoing and donor partners are encouraged to contribute through dialogues and project appraisal.

1.3.2 Identification of Barriers of the Technology

Using the methods described in Chapter One, the technical working group identified four key barriers hindering the up-scaling of the technology in the country. These barriers were then categorized into two broad categories, i.e. economic/financial and non-financial. These barriers are presented in Table 1.2 below.

Table 1.2: Barriers hindering the technology diffusion

Barrier Category	Barriers	Measures
Economic and Financial	*Inadequate investment into land reclamation technology.*	• *Seeking for funding from necessary donors.* • *Engage in island community savings through local government.*

Non-financial	*Limited technical skills of existing experts in the country.*	*Expanded mentorship of frontline staffs at the Public Works Department and other private institutions or contractors obtaining adequate knowledge of the technology.*
	Poor access to information and communication.	*Enhance capacity to collect, interpret, and internalize on-line data and information about land reclamation technology.*
	Gender inequality	*Transform gender relations through providing incentives and participatory education and training oriented specifically to women.*
	Political influence	*Government influence through a project proposal is critical and highly recommended.*

1.3.2.1 Economic and Financial Barriers

Inadequate investment into land reclamation technology.
Aiming to adopt land reclamation throughout the country is normally a constrained by insufficient fund to invest in the technology. Lack access to direct funding assistances from commercial banks and other financial lending institutions again contribute to economic and financial barrier for Tuvalu to procure and diffusion of such technology. Given this status, it is logically appropriate to tap for project proposal.

The status of the current QEII Park existing in Funafuti, is the central focus of this technology which aimed to apply for the whole country. However, sufficient funding is a prerequisite for the diffusion of the technology.

1.3.2.2 Non-financial Barriers

Limited technical skills of existing experts in the country.
Technical skills and knowledge about the technology is limited within front-line staffs from the Public Works Department and other national private sectors. Although there have been national workers involved in the QEII Park reclamation land, still there is a need for proper supervision and

further assistances required from external experts. With limited technical know-how about the technology, these front-line staff would not be able to effectively offer the required services for the implementation of the technology. Machineries and equipment required for the diffusion and operation of the technology are the essential items that mostly require capacity building for the local experts.

Poor access to information and communication.
Information sharing, internet connection and telecommunication status in Tuvalu is poor compared to other developing countries. Outer islands telecommunication is still in a poor stage and therefore accessing information that are mostly required remains a challenge that will contribute to poor extension and outreach coverage that will prevent the transfer and widespread diffusion of the technology. Given this status, it is appropriate that an external corporation is invited to fully operate the technology and provides capacity buildings to the local experts.

Gender inequality
Gender continues as a significant barrier to the adoption of the technology by women; stemming largely from customary gender roles. This is irrespective of their significant contribution to the technology at the technical operational level. Gender biases in institutions where women have limitations often reproduce assumptions that it is men who should operate such technology. This type of assumption resulted in the limitation of women participation in technology advancement and operation.

1.3.3 Identified Measures
The following identified measures were based from the stakeholder consultations as a group as well individual interviews and dialogue. However, these identified measures were based from the identified barriers following the Barriers Analysis Guideline.

1.3.3.1 Economic and Financial Measures

Seeking financial support through project proposal and community savings

Given the country economic and financial poor status and cannot afford such technology immediately, it is highly essential that Government provides project proposals through the Ministry of Home Affairs, Climate Change and Environment to acquire the technology and procure services to enable the diffusion of the technology.

As highlighted previously, it was assumed that such technology is anticipated to be implementable as it is already piloted in Funafuti. Refer to the QEII Park reclaim land. So, a similar approach in providing a proposal from previous attempt has to be followed and to be aligned with donors' policies. The cost for the QEII Park is approximately US36M. Now for the new attempt and ongoing reclamation, it is required to secure more than US50M.

At the community level, seeking for funding support through Kaupule or Island Council savings is recommended. There is a national fund called the Falekaupule Trust Fund (FTF) and other funding sources that were normally distributed to Island Kaupule each year for community

development. These available funds be able to be utilized to assist for the diffusion of the technology.

1.3.3.2 Non-financial Measures

Upgrading technical skills of existing experts in the country.
Proper technical skills of the technology is implicitly a concern in those institutions (eg: PWD, Environment Department, Meteorological Department, etc) that are anticipated to implement the technology. So, building capacity of these workers or any other capable person on the technical aspects of the technology will enable them to adequately facilitate the widespread adoption of the technology with appropriate diffusion as anticipated. Overall, capacity building enhancement will speed up the technology transfer and diffusion.

Generally, the existing piloted land reclamation (Reference QEII Park) in Funafuti may have provided relevant skills and knowledge to some national experts, however, it is still favourable to acquire external assistances for capacity building of local workers.

Upgrading access to information and communication
Given that information sharing, internet connection and telecommunication status in Tuvalu is poor compared to other developing countries. Accessing of information that are mostly required remains a challenge that will contribute to poor extension and outreach coverage that will prevent the transfer and widespread diffusion of the technology. Given this status, it is appropriate that an external corporation is invited to fully operate the technology and provides capacity buildings to the local experts.

Gender transformative programmes and awareness raising

In the sense that gender continues as a significant barrier to the adoption of the technology by women; stemming largely from customary gender roles. Gender biases in institutions where women have limitations often reproduce assumptions that it is men who should operate such technology. This type of assumption resulted in the limitation of women participation in technology advancement and operation. So given this status, it is appropriate that women participation are highly considered in this case.

1.4 Barrier analysis and possible enabling measures for Wave Breaker (lagoon and ocean)

The identification of barriers and enabling measures for the Wave Breaker Technology were identified and categorised by the Consultant through expert knowledge, literature review and consultation with stakeholders on the Adaptation Technology Working Group. TNA guidelines provided by the TNA team and institutions concerned are key information used throughout the assignment.

1.4.1 General Description of the Technology

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

It is intended in this sense that wave breakers are distributed along the coastal areas in a way recommended by Engineers and Technical Experts. Mostly those coastal areas that are permanently occupied by communities and where their livelihood are based at have been ruined by coastal inundation and erosions.

It was highly recommended that this technology will provides prevention measures to existing community livelihoods, boat harbor projects which are currently ongoing; current man-made boat channels on each island and moreover, the preventative measure that it will arrange for the above proposed technology of land reclamation.

Designing of wave breakers can be like tripod structures that already implemented in other countries and have been proved to be robust.

1.4.2 Identification of Barriers of the Technology

Using the methods described in previous sections, desktop review and the technical working group (Refer to stakeholder details provided in the Annex) identified four key barriers hindering the up scaling of the technology in the country. These barriers were then categorized into two broad categories, i.e. economic/financial and non-financial. These barriers are presented in Table 1.3 below.

Table 1.3: Barriers hindering the technology diffusion.

Barrier Category	Barriers	Measures
Economic and Financial	*Inadequate investment into wave breakers technology.*	• *Seeking for funding from necessary donors.* • *Engage in island community savings through local government.*
Non-financial	*Limited technical skills of existing experts in the country.*	*Expanded mentorship of frontline staffs at the Public Works Department and other private institutions or contractors obtaining adequate knowledge of the technology.*

	Poor access to information and communication.	*Enhance capacity to collect, interpret, and internalize on-line data and information about land reclamation technology.*
	Gender inequality	*Transform gender relations through providing incentives and participatory education and training oriented specifically to women.*

1.4.2.1 Economic and Financial Barriers

Inadequate investment into wave breakers technology
Aiming to adopt wave breakers technology throughout the country is normally constrained by insufficient fund to invest in the technology. Lack of access to direct funding assistances from commercial banks and other financial lending institutions again contribute to economic and financial barrier for Tuvalu to procurement and diffusion of such technology. Given this status, it is logically appropriate to develop for project proposal for climate fund donors.

1.4.2.2 Non-financial Barriers

Limited technical skills of existing experts in the country.
Technical skills and knowledge about the technology is limited within front-line staffs from the Public Works Department and other national private sectors. Although there have been national workers involved in reclamation land activities, still there is a need for proper supervision and further assistances required from external experts. With limited technical know-how about the technology, these front-line staff would not be able to effectively offer the required services for the implementation of the technology. Machineries and equipment required for the diffusion and operation of the technology are the essential items that mostly require capacity building for the local experts.

Poor access to information and communication.
Information sharing, internet connection and telecommunication status in Tuvalu is poor compared to other developing countries. Outer islands telecommunication is still in a poor stage and therefore accessing information that are mostly required remains a challenge that will contribute to poor extension and outreach coverage that will prevent the transfer and widespread diffusion of the technology. Given this status, it is appropriate that an external corporation is invited to fully operate the technology and provides capacity buildings to the local experts.

Gender inequality

Gender continues as a significant barrier to the adoption of the technology by women; stemming largely from customary gender roles. This is irrespective of their significant contribution to the technology at the technical operational level. Gender biases in institutions where women have limitations often reproduce assumptions that it is men who should operate such technology. This type of assumption resulted in the limitation of women participation in technology advancement and operation.

1.4.3 Identified Measures

The following identified measures were based from the stakeholder consultations as a group as well individual interviews and dialogue. However, these identified measures were based from the identified barriers following the Barriers Analysis Guideline.

1.4.3.1 Economic and Financial Measures

Seeking for funding from necessary donors.

Given the country economic and financial poor status and cannot afford such technology immediately, it is highly essential that Government provides project proposals through an appropriate Ministry or Institution to acquire the technology and procure services to enable the diffusion of the technology.

As highlighted previously, it was assumed that such technology is anticipated to be implementable as it is already piloted in Funafuti. Refer to the QEII Park reclaim land.

Engage in island community savings through local government.

At the community level, seeking for funding support through Kaupule or Island Council savings is recommended. There is a national fund called the Falekaupule Trust Fund (FTF) and other funding sources that were normally distributed to Island Kaupule each year for community development. These provisional funds are applicable to support the diffusion of such technology.

1.4.3.2 Non-financial Measures

Upgrading technical skills of existing experts in the country.

Proper technical skills of the technology is implicitly a concern in those institutions (eg: PWD, Environment Department, Meteorological Department, etc) that are anticipated to implement the technology. So, building capacity through expanded mentorship of these workers or any other capable person on the technical aspects of the technology will enable them to adequately facilitate the widespread adoption of the technology with appropriate diffusion as anticipated. Overall, capacity building enhancement will speed up the technology transfer and diffusion.

Generally, the existing piloted land reclamation (Reference QEII Park) in Funafuti may have provided relevant skills and knowledge to some national experts, however, it is still favourable to acquire external assistances for capacity building of local workers.

Upgrading access to information and communication

Given that information sharing, internet connection and telecommunication status in Tuvalu is poor compared to other developing countries. Accessing of information that are mostly required remains a challenge that will contribute to poor extension and outreach coverage that will prevent the transfer and widespread diffusion of the technology. Given this status, it is appropriate that an external corporation is invited to fully operate the technology and provides capacity buildings to the local experts.

Enhance capacity to collect, interpret, and internalize on-line data and information about land reclamation technology is highly recommended.

Gender transformative programmes and awareness raising

In the sense that gender continues as a significant barrier to the adoption of the technology by women; stemming largely from customary gender roles. Gender biases in institutions where women have limitations often reproduce assumptions that it is men who should operate such technology. This type of assumption resulted in the limitation of women participation in technology advancement and operation. So given this status, it is appropriate that women participation are highly considered in this case.

Transformation of gender relations through providing incentives and participatory education and training oriented specifically to women is highly recommended.

1.5 Linkages of the barriers identified

Throughout the barrier analysis process, observation was made and confirmed that all barriers were common to all the three priority technologies in the coastal sector as tabulated in Table 1.4 below. The common barriers suggest that overcoming these in all the technologies will result in paving the way for the smooth adoption and diffusion of these technologies in the sector.

Table 1.4: Common barriers identified for the technologies in the Coastal Sector

Barrier category	Common barriers	Technologies affected
Economic and Financial	Limited access to credit and finance	All - Computer Monitoring Model/Tool to monitor coastal erosion; Land Reclamation - seawalls, sand bags; Wave Breaker (lagoon and ocean)
Non-financial	Inadequate information and awareness	All - Computer Monitoring Model/Tool to monitor coastal erosion; Land Reclamation - seawalls, sand bags; Wave Breaker (lagoon and ocean)
	Limited human and institutional capacity	All - Computer Monitoring Model/Tool to monitor coastal erosion; Land

		Reclamation - seawalls, sand bags; Wave Breaker (lagoon and ocean)

Limited access to credit and finance

This is one of the major barriers in adopting the climate adaptation technologies in the coastal sector. The Government and Private Sector status of lacking of finance and access to credit remain the leading impediment to technology transfer and diffusion in the sector. It is important to note that Tuvalu status in terms of financial support and expertise for these kind of technologies is very limited. Relying on Overseas Development Assistance (ODA) is highly common. Therefore developing project proposals by concerns Ministries and Institutions mainly in the Government to procure these technologies is highly essential.

Inadequate information and awareness

Limited access to appropriate information and lack awareness about climate adaptation on coastal protection technologies is common. Again the lack of knowledge on technical and market aspects of the technologies are also contributing to hinder the widespread and diffusion of the technologies in the sector.

The provision of adequate information and awareness programs on the three identified technologies is very essential and highly recommended.

Limited human and institutional capacity

Although the country is having an institution like the PWD with few experts on infrastructure knowledge, however, there is still limited knowledge within the Institution. Therefore, capacity building and technical skills upgrading is highly required for local transformation in the coastal sector. Effective diffusion of a climate technology requires know-how and capacity of technological adaptation.

1.6 Enabling framework for overcoming the barriers in the Coastal Sector

As highlighted in the IPCC 2000, the key component of the enabling framework for overcoming the barriers to diffusion and transfer of technologies in the coastal sector is the operationalizing of the entire range of institutional, regulatory and political framework conditions. In this assessment as highlighted above in Sub-section 1.5 (Table 4), three major elements of enabling framework were identified to be mostly important for promoting and facilitating the transfer and diffusion of adaptation technologies in the coastal sector; i.e. (i) Limited access to credit and finance; (ii) Inadequate information and awareness, and (iii) Limited human and institutional capacity. Table 1.5 below specifies areas of political influence that can facilitate the transfer and diffusion of the adaptation technologies in the coastal sector.

Table 1.5: Enabling framework for common barriers identified for the priority technologies in the coastal sector

Broad/common barriers addressed	Government Fiscal Policy	Areas of influence to facilitate transfer and diffusion of the coastal technologies
Limited access to credit and finance	National plans and monetary instructions condition	National Plans: 1. *Tuvalu National Strategy for Sustainable Development 2021-2030 (Te Kete):* • *Strategic Priority Area 1: Enabling Environment – Outcome 4: Climate Change and Disaster Resilience Increased.* • *Strategic Priority Area 5: Infrastructure Development – Outcome 17: Resilient Housing and National Building Facilities Upgraded.* 2. *National Climate Change Policy 2021-2030 (Te Vaka Fenua o Tuvalu).* • *Section 3: Policy outcomes and objectives – Coastal management: To promote and protect coastal environments from rising sea levels and the impacts of climate change.* 3. *Tuvalu Priority Infrastructure Investment Plan 2020–2025.* • *This plan is a guide to public infrastructure investment planning and budgeting, and development partner support. Sub-section 3.3.1: Climate adaptation infrastructure highlighted - The Tuvalu Coastal Adaptation Project (TCAP) financed by the Green Climate Fund that approved in 2017 for A$52 million seeks to fortify the coastline against climate change impacts. The government is also looking beyond this important project to adapt to climate change.* 4. *Tuvalu: Preparation of the Third National Communication under UN Framework Convention on Climate Change (UNFCCC).* • *Component 3: Vulnerability and adaptation assessment. The identified measures to facilitate adequate adaptation includes the preparation of NAPA1 and NAPA2; JICA support on a project called Beach Gravel*

		Nourishment Project along with the beach profile study called the Project Against Coastal Erosion (PACE). • *Also highlighted under this component is the instrument called Tuvalu Integrated Vulnerability Assessment (TIVA) which identify and prepare the nation and its people to the risks posed by climate change and disaster. Physical adaptation measures will not always be enough to prevent significant loss and damage to the infrastructure and economy of Tuvalu. Therefore, the need to rely mostly on most appropriate technology transfer and financial support is of high priority.* 5. *Second National Communication to the UNFCCC – 2015: This Second National Communication (SNC) provides an update on the activities undertaken domestically since the initial national communication in 1999. As a Least Developing Small Island State, funding and expertise are extremely limited. Tuvalu acknowledges the financial assistance through enabling activities, medium- and large-scale environment projects and will continue to request more of this funding arrangement to ensure Tuvalu achieves sustainable development.* 6. *Customs Revenue and Boarder Protection Act 2014: Section 81 Customs and Excise Duties describe the that The Minister may by Order —* *(a) impose import or export customs duties and excise duties upon any* *goods whatsoever which may be imported into or exported from Tuvalu* *and revoke, suspend, reduce, increase or alter any such duties;*
Inadequate information and awareness	Awareness campaign and learning about the technologies	Build effective public awareness and learning about climate adaptation technologies – the much-needed political will for the transfer and diffusion of climate technologies requires informed public support. Information is a

		valuable resource and lack of it will hinder widespread transfer and diffusion of the technologies.
Limited human and institutional capacity	Human and institutional capacity	• Public sector reform programme – to improve public sector governance, efficiency and effectiveness that are crucial for the delivery of quality services, including climate adaptation related actions. • Capacity-building programmes of governmental agencies and institutions – to obtain, strengthen and maintain the capabilities to set and achieve national development objectives of climate adaptation technologies over time. • Enhance publicly funded research and development and training programmes – to support pilot implementation of climate technologies in the country.

Chapter 2 Water Sector

Introduction

At the outset, the climate change vulnerabilities in the water sector is a serious issue in Tuvalu. The severe impacts of the 2011 drought cannot forgotten and again another challenging drought of 2022 are both creating burden to the nation in terms of water shortages (. Given that rainwater is the only water resource that is essentially free, safe, and delivered by nature directly to the consumer. Now it is the time to put in place practical measures to secure safe drinking water and sanitation for all Tuvaluans.

Groundwater is also used for non-potable uses throughout Tuvalu, and is therefore an important factor in reducing the pressure on drinking water supplies and for other domestic purposes. Further assessment and development of most appropriate technology required to distribute safe underground water to residences is vital and highly recommended during this assignment.

The first Reverse Osmosis was installed on Funafuti in 1992 and later on Nanumaga and Vaitupu where local conditions necessitate that a reliable back up supply be in place. The number of desalination units has recently increased through partner supports, and in response to a number of drought conditions. The 2022 drought prompt more actions to procure more desalination plants though partnership support and distributed to other islands to overcome the drought crisis is highly important. Funafuti the only urban centre of Tuvalu suffered mostly from the 2022 drought as the population is high with limited rainwater storage facilities. The Public Works Department (PWD) provides water supplies stations, where 10,000 litres water tanks are filled with desalinated water

and rationed to nearby households with six buckets of rainwater daily. It is the responsibility of a household to utilize its water ration wisely.

During the first stage of preparing the Technology Needs Assessment (TNA) in the country, with consensus from the climate change Adaptation Technical Working Group members and other important stakeholders, a set of 5 adaptation technologies of Water sector were identified as highlighted in Table 2.1 below. However the first three technologies highlighted in light green color are the most prioritized technologies through multi-criteria assessment process based on their importance in reducing vulnerability of communities and individuals to severe water shortages imposed from severe impacts of climate change.

Table 2.1: Adaptation technologies

Technologies	**Rank**	**Status in the country**
Solar Reverse Osmosis System (mobile)	1	• Existence but not solar powered. Electricity powered. • Electricity bill will be a burden. • Technical capacity building is required. • Expensive but there are available donor assistances.
Water reticulation system (gravity process)	2	• Common at household level. • Require a national or communal system. • Donor funding assistance is priority.
Groundwater solar extraction	3	• Non-exist. • Require a study that will provide clear information on the best extraction system, utilizing ground water efficiently. • Costly, therefore donor funding assistance is priority. • Technical capacity building is required.
Plate type fresh water generator	4	• Non-existence. • Proposed for a trial. • Seeking for donor assistance. • Capacity building on technical aspects is priority.
UV Filter system	5	• Used by few households to filter drinking water. • Some households sell their water at AUD$2 per bucket. • Funding assistance is priority. • Capacity building required for proper maintenance.

2.1 Preliminary targets for technology transfer and diffusion

The transfer and diffusion of water technologies are critical to addressing the pressing water-related challenges faced by communities due to climate change impacts. The followings outlines the preliminary targets for the successful implementation and dissemination of these technologies:

- **Development of Advanced Water Monitoring Systems:** Target: To establish comprehensive water monitoring systems in Tuvalu by 2026. Implementation: This involves deploying state-of-the-art sensors and remote sensing technologies to monitor water quality and quantity in real-time. The data collected will be used to inform water management practices, ensuring sustainable use and conservation of water resources.

- **Introduction of Desalination Technologies:** Target: To install desalination plants capable of providing potable water to about more than 90% of the population in coastal areas by 2028. Implementation: Utilizing reverse osmosis and other advanced desalination techniques, these plants will convert seawater into drinkable water. The focus will be on energy-efficient and environmentally friendly technologies to minimize the ecological footprint.

- **Implementation of Rainwater Harvesting Systems:** Target: To equip 100% of households in all communities with rainwater harvesting systems by 2028. Implementation: This includes the installation of rooftop rainwater collection systems, storage tanks, and filtration units. Public awareness campaigns and training programs will be conducted to educate communities on the benefits and maintenance of these systems.

- **Enhancement of Groundwater Usage Techniques:** Target: To increase groundwater usage rates by 90% in areas experiencing water scarcity by 2029. Implementation: Techniques such as artificial usage methods, managed aquifer sustainability, and the construction of expended and new wells will be employed. These methods will help replenish depleted aquifers and ensure a sustainable supply of groundwater.

- **Promotion of Water-Efficient Agricultural Practices:** Target: To reduce agricultural water consumption by 30% through the adoption of water-efficient practices by 2030. Implementation: This involves the introduction of drip irrigation, soil moisture sensors, and drought-resistant crop varieties. Training programs for farmers and individual household members will be conducted to promote the adoption of these practices and improve water use efficiency in agriculture.

- **Strengthening Institutional Capacity and Governance:** Target: To build the capacity of local institutions and improve water governance frameworks by 2025. Implementation: This includes providing technical training to water management authorities, developing policies and regulations for sustainable water use, and fostering collaboration between government agencies, NGOs, and local communities.

- **Integration of Gender and Social Inclusion in Water Management:** Target: To ensure that water management initiatives are inclusive and consider the needs of all community members

by 2026. Implementation: Gender-sensitive approaches will be integrated into all water projects, ensuring that women and marginalized groups have equal access to water resources and decision-making processes. Capacity-building programs will be tailored to address the specific needs of these groups.

- **Establishment of Public-Private Partnerships (PPPs):** Target: To create at least two or three PPPs to support the development and diffusion of water technologies by 2027. Implementation: Engaging private sector partners to invest in water infrastructure projects and technology development. These partnerships will leverage private sector expertise and resources to enhance the scalability and sustainability of water solutions.

- **Monitoring and Evaluation Framework:** Target: To develop a robust monitoring and evaluation framework to track the progress and impact of water technology initiatives by 2025. Implementation: Establishing key performance indicators (KPIs) and regular reporting mechanisms to assess the effectiveness of water technologies. Continuous feedback loops will be created to make necessary adjustments and improvements to the implementation strategies.

By setting these preliminary targets, we aim to create a comprehensive and sustainable approach to water technology transfer and diffusion. These efforts will not only address immediate water challenges but also build resilience against future climate impacts, ensuring the well-being and prosperity of communities.

2.2 Barrier analysis and possible enabling measures for a mobile Solar Reverse Osmosis System

2.2.1 General description of the technology on a mobile Solar Reverse Osmosis System

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

The technology comprises of the removal of salt water elements like sodium chloride and other salt components from seawater using efficient solar pump to acquire safe drinking water. Seawater is pushed through a reverse osmosis (RO) membrane to remove salt and other elements while filtering safe water for human use. Highly used in arid areas and in countries with very limited rainfall or frequently experiencing long drought periods. So, it is very essential to the context of Tuvalu.

The Public Works Department (PWD) under the Ministry of Public Works, Infrastructure, Environment, Labour and Disaster (MPWIELD) had installed this type of technology in Funafuti that is currently servicing the communities during dry seasons. This technology was also distributed to the outer islands. The value of the technology in its relevance to reducing

vulnerability to cyclones, prolonged dry periods and salinization manifestation is the main observation of the Working Group in selecting this technology as high priority.

It is considered as an excellent adaptation technology that can be used during prolonged droughts and dry seasons.

2.2.2 Identification of barriers of the technology on a mobile Solar Reverse Osmosis System

The mobile solar reverse osmosis system represents a market good, as it is a product that can be bought and sold, and its usage can be commercially viable. This technology is specifically designed to address water scarcity by converting seawater into potable water using solar energy, making it both innovative and sustainable.

Tools Used to Identify Barriers and Measures

In identifying the barriers and measures for the mobile solar reverse osmosis system, we used a combination of SWOT Analysis (Strengths, Weaknesses, Opportunities, and Threats) and Stakeholder Consultations. These tools highly provided specific challenges and propose actionable solutions.

How Barriers and Measures Were Derived

SWOT Analysis:

The SWOT analysis was conducted in the initial phase of the project planning, involving stakeholders from various sectors.

Critical analysis was conducted for both internal and external factors affecting the implementation of the technology. This involved assessing the strengths and weaknesses of the technology itself, and identifying opportunities and threats posed by external factors.

Stakeholder Consultations:

These consultations took place during two workshops and several meetings over the course of the TNA development. Reference to these workshops and meetings were mentioned in previous reports (TNA first report and the BAEF report).

In fact, local communities, government agencies, technical experts, and private sector partners were engaged to gather their insights and feedback. This participatory approach ensured that the identified barriers were comprehensive and the proposed measures were practical and acceptable to all stakeholders.

Barriers and Measures

- *High Initial Costs:*

The key barrier been identified is that the initial investment required for purchasing, installing, and maintaining the mobile solar reverse osmosis systems can be high. Therefore, a suggested measure is to explore funding opportunities through public-private partnerships, grants, and subsidies to offset initial costs. Additionally, implementing a phased rollout can distribute the financial burden over time.

- *Technical Complexity and Maintenance:*

In fact this advanced technology may require specialized knowledge for maintenance and troubleshooting. So, overcoming this barrier it is essential to provide technical training for local technicians and establish partnerships with technical service providers to ensure ongoing support and maintenance.

- *Energy Dependence and Efficiency:*

Sometimes, solar energy availability can be inconsistent, affecting the system's efficiency. Therefore it is essential to incorporate energy storage solutions such as batteries to store excess solar energy for use during low sunlight periods. Additionally, integrating hybrid systems that can use alternate energy sources can enhance reliability.

- *Water Quality and Pre-treatment Requirements:*

High levels of contaminants in the source water may necessitate additional pre-treatment steps. Therefore, it is essential to implement pre-treatment processes such as sedimentation, filtration, and chlorination to ensure the source water quality is suitable for reverse osmosis.

- *Infrastructure and Transportation:*

Deploying mobile units to remote or hard-to-reach areas like Tuvalu can be logistically challenging. So it is important to consider the development and deployment strategies that consider local environment and infrastructure procurement challenges. Utilize flexible design for easier transport and assembly on-site.

- *Socio-economic and Cultural Acceptance:*

Community acceptance can be influenced by socio-economic factors and cultural preferences. Therefore, it is essential to conduct awareness campaigns and engage with community leaders to build trust and highlight the benefits of the technology. Ensure that the system is affordable and accessible to all community members.

- *Policy and Regulatory Barriers:*

Regulatory approvals and compliance with local water quality standards can be complex. Therefore, it is recommended to work closely with regulatory bodies to streamline the approval process and ensure compliance. Advocate for supportive policies and regulations that facilitate the adoption of sustainable water technologies.

- *Sustainability and Scalability:*

Ensuring long-term sustainability requires ongoing funding and support. It is important here to develop sustainable financing models, such as water tariffs or community-based management

systems, to ensure ongoing operation and maintenance. Engage with donors and investors to secure long-term funding.

- *Environmental Considerations:*

Proper management of brine, a byproduct of the reverse osmosis process, is necessary to prevent environmental harm. Overcoming this, it better to implement environmentally friendly brine disposal methods, such as dilution in large bodies of water or use in agricultural applications. Develop guidelines for the safe disposal and management of all system components.

By addressing these barriers through well-thought-out measures, the transfer and diffusion of mobile solar reverse osmosis systems can be significantly enhanced. This holistic approach ensures that the technology is not only adopted but also sustainable and effective in providing clean water solutions to communities in need.

Table 2.2 below attempt to briefly outlined the above barriers and measures under the economic and financial and non-financial categories.

Table 2.2: Barriers in implementing the Solar Reverse Osmosis System

Barrier Category	**Barriers**	**Measures**
Economic and Financial	*High cost and inadequate investment into water reverse osmosis technology.*	• *Seeking for funding from necessary donors.* • *Engage in island community savings through local government.* • *Project proposals development.*
Non-financial	*Limited technical skills of existing experts in the country.*	*Expanded mentorship of frontline staffs at the Meteorological Department and the Public Works Department in computer modelling.*
	Poor access to information and communication.	*Enhance capacity to collect, interpret, and internalize on-line data and information about solar reverse osmosis technology.*
	Gender inequality	*Transform gender relations through providing incentives*

		and participatory education and training oriented specifically to women

2.2.2.1 Economic and financial barriers

Inadequate investment into water reverse osmosis technology.

The financial barriers to investing in water reverse osmosis (RO) technology are multifaceted. Here are some key root causes:

- **High Initial Capital Costs:** The cost of setting up a full-scale RO plant can be substantial. For instance, a medium-sized RO plant can cost anywhere from $500,000 to $2 million or more, depending on capacity and specific requirements.
- **Operational and Maintenance Costs:** Running an RO plant involves continuous expenses for energy, chemicals, and regular maintenance. These ongoing costs can add up significantly over time.
- **Lack of Financial Support:** Many regions like Tuvalu lack sufficient financial support mechanisms, such as grants, subsidies, or low-interest loans, which can make it difficult for communities or governments to afford the initial investment.
- **Economic Viability:** In some cases, the economic return on investment (ROI) may not be immediately apparent, especially in areas where water scarcity is not as severe. This can deter potential investors who are looking for quicker returns.
- **Technological Complexity:** The complexity of RO technology can also be a barrier. It requires skilled personnel for operation and maintenance, which can be a challenge in regions with a shortage of trained professionals.
- **Policy and Regulatory Issues:** Inadequate policies or regulatory frameworks can also hinder investment. Clear and supportive regulations are essential to encourage investment in water treatment technologies

2.2.2.2 Non-financial barriers

Limited technical skills of existing experts in the country.

Given the fact that, Tuvalu had installed a desalination plant on the capital of Funafuti and the other outer islands by the Public Works Department, still there is a need for further capacity building amongst the local experts, who are currently operating the system. An ongoing skill upgrading is highly essential and vital, to ensure that the system last long and operating in good condition.

Computer modelling is another requirement for this technology and therefore frontline staffs at the PWD as well the Meteorology Department requires mentorship guidance and training. A regional or international expert is required to visit the country for mentorship of local experts.

The lack and limited technical skills of local experts are significant determinant of the diffusion and transfer of the technology.

Poor access to information and communication.

Again information access is another problem in the country, given the telecommunication system situation is not yet stable compared to other countries situation. In addition, the lack of data on the technology itself is really a challenge due to the fact that the technology is an imported technology and not nationally invented. These aspects will hinder the diffusion of the technology.

Gender in-equality

At the national level, gender disproportion on most projects that are not office related has become barriers. Civil works and engineering on the field usually not suit to Tuvaluan women as it seems to clash with traditional customs and taboos. Again this will hinder the transfer of the technology.

2.2.3 Identified measures

The following identified measures derived from the stakeholder consultations as a group as well individual interviews and dialogue in April and May 2022. Consulted stakeholders listed in Annex 4. The identified measures arises from the identified barriers following the Barriers Analysis Guideline.

2.2.3.1 Economic and financial measures

Tap for financial support through project proposal

Overcoming the barrier on economic and financial situation, it is essential that the government and/or development partners can engage in cost-sharing mechanism in the procurement and implementation of the technology. Cost sharing mechanisms is always encouraging ownership and responsibility in a project and thus longer lasting effects. However, for the situation of Tuvalu, it relies mostly on project schemes given its financial status.

A small poor country like Tuvalu cannot rely heavily on its own budget to ensure long lasting involvements. This kind of technology looks to be expensive and therefore require a donor funding and cost sharing for maintenance and operation services.

2.2.3.2 Non-financial measures

Non-financial measures should also be described in as much detail as possible.

Limited technical skills in country

As usual, capacity building of local experts is the key entity to ensure project sustainability. Although the Public Works Department (PWD) are currently operating a small Desalination Plant

on the Capital (Funafuti), their skills still limited particularly on the maintenance of the technology when encountering various problems. So, it is highly recommended that the operators and senior staffs of this Water Section in PWD, must undergo ongoing trainings on the maintenance of the technology as well the procuring of spare parts.

Poor access to information and communication
Given the status of the national telecommunication system that the PWD do not have a large bandwidth of telecommunication for internet access, it has contributed to challenges in obtaining large information like manuals and other related information.

Gender transformative programmes and awareness raising
Given that gender is a fundamental aspect in all project diffusion and implementation, it is therefore important that the involved of women and men in the project implementation and operation must be considered as high priority. Conducting awareness programmes in the diffusion and implementation of the technology can be carried out by women as is an indoor activity that suit traditional working environment for women. While men do the field work distributing water rations, the women will do most of the indoor activities for the technology.

2.3 Barrier analysis and possible enabling measures for Water Reticulation System.

2.3.1 General Description of the Technology

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

2.3.2 Identification of Barriers of the Technology

Barriers of the technology for diffusion, again based on economic and financial constraints given the limited capacity of the country status pertaining to economic restriction. The identified barriers are tabulated below in Table 2.3.

Table 2.3: Barriers hindering the technology diffusion

Barrier Category	Barriers	Measures

Economic and Financial	*Inadequate investment into water reticulation technology.*	• *Seeking for funding from necessary donors.* • *Engage in island community savings through local government.*
Non-financial	*Limited technical skills of existing experts in the country.*	*Expanded mentorship of frontline staffs at the Public Works Department and other private institutions or contractors obtaining adequate knowledge of the technology.*
	Poor access to information and communication.	*Enhance capacity to collect, interpret, and internalize on-line data and information about land reclamation technology.*
	Policy and Regulatory Framework	*Provide policies or regulatory frameworks that are clear and supportive to encourage investment in water treatment technologies*
	Gender inequality	*Transform gender relations through providing incentives and participatory education and training oriented specifically to women.*

2.3.2.1 Economic and Financial Barriers

Inadequate investment into water reticulation technology.
Economic and financial situation of the country is always the key barrier for this technology diffusion. Tuvalu do not have adequate investment into the technology. Even relying on national budget at individual Ministries within the Government or at the Local Government level, still there is insufficient financial support. Given this status, a public reticulation system cannot be installed without seeking assistances from outside sources.

2.3.2.2 Non-financial Barriers

Limited technical skills of existing experts in the country.
Water reticulation system only limited at individual household levels and there is no public reticulation system which is the requirement for this technology. The current skills possessed by very few workers in the PWD is limited and this applies only to individual household level installation and maintenance which may not meet the skills standard required for the implementation of a larger system. Most of the workers/experts are locally taught and learn from experience only.

Poor access to information and communication.

Information sharing, internet connection and telecommunication status in Tuvalu is poor compared to other developing countries. Outer islands telecommunication is still in a poor stage and therefore accessing information that are mostly required remains a challenge that will contribute to poor extension and outreach coverage that will prevent the transfer and widespread diffusion of the technology.

Gender in-equality

Gender continues as a significant barrier to the adoption of the technology by women; stemming largely from customary gender roles. This is irrespective of their significant contribution to the technology at the technical operational level. Gender biases in institutions where women have limitations often reproduce assumptions that it is men who should operate such technology. This type of assumption resulted in the limitation of women participation in technology advancement and operation.

2.3.3 Identified Measures

The following identified measures were based from the stakeholder consultations as a group as well individual interviews and dialogue. However, these identified measures were based from the identified barriers following the Barriers Analysis Guideline.

2.3.3.1 Economic and Financial Measures

Seeking financial support through project proposal and community savings

On the contrary that the country economic and financial status is very poor and cannot afford such technology immediately, it is highly essential that Government provides project proposals through an appropriate Ministry or Institution to acquire the technology and procure services to enable the diffusion of the technology. In fact, the technology been confirmed to be very expensive, therefore a project proposal of 3-5M funding support is recommended.

At the community level, seeking for funding support through Kaupule or Island Council savings is recommended. There is a national fund called the Falekaupule Trust Fund (FTF) and other funding sources that were normally distributed to Island Kaupule each year for community development. These available funds be able to be used to support the diffusion of the technology.

2.3.3.2 Non-financial Measures

Limited technical skills in country
Proper technical skills of the technology is implicitly a concern in those institutions (eg: PWD, Environment Department, Meteorological Department, etc) that are anticipated to implement the technology. So, building capacity through trainings on a quarterly basis of these workers or any other capable person on the technical aspects of the technology will enable them to adequately facilitate the widespread adoption of the technology with appropriate diffusion as anticipated. Overall, capacity building enhancement will speed up the technology transfer and diffusion.

Poor access to information and communication
Access to appropriate information and communication support is critical to enable local workers build their knowledge to access the technology for proper diffusion and operational services. Information comes in many different forms of varying relevance, accessibility and quality. So, such information necessitated to be assessed, synthesized, translated, and simplified for the ordinary workers to easily understand and use it. Presenting the information in a Tuvaluan language using appropriate mode of communication would enhance assimilation and use of the information for appropriate decision-making at a community as well at the national level. The media and other entities, such as community organizations (women groups, old men groups, local government officials and CSOs can play this critical role.

Gender transformative programmes and awareness raising
The element of gender inequality in most project or development at the national level is always a priority to prevent hindrance and diffusion of the technology. Therefore, the gender roles, identities and expectations are socially, culturally and politically constructed to ensure gender transformative approaches and awareness raising are in place to overcome gender inequality that hence promoting the transfer and diffusion of the technology. From project definitions, through this exercise guideline, clearly indicated that gender transformative approaches and programmes, including interventions that create opportunities for individuals to actively challenge gender norms and promote positions of social and political influence for women in communities, and address power inequalities between persons of different genders.

2.4 Barrier analysis and possible enabling measures for Groundwater Solar Extraction

The identification of barriers and enabling measures for the Groundwater Solar Extraction were identified and categorised by the Consultant through expert knowledge, literature review and consultation with stakeholders on the Adaptation Technology Working Group. TNA guidelines provided by the TNA team and institutions concerned are key information used throughout the assignment.

2.4.1 General Description of the Technology

Groundwater Solar Extraction is the approach of transporting safe groundwater supply from a source through a pipeline to reach households at various destinations or sites. It can be transported through gravity process or using a pressure pump on long distance locations. This technology requires solar pump to extract underground water to be distributed to household. Pipelines are

critical in this technology as damages may occur anytime. So proper connection and sizes selection of pipes at various points is crucial to avoid very slow water flow.

2.4.2 Identification of Barriers of the Technology

Using the methods described in Chapter One, the technical working group identified four key barriers hindering the upscaling of the technology in the country. These barriers were then categorized into two broad categories, i.e. economic/financial and non-financial. These barriers are presented in Table 2.4 below.

Table 2.4: Barriers hindering the technology diffusion.

Barrier Category	**Barriers**	**Measures**
Economic and Financial	*Inadequate investment into water reticulation system technology.*	• *Seeking for funding from necessary donors.* • *Engage in island community savings through local government.*
Non-financial	*Limited technical skills of existing experts in the country.*	*Expanded mentorship of frontline staffs at the Public Works Department and other private institutions or contractors obtaining adequate knowledge of the technology.*
	Poor access to information and communication.	*Enhance capacity to collect, interpret, and internalize on-line data and information about water reticulation technology.*

2.4.2.1 Economic and Financial Barriers

Inadequate investment into groundwater solar extraction technology

Economic and financial situation of the country is always the key barrier for this technology diffusion. Tuvalu do not have adequate investment into the technology. Even relying on national budget at individual Ministries within the Government or at the Local Government level, still there is insufficient financial support even to the amount of AUD$500,000.00. Given this status, a groundwater solar extraction system will be difficult to install without seeking assistances from outside sources.

2.4.2.2 Non-financial Barriers

Limited technical skills of existing experts in the country.
Groundwater extraction solar system is not common in Tuvalu as all households highly dependent on rainwater harvesting. Simple water distribution through direct piping systems from the water tanks to the household is a common system. So underground water solar extraction system although been proved to be operational in two island communities, however, it is only used mostly during dry seasons. Still there is lack operational and maintenance skills by the locals. In addition, few workers in PWD also have limited skills and so may not meet the skills standard required for the diffusion of the system. Levels of local expertise are mostly locally taught and learnt from experience only.

Poor access to information and communication.

Information sharing, internet connection and telecommunication status in Tuvalu is poor compared to other developing countries. Outer islands telecommunication is still in poor stage and therefore accessing information that are mostly required remains a challenge that will contribute to poor extension and outreach coverage that will prevent the transfer and widespread diffusion of the technology.

Gender in-equality

Gender continues as a significant barrier to the adoption of the technology by women; stemming largely from customary gender roles. This is irrespective of their significant contribution to the technology at the technical operational level. Gender biases in institutions where women have limitations often reproduce assumptions that it is men who should operate such technology. This type of assumption resulted in the limitation of women participation in technology advancement and operation.

2.4.3 Identified Measures

The following identified measures were based from the stakeholder consultations as a group as well individual interviews and dialogue. However, these identified measures were based from the identified barriers following the Barriers Analysis Guideline.

2.4.3.1 Economic and Financial Measures

Seeking for funding from necessary donors.

On the contrary that the country economic and financial status is very poor and cannot afford such technology immediately, it is highly essential that Government provides project proposals through an appropriate Ministry or Institution to acquire the technology and procure services to enable the diffusion of the technology.

Engage in island community savings through local government.

At the community level, seeking for funding support through Kaupule or Island Council savings is recommended. There is a national fund called the Falekaupule Trust Fund (FTF) and other

funding sources that were normally distributed to Island Kaupule each year for community development. These available funds be able to be used to support the diffusion of the technology.

2.4.3.2 Non-financial Measures

Upgrading technical skills of existing experts in the country.
Proper technical skills of the technology is implicitly a concern in those institutions (eg: PWD, Private Companies and Individual Householders) that are anticipated to implement the technology. So, building capacity of these workers or any other capable person on the technical aspects of the technology will enable them to adequately facilitate the widespread adoption of the technology with appropriate diffusion as anticipated. Overall, capacity building enhancement will speed up the technology transfer and diffusion.

Upgrading access to information and communication
Access to appropriate information and communication support is critical to enable local workers build their knowledge to access the technology for proper diffusion and operational services. Information comes in many different forms of varying relevance, accessibility and quality. So, such information necessitated to be assessed, synthesized, translated, and simplified for the ordinary workers to easily understand and use it. Presenting the information in a Tuvaluan language using appropriate mode of communication would enhance assimilation and use of the information for appropriate decision-making at a community as well at the national level. The media and other entities, such as community organizations (women groups, old men groups, local government officials and CSOs) can play this critical role.

Gender transformative programmes and awareness raising

The element of gender inequality in most project or development at the national level is always a priority to prevent hindrance and diffusion of the technology. Therefore, the gender roles, identities and expectations are socially, culturally and politically constructed to ensure gender transformative approaches and awareness raising are in place to overcome gender inequality that hence promoting the transfer and diffusion of the technology. From project definitions, through this exercise guideline, clearly indicated that gender transformative approaches and programmes, including interventions that create opportunities for individuals to actively challenge gender norms and promote positions of social and political influence for women in communities, and address power inequalities between persons of different genders.

2.5 Linkages of the barriers identified

Throughout the barrier analysis process, observation was made and confirmed that all barriers were common to all the three priority technologies in the water sector as tabulated in Table 2.5 below. The common barriers suggest that overcoming these in all the technologies will result in resolving the way for the smooth adoption and diffusion of these technologies in the sector.

Table 2.5: Common barriers identified for the priority technologies in the Water Sector

Barrier category	Common barriers	Technologies affected

Economic and Financial	Limited access to credit and finance	All – Solar Reverse Osmosis System; Water Reticulation System; Groundwater Extraction Solar System.
Non-financial	Inadequate information and awareness	All - Solar Reverse Osmosis System; Water Reticulation System; Groundwater Extraction Solar System.
	Limited human and institutional capacity	All - Solar Reverse Osmosis System; Water Reticulation System; Groundwater Extraction Solar System.

Limited access to credit and finance

This is one of the major barriers in adopting the climate adaptation technologies in the water sector. The Government and Private Sector status of lacking of finance and access to credit remain the leading impediment to technology transfer and diffusion in the sector. It is important to note that Tuvalu status in terms of financial support and expertise for these kind of technologies is very limited. Relying on Overseas Development Assistance (ODA) is highly common. Therefore developing project proposals by concerned Ministries and Institutions mainly in the Government to procure these technologies is highly essential.

Inadequate information and awareness

Limited access to appropriate information and lack awareness about climate adaptation on water protection technologies is common. Again the lack of knowledge on technical and market aspects of the technologies are also contributing to hinder the widespread and diffusion of the technologies in the sector.

The provision of adequate information and awareness programs on the three identified technologies is very essential and highly recommended.

Limited human and institutional capacity

Although the country is having an institution like the PWD with few experts on infrastructure knowledge, however, there is still limited knowledge within the Institution. Therefore, capacity building and technical skills upgrading is highly required for local transformation in the water sector. Effective diffusion of adaptation climate technology requires know-how and capacity of technological adaptation.

2.6 Enabling framework for overcoming the barriers in the Water Sector

As highlighted in the IPCC 2000, the key component of the enabling framework for overcoming the barriers to diffusion and transfer of technologies in the water sector is the operationalizing of the entire range of institutional, regulatory and political framework conditions. In this assessment

as highlighted above in Sub-section 2.5, three major elements of enabling framework were identified to be mostly important for promoting and facilitating the transfer and diffusion of adaptation technologies in the water sector; i.e. (i) Limited access to credit and finance; (ii) Inadequate information and awareness, and (iii) Limited human and institutional capacity. Table 2.6 below specifies areas of political influence that can facilitate the transfer and diffusion of the adaptation technologies in the coastal sector.

Table 2.6: Enabling framework for common barriers identified for the priority technologies in the water sector

Broad/common barriers addressed	**Enabling environment**	**Areas of influence to facilitate transfer and diffusion of the coastal technologies**
Limited access to credit and finance	National plans and monetary instructions condition	National Plans: *Tuvalu National Strategy for Sustainable Development 2021-2030 (Te Kete):* • *Strategic Priority Area 1: Enabling Environment – Outcome 4: Climate Change and Disaster Resilience Increased.* • *Strategic Priority Area 5: Infrastructure Development – Outcome 17: Resilient Housing and National Building Facilities Upgraded.* *National Climate Change Policy 2021-2030 (Te Vaka Fenua o Tuvalu).* • *Section 3: Policy outcomes and objectives – Coastal management: To promote and protect coastal environments from rising sea levels and the impacts of climate change.* *Tuvalu Priority Infrastructure Investment Plan 2020–2025.* • *This plan is a guide to public infrastructure investment planning and budgeting, and development partner support. Sub-section 3.3.1: Climate adaptation infrastructure highlighted - The Tuvalu Coastal Adaptation Project (TCAP) financed by the Green Climate Fund that approved in 2017 for A$52 million seeks to fortify the coastline against climate change impacts. The government is also looking beyond this important project to adapt to climate change.*

		Tuvalu: Preparation of the Third National Communication under UN Framework Convention on Climate Change (UNFCCC). • *Component 3: Vulnerability and adaptation assessment. The identified measures to facilitate adequate adaptation includes the preparation of NAPA1 and NAPA2; JICA support on a project called Beach Gravel Nourishment Project along with the beach profile study called the Project Against Coastal Erosion (PACE).* • *Also highlighted under this component is the instrument called Tuvalu Integrated Vulnerability Assessment (TIVA)which identify and prepare the nation and its people to the risks posed by climate change and disaster. Physical adaptation measures will not always be enough to prevent significant loss and damage to the infrastructure and economy of Tuvalu. Therefore, the need to rely mostly on most appropriate technology transfer and financial support is of high priority.* *Second National Communication to the UNFCCC – 2015: This Second National Communication (SNC) provides an update on the activities undertaken domestically since the initial national communication in 1999. As a Least Developing Small Island State, funding and expertise are extremely limited. Tuvalu acknowledges the financial assistance through enabling activities, medium- and large-scale environment projects and will continue to request more of this funding arrangement to ensure Tuvalu achieves sustainable development.*
Inadequate information and awareness	Awareness campaign and learning about the technologies	Build effective public awareness and learning about climate adaptation technologies – the much-needed political will for the transfer and diffusion of climate technologies requires informed public support. Information is a

		valuable resource and lack of it will hinder widespread transfer and diffusion of the technologies.
Limited human and institutional capacity	Human and institutional capacity	Public sector reform programme – to improve public sector governance, efficiency and effectiveness that are crucial for the delivery of quality services, including climate adaptation related actions. Malawi government is already implementing the programme. v. Capacity-building programmes of governmental agencies and institutions – to obtain, strengthen and maintain the capabilities to set and achieve national development objectives of climate adaptation technologies over time. vi. Enhance publicly funded research and development and training programmes – to support pilot implementation of climate technologies in the country. Execution of the pilot allows risks associated with the technology to be identified, documented, authenticated, mitigated, tested, or possibly solved in a less intense environment, thereby lowering risk of failure of the main technology

Chapter 3. Agriculture Sector

Introduction

Agriculture is the primary production that the whole population of Tuvalu being dependent on at a subsistence level. Subsistence agriculture plays a pivotal role in the livelihoods of communities and individual families. Conversely, the impacts of climate variability and climate change pose a serious risk to the agriculture sector and the entire food security for Tuvalu. Other natural factors like severe rainfall, drought, salt intrusion and inundation associated with hurricanes, king tides and storm surges and the impacts of Tropical Cyclones like TC Pam in 2015, TC Ula in 2016 and TC Tino in 2020, again intensify and contribute severe impacts to food crops. Crop growth will be impeded while land availability for crop production will be decreasing.

The Department of Agriculture (DOA) has already developed a programme to address food security through the assistance of the SPC. The DOA efforts include, the introduction of giant swamp taro *(pulaka)* tolerant species, banana species and other crops and facilitate home gardening for households at the community level. The Taiwan gardening programme through their *Fatoaga*

Fiafia have demonstrated high assistance in providing variety of vegetables for the public. Although not widely sufficient, however, highly contribute to the diet of communities. Other small organizations like the Live and Learn and the Biofilta also contribute effectively at house level gardening.

In general, Biodiversity and Ecosystem Services (BES) are increasingly critical to the future survival of the people and culture of Tuvalu in the face of intensifying extreme events and climate and global change. Given that there are few opportunities for modern urban commercial development in Tuvalu, especially on the atolls outside Funafuti, future food, livelihood, energy, environmental and cultural security will have to depend on the conservation, sustainable use and enrichment of our very limited but fragile atoll biodiversity and our somewhat richer, but also limited and threatened marine biodiversity (Government of Tuvalu, 2017).

Local food production including crops and livestock with small agri-businesses are key milestones for agriculture over the plan period. (Te Kete - Tuvalu National Strategy for Sustainable Development 2021-2030).

During the first stage of preparing the Technology Needs Assessment (TNA) in the country, with consensus from the climate change Adaptation Technical Working Group members and other important stakeholders, a set of 5 adaptation technologies of the Agriculture Sector were identified as highlighted in Table 3.1 below. However, the first three technologies highlighted in light green color are the most prioritized technologies through multi-criteria assessment process based on their importance in reducing vulnerability of communities and individuals to food shortages imposed from severe impacts of climate change.

Table 3.1: Identified technologies in the Agriculture Sector

Priority Ranking	Technology	Relevance/Importance for Adaptation	Barriers
Agriculture Sector Technology			
1	Composting for tolerant varieties	• Composting is common in Tuvalu. • Climate change impact on plants and crops is high and ongoing. • Tolerant varieties are most essential.	• Technical expert requirement is essential. • Procurement of tolerant varieties.
2	Horticultural technology through Beddings (concrete, wooden, etc)	• Concrete based cultivation is now practice in Tuvalu (eg: swamp taro cultivation). • Raising farming above the ground is very essential for Tuvalu given its status to salt water intrusion and heavy/frequent drought.	• Technical expert may be required on new technologies.

3	Cultivator with Irrigation	• The status of poor soil quality in Tuvalu couple with in-favourable temperature with prolonged drought periods, it is a requirement to cultivate and irrigate the soil very often.	• Technology is expensive and require technical expertise and equipment. • Seeking donor assistance.
4	Plow and Crop rotation	• Similar to above technology (3). However, deeper soil cultivation will be more essential to overcome worst drought periods.	• Also the technology is expensive. • Donor assistances are available.
5	Livestock Farming technology	• Tuvaluans are very keen in livestock farming. So appropriate technologies are highly recommended.	• Improve current status of farming with marketing capacity building.

3.1 Preliminary targets for technology transfer and diffusion

Here are some preliminary targets for technology transfer and diffusion in the agriculture sector:

- *Increase in Crop Yields:* Aim for a 20-30% increase in crop yields through the adoption of improved seed varieties and precision farming techniques.
- Water Management: Implement efficient irrigation systems and water management practices to reduce water usage by 25%.
- *Sustainable Practices:* Promote the adoption of sustainable agricultural practices, such as organic farming and integrated pest management, to reduce chemical inputs by 30%.
- *Access to Technology:* Ensure that at least 50% of smallholder farmers have access to modern agricultural technologies, including mobile apps for market information and weather forecasts.
- *Training and Education:* Provide training and education programs to at least 70% of farmers on the use of new technologies and practices.
- *Research and Development:* Invest in research and development to create and disseminate new agricultural technologies and practices.
- *Market Access:* Improve market access for farmers by establishing better supply chain infrastructure and market linkages.

These targets can help enhance productivity, sustainability, and profitability in the agriculture sector.

3.2 Barrier analysis and possible enabling measures for Composting for tolerant varieties

3.2.1 General description of the technology on Composting for Tolerant Varieties

In the case of Tuvalu, the technology can be categorized as a market or non-market good. It is a market good in the sense that the Department of Waste and Management in collaboration with the Department of Agriculture operated a composting project utilizing green leaves waste to produce compost and sell the compost to the public. Refer below. In addition, it is a non-market good in the sense that local farmers at the community level used rotten leaves as compost. Also refer below.

Composting is a mixture of ingredients used for plant fertilizer and improve soil physical, chemical and biological properties. Given the fact that it is commonly practiced throughout Tuvalu by individual farmers, coupled with the fact that the Department of Agriculture had introduced new tolerant varieties of giant swamp taro *(pulaka)* and banana which are the common food crops been cultivated in past decades, it is therefore highly recommended to continue applying such method in a more modern technology. Simple method used in the past by local farmers, they used rotten leaves to cultivate their giant swamp taro, the only staple food crop grown and been passed on from forefathers to recent generations.

Given that new composting technologies are practiced by many farmers and individual households through assistance from the Department of Agriculture and the current Taiwan Farming Assistance Project, it is recommended that the diffusion of such technology will be viable and easily adopted by local farmers. Simultaneously, the Department of Waste Management is running a composting system through green leaves shredding and store the compost over time to be rotten and sell it to farmers or the public at a rate of $2.00 per garbage bin. This approach is confirmed to exist very well and supported by farmers and individual households gardening.

3.2.2 Identification of barriers of the technology on Composting for Tolerant Varieties

Using the method described in the guideline, the adaptation on the Agriculture sector identified four key barriers that hinder accelerated implementation of Composting. These barriers were categorized as economic/financial and non-financial (Table 3.2).

Table 3.2: Barriers in implementing composting for tolerant varieties

Barrier Category	**Barriers**	**Measures**
Economic and Financial	*Inadequate investment into composting technologies.*	• *Seeking for funding from necessary donors.* • *Engage in island community savings through local government.* • *Application of local methods with less or no cost.*

Non-financial	*Limited technical skills of existing experts in the country.*	• *Expanded mentorship of frontline staffs at the Department of Agriculture.* • *Ad hoc trainings of farmers.*
	Poor access to information and communication.	*Enhance capacity to collect, interpret, and internalize on-line data and information about composting.*
	Gender inequality	*Transform gender relations through providing incentives and participatory education and training oriented specifically to women.*

3.2.2.1 Economic and financial barriers

Inadequate investment in Composting Technologies.

Economic and financial situation of the country is always the key barrier for this technology diffusion. Tuvalu do not have adequate investment into the technology. Even relying on national budget at individual Ministries within the Government or at the Local Government level, still there is insufficient financial support of around AUD$500,000.00. Given this status, immediate composting technology cannot be applied without seeking assistances from outside sources.

The technology has been proven to be cheap and viable in both its operation and maintenance, however proper consideration still required for investment into the technology is recommended. Procuring of necessary machineries are vital for investment as the country lack these equipment. The current composting system managed by the Waste Management Department, always rely on donor scheme to procure necessary equipment.

3.2.2.2 Non-financial barriers

Limited technical skills of existing experts in the country.

Given the fact that, Tuvalu had been practiced composting for decades, still there is a need for further capacity building amongst farmers and individual household members, who are currently using the technology. An ongoing skill upgrading in composting techniques and tools maintenance is highly essential and vital, to ensure that the technology last long and operating in good condition.

The lack and limited technical skills of local experts are significant determinant of the diffusion and transfer of the technology. It is essential that a regional or international expert is required to visit the country for mentorship of local experts.

Poor access to information and communication.

Again information access is another problem in the country, given the telecommunication system situation is not yet stable compared to other countries situation. In addition, the lack of data on the technology itself is really a challenge due to the fact that the technology is required to be blended to modern concepts. These aspects will hinder the diffusion of the technology.

Gender in-equality

At the national level, gender disproportion on most projects that are not office related has become barriers. Farming and field works usually not suit to Tuvaluan women as it seems to clash with traditional customs and taboos. Again this will hinder the transfer of the technology.

3.2.3 Identified measures

The following identified measures is base from the stakeholder consultations in April and May in 2022 as well individual interviews and dialogue. Consulted stakeholders provided in Annex 4. However, these identified measures arises from the identified barriers following the Barriers Analysis Guideline.

3.2.3.1 Economic and financial measures

Tap for financial support through project proposal

On the contrary that the country economic and financial status is very poor and cannot afford such technology immediately, it is highly essential that Government provides project proposals through an appropriate Ministry or Institution to acquire the technology and procure services to enable the diffusion of the technology.

At the community level, seeking for funding support through Kaupule or Island Council savings is recommended. There is a national fund called the Falekaupule Trust Fund (FTF) and other funding sources that were normally distributed to Island Kaupule each year for community development. These available funds be able to be used to support the diffusion of the technology.

3.2.3.2 Non-financial measures

Limited technical skills in country

Proper technical skills of the technology is implicitly a concern in those institutions (eg: Department of Agriculture, Environment Department, Individual Farmers and Household Members) that are anticipated to implement the technology. So, building capacity of these workers or any other capable person on the technical aspects of the technology will enable them to adequately facilitate the widespread adoption of the technology with appropriate diffusion as

anticipated. Overall, capacity building enhancement will speed up the technology transfer and diffusion.

Poor access to information and communication
Access to appropriate information and communication support is critical to enable local farmers and individuals build their knowledge to access the technology for proper diffusion and operational services. Information comes in many different forms of varying relevance, accessibility and quality. So, such information necessitated to be assessed, synthesized, translated, and simplified for the ordinary workers to easily understand and use it. Presenting the information in a Tuvaluan language using appropriate mode of communication would enhance assimilation and use of the information for appropriate decision-making at a community as well at the national level. The media and other entities, such as community organizations like the women groups, old men groups, local government officials and CSOs can play this critical role.

Gender transformative programmes and awareness raising
The element of gender inequality in most project or development at the national level is always a priority to prevent hindrance and diffusion of the technology. Therefore, the gender roles, identities and expectations are socially, culturally and politically constructed to ensure gender transformative approaches and awareness raising are in place to overcome gender inequality that hence promoting the transfer and diffusion of the technology. From project definitions, through this exercise guideline, clearly indicated that gender transformative approaches and programmes, including interventions that create opportunities for individuals to actively challenge gender norms and promote positions of social and political influence for women in communities, and address power inequalities between persons of different genders.

3.3 Barrier analysis and possible enabling measures for Horticulture Technology through Beddings (concrete, wooden, etc)

3.3.1 General Description of the Technology

Horticulture is the science and art of the development, sustainable production, marketing and use of high value, intensively cultivated food and ornamental plants. These include crops that are diverse like annual and perennial species, fruits and vegetables and decorative indoor plants. Given the fact that poor soil is very common in Tuvalu, it is therefore recommended that raised beddings to grow these crops and plants is highly essential. The technology is now being practiced at household levels through individual initiatives or small projects initiatives.

The Taiwan Fatoaga Fiafia Garden in Funafuti, Vaitupu and now extended to Papaelise and Funafala small communities, and even to outer islands is promoting such technology that had resulted in providing good amount of vegetables and fruits for the benefit of communities. The technology was proven to promote adaptation by avoiding soil salinity, salt intrusion and inundation which are the key climate impacts throughout Tuvalu.

3.3.2 Identification of Barriers of the Technology

Using the method described in the guideline, the adaptation on the Agriculture sector identified four key barriers that hinder accelerated implementation of Composting. These barriers were categorized as economic/financial and non-financial (Table 3.2).

Table 3.2: Barriers hindering the technology diffusion

Barrier Category	**Barriers**	**Measures**
Economic and Financial	*Inadequate investment into Horticultural technology through Beddings (concrete, wooden, etc)*	• *Seeking for funding from necessary donors.* • *Engage in island community savings through local government.*
Non-financial	*Limited technical skills of existing experts in the country.*	*Expanded mentorship of frontline staffs at the Department of Agriculture, household gardeners and other private institutions and individual farmers.*
	Poor access to information and communication.	*Enhance capacity to collect, interpret, and internalize on-line data and information about horticulture technology.*
	Gender inequality	*Transform gender relations through providing incentives and participatory education and training oriented specifically to women.*

3.3.2.1 Economic and Financial Barriers

Inadequate investment into horticulture technology.
Economic and financial situation of the country is always the key barrier for this technology diffusion. Tuvalu do not have adequate investment of around AUD1M into the technology. Even relying on national budget at individual Ministries within the Government or at the Local Government level, still there is insufficient financial support. Given this status, immediate horticulture technology cannot be applied without seeking assistances from outside sources.

The technology has been proven to be cost-effective and viable in terms of both operation and maintenance. However, it is still essential to carefully consider investment in this technology.

Procuring the necessary resources and adopting appropriate approaches are vital for successful investment, especially since the country lacks a habit of using this technology. Currently, the Agriculture Department relies on donor schemes to acquire essential equipment, such as gardening tubs, which have consistently benefited farmers.

3.3.2.2 Non-financial Barriers

Limited technical skills of existing experts in the country.

Given the fact that, Tuvalu had already practiced horticulture methods recently, still there is a need for further capacity building amongst farmers and individual household members, who are currently using the technology. An ongoing skill upgrading is highly essential and vital, to ensure that the technology last long and operating in good condition.

The lack and limited technical skills of local experts are significant determinant of the diffusion and transfer of the technology. It is essential that a regional or international expert is required to visit the country for mentorship of local experts.

Poor access to information and communication.

Again information access is another problem in the country, given the telecommunication system situation is not yet stable compared to other countries situation. In addition, the lack of data on the technology itself is really a challenge due to the fact that the technology is required to be blended to modern concepts. These aspects will hinder the diffusion of the technology.

Gender in-equality

At the national level, gender disproportion on most projects that are not office related has become barriers. Farming and field works usually not suit to Tuvaluan women as it seems to clash with traditional customs and taboos. Again this will hinder the transfer of the technology.

3.3.3 Identified Measures

The following identified measures were based from the stakeholder consultations as well individual interviews and dialogue. However, these identified measures were based from the identified barriers following the Barriers Analysis Guideline.

3.3.3.1 Economic and Financial Measures

Seeking financial support through project proposal and community savings

On the contrary that the country economic and financial status is very poor and cannot afford such technology immediately, it is highly essential that Government provides project proposals through an appropriate Ministry or Institution to acquire the technology and procure services to enable the diffusion of the technology.

At the community level, seeking for funding support through Kaupule or Island Council savings is recommended. There is a national fund called the Falekaupule Trust Fund (FTF) and other

funding sources that were normally distributed to Island Kaupule each year for community development. These available funds be able to be used to support the diffusion of the technology.

3.3.3.2 Non-financial Measures

Upgrading Limited technical skills in country
Proper technical skills of the technology is implicitly a concern in those institutions (eg: Department of Agriculture, Individual Farmers and Household Members) that are anticipated to implement the technology. So, building capacity of these workers or any other capable person on the technical aspects of the technology will enable them to adequately facilitate the widespread adoption of the technology with appropriate diffusion as anticipated. Overall, capacity building enhancement will speed up the technology transfer and diffusion.

Upgrading Poor access to information and communication
Access to appropriate information and communication support is critical to enable local farmers and individuals build their knowledge to access the technology for proper diffusion and operational services. Information comes in many different forms of varying relevance, accessibility and quality. So, such information necessitated to be assessed, synthesized, translated, and simplified for the ordinary workers to easily understand and use it. Presenting the information in a Tuvaluan language using appropriate mode of communication would enhance assimilation and use of the information for appropriate decision-making at a community as well at the national level. The media and other entities, such as community organizations like the women groups, old men groups, local government officials and CSOs can play this critical role.

Upgrading Gender transformative programmes and awareness raising
The element of gender inequality in most project or development at the national level is always a priority to prevent hindrance and diffusion of the technology. Therefore, the gender roles, identities and expectations are socially, culturally and politically constructed to ensure gender transformative approaches and awareness raising are in place to overcome gender inequality and thereby promoting the transfer and diffusion of the technology. From project definitions, through this exercise guideline, clearly indicated that gender transformative approaches and programmes, including interventions that create opportunities for individuals to actively challenge gender norms and promote positions of social and political influence for women in communities, and address power inequalities between persons of different genders.

3.4 Barrier analysis and possible enabling measures for Cultivator with Irrigation

A cultivator with an irrigation system is a modern agricultural technology that combines soil cultivation with efficient water delivery. This integrated approach ensures that crops receive the necessary moisture directly at the root zone, enhancing growth and yield.

Barrier Analysis

- High Initial Investment:

The barrier here seems to be the cost of purchasing and installing a cultivator with an integrated irrigation system can be high, making it unaffordable for many small-scale farmers. Of course the root cause to this barrier can be the fact that technology involves advanced components and materials that drive up the price, along with installation and training costs.

- Technical Complexity and Maintenance:

The barrier here can be the system requires technical knowledge for operation and maintenance, which may be lacking among local farmers. Maybe the root cause to this can be as the combination of irrigation and cultivation technologies involves intricate mechanisms that need regular upkeep and proper handling.

- Limited Access to Financing:

In the local context, the barrier here can be that farmers may find it challenging to secure loans or financial support to invest in this technology. However, the root cause is due to Financial institutions may be hesitant to lend to small-scale farmers due to perceived risks or lack of collateral.

- Water Source Reliability:

The main barrier here is that the effectiveness of the irrigation system depends on a reliable water source, which is a major existing challenge throughout the country. So areas mostly on the northern part of the country with limited water resources or inconsistent rainfall can struggle to support the needs of an irrigation system.

- Adoption and Awareness:

Farmers may be unaware of the benefits or hesitant to adopt new technology due to traditional farming practices. The main root cause to this is due that lack of exposure to modern agricultural practices and insufficient extension services to educate farmers.

Possible Enabling Measures

- Financial Incentives and Subsidies:

It is critical to provide subsidies or grants to reduce the initial investment costs for farmers. Implement low-interest loan programs to make financing more accessible. The expected outcome to this will be lowering financial barriers that will encourage more farmers to adopt the technology.

- Capacity Building and Training:

Conduct training programs and workshops to educate farmers on the operation, maintenance, and benefits of cultivator with irrigation systems will provide an excellent measure to increase technical knowledge and skills among farmers for proper use and maintenance of the technology.

- Strengthening Extension Services:

Enhancing agricultural extension services to provide ongoing support and guidance to farmers adopting the technology will probably provide continuous support helping farmers overcome initial challenges and improve adoption rates.

- Development of Water Management Plans:

It is very essential to implement water management strategies to ensure reliable water sources for irrigation, such as rainwater harvesting, groundwater recharge, and efficient water use practices. Through this approach, it will secure reliable water sources that will ensure the effective operation of the irrigation systems.

- Promotion and Awareness Campaigns:

It is essential to launch awareness campaigns to highlight the benefits and success stories of using cultivators with irrigation systems. This will be resulted to increase awareness and positive perceptions to drive higher adoption rates among farmers.

By addressing these barriers with targeted enabling measures, the adoption and diffusion of cultivators with irrigation systems can be significantly enhanced, leading to improved agricultural productivity and sustainability.

3.4.1 General Description of the Technology

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

3.4.2 Identification of Barriers of the Technology

Using the methods described in Chapter One, the technical working group identified four key barriers hindering the upscaling of the technology in the country. These barriers were then categorized into two broad categories, i.e. economic/financial and non-financial. These barriers are presented in Table 3.3 below.

Table 3.3: Barriers hindering the technology diffusion.

Barrier Category	**Barriers**	**Measures**
Economic and Financial	*Inadequate investment into cultivator with irrigation technology.*	• *Seeking for funding from necessary donors.* • *Engage in island community savings through local government.*
Non-financial	*Limited technical skills of existing experts in the country.*	*Expanded mentorship of frontline staffs at the Agriculture Department, individual farmers and other private institutions or contractors obtaining adequate knowledge of the technology.*

	Poor access to information and communication.	*Enhance capacity to collect, interpret, and internalize on-line data and information about cultivator with irrigation technology.*
	Water source reliability	*Creation of new technologies like providing more wells and desalination plants to overcome lack of water sources reliability on islands.*
	Gender inequality	*Transform gender relations through providing incentives and participatory education and training oriented specifically to women.*

3.4.2.1 Economic and Financial Barriers

Inadequate investment into cultivator with irrigation technology
Economic and financial situation of the country is always the key barrier for this technology diffusion. Tuvalu do not have adequate investment into the technology. Even relying on national budget at individual Ministries within the Government or at the Local Government level, still there is insufficient financial support. Given this status, immediate horticulture technology cannot be applied without seeking assistances from outside sources.

The technology has been proven to be cost-effective and viable in terms of both operation and maintenance. However, it is still essential to carefully consider investment in this technology. Procuring the necessary resources and adopting appropriate approaches are vital for successful investment, especially since the country lacks a habit of using this technology. Currently, the Agriculture Department relies on donor schemes to acquire essential equipment, such as gardening tubs, which have consistently benefited farmers.

3.4.2.2 Non-financial Barriers

Given the fact that, Tuvalu had already practice cultivator with irrigation methods in the past to present, still there is a need for further capacity building amongst farmers and individual household members, who are currently using the technology. An ongoing skill upgrading is highly essential and vital, to ensure that the technology last long and operating in good condition.

The lack and limited technical skills of local experts are significant determinant of the diffusion and transfer of the technology. It is essential that a regional or international expert is required to visit the country for mentorship of local experts.

Poor access to information and communication.

Again information access is another problem in the country, given the telecommunication system situation is not yet stable compared to other countries situation. In addition, the lack of data on the technology itself is really a challenge due to the fact that the technology is required to be blended to modern concepts. These aspects will hinder the diffusion of the technology.

Gender in-equality

At the national level, gender disproportion on most projects that are not office related has become barriers. Farming and field works usually not suit to Tuvaluan women as it seems to clash with traditional customs and taboos. Again this will hinder the transfer of the technology.

3.4.3 Identified Measures

The following identified measures were based from the stakeholder consultations as a group as well individual interviews and dialogue. However, these identified measures were managed to be identified following the Barriers Analysis Guideline.

3.4.3.1 Economic and Financial Measures

Seeking for funding from necessary donors.

On the contrary that the country economic and financial status is very poor and cannot afford such technology immediately, it is highly essential that Government provides project proposals through an appropriate Ministry or Institution to acquire the technology and procure services to enable the diffusion of the technology.

Engage in island community savings through local government.

At the community level, seeking for funding support through Kaupule or Island Council savings is recommended. There is a national fund called the Falekaupule Trust Fund (FTF) and other funding sources that were normally distributed to Island Kaupule each year for community development. These available funds be able to be used to support the diffusion of the technology.

3.4.3.2 Non-financial Measures

Upgrading Limited technical skills in country

Proper technical skills of the technology is implicitly a concern in those institutions (eg: Department of Agriculture, Individual Farmers and Household Members) that are anticipated to implement the technology. So, building capacity of these workers or any other capable person on the technical aspects of the technology will enable them to adequately facilitate the widespread adoption of the technology with appropriate diffusion as anticipated. Overall, capacity building enhancement will speed up the technology transfer and diffusion.

Upgrading Poor access to information and communication

Access to appropriate information and communication support is critical to enable local farmers and individuals build their knowledge to access the technology for proper diffusion and operational services. Information comes in many different forms of varying relevance, accessibility and

quality. So, such information necessitated to be assessed, synthesized, translated, and simplified for the ordinary workers to easily understand and use it. Presenting the information in a Tuvaluan language using appropriate mode of communication would enhance assimilation and use of the information for appropriate decision-making at a community as well at the national level. The media and other entities, such as community organizations like the women groups, old men groups, local government officials and CSOs can play this critical role.

Upgrading Gender transformative programmes and awareness raising

The element of gender inequality in most project or development at the national level is always a priority to prevent hindrance and diffusion of the technology. Therefore, the gender roles, identities and expectations are socially, culturally and politically constructed to ensure gender transformative approaches and awareness raising are in place to overcome gender inequality and enhance promoting the transfer and diffusion of the technology. From project definitions, through this exercise guideline, clearly indicated that gender transformative approaches and programmes, including interventions that create opportunities for individuals to actively challenge gender norms and promote positions of social and political influence for women in communities, and address power inequalities between persons of different genders.

3.5 Linkages of the barriers identified

Throughout the barrier analysis process, observation was made and confirmed that all barriers were common to all the three priority technologies in the coastal sector as tabulated in Table 3.4 below. The common barriers suggest that overcoming these in all the technologies will result in resolving the way for the smooth adoption and diffusion of these technologies in the sector.

Table 3.4: Common barriers identified for the priority technologies in the Agriculture Sector

Barrier category	**Common barriers**	**Technologies affected**
Economic and Financial	Limited access to credit and finance	All – Composting with tolerant varieties; Horticultur using beddings; Cultivator with irrigation.
Non-financial	Inadequate information and awareness	All - Composting with tolerant varieties; Horticultur using beddings; Cultivator with irrigation.
	Limited human and institutional capacity	All - Composting with tolerant varieties; Horticultur using beddings; Cultivator with irrigation.

Limited access to credit and finance

This is one of the major barriers in adopting the climate adaptation technologies in the agriculture sector. The Government and Private Sector status of lacking of finance and access to credit remain the leading impediment to technology transfer and diffusion in the sector. It is important to note that Tuvalu status in terms of financial support and expertise for these kind of technologies is very limited. Relying on Overseas Development Assistance (ODA) is highly common. Therefore

developing project proposals by concerns Ministries and Institutions mainly in the Government to procure these technologies is highly essential.

Inadequate information and awareness

Limited access to appropriate information and lack awareness about climate adaptation on agriculture protection technologies is common. Again the lack of knowledge on technical and market aspects of the technologies are also contributing to hinder the widespread and diffusion of the technologies in the sector.

The provision of adequate information and awareness programs on the three identified technologies is very essential and highly recommended.

Limited human and institutional capacity

Although the country is having an institution like the Agriculture Department with few experts in the Department, however, there is still limited knowledge within the Institution. Therefore, capacity building and technical skills upgrading is highly required for local transformation in the agricuture sector. Effective diffusion of adaptation climate technology requires know-how and capacity of technological adaptation.

3.6 Enabling framework for overcoming the barriers in the Agriculture Sector

The key component of the enabling framework for overcoming the barriers to diffusion and transfer of technologies in the Agriculture Sector is the operationalizing of the entire range of institutional, regulatory and political framework conditions. In this assessment as highlighted above three major elements of enabling framework were identified to be mostly important for promoting and facilitating the transfer and diffusion of adaptation technologies in the agriculture sector; i.e. (i) Limited access to credit and finance; (ii) Inadequate information and awareness, and (iii) Limited human and institutional capacity. Table 3.5 below specifies areas of political influence that can facilitate the transfer and diffusion of the adaptation technologies in the agriculture sector.

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 the agriculture sector technologies implementations at national and local levels.

Table 3.5: Enabling framework for common barriers identified for the priority technologies in the Agriculture Sector

Broad/common barriers addressed	**Enabling environment**	**Areas of influence to facilitate transfer and diffusion of the coastal technologies**

Limited access to credit and finance	National plans and monetary instructions condition	National Plans: 1. *Tuvalu National Strategy for Sustainable Development 2021-2030 (Te Kete):* • Strategic Priority Area 1: Enabling Environment – Outcome 4: Climate Change and Disaster Resilience Increased. • Strategic Priority Area 5: Infrastructure Development – Outcome 17: Resilient Housing and National Building Facilities Upgraded. 2. *National Climate Change Policy 2021-2030 (Te Vaka Fenua o Tuvalu).* • Section 3: Policy outcomes and objectives – Coastal management: To promote and protect coastal environments from rising sea levels and the impacts of climate change. 3. *Tuvalu Priority Infrastructure Investment Plan 2020–2025.* • This plan is a guide to public infrastructure investment planning and budgeting, and development partner support. Sub-section • Climate adaptation infrastructure highlighted - The Tuvalu Coastal Adaptation Project (TCAP) financed by the Green Climate Fund that approved in 2017 for A$52 million seeks to fortify the coastline against climate change impacts. The government is also looking beyond this important project to adapt to climate change. 4. *Tuvalu: Preparation of the Third National Communication under UN Framework Convention on Climate Change (UNFCCC).* • Component 3: Vulnerability and adaptation assessment. The identified measures to facilitate adequate adaptation includes the preparation of NAPA1 and NAPA2; JICA support on a project called Beach Gravel Nourishment Project along with the beach profile study called the Project Against Coastal Erosion (PACE). • Also highlighted under this component is the instrument called Tuvalu Integrated Vulnerability Assessment (TIVA) which

		identify and prepare the nation and its people to the risks posed by climate change and disaster. • Physical adaptation measures will not always be enough to prevent significant loss and damage to the infrastructure and economy of Tuvalu. Therefore, the need to rely mostly on most appropriate technology transfer and financial support is of high priority. 5. *Second National Communication to the UNFCCC – 2015:* • This Communication (SNC) provides an update on the activities undertaken domestically since the initial national communication in 1999. As a Least Developing Small Island State, funding and expertise are extremely limited. Tuvalu acknowledges the financial assistance through enabling activities, medium- and large-scale environment projects and will continue to request more of this funding arrangement to ensure Tuvalu achieves sustainable development.
Inadequate information and awareness	Awareness campaign and learning about the technologies	Build effective public awareness and learning about climate adaptation technologies – the much-needed political will for the transfer and diffusion of climate technologies requires informed public support. Information is a valuable resource and lack of it will hinder widespread transfer and diffusion of the technologies.
Limited human and institutional capacity	Human and institutional capacity	Public sector reform programme to improve public sector governance, efficiency and effectiveness that are crucial for the delivery of quality services, including climate adaptation related actions.

4.0 Conclusion

Technology Needs Assessment (TNA) is a country-driven participatory process aiming to identify viable technologies in the sectors of coastal areas, water, and agriculture for Tuvalu. During the preparation of the TNA, through stakeholders' consultation meetings, Tuvalu has selected and prioritized nine (9) technologies, with three technologies each under the selected sectors of coastal areas, water, and agriculture.

In the coastal sector, the three technologies include:

- Computer Monitoring Model/Tool to monitor coastal erosion and wave strengths.
- Land reclamation (seawalls, sandbags).
- Wave Breakers (lagoon and ocean).

For the water sector, the technologies are:

- Solar Reverse Osmosis System (Desalination Plant).
- Water reticulation system (gravity pressure).
- Groundwater solar extraction.

For the agriculture sector, the technologies are:

- Composting for tolerant varieties.
- Horticulture, and
- Cultivator with irrigation.

The process include:

- Identification of preliminary targets for technology development and diffusion at the sectoral scale.
- Describing each technology's properties and potential adaptation benefits, categorizing the technology either as a market or a public good, and briefly elaborating on its current status in the country.
- Identifying important barriers to the diffusion of technologies through expert opinions, literature reviews, consultation meetings with important stakeholders, and the development of barrier analysis tools, including problem and objective trees and market mapping tools. The report also categorizes the barriers into financial and non-financial barriers.
- Identifying the measures for overcoming the barriers, possible linkages between different technology barriers within a sector, and outlining a technological enabling framework that would help to overcome barriers and create a supportive environment for the development and successful diffusion of the selected technologies.

In fact the whole process is fully guided through the barrier analysis guideline and other available resources provided by specialist from UNEP and USP partners. The Table below summarizes the sectors and the identified barriers with measures to be taken to overcome the respective barriers.

Table 4.1: Identified sectors with their barriers and measures to overcome respective barriers

Key Sectors Technology	Identified barriers	Measures to be taken to overcome barriers
Coastal		
Computer monitoring tool	High capital cost and lack of skills	Government subsidy and community investment.
Reclamation	High capital cost and limited skills	Seek funding sources through project proposal.
Wave breakers	Capital cost	Seeking funding sources through project proposals
Water		
Solar reverse osmosis system	High capital cost	Government and community investment
Water reticulation	High capital cost	Government subsidy and community support
Groundwater solar reticulation	High capital cost	Seeking funding sources through project proposals
Agriculture		
Composting	High capital cost and limited skills	Government subsidy through the Department Waste Management and the Agriculture Department.
Horticulture	Capital cost and limited skills	Government investment through the Department of Agriculture.
Cultivator	Capital cost and limited skills	Government investment through the Department of Agriculture.

The identified technologies face common barriers, including high costs to the government and the nation as a whole. Additionally, limited skills and lack of equipment hinder the transfer and diffusion of these technologies. To overcome these barriers, several strategies can be employed: upgrading skills through training programs, providing subsidies, and making investments in the technologies. Furthermore, financial support can be sought through project proposals to ensure successful diffusion of these technologies.

References

Government of Tuvalu and PRIF Coordination Office. Dec 2020. Tuvalu Priority Infrastructure Investment Plan 2020–2025.

Government of Tuvalu and SPC- Applied Geoscience and Technology Division (SOPAC). 2013. Sustainable and Integrated Water and Sanitation Policy 2012-2021.

Government of Tuvalu, 2015. Tropical Cyclone Pam Report. Funafuti: Government of Tuvalu.

Government of Tuvalu, 2016. Tropical Cyclone Pam Recovery Update November 2016. Disaster Relief Unit, Office of the Prime Minister. Government of Tuvalu

Government of Tuvalu, Department of Fisheries. 2015. Cyclone Pam Damage Assessment Update: 6 November 2015. Funafuti: Department of Fisheries.

Government of Tuvalu, May 2007. Tuvalu's National Adaptation Programme of Action Under the auspices of the United Nations Framework Convention on Climate Change.

Government of Tuvalu. 1999. Tuvalu Initial Communication under the United Nation Framework Convention on Climate Change.

Government of Tuvalu. 2015. Intended Nationally Determined Contributions - Communicated to the UNFCCC on 27 November 2015.

Government of Tuvalu. 2017. Te Vaka Fenua o Tuvalu - National Climate Change Policy 2017-2020.

Government of Tuvalu. 2020. Tuvalu Six National Report to the Convention on Biological Diversity.

Government of Tuvalu. 2021. Te Kete - Tuvalu National Strategy for Sustainable Development 2021-2030.

Government of Tuvalu. August 2009. Tuvalu National Energy Policy.

Government of Tuvalu. Dec 2015. Second National Communication of Tuvalu to the United Nations Framework Convention on Climate Change.

Ivan Nygaard and Ulrich Elmer Hansen Trærup, *Overcoming Barriers to the Transfer and Diffusion of Climate Technologies*. This guidebook is available at www.tech-action.org.

https://tech-action.unepccc.org/tna-database/?fwp_tna_database_type=tna_report&fwp_tna_reports_region=fiji%2Cnauru%2Cvanuatu%2Ccook-islands

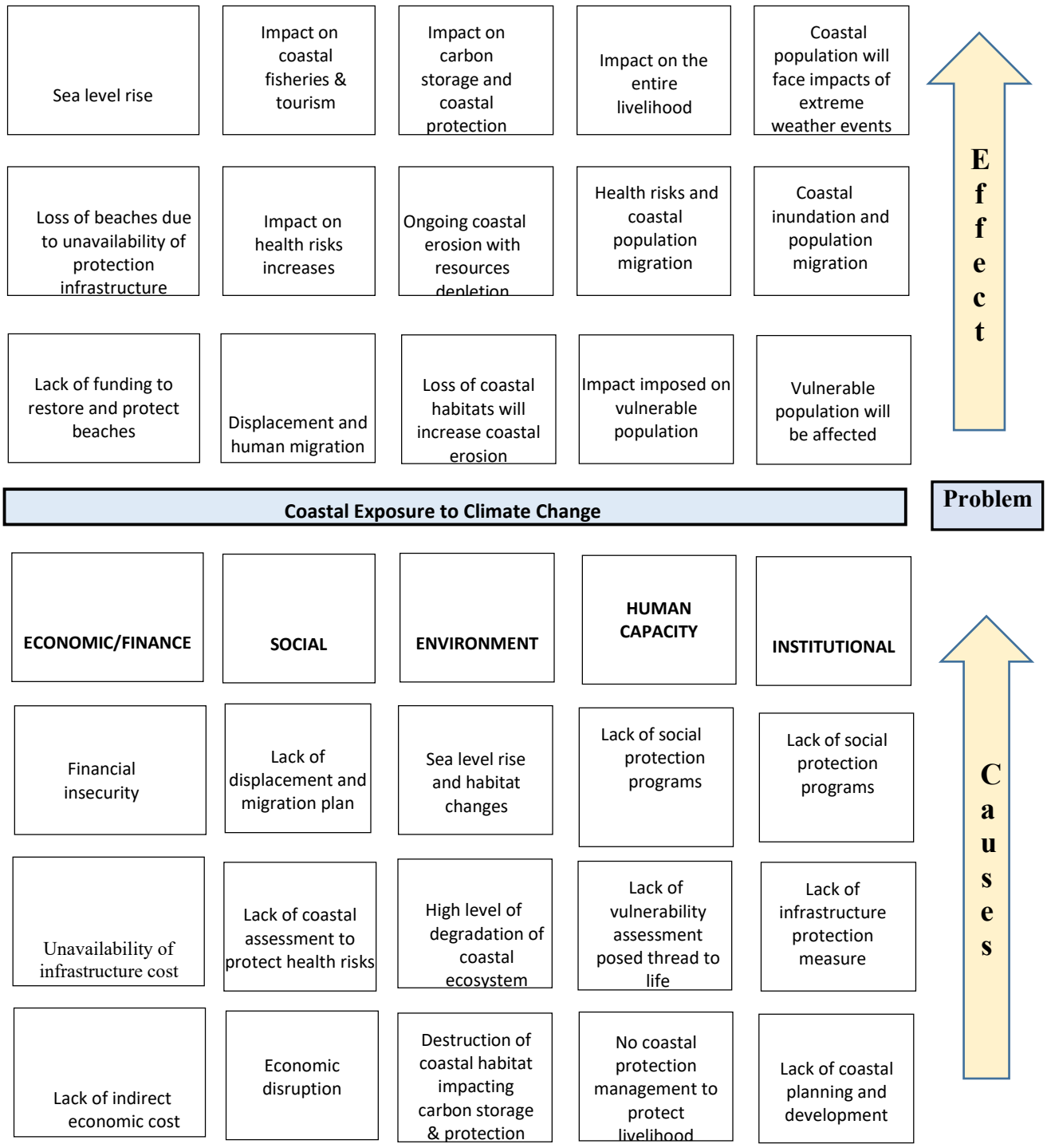
Annex I: Market mapping, problem and solution trees for the Coastal Sector

1.1 Land Reclamation Technology

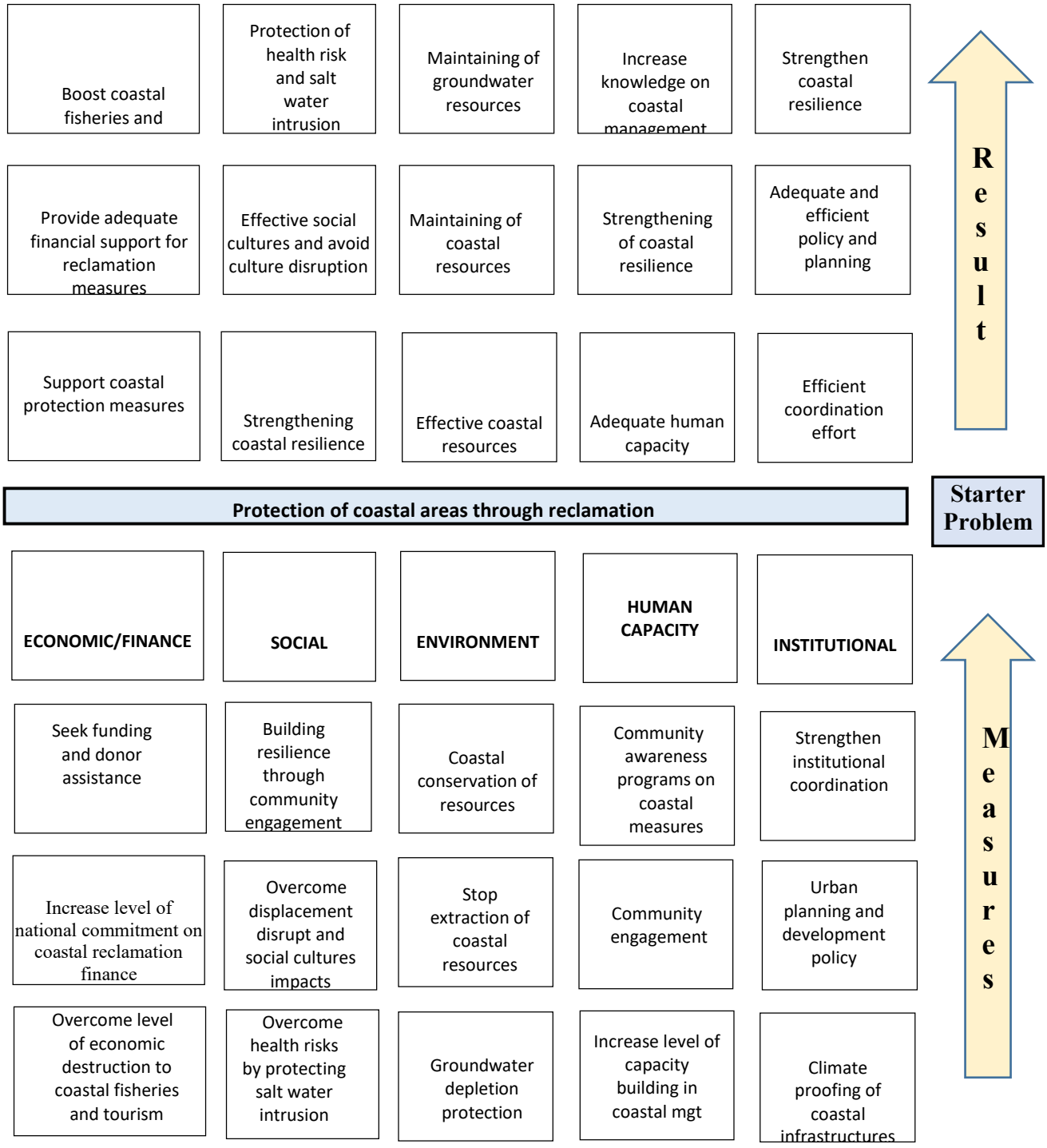
1.1.1 Market mapping – *Land reclamation technology*

BUSINESS ENVIRONMENT	1. Government Scheme for Subsidy/Loan 2. Policy formulation for coastal area 3. Trade and Quality standard 4. Skill workers
MARKET ACTORS	1. Household Units 2. NGOs, CSOs and Communities 3. Landowners 4. Maintenance Providers
SERVICE PROVIDERS	1. Financial Support Services 2. Technical Support 3. Market information 4. Training and capacity Building 5. Awareness

1.1.2 Problem tree - *Land reclamation technology*



1.1.3 Solution tree - *Land reclamation technology*

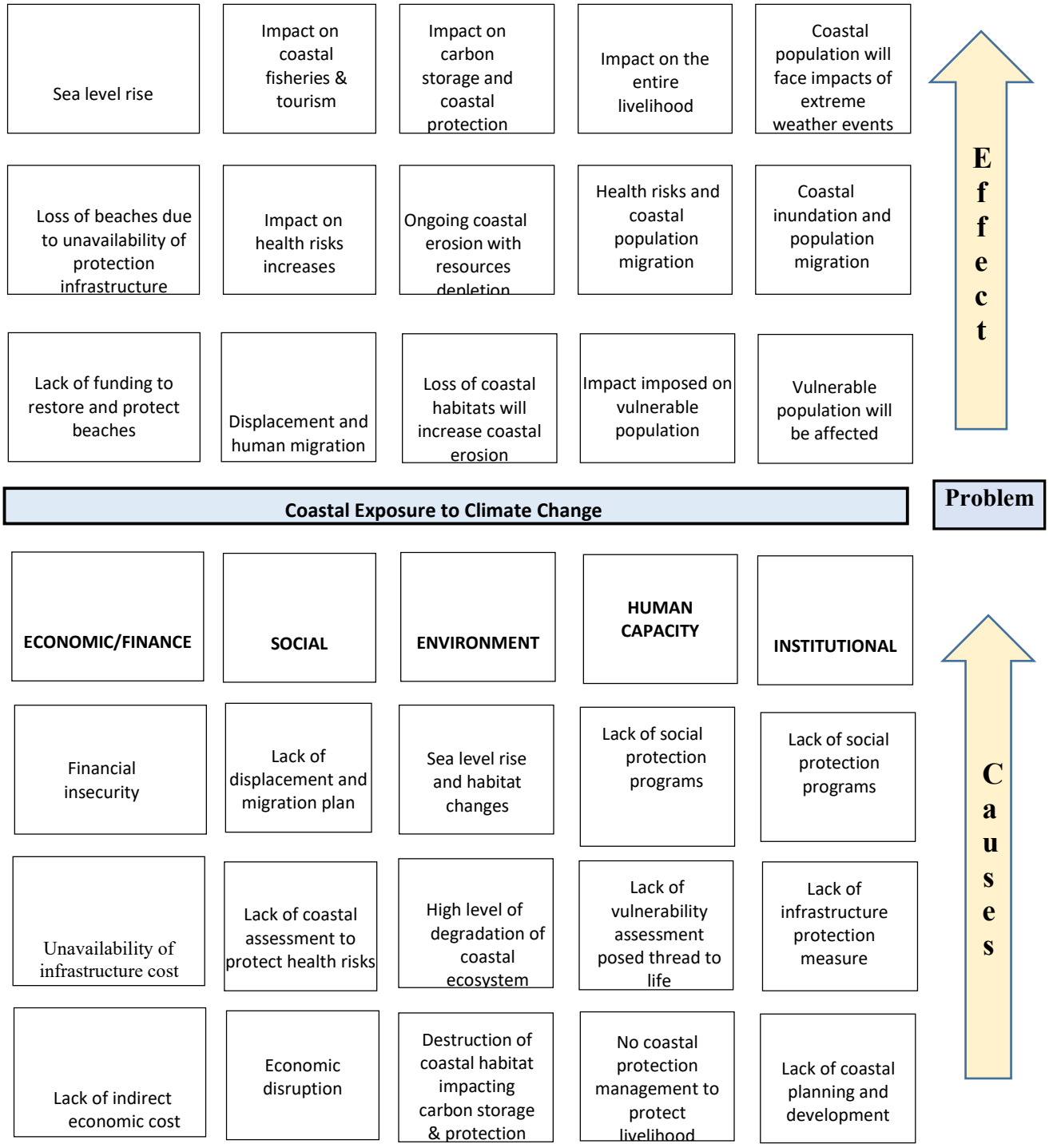


1.2 Wave breakers Technology

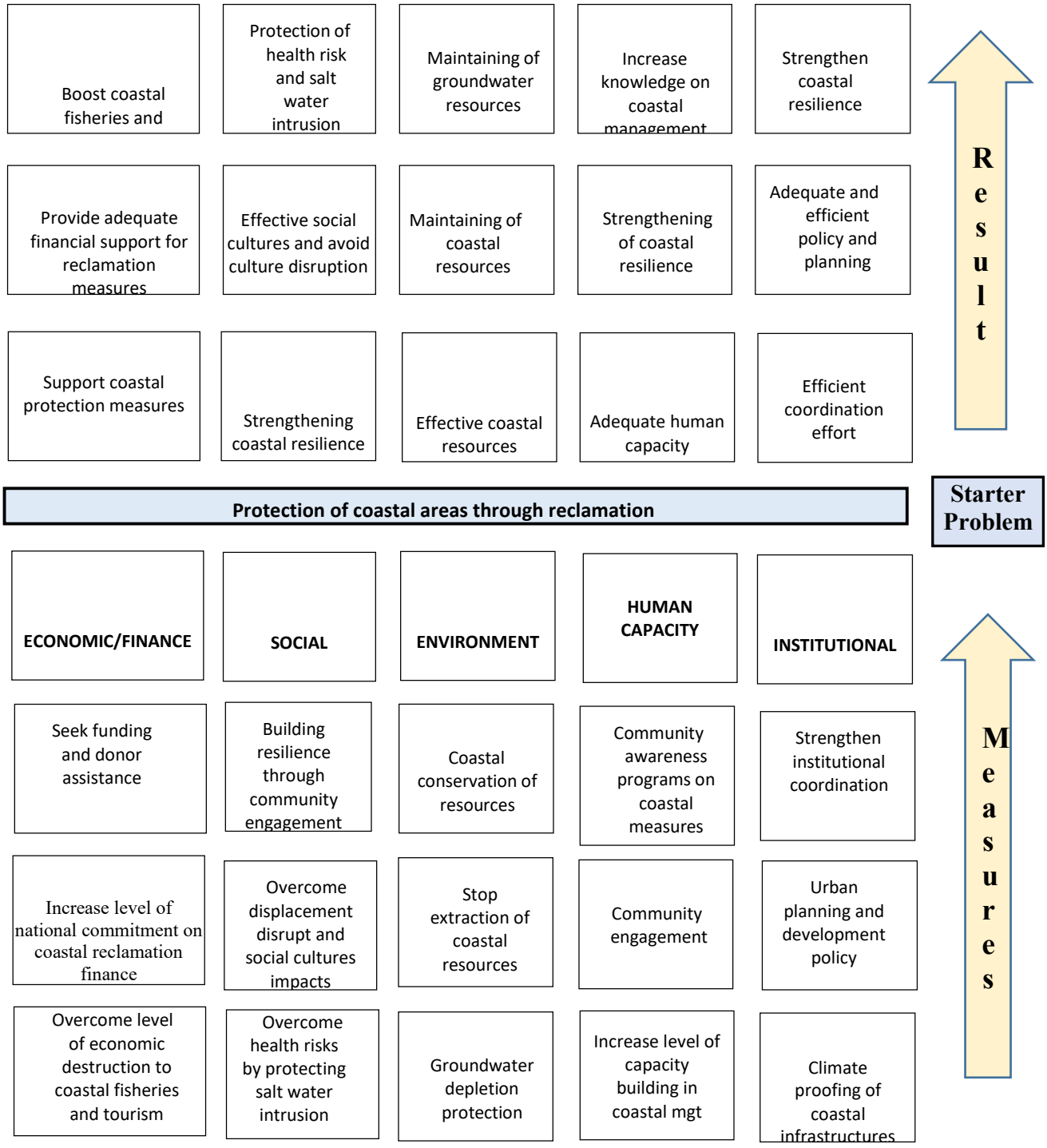
1.2.1 Market mapping – *Wave breakers technology*

BUSINESS ENVIRONMENT	1. Government Scheme for Subsidy/Loan 2. Policy formulation for coastal area 3. Trade and Quality standard 4. Skill workers
MARKET ACTORS	1. Institutional Units 2. NGOs, CSOs and Communities 3. Landowners 4. Maintenance Providers
SERVICE PROVIDERS	1. Financial Support Services 2. Technical Support 3. Market information 4. Training and capacity Building 5. Awareness

1.2.2 Problem tree – *Wave breakers technology*



1.2.3 Solution tree – *Wave breakers technology*



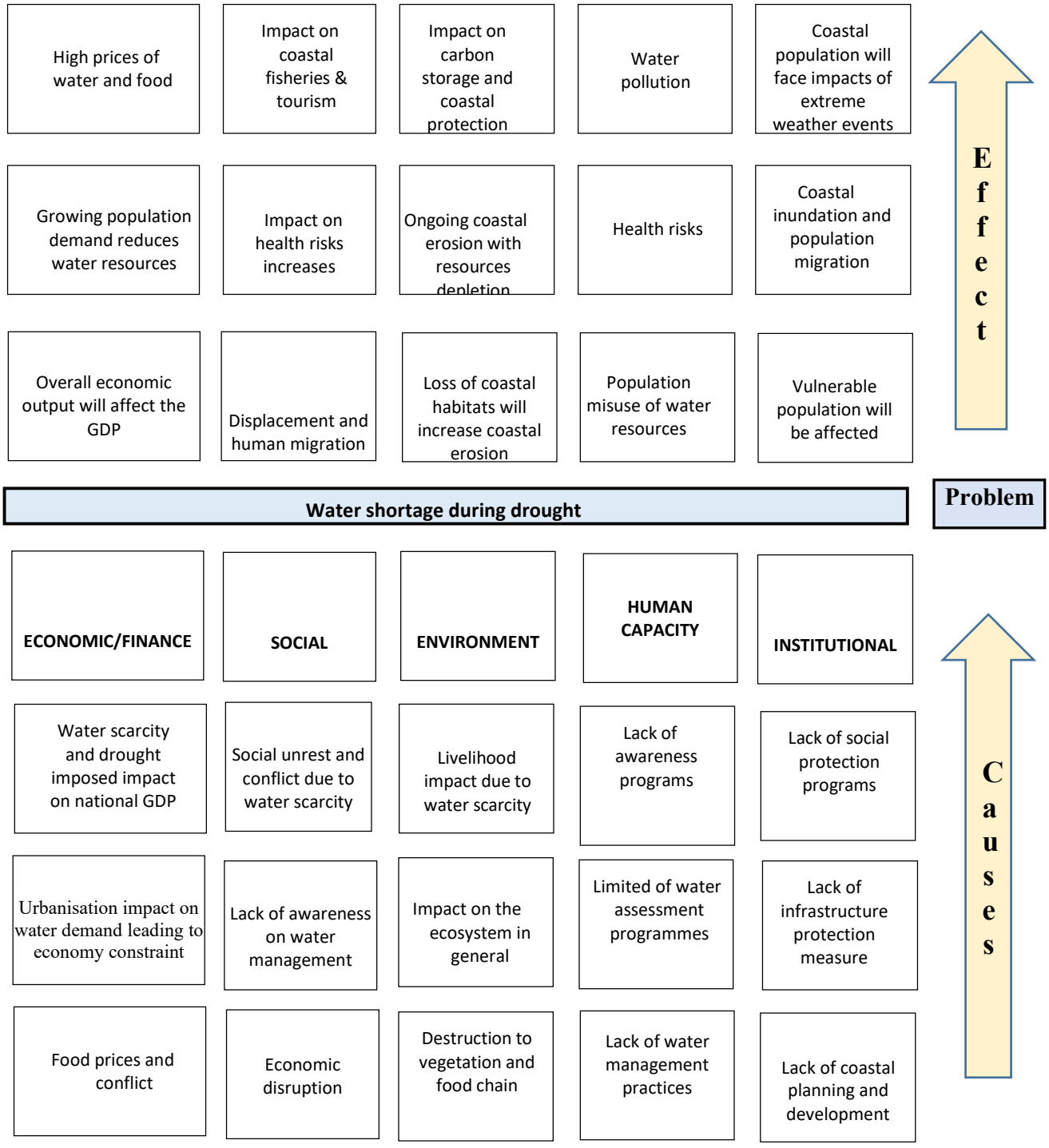
Annex 2: Market mapping, problem and solution trees for the Water Sector

2.1: Solar reverse osmosis technology

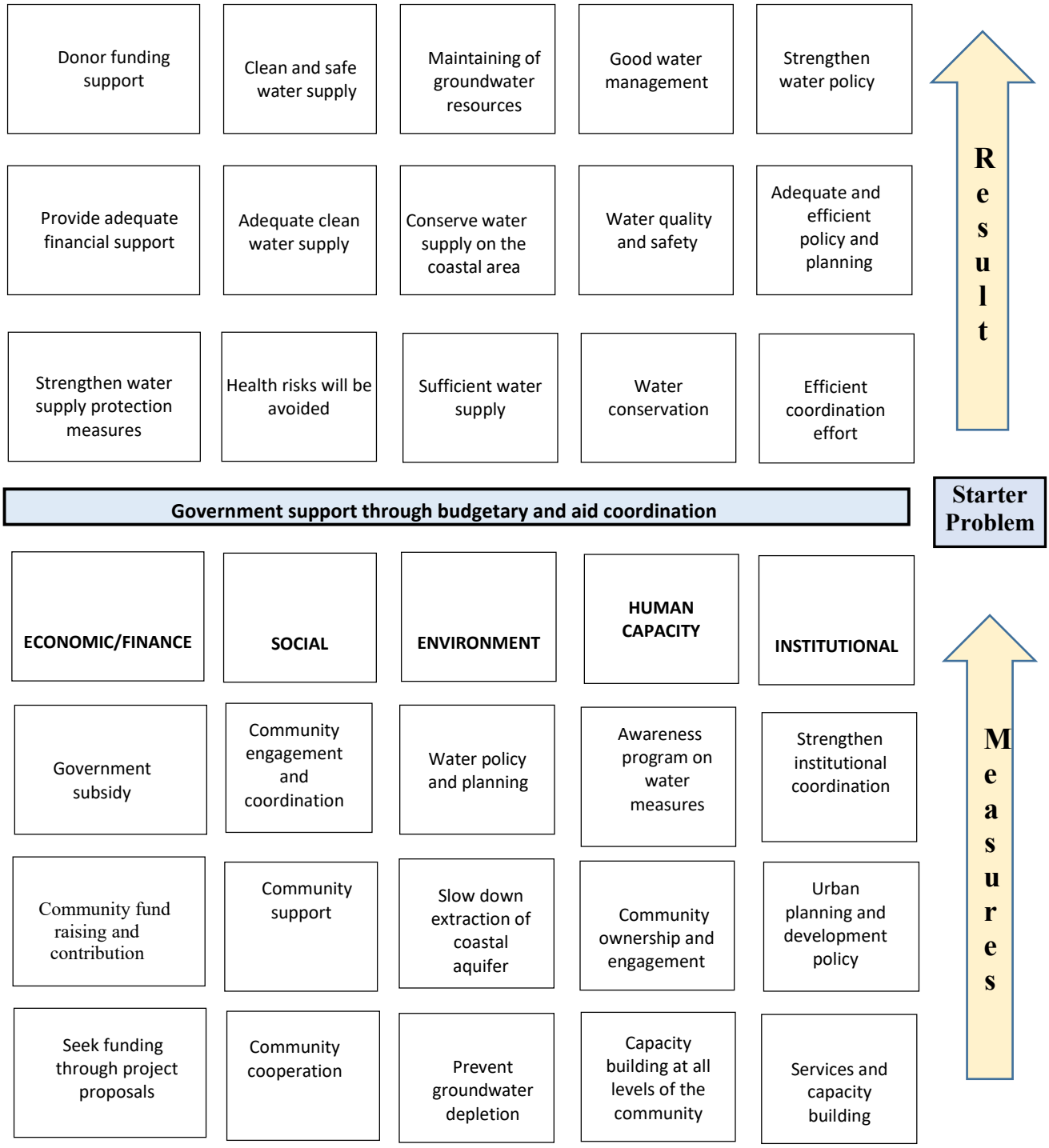
2.1.1 Market mapping – *Solar reverse osmosis technology*

BUSINESS ENVIRONMENT	1. Government Scheme for Subsidy/Loan 2. Policy formulation for water management 3. Trade and Quality standard 4. Skill workers
MARKET ACTORS	1. Household Units 2. NGOs, CSOs and Communities 3. Landowners 4. Maintenance Providers 5. Retailers
SERVICE PROVIDERS	1. Financial Support Services 2. Technical Support 3. Market information 4. Training and capacity Building 5. Awareness

2.1.2 Problem tree – *Solar reverse osmosis technology*



2.1.3 Solution tree – *Solar reverse osmosis technology*

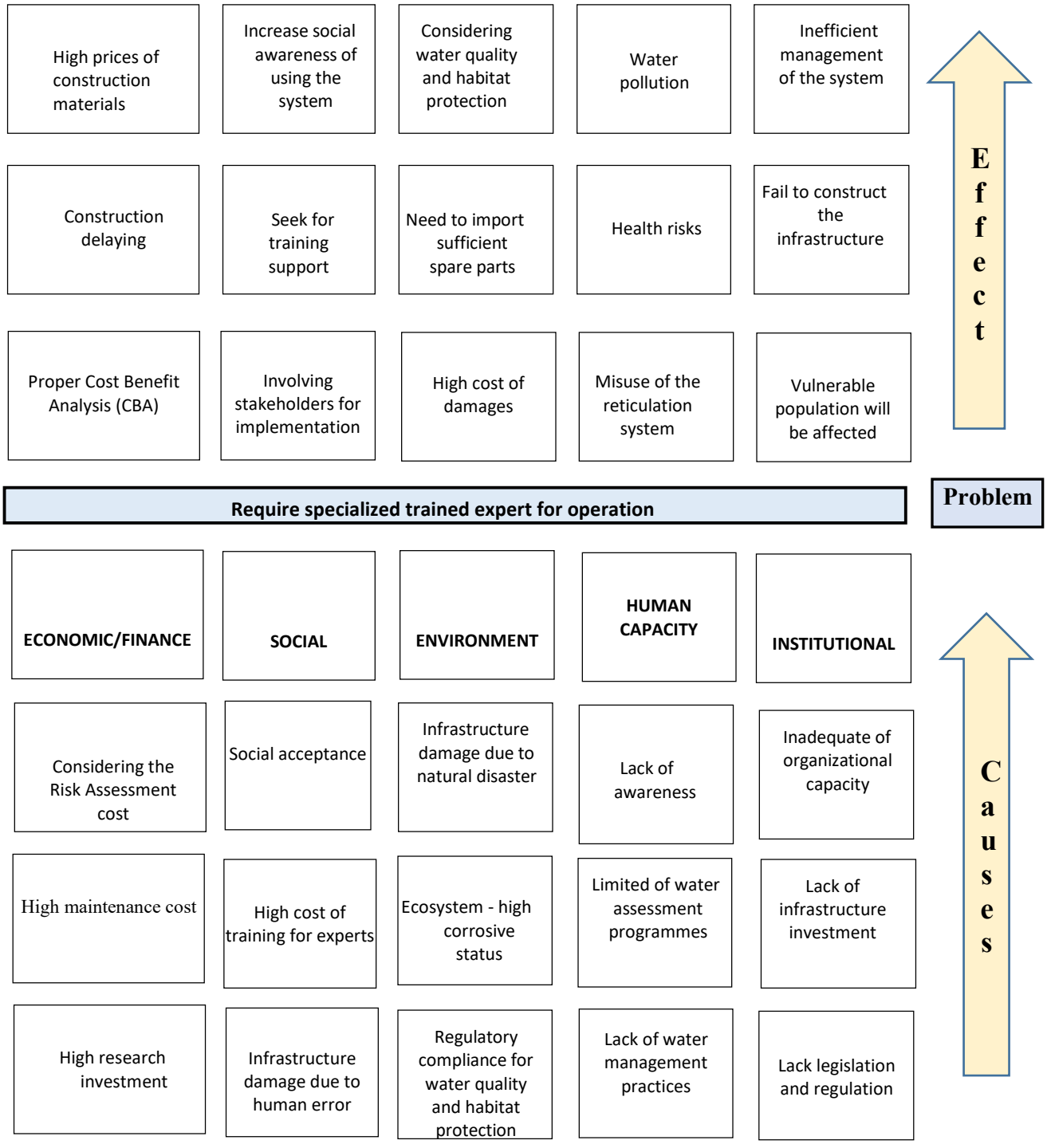


2.2 Water reticulation technology

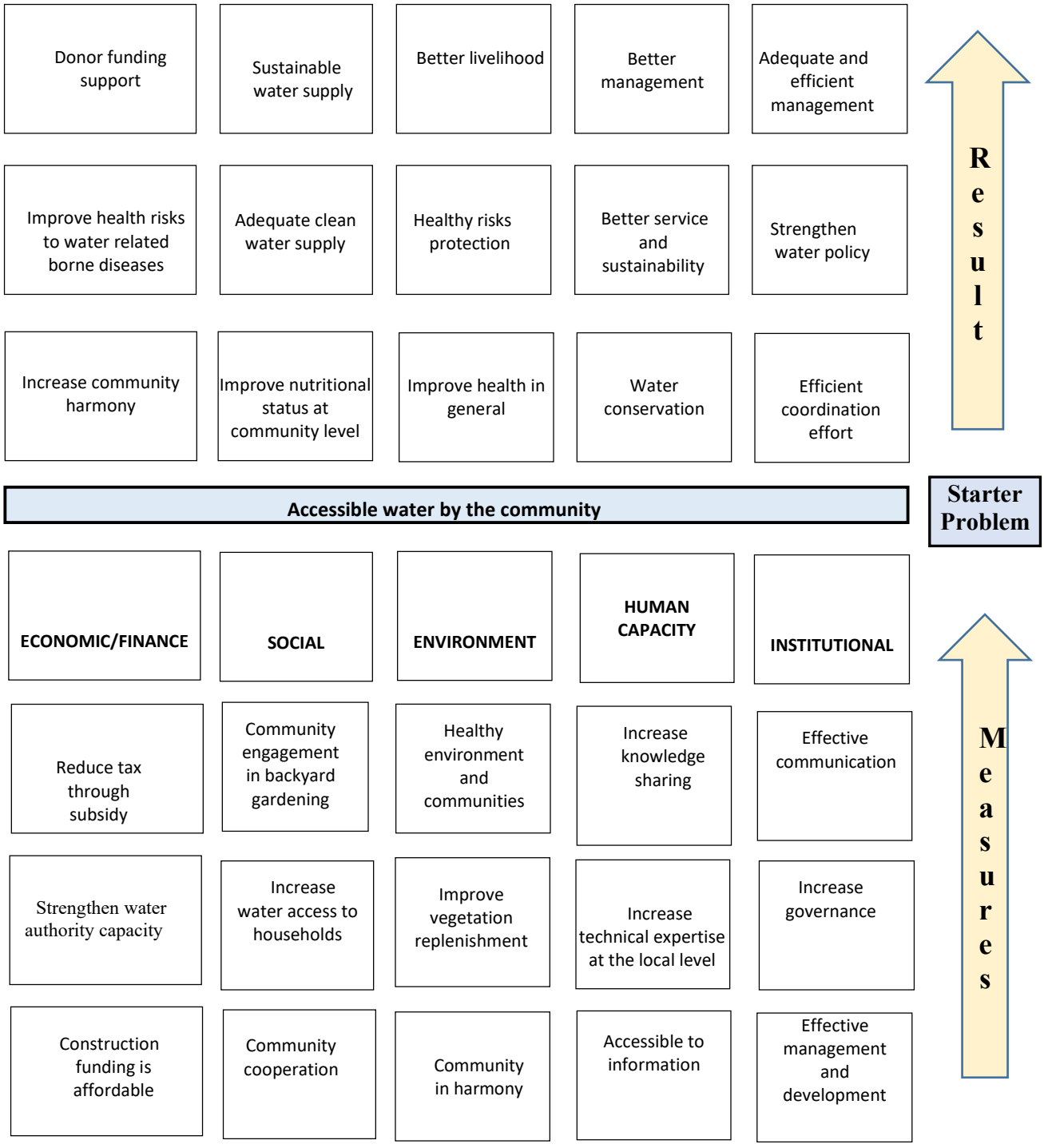
2.2.1 Market mapping – *Water reticulation technology*

BUSINESS ENVIRONMENT	1. Government Scheme for Subsidy/Loan 2. Policy formulation for water management 3. Trade and Quality standard 4. Skill workers
MARKET ACTORS	1. Household Units 2. NGOs, CSOs, Communities and Government 3. Landowners 4. Maintenance Providers 5. Retailers
SERVICE PROVIDERS	1. Financial Support Services 2. Technical Support 3. Market information 4. Training and capacity Building 5. Awareness

2.2.2 Problem tree – *Water reticulation technology*



2.2.3 Solution tree – *Water reticulation technology*

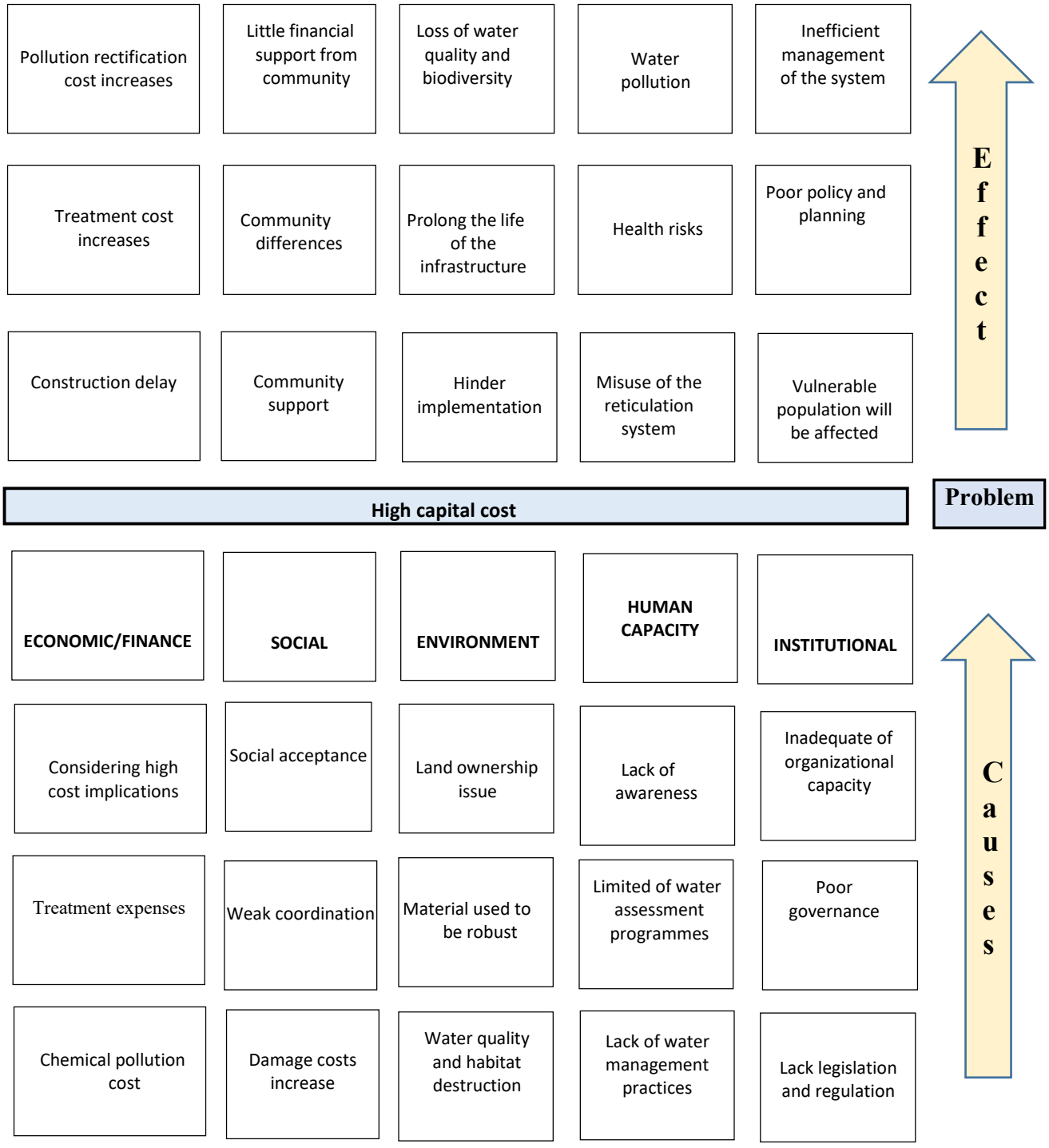


2.3 Groundwater reticulation technology

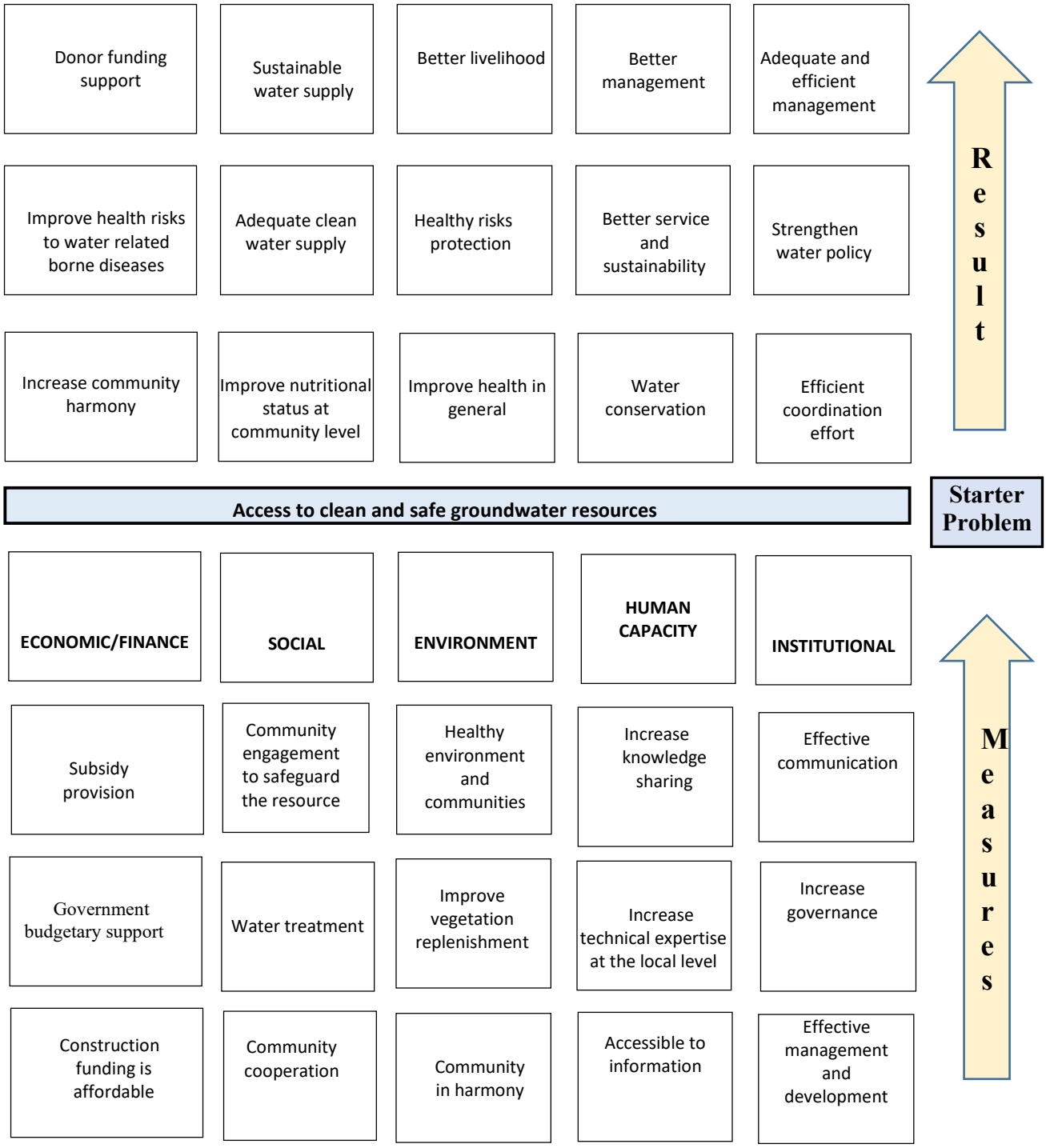
2.3.1 Market mapping – *Groundwater reticulation technology*

BUSINESS ENVIRONMENT	1. Government Scheme for Subsidy/Loan 2. Policy formulation for ground water management 3. Trade and Quality standard 4. Skill workers
MARKET ACTORS	1. Household Units 2. NGOs, CSOs, Communities and Government 3. Landowners 4. Maintenance Providers 5. Retailers
SERVICE PROVIDERS	1. Financial Support Services 2. Technical Support 3. Market information 4. Training and capacity Building 5. Awareness

2.3.2 Problem tree – *Groundwater reticulation technology*



2.3.3 Solution tree – *Groundwater reticulation technology*



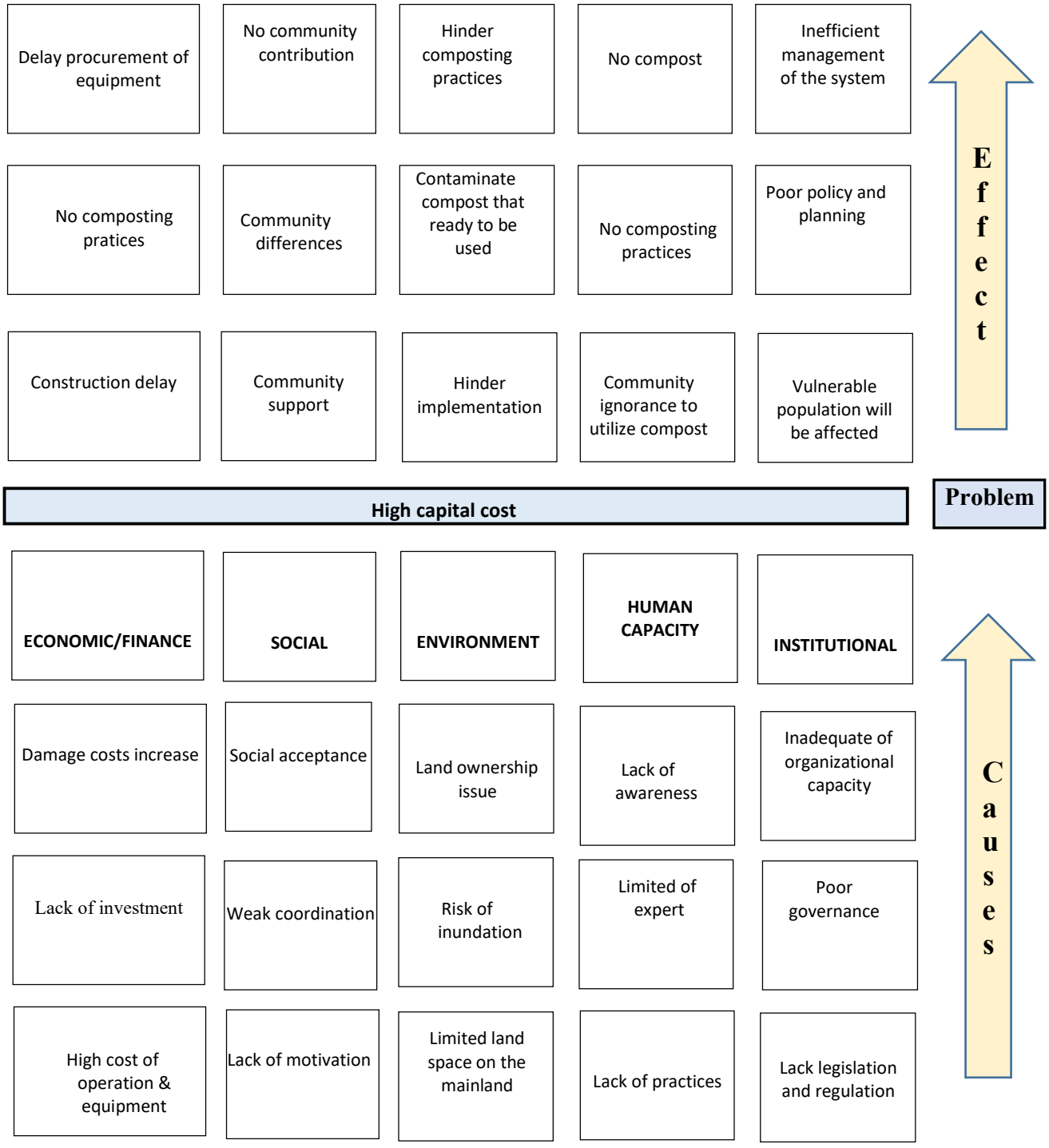
Annex 3: Market mapping, problem and solution trees for the Agriculture Sector

3.1: Composting technology

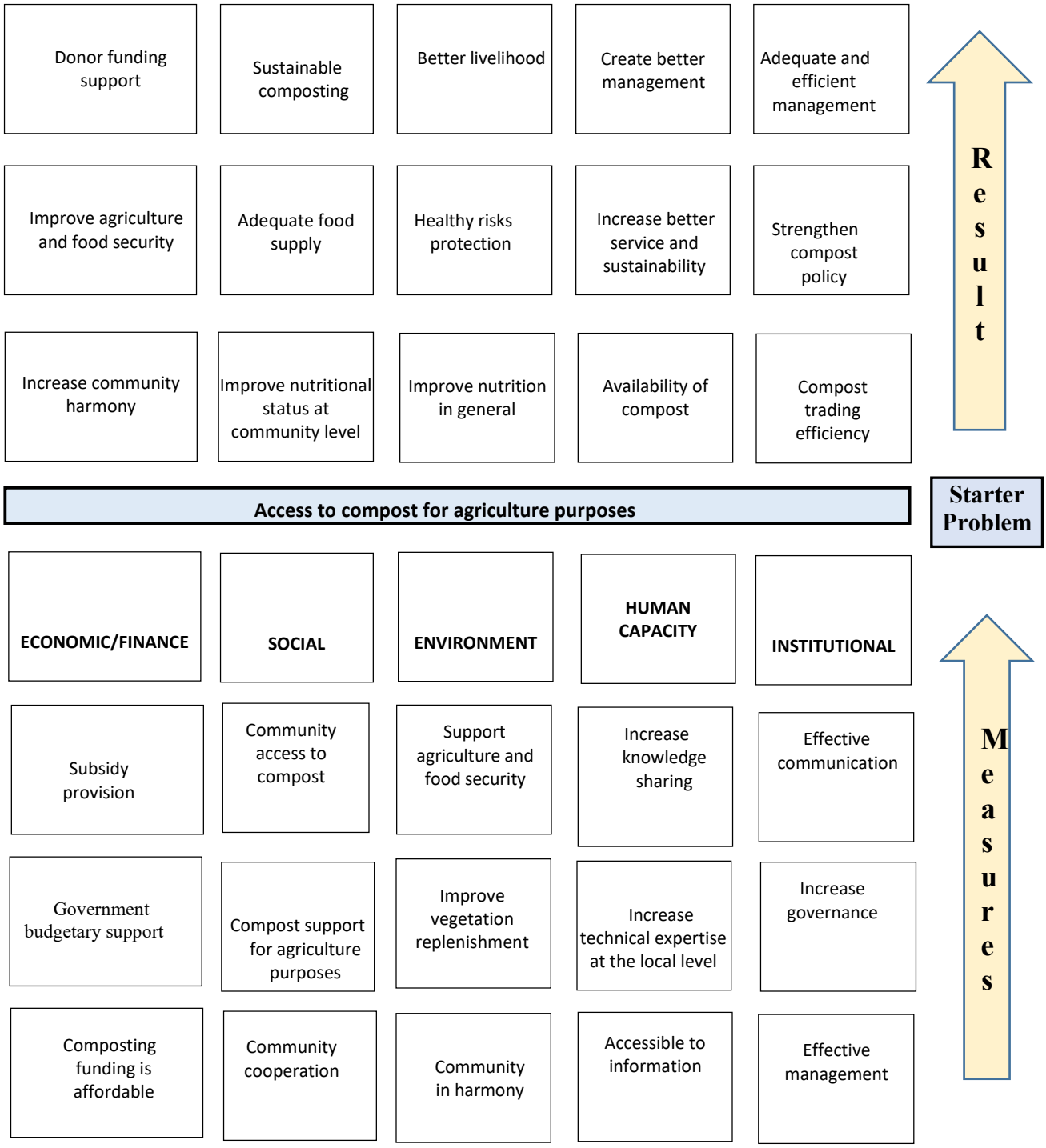
3.1.1 Market mapping – *Composting technology*

BUSINESS ENVIRONMENT	1. Government Scheme for Subsidy/Loan 2. Policy formulation 3. Trade and Quality standard 4. Skill workers
MARKET ACTORS	1. Household Units 2. NGOs, CSOs, Communities and Government 3. Landowners 4. Maintenance Providers 5. Retailers
SERVICE PROVIDERS	1. Financial Support Services 2. Technical Support 3. Market information 4. Training and capacity Building 5. Awareness

3.1.2 Problem tree – *Composting technology*



3.1.3 Solution tree – *Composting technology*

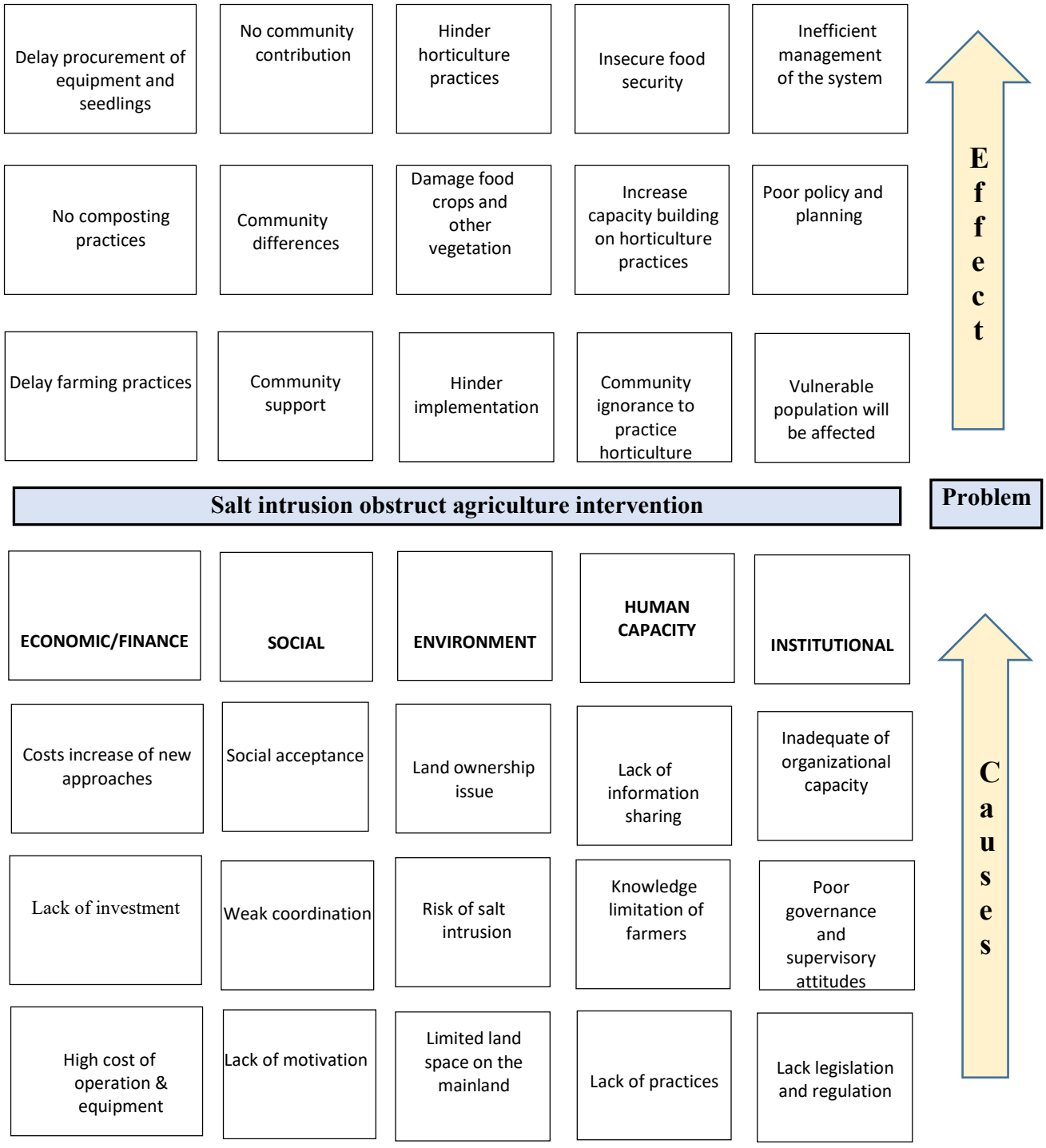


3.2: Horticulture technology

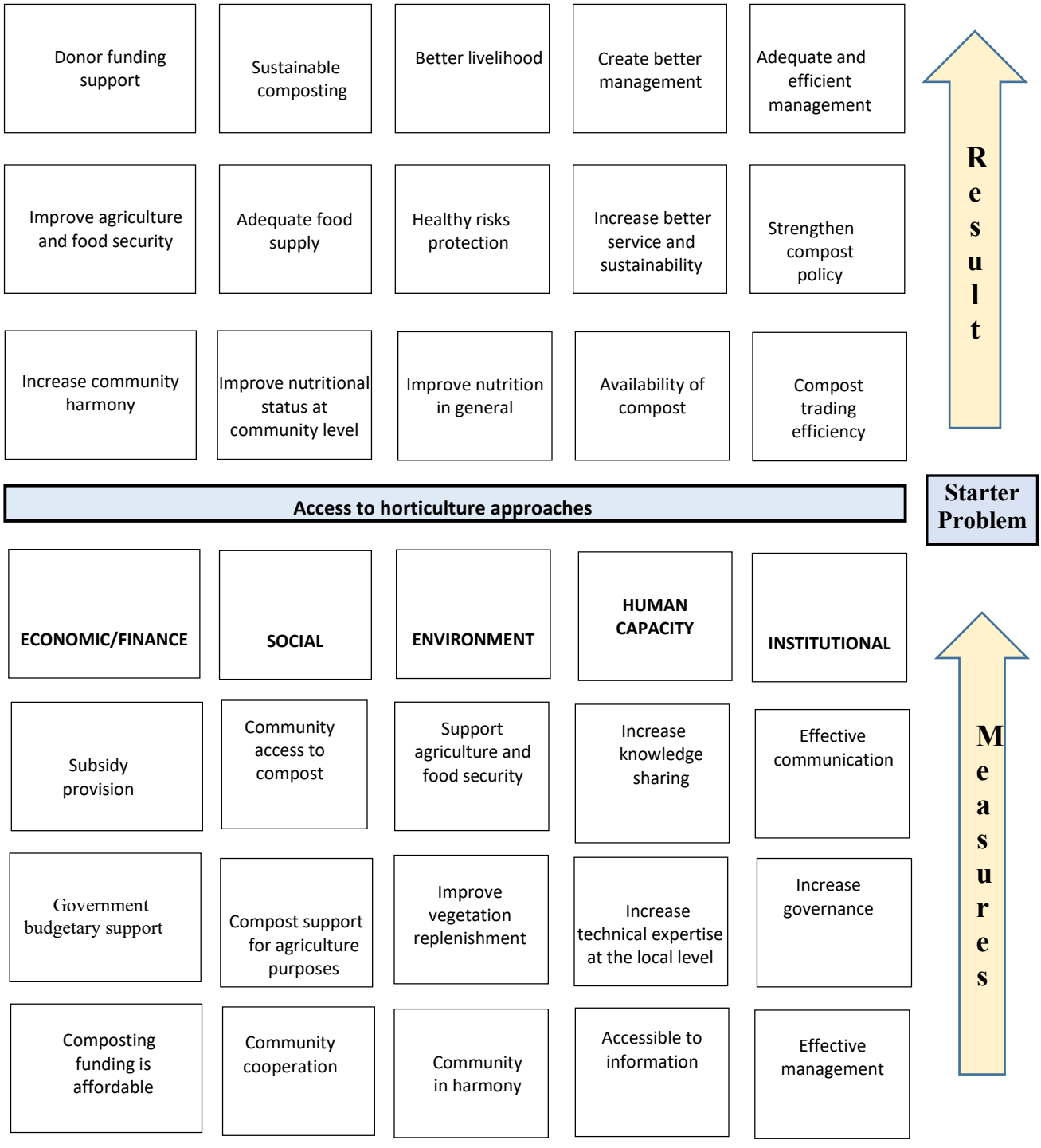
3.2.1 Market mapping – *Horticulture technology*

BUSINESS ENVIRONMENT	1. Government Scheme for Subsidy/Loan 2. Policy formulation 3. Trade and Quality standard 4. Skill workers
MARKET ACTORS	1. Household Units 2. NGOs, CSOs, Communities and Government 3. Landowners 4. Maintenance Providers 5. Retailers
SERVICE PROVIDERS	1. Financial Support Services 2. Technical Support 3. Market information 4. Training and capacity Building 5. Awareness

3.2.2 Problem tree – *Horticulture technology*



3.2.3 Solution tree – *Horticulture technology*

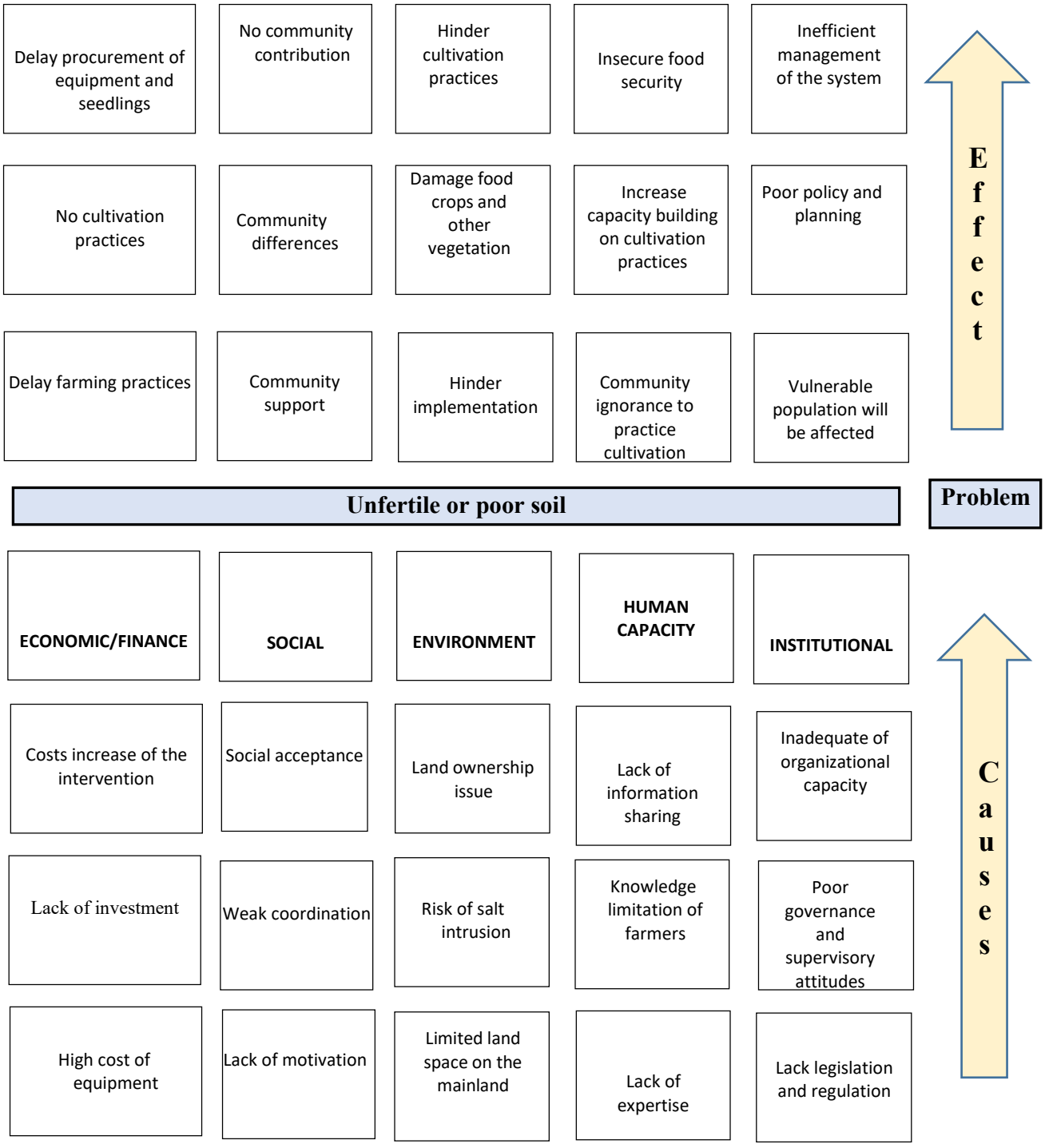


3.3: Cultivator technology

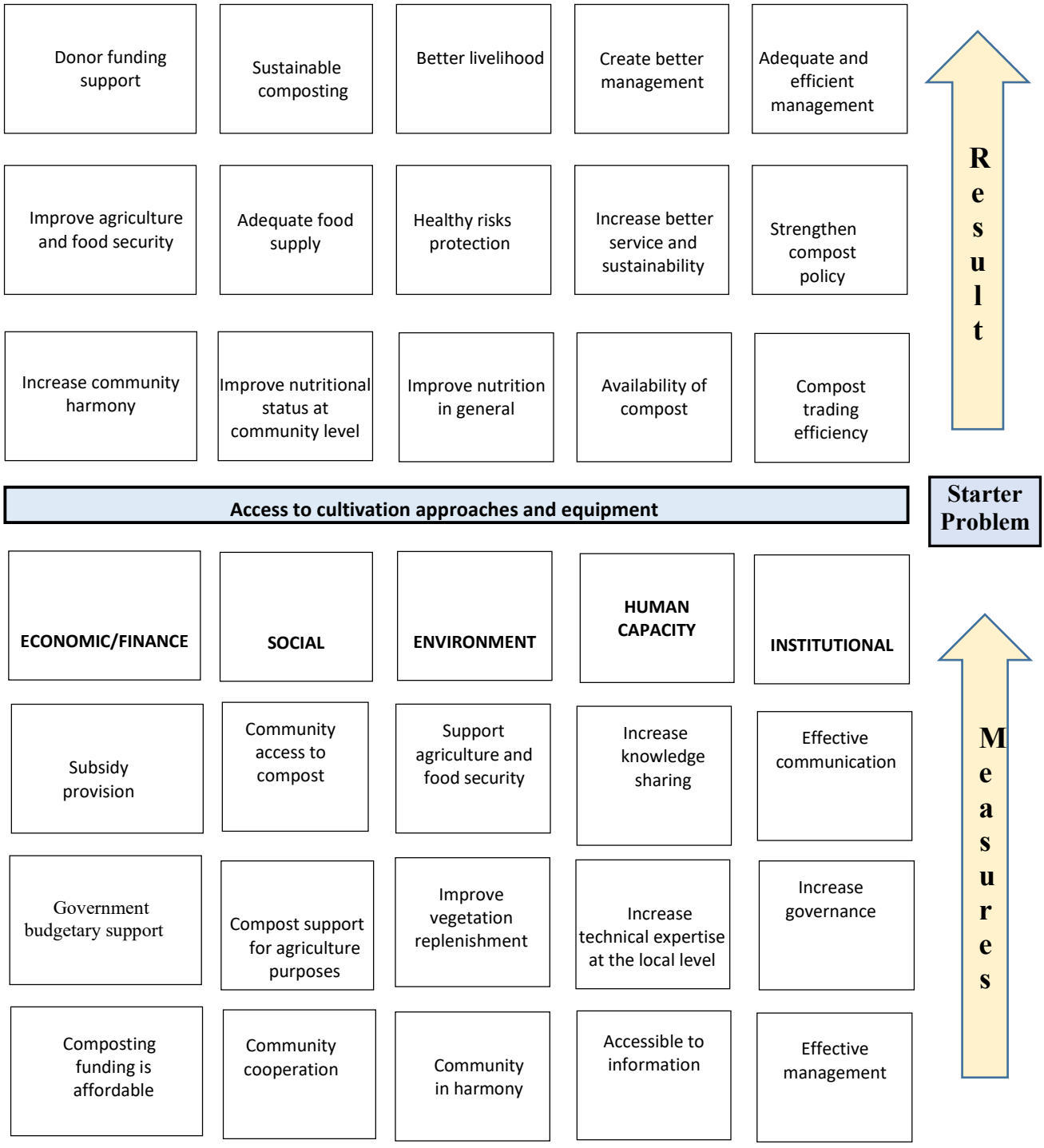
3.3.1 Market mapping – *Cultivator technology*

BUSINESS ENVIRONMENT	1. Government Scheme for Subsidy/Loan 2. Policy formulation 3. Trade and Quality standard 4. Skill workers
MARKET ACTORS	1. Household Units 2. NGOs, CSOs, Communities and Government 3. Landowners and individual farmers 4. Agriculture department 5. Retailers
SERVICE PROVIDERS	1. Financial Support Services 2. Technical and Agricultural Support 3. Market information 4. Training and capacity Building 5. Awareness

3.3.2 Problem tree – *Cultivator technology*



3.3.3 Solution tree – *Cultivator technology*



Annex 4: List of stakeholders involved and their contacts

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7	Lono Leneuoti	MCAP Coordinator	Climate Change Department	lleneuoti@gmail.com
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11	Patuki Faletiute	Finance Officer	IASP	faletiute7@gmail.com
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13	Evoloni Mami	Biosecurity Officer	Agriculture Department	evolinim@gmail.com
	Selotia Tausi		Agriculture Department	Sltausigeorge@gmail.com
Consultation Groups in April and May 2022				
	Coastal Group	**Water Group**	**Agriculture Group**	**Comments**
	Salesa Falesene	Alitaake Alefaio	Evolini Mami	
	Reena Mataio	Richard Gorkrun	Talua Nivaga	
	Alamoana Tofuola	Sailoto Leauma	Lomiata Niuatui	
	Lono Leneuoti	Talafou Esekia	Selotia Tausi	
	Sitia Maheu	Patuki Faletiute		