Report II

Barrier Analysis and Enabling Framework

TNA TECHNOLOGY NEEDS ASSESSMENT

March, 2025

REPORT

Barrier Analysis and Enabling Framework for KIRIBATI

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ACRONYMS

ADB	Asian Development Bank
BAEF	Barrier Analysis Enabling Framework
EO	Earth Observation
EIA	Environmental Impact Assessment
IPCCC	International Panel Climate Change Conference
KOIRAP	Kiribati Outer Islands Resilience Adaptation Project
KNEG	Kiribati National Expert Group
MCA	Multi-criteria Assessment
MDB	Multi-Development Banks
NCSA	National Capacity Self-Assessment
NGO	Non-Government Organizations
GIS	GeoScience Information System
GCF	Global Climate Fund
GCM	Global Climate Models
GEF	Global Environmental Fund
GDP	Gross Domestic Product
SGD	Sustainable Development Goal
TNA	Technology Need Assessment
UNEP CCC	United Nations Environmental Program Copenhagen Climate Centre
UNEP	United Nations Environmental Program
UNOPS	United Nations Office for Partnerships
WB	World Bank

FOREWORD

Kiribati's significant vulnerability to the impacts of climate change mostly arises from exposure to severe weather events and rising sea levels that results in coastal soil erosion in several rural areas. This highlights the urgent requirement for innovative technologies to increase adaptive capacity of the society to such impacts of climate change and safeguard human lives, properties, natural ecosystems, and the economy

The Technology Needs Assessment (TNA) process, spearheaded by the Office of Te Beretitenti in partnership with the Climate Change and Disaster Management Division, UNEP Copenhagen Climate Centre (UNEP CCC), and the University of the South Pacific (USP), will significantly bolster our resilience to climate change vulnerabilities. This initiative is designed to facilitate the transfer and adoption of prioritized technologies across critical sectors, including coastal erosion management within the adaptation sector.

I am especially encouraged by the transparent and collaborative nature of this process, which has effectively prioritized sectors and identified relevant technologies that align with the needs and insights of all stakeholders. The consultative efforts involved a diverse array of participants, including representatives from various government ministries and non-governmental organizations. This approach has fostered a comprehensive and inclusive framework for tackling our climate challenges, ensuring that every voice is heard and considered in our collective response.

I strongly believe that the implementation of both adaptation and mitigation technologies identified in the TNA Phase-I report will be critical in building our country's resilience to cope with the adverse effects of climate change. I would like to extend my sincere gratitude to the members of the TNA National Team, and experts from each Technical Working Group for their invaluable contributions to this report. I would also like to acknowledge the national consultants and experts from USP, UNEP CCC for their unwavering support and guidance throughout the TNA project.

Best regards,

Mr. Tebwaatoki. T. Taawetia

Secretary,

Office of Te Beretitenti

EXECUTIVE SUMMARY

In Kiribati, every aspect of our natural, built, or human environment is intrinsically linked to the coastal regions. Our climate, the land we inhabit, the groundwater we rely on, and the soils that support our agriculture and forestry—all of our resources—are shaped, sustained, and influenced by both historical and ongoing coastal processes (Arthur W., 2016).

In light of this context, the Office of Te Beretitenti – Climate Change and Disaster Risk Management Division (OB-CCDRM) has initiated a collaborative multi-country project known as the "Technology Needs Assessment (TNA) - Stage II," with financial support from the Global Environment Facility (GEF). This report is the second output in the TNA series, building on the initial findings from the first TNA report, which concentrated on the identification and prioritization of adaptation technologies in coastal protection sector. As part of this continuous endeavour, Kiribati will be submitting the Barrier Analysis and Enabling Framework (BAEF) as the next deliverable. This thorough assessment will pinpoint existing obstacles and propose a framework to promote the adoption and implementation of the prioritized technologies.

The selected technologies for the coastal protection sector were determined based on the findings from a technology needs assessment aimed at enhancing adaptation strategies, while also aligning with national development goals to leverage the co-benefits of these technologies and strengthen overall climate resilience in Kiribati. For coastal protection, the recommended technologies include land reclamation for coastal rehabilitation, green-grey infrastructure, and mass concrete seawalls. The BAEF report identifies and summarizes potential barriers to the deployment and diffusion of identified adaptation technologies for coastal protection. The entire process of identifying technology barriers and implementing measures drew from various sources, including literature reviews, and the retreat where input from technology experts was gathered. The adaptation consultant also seek reference to the TNA barrier analysis guideline, resources, information, and templates provided by specialists UNEP-Copenhagen Climate Centre and USP after capacity building training. The technology implementation barrier for coastal rehabilitation, Green-grey infrastructure and Mass concrete seawall is identified. Financial constraints, insufficient capacity gaps and sourcing materials and resources. Policy, legal, and regulatory barriers identified were lack of sound and robust cross-sectoral policies, data gaps, and management, and ineffective current policies. Lack of public information and awareness about the existence and usefulness of the technology because the information is not sufficient and effective, is part of the barrier to information and awareness variable. Limited institutional capacities, especially at the national level, in integrating climate change risks in development planning is identified as the barrier

to institutional and organisational capacity and limited human skills and maintenance, especially at the local level. To overcome the barriers for the three technologies, several measures have been identified, including:

1. Financing - In Kiribati, finance can help overcome barriers to the diffusion of coastal protection technologies by leveraging various funding sources through Climate Finance, Strategic Funding Approaches. Partnerships and Grants, Economic Diversification,
2. Technical Expertise - Technical expertise plays a critical role in diffusing coastal protection technologies in Kiribati, particularly for land reclamation, green-grey infrastructure, and cement seawalls through Capacity Building, Integration of Nature-Based Solutions.
3. Infrastructure Design and Maintenance: Expertise ensures that engineered solutions like seawalls are designed to withstand rising sea levels and storm surges while complementing natural defences like mangroves.
4. Data-Driven Decision Making: Technologies such as Earth Observation (EO) and GIS enable real-time monitoring of environmental changes, supporting precise interventions for coastal rehabilitation.
5. Community Involvement: Participatory consultations ensure the integration of local knowledge and address the needs of marginalized groups during infrastructure design and implementation
6. Capacity Building: Research-driven programs enhance the ability of local communities and governments to plan, execute, and maintain climate-resilient solutions. This includes training in monitoring land changes and maintaining infrastructure.
7. Policies and regulations - In Kiribati, policies and regulations play a crucial role in diffusing coastal protection technologies. Review of some of the outdated and ineffective policies is appropriate and pivotal.

Chapter 1.0 Introduction

1.1 Preliminary target for technology transfer and diffusion

Atmospheric greenhouse gas concentrations have increased rapidly in the past century and are almost certain to continue to increase in the future (IPCC 2001a). Global Climate Models (GCMs) are the best available tools for simulating future climates based on various greenhouse gas and aerosol emission scenarios. GCM experiments indicate a global warming of 1.4 to 5.8°C by the year 2100, relative to 1990 (IPCC 2001a). This is likely to be associated with changes to weather patterns, sea-level rise and impacts on ecosystems, water resources, agriculture, forests, fisheries, industries, settlements, energy, tourism and health (IPCC 2001b).

[1]Rising sea levels and coastal erosion pose imminent threats to Kiribati's coastal communities, prompting fears of displacement and loss of livelihoods. With much of the landmass barely above sea level, the islanders are acutely aware of the urgent need to adapt to a changing climate. Compounding these challenges are socioeconomic pressures, including rapid population growth and limited economic opportunities. Overcrowding strains resources and infrastructure, while dependence on external aid hampers efforts for self-sufficiency and sustainable development. The negative impacts include coastal erosion, washing away of sediments into coastal waters, affecting food production, poor water quality, coastal fisheries/reefs, and tourism (Pioch et al., 2011)[2].

Existing literature has extensively documented the numerous adverse effects of climate change and rising population pressures on land and ecosystem systems, particularly concerning current and future island populations. These impacts threaten not only the ecological balance but also the social and economic stability of coastal communities in Kiribati.(Pelling & Uitto, 2001; Stephenson, et al 2010).[3]

In light of these circumstances, the Kiribati Government, through the Office of Te Beretitenti's Climate Change and Disaster Risk Management Division, has recommended that the Technology Needs Assessment (TNA) process to prioritize the development of technologies specifically aimed at enhancing coastal protection within this project.

To facilitate the widespread adoption of the three prioritized technologies in coastal protection, it is essential to integrate these technologies into the national adaptation plan and ensure they are prioritized in climate change policy development and implementation. A cohesive policy framework that supports the dissemination of these technologies will attract political backing, opening doors to climate change funding—currently a significant obstacle to their adoption. However, in addition to political support, other enabling conditions are necessary to guarantee the successful and sustainable national implementation of these technologies.

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[1] Kiribati Island: Battling Adversity with Resilience - Ministry of Fisheries & Marine Resources Development
[2] Pioch, S., Kilfoyle, K., Levrel, H., & Spieler, R. (2011). Green marine construction. Journal of Coastal Research, (61), 257 268.
[3] Stephenson, J., Newman, K., & Mayhew, S. (2010). Population dynamics and climate change: what are the links. Journal of Publi c Health, 32(2), 150-156.

1.2 Prioritized Technologies

In the initial phase of the Training Needs Assessment (TNA), input from members of the Adaptation Working Group and various stakeholders led to the identification of three key adaptation technologies within the coastal protection sector. These technologies were subsequently prioritized through a Multi-Criteria Assessment (MCA) process, which evaluates their impact on reducing community vulnerability to the severe consequences of sea-level rise and wave overtopping.

The Multi Criteria Assessment (MCA) serves as a crucial decision-making tool that allows for a comprehensive evaluation by considering multiple criteria during the selection process. This approach ensures that the chosen technologies not only address immediate concerns but are also sustainable in the long term.

The technologies that emerged as top priorities per outcome of the TNA processes phase I are summarized in Table 1 below.

Table 1: Prioritized technologies

Prioritized Technologies	**Ranked**
Coastal rehabilitation by land reclamation	1
Green – Grey Infrastructure	2
Mass Concrete seawall	3

Table 2: Description of the prioritized technologies

Technology	**Description**
1. Coastal Rehabilitation by land reclamation	An in-depth discussion among stakeholders regarding this additional technology has cultivated a profound understanding of its potential. As population pressures increase, many individuals are compelled to live in vulnerable areas where they constantly battle natural forces to mitigate wave overtopping, prevent flooding, and secure their survival amid the significant challenges posed by rising sea levels. Despite these adversities, successful small-scale implementations of this technology have yielded promising results that support its broader adoption. The creation of new land presents a valuable opportunity to alleviate the strain

	caused by land shortages in South Tarawa. Similarly, in Tuvalu, a major project involving seven hectares of coastal rehabilitation through land reclamation has been completed successfully, drawing additional funding and interest for similar initiatives.
2. Green-grey infrastructure	This technology is highly sophisticated, yet its importance in coastal protection is undeniable. It seamlessly integrates green infrastructure with grey infrastructure, incorporating nature-based solutions to enhance its effectiveness. Stakeholders believe that a smaller-scale version of this technology could be tailored to address the climate change challenges faced in Kiribati. The pressing need to safeguard the islands from severe coastal erosion has captured the interest of these stakeholders, prompting them to explore and identify the most effective technological solutions available.
3. Mass concrete seawall	Mass concrete seawalls have gained widespread recognition as an effective solution to combat coastal erosion. The Ministry of Infrastructure and Sustainable Energy, along with the Office of Te Beretitenti, has employed this technology as an immediate intervention to address pressing coastal erosion challenges. One of the primary advantages of mass concrete seawalls is their simplicity in implementation, which allows for reduced technical supervision during construction. However, it is important to consider the potential drawbacks of this approach. One notable consequence is the exacerbation of coastal erosion in adjacent areas that remain unprotected, as water flow dynamics can be disrupted. The costs associated with constructing mass concrete seawalls can vary significantly, typically ranging from AUD$20,000 per cubic meter to higher amounts depending on the scope of the project and the specific requirements of the site. As a result, careful planning and evaluation are essential to ensure that this solution is both effective and sustainable in the long run.

1.3 Level of experience with the technology

The Kiribati Government possesses varying degrees of experience with two of the technologies outlined in Table 1: coastal rehabilitation through land reclamation and mass concrete seawalls. These technologies are currently implemented in different forms at several locations throughout the country, each facing unique challenges regarding ease of deployment and the ability to rapidly disseminate to other communities. To promote the sustainability of these technologies following their implementation, stage II of the Technology Needs Assessment (TNA) process aims to set initial targets for their transfer and diffusion, specifically concentrating on the three prioritized technologies within the coastal protection sector.

However, Green-grey infrastructure represents an innovative approach that has yet to be introduced in Kiribati. This technology combines natural and engineered solutions to address environmental challenges, but its implementation requires advanced technology and significant financial investment. As one of the least developed countries, Kiribati faces considerable challenges in securing the necessary funding, which largely depends on support from external development partners. The successful adoption of green-grey infrastructure could offer sustainable benefits for the nation, but it will necessitate collaborative efforts and strategic financial planning.[4]

[5, 6]Green - grey infrastructure can significantly contribute to building resilience against sea level rise and strong storm surges in Kiribati by integrating natural and engineered systems. Some which could help to improve coastal community resilience in Kiribati include the following;

- Natural barriers – Restoring and enhancing natural barriers like coral reefs and mangroves can protect against storm surges and erosion while also supporting biodiversity
- Hybrid solutions – combining seawall and natural ecosystems can provide robust protection against flooding and erosion while maintaining ecological integrity
- Land raising – projects like the Temwaiku land and urban development can raise land levels reducing flood risk and providing safer habits
- Sustainable practices – implementing green building codes and energy-efficient practices can enhance resilience in infrastructure, supporting long term sustainability

[4] https://www.wri.org/initiatives/green-gray-infrastructure-accelerator?utm_
[5] https://www.conservation.org/projects/green-gray-infrastructure?utm_
[6] https://www.conservation.org/projects/green-gray-infrastructure?utm_

1.4 Objectives of the Prioritized technologies

- Secure funding to initiate and implement coastal rehabilitation projects through land reclamation. This initiative aims to foster sustainable development by integrating eco-friendly technologies that safeguard coastal communities from the adverse effects of sea level rise and wave overtopping. By creating additional land area, we can alleviate the pressures of overpopulation, particularly in South Tarawa, where residents face significant challenges due to limited space and resources. This holistic approach not only enhances environmental resilience but also improves the quality of life for local communities.
- Introduce Green-Grey Infrastructure: This approach will promote sustainable management of coastal zones by integrating natural (green) and engineered (grey) solutions. By doing so, we can enhance the resilience of coastal communities, stimulate economic growth, and safeguard the health of marine ecosystems. Emphasizing this synergy will help balance environmental protection with development needs, ensuring a thriving coastal area for both people and nature.
- Construct a mass concrete seawall. This widely utilized technique serves as an effective immediate response to coastal erosion challenges. The process involves filling bags with concrete, which are then stacked strategically to create a robust barrier. This structure is designed to safeguard coastal areas against the harsh effects of climate change, providing resilience and protection to vulnerable shorelines.

1.5 Stakeholders Participation and Gender consideration in the TNA Process

It is acknowledged that to achieve the preliminary targets of transfer and diffusion of technologies in coastal erosion sector, the relevant stakeholders must get involved and play active roles in the successful implementation of the identified technologies. The important stakeholders include coastal sectors experts, relevant authorities such as Ministry of Sustainable Energy and Infrastructure, Ministry of Environment, Lands and Agriculture Development, Ministry of Culture and Internal Affairs, Ministry of Fisheries and Ocean Resources. Other players include technology dealers, technicians, and experts in coastal sector. The implementers include Non-Government Organizations (NGO) who play key role and focusing on communities, advocacy groups of women, youth, marginalized members in the communities, village leaders active at local and national levels.

According to Roberts (2011)[7] stakeholder analysis can also help a project or programme identify, the interests of all stakeholders who may affect or be affected by the programme/project; potential

[7] Roberts, P. (2011). Effective project management: Identify and manage risks plan and budget keep projects under control. Kogan Page Publishers.

conflicts or risks that could jeopardize the initiative; Opportunities and relationships that can be built on during implementation.

Gender considerations were integrated throughout the entire process, ensuring that women's perceptions, insights, and voices played a crucial role in shaping outcomes.

1.6 Different stages of the TNA project Implementation.

The figure 1 below summarizes the TNA project implementation in Kiribati.

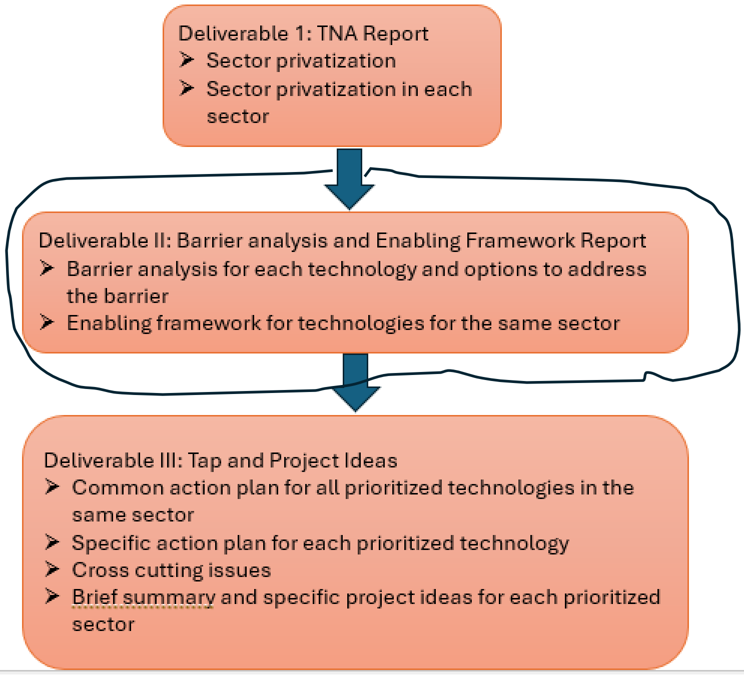

Figure 1: Different stages of TNA project implementation in Kiribati

1.7 Methodology

This document reports the output of the stage II of the TNA process for Adaptation for Kiribati. The paper primarily covers the barriers analysis and transfusion, enabling framework and key measures collectively identified to overcome the barriers. For each prioritized technology identified, a systematic approach of describing and analyzing each technology related barrier and identification of enabling framework was adopted. The following keys steps were undertaken as part of the process.

1.7.1 TNA stage II Process:

The consultant's desktop review and the outcomes from the group work conducted by the adaptation working group have collectively led to several important decisions, which include the following:

a) Identifying of preliminary targets for technology development and diffusion at the sectoral scale.

b) Describing of technologies identified. Provision of its potential adaptation benefits. Determine and categorize whether such technology is a market or public good with some description of its status across the country.

c) Identifying of key measures for overcoming the barriers, possible linkage between different technology barriers within a sector and device a technology enabling framework would help overcome potential barriers while creating a supporting environment for the development and successful diffusion of the selected technologies.

1.7.2 Desktop Reviews

The consultants conducted a comprehensive literature review of existing country reports and scholarly articles to enhance the understanding of coastal erosion issues and opportunities. Their research focused on past initiatives, current challenges, future projections, and strategies for effective intervention moving forward. Bilge & Dumitraş (2012)[8] emphasize the critical role of desktop reviews in understanding researched topics. Thus, the report undertook literature review to understand the context of the selected adaptation technologies in the country. Some of the documents studied include, National coastal policy, Intended Nationally Determined Contribution, Kiribati National Climate Change Policy, Kiribati National Coastal Policy, Kiribati Joint Implementation Plan (2019 – 2028), and the Kiribati National Development Plan. This process has helped to formulate and finalize the Second Phase of the TNA report.

1.7.3 Stakeholder consultation and validation meeting

After the desktop review process, a stakeholder consultation through a retreat was held by the Adaptation consultants with the support of Office of Te Beretitenti with respective Technical Working Groups (refer annex 5). This retreat was critical to verify and validate information collected through a desktop review and to carry out a Barrier analysis and Enabling Framework exercise. During the stakeholder consultation (retreat), a guideline was followed as part of the process.

Table 3: Checklist for list of activities to be accomplished in the retreat 14-16 March 2025

	Main stages of analysis	**Method and tools**
1	Preliminary targets for technology transfer and diffusion	Desk top review and stakeholder group work

[8] Bilge, L., & Dumitraş, T. (2012, October)

1	Barrier analysis and enabling measures	Problem analysis through construction of problem tree
	• General description of technology A1	Literature review
	• Identification of barriers for technology A1	Desk top review and stakeholder group work
	○ Economic and financial barriers	Problem tree
	○ Non-financial barriers	Problem tree and group work
	○ Identified measures	Group work
2	Barrier analysis and possible enabling measures for technology 2	Group work and
3	Barrier analysis and possible enabling measures for Technology A3	Problem analysis through construction of a solution tree
4	Linkages of the barriers identified	Consultant
5	Enabling framework for overcoming the barriers in Sector A	Consultant

1.7.4 The TNA Project Steering Committee

The Kiribati National Expert Group (KNEG) serves as the steering committee for the Technical Needs Assessment (TNA) process. Comprising senior representatives from various government ministries, NGOs, civil society organizations, and faith-based groups, the KNEG brings diverse expertise to the table. During the inception meeting, key sectors were identified to create a committee specifically tasked with overseeing the adaptation TNA process. The committee is chaired by Ms. Takena Redfern, the Director of Climate Change and Disaster Risk Management Division. The primary role of this steering committee is to monitor the progress of the TNA, ensuring that all milestones are met within the established timeframe and scope of work.

CHAPTER 2.0: Coastal rehabilitation by land reclamation

2.1 General description of Technology

A successful small-scale implementation of this technology has yielded promising results that support its broader adoption. The creation of new land presents a valuable opportunity to alleviate the strain caused by land shortages in South Tarawa. Similarly, in Tuvalu, a major project involving seven hectares of coastal rehabilitation through land reclamation has been completed successfully, drawing additional funding and interest for similar initiatives. The technology has been considered effective in addressing congested living problems where population pressure is the main underlying cause. [9]This is evident in South Tarawa where half of the total population of Kiribati resides.

[10]The coastal rehabilitation project in Kiribati, known as the Temaiku Land and Urban Development initiative, focuses on land reclamation technology to address climate change resilience and urban development challenges. Key characteristics include.

- Land reclamation and elevation: Approximately 300 hectares of low-lying land in the Temwaiku Bight area will be reclaimed and raised by 2 to 5 meters, protecting against sea level rise for up to 200 years[11]
- Climate Resilience Design: The project incorporates finished surface levels of +5.6m on the ocean side and +4.6m on the lagoon side to prevent inundation. It also includes a coastal hazard buffer zone and phased soft and hard coastal defences like rock revetment seawalls[12]
- Environmental and social integration: Native vegetation will be planted on slopes to reduce erosion, while a green buffer zone will provide ecological benefits and offset resources loss from construction [13]
- Freshwater Protection: Measures are in place to safeguard the Bonriki Freshwater Lens from saltwater intrusion due to sea levels[14]

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[9] https://www.worldbank.org/en/results/2012/04/16/kiribati-adaptation-program-phase-2?utm_source=perplexity

[10] S. Watkin, M.Foon, S.Liddel. Australasian Coast and Ports 2019 conference – Hobart, 10-13 September 2019, Temwaiku Land and Urban Development – Building Sustainable Climate Change Resilience for Kiribati

[11] ibid

[12] ibid

[13] ibid

[14] ibid

This initiative is expected to house over 35,000 people, reduce population density pressure, and serve as a governance hub for Kiribati.[15]

2.2 Preliminary targets for technology transfer and diffusion

[16] A seawall is the most easily identified hard engineered structure in the Pacific Islands. When the word 'seawall' is mentioned, majority of those hearing it immediately picture a vertical concrete or rock wall alongside the coastal embankment. Seawalls are constructed parallel to the shoreline, sandwiched by the existing landform or reclamation on one side while exposed to ocean waves or river currents on the other. Like any structure, a seawall will require thorough geotechnical testing and subsurface investigation to assess the existing conditions in order to proceed with the design accordingly. An environmental impact assessment (EIA) is also conducted to ensure that there is minimal disturbance to the existing ecosystem and/or the natural flora and fauna is enhanced. The seawall category branches out into different types based on the type of material used and formation of the structure. These include concrete wall, sheet piling, gabions, and geotextile containers of which the two commonly used are concrete and sheet piling. Components of seawall design include location of the seawall, height, weight of the structure, structural connections, fill material (landward of the seawall face), seawall cap, provisions for subsoil drainage, and toe protection. Hard Structural Engineering Options involve the construction of engineered structures designed to protect coastlines from the impacts of climate change, such as seas walls, revetments, and breakwaters. While these solutions can offer long-term protection, their effectiveness depends on specific local conditions and resource availability. Innovative materials like geotextile containers are also being explored for enhanced coastal protection.

While the hard engineered solutions may propose a longer design life compared to soft engineered solutions, there are many critical factors that contribute to the sustainability of each structure. Furthermore, the detailed design solution will vary case by case taking into account the existing features of the area and the available resources in Kiribati.

Overall, integrating natural solutions in Kiribati like vegetation planting with engineered methods presents a comprehensive approach to safeguarding Kiribati's coastlines against erosion and climate impacts. The focus on sustainable practices is essential to ensure the longevity and effectiveness of coastal protection strategies (Paeniu et al,.2015).

[15] Ibid
[16] Cummings, *et al*., 2012

Coastal rehabilitation by land reclamation processes in Kiribati faces several challenges due to i) financial constraints[10], iv) population pressure, v) Legislative and regulatory gaps, vii) lack of local expertise, viii) lack of community engagement.

2.3 Technology status in Kiribati

Coastal rehabilitation efforts in Kiribati, particularly through land reclamation, face significant challenges but are crucial for addressing coastal erosion and flooding risks. This is particularly the case with small island developing states (SIDS), where sea-level rise could threaten livelihoods and sovereignty, and the capacity to adapt is thought to be limited (Barnett and Adger 2003; Mimura et al. 2007; Hay 2013).

Coastal rehabilitation by land reclamation is not new across the country, however it just needs to be designed properly to yield maximum benefits to the communities. According to Duvat (2013), an assessment of coastal structures on Tarawa Atoll in Kiribati was carried out to facilitate the establishment of consistent construction and maintenance programmes and also contribute to a better understanding of shoreline changes. The results highlight the abundance of structures, mostly seawalls (94.7 % of the total), which stretch along of the coastline. The protected shoreline decreases from urban (53.9 % at Bairiki) to rural islands (27.3 % at Buota), in proportion to population pressure. The occurrence and height of structures are greater on windward, ocean shores than on lagoon shores. Seawall condition is better in rural islands, compared to urban and semi-urban areas. The observed differences in the characteristics and physical condition of coastal structures mainly reflect differences in the management status of structures and the availability of building materials and funding. More generally, the occurrence and characteristics of coastal structures are strongly correlated to population densities, land-use dynamics and shoreline mobility. At some locations, the failure of coastal protection highlights the seriousness of the problems raised by land-use practices in Tarawa.

Land reclamation has been used to expand islets and redirect sediment flow. However, these efforts have sometimes disrupted natural sediment dynamics, leading to long-term erosion issues. A notable project involves raising 300 hectares of land to 2 meters above the highest sea level, supported by the New-Zealand government.

2.4 Technology category and market characteristics

Coastal rehabilitation by land reclamation can be classified as a public good at the community level, necessitating the support of the governments for effective implementation and management. This classification stems from the intention to generate widespread benefits for entire communities or villages, rather than serving the interests of individual stakeholders. By prioritizing community well-being over private gain, coastal rehabilitation initiatives can foster sustainable development and enhance the resilience of local ecosystems. As a result, this technology necessitates substantial funding for implementation, despite its potential positive impact on community well-being.

2.5. Identification of barriers

2.5.1 Screening and prioritization of identified barriers

Following the creation of the potential barriers list by members of the adaptation working group, the discussion that follows focused on coastal erosion to evaluate and pinpoint the critical barriers that must be tackled for effective technology transfer and dissemination. To streamline the prioritization of these barriers, tools like starter problem and solution trees were employed, fostering a consensus within the working group. The result of this process was the formulation of the final list of barriers, which is summarized in the following discussion.

During the initial breakout session, the members of the adaptation working group identified potential barriers that include the following;

Table 4: Barriers to coastal rehabilitation by land reclamation

Barriers	Category
Limited access to funding	Finance
Competing government priorities	Policy
Absence of clear national policy direction on coastal rehabilitation	Policy
Poor national data collection and management	Research
Lack of human resources and technical expertise	Resources
Weak design	Institutional capacity
Poor law enforcement	Regulation
Higher cost of equipment and materials	Resources
Coastal erosion and sea level rise	Environment
Salt water intrusion	Environment
Mining of beach and aggreggates	Resources
Population pressure	Social

Legislative and regulatory gap	Policy
Financial constraints	Finance
Use of inexpensive materials	Resources

In the next step, we systematically evaluated the identified barriers based on their significance priorities. This process led to the creation of a shortlist highlighting the most critical barriers to technology transfer and diffusion (refer to Table 5). Furthermore, these selected barriers were organized into a hierarchical structure, and a logical problem tree approach was employed to uncover the underlying 'root' barriers contributing to these challenges.

From the list developed above, a further categorisation was undertaken through which the barriers were prioritized according to their significance.

Table 5: Prioritised barriers for coastal rehabilitation by land reclamation technology

Problem	**Category**
High priority	
Limited access to funding	Finance
Limited government fiscal capacity to finance its own development programs	Finance
Higher investment cost	Finance
Insufficient funding for implementation	Finance
Medium priority	
Weak design	Institutional capacity
Lack of local expertise	technological
Competing government priorities	Policies
Community engagement	Social
Lack of awareness	Social
Low priority	
Absence of clear national policy direction on coastal rehabilitation	Policy
Poor national data collection and management	Research

These barriers were decomposed, and the simplified problem tree was developed which was transposed into objective tree identifying measures to overcome these barriers.

2.5.2 Economic and financial barriers

One of the primary obstacles to scaling up coastal rehabilitation through land reclamation technology is the economic and financial barrier, characterized by limited access to funding, high investment costs and insufficient funding for implementation. When developing the factsheet for this technology, cost estimates varied significantly depending on factors such as size, elevation above sea level, the volume of infill and other materials, machinery requirements, and additional technical inputs. For instance, project costs ranges between AUD$6 millions to AUD$123 millions.

The lack of funding to support implementation of the technology poses the greatest challenge. Generally, the implementation of the technology rely on donor agencies for financial support, which must be sustainable throughout all project phases, including planning, implementation, and post-management. [17]Moreover, there is often a deficiency in the economic valuation of both tangible and intangible benefits associated with coastal rehabilitation by land reclamation. This gap in valuation leads to an underappreciation of the economic significance of the ecosystems affected by such projects, particularly considering the potential adverse impacts on local environments and communities. Addressing these financial challenges is crucial for facilitating effective coastal rehabilitation by land reclamation initiatives.

Additionally, the country's limited fiscal capacity restricts its ability to fund larger scale projects, while reliance on volatile fishing revenues and external grants introduces uncertainty in financing. Additionally, Kiribati geographic isolation raises costs for importing materials and expertise, compounded by infrastructure gaps and climate vulnerabilities such as rising sea levels and coastal erosion[18]

2.5.3 non-financial barriers

Table 5 clearly identified non-financial barriers that were discussed by the adaptation working group in the retreat. These non-financial barriers include;

1. Community engagement
2. Lack of human resources and technical expertise
3. Weak design
4. Legislative and regulatory gap

[17] https://www.worldbank.org/en/results/2012/04/16/kiribati-adaptation-program-phase-2?utm_
[18] https://www.elibrary.imf.org/view/journals/002/2023/329/article-A001-en.xml?utm

5. Competing Government policies
6. Absence of clear national policy direction on coastal rehabilitation
7. Poor national data collection and management
8. Poor law enforcement
9. Higher cost of equipment and materials
10. Coastal erosion and sea level rise
11. Salt water intrusion
12. Mining of beach and aggregates
13. Population pressure
14. Use of inexpensive materials

Once the list was created, the identified barriers were ranked based on their significance. From this ranking, the adaptation group recognized the following top barriers as crucial challenges.

The successful implementation of hard measures like sea walls technologies such as coastal rehabilitation by land reclamation is challenging in SIDS, where institutions may not be capable of adequate planning, hydrodynamic analysis, maintenance, monitoring or sourcing of construction materials and capital (Barnett 2001). Nevertheless, the long history of constructing sea walls to protect from the sea, the lack of local understanding of the adverse effects, and the status associated with an expensive, mod ern sea wall protecting a village, church or maneaba (community house) means that sea walls are often a default or preferred adaptation option both to i-Kiribati and to the institutions providing financing.

[19]The **Kiribati National Coastal Policy** focuses on protecting natural shorelines to enhance coastal resilience and ensure the long-term safety of the local population. Developed as part of the Kiribati Adaptation Program Phase III, the policy involves collaboration among various government ministries and stakeholders to tackle issues related to coastal management.

[20]For constructing a seawall in Kiribati, there is a defined application process, which includes submitting a detailed application and site plan, obtaining a coastal assessment

[19] National Coastal Policy -
[20] ibid

certificate at no cost, getting design approval which may incur fees, and undergoing post-construction evaluations by relevant agencies.

While seawalls can offer immediate coastal protection, the **Shoreline Protection Guidelines (regulatory processes**) caution that they may unintentionally exacerbate erosion in front of the structures due to wave reflection. As a result, some communities, such as Aonobuaka, have opted to ban seawall construction, favouring natural strategies that enhance sediment accumulation and facilitate beach restoration.

Seawalls are generally made from materials like coral rock, sandbags, and concrete blocks, but their effectiveness is challenged by climate change-related issues like rising sea levels and intensified storms. Maintenance of these structures is often insufficient due to resource constraints.

Community involvement is crucial in the decision-making surrounding seawall construction, with local consensus significantly influencing whether such projects proceed. As demonstrated in Aonobuaka, community decisions may lean towards preserving natural coastal processes over engineered solutions. The qualitative analysis of the real-world process of climate change adaptation reveals that embracing a culturally appropriate and short-term (*20 years) planning horizon, while not ignoring the longer-term future, may reduce the influence of scientific uncertainty on decisions and provide opportunities to learn from mistakes, reassess the science, and adjust suboptimal investments. The limiting element in this approach to adaptation is likely to be the availability of consistent, long-term financing (Donner S and Webber S, (2014)).

In essence, the regulations governing seawall construction in Kiribati strive to harmonize coastal protection needs with environmental sustainability and community input, emphasizing the importance of adaptive management in the face of climate change and its impacts.
It is important to also emphasize that any discussion of the degree of natural shoreline resilience is only relevant to islands which have intact shoreline systems.
South Tarawa does not have a single unaltered shoreline left and many of its shores are heavily degraded through direct human impacts (Webb, 2016).

Lack of technical capacity which always resulted in a poor and weak design of sea wall technologies is one is one chronic barrier that affect the durability and capacity of seawall designs to withstand and counter the impact of strong waves.

Additionally, the government's recurrent budget for ministries is inadequate to support the implementation of robust and durable seawall designs. As a result, efforts have been made to seek funding from development partners to fill this financial gap. However, this approach often proves to be a lengthy process, and there are instances where requests for funding do not secure the necessary support from these partners.

2.6 Identified measures

This activity stems from the problem tree we developed, which offers valuable insights into the root causes of various issues and their subsequent effects. As part of our process, we transformed the identified problems into a solution tree, which helped us formulate effective strategies for resolution. Below are the solutions derived from this solution tree:

- **Increasing access to climate finance** is essential for implementing coastal rehabilitation technology in Kiribati. The Climate Finance Division of the Ministry of Finance and Economic Development was established to facilitate access to climate finance resources in support of this initiative. Enhancing institutional capacity within the climate finance division will enable better proposal development and fund management, fostering donor confidence.
- **Improving and strengthen national coastal legislations and regulations**. A review of the current legislations and regulations is an appropriate measure to address this issue.
- **Strengthening partnerships** – Kiribati should continue to leveraging bilateral support (e.g., from major development partners such as Australia, Japan, New Zealand and multi-lateral donors like ADB, and WB. These partnerships are vital for development partners to stay informed about the government's priority list. By understanding these priorities, the process of applying for assistance can become more efficient, providing greater assurance of receiving the necessary support.
- **Enhancing Community engagement** through awareness programs is essentially critical to change people's mindset from a traditional believe to a more informed decision making.

Chapter 3.0: Green-Grey Infrastructure

3.1 General description of the Technology

In Phase I of the Training Needs Assessment (TNA) process, we developed a Technological Fact Sheet that delivered a detailed overview of the technology. This document encompassed critical information about the technology's features, functions, and applications, establishing a solid foundation for further analysis and informed decision-making in the subsequent phases of the assessment.

[21]Green infrastructure (also sometimes called natural infrastructure, or engineering with nature) intentionally and strategically preserves, enhances, or restores elements of a natural system, such as forests, agricultural land, floodplains, riparian areas, coastal forests (such as mangroves), among others, and combines them with green - grey infrastructure to produce more resilient and lower-cost services.

[22]Grey infrastructure is built structures and mechanical equipment, such as reservoirs, embankments, pipes, pumps, water treatment plants, and canals. These engineered solutions are embedded within watersheds or coastal ecosystems whose hydrological and environmental attributes profoundly affect the performance of the Green - Gray infrastructure.

[23]Nature-based solutions (NBS) is an umbrella term referring to "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."

This technology has yet to be implemented in Kiribati. However, it is important to note that similar concepts have been adopted in the region. [24]In urban South Tarawa, adaptation planners often recommend a hybrid approach that combines hard measures—such as engineering solutions to safeguard critical infrastructure against flooding and land loss—with soft measures aimed at mitigating erosion. These soft measures also address the potential indirect erosion caused by the hard interventions.

3.2 Preliminary targets for technology transfer and diffusion

Kiribati preliminary targets for the transfer and diffusion of green-grey infrastructure are not explicitly detailed in the available information. However, the country is actively engaged in climate resilience and adaptation efforts, including projects like the Kiribati Outer Islands Resilience and

[21] GREEN-GRAY INFRASTRUCTURE PRACTICAL GUIDE
[22] ibid
[23] ibid
[24] Juillerat, 2012

adaptation project which focuses on enhancing infrastructure resilience. Additionally, Kiribati aims to integrate green and climate-resilience development through initiatives such as the Kiribati Joint Implementation Plan for climate change and disaster risk management. These efforts suggest a broader strategy towards incorporating sustainable infrastructure solutions.

3.3 Technology category and market characteristics

Similar to coastal rehabilitation, green – grey infrastructure can be classified as a non-market public good at the community level, necessitating the support of the governments for effective implementation and management. While in certain contexts, such initiatives may be considered private goods—particularly when aimed at recreational or tourism investments—the primary focus here is on their role as public goods. This classification stems from the intention to generate widespread benefits for entire communities or villages, rather than serving the interests of individual stakeholders. By prioritizing community well-being over private gain, coastal rehabilitation initiatives can foster sustainable development and enhance the resilience of local ecosystems.

Inadequate construction and design of seawalls remains a persistent issue across Kiribati and the broader Pacific Islands (Nunn 2009). This challenge stems from limited local technical expertise, which has led to a reliance on costly international consultants who may not fully understand the specific needs and conditions of the region. Consequently, the solutions proposed often fail to adequately address local circumstances, exacerbating the vulnerabilities of these communities to climate change and rising sea levels.

3.4 Technology status in Kiribati

Green – grey infrastructure technology in Kiribati is being implemented on a small scale as part of the efforts to enhance climate resilience and address environmental challenges. Below are examples of such initiatives:

- Kiribati Outer Island Resilience and Adaptation Project (KOIRAP): This project includes small-scale, risk informed infrastructure such as climate-sensitive drainage systems that integrate green and grey elements. These systems aim to improve water management and reduce flood risks while enhancing sustainability[25]
- Rainwater harvesting and groundwater: Pilot programs in South Tarawa focus on recharging urban ground water lenses using treated greywater of rainwater overflow. These efforts aim

[25] https://www.koirap.com.ki

to improve water availability and quality while addressing environmental concerns[26] to enhance resilience against coastal flooding[27]

- Temaiku Urban Expansion: A pilot site in Temaiku, South Tarawa, integrates land raising and green-grey infrastructure for climate-protected urban development. This approach combines natural systems with engineered structures[25]

3.5 Identification of barriers for Green-Grey Infrastructure technology

3.5.1 Screening and prioritization of identified barriers

Some suggestions derived from a desktop review suggested that governments, utilities, and companies that invest in a combined infrastructure approach can cost-effectively improve performance, promote resilience, and provide multiple benefits to communities. However, the challenges presented by identifying, designing, and evaluating green infra-structure with the necessary rigor and exactitude to meet engineering standards are relatively new. Successful green infrastructure projects must also map the interests of all stakeholders and find common priorities.[28]

A desktop review was conducted independently by consultants where some of the questions were identified critical to understanding the barriers that may impacted the implementation of the technology, some of which are listed below[29];

- Technical dimensions: Would green infrastructure-grey infrastructure lower the cost, increase the quality, or improve the resilience of the service?
- Social dimensions: is it possible to get multiple stakeholders to support the proposed green-grey infrastructure design
- Economic dimensions: Can the green-grey infrastructure be justified in terms of cost, as well as in broader economic terms
- Financial dimensions: Can the green - grey infrastructure be financed and financially sustained over time?
- Enabling policies: What can the service provider do to improve the enabling environment for green - grey infrastructure?

Building on the previous inquiries regarding technological challenges, the issue of inadequate sea wall construction and design remains a persistent concern across Kiribati and the broader Pacific Islands

[27] Building Urban Water Resilience in Small Island Countries – The case of South Tarawa, KIRIBATI available online at www.worldbank.org/gwsp
[28] Browder et.al,. Integrating Green-grey. Creating new generation infrastructure , World Bank group
[29] ibid

(Nunn, 2009). Numerous experts advocate for decision-makers to adopt flexible policies and "no-regret" strategies that enhance living standards and mitigate disaster risks, irrespective of the varying impacts of climate change (Hallegatte, 2009; Adger et al., 2005; Dessai et al., 2009). Such adaptive decision-making frameworks are particularly vital in Kiribati, where uncertainty and variability are inherent due to environmental factors.

The episodic nature of El Niño events, characterized by unpredictable erosion and flooding incidents, exacerbates the challenges faced in coastal protection. Furthermore, the lack of technical expertise, comprehensive data, and proactive planning has resulted in poorly designed coastal infrastructure and disjointed initiatives—such as unregulated beach mining—which undermine resilience against rising sea levels (ADB, 2008). To effectively address these challenges, a coordinated and informed approach is essential for sustainable coastal management and resilience building in Kiribati.

3.5.2 Economic and Financial barriers

The economic and financial barriers to implementing green-grey infrastructure seawalls in Kiribati are primarily driven by financial constraints, which can be characterized by the following factors:;

a) High cost: Building and maintaining green-grey infrastructure requires substantial investment, which can reach up to 25% of Kiribati GDP (USD$70 millions)[30] annually for climate adaptation projects. This is a significant financial burden for a small economy reliant on external funding[31]
b) Limited access to climate Finance: Securing climate funding involves fulfilling complex criteria, including fiduciary standards and environmental safeguards.
c) Budget limitations: Budget limitations are a significant financial challenges for implementing green-grey infrastructure technologies. These projects often require higher upfront cost making them less attractive to municipalities with limited budget. Additionally, long-term benefits of green infrastructure, such as climate adaptation and biodiversity support, may take 10-15 years to materialize which does not align with short term political cycles or immediate financial priorities[32].
d) Unsustainability of Green-Grey lifespan – Green-grey infrastructure faces challenges in proving return on investment and cost-effectiveness. While it can complement grey infrastructure by reducing energy costs and enhancing liveability, its dispersed nature and lack of market-based

[30] https://www.theglobaleconomy.com/Kiribati/GDP_current_USD
[31] https://thecommonwealth.org/news/climate-risk-assessment-kiribati-finds-significant-ecological-and-financial-risk?
[32] https://www.epa.gov/green-infrastructure/overcoming-barriers-green-infrastructure?utm_

valuation make funding difficult. Public-private partnerships and innovative financing strategies, like blended finance, are seen as potential solutions to overcome these barriers

3.5.3 non-financial barriers

a) Workforce skill gaps/Lack local expertise – There is always a lack of skilled human resources and expertise.

b) Insufficient research development – lack of adequate data creates uncertainty about the effectiveness of the traditional grey system

c) Inadequate government policies – There is obviously a lack of standardized guidelines or performance metrics for green infrastructure project which creates uncertainty for planners and developers. Government and agencies often default to grey infrastructure due to entrenched practices, technical familiarity and existing bureaucratic workflows.

Addressing these barriers requires better urban planning, environmental restoration and stronger regulatory support for green infrastructure integration.

d) Environmental degradation poses significant barriers to integrating green-grey infrastructure. The loss of natural systems like forests and wetlands reduces the availability of essential resources of green infrastructure. Urban development codes often conflict with green infrastructure principles, hindering its implementation. Scepticism about the reliability of green solutions in degraded environment further discourages adoption. Additionally, degraded ecosystem may fail to deliver benefits such as water filtration or flood control, reducing their effectiveness in integrated system.

3.6 Identified measures

3.6.1 Financial measures

Enhancing access to climate finance is critical for successfully implementing coastal rehabilitation projects in Kiribati, especially through innovative land reclamation technologies. To improve access to these crucial financial resources, several strategies can be employed:

1. Strengthening Partnerships: Foster collaboration among governmental agencies, non-governmental organizations, and international bodies to pool resources and share expertise in climate finance.

2. Capacity Building: Invest in training and educational programs for local stakeholders to enhance their skills in project design, proposal writing, and financial management, enabling them to effectively navigate and utilize climate finance opportunities.

3. Innovative Approaches: Explore new funding mechanisms, such as public-private partnerships or blended finance models that combine public funding with private investment, to unlock additional resources for coastal rehabilitation initiatives.

During a recent retreat with experts from key sectors involved in coastal protection, several actionable measures were identified to support these strategies, including:

- **Establishing a dedicated fund** for coastal projects that can provide seed capital and attract further investment.

- **Promoting awareness and understanding** of climate finance options available to local communities and organizations.

Implementing these measures will pave the way for more effective coastal rehabilitation efforts, ultimately safeguarding Kiribati's vulnerable coastlines in the face of climate change.

3.6.2 non-financial measures

1. Improved workforce skill gaps – Addressing workforce skill gaps is critical for enhancing the implementation of green and grey infrastructure technologies in Kiribati, particularly in the context of climate resilience and sustainable development. Some suggestions to provide insightful contribution on how improved workforce skills could serve as a measure to facilitate the implementation of the technology;

a). Bridging Technical and Environmental Expertise

- Integrated project management: Training programs that combine traditional engineering skills (e.g., construction, surveying) with ecological knowledge (e.g., wetland restoration, coastal resilience)[33] enable workers to design and maintain hybrid green-grey infrastructure systems. For example, constructing seawalls (grey) alongside mangrove restoration (green) requires expertise in both areas (Haucer, C. 2024).

[33] GGI Country Planning Framework (2019 – 2023), KIRIBATI

- Climate adaptation techniques: Workforce training in climate-resilient design, such as stormwater management and living shorelines, ensures infrastructure can withstand rising sea levels and extreme weather.

b). Strengthening Institutional Capacity

- Policy implementation: Skilled professionals are needed to enforce environmental regulations and mainstream green growth into national strategies. Kiribati's National Capacity Development Action Plan highlights gaps in coordination, legislation, and enforcement, which targeted training could address.
- Public-private collaboration: Programs like Delaware's partnership with industry partners (source2) demonstrate how hands-on training with stakeholders fosters practical skills and ensures projects align with community needs. Similar models could be replicated in Kiribati to improve coordination between government, NGOs, and contractors.

c). Supporting Economic Diversification

- Green entrepreneurship: Training in sustainable agriculture, renewable energy, and eco-tourism (as outlined in Kiribati's Country Planning Framework) can diversify livelihoods while promoting climate-resilient infrastructure. For instance, GGGI's focus on green micro-businesses helps communities develop income streams tied to environmental stewardship.

- Mainstreaming "greening" skills: Even workers in traditional sectors (e.g., construction, drafting) benefit from green infrastructure training, as these skills are increasingly integrated into broader projects.
- d). Addressing Specific Skill Gaps in Kiribati
    - Technical shortfalls: Kiribati's National Capacity Self-Assessment (NCSA) identifies gaps in environmental law enforcement, data management, and public awareness. Tailored training in GIS mapping, environmental impact assessments, and community engagement would directly address these challenges.
    - Financial and project management: Capacity-building programs for government officials on cost-benefit analysis and accessing climate finance (as supported by GGGI) ensure sustainable project pipelines.

e). Long-Term Sustainability

- Local ownership: Investing in local workforce skills reduces reliance on foreign expertise and ensures infrastructure is maintained long-term. Kiribati's Whole of Island Approach emphasizes community-led solutions, which require trained locals to manage.
- Alignment with global goals: Workforce development supports SDG targets on decent work (SDG 8), climate action (SDG 13), and sustainable infrastructure (SDG 9).

2. Improved research development enhances the implementation of green-grey infrastructure by providing rigorous, integrated approach to design, assess amd optimize the systems, it creates spatially explicit models and analytical tools that assess urbanization impacts on both green and grey infrastructures helpting planners to optimize land use to expand green infrastructure alongside urban growth, its promotes combining traditional engineering with ecological principles. Research informs policy guidance and institutional capacity building. Its support developing business cases and innovative financing mechanisms and promotes knowledge sharing and capacity building.

3. Effective government policies – Effective government policies enhance the implementation of green-grey infrastructure by creating enabling frameworks that support planning, funding, and integration of green infrastructure with traditional grey infrastructure.

4. Improved Environmental concerns – it promotes the integration of natural ecosystem conservation engineering solutions, resulting in more resilient, cost-effective and multi-functional infrastructure systems.

Chapter 4.0: Mass concrete seawall

4.1 General description of technology

Mass concrete seawalls have been extensively employed in Kiribati as an effective strategy to combat the adverse effects of climate change. These seawalls are designed to mitigate wave overtopping and protect coastal communities from the challenges posed by rising sea levels. By providing a robust barrier against oceanic forces, these structures play a crucial role in safeguarding the livelihoods and homes of residents facing the increasing threats of erosion and flooding. Mass concrete seawalls in Kiribati are engineered structures designed to protect coastlines from erosion and flooding caused by rising sea levels and wave actions. These seawalls are typically constructed using locally sourced materials such as coral rubble, sand, and aggregates or imported durable materials when necessary[34].

Key features include;

1. Construction materials - reinforced concrete or mass concrete, often mixed with lagoon - derived aggregates and sands as per the Kiribati Building code[35]
2. Design – vertical or sloped walls with a robust toe foundation to resist scour and wave impact. Some designs incorporate wave walls for added protection[36].
3. Durability – seawalls vary in effectiveness depending on design considerations like curing, bonding, and placement orientation. Proper maintenance is crucial to prevent degradation over time[37].
4. Land involvement – many seawalls are built by local contractors using cost-effective methods, achieving significant savings compared to international bids[38].

While these structures play a crucial role in coastal protection, they face several challenges, including erosion at their base, overtopping during high waves, and the need for continuous monitoring and adaptation.

4.2 Preliminary targets for technology transfer and diffusion

In Kiribati, preliminary targets for mass concrete seawall transfer and diffusion must align with the nation's unique environmental challenges and community driven approaches. While seawalls are often

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[34] Brown C,T 2019; Seawalls on Atolls: Lessons for US all, Australian Coast & Ports 2019 conference, Hobart, 10-23 September 2019
[35] LDS-Bairiki, Seawall and land development project, Tabonikabauea : Environmental Impact Assessment (EIA) Report
[36] Brown C,T 2019; Seawalls on Atolls: Lessons for US all, Australian Coast & Ports 2019 conference, Hobart, 10-23 September 2019
[37] ibid
[38] ibid

constructed to protect infrastructure such as roads, airfields, and causeways, they can exacerbate coastal erosion through wave reflection and sediments disruption as highlighted in the Kiribati shoreline protection guidelines[39]. Communities like Aonobuaka have opted for natural solutions such as the *te buibui* method, which uses local materials to rebuild coastal dunes and beaches while minimizing ecological harm.**Error! Bookmark not defined.** The approach reflects a broader shift toward ecosystem-based adaptation strategies, including vegetation recovery and mangrove planting, which have shown positive results in sand accretion across project sites.[9] However for critical infrastructure in South Tarawa, seawalls remain essential, requiring improved designs to withstand storms and rising sea levels while mitigating environmental impacts.[39] Balancing these measures ensures both protection against climate-related disaster and preservation of Kiribati's fragile coastal ecosystems.

4.3 Identification of barriers for mass concrete seawall

4.3.1 Screening and prioritization of identified barriers

4.3.1.1 Desktop review

To address the challenges associated with this classification, an independent desktop review was conducted independently by the adaptation consultant. From this review, the following barriers were identified;

1. Environmental impacts: seawalls can accelerate erosion by reflecting wave energy, removing sediments in front of the structure, and disrupting sediment flow to neighbouring areas. This can lead to beach narrowing, ecosystem degradation and biodiversity loss[40]
2. Poor construction and maintenance: many seawalls in Kiribati are built with cheap materials or inadequate design due to limited funding and expertise. These structures often degrade quickly, requiring regular maintenance that is rarely provided, leading to infrastructure failures[41]
3. Social conflicts: Seawalls can cause disputes among communities when erosion impacts neighbouring properties. Some villages, like Aonibuaka, have banned seawalls to avoid social friction and promote natural coastal protection methods[42]

[39] Kiribati Nati National Coastal Policy 2016 – Building coastal resilience and security
[40] https://www.sprep.org/news/village-banned-seawalls?utm_
[41] https://www.marinesocialscience.uni-kiel.de/en/artistic-research/artistic-research-climate-justice-in-kiribati/sea-walls-gone-wrong/the-case-of-sea-walls?utm
[42] ibid

4. Economic constraints: The cost of constructing durable seawalls is high, especially when relying on imported materials. Locally built seawalls using lagoon-derived aggregates have been more cost effective but still face durability challenges[43]
5. Limited data and planning: Insufficient data on coastal dynamics often results in poorly positioned or designed seawalls, exacerbating their negative impacts[44]

Alternative solutions like eco-system-based approaches (e.g te buibui structures) are gaining traction as sustainable options for coastal protection.

4.3.1.2 Stakeholder consultation

A systematic evaluation of barriers was conducted during a stakeholder consultation (retreat) that was held from March 14-16, 2025. This process involved screening and decomposition exercises with adaptation working group which facilitated the identification and classification of barriers into a structured hierarchy. By employing a logical problem tree analysis, we were able to pinpoint the underlying 'root' barriers impeding the implementation of mass concrete seawalls.

The enabling framework process was established to devise measures for the identified barriers, carefully considering the prevailing market conditions, technological capabilities, institutional frameworks, policies, and practices. A problem tree was constructed to elucidate the root causes of these barriers. Subsequently, this problem tree was inverted to create an objective tree, which served to propose actionable measures for overcoming the identified challenges. This structured approach ensures that the necessary steps are taken to facilitate the effective deployment of mass concrete seawalls in our coastal infrastructure planning.

The following barriers were identified with stakeholders during the stakeholder consultation (retreat) which then prioritised according to their significance.

Table 6: Prioritized barriers for Mass concrete seawall

Barrier	**Significance** (High, medium, low)
1. Limited budget – High construction cost	High
2. Data gaps	Medium
3. Weak institutional capacity/expertise/budget	High

[43] ibid
[44] ibid

4. Weak policies	Low
5. Lack of awareness	Low
6. Increased environmental risk	Medium
7. Prolong timeline	Low
8. Loss of funds	High
9. Restrict coastal accessibility	Medium
10. Aggregate challenges	Low

4.3.1.3 Economic and financial barriers

From a literature review, the following Economic barriers to building mass concrete seawalls in Kiribati include;

i) High Construction cost – Concrete seawalls can cost up to A$5,000 per meter with capital investment reaching several million dollars. Maintenance cost are also significant, exceeding A$100,000 annually[45]

ii) Funding dependence – Projects often rely on unsustainable financing donor funding, making long-term planning difficult[46]

iii) Aggregate supply challenges – Kiribati relies heavily on coastal mining for sand and gravel, which accelerates erosion and depletes resources. Sustainable alternatives like lagoon dredging require substantial initial investments, such as the €2.2 million grant proposed for a state-owned enterprise[47]

During the stakeholder consultation, the following economic and financial barriers were identified;

1. Limited budget – The government of Kiribati is dependent on donor support to finance major projects especially seawalls and other major infrastructure. The insufficient budget that the Ministries operate on could not allow Ministries to fund development project such as seawalls and so forth.

[45] KIRIBATI TECHNICAL REPORT ECONOMIC ANALYSIS OF AGGREGATE MINING ON TARAWA March 2007
[46] ibid
[47] ibid

4.3.2 non-financial barriers

Non-financial barriers that were prioritized from the list include the following

1. Weak institutional capacity – Weak institutional capacity in Kiribati is a significant barrier to implementing seawall technologies because the Country lacks a dedicated coastal management authority and sufficient technical expertise to plan, design, and enforce effective coastal protection measures. Currently, coastal management responsibilities are fragmented across several government ministries that are overwhelming and under resourced, resulting in ad hoc, poorly designed seawall construction that often fail or cause further problems.[19]
2. Data gaps – Data gaps create uncertainty and risk in seawall implementation in Kiribati, environmental harm, and increased vulnerability of communities to climate change impacts.[19]
3. Lack of awareness – Lack of awareness is a significant barrier affecting the implementation of seawall technologies in Kiribati for several reasons:Error! Bookmark not defined.
   a) Limited local understanding of seawall impacts
   b) Insufficient data and technical capacity
   c) Short term project focus and donor dependency
   d) Social and cultural factors
4. Increased environmental risk – Increased environmental risk is a significant barrier to implementing seawall technologies in Kiribati due to several reasons:[31]
   a) High vulnerability to coastal flooding and erosion
   b) Adverse effects of seawall on coastal dynamics
   c) Ecological degradation
   d) Maintenance and sustainability challenges
   e) Social and community concerns
   f) Limited technical data and planning capacity
5. Restrict coastal accessibility – Restricted coastal accessibility in Kiribati is not just a physical barrier but also a socio-economic and technical challenge that affects the sustainable implementation of seawall technologies. Communities often prefer natural or community - driven solutions that maintain access and ecosystem health over hard infrastructure that can exacerbate erosion and social tensions.[40]

4.4 Identified measures

To effectively identify measures that promote the transfer and diffusion of technology, a solution tree was developed by the technical working group (refer annex 5). This collaborative effort yielded the following key findings:

4.4.1 Financial measures

6. To secure adequate funding from donor agencies, typically around AUD$100,000, the Government of Kiribati should prepare proposals that effectively showcase the potential successful implementation of mass concrete seawall.

4.4.2 non-financial measures

7. Strengthened institutional capacity – to strengthen institutional capacity for implementing seawall technologies in Kiribati, a multi-faceted approach is required, combining technical upgrades, policy reforms, community engagement, robust monitoring systems. Some key strategies include the following:
    a. Enhanced technical expertise and design standards through invest in specialized training, develop standardized construction guidelines, integrate hybrid solutions.
    b. Strengthened policy and regulatory frameworks – this include update permitting systems, align national policies with localized adaptation strategies, establish clear institutional mandates,
    c. Community involvement and local capacity building
    d. Interinstitutional coordination
    e. Leverage regional partnerships for knowledge exchange on seawall technologies
    f. Monitoring evaluation and adaptive management
    g. Develop clear indicators
    h. Securing sustainable financing
8. Improved data collection, processing and storage – improved data collection and storage provide the scientific and institutional foundation needed to implement seawall technologies effectively
9. Strong awareness program – strong awareness program to improve seawall implementation in Kiribati addresses technical, social and environmental challenges by combining education, community engagement and capacity building and it works through taking these approaches: community education and seawall impacts, participatory decision making, Integration of

traditional and technical knowledge, technical training on maintenance, addressing misconceptions and multi-channel communications.

10. Strong and effective policies – This is already mentioned in the institutional capacity section
11. Environmental risks are eliminated – Implementing seawall technologies in Kiribati requires addressing environmental risks to ensure effectiveness and sustainability. While seawalls are often seen as immediate solutions to coastal erosion and flooding, their improper design and placement can exacerbate ecological and social challenges. Eliminating these risks involves integrating adaptive engineering, community-driven strategies, and hybrid approaches with natural ecosystems.
12. Access to coastal resources – Access to coastal resources can improve the implementation of seawall technologies in Kiribati through community involvement, sustainable material sourcing, and integrated coastal management strategies.

Chapter 5.0: Linkages of barriers identified and measures to overcome barriers

The three adaptation technologies prioritised in the coastal protection sector, that is, coastal rehabilitation by land reclamation, green-grey infrastructure and mass concrete seawall have interrelated implementation barriers in the areas of funding, technical expertise, data gaps, policies and regulations. See figure 2 below.

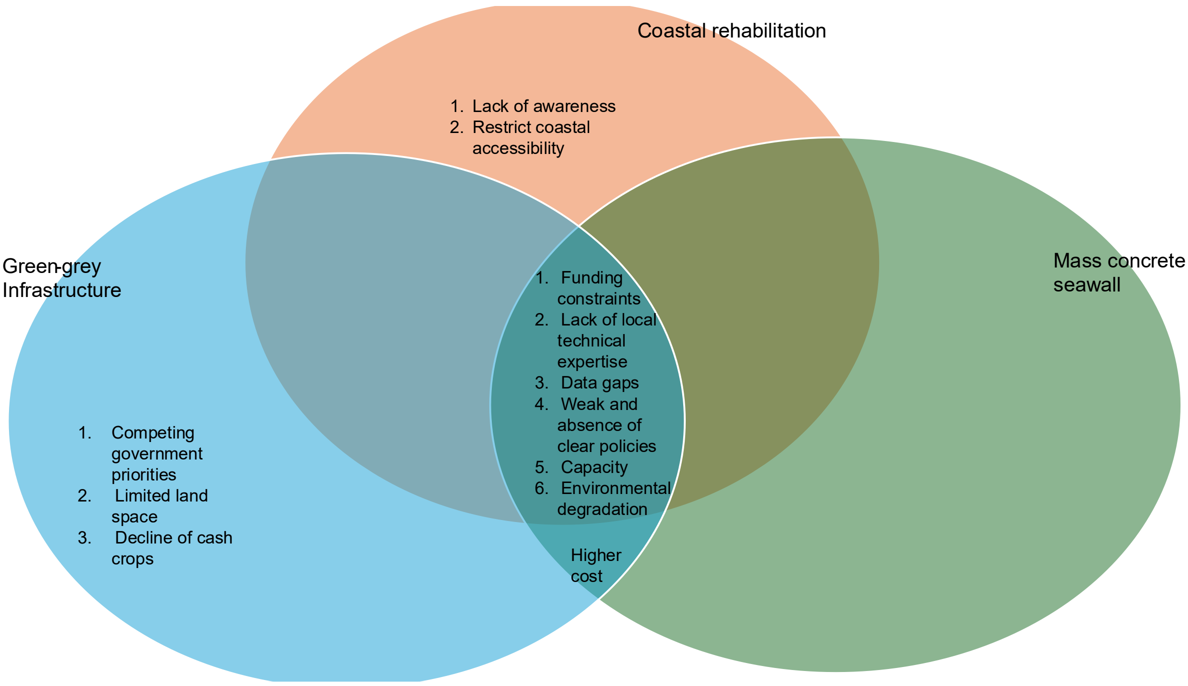

Figure 2: An illustration of an overlap of barriers identified in the three technologies prioritized in the coastal protection sector.

There were several common barriers identified across the three technologies, primarily linked to the need for secure funding for their transfer and diffusion, data gaps, ineffective policies, and a lack of technical capacity. The limited understanding of green-grey infrastructure adoption was reflected in the few barriers uniquely associated with that technology. Conversely, the mass concrete seawall presented a greater number of shared barriers, highlighting its more widespread use, albeit in various forms. The lack of technical capacity significantly impacts the quality and effectiveness of seawalls, affecting their ability to withstand challenges such as rising sea levels and wave overtopping. As coastal rehabilitation and mass concrete seawalls often share similar underlying issues, addressing these barriers is crucial for enhancing their performance and sustainability in coastal protection efforts.

Table 7: An explanation of the linkages of barriers in the coastal protection sector

Barriers	Linkages
Finance and Economic barriers	Funding is the most common barrier affecting coastal rehabilitation techniques in Kiribati due to the country's economic constraints and reliance on external aid. 1. High cost of infrastructure: Techniques like land reclamation, green-grey infrastructure and mass concrete seawalls require substantial financial investment for construction and maintenance. Kiribati 's limited budget and dependence on donor funded projects often lead to short term solutions that lack sustainability[48, 49] 2. Maintenance challenges: Expensive hard measures like seawalls demand regular upkeep, which is rarely funded by international donors after initial construction. This leads to degradation and failure of infrastructure over time[49] 3. Limited local resources: Kiribati remote location and lack of local materials make projects costlier, as importing resources adds to expenses[34, 49] 4. Dependence on External Aid: The country relies heavily on aid for climate adaptation projects, but funding is inconsistent and often insufficient to address long-term needs[50] 5. Additionally, the country's limited fiscal capacity restricts its ability to fund larger scale projects, while reliance on volatile

[48] Climate risk assessment of Kiribati available online at: https://thecommonwealth.org/news/climate-risk-assessment-kiribati-finds-significant-ecological-and-financial-risk?utm
[49] Climate change adaptations gone wrong – The case of seawalls in Kiribati available online at: https://www.marinesocialscience.uni-kiel.de/en/artistic-research/artistic-research-climate-justice-in-kiribati/sea-walls-gone-wrong/the-case-of-sea-walls?utm
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	fishing revenues and external grants introduces uncertainty in financing. Additionally, Kiribati geographic isolation raises costs for importing materials and expertise, compounded by infrastructure gaps and climate vulnerabilities such as rising sea levels and coastal erosion
Policy	Some key characteristics of policy that act as barriers to implementing coastal protection technologies in Kiribati include; 1. Fragmented institutional arrangement – coastal management responsibilities are spread across several ministries without a dedicated authority or unit with coastal expertise, resulting in ad hoc, uncoordinated decision-making and weak enforcement 2. Reactive and piecemeal measures – Coastal protection efforts, especially in urban South Tarawa are often reactionary, lacking technical assessment, proper design or construction standards, which undermines long-term coastal security 3. Inadequate coastal land use planning – Essential tools like zoning and setback criteria to control development in vulnerable coastal areas are underdeveloped and poorly implemented, increasing exposure to hazards and reliance on costly engineering solutions 4. Policy mismatch between urban and rural areas – Existing policies promoting

	natural shorelines resilience are suitable for rural outer islands but are insufficient for the degraded and highly vulnerable urban coastal systems of South Tarawa where remedial actions are urgently needed 5. Limited enforcement and monitoring – Even when policies exist, lack of capacity to monitor, assess and enforce, compliance leads to unauthorized and substandard coastal protection structures, exacerbating vulnerability
Lack of local technical expertise	Technical barriers are a significant challenge for coastal rehabilitation in Kiribati due to several factors: 1. Inadequate design and materials: many seawalls and other protective structures in Kiribati are built using substandard materials like coral rocks or sandbags, often without proper engineering assessment. This leads to structural failures, exacerbating coastal erosion and damaging ecosystems[49] 2. Poor planning availability: There is insufficient hazard mapping and disaster risk information to guide the placement and design of protective structures. This results in poorly positioned infrastructure that fails to address long-term risks effectively [49] 3. Maintenance challenges: Hard infrastructure like seawalls requires regular maintenance, but Kiribati lacks the financial and institutional capacity

	for this. Consequently, many structures degrade quickly, creating a cycle of ineffective investment[49] 4. Lack of Technical capacity and resources: Kiribati faces fundamental shortages in technical expertise and resources to implement coastal policies effectively. Ministries responsible for coastal management are overwhelmed by the complexity of issues and lack the capacity to lead efforts [39]
Data gaps	Kiiribati, data gaps are a significant barrier to implementing coastal rehabilitation technologies such as land reclamation, green-grey infrastructure, and mass concrete seawalls. These challenges are rooted in several local factors: 1. Insufficient data on coastal processes: Coastal erosion and flooding risks are well-documented but quantifying the effects of specific activities like aggregates mining remains challenging. This limits informed decision-making for sustainable coastal management[51] 2. Urban vs. Rural Disparities: Urban areas like South Tarawa suffer from degraded coastal systems due to population pressures and development, while rural areas have healthier shorelines but lack adequate support for local councils[39] 3. Community challenges: Land disputes and community opposition further

[51] Kiribati Technical Report: Economic analysis of aggregate mining on Tarawa, March 2007, EU EDF 8 – SOPAC Report 71, Reducing vulnerability of Pacific ACP States

	complicate projects like seawall construction and green-grey infrastructure development. These social issues delay timelines and reduce project effectiveness[52] Addressing these data gaps requires improved mapping, monitoring, and capacity building initiatives tailored to Kiribati unique geographical and socio-economic context[53]

5.1 Enabling Framework for Overcoming the Barriers

To facilitate the widespread adoption of the three prioritized technologies in the coastal sector, it is crucial to incorporate them into the national adaptation plan, along with integrating them into the formulation and enforcement of climate policy. A comprehensive and cohesive policy framework will help secure political support, creating avenues to access climate change funding, which is a significant barrier to the dissemination of these technologies. However, gaining political backing is not sufficient on its own. For these technologies to be adopted successfully and sustainably, it is necessary to cultivate a supportive enabling environment. Vital elements to focus on include community involvement, capacity development, and the creation of partnerships with both local and global stakeholders. These elements are essential for ensuring that the technology adoption is effective, culturally sensitive, and advantageous for the people of Kiribati. The following section will explore these enabling factors in greater detail.

1. **Financing** - In Kiribati, finance can help overcome barriers to the diffusion of coastal protection technologies by leveraging various funding sources:
    a. Climate Finance: Kiribati can access climate finance through bilateral donations, multilateral development banks (MDBs), and climate funds like the Green Climate Fund (GCF) and Adaptation Fund. These funds can support projects such as coastal rehabilitation and green infrastructure.[54]

[52] Kiribati health and safety snapshot a case studies, case study one - KOITIIP
[53] Navigating climate change: Kiribati's effort to address sea-level rise available online at: https://www.hydro-international.com/content/article/navigating-climate-change-kiribati-s-efforts-to-address-sea-level-rise?utm
[54] **Kiribati: Selected Issues – IMF elibrary**

b. Strategic Funding Approaches: Kiribati should strategically direct proposals to both bilateral and multilateral sources. Regional institutions are often successful in securing funding for smaller projects, while MDBs can navigate complex requirements for larger projects[54].
c. Partnerships and Grants: Collaborations with organizations like the Australian Government and UNOPS can provide significant financial support for initiatives like the Australia-Kiribati Climate Security Initiative[55]. Grants from international partners can also fund infrastructure projects, such as seawalls[54].
d. Economic Diversification: Diversifying Kiribati's economy by developing sustainable tourism and green innovation can reduce reliance on vulnerable industries and generate more internal resources for climate projects[56]

2. **Technical Expertise** - Technical expertise plays a critical role in diffusing coastal protection technologies in Kiribati, particularly for land reclamation, green-grey infrastructure, and cement seawalls. Here's how:
   a. Capacity Building: Training programs, such as GIS workshops, enhance the ability of government agencies and stakeholders to plan and manage coastal protection projects effectively. These tools help identify erosion risks, monitor mangrove health, and optimize infrastructure planning[57].
   b. Integration of Nature-Based Solutions: Projects like the Australia-Kiribati Climate Security Initiative combine technical knowledge with community consultations to implement scalable solutions such as mangrove planting and green-grey infrastructure. This ensures sustainability and inclusivity in addressing climate challenges[58]
   c. Infrastructure Design and Maintenance: Expertise ensures that engineered solutions like seawalls are designed to withstand rising sea levels and storm surges while complementing natural defenses like mangroves[17].
   d. Data-Driven Decision Making: Technologies such as Earth Observation (EO) and GIS enable real-time monitoring of environmental changes, supporting precise interventions for coastal rehabilitation[57].

[55] Affordable coastal protection in the Pacific islands, February 2017.PRIF,Sydney, Australia
[56] Climate risk assessment of Kiribati finds significant ecological and financial risk available online at: Climate risk assessment of Kiribati finds significant ecological and financial risk | Commonwealth
[57] Spatial technologies help chart sustainable development pathways in Kiribati anailanle online at: Spatial technologies help chart sustainable development pathways in Kiribati | Pacific Environment

By leveraging technical expertise, Kiribati can build resilience against climate change while ensuring community involvement and sustainable development.

3. **Research and data** - Research plays a critical role in diffusing coastal protection technologies in Kiribati by providing evidence-based strategies, fostering community engagement, and supporting scalable solutions. Here are keyways research contributes:
    a. Technology Identification and Piloting: Research helps identify effective coastal protection measures, such as land reclamation, green-grey infrastructure, and seawalls. For instance, initiatives like the Kiribati Adaptation Program have piloted mangrove planting and seawall construction to reduce erosion and enhance resilience[17,].
    b. Community Involvement: Participatory consultations ensure the integration of local knowledge and address the needs of marginalized groups during infrastructure design and implementation[58]
    c. Capacity Building: Research-driven programs enhance the ability of local communities and governments to plan, execute and maintain climate-resilient solutions. This includes training in monitoring land changes and maintaining infrastructure.
    d. Nature-Based Solutions: Studies emphasize combining artificial structures with ecosystem restoration, such as coral reefs and mangroves, to create sustainable coastal defenses[48].
4. **Scalable Frameworks**: Research introduces frameworks for long-term climate adaptation, enabling replication across vulnerable areas[48].

These efforts collectively enable Kiribati to mitigate coastal flooding impacts and adapt to rising sea levels effectively.

5. **Policies and regulations** - In Kiribati, policies and regulations play a crucial role in diffusing coastal protection technologies. Here's how they can help:
    a. **Promoting Natural Solutions**: The Kiribati National Coastal Policy emphasizes maintaining natural shoreline processes to ensure coastal security. Policies like these encourage the use of natural solutions, such as the *'te buibui'* method, which involves building brush structures to catch sediment and allow beach recovery[40].
    b. **Regulating Infrastructure**: The Shoreline Protection Guidelines caution against seawalls due to potential erosion issues, promoting community agreements to avoid

[58] Forging coastal resilience in Kiribai available online at: Forging coastal resilience in Kiribati - Kiribati | ReliefWeb

their construction. This regulatory framework supports the adoption of green infrastructure over massive cement seawalls.

c. **Zoning and Setbacks**: The policy suggests implementing zoning and setbacks to control development in vulnerable areas, reducing the need for costly engineering solutions. This approach can help integrate green and grey infrastructure more effectively.

d. **Fisheries Regulations**: New fisheries regulations focus on sustainable management of coastal resources, which indirectly supports coastal health and resilience[59]. Healthy marine ecosystems are crucial for natural coastal protection.

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Annexes

Annex 1: Stakeholder consultation (Retreat program)

Checklist for the Barrier Analysis and Enabling Framework

Stakeholder analysis:

Day 1: Friday 14th March 2025 - evening

1. Plenary session
    - Overview of the Barrier analysis and enabling framework
2. Dinner

Day 2: Saturday 15th March 2025 - Morning session

1. Breakfast
2. Participants break up into a Adaptation and Mitigation Group

- Present final TNA prioritization of technologies from the one sector prioritized for Adaptation and Mitigation (as we discussed)
- Undertake barriers analysis for each of the three technologies prioritized for each sector (Adaptation and Mitigation)
- List all identified barriers through stakeholder consultations for each technology separately.
- Screen barriers according to significance
- Categorize barriers (Financial, Regulatory, Institutional, Technical etc.)

Saturday 15th March 2025 - Afternoon session

1. Lunch
2. Undertake Barrier Analysis using the Problem tree (Non-market good) or Market Mapping (Market Good)
3. Undertake Measures and Enabling Framework for each of the three technologies for each sector (Adaptation & Mitigation), now using the Solution Tree (Non-market good). You may want to use the exercises on the Market Mapping and the Problem Tree that were given to you during the workshop for this exercise

Saturday 15th March 2025 - Evening session

1. Dinner

2. Adaptation and mitigation group continue working to finish up remaining exercises

Sunday 16th March 2025 – Morning

1. Return to South Tarawa

Annex 2: Participants list

Day 1

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TNA Retreat March 14 – March 16 2025, Uaai Resort

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Day 2

TNA Retreat March 14 – March 16 2025, Uaai Resort

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15/03/25	Arata Tabuaka	KGES	atabta600@gmail.com	[signature]	Mitigation
15/03/25	Ata Taoaba	MARINE (MICT)	ata.taoaba@mict.gov.ki	[signature]	mitigation
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15/03/25	Paul Tekanene	PVU / MISE	detaxman@gmail	[signature]	MIT
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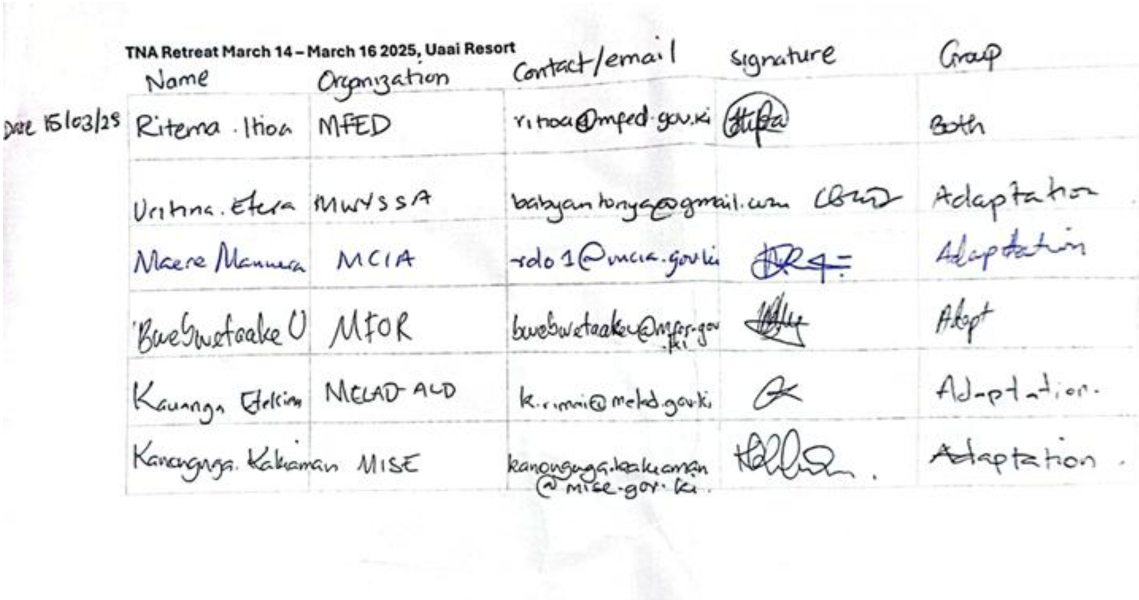
15/03/25	TURIA BOKAI	GSD / MFOR	turiab@mfor.gov.ki	[signature]	Adaptation



TNA Retreat March 14 – March 16 2025, Uaai Resort

	Name	Organization	Contact/email	Signature	Group
Date 15/03/25	Riterea Itioa	MFED	ritioa@mfed.gov.ki	[signature]	Both
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Annex 3: Barrier analysis, barrier screening and barrier categorization

Session 2: Undertake barrier analysis for each of the three technologies prioritized for each sector

Exercise 1: i) List all identified barriers through stakeholder consultations for each technology separately. ii) Screen barriers according to significance iii) Categorize barriers (Financial, Regulatory, Institutional, Technical etc.)

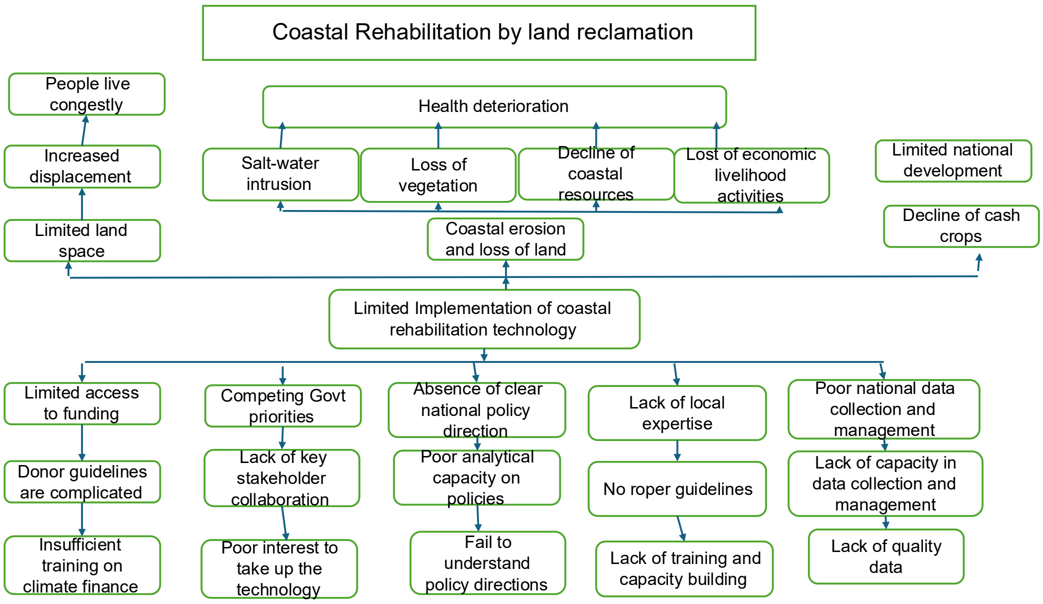
Barriers	Category
Financial constraints	Macroeconomic conditions
High import duties	Macroeconomic conditions
Lack of coordinating body that will lead in coastal rehab	Institutions
Long term maintenance and sustainability	Technological
Limited skills	Technological
Engagement of locals with Technical Experts	Technological
Outdated land foreshore management FMC	Policies and regulations
Policies and Regulatory barrier	Policies and regulations

High tech (lacking materials and equipment)	Resources
Limited supplier	Resources
Reclamation should limited to state land	Social
Environmental Impact	Social
Social and community impact	Social
Limited awareness	Social

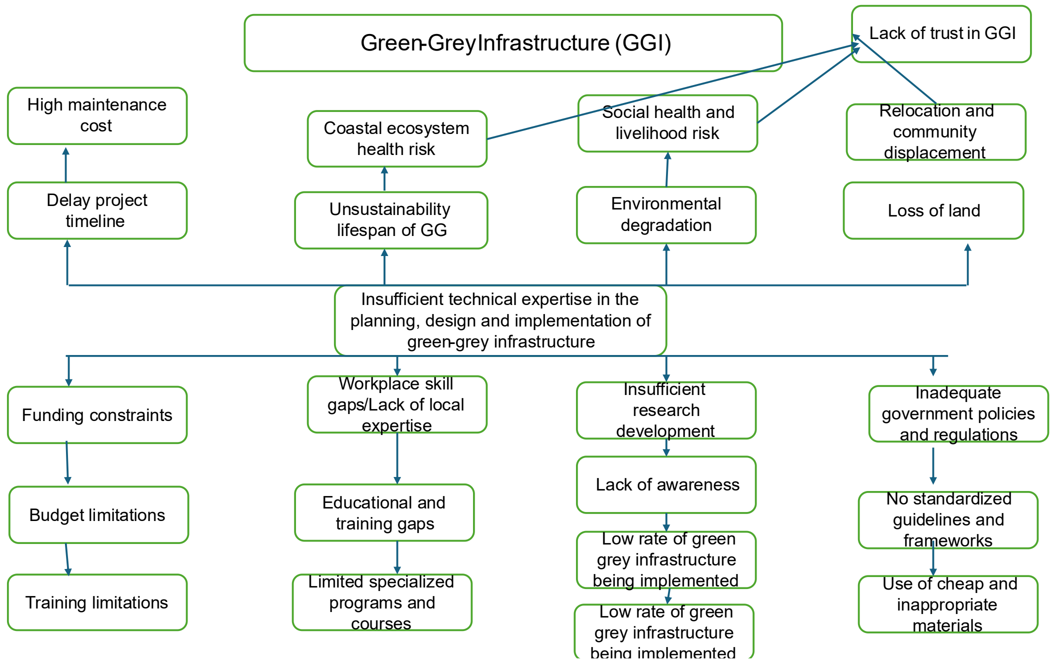
Annex 4: Barrier Analysis using the Problem tree (Non-market good)

Exercise 1: Construction of a Problem tree

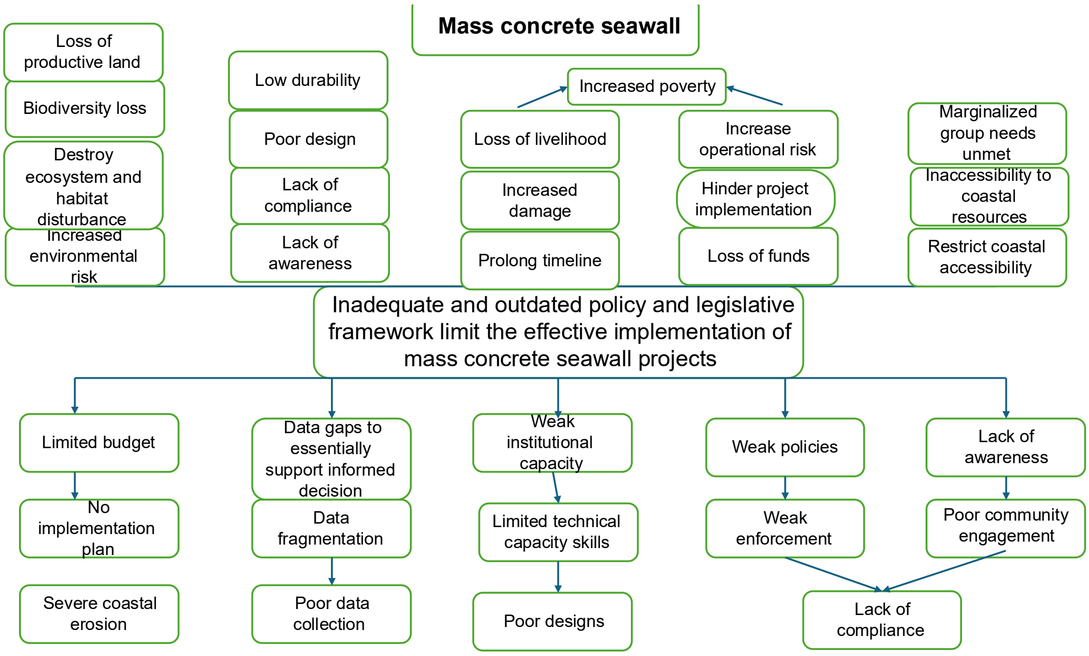
a) <u>Coastal rehabilitation by land reclamation</u>



b) Green-Grey Infrastructure

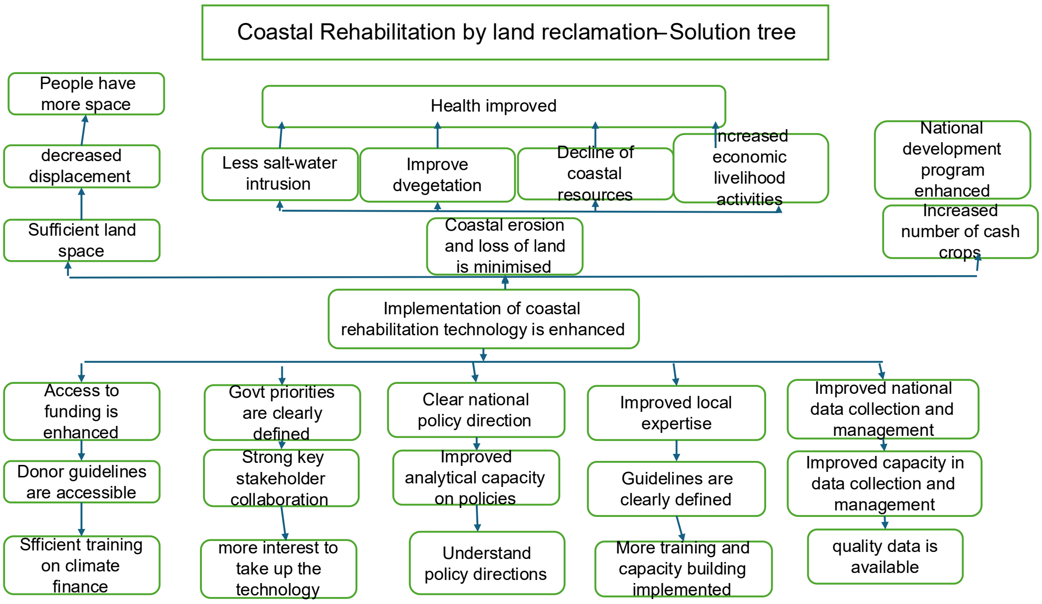


c) Mass concrete seawall

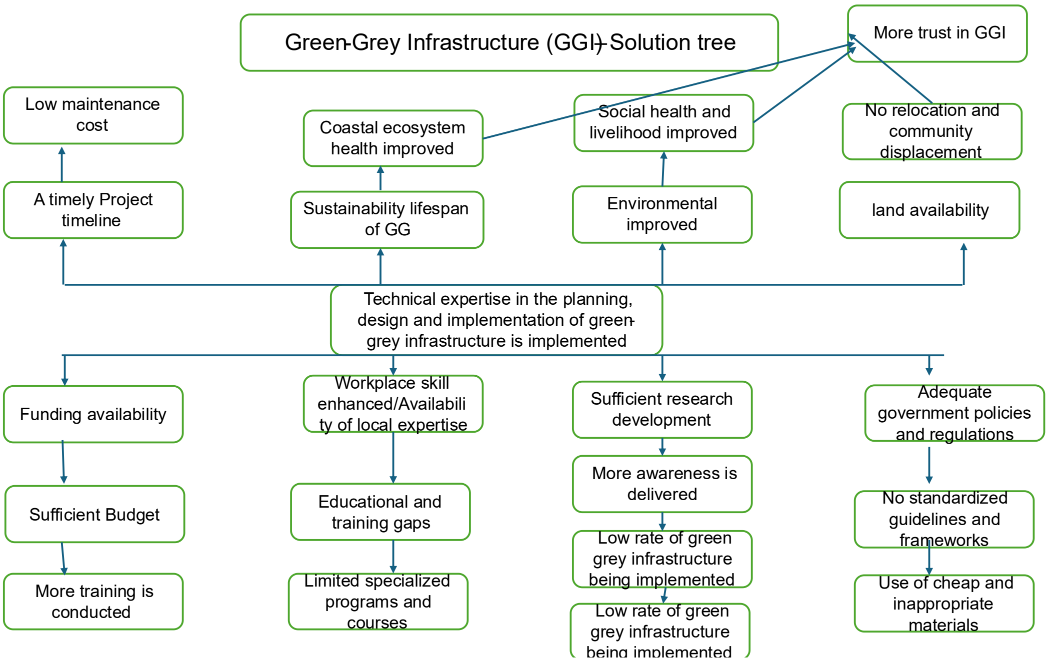


Annex 5: Measures analysis by constructing a solution tree

(a) Coastal rehabilitation by land reclamation



b) Green – Grey Infrastructure



d) Mass concrete seawall – Solution Trap