REPORT

IDENTIFICATION AND PRIORITISATION OF ADAPTATION TECHNOLOGIES FOR KIRIBATI

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Foreword

The report represents a collective effort, drawing on input from a fully country-led process that includes perspectives and information generated by TNA stakeholders, an adaptation consultant, and the TNA National Coordinator. The Government of Kiribati (GOK) has incorporated climate change considerations into national policies, strategies, and plans, demonstrating this commitment through documents such as the Kiribati Joint Implementation Plan (KJIP), Climate Change Policy, and Nationally Determined Contributions (NDC) Investment Plans.

The TNA process was undertaken to complement the Nationally Determined Contributions (NDC), the National Development Plan (NDP) the joint Implementation Plan for climate change and disaster risk reduction (also known as National Adaptation Plan), and the National Climate Change Policy by addressing capacity gaps and fostering partnerships for development assistance. Notably, the TNA adaptation approach will assist Kiribati in focusing on critical areas such as coastal erosion, thereby enhancing the nation's capacity to adapt to climate impacts, including rising sea levels and extreme weather events.

This TNA report will serve as a strategic guide for Kiribati in securing the necessary partnerships and resources required to implement sustainable solutions mainly on coastal protection.

Building on that, I would like to extend my heartfelt gratitude to the TNA National Stakeholders, the TNA National Coordinator, and the dedicated staff of the Office of Te Beretitenti for their invaluable contributions to the preparation of this report. Their support has been instrumental in ensuring its success. Stakeholder engagement has been crucial in creating a collective effort that has led to effective technology prioritization within the TNA, ensuring that diverse perspectives are taken into account for more informed and widely accepted decisions.

Finally, I wish to acknowledge the contributions of the national consultants and experts from UNEP Copenhagen Climate Centre (UNEP CCC) and USP for their steadfast support and guidance throughout the implementation of the TNA project. I would also like to acknowledge the invaluable role that Kindling, Kiribati has played in organizing and managing events that are essential for the successful implementation of the TNA activities.

Mr. Tebwaatoki Taawetia
Secretary
Office of Te Beretitenti

List of Abbreviations

AUD	Australian Dollar
CC	Climate Change
CCA	Climate Change Adaptation
CORVI	Kiribati and Ocean Risk Vulnerability Index
DRM	Disaster Risk Management
ENSO	El Nino Southern Oscillation
GEF	Global Environmental Fund
TNA	Technology Need Assessment
NC	National Coordinator
NGO	Non-Government Organization
INDC	Intended Nationally Determined Contribution
KDP	Kiribati Development Plan
KSFCP	Kiribati Climate Change Finance Strategic Framework Country Program
KJIP	Kiribati Joint Implementation Plan
KNCCP	Kiribati National Climate Change Policy
KPA	Kiribati Priority Areas
KV20	Kiribati Vision for 20 Years
MCA	Multi Criteria Assessment
NDC	Nationally Determined Contributions
NDP	National Development Plan
OB	Office of Te Beretitenti

UNEP CCC	UNEP Copenhagen Climate Centre
UNFCCC	United Nations Framework Conventions on Climate Change
USP	University of the South Pacific

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Executive Summary

Kiribati, officially known as the Republic of Kiribati, is an island nation located in the Micronesia subregion of Oceania in the central Pacific Ocean. As of the 2020 census, it has a permanent population exceeding 120,000, with more than half residing on Tarawa Atoll. The country consists of 32 atolls and one isolated raised coral island, Banaba, covering a total land area of 811 km^2 (313 sq mi) spread across a vast ocean territory of 3,441,810 km^2 (1,328,890 sq mi).

Kiribati is recognized as one of the nations most vulnerable to climate change, primarily due to the small size of its islands, which render them particularly susceptible to extreme weather events, including rising sea levels, coastal erosion, and storm surges. Kiribati has engaged in the Technical Needs Assessment (TNA) program to develop effective strategies to mitigate the impacts of climate change and determine sustainable climate adaptation measures. This initiative is part of the technical assistance provided by the United Nations Environment Program (UNEP), which is funded by the Global Environment Facility (GEF).

The Technology Needs Assessment (TNA) is a systematic process utilized by countries to identify their development priorities from a sustainable perspective (Charlery & Trærup, 2019)[1]. These priorities are informed by existing policies, programs, projects, long-term vision documents, and strategies for climate change adaptation that are already in place. The TNA aligns with the United Nations Framework Convention on Climate Change (UNFCCC), particularly Article 4.5, and various national climate change enabling activities. In Kiribati, these considerations have been incorporated into the National Communication (NC) and the National Development Plan (NDP 2020 - 2023). Additionally, the NC and the Nationally Determined Contribution (NDC), which were submitted to the Conference of Parties through the UNFCCC Secretariat, further support the TNA process.

The Government of Kiribati, through the Office of Te Beretitenti and the TNA National Coordinator, who also serves as the Acting Director of the Climate Change and Disaster Risk Management Division, has emphasized that "coastal protection" is the primary focus area for the Kiribati Adaptation Strategies. This commitment is clearly articulated in the Kiribati National Climate Change Policy, Enhanced NDC, Kiribati Climate Finance Strategic Framework & Country Program (KSFCP), and Kiribati Joint Implementation Plan (KJIP 2019 – 2028) which guides and drives national efforts toward enhancing resilience and developing effective adaptation strategies.

[1] Charlery, L., & Trærup, S. L. M. (2019). The nexus between nationally determined contributions and technology needs assessments: a global analysis. Climate Policy, 19(2), 1890205.

The decision to prioritize these areas was discussed with TNA stakeholders, who endorsed this choice based on its alignment with national priorities. This endorsement also acknowledges adaptive policies such as the National Adaptation Plan, now officially recognized as the Kiribati Joint Implementation Plan (KJIP); the Kiribati Development Plan (NDP) for 2024 – 2027; and the Enhanced Nationally Determined Contributions (NDC). Together, these frameworks provide a comprehensive approach to addressing the challenges posed by climate change and ensuring sustainable development for the nation.

Overview

Technology Needs Assessment (TNA)

[2] The Technology Needs Assessment (TNA) process serves as a vital mechanism for least developed countries (LDCs) to identify and address technological gaps affecting their ability to combat the impacts of climate change on livelihoods and national development. This comprehensive assessment provides an opportunity to pinpoint specific technological solutions that can effectively mitigate constraints posed by climate change.

The TNA process actively engages key stakeholders across various sectors, each playing a crucial role in the successful implementation of identified interventions. Central to this process is the collaboration between the National TNA Coordinator and the Adaptation Consultant, both supported by Kindling, an NGO dedicated to facilitating the necessary events and activities for TNA implementation.

Key Components of Step 1: Identification and prioritization of the technology

Technology Prioritisation by Stakeholders

The TNA report main output is a list of prioritised technologies or project ideas which could be developed into a concept note and full proposal for funding considerations. Nevertheless, prior to that, the process must entail stakeholders' inputs in identifying and selecting the most appropriate technologies for the country to implement based on certain agreed criterion adopted in the TNA process and aligned to national priorities. Given that coastal erosion has already been recognized as a top national adaptation priority, stakeholders used TNA exercise to prioritize technologies that should be adopted to improve Kiribati's adaptive capacity to face the impacts of climate change due to coastal erosion.

The technologies that were identified by the stakeholders for this purpose under Adaptation-Coastal protection includes: Geobag, Green-grey Infrastructure, Mass concrete seawall, Groyne and Coastal rehabilitation by land reclamation.

Adaptation: Coastal Protection technologies

Coastal rehabilitation by land reclamation – An in-depth discussion among stakeholders regarding this additional technology has cultivated a profound understanding of its potential.

[2] TNA Technology Needs Assessment - Technology Needs Assessment

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.

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.

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. Two notable consequences are the high costs involved and 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 $20,000 per cubic meters, to higher amounts depending on the scope of the project and the specific features and thus 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.

Geobag - Geobags are specialized containers made from high-strength textile materials designed for durability and longevity. Recommended by civil engineers, these bags have yet to be implemented in Kiribati, making it difficult to assess their effectiveness based on local conditions. The textiles used in geobag manufacturing are particularly engineered to hold sand, which positions them as a viable alternative to traditional sandbags.

While geobags share a superficial resemblance to standard bags, they are uniquely crafted for specific applications in construction and erosion control. However, the primary concern lies in their longevity, especially concerning how well the textile can withstand physical abrasion from external elements.

Cost considerations for geobags remain unclear, as there is limited information available about their pricing. Nevertheless, stakeholders have raised concerns about potential financial implications tied to the adoption of this technology. Compared to conventional sandbags, geobags may incur higher costs due to their advanced design features, which enhance their capacity to resist wave action and securely contain sand.

In summary, while geobags offer promising advantages in terms of durability and functionality, further investigation into their performance and cost-effectiveness in the context of Kiribati is essential before making implementation decisions.

Groyne – Interest in the technology has been limited due to its relatively ineffective role in safeguarding coastlines from wave overtopping and rising sea levels. While it is often touted for its ability to build sand along the coast, this function is largely passive and insufficient to withstand the forces of currents that can accelerate coastal erosion. Furthermore, the cost of implementing this technology does not align with the pressing need for robust solutions to combat severe erosion along vulnerable shorelines.

Chapter 1: Introduction

1.1 About the project

A TNA is a country-driven process, grounded in national sustainable development plans, building national capacity and facilitating the analysis and prioritisation of climate technologies to support the implementation of the UNFCCC Paris Agreement. TNA's are central to the work of Parties to the Convention on technology development and transfer and present an opportunity to track on evolving needs for new equipment, techniques, and practical knowledge and skills, which are necessary to mitigate greenhouse gas emissions and reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change. The enhancement of technology development, its transfer, deployment and dissemination is a key pillar of the international response to climate change.

The TNA is a three-stage process and has three key objectives:

- To identify and prioritise mitigation and adaptation technologies for selected sectors.
- To identify, analyse and address barriers hindering the deployment and diffusion of the prioritised technologies, including the enabling framework for these technologies.
- To conduct, based on the inputs obtained from the previous two steps, a Technology Action Plan, which is a medium/long term plan for increasing the implementation of identified technologies. The Technology Action Plan outlines actions to be undertaken.

1.2 Existing national policies on climate change adaptation and their priorities

1.2.1 National Circumstances

Kiribati, officially the Republic of Kiribati, is an island country in the Micronesia subregion of Oceania in the central Pacific Ocean. Its permanent population is over 119,000 as of the 2020 census, with more than half living on Tarawa atoll. The state comprises 32 atolls and one remote raised coral island, Banaba. Its total land area is 811 km^2 dispersed over 3,441,810 km^2 of ocean. The climate of Kiribati is hot and humid year around. This tropical climate is closely related to the temperature of the oceans surrounding the atolls and small islands. However, its seasonal rainfall is highly variable from year to year, mostly due to the El Niño–Southern Oscillation (ENSO). Kiribati is blessed with a vast ocean territory and great diversity of marine biodiversity but is limited in its land area and terrestrial resources.

The Kiribati economy depends heavily on its rich marine resources for employment, income and subsistence living. However, the resources provided by its limited land and terrestrial biodiversity are also central to the Kiribati way of life.

The public sector dominates Kiribati's economy. It provides two-thirds of all formal sector employment and accounts for almost 50% of gross domestic product. Kiribati is highly exposed to external economic shocks, particularly surges in food and fuel commodity prices, due to its limited revenue base and high dependency on imports. Kiribati is categorised by the United Nations as both a 'Small Island Developing State' and a 'Least Developed Country'.

1.2.2 National Strategies, Policies and Actions Related to Climate Change

Due to its fundamental traits as an atoll nation and a least developed country, along with its delicate economy and environment, Kiribati is highly susceptible to climate change and has limited ability to manage both natural and human-induced disasters.

[3] Natural events like ENSO lead to fluctuations in climate that can result in severe weather conditions. In addition to these weather-related dangers, there are other hazards like oil spills caused by human activity and tsunamis triggered by tectonic shifts. With climate change, the occurrence of extreme weather is expected to increase. At the same time, the current socio-economic and environmental challenges are becoming more pronounced. This demonstrates the interconnectedness of these issues in the context of Kiribati. As a result, it makes sense to approach climate change adaptation and disaster risk management in a comprehensive and unified way.

Climate variability and climate change are already causing and are predicted to continue to cause; increasing surface air and sea temperatures; increasing precipitation throughout the year; more days of extreme rainfall and heat; rising sea-levels and increasing ocean acidification. In addition, although the risks are generally considered minimal, Kiribati could also be affected by a tsunami.

The social, economic, and environmental impacts of the current and anticipated climate changes and hazards are exacerbated by the high vulnerability of both people and their ecosystem. Policies and strategies concerning population, water and sanitation, health, and the environment are increasingly tackling climate change and disaster risks. Additionally, these concerns are slowly being integrated into policies related to fisheries, agriculture, labour, youth, and education. Nevertheless, only a limited number of sectors have effectively integrated strategic actions to manage climate and disaster risks into their annual Sector Operational Plans and Ministerial Plans of Operations and budgets.

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[3] Simon D. Donner and Sophie Webber, 2019. Obstacles to climate change adaptation decisions: a case study of sea level rise and coastal protection measures in Kiribati, Sustain Sci DOI 10.1007/s11625-014-0242-z, Springer, Japan

According to the KJIP, a climate change and disaster risk management rapid assessment report on budgetary allocations for 2011, 2012 and 2013 revealed that, over this period, a total of AUD 103 million (about 15.7% of the national budget) was allocated to programs related to climate change while AUD 90 million (about 17% of the national budget) was allocated to disaster risk management programs.

Further analyses showed that between 2011 and 2013, the Consolidated Budget and Development Fund committed approximately AUD 82 million to addressing climate change and AUD 89 million to disaster risk management. Such budgetary commitments support the notion that, while measures to address climate change and disaster risks seem to be well integrated into key sectors, these efforts need to be maintained and upscaled in order to improve the resilience of the Kiribati population.

On December 2, 2021, the Government of Kiribati officially launched its Kiribati Development Plan (KDP) for 2020-2023 at the House of Parliament. This comprehensive plan serves as a roadmap to help Kiribati navigate its path toward the long-term aspirations outlined in the Kiribati 20-Year Vision (KV20), which aims for a prosperous, healthy, and peaceful nation with its people at the heart of development.

The core priorities of the KDP are to eliminate poverty and reduce inequality and injustice through inclusive economic growth, building human capabilities, enhancing the capacity of the state, and upholding the rule of law and principles of democracy.

The KDP maintains the six Key Policy Areas (KPAs) of the previous KDPs which have been rephrased to add more weight and meaning to them. These KPAs include (i)Harnessing Our Human Wealth, (ii) Growing our Economic Wealth and Leaving No-One Behind, (iii) Improving our Health, (iv) Protecting and Managing our Environment and Strengthening Resilience, (v) Good Governance and (vi) Developing our Infrastructure.

1.2.3 Kiribati National Climate Change Policy

The Kiribati National Climate Change Policy unequivocally identifies coastal protection as a critical priority in its mission to enhance the nation's resilience against climate change impacts. Due to the low-lying atoll topography, coastal areas in Kiribati face extreme vulnerability. Increasingly high spring tides, along with more frequent and severe storm surges and rising sea levels, significantly elevate the risk of flooding and coastal erosion throughout the country. These factors have already led to detrimental effects on food crops and freshwater groundwater lenses, as well as the loss of land and habitats. Additionally, they have heightened vulnerability to invasive alien species, resulted in physical damage to assets, and inflicted both economic and non-economic repercussions on the government and local communities.

Coastal protection measures, such as seawalls, continue to encounter failures due to inadequate engineering capabilities on seawall design, resulting in the need for long-term financial commitments for maintenance and repairs. To effectively safeguard our coastlines and enhance resilience, a strategic and systematic approach is essential to minimize the nation's vulnerability. No single solution can comprehensively address all facets of coastal change and inundation; therefore, a diverse array of actions is necessary. This includes a combination of soft and hard measures, such as mangrove restoration, traditional seawalls (te buibui), and elevating ground levels, to effectively tackle the emerging impacts of climate change.

A meaningful and holistic integrated coastal zone management strategy is crucial to confront the pressing coastal hazards we face today. Moreover, Kiribati is deeply concerned about projections indicating significant sea-level rise, which suggest that many coastal areas of its island atolls may experience permanent shoreline retreat and inundation. Preliminary data has already shown a slight increase in sea levels, underscoring the urgent need for an updated and comprehensive assessment. Addressing these challenges requires an integrated approach that encompasses ecological, social, and economic considerations.

1.2.4 Kiribati Joint Implementation Program (KJIP)

In 2011, the Government of the Republic of Kiribati began developing the Kiribati Joint National Action Plan on Climate Change and Disaster Risk Management (KJIP) after consulting with regional technical advisory organizations. The KJIP aims to enhance existing frameworks, including the National Disaster Risk Management Plan and the National Framework for Climate Change and Climate Change Adaptation.

By identifying tangible, on-the-ground actions for resilience and measures that enable the Government to facilitate these, the plan will guide the implementation of these complementary policies in an integrated and holistic approaches.

The rationale for developing the Kiribati Joint National Action Plan on Climate Change and Disaster Risk Management (KJIP) is to create a systematic and integrated framework that identifies tangible actions. This approach aims to maximize the efficiency of resources and ensure new initiatives are targeted for maximum impact. The plan also serves as a key tool for integrating climate change and disaster risks across all sectors, promoting a collaborative effort among the government, civil society, churches, and the private sector.

The KJIP will serve as a guiding tool for the implementation of technologies identified in the TNA by incorporating the plan into the Ministries’ operational strategies.

Chapter 2: Vulnerability assessment in the country

Kiribati is one of the world's most vulnerable countries to the effects of CC and climate-related disasters. Its ability to respond to climate risks is hampered by its highly vulnerable socio-economic and environmental conditions and geographical situation. Low atolls, isolation, small land areas separated by a vast expanse of ocean, a highly concentrated population, and the costs of providing basic services make Kiribati, like all Least Developed Countries and Small Island Developing States, especially vulnerable to external shocks including the adverse impacts of CC and disasters. Sea-level rise and exacerbated natural disasters, such as drought and extreme weather fluctuations, pose significant and direct additional threats to sectors and resources central to the provision of basic services and national development. The following factors contribute to the nation's vulnerability to CC and disaster risks and apply across the various sectors outlined in Kiribati National Climate Change policy:

- The already high population density and growth rate on South Tarawa in the Gilbert Group continue to increase.
- Sea-level rise poses the greatest threat to the people of Kiribati, given that the atolls are low lying and the majority of people live on the coast.
- Kiribati's atoll islands provide only a small area of land for people to reside on. Where coastal areas have been highly affected by sea-level rise in association with other factors, people have relocated within the atoll itself, which is problematic given the scarcity of land in general and certain land tenure issues.
- Available underground water sources are vulnerable and can be easily contaminated by saltwater intrusion, which will diminish water security and cause health and food security problems for the population.

2.1 Climate Change Impact

[4]Kiribati has a hot, humid, tropical climate with an average temperature of 28.3°C and average rainfall of about 2,100 mm per year in Tarawa (1980 - 1999). Its climate is closely related to the temperature of the oceans surrounding the small islands and atolls. Across Kiribati the average temperature is relatively constant year-round. From season to season the temperature changes by no more than 1°C. Kiribati has two seasons - the dry season (te Au Maiaki) and the wet season (te Au Meang). The periods of seasons vary from location to location and are strongly influenced by the seasonal movement of the South Pacific Convergence Zone (SPCZ) and the Inter-Tropical

[4] Kiribati - Climatology | Climate Change Knowledge Portal

Convergence Zone (ITCZ).[5]The six-month dry season starts in June, with the lowest mean rainfall in October. The wet season starts in November and lasts until April; the highest rainfall occurs from January to March, peaking with a mean of 268 mm in January. The Walker Circulation and associated El Niño and La Niña with their marked opposite conditions of flooding and drought for different parts of the South Pacific and the wider tropical region of the globe are predominating phenomena that determine Kiribati climate. These phenomena have also marked conditions on the temperature and movement (east to west) of the waters of the Central Pacific Ocean, and on wind direction.

2.2 Sea Level Rise (SLR)

[6] Sea levels are expected to rise by 0.44-0.76 meters by 2100 (Gerd and Paul, 2022) and sea level rise may cover more than 50 percent of Tarawa's land threatening over 60 percent of the island's population (Audrius et al., 2021)[7]. Tarawa population alone according to the 2020 census,[8] made up half of the total entire population in Kiribati. However, based on model results from the IPCC's Third Assessment Report, the estimated sea-level rise by 2100 in Kiribati's initial National Climate Change Adaptation Strategy and the subsequent analyses conducted for the KAP ([9]Hay 2006; [10]Ramsay et al., 2008) was anticipated to rise to 36 cm higher than that in the initial adaptation strategy and 23 cm higher than that employed in a related Tarawa case study (Ramsay et al. 2008).

2.3 Rainfall

Increased rainfall throughout the country may mean that flooding throughout the country during the wet season becomes more severe, leading to increased health risks to flood prone

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[5] ibid

[6] Gerd Masselink and Paul Simon Kench, "Coastal Flooding Could Save Atoll Islands from Rising Seas – but Only If Their Reefs Remain Healthy," The Conversation, September 16, 2021, accessed April 29, 2022, http://theconversation.com/coastal-flooding-could-save-atoll-islands-from-rising-seas-but-only-if-their-reefsremain-healthy-167964.

[7] Audrius Sabūnas et al., "Impact Assessment of Storm Surge and Climate Change-Enhanced Sea Level Rise on Atoll Nations: A Case Study of the Tarawa Atoll, Kiribati," Frontiers in Built Environment 7 (2021), https://www.frontiersin.org/article/10.3389/fbuil.2021.752599.

[8] Kiribati 2020 Population and Housing Census provisional figures | Kiribati National Statistics Office

[9] Hay JE (2006) Climate risk profile for Kiribati. John Hay and Associates Limited, New Zealand

[10] Ramsay D, Stephens S, Gorman R, Oldman J, Bell R (2008) Kiribati Adaptation Program. Phase II. Information for climate risk management: sea-levels, waves, run-up and overtopping. NIWA Report: HAM 2008-022. National Institute of Water and Atmospheric Research Ltd., Hamilton, New Zealand

communities and to their properties and food gardens as well as increased risks to the country's infrastructures such as roads and bridges. These changes may also lead to some parts of the country becoming wetter while other parts become dryer (droughts). The seasonality of rainfall may also change. Annual rainfall already ranges from a low of 15m

to a high of 4000 mm11 and such variability is expected to increase due to climate change[12].

2.4 Increasing atmospheric Temperatures and carbon

[13]Future projections of climate change for Kiribati generally show the following changes over the next 20 to 30 years (2030 – 2055): (i) average air temperature will increase by 0.30C to 1.30C; (ii) increase in the number of very hot days; (iii) decrease in the cooler weather; (iv) increase in average annual and seasonal rainfall; (v) increase in sea surface temperature; (vi) increases in ocean acidification; and (vii) sea level will continue to rise. Projections about the future behaviour of El Niño-Southern Oscillation are uncertain at the moment.

2.5 Unpredictable Weather

Rising temperatures may also lead to the increased likelihood of more intense and longer periods of rainfall, leading to an increased risk of flooding. The likelihood of tropical cyclones developing may also increase along with increased storms and general bad weather out in the ocean, leading to increased risks to sea farers. On land, risks due to these changes may include risks to human lives, properties, infrastructure damage, diseases and risks to certain economic activities such as tourism.

2.6 Increased Risk of Diseases

14 Climate change could also increase the incidence of insects/ pests, food and water-borne diseases. Heat stress, skin diseases, respiratory infections and asthma could also increase with climate change. 15Climate change intensifies extreme weather events like heavy rainfall and flooding, which increases the risk of waterborne illnesses such as cholera and diarrhea by contaminating water supplies.

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[11] Kiribati Joint Implementation Plan for Climate Change and Disaster Risk Management (KJIP) 2019-2028." Government of Kiribati

[12] Donovan Storey and Shawn Hunter, "Kiribati: An Environmental 'Perfect Storm'," Australian Geographer 41, no. 2 (June 1, 2010): 167–81, https://doi.org/10.1080/00049181003742294.

[13] Kiribati-Climate-Change-Profile.pdf

[14] Bijay Subedi et al,.2023 https://doi.org/10.1016/j.jafr.2023.100733

[15] Climate Council, 2022. Climate Council Annual Report 2021 | Climate Council

2.7 Economic vulnerability

Kiribati is concerned that the response to climate change (CC) impacts has been slow and reactive at the international level, even though the science is clear and these impacts are becoming very apparent. Efforts over the past few years to catalyse assistance through international advocacy have not produced action at the national level to match the CC impacts being felt by our communities. This situation is due both to the difficulty of accessing multilateral funding sources directly, and to slow progress in preparing our national systems to access, receive and implement scaled-up assistance. It is clear that our national efforts to implement adaptation measures are conditional on increased support from the international community. To enhance the resilience of our country and our economy, and to address our people's desire to stay in our motherland, it is vital that this Climate Change Policy is focused on actions that are necessary to boost our adaptation efforts through improved access to financing sources and a clear direction for interventions in Kiribati. *To* better prepare our national systems, as noted above, the Government of Kiribati has established centralized coordination of climate change adaptation (CCA) and financing. This has started by assigning coordination of CCA, mitigation and disaster risk management (DRM) to the Office of Te Beretitenti. In parallel, and to ensure efficiency and coordination, a Climate Finance Division has been established in the Ministry of Finance and Economic Development to access and channel external financial assistance to support implementation. These steps are essential in harmonizing a whole-of-government response to this issue.

2.8 Geographic vulnerability

A second definition of vulnerability relates to geographic vulnerability. The most geographically vulnerable locations to climate change are those that will be impacted by side effects of natural hazards, such as rising sea levels and by dramatic changes in ecosystem services, including access to food. Island nations are usually noted as more vulnerable but communities that rely heavily on a sustenance-based lifestyle are also at greater risk, such as: food insecure, water scarce, delicate marine ecosystem, fish dependent and small island community

Chapter 3: Sector selection for adaptation

The baseline for the selection of the priority adaptation sectors for Kiribati is based on the identified key areas emphasized in the Kiribati Climate Change policy, Kiribati Joint Implementation Plan which has become the National Adaptation Plan of Action, Kiribati NDC Investment Plan which they all informed decision taken by the TNA stakeholders.

3.1 An overview of expected climate change and its impacts in Sectors vulnerable to climate change

Based on the KJIP 2019 - 2028 and Kiribati Intended Nationally Determined Contributions (INDC) the following information on climate change impacts in sectors vulnerable to climate change are clearly emphasised. Kiribati is one of the most vulnerable countries in the world to the effects of climate change. The country's ability to respond to climate risks is hampered by its highly vulnerable socio-economic and geographical situation. Low atolls, isolated location, small land area separated by vast oceans, high population concentration, and the costs of providing basic services make Kiribati, like all Small Island Developing States (SIDS), especially vulnerable to external shocks including the adverse impacts of climate change. Sea-level rise and exacerbated natural disasters such as drought and weather fluctuations pose significant and direct additional threats to sectors and resources central to human and national development and the provision of basic human needs. The following factors are contributing to the nation's vulnerability to climate change and disaster risks, which apply across the various sectors vulnerable to climate change (KJIP 2019-2028, IDNC):

- A high population and growth rate on South Tarawa in the Gilbert Group (50,182 inhabitants with a population density of 3,184 persons per square kilometre) as well as on Kiritimati in the Line Islands Group (5,586 inhabitants), which is due to: a high proportion of children and youth, high levels of fertility, low rates of contraceptive use, and disparities between the different islands of Kiribati (resulting in internal migration, displacement, and urbanisation), all effecting the resilience of the population and natural ecosystems;
- In fast-growing urban areas, especially South Tarawa with a growth rate of 4.4% and to a certain extent also North Tarawa and Kiritimati, the population pressure and lifestyle changes have strained the already limited freshwater resources - in many areas, the freshwater consumption rates are already exceeding the estimated sustainable yield of groundwater sources (such as in the Bonriki and Buota Water Reserves on South Tarawa);

- The increase in non-biodegradable waste usage in urban areas, as well as poor waste and sanitation management, result in limited access to unpolluted land and sea, degradation of land and ocean based ecosystems, and numerous isolated occurrences of diarrhoeal and vector borne diseases, all affecting the resilience of the population and natural ecosystems;
- Traditional food systems are declining in favour of imported food, and the number of people who preserve and apply traditional knowledge is decreasing, affecting food security;
- In rural outer islands, the people have limited access to employment opportunities, effective transport, communication, and community services such as education and health - these factors, combined with a high dependency on subsistence agriculture and coastal fisheries, make rural communities more vulnerable;
- Government revenue is declining and highly dependent on fisheries revenue (40– 50%) with limited capacity to maximise the benefits of these resources;
- Many laws do not take into account sustainable management concerns, climate change predictions and disaster risks;
- Safety and emergency response capacities of Kiribati are limited;
- The low-lying atoll islands are already experiencing severe coastal erosion and inundation due to natural and human causes, leading to a loss of land, public and private buildings, and infrastructure.

In the long-term, the most serious concern is that sea-level rise will threaten the survival of Kiribati as a nation. But in the short to medium term, a number of other projected impacts are of immediate concern. Of particular note is the concern as to whether the water supply and food production systems can continue to meet the basic needs of the rapidly increasing population of Kiribati. The effects of climate change are felt first and most acutely by vulnerable and marginalised populations, including women, children, youth, people with disabilities, minorities, the elderly and the urban poor. [16] Violence against women and children is a widespread issue within Kiribati society, which can be exacerbated in times of disasters when normal social protection may be missing (SPC, 2010).

In addition, the population is facing stress due to the uncertainty over their livelihood, culture and homeland. Climate variability, climate change and disaster risks, in combination with the factors that make Kiribati particularly vulnerable to them, are affecting the environment and all socio-

[16] SPC, 2010. Kiribati Family Health and Support Study: A study on violence against women and children

economic sectors, including agriculture, education, fisheries, freshwater, health, infrastructure, trade and commerce.

3.2 Process and results of sector selection

The TNA is functioning through the existing adaptation committee that is currently operational. The Office of Te Beretitenti, through CCDRM division, is coordinating the work of this committee, which consists of key stakeholders essential to the advancement of national adaptation strategies. During the initial inception meeting of the TNA, attended by key stakeholders, it was decided that the TNA National Coordinator would serve as the chair of the committee. This appointment does not diminish the committee's established responsibilities rather, it allows the chair to focus specifically on the TNA process.

The selection of the sector was not made by the committee; instead, it aligned with the priorities set forth by the Government of Kiribati, which could not be altered. Guidance was provided by the Office of Te Beretitenti, which identified the sectors to be prioritized in the TNA process. 17Coastal protection emerged as the primary focus for adaptation, a priority clearly outlined in the Kiribati Joint Implementation Plan (KJIP), the Intended Nationally Determined Contribution (INDC), and the Kiribati Climate Change Policy. The KJIP outlines twelve key strategies, with Strategy 6 specifically highlighting the urgent need to protect coastal areas from the severe impacts of climate change. This emphasis on coastal protection is echoed in the Kiribati National Climate Change Policy, which adopts the recommendations from the KJIP, placing Strategy 6 at the top of its priority list. Similarly, the Intended Nationally Determined Contribution reiterates coastal protection as a critical national priority within the adaptation strategy.

[17] The rationale behind the decision is thoroughly articulated in the Executive Summary and further detailed in the methodology section of the report.

Chapter 4: Methodology for selection of technologies

Before the consultants were engaged in the Training Needs Assessment (TNA) field activities, both the adaptation and mitigation sector consultants were responsible for creating a work plan outlining their progress over the designated timeline. According to the briefing provided to the consultants, this phase of the TNA process is expected to be completed by the end of December 2024. As a result, the following work plan for the adaptation sector was approved, encompassing the tasks for steps 1.1 to 1.7. The workplan is appended as Annex 1.

During the inception workshop, stakeholders engaged in an in-depth discussion about the various factors contributing to coastal challenges. The emphasis was placed on ensuring that the outcomes of these discussions would provide valuable insights to guide the selection of appropriate technologies aimed at enhancing coastal resilience. This is particularly critical in addressing the devastating impacts of intense waves and rising sea levels. The collaborative effort aimed to identify strategies that are both effective and sustainable for protecting vulnerable coastal communities.

It is encouraging to see a collaborative approach emerging from the discussions during the inception workshop, particularly regarding the adaptation component's focus on water and coastal protection. The recognition of previous efforts in the water sector by NGOs, church-based organizations, and various projects is a testament to the strong foundation already laid in Kiribati. However, it is clear that the pressing challenges posed by coastal erosion affect the entire population and require urgent action.

Given the Government of Kiribati's acknowledgment of these challenges and its commitment to addressing them, we commend the decision to concentrate efforts specifically on coastal erosion. By streamlining our focus, we can dedicate the necessary resources and attention to thoroughly analyse the complexities of coastal protection, ultimately leading to innovative and effective solutions. This targeted approach will facilitate more in-depth discussions and evaluations, allowing stakeholders to collaborate more effectively and leverage their collective expertise. The TNA Coordinator, who guided the discussion on this issue, agreed and confirmed the government's stance, which aligns with the group's recommendations. This decision also took into account the guidance provided by national documents, which were adopted to inform the work on the adaptation component, ensuring a comprehensive approach to policy development.

Building on the group's previous discussions and the consensus reached during the meeting, they unanimously agreed to prioritize this recommendation and focus their efforts on enhancing coastal protection initiatives.

4.1 Training for adaptation and mitigation sector consultants

Due to both consultants being unable to attend the widely attended TNA training for participating countries, a separate training session was organized to equip them with the necessary skills for the TNA fieldwork. Given the time constraints, this training primarily focused on the MCA, as it is a key component of the identification and prioritization phase of the TNA. The remaining sessions were assigned for the consultants to review independently, with TNA experts at UCCC and USP available for any questions or clarifications.

4.2 Introductory meeting with local TNA Stakeholders

During the introductory meeting, nine different Government Ministries including representatives of NGOs attended. Prior to this meeting, an invitation letter was sent to all key Ministries with a follow up emails and telephone calls to remind them of their participation in the meeting.

The introductory meeting was held on December 5, 2024, and adhered to the agenda that had been distributed to all stakeholders in advance. The session commenced with a presentation by the Acting Director of the Climate Change and Disaster Unit of the Office of the President. During the presentation, the director provided a comprehensive overview of the Technology Needs Assessment (TNA) processes, emphasizing key details and objectives.

The outcome of this introductory meeting as stipulated in the meeting agenda was the achievement of result for Steps 1.1 – 1.2.

4.2.1 Retreat to complete TNA processes for Steps 1.3 – 1.7

The retreat took place from December 11th to 13th at the Midland Resort in North Tarawa. The primary objective was to finalize the remaining steps of the Technology Needs Assessment (TNA) focusing on the identification and prioritization of technologies for coastal protection (adaptation) and transport (mitigation). Given the tight timelines and the urgency to meet TNA reporting deadlines, this retreat provided an opportunity to adopt a more concentrated and efficient approach to complete this essential component of the project.

The Technology Fact Sheet (TFS) prepared by the consultant served as a comprehensive resource, offering in-depth background information on each technology. This information played a crucial role in guiding stakeholders as they conducted the Multi-Criteria Analysis (MCA) to make informed decisions.

At the completion of the retreat, adaptation and mitigation working group were successfully completed the work through which a finalised technologies for both adaptation and mitigation were endorsed by stakeholders.

Chapter 5: Institutional arrangement for the TNA and stakeholder involvement

5.1 National TNA Team

A schematic of the institutional arrangement for the National TNA Project for Kiribati is shown in **Figure 1** below.

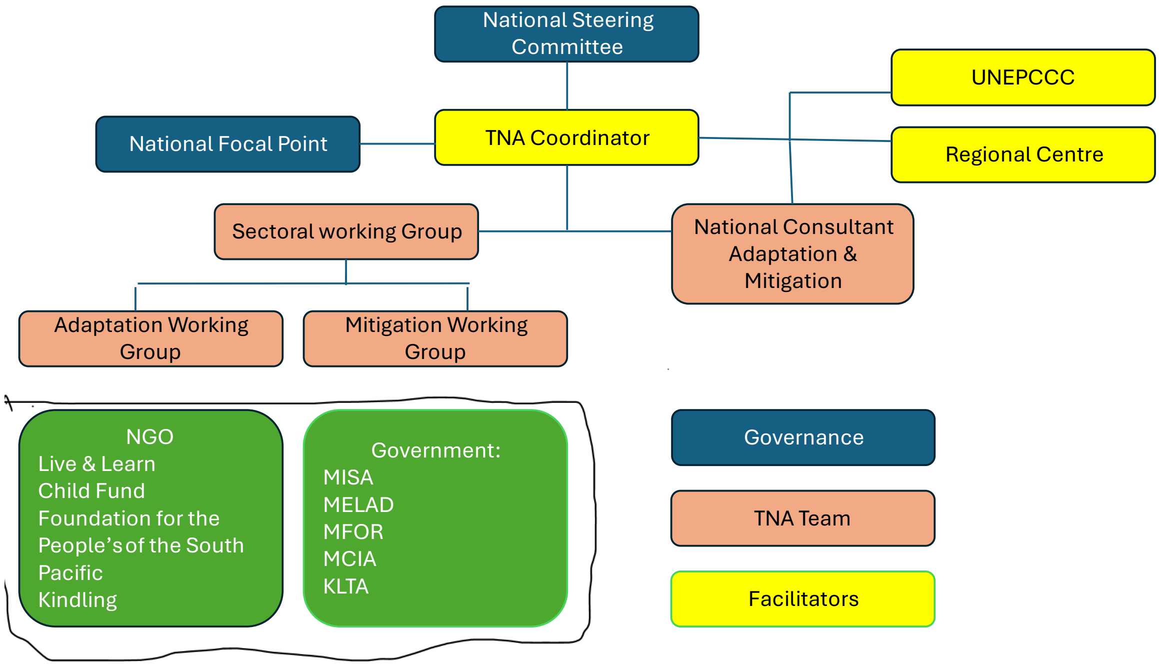

Figure 1: Kiribati National TNA Team Structure

5.2 National Steering Committee

The Kiribati National Expert Group which consists of representatives from Government Ministries, NGOs, and Faith-based organizations plays a coordination and oversighting role in the management of the TNA exercise.

5.3 National TNA Coordinator

The Director of Climate Change and Disaster Risk Management at the Office of Te Beretitenti serves as the National TNA Coordinator. In this role, the TNA Coordinator is responsible for overseeing the entire TNA process. This includes recruiting national consultants for both adaptation and mitigation efforts, as well as facilitating consultations and workshops to identify priority sectors for the TNA process.

5.4 National TNA Consultant

The lead national consultants were selected by UNEP CCC and the Pacific Regional TNA Hub the University of the South Pacific, following an open and transparent selection process.

National expert consultants are responsible for finalising the TNA Report after thoroughly identifying and prioritising technologies for the two sectors identified under climate change adaptation and mitigation after exhaustive consultation with the relevant stakeholders and experts. The National Consultants lead the process of multiple-criteria analysis, along with the national stakeholder groups, and facilitate the process of technology prioritisation, addressing the barriers and developing an enabling framework.

5.5 TNA Sectoral Working Group

During the initial TNA meeting, there were two (2) sectoral working groups that were established as working technical groups under the TNA process. These 2 Sectoral Working Groups include:

- Coastal protection working Group (Adaptation)
- Transportation working Group (Mitigation)

The primary role of each sectoral working group is to review and analyse each fact sheet and corresponding Multi-Criteria Analysis (MCA).

5.6 Stakeholder engagement process followed in the TNA – overall assessment

The stakeholder consultation process for the Technology Needs Assessment (TNA) in Kiribati was designed with a strong emphasis on sustainable wellbeing and inclusivity. Key principles guiding this process included social cohesion, partnership, agility, urgency, transparency, effective communication, and integrated learning. Participants comprised various government agencies alongside representatives from non-governmental organizations (NGOs), ensuring a diverse and comprehensive perspective in the discussions.

The TNA report was prepared after an extensive stakeholder process. The stakeholder engagement methods included:

(i) Email correspondence and exchanges on the Technology Factsheets (TFS) with key stakeholders;

The national consultants held a series of one-on-one bilateral meetings with key stakeholders mainly the Office of the Beretitenti seeking guidance and information regarding the TNA processes and Government of Kiribati adaptation priorities. The objective of these meetings was to gather insights and perspectives on essential sectors identified as critical for urgent development and investment within the Technology Needs Assessment (TNA) process. Through direct engagement with stakeholders, the consultants facilitated meaningful dialogue and pinpointed priority areas that necessitate immediate focus and support.

(ii) Introductory workshop for selected sectors that facilitated the formation of a technical working group; formation of TNA working groups and the identification of a Chair for each working group.

(iii) National stakeholder consultation of key stakeholders for technology prioritisation.

Chapter 6. Consideration of the gender aspect in the TNA process

It is crucial to note that gender considerations are a significant component of the overall process. Gender considerations in the TNA processes as clearly articulated in the [18] TNA gender guidelines, to quote – “women can significantly contribute to combating climate change as knowledgeable leaders of climate change adaptation and mitigation initiatives just as much as men can (GCF 2018). As it is, women can (and do) play a critical role in responding to climate change due to their local knowledge and leadership of, for example, sustainable resource management and/or sustainable practices at the household and community levels. Women also play key roles in promoting new technologies and facilitate their implementation. Because women are agents of transformation at societal level, their participation at the political level has, therefore, resulted in greater responsiveness to citizen’s needs in climate change adaptation and mitigation solutions”.

In the Pacific region, gender roles are shaped by a complex interplay of culture, social systems, local institutions, and religious beliefs, resulting in variations across different communities. Understanding the dynamics of gender relations—specifically the power imbalances between men and women and the roles they assume within their families and communities—is essential. This understanding can inform the TNA process, ensuring that it is inclusive and responsive to the needs of all genders.

[18] TNA gender guidelines-https://tech-action.unepdtu.org/wp-content/uploads/sites/2/2019/07/web-tna-gender-guidebook-01.pdf

Chapter 7: Adaptation technology prioritization for coastal protection

7.1 Key Climate Change vulnerabilities in the coastal protection sector

[19] Atmospheric greenhouse gas concentrations have increased rapidly in the past century and are almost certain to continue to increase in the future. 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. 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.

[20] According to the Kiribati Joint Implementation Plan (KJIP) for 2019-2028, the detrimental impacts of climate change will significantly disrupt critical human systems in Kiribati, including agriculture, food security, water supply, sanitation, human settlements, and public health.

These vulnerabilities are further intensified by a lack of understanding and awareness of the adverse effects of climate change and rising sea levels. However, many communities can enhance their resilience against the negative impacts of climate change if they gain a better understanding of the connections between their lived experiences and the challenges posed by climate change in the key sectors they rely on. Empowering these communities with knowledge and awareness will be crucial in helping them adapt and cope with the ongoing changes.

During the introductory meeting, a session on developing a list of vulnerabilities in the coastal protection sector came up with the following vulnerabilities.

- Low lying atolls – coastal erosion, inundation, brackish water, storm surges, drought, poor soil, overflooding,
- Capacity to act – social-economic issues, limited opportunities, limited budget, poor health, disability, local mentalities, poor leadership & coordination
- Awareness – lack of knowledge, local mentality and beliefs, lack of interest, lack of support, poor community engagement,
- Resources/materials – ineffective implementation, high recovery cost, lack of immediate response, inadequate human resources, paid services, political interest, costly, over resource extraction (beach mining), local mentality (ignorance), unsustainable behaviour

[19] Suppiah R *et al.*, 2007. Australian climate change projections derived from simulations performed for the IPCC 4th Assessment Report, Aust. Met. Mag. 56 (2007) 131-152
[20] ibid

- Land space – congested living, pollution, land dispute, increased crime rate, congested land transport,
- Population – congested living, waste increased, gender imbalance, poor health and sanitation, pollution, increased crime rate, coastline instability, unemployment, congested land transport, epidemic, deforestation, mangrove and other marine life destruction, higher consumption, shortage of food, population density,
- Funding & Finance – inaccessibility to funding sources, limited socio-economic alternative livelihoods opportunities,
- Logistic issues – distribution of materials to outer islands
- Waste – pollution, coral health, consume land space, affect marine habitat and resources, inadequate waste disposal system
- Compliance to rules and regulations – lack of enforcement, lack of cooperation and coordination, behavioural change, lack of human and technical resources, work horizontally and vertically,

7.2 Decision context

Through a review of reports/policies on development and climate change key documents, the Adaptation Consultant conducted a comprehensive review of key documents related to development and climate change, highlighting national adaptation priorities. The analysis focused on three critical national documents: the Kiribati Joint Implementation Plan (KJIP), the National Climate Change Policy, and the Intended Nationally Determined Contribution (INDC). All three documents identified coastal erosion as the most urgent challenge requiring immediate action to enhance national resilience in the face of ongoing climate change and disaster threats. Based on the analysis outcomes, the KJIP has identified twelve key strategies, with coastal protection being a significant focus. In line with the National Climate Change Policy, coastal protection has been prioritized as a vital sector for adapting to the impacts of climate change and disasters. Additionally, the Intended Nationally Determined Contributions (INDCs) also recognize coastal protection as a critical area in the national framework aimed at building resilience.

The KJIP clearly emphasised that low-lying atoll islands in Kiribati are facing significant coastal erosion and flooding, resulting in the loss of land and infrastructure due to both natural and human activities. The primary long-term concern is that rising sea levels may jeopardize the nation's survival.

Furthermore, the INDC added that Kiribati is highly vulnerable to climate change due to its socio-economic and geographical challenges, including low-lying atolls, isolation, limited land area, and high population density. Rising sea levels and extreme weather events pose significant threats to its development. The islands, which are often less than 2 meters above sea level, face ongoing coastal erosion and flooding during storms, with storm surges occurring approximately every 14 years. These factors hinder Kiribati's ability to effectively respond to climate risks and external shocks.

Based on the INDC, by 2050, it was estimated that 18-80% of the land in Buariki, North Tarawa, and up to 50% of the land in Bikenibeu, South Tarawa could become inundated.

The results of sea level rise and increasing storm surge threaten the survival and livelihoods of large segments of the population, increase the incidences of water-borne and vector-borne diseases undermining water and food security and the livelihoods and basic needs of the population, while also causing incremental damage to buildings and infrastructure.

Moreover, the Kiribati Climate Change Policy identifies the insufficient capacity for engineered coastal protection measures as a significant factor exacerbating the impacts of rising sea levels and increased storm surges. Many existing seawalls are prone to failure because of suboptimal design, leading to the need for extensive long-term maintenance. To effectively tackle coastal changes, it is essential to implement a combination of hard and soft strategies, such as the construction of traditional seawalls and the restoration of mangroves. Additionally, a comprehensive Integrated Coastal Zone Management (ICZM) approach is vital for ensuring the resilience of coastal ecosystems and communities.

With limited land available and environmental degradation threatening livelihoods, a sustainable approach involves rehabilitating coastal areas, constructing protective structures, and expanding habitable land. Future infrastructure must be climate-proofed. Key objectives include developing innovative engineering solutions, enhancing national capacity for coastal management, planning for climate-proof infrastructure, and engaging communities in building resilience against climate-related hazards.

Chapter 8: An overview of existing adaptation technology of coastal protection sector

[21]In the context of coastal protection in Kiribati, several strategies can be highlighted: Planting Coastal Vegetation is often overlooked by local communities. These plants play a crucial role in stabilizing beaches and protecting coastlines from erosion. Human activities frequently lead to the removal of these plants without understanding their ecological value. There is a strong recommendation for the replanting and cultivation of native coastal vegetation to enhance shoreline resilience in Kiribati. Beach Nourishment involves adding sand to eroding beaches to restore and widen shorelines. It serves as a direct intervention to combat beach erosion and is a viable option for improving coastal infrastructure in Kiribati.

[22] 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 (Cummings, *et al.*, 2012). 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.

[21] Paeniu *et al.*,2015
[22] Cummings, *et al.*, 2012

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).

Some of the existing seawall structures currently exists in Kiribati.

Figure 2: Sea wall structures in Kiribati (Source: Paeniu et al,. 2015)

Chapter 9: Adaptation technology options for coastal protection sector

A desktop review was carried out to gather comprehensive background information on the types of seawalls currently utilized in Kiribati, alongside the challenges faced in their implementation. This analysis aims to inform discussions and guide the selection of appropriate technologies tailored to the unique needs of Kiribati's coastal environment. Apparently, inadequate sea wall construction is a persistent issue in Kiribati and the Pacific Islands (Nunn, 2009)[23]. Increased settlement along vulnerable shorelines has resulted in a cycle of reef rock and gravel mining for sea walls, leading to flooding and greater vulnerability (Webb 2005; Duvat 2013)[24]. Current sea wall designs often use steep angles and local materials, but experts recommend best practices that include (i) shallower slopes (33"–40"), (ii) protective mesh, (iii) adequate drainage and elevation, and (iv) flank protection to better manage wave energy and sediment loss (Kench 2005; Juillerat 2012)[25]. Furthermore, soft measures like beach nourishment, reef restoration, and mangrove planting offer low-cost, effective alternatives (Sovacool 2011)[26]. Mangrove restoration, particularly in outer Kiribati atolls, can stabilize sediment and mitigate flooding over time (World Bank 2011b, c)[27]. However, relying solely on soft measures has drawbacks, as mangroves take years to mature and are ineffective in high-energy environments (Hallegatte 2009; Kench 2005; Nunn 2009)[28]. Consequently, urban planners in South Tarawa often advocate for a combination of hard and soft measures to safeguard against flooding and erosion (Juillerat 2012)[29].

For the TNA process, the following adaptation technologies were identified in consultation with stakeholders as key technologies in the Coastal Protection sector in Kiribati. The TFS for each of

[23]Nunn PD (2009) Responding to the challenges of climate change in the Pacific Islands: management and technological imperatives. Clim Res 40:211–231

[24] Webb A (2005) Technical report—an assessment of coastal processes, impacts, erosion mitigation options and beach mining (Bairiki/Nanikai causeway, Tungaru Central Hospital coastline and Bonriki runway—South Tarawa, Kiribati), EU-SOPAC Project Report 46, South Pacific Applied Geosciences Commission, Suva, Fiji

[11] Duvat V (2013) Coastal protection structures in Tarawa Atoll, Republic of Kiribati. Sustain Sci. doi:10.1007/s11625-013-0205-9

[25] Kench P (2005) Coastal protection measures report: Kiribati adaptation program. Preparation for Phase II Project. Kiribati Adaptation Program, Tarawa, Kiribati

[26] Sovacool BK (2011) Hard and soft paths for climate change adaptation. Clim Pol 11:1177–1183

[27] World Bank (2011b) Kiribati Adaptation Project—Implementation Phase (KAPII): Project Implementation Completion and Results Report. Report No: ICR00001751. Washington, DC

[14]World Bank (2011c) Kiribati Adaptation Program Phase III Project Appraisal Document. Report No: 63874-KI. World Bank, Washington, DC

[28] Hallegatte S (2009) Strategies to adapt to an uncertain climate change. Glob Env Chang 19:240–247

[29] Juillerat C (2012) Site Visit/Technical Assessment Nippon causeway Bairiki side seawall/land reclamation for Maiana Maneaba. Report prepared by Cliff Juillerat, Senior Coastal/Civil Engineer Ministry of Public Works and Utilities, Tarawa, Kiribati

the technologies were prepared by the National adaptation consultant and discussed with stakeholders for validation.

The discussion in this session drew upon the technical expertise of participants representing the Civil Engineering Department as well as the empirical insights offered by members of the adaptation group. The information gathered from the desktop review has enhanced our understanding of the existing efforts in coastal protection in Kiribati. This review provides valuable background information on previously implemented initiatives, highlighting their significance in safeguarding the coastal regions of the country. The Adaptation Consultant effectively presented the available facts regarding various technologies, while also highlighting that most of these technologies have yet to be tested or implemented in Kiribati. This lack of prior experience made it challenging to source reliable information on certain technologies.

However, the information presented in the Technology Feasibility Study (TFS) is primarily drawn from the experiences of other countries where these technologies have been tested and successfully implemented. Much of this information has been adapted to reflect the local context of Kiribati, providing a more accurate estimate of potential costs that are relevant for our specific needs and circumstances.

During the inception meeting held on December 5, 2024, stakeholders engaged in a brainstorming session where they identified potential coastal protection options for further consideration in the selection process. The initial list of ideas generated during this exercise included several technologies, but many were ultimately deemed less effective. The following options were initially proposed:

- Sandbag (deleted)
- Geobag
- Mass concrete sea wall
- Green-grey infrastructure (a combination of hard and nature-based solutions)
- Buibui (beach brush) – local technology (deleted)
- Mangrove, coral, and seagrass planting (deleted)
- Rock boulders (deleted)
- Beach nourishment (deleted)
- Groyne
- Wave breaker (deleted)
- Coastal rehabilitation (deleted)

After a thorough review, the list was streamlined to five promising technologies that would move forward into the Multi-Criteria Analysis (MCA) screening process. This screening was guided by the stakeholders' collective experience and knowledge of the technologies' effectiveness in mitigating the impacts of rising sea levels and wave overtopping. The four technologies chosen to advance included:

- Geobag
- Mass concrete sea wall
- Green-grey infrastructure
- Groyne

However, during a subsequent retreat, it was decided to reintroduce Coastal Rehabilitation into the selection due to its significant potential to address the impacts of sea level rise, wave overtopping, and increased population pressure. Consequently, Coastal Rehabilitation through land reclamation was designated as the fifth technology to advance to the MCA screening process.

Table 2: Adaptation Technology Options for Coastal Protection Sector

	Type of Technology	Benefit	Brief Description
1	Geobag Seawall	The textiles used in geobag manufacturing are particularly engineered to hold sand, which positions them as a viable alternative to traditional sandbags.	Geobags are specialized containers made from high-strength textile materials designed for durability and longevity. Recommended by civil engineers, these bags have yet to be implemented in Kiribati, making it difficult to assess their effectiveness based on local conditions. The textiles used in geobag manufacturing are particularly engineered to hold sand, which positions them as a viable alternative to traditional sandbags. While geobags share a superficial resemblance to standard bags, they are uniquely crafted for specific applications in construction and erosion control. However, the primary concern lies in their longevity, especially concerning how well the textile can withstand physical abrasion from external elements. Cost considerations for geobags remain unclear, as there is limited information available about their pricing. Nevertheless, stakeholders have raised concerns about potential financial implications tied to the adoption of this technology. Compared to conventional sandbags, geobags may incur higher costs due to their advanced design features, which enhance their capacity to resist wave action and securely contain sand. In summary, while geobags offer promising advantages in terms of durability and functionality, further investigation into their performance and cost-effectiveness in the context of Kiribati is essential before making implementation decisions.

2	Mass concrete	One of the primary advantages of mass concrete seawalls is their simplicity in implementation, which allows for reduced technical supervision during construction.	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 $20,000 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.
3	Green-grey infrastructure	its importance in coastal protection is undeniable. It seamlessly integrates green infrastructure with grey infrastructure, incorporating nature-based solutions to enhance its effectiveness	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.
4	Groyne	its ability to build sand along the coast	Interest in the technology has been limited due to its relatively ineffective role in safeguarding coastlines from wave overtopping and rising sea levels. While it is often

			touted for its ability to build sand along the coast, this function is largely passive and insufficient to withstand the forces of currents that can accelerate coastal erosion. Furthermore, the cost of implementing this technology does not align with the pressing need for robust solutions to combat severe erosion along vulnerable shorelines.
5	Coastal rehabilitation by land reclamation	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.	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.

Chapter 10: Criteria and process of technology prioritization for coastal erosion sector

Developing a Technology Fact Sheet for each technology was assumed independently by the adaptation consultants which was presented and discussed during the introductory meeting with stakeholders. During the deliberation in this meeting, stakeholders reached a consensus to expand the initial proposal to include coastal rehabilitation by land reclamation, emphasizing the need for solutions that protect land from coastal erosion. This technology has been successfully implemented in Kiribati and similar regions, albeit at varying scales. The addition suggests that the technology should be informed by lessons learned from neighbouring countries while being specifically tailored to address the unique climate change challenges faced in Kiribati.

This technology not only effectively serves its primary purpose but also significantly enhances the island's resilience against the adverse effects of climate change. It contributes to the rehabilitation of reclaimed land by promoting the growth of trees and food crops, safeguarding buildings from coastal erosion, and stimulating both private and public investments to foster new business opportunities. Thus, a list of technologies that were discussed and considered in the selection of a priority technology include the following.

1. Geobag
2. Mass concrete seawall
3. Green-grey infrastructure
4. Groyne
5. Coastal rehabilitation by land reclamation

During this process, the multi-criteria analysis (MCA) tool is used in ranking the five (5) identified technologies in their priority order based on a set of criteria that are relevant to country context. In consultation with the stakeholders, it was decided that nine (7/9) criterions such as: (i) Cost, (ii) Economic, (iii) Social (iv) Environment (v) Climate Related and (vi) Political was to be used in the analysis.

- The rating for performance matrix identified based on cost investigation from the technology providers and feasibility study also the qualitative expert judgment.
- The scoring matrix determined by the value preferred and the scored generated using stakeholders best judgement.

- the allocation of weights for the weight matrix is conducted through a participatory process. Stakeholders are given a budget of 100 points, which has to be divided among all the criteria. The weight distribution is based on the correlation between criterion with the climate change adaptation and the Country need to build a strong resilience against the threat of climate change and disaster risks.

10.1 Identifying criteria

The evaluation of the five technologies was conducted based on several criteria derived from the information provided in the Technology Fact Sheet (TFS). Additionally, the technical expertise of participants from the Civil Engineering Department and the empirical insights shared by adaptation group members also contributed significantly to the assessment process. Information derived from the desktop review also presented to provide some critical background information that also helps to inform decisions being made. To effectively analyse and prioritize the five technologies, we established the following criteria (table 1.3):

Table 3: Identifying criteria – Step 1.3

Criteria	**Description**	
Cost	Cost to setup	Evaluating the initial investment required to implement each technology.
Economic	Preserving property/asset values	Assessing the potential contribution to economic growth and job creation.
	Trigger Public and private investment	Examining the technology's effects on community wellbeing and social equity.
Social	Inclusivity (size of beneficiaries)	Environmental Impact - Analysing the ecological footprint and sustainability of each technology.
Environmental	Contribution of the technology to protect and sustain ecosystem Services	

Climate related	Improvement of resilience to climate change (i.e. to what extent the technology will contribute o reduce vulnerability to ease of climate change impacts).	Determining how each technology contributes to addressing climate change and enhancing resilience.
Institutional/other	Ease of implementation	Considering regulatory frameworks, governance, and institutional readiness to adopt the technology.
	Replicability	Considering the easy adoption of the technology
Political	Coherence with national development policies and priorities	Evaluating the political landscape and public acceptance related to the implementation of each technology.

The process of assigning weights to the criteria by distributing a total budget of 100 prompted considerable discussion among the working group, reflecting the diverse priorities of their respective departments. While initially divergent in their viewpoints, the group successfully achieved consensus by collaboratively developing a prioritized list for each criterion. This systematic approach not only fostered agreement but also ensured that all perspectives were valued and integrated into the decision-making process.

Table 4: Assigning weight to criteria – step 1.4

Criteria	**Indicators**	**Weight (out of 100)**
Cost	Cost to setup	12 It was critical that cost consideration comes after the key pillars has been finalized

Economic	Preserving property/asset values	13 Loss of properties and assets due to acute function of coastal erosion is profoundly influence the level of resilience
	Trigger Public and private investment	7 Benefit to be gained from the technology
Social	Inclusivity (size of beneficiaries)	14 Size of beneficiaries is considered an important pillar that the larger the beneficiaries the better
Environmental	Contribution of the technology to protect and sustain ecosystem Services	15 This is one of the key pillars that significantly contributes to the protection and preservation of ecosystems.
Climate related	Improvement of resilience to climate change (i.e. to what extent the technology will contribute to reduce vulnerability to ease of climate change impacts).	20 This is regarded as crucial because it effectively aligns with the need to enhance the country's resilience to the threats posed by climate change and disaster risks.
Institutional/other	Ease of implementation	6 More at the political sphere and does not have a significant influence on resilience building
	Replicability	5 More at the political sphere and does not have a significant influence on resilience building

Political	Coherence with national development policies and priorities	8 Serve political interest

Step 1.5: Scoring (Performance matrix)

During the scoring process, the stakeholders for the coastal protection sector referred to the Technology Fact Sheets, used their experiences and deliberated on each of the criteria. Then they collectively decided to give individual scores and average out the scores for each of the criteria. Hence, a performance matrix was constructed, and the scoring was carried out after discussing the information provided in the technology factsheets and experiences of respective stakeholders.

The identified technologies were then processed through the MCA tool for decision making. The consultants had gone through the different functions of the MCA such as, performance matrix, scoring matrix and decision matrix. To calculate these different functions, each technology is allocated with various categories such as capex, opex, maintenance (costs) and were weighted against the benefits such as cost, economic, social costs, environment, climate change related institutional/others and political. Each category was then weighted with a figure which all together adds up to 100. The method in which the performance marks were allocated was, for cost, if the technology is expensive the percentage awarded would be low (20%), likewise if the technology is cheap then the mark allocated would be high, for example 90%. The same method was also applied with both the scoring and decision function. That percentage was then applied to the weighting of each category then add all up to 100, technology with the highest aggregate score was then given the highest priority.

Table 5: Performance matrix – Step 1.6

Annex 2: Example of simple multi-criteria analysis tool – Table A2.1 Prioritisation example – Simple MCA Tool – Scoring Matrix									
	Cost	Economic		Social	Environmental	Climate related	Institutional/Implementation		Political
	Cost to setup	Preserving property/asset values	Trigger Public and private investment	Inclusivity (size of beneficaries).	Contribution of the technology to protect and sustain ecosystem Services	Improvement of resilience to climate change (i.e. to what extent the technology will contribute o reduce vulnerability to ease of climate change impacts).	Ease of implementation	Replicability	Coherance with national development policies and priorities
1. Geobag	Low cost: 39	Low: 30	Low:30	High: 78	Medium:75	High: 80	Medium: 65	High: 75	Low: 25
2. Green and Gray infrastructure	High: 75	High:100	high:85	High:85	High: 90	High:95	Low: 25	Medium: 40	High:95
3. Mass concrete Seawall	Medium:69	High : 70	High:80	High:70	Medium: 50	High: 90	High:90	High: 95	High: 100
4. Groyne	High: 70	Low:20	Low:30	Low:30	Low: 30	Low: 30	Low: 25	Low: 30	Low: 15
5. Coastal Rehabilitation	High: 96	High:100	High:90	High:95	Medium:65	High:98	High: 90	Medium: 65	High: 100
Scoring scale	0-very high cost-> 100-very low cost	0-very low-> 100-very high	0-very low-> 100-very high	0-very low-> 100-very high	0-very low-> 100-very high	0-very difficult-> 100-very easy	0-very high cost-> 100-very low cost	0-very high cost-> 100-very low cost	0-very high cost-> 100-very low cost
Criterion weight	12	13	7	14	15	20	6	5	8

Table 6: Combining scores and weights – **step 1.6**

		Benefits								
	Costs	Economic		Social	Environmental	Climate related	Institutional		Politics	
	Set up cost	Preserving property/assests values	Trigger private/public investment	Inclusivity /size of brneficiaries	contribution of the technology to protect and sustain ecosystem	Improvement of resilience to climate change	Ease of implementation	Replicability	alignment to Govt policies	
	Unit /Scale	H/M/L	H/M/L	H/M/L	H/M/L	H/M/L	H/M/L	H/M/L	H/M/L	
Geobag	39	L	L	H	H	H	M	H	L	
Green-grey Infrastructure	75	H	H	H	H	H	L	M	H	
Mass concrete sea wall	69	H	H	H	M	H	H	H	H	
Groyne	70	L	L	L	L	L	L	L	L	
Coastal rehabilitation	96	H	H	H	M	H	H	M	H	

		Benefits								
	Costs	Economic		Social	Environmental	Climate related	Institutional		Politics	
	Set up cost	Preserving property/assests values	Trigger private/public investment	Inclusivity /size of brneficiaries	contribution of the technology to protect and sustain ecosystem	Improvement of resilience to climate change	Ease of implementation	Replicability	alignment to Govt policies	
	Unit /Scale	Unit /Scale	Unit /Scale	Unit /Scale	Unit /Scale	Unit /Scale	H/M/L			
Geobag	100	30	30	78	75	80	65	75	25	
Green-grey Infrastructure	20	100	85	85	90	95	25	40	95	
Mass concrete sea wall	50	70	80	70	50	90	90	95	100	
Groyne	30	20	30	30	30	30	25	30	15	
Coastal rehabilitation	10	90	90	95	65	98	90	65	100	
Criterion weight	12	13	7	14	15	20	6	5	8	should add to 100

The values presented above are the result of a normalization process used to assess various technologies. This normalization can be approached in two ways: (1) utilizing mathematical formulas or (2) conducting manual calculations. In this exercise, we opted for a manual method, where values from the performance matrix were normalized by converting them into scores that reflect the technologies' cost-effectiveness.

In this rating system, a technology rated very low in terms of cost receives a score of 0, while a technology rated highly is assigned a score of 100. Scores for all other technologies fall within this range, depending on their relative performance. Additionally, the values in the weight matrix are calculated automatically, with scores divided by the relevant criteria, as demonstrated in step 7. This systematic approach ensures that all technologies are evaluated consistently and transparently, allowing for informed decision-making based on their cost-related performance and the rest of the criteria.

Table 7: Decision Matrix- Step 1.7:

	Costs	Benefits									
		Economic		Social	Environmental	Climate related	Institutional		Politics		
	Set up cost	Preserving property/assests values	Trigger private/public investment	Inclusivity /size of brneficiaries	contribution of the technology to protect and sustain ecosystem	Improvement of resilience to climate change	Ease of implementation	Replicability	alignment to Govt policies		
	Unit /Scale	Unit /Scale	Unit /Scale	Unit /Scale	Unit /Scale	Unit /Scale	h/m/l				
Geobag	1200	390	210	1092	1125	1600	390	375	200	6382	4
Green-grey Infrastructure	240	1300	595	1190	1350	1900	150	200	760	6925	2
Mass concrete sea wall	600	910	560	980	750	1800	540	475	800	6615	3
Groyne	360	260	210	420	450	600	150	150	120	2600	5
Coastal rehabilitation	120	1170	630	1330	975	1960	540	325	800	7050	1
Criterion weight	12	13	7	14	15	20	6	5	8	100	

Step 1: Add your criteria: B6 - N6
Step 2: Add your options: A8 - A17
Step 3: Rate how well the options contribute to each criterion: B8 - N17
Step 4: Covert your ratings into a score from 0 to 100 for each of the options B24 - N33
Step 5: Add criteria weights: B35 - N35

During the final review process, a minor disagreement was identified regarding incorrectly inputted scores in the template. This issue came to light when the results were presented to the group, prompting questions and expectations from team members. Since everyone actively participated in the discussion, they collectively agreed to address the error. An error stems from the allocation of a higher point to Green-grey infrastructure, which should actually be rated lower than Coastal rehabilitation and land reclamation. This was due to the incorrectly inputted scores in the template. The team re-evaluated the scoring input in the template, which revealed that certain points had been overlooked. This prompted a minor adjustment that led to a slight modification that ultimately addressed the concerns of all team members, thereby solidifying the ranking of the technologies outlined above in the TNA selection processes. As a result, coastal rehabilitation, green-grey infrastructure and mass concrete seawall became the group's chosen options, now fully endorsed by everyone involved.

Chapter 11: Results of technology prioritization for coastal protection

[30]The working group for coastal erosion sector under the adaptation has concluded that the TNA process considers prioritization of **Coastal rehabilitation by land reclamation, Green – Grey Infrastructure and Mass concrete seawall** as the three prioritized technologies to progress further through the TNA process. The three technologies get the highest ranking after the MCA assessment as presented in *Table 8* below.

Table 8: Result of prioritization of Technologies for Coastal Erosion Sector

No	Types of Technology Adaptation (Coastal Erosion Management)	Total	Rank
1	Coastal rehabilitation by land reclamation	7050	1
2	Green-Grey infrastructure	6925	2
3	Mass concrete seawall	6615	3
4	Geobag	6382	4
5	Groyne	2600	5

[30] As suggested the three technologies in the top three on the list should be progressed to the barrier analysis phase

Chapter 12: Summary and Conclusion

The technology needs assessment was a nationally driven, gender-inclusive process that actively engaged relevant stakeholders. The initial consultations and reviews of key documents such as the Kiribati Development Plan, National Climate Change Policy, and Intended Nationally Determined Contributions helped identify and prioritize technologies within the adaptation sector.

Coastal erosion emerged as a critical national priority, guiding the TNA process through the efforts of the TNA National Coordinator and receiving validation from stakeholders. In response to this priority, a comprehensive long list of technologies was generated for the coastal protection sector, which was subsequently refined based on the acceptability of each technology among stakeholders.

During a workshop held on December 5, 2024, stakeholders reached consensus on four key technologies to advance into the Multi-Criteria Analysis (MCA). This selection process was further expanded during a retreat from December 11-13th, 2024, where additional insights and considerations were incorporated which resulted in the addition of Coastal rehabilitation to the list.

The technology factsheets were developed further for these shortlisted technologies in consultation with stakeholder experts in the field and through a retreat with stakeholders. The shortlisted technologies underwent further analysis and prioritization using the MCA tools. The decisions were based on criteria set such as cost, economic, social, environment, climate related, institutional/others and political.

Following the discussion of the initial evaluation results, a minor discrepancy in the input scores for the matrix was identified. To rectify this issue, a re-evaluation was initiated to address the concern of elevated scores assigned to Green-Grey Infrastructure. This process benefited significantly from the active engagement of group members, whose sharp observations helped uncover errors related to the input scores in the template. Their collaborative efforts resulted in a slight adjustment that addressed the concerns of all team members, reinforcing the validity of the technology rankings established in the TNA selection process.

The final decision confirmed the selection of **i) Coastal rehabilitation by land reclamation, ii) Green-Grey Infrastructure and iii) the Mass Concrete Seawall** as the TNA priorities - coastal protection sector in Kiribati and the technologies selected and ranked through MCA according to the list below;

1. Coastal rehabilitation by land reclamation
2. Green-Grey infrastructure
3. Mass concrete seawall
4. Geobag
5. Groyne

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Annexes

Annex 1: Work plan

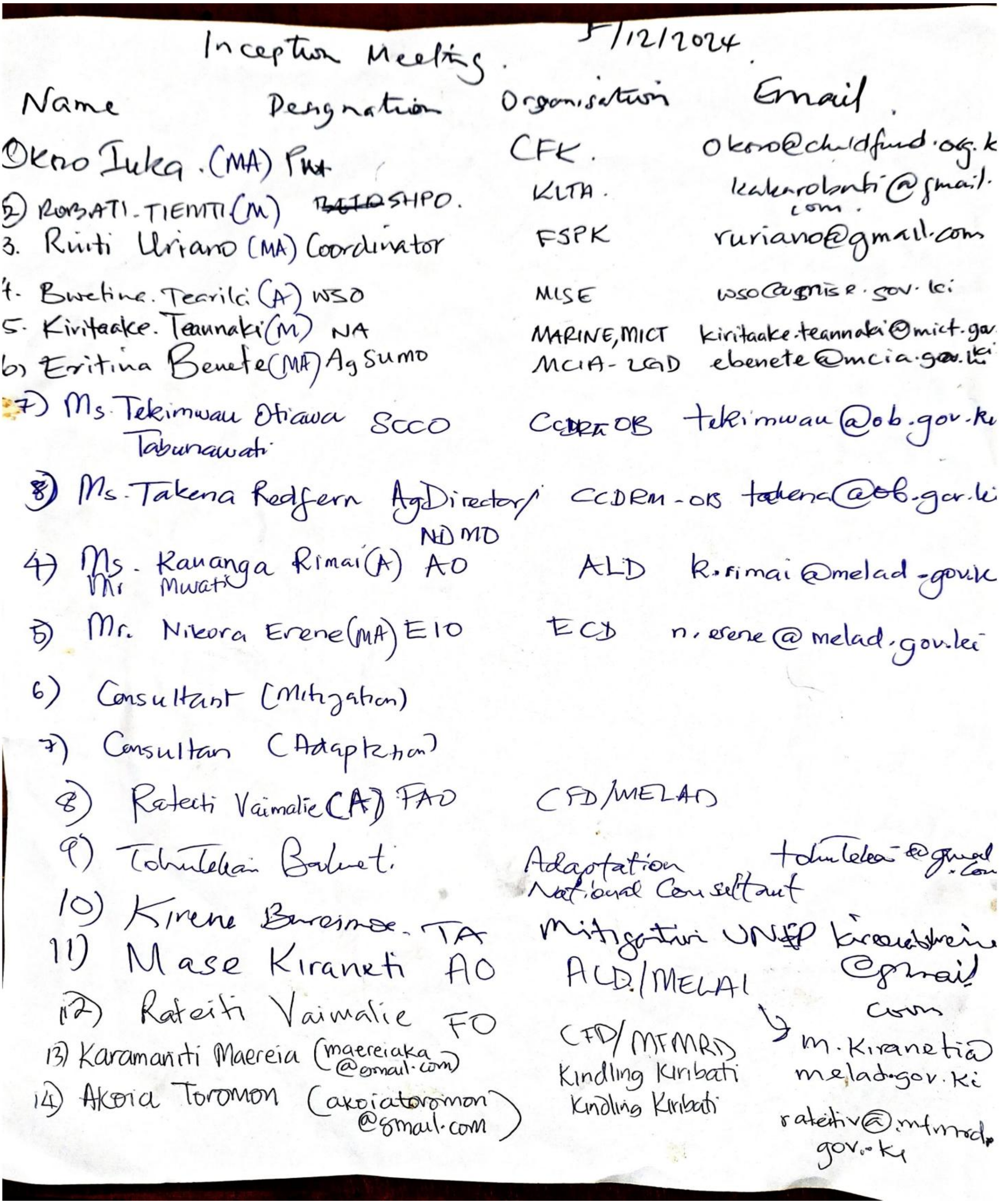
Consultant - Adaptation to climate change Coastal Protection

Detailed workplan		**2024**								**2025**																							
		Nov				**Dec**				**Jan**				**Feb**				**Mar**				**Apr**				**May**				**June**			
Activities	**Tasked to**	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Training																																	
Activity 1: TNA training for consultants	UNEP																																
2. Workplan																																	
Activity 2: Review process	Consultant																																
Activity 3: Finalize workplan, timetable and working group	Consultant																																
3. Inception workshop																																	
Activity 4: Review the national policies on coastal and water sectors (NDC, sectoral policies, National Communications, first TNA, etc.)	Consultant																																
Activity 5: Inception workshop - identification of relevant technologies	TNA Team																																

Activity 6. Prioritization of the selected technologies (water and coastal)using MCA.	TNA Team																																
4. Prepare Technology need assessment (TNA) report																																	
Activity 7: First draft TNA report	Consultan t																																
Activity 8: Review and validation of TNA draft	TNA Team																																
Activity 9: Final TNA report	Consultan t																																
5. Prepare Technology Need Assessment report (TNA)																																	
Activity 10. Analysis of market and barriers for development, deployment and diffusion of priority technologies. Identify measures to overcome barriers	TNA Team																																
Activity 11. Propose Enabling Framework to overcome barriers identified for the 8-12 prioritised technologies.	TNA Team																																
Activity 12: First draft BAEF report	Consultan t																																
Activity 13: Review and validation of BAEF report	TNA Team																																

Activity 14. Final BA&EF reports	Consultant																																
6. Prepare a Technology Action Plan (TAP)																																	
Activity 15. Develop technology action plan for deployment and diffusion of prioritised technologies in the country.	TNA Team																																
Activity 16. Propose project/programme concepts note based on priority technologies selected for future funding.	TNA Team																																
Activity 17. 1st Draft TAP report	Consultant																																
Activity 18. Review and validate TAP report	TNA Team																																
Activity 19. Final TAP report	Consultant																																

Annex 2: Participants list for the introductory meeting 5th December, 2024



Inception Meeting. 5/12/2024.

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Annex 3: Agenda for Inception meeting

Agenda for Inception Meeting with key stakeholders

1. Introduction of TNA Project

By OB TNA Coordinator

2. Step 1.1: Decision context

National consultants for Adaptation and Mitigation through a review of reports/policies on development and climate change

a) Mitigation: What is the current level and growth of GHG emissions in the chosen sectors?

b) Adaptation: What are the key vulnerabilities in the sectors?

c) What will be the focus areas of the TNA analysis?

d) What are the current objectives and challenges in the sector?

e) What are the existing efforts (projects, programmes, policies, etc.) to reduce GHG emissions, or enhance resilience / promote adaptation, in the key focus areas?

f) How are these focus areas linked to existing climate and development efforts.

Intermediate output: A draft introductory chapter for the TNA Report describing key sector issues, decision context

Operationalisation

a) Establish who the decision-makers are

b) e.g., Chair and members of sectoral workgroup

c) Need to identify other key stakeholders and the extent of their participation in the analysis

3. Step 1.2: Identify technology options in the sectors

National consultant for Adaptation and Mitigation- procedure

a) Draw up long lists of potential climate technologies for each selected sector.

b) Information from existing planning documents (NDC, NAP, Energy Plans, NC etc.), TNA Sectoral Guidebooks, from data sources such as the Green Database (WIPO 2024a) and the Green Technology Book (WIPO 2024b), local stakeholders.

c) All options to be discussed with the relevant stakeholders to ensure 'buy-in'.

d) Conclude with a long list of technologies, with technology factsheets providing input for the prioritisation step, reducing to 2 or 3 technologies per sector.

Intermediate output:

I. Long list of up to 5 technologies

II. Technology factsheets for each longlisted technology.

Annex 4: Decision context

1. Introduction of TNA Project

- By OB TNA Coordinator

2. Step 1.1: Decision context

National consultants for Adaptation and Mitigation through a review of reports/policies on development and climate change

National adaptation priority – coastal erosion. This was derived from the review of the three key documents listed below.

Adaptation – review of reports/policies on development and climate change

- **KJIP**
  - The low-lying atoll islands are already experiencing severe coastal erosion and inundation due to natural and human causes, leading to a loss of land, public and private buildings, and infrastructure.
  - The Environmental Impact Assessment under the Environment Act may need to be enforced on major projects throughout all of Kiribati's islands. This would help curb the removal of mangroves and mining of sand and aggregates that contribute to erosion.
  - In the long term, the most serious concern is that sea level rise will threaten the very existence of Kiribati as a nation.
- **Intended Nationally Determined Contribution (INDC)**
  - Kiribati is one of the most vulnerable countries in the world to the effects of climate change its ability to respond to climate risks is hampered by its highly vulnerable socio-economic and geographical situation.

- Low atolls, isolated location, small land area separated by vast oceans, high population concentration, and the costs of providing basic services make Kiribati, like all Small Island Developing States (SIDS), especially vulnerable to external shocks including the adverse impacts of climate change.
- Sea-level rise and exacerbated natural disasters such as drought and weather fluctuations pose significant and direct additional threats to sectors and resources central to human and national development.
- The country is located in relatively calm latitudes but its low atolls (in many places no more than 2m above mean sea level and only a few hundred meters wide) are subject to long-term sea level rise and, more immediately, are exposed to continuing coastal erosion and inundation during spring tides, storm surges and strong winds.
- The islands are subject to periodic storm surges with a return period of 14 years.
    - By 2050, 18-80% of the land in Buariki, North Tarawa, and up to 50% of the land in Bikenibeu, South Tarawa could become inundated.
- The results of sea level rise and increasing storm surge threaten the very existence and livelihoods of large segments of the population, increase the incidences of water-borne and vector-borne diseases undermining water and food security and the livelihoods and basic needs of the population, while also causing incremental damage to buildings and infrastructure.
- The Climate Change in the Pacific Report (2011) describes Kiribati as having a low risk of cyclones. However, in March 2015 Kiribati experienced flooding and destruction of seawalls and coastal infrastructure as the result of Cyclone Pam, a Category 5 cyclone that devastated Vanuatu. Thus Kiribati remains exposed to the risk that cyclones will strip the low lying islands of their vegetation and soil.

- **Kiribati Climate change policy**

  Coastal protection and infrastructure are the top priority

    - Coastal areas in Kiribati are extremely vulnerable due to the low-lying atoll topography.
    - Higher spring tides and more frequent and stronger storm surges coupled with sea-level rise significantly increase the country's exposure to flooding and coastal erosion.

- A concern is the lack of capacity in coastal engineering to provide innovative, practical solutions contextualized to national needs and local circumstances.
    - Coastal protection seawalls continue to fail due to inappropriate design, requiring long-term financial commitments to maintenance and repair.
- No single action will address all aspects of coastal change and inundation.
    - A range of actions, including both soft and hard measures, such as mangrove planting, traditional seawalls (te buibui) and raising of ground levels, is needed to effectively address emerging climate change impacts.
- A meaningful and comprehensive integrated coastal zone management approach is required to address current coastal hazard issues.
    - The projected rise in sea level, with the already limited land area of a typical atoll and the current human-induced degradation of the environment, will further jeopardize the country's ability to continue to support the livelihoods of the growing population.
- A practical approach towards the long-term sustainability of Kiribati's islands is to continue to rehabilitate and restore coastal areas through constructing protective structures or replenishing eroded areas, promoting setbacks and internal migration, raising ground levels and expanding inhabitable areas of land.
- Current and future infrastructure must be climate proofed. The development and implementation of the long-term coastal strategy will assist national efforts to address the impacts of shoreline retreat and inundation and will build resilience and adaptive capacity in parallel.
    - Objective 1: Develop bold and innovative engineering solutions to address coastal management issues (coastal protection) and long-term measures to build up our islands through collaborative efforts with potential partners.
    - Objective 2: Strengthen national capacity to manage, monitor and protect coastal areas in a coordinated manner.
    - Objective 3: Develop planning processes and programs for climate proofing infrastructure throughout Kiribati.
    - Objective 4: Engage communities in becoming active partners in building coastal resilience and reducing hazards and risks related to climate change

INDC – build on KJIP emphasising implementation of Strategy 6

a) Mitigation: What is the current level and growth of GHG emissions in the chosen sectors?

b) Adaptation: What are the key vulnerabilities in the sectors?

Vulnerabilities – Sector; coastal protection

- Low lying atolls – coastal erosion, inundation, brackish water, storm surges, drought, poor soil, overflooding,
- Capacity to act – social-economic issues, limited opportunities, limited budget, poor health, disability, local mentalities, poor leadership & coordination
- Awareness – lack of knowledge, local mentality and beliefs, lack of interest, lack of support, poor community engagement,
- Resources/materials – ineffective implementation, high recovery cost, lack of immediate response, inadequate human resources, paid services, political interest, costly, over resource extraction (beach mining), local mentality (ignorance), unsustainable behaviour
- Land space – congested living, pollution, land dispute, increased crime rate, congested land transport,
- Population – congested living, waste increased, gender imbalance, poor health and sanitation, pollution, increased crime rate, coastline instability, unemployment, congested land transport, epidemic, deforestation, mangrove and other marine life destruction, higher consumption, shortage of food, population density,
- Funding & Finance – inaccessibility to funding sources, limited socio-economic alternative livelihoods opportunities,
- Logistic issues – distribution of materials to outer islands
- Waste – pollution, coral health, consume land space, affect marine habitat and resources, inadequate waste disposal system
- Compliance to rules and regulations – lack of enforcement, lack of cooperation and coordination, behavioural change, lack of human and technical resources, work horizontally and vertically,
-

c) What will be the focus areas of the TNA analysis? Coastal protection

d) What are the current objectives and challenges in the sector?

Issues with coastal protection

- Refer above exercise

e) What are the existing efforts (projects, programmes, policies, etc.) to reduce GHG emissions, or enhance resilience / promote adaptation, in the key focus areas?

Participants were asked to bring with them to the retreat existing efforts (projects, programmes, policies, etc) their sector focusses on.

f) How are these focus areas linked to existing climate and development efforts.

The consultant will develop and present it in the retreat

Intermediate output: A draft introductory chapter for the TNA Report describing key sector issues, decision context

Operationalisation

a) Establish who the decision-makers are

b) e.g., Chair and members of sectoral workgroup The chair will be the TNA Coordinator for the Adaptation – Takena Redfern

c) Need to identify other key stakeholders and the extent of their participation in the analysis

OB will work on this if necessary

3. Step 1.2: Identify technology options in the sectors

National consultant for Adaptation and Mitigation- procedure

Adaptation: Coastal erosion

KJIP

Strategy 6: Promoting sound and reliable infrastructure development and land management	6.3: Building coastal resilience through strategic coastal protection initiatives ○ KEY NATIONAL ADAPTATION PRIORITIES – COASTAL PROTECTION AND INFRASTRUCTURE #2 & #3: Strengthen national capacity to manage, monitor and protect coastal areas in a coordinated manner (KNAP

	#2); Develop planning processes and programmes for climate proofing infrastructure throughout Kiribati (KNAP #3). ○ KEY NATIONAL ADAPTATION PRIORITY – COASTAL PROTECTION AND INFRASTRUCTURE #4. Engage communities in becoming active partners in building coastal resilience and reducing hazards and risks related to climate change. ○ KEY NATIONAL ADAPTATION PRIORITY – COASTAL PROTECTION AND INFRASTRUCTURE #1. Develop bold and innovative engineering solutions to address coastal management issues (coastal protection) and long-term measures to build up our islands through collaborative efforts with potential partners).

a. Draw up long lists of potential climate technologies for each selected sector.

Technologies:

The below technologies were identified and then selected based on what the stakeholders most appropriate and suitable for Kiribati

- Sandbag - delete
- Geobag
- Mass concrete sea wall
- Green – grey infrastructure (hard and nature-based)
- Buibui (beach brush) – local technology - delete
- Mangrove, coral, sea grass planting - delete
- Rock boulders - delete
- Beach nourishment - delete
- Groyne
- Wave breaker - delete
- Coastal rehabilitation - delete

From the selection above, the following are the list of technologies to be prioritized using the MCA process;

1, Geobag

2. Green – Grey Infrastructure (hard and nature-based)

3. Mass concrete seawall

4. Groyne

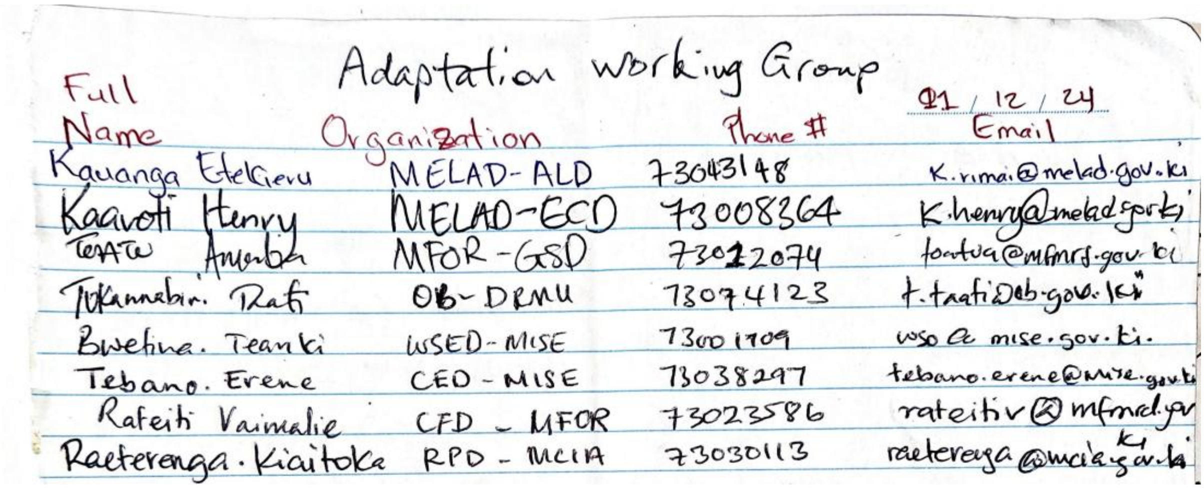
b. Information from existing planning documents (NDC, NAP/KJIP, Energy Plans, NC etc.), TNA Sectoral Guidebooks, from data sources such as the Green Database (WIPO 2024a) and the Green Technology Book (WIPO 2024b), local stakeholders.
c. All options to be discussed with the relevant stakeholders to ensure 'buy-in'.
d.
e. Conclude with a long list of technologies, with technology factsheets providing input for the prioritisation step, reducing to 2 or 3 technologies per sector.

Annex 5: Retreat program

Retreat at Midland Resort, North Tarawa 11-13th December, 2024

DAY 1 – Wednesday 11th December 2025			
TIME	**ITEM**	**SUB-ACTIONS**	**LEAD OFFICER**
11:00 – 13:00	Departure from Bwangantebure		ALL
13:00 – 14:00	Settle-in		ALL
14:00 – 16:00	1.3 Set Criteria	Open Plenary	TNA Consultants
16:00 – 18:00	1.4 Assign weights to the criteria	Open Plenary	TNA Consultants
DINNER			
DAY 2 – Thursday 12th December 2025			
09:00 – 10:00	1.5 Assign sores to technologies according to the criteria (Adaptation)	Open Plenary	TNA Consultants
Morning Tea			
10:30 – 11:30	1.5 Assign sores to technologies according to the criteria (Mitigation)	Open Plenary	TNA Consultants
11:30 – 12:30	1.6 Combine scores and weights (Adaptation)	Open Plenary	TNA Consultants
LUNCH			
13:30 – 14:30	1.6 Combine scores and weights (Mitigation)	Open Plenary	TNA Consultants
14:30 – 15:30	1.7 Examine results and conduct sensitivity analysis (Adaptation)	Open Plenary	TNA Consultants
15:30 – 17:30	1.7 Examine results and conduct sensitivity analysis (Mitigation)	Open Plenary	TNA Consultants
Afternoon Tea and Workshop Adjourned			
DAY 3 – Friday 13th December 2025			
Breakfast			
09:00 – 11:00	Space to Improve things needed	Open Plenary	ALL
11:00	Backup and Return to South Tarawa		ALL

Annex 6: Participants list for the Adaptation working group – Retreat 11-13th December, 2024



Adaptation working Group 11/12/24

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Annex 7: Retreat Summary Report – Adaptation Working Group

Retreat 11-13th December, 2024

Venue: Midland Resort, Tabiteuea, North Tarawa

Adaptation working group

This report summarises main activities and outcomes that the Adaptation working group achieved during the retreat period.

Stakeholders that involved as members of the adaptation working group include the following;

1. Ministry of Infrastructure and Sustainable Energy
    a. Bwetina Teariki (WSED)
    b. Tebano Erene (CED)
2. Ministry of Environment, Lands and agriculture Division
    a. Kauanga Etekieru (ALD)
    b. Kaaroti Henry (ECD)
3. Ministry of Culture and Internal Affairs
    a. Raeterenga Kiaitoka (RPD)
4. Ministry of Fisheries and Oceans Development
    a. Toatu Ameriba (GSD)

    b. Rateiti Vaimalie (CFD)
5. Office of Teberetitenti
    a. Tokannabiri Rati (DRMU)

Day 1:

Plenary session – opening session, meeting stakeholders and introducing purpose and session outlines.

Presentation:

6. **Recapping on previous meetings outcomes**
    a. **Presentations**
        1. Overall guide of the TNA processes
        2. Discussion; outcomes of step 1.1 – 1.2 from previous meeting for adaptation and mitigation
7. **Technology Fact Sheet**
    i. Geobag
    ii. Mass concrete seawall
    iii. Green-grey infrastructu
    iv. Groyne
    v. Coastal rehabilitation by land reclamataion

Stakeholders reached a consensus to expand the initial proposal to include coastal rehabilitation by land reclamation, emphasizing the need for solutions that protect land from coastal erosion. This technology has been successfully implemented in Kiribati and similar regions, albeit at varying scales. The addition suggests that the technology should be informed by lessons learned from neighbouring countries while being specifically tailored to address the unique climate change challenges faced in Kiribati.

This technology not only effectively serves its primary purpose but also significantly enhances the island's resilience against the adverse effects of climate change. It contributes to the rehabilitation of reclaimed land by promoting the growth of trees and food crops, safeguarding buildings from coastal erosion, and stimulating both private and public investments to foster new business opportunities.

8. **Going through the details on each Technology Fact Sheet**

    The discussion in this session drew upon the technical expertise of participants representing the Civil Engineering Department as well as the empirical insights offered by members of the adaptation group. The Adaptation Consultant effectively presented the available facts regarding various technologies, while also highlighting that most of these technologies have yet to be tested or implemented in Kiribati.

1. **Geobag** - Geobags are specialized containers made from high-strength textile materials designed for durability and longevity. Recommended by civil engineers, these bags have yet to be implemented in Kiribati, making it difficult to assess their effectiveness based on local conditions. The textiles used in geobag manufacturing are particularly engineered to hold sand, which positions them as a viable alternative to traditional sandbags.

   While geobags share a superficial resemblance to standard bags, they are uniquely crafted for specific applications in construction and erosion control. However, the primary concern lies in their longevity, especially concerning how well the textile can withstand physical abrasion from external elements.

   Cost considerations for geobags remain unclear, as there is limited information available about their pricing. Nevertheless, stakeholders have raised concerns about potential financial implications tied to the adoption of this technology. Compared to conventional sandbags, geobags may incur higher costs due to their advanced design features, which enhance their capacity to resist wave action and securely contain sand.

   In summary, while geobags offer promising advantages in terms of durability and functionality, further investigation into their performance and cost-effectiveness in the context of Kiribati is essential before making implementation decisions.

2. **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 $20,000 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.

3. **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.
4. **Groyne –** Interest in the technology has been limited due to its relatively ineffective role in safeguarding coastlines from wave overtopping and rising sea levels. While it is often touted for its ability to build sand along the coast, this function is largely passive and insufficient to withstand the forces of currents that can accelerate coastal erosion. Furthermore, the cost of implementing this technology does not align with the pressing need for robust solutions to combat severe erosion along vulnerable shorelines.
5. **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.

Day 2

1. Identifying criteria **– step 1.3**

Criteria	**Description**
Cost	Cost to setup
Economic	Preserving property/asset values
	Trigger Public and private investment
Social	Inclusivity (size of beneficaries)
Environmental	Contribution of the technology to protect and sustain ecosystem Services
Climate related	Improvement of resilience to climate change (i.e. to what extent the technology will contribute o reduce vulnerability to ease of climate change impacts).
Institutional/other	Ease of implementation
	Replicability
Political	Coherence with national development policies and priorities

2. Assigning weight to criteria **– step 1.4**

	Criteria	Weight
Cost	Cost to setup	12
	Preserving property/asset values	13

Economic	Trigger Public and private investment	7
Social	Inclusivity (size of beneficiaries)	14
Environmental	Contribution of the technology to protect and sustain ecosystem Services	15
Climate related	Improvement of resilience to climate change (i.e. to what extent the technology will contribute to reduce vulnerability to ease of climate change impacts).	20
Institutional/other	Ease of implementation	6
	Replicability	5
Political	Coherence with national development policies and priorities	8

3. Performance matrix - Step 1.5

	Cost	Economic		Social	Environmental	Climate related	Institutional/Implementation		Political
	Cost to setup	Preserving property/asset values	Trigger Public and private investment	Inclusivity (size of beneficiaries)	Contribution of the technology to pretect and sustain ecosystem Services	Improvement resilience to climate changes	Ease of implementation	Replicability	Coherence with national development policies and priorities
1. Geobag	Low cost: 30	Low: 30	Low:78	High: 78	Medium: 75	High: 80	Medium: 65	High: 75	Low: 25
2. Green and Gray Infrastructure	High: 75	High: 100	High: 85	High:85	High: 90	High: 95	Low: 25	Medium: 40	High: 95
3. Mass concrete seawall	Medium: 69	High: 70	High 80	High: 70	Medium: 50	High: 90	High: 90	High: 95	High: 100
4. Groyne	High: 70	Low: 20	Low: 30	Low: 30	Low: 30	Low:30	Low: 25	Low: 30	Low: 15
5. Costal Rehabilitation	High 96	High: 100	High: 90	High: 95	Medium: 65	High: 98	High: 90	Medium: 65	High: 100
6. Scoring Scale	0-very high cost ->100-very low cost	0-very low -> 100-very high	0- very low ->100- very high	0-very low->100-very high	0-very low-> 100-very high	0-very difficult -> 100 very easy	0-very high cost -> 100-very low cost	0-very high cost-> 100-very low cost	0-very high cost -> 100-very low cost
7. Criterion weight	12	13	7	14	15	20	6	5	8

4. Combining scores and weights – **step 1.6**

	Costs			Economic			Social			Environmental			limate relate	Institutional		Politics
	Set up co	Criterion	Criterion (	Preserving property/assets values	Trigger private/ public investment	Criterion F	Inclusivity/size of brneficiaries	Criterion H	Criterion	contribution of the technology to protect and		Criterion L	Improvement of resilience to climate change	Ease of implementation	Replicability	alignment to Govt policies
	Unit /Scal	Unit /Scal	Unit /Scal	h/m/l	h/m/l	h/m/l	h/m/l	Unit /Scal	Unit /Scal	h/m/l	Unit /Scal	Unit /Scale	h/m/l	h/m/l		h/m/l
Geobag	39			L	l		h			h			h	m	h	l
Green-grey Infrastructure	75			h	h		h			h			h	l	m	h
Mass concrete sea wall	69			h	h		h			m			h	h	h	h
Groyne	70			L	l		l			l			l	l	l	l
Coastal rehabilitation	96			h	h		h			m			h	h	m	h

Scoring Matrix (For each criterion scores should vary from 0 to 100)

	Costs			Benefits													
				Economic			Social			Environmental			limate relate	Institutional		Politics	
	Set up co	Criterion	Criterion (	Preserving property/assets values	Trigger private/ public investment	Criterion F	Inclusivity/size of brneficiaries	Criterion H	Criterion	contribution of the technology to protect and		Criterion L	Improvement of resilience to climate change	Ease of implementation	Replicability	alignment to Govt policies	
	Unit /Scal	Unit /Scal	Unit /Scal	Unit /Scal	Unit /Scal	Unit /Scal	Unit /Scal	Unit /Scal	Unit /Scal	Unit /Scale	Unit /Scal	Unit /Scale	Unit /Scale	h/m/l			
Geobag	100			30	30		78			75			80	65	75	25	
Green-grey Infrastructure	20			100	85		85			90			95	25	40	95	
Mass concrete sea wall	50			70	80		70			50			90	90	95	100	
Groyne	30			20	30		30			30			30	25	30	15	
Coastal rehabilitation	10			90	90		95			65			98	90	65	100	
Criterion weight	12			13	7		14			15			20	6	5	8	should add to 100

Decision Matrix: Weighted Scores																	
	Costs			Benefits													
				Economic			Social			Environmental			limate relate	Institutional		Politics	
	Set up co	Criterion	Criterion (	Preserving property/assets values	Trigger private/ public investment	Criterion F	Inclusivity/size of brneficiaries	Criterion H	Criterion	contribution of the technology to protect and		Criterion L	Improvement of resilience to climate change	Ease of implementation	Replicability	alignment to Govt policies	
	Unit /Scal	nit /Scal	nit /Scal	nit /Scal	Jnit /Scal	nit /Scal	Unit /Scal	nit /Scal	nit /Scal	Unit /Scal	Unit /Scal	Unit /Scale	Unit /Scale	h/m/l			
Geobag	1200	0	0	390	210	0	1092	0	0	1125	0	0	1600	390	375	200	**6382**
Green-grey Infrastructure	240	0	0	1300	595	0	1190	0	0	1350	0	0	1900	150	200	760	**6925**
Mass concrete sea wall	600	0	0	910	560	0	980	0	0	750	0	0	1800	540	475	800	**6615**
Groyne	360	0	0	260	210	0	420	0	0	450	0	0	600	150	150	120	**2600**
Coastal rehabilitation	120	0	0	1170	630	0	1330	0	0	975	0	0	1960	540	325	800	**7050**
Criterion weight	12	0	0	13	7	0	14	0	0	15	0	0	20	6	5	8	**100**

Step 1: Add your criteria: B6 - N6
Step 2: Add your options: A8 - A17
Step 3: Rate how well the options contribute to each criterion: B8 - N17
Step 4: Covert your ratings into a score from 0 to 100 for each of the options B24 - N33
Step 5: Add criteria weights: B35 - N35
Step 6: View weighted results and total score in second table, 'Weighted Scores': B41 - N50

5. Result examination During the final review process, a minor disagreement was identified regarding incorrectly inputted scores in the template. This issue came to light when the results were presented to the group, prompting questions and expectations from team members. Since everyone actively participated in the discussion, they collectively agreed to address the error.

This led to the the team re-evaluated the scoring input in the template, which revealed that certain points had been overlooked. This prompted a minor adjustment that ultimately satisfied all members of the team. As a result, the second-ranked technology, coastal rehabilitation, became the group's chosen option, now fully endorsed by everyone involved.

Coastal rehabilitation with land reclamation

Closing plenary session – Presentations from Adaptation and Mitigation consultant on their group evaluation outcomes.

Annex 7: Technology Factsheet

Technology Factsheets for Coastal Erosion Adaptation sector

Adaptation Technology 1: Coastal Rehabilitation by land reclamation	
1. Sector	Coastal Erosion
2. Technology Characteristics	
2.1 Technology Name:	Coastal rehabilitation by land reclamation
2.2 Introduction:	**Definitions** **This is an extract from the Ministry of Fisheries and Ocean Resources project proposal that was submitted to Ministry of Finance and Economic Planning to seek for a funding support.** The primary technology utilized in this project is Coastal Rehabilitation by land reclamation, aimed specifically at safeguarding areas severely impacted by rising sea levels and storm surges, including wave overtopping. The extent of the reclaimed land will be determined by the size of the targeted area and the available budget for implementing the project. **<u>Background</u>** The limited landmass of Kiribati, coupled with the looming threat of climate change, is profoundly impacting its communities. Coastal protection measures, such as seawalls, are currently the most prevalent solution employed to combat these issues. However, these measures are often unsustainable and financially burdensome, as the costs for construction frequently fall on local residents.

	Meanwhile, the booming population, coupled with an increase in car imports and limited land availability, has led to several critical challenges. These include the rapid spread of diseases, a rise in road accidents, and the looming threat of rising sea levels that jeopardize crops, households, and freshwater resources. Given these pressing issues, there is an urgent need for land reclamation to create climate-resilient infrastructure and foster sustainable development. The South Tarawa Coastal Resilience Project aims to address these challenges by implementing land reclamation strategies. This initiative will not only increase the landmass but will also enhance adaptation to climate change, thereby reducing associated risks while providing valuable opportunities for much-needed development in the region. **<u>Climate Rational for the technology</u>** The technology as anticipated will improve community and country resilience against the pressing climate change and disaster risks problems by; 1. enhancing coastal resilience by Land reclamation. 2. Create buffer zones in high risks area around South Tarawa 3. Provide space for climate-resilience infrastructures. 4. Create Safer Land from the Sea 5. Provide land for income generating infrastructure development.

2.3 Technology Characteristics/ Highlights: Few bullet points, i.e. low/high cost; advance technology; low technology.	A small scale land reclamation project could target; 1. Specific areas: Targeting critically eroded and inundated areas or creating safe land to reduce community vulnerability and exposure to erosion and inundation 2. Natural materials: Utilizing techniques like using dredged sand from designated areas within minimal ecological impact 3. Community involvement: incorporating local knowledge and participation in the planning and execution of the project to ensure its effectiveness and sustainability
2.4 Institutional and Organizational Requirement:	The successful implementation of the project will necessitate a collaborative effort that leverages the expertise of various institutions, each bringing their unique specialties to the table. For instance, the following partners could be integral members of the project team: • TACL – Dredging Operation • MISE – Architecture and Structural Design • LANDS – Landscaping concept design • GSD – Preliminary Surveys and geotechnical studies • MELAD – Environmental Impact Assessments and Management Plan • FINANCE – Securing Funds and financial project management
3.0 Operations and maintenance	
3.1 Endorsement by Experts:	This technology proposal outlines a strategic framework for Coastal Adaptation—an imperative initiative aimed at proactively addressing the

	vulnerabilities of our coastal zones. Hence, the Project aims to build resilience by land reclamations in potential areas around south Tarawa to withstand and exceeds sea level risks in the future.
3.2 Adequacy for current climate: Are there negative consequences of the adaptation option in the current climate? Some adaptation may be targeted at the future climate but may have costs and consequences under the current climate.	Large scale projects can be expensive and disruptive to the environment. A small-scale land reclamation project could potentially targeting specific areas which are critically eroded and inundated areas or creating safe land to reduce community vulnerability and exposure to erosion and inundation. Land reclamation projects often face scrutiny due to their potential impact on marine ecosystems, coastal habitats, and water quality. Retaining walls must be designed and constructed with environmental sustainability in mind, minimizing disruption to natural processes and mitigating any negative effects on biodiversity and water resources.
3.3 Size of beneficiaries group: Technology that provides small benefits to larger number of people will often be favoured over those that provide larger benefits, but to fewer people.	Beneficiaries include the household sectors, business houses, government departments, schools, health, and private sectors. There will be no individual or group of people who would be primary beneficiaries of such developments. While homes located at the identified locations may directly benefit from such undertakings, the positive externality to the community at large is immeasurable. The benefits are distributed and shared among almost everyone on the Islands.
4. Costs	

4.1 Cost to implement adaptation options: Cost measures	The cost varies which based on the height above the sea level, volume of infill and other materials, machineries, and other technical inputs. By comparison the cost of the technology varies in the region; 1. In Tuvalu the cost ranges from $49 - $123 millions for a 6.61 hectare reclaimed land 2. Denarau in Fiji cost ranges from more than $3 – 9 millions 3. Maldives cost ranges between $6 – 16 million Considering the similarities between Kiribati and Tuvalu, the cost estimates proposed for the Tuvalu project can be reasonably applied to Kiribati. For instance, the cost of constructing 6.61 hectares in Tuvalu is projected at $49 million, which translates to approximately $104,346 per cubic meter. However, it is important to note that costs can fluctuate based on several factors, including elevation above sea level, the volume of infill required, and the types of materials and machinery utilized. These costs may also be subject to adjustments depending on the availability of funding. Additionally, it's crucial to recognize that this estimate excludes ongoing maintenance expenses, which can range from **thousands to potentially millions of dollars over time.**

4.2 Additional costs to implement adaptation option, compared to "business as usual"	There maybe different versions of the technology which also warrant different financial needs.
5.0 Benefits	
5.1 Development impact, indirect /benefits	The most likely development impact would be opportunities enhanced for public and private investment

5.2 Economic benefits: **Employment –Jobs** **Investment** – Capital requirements	The newly reclaimed area has the potential to become a dynamic hub for both public and private investment. These investments can generate significant job opportunities, enhance marketing potential for various commodities, and create a fertile environment for diverse businesses to establish themselves. This vibrant ecosystem can support a wide range of services, fostering economic growth and community development in the process.
5.3 Social benefits: **Income** Income generation and distribution **Education** – Time available for education **Health** – Number of people with different diseases.	To gain support for green infrastructure designs, it's essential to engage multiple stakeholders effectively. This includes: Land Acquisition: Ensure the feasibility of purchasing land or influencing its use to facilitate the project. Community Engagement: Foster long-term support from local communities. Partnerships: Collaborate with local governments and civil society organizations to build coalitions that advocate for natural system integration.

	Social Cobenefits: Create mutually beneficial solutions that provide advantages for affected communities and address any potential negative social impacts.
5.4 Environment benefits:	Reclaimed land represents an expansion of usable land that has the potential to support tree growth, which can effectively contribute to the environmental benefit through enhancing ecosystem services.
Reductions in GHG emissions, local pollutants, Ecosystem degradation etc.	Reclaimed land represents an expansion of usable land that has the potential to support tree growth, which can effectively capture greenhouse gases and contribute to the reduction of overall emissions.
6. Local context	
6.1 Opportunities and Barriers: Barriers to implementation and issues such as the need to adjust other policies.	The success of the technology developed from projects implemented across the region can serve as a valuable baseline for making informed decisions about the project's viability. Although the costs may be higher, it is essential to consider this investment against the potential benefits that the technology could bring to the country and local communities. Ultimately, this assessment could highlight a worthwhile trade-off.
6.2 Status: Status of technology in the country	The successful implementation of the smaller version of the technology has demonstrated the feasibility and potential effectiveness of deploying a larger version.
6.3 Timeframe: Specify timeframe for implementation	36 months

6.4 Acceptability to local stakeholders: Where the technology will be attractive to stakeholders	Yes

Adaptation Technology 2: Green – Grey Infrastructure	
1. Sector	Coastal Erosion (CE)
2. Technology Characteristics	
2.1 Technology Name:	Green – Grey Infrastructure
2.2 Introduction:	**Definitions** 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 gray infrastructure to produce more resilient and lower-cost services. Gray 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 gray infrastructure. 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.” **<u>Background</u>** Integrating Green and Gray Infrastructure shows how weaving the power of ‘green’ natural systems, including flood plains and forests, into ‘gray’ traditional infrastructure systems can lower cost and increase resilience. Green infrastructure can be cheaper and more resilient than grey infrastructure alone—and it can produce substantial benefits beyond what the balance sheets measure,” said Andrew Steer, President and CEO of World Resources Institute. Kiribati may realize the complexity of the infrastructure unless service providers conduct an early, thorough, and robust assessment to inform the utilization, design, and implementation of combined green-grey solutions. Adaptation planners in Kiribati sometimes recommend a combination of hard measures, to protect key assets from flooding and land loss, and soft measures, to protect against erosion including that indirectly caused by the hard measures. **<u>Climate Rational for the technology</u>** Integrating Green and Gray Infrastructure which means weaving the power of ‘green’ natural systems, including flood plains and forests, into ‘gray’ traditional infrastructure systems can lower cost and increase resilience. These nature-based solutions can help us meet the

	infrastructure investment gap in a cost-effective manner, while lifting up local communities with benefits in their backyards. We're at a climate inflection point, and in the midst of an infrastructure crisis. Now more than ever, the world must tap into nature's wealth.

2.3 Technology Characteristics/ Highlights: Few bullet points, i.e. low/high cost; advance technology; low technology.	• It is a clean and green technology that plays a number of advantage roles to the ecosystem as well as to people in the community. • In most cases, community engagement in the project is vital to strength community ownership to serve as custodians of the project. • Strategically combining green and gray infrastructure to lower costs and improve resiliency can help tackle the looming financial and environmental crisis facing global infrastructure systems. With the right conditions, green infrastructure components can cost-effectively enhance service delivery, while also empowering communities and increasing infrastructure systems' resilience and flexibility in a changing climate

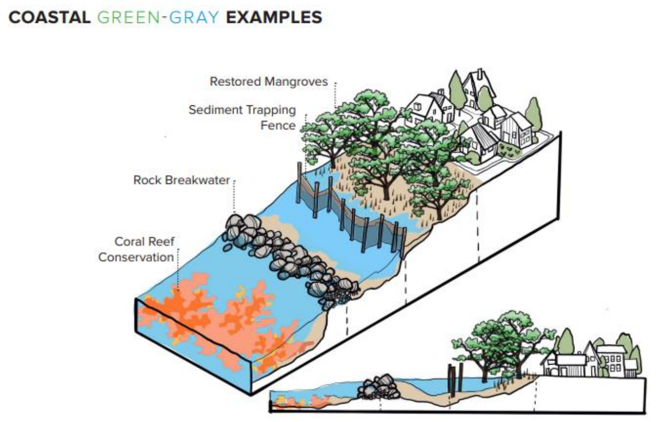
2.4 Institutional and Organizational Requirement:	Exploring and amplifying the power of nature-based solutions is a key priority for the World Bank. That's why the Bank is working with partners

	including GFDRR (Global facility of Disaster Reduction and Recovery) and GWSP (Global Water Security & Sanitation Partnership) on the Nature-Based Solutions (NBS) initiative
3.0 Operations and maintenance	
3.1 Endorsement by Experts:	Building community resilience and adaptation amidst the continuing threat climate change is superimposing on the way people manage their life is important. Integrating green and grey infrastructure are more culturally accepted and fit in well with the natural system. Preventing coastlines from any further damage due to sea level rise and other catastrophic events will allow any form of economic, social and environmental activities to happen. This from the development point of view is a leverage to achieve an improved livelihood. *In the coastal province of Ca Mau, for example, the project is working to restore and expand mangroves in conjunction with rehabilitating existing sea dikes.* *"This has a double-dividend for local communities. Firstly, it helps protect them from flooding and coastal erosion. Secondly, it also offers new and innovative economic opportunities, better aligned with the subregion's natural soil and water conditions. This includes promoting mangrove-shrimp systems– which are less intensive, more organic, and can help farmers become internationally certified as sustainable seafood operations. This means they can fetch a premium price in the market, therefore increasing their revenues."*

3.2 Adequacy for current climate: Are there negative consequences of the adaptation option in the current climate? Some adaptation may be targeted at the future climate but may have costs and consequences under the current climate.	The mixed success of green infrastructure projects to date suggests that these advantages may not be realized unless service providers conduct an early, thorough, and robust assessment to inform the utilization, design, and implementation of combined green-grey solutions. Fits well for both the current and future expected climate change across the country. Since the forecasts are predicting future SLR with increasing intensity and frequency of storm surges which may cause further coastal erosion and washing away of beaches, such NbS coastal planting at identified vulnerable locations around the island would be beneficial to the communities at large.
3.3 Size of beneficiaries group: Technology that provides small benefits to larger number of people will often be favored over those that provide larger benefits, but to fewer people.	Beneficiaries include the household sectors, business houses, government departments, schools, health, and private sectors. The NbS coastal planting would ensure the general community at large is protected. There will be no individual or group of people who would be primary beneficiaries of such developments. While homes located at the identified locations may directly benefit from such undertakings, the positive externality to the community at large is immeasurable. The benefits are distributed and shared among almost everyone on the Islands.
4. Costs	

4.1 Cost to implement adaptation options: Cost measures	In 2010, Onondaga County became one of the first communities to share the costs of widespread green infrastructure implementation with the private sector, according to a business case evaluation. The county's Green Infrastructure Fund is available in specific

	combined sewer sheds. Since its inception, the program has provided more than $7 million in funding on projects that have captured more than 110,000 m^3 (29 million gal) across the City of Syracuse. As of July 2015, this grant program has led to the development of 76 projects. Construction on the green infrastructure components of these projects cost $8.3 million as part of more than $18 million in overall redevelopment. Average constructed costs of $462,000 per hectare of impervious area managed ($187,000 per acre) are competitive with other cost-effective implementation programs. From the above example, Kiribati can build a simple version of the technology by incorporating soft measures such as planting mangroves combined with building hard structures to further strengthen Phase III of the KAP project in Kiribati budgeted US$2.8 million for coastal protection, which includes protecting an ambitious 1.6 km of shoreline for a 25-year period using various measures, maintenance funds for three of the 25 years, as well as advisory support and other inexpensive supporting projects. A $2.8 millions to invest in 300 meters to build a simple version of a green-grey infrastructure seawall is sufficient to put the technology on trial in Kiribati.

	 **BREAKWATERS** reduce wave energy to buffer impacts of weather events to vulnerable communities and facilitate sediment accumulation for ecosystem restoration, such as for mangroves.
4.2 Additional costs to implement adaptation option, compared to "business as usual"	There may be different versions of the technology, each requiring distinct financial needs.
5.0 Benefits	
5.1 Development impact, indirect /benefits	Below would likely be some of the major benefits on the communities. • Eco system is restored along the implemented coastal line communities. There is high confidence of wellbeing and food security. • Safety and security of the community alone the coast lines: it is the primary motivator for the implementation this sea wall structure, meaning more households/ public depends on the secure and safer environment from coastal erosion. • Contributing to food security by households participating in backyard gardening since they now have access to safer land growing some of their basic crops supplementing their budgets. • Roads, electricity and perhaps water are an integral part of the system

5.2 Economic benefits: **Employment –Jobs** **Investment** – Capital requirements	ECONOMIC DIMENSIONS: Can the green infrastructure be justified in terms of cost, as well as in broader economic terms? ▪ Cost-effectiveness: Assess whether the proposed project will reduce or at least not significantly increase the cost of service. ▪ Cobenefits: Account for the environmental and social cobenefits using quantitative and qualitative indicators. ▪ Multi-criteria Analysis: Systematically consider all relevant factors, including monetary and nonmonetary benefits to determine if the project is justified Some of the directs benefits realized in places where the technology has been implemented. Based on the World Bank report, project in Brazil, forests filter biological impurities to protect water sources and reduce the need for expensive water treatment plants upgrades. In Vietnam, mangroves are used as a first line of defense against typhoons and sea surges, helping to reduce investments in expensive man-made sea dikes. And in Somalia, natural river sediments are trapped behind dams, helping to recharge local aquifers, thus eliminating the need for deep and expensive groundwater pumps. The report illustrates how emerging technology such as earth-based observations and advanced modelling make it cheaper and easier to design and assess the performance of green infrastructure. It also lays out a new framework for practitioners and service providers to

	integrate green infrastructure into gray, including technical, environmental, social, and economic dimensions. The report finds that integrating green and gray infrastructure can help deliver a "triple-win" with benefits for the economy, communities, and the environment. "Green infrastructure can be cheaper and more resilient than gray infrastructure alone—and it can produce substantial benefits beyond what the balance sheets measure," said Andrew Steer, President and CEO of World Resources Institute.
5.3 Social benefits: Income Income generation and distribution Education – Time available for education Health – Number of people with different diseases.	SOCIAL DIMENSIONS: Is it possible to get multiple stakeholders to support the proposed green infrastructure design? ▪ Land: Ensure that it's possible to purchase land or influence land use to support the project. ▪ Communities: Obtain local community support, particularly over the long run. ▪ Government and civil society partners: Work with local governments and relevant government agencies in coordination with civil society organizations to help build strong coalitions to support use of natural systems. ▪ Social cobenefits: Develop win-win solutions so that affected communities benefit from green infrastructure; identify any negative social impacts and ensure they are mitigated.
5.4 Environment benefits:	Coastal erosion caused by SLR will be controlled and managed at these sites because of the NbS Sea wall design at the local level. Addition to the revitalization of the

Reductions in GHG emissions, local pollutants, Ecosystem degradation etc.	Ecosystem - the replanting of vegetation at these sites may also contribute towards reduction of the GHG and pollution into the atmosphere.
6. Local context	
6.1 Opportunities and Barriers: Barriers to implementation and issues such as the need to adjust other policies.	This project is promoted by the World Bank which can provide funding support to implement the project. Barriers include lack of access to finance for promotion and awareness of communities etc. According to IPCC report, sea wall (hard structure) is an example of mal adaptation at the local communities. Thus, communities must made aware of this technology. Furthermore, higher amount of initial investment may involve compared to other adaptations options. Technical requirements such as V&A, EIA and structural design may increase implementation and maintenance costs.
6.2 Status: Status of technology in the country	Certain communities have already participated in forms of NbS coastal rehabilitation across the country. However, the rate of soil erosion is worrisome and thus calls for prioritizing of this technology at selected vulnerable sites across islands.
6.3 Timeframe: Specify timeframe for implementation	36 months
6.4 Acceptability to local stakeholders:	Yes

Where the technology will be attractive to stakeholders	

Adaptation Technology 3: Mass concrete structure seawalls	
1.0 Sector	Coastal Erosion (CE)
2.0 Technology Characteristics	
2.1 Technology Name:	Construction of hard structure seawall (Mass concrete).
2.2 Introduction:	*<u>Background</u>* A mass concrete seawall is typically a sloping concrete structure; it can be smooth, stepped-faced, or curved-faced. It can also be built as a rubble-mound structure, a block seawall, a steel seawall, or a wooden seawall. The common characteristic is that the structure is designed to withstand severe wave action and forces and storm surge. Seawall construction is a fast-growing industry. **See figure 1 below**. It's a great way to improve residential and commercial properties that are bordered by water. Many property owners see the advantages of seawall construction to protect the environment and their property. **Figure 1: Seawall structure** 

	One of the primary environmental concerns today is land erosion. As sea levels rise, coastal erosion increases. Awareness of this is rising in a social consciousness level, as we become more educated about the interaction of land and water on our planet. However, coastal communities are particularly aware of the effects of erosion. For them, it has a very direct effect on the livelihoods and continue existence at their communities. **Climate rationale for the Technology** • Protect coastal areas from acute erosion adversities • Protect beach erosion from wave overtoppings • Protect community or private infrastructure from sea level rise and coastal erosion • Reclaim land which can be turned into a productive area
2.3 Technology Characteristics/ Highlights: Few bullet points, i.e. low/high cost; advance technology; low technology.	• High cost (potentially high initial cost) • Low technology (requires cements, movement of ground, concretes, etc.) • Hard Technology

2.4 Institutional and Organizational Requirement:	The Ministry of Infrastructure and Sustainable Energy (MISE) and the Office of Te Beretitenti (OB) will provide institutional and organizational support to the formulation and implementation of this project.
3.0 Operations and maintenance	

3.1 Endorsement by Experts:	To strengthen and improve community resilience and prevent coastal erosion, it is crucial to implement seawall structures and refurbish coastline areas at selected vulnerable sites across the island. This approach would ensure the continuity of businesses along the coast, even during strong winds, storm surges, and catastrophic events. Coastal communities would be protected against the risks associated with climate change and extreme storms if seawalls are constructed at these identified locations. This would allow business owners to focus on their operations without the constant worry of their homes being swept away in the coming years and the entire community to enjoy life along the coastal areas. The catastrophic profound effect of an acute coastal erosion across the entire country could lead into reducing the EZZ thus harming the nation's sovereignty.
3.2 Adequacy for current climate: Are there negative consequences of the adaptation option in the current climate? Some adaptation may be targeted at the future climate but may have costs and consequences under the current climate.	Fits well for both the current and future expected climate change across the Island. Since the forecasts are predicting future SLR with increasing intensity and frequency of storm surges which may cause further coastal erosion and washing away of beaches, such sea wall constructions at identified vulnerable locations around the island would be beneficial to the communities at large.
3.3 Size of beneficiaries group: Technology that provides small benefits to larger number of people will often be favoured over those that provide larger benefits, but to fewer people.	Beneficiaries include the household sectors, business houses, government departments, schools, health, and private sectors. The sea wall structure build would ensure the general community at large is protected. There will be no individual or group of people who would be primary beneficiaries of such developments. While homes located at the identified locations may directly benefit from such undertakings, the positive externality to the community at large is immeasurable. The benefits

	are distributed and shared among almost everyone on the Islands.
4. Costs	
4.1 Cost to implement adaptation options: Cost measures	The cost of building seawalls in Kiribati is generally varies significantly depending on the project scale and materials used. • 1Kiribati Adaptation Program (Phase II): Constructing 500 meters of seawall cost approximately $7.7 millions, equating to about $15,400 per meter • 2Bairiki seawall Project: A smaller project to construct 112 meters of seawall and reclaim of land was estimated at $2 millions or about $17,860 per meter • OB Seawall budgeted for $20,000 per M3 Due to fluctuations in material costs and the location of imports, the expense of constructing a seawall in Kiribati varies between $15,400 and $17,860 per cubic meter. Maintenance costs for a seawall are closely tied to the extent of damage it incurs. The level of damage is influenced by several factors, including the seawall's design, the quality of construction, and the materials used. The rate the OB is using is safe for building seawalls. However, as mentioned above, the increased price of overseas materials could lead to greater variability in the project's total cost.

	[1]https://www.worldbank.org/en/results/2012/04/16/kiribati-adaptation-program-phase-2 [2]eia-lds-bairiki-seawall-land-development-project (_250204_194528.pdf

4.2 Additional costs to implement adaptation option, compared to "business as usual"	The additional costs which may be required to implement this technology includes cost for beach nourishment and replanting of trees to ensure long term resilience is achieved at these coastal areas. The cost is factored into the initial costs above.
5.0 Benefits	
5.1 <u>Development impact, indirect /benefits</u>	The new initiative would reduce coastal erosion and bring confidence in the communities along the coast lines areas that their properties are safe and can continue with development initiatives at these sites. Below would likely be some of the major benefits on the communities. • Safety and security of the community alone the coast lines: it is the primary motivator for the implementation this sea wall structure, meaning more households/ public depends on the secure and safer environment from coastal erosion. • Contributing to food security by households participating in backyard gardening since they now have access to safer land growing some of their basic crops supplementing their budgets. • There wouldn't be disruptions on major infrastructures such as roads, electricity and perhaps water when it is reticulated.

	• More funding will spend on economic development by the government rather than just building a seawall or barriers which would be seen uneconomical to this cash trapped nation.
• 5.2 Economic benefits: • Employment –Jobs • Investment - Capital requirements	• Construction of the sea wall various locations around in the country would create tens of jobs to Solomon Islanders for the next 12 to 18 months. • This will ensure that locals participate in construction, maintenance, and rehabilitation of the beaches during the implementation stages. • The general community will continue to live and operate their business at the coastal areas thus contributing to the economic growth of the country. • Mostly locals that participate in this technology would earn the income and support their families to meet school fees and other related expenses.

5.3 Social benefits: **Income** Income generation and distribution **Education** – Time available for education **Health** – Number of people with different diseases.	• The Social benefit of this technology on the households is that they are secured and protected from impact of SLR and coastal erosion. The little money they earn could now be invested in other income generating activities to improve their livelihood rather than worrying about the coastal erosion. • The sea wall will be constructed at areas which are vulnerable to coastal erosion and SLR. The responsible authorities must ensure that primary and secondary schools across the island are safe and secure from such impact of SLR. This will ensure the youths and the weak are protected from the SLR and soil erosion. • Subsequently, health and gender issues will be considered and filtered through every process of decision making in this project.
5.4 Environment benefits: Reductions in GHG emissions, local pollutants, Ecosystem degradation etc.	Coastal erosion caused by SLR will be controlled and managed at these sites because of Sea wall structure construction etc. Replanting of vegetation at these sites may also contribute towards reduction of the GHG and pollution into the atmosphere.
Local context	
6.1 Opportunities and Barriers: Barriers to implementation and issues such as the need to adjust other policies.	Sea wall construction is a technology that can be employed in conjunction with other adaptation measures such as Coastal zone management – and locally managed protected area etc. In the case of Kiribati there must be a lot of investment and commitment into these options to make them viable Sea wall construction increases the

	opportunities for effective resilience with different purposes (domestic, agriculture use, etc.) Barriers include lack of access to finance for purchasing of these structures and awareness by communities etc. According to IPCC report, sea wall (hard structure) is an example of mal adaptation at the local communities. Furthermore, higher amount of initial investment may involve compared to other adaptation options. Technical requirements such as V&A, EIA and structural design may increase implementation and maintenance costs. – Although sea wall structural construction may be costly and expensive, it is cheaper on the longer run. A low level of public awareness is critical to support the technology.
6.2 Status: Status of technology in the country	Certain communities have already constructed some structures of sea wall but with stones stacked together to form seawalls around the Island. However, most of these seawalls were built far out into the ocean that the continuing force of waves could slowly weaken the structure overtime and thus cause the structure to collapse if there is no regular maintenance. A more stable seawall has been experienced with the adoption of a hard structure seawall.
6.3 Timeframe: Specify timeframe for implementation	36 months

6.4 Acceptability to local stakeholders: Where the technology will be attractive to stakeholders	Yes

Adaptation Technology 4: Geobag Seawalls	
1.0 Sector	Coastal Erosion sector
2.0: Technology characteristics	
2.1: Technology name:	Geobag seawalls
2.2: Introduction	*Background:* Geotextile bags, or geobags, are engineered containers consisting of various geosynthetic materials. These bags are intended to be filled with soil, sand, or other granular materials and strategically put in places susceptible to erosion or landslides. Geobags prevent soil erosion, manage sediment movement, and stabilise slopes, making them a useful tool in a variety of industries ranging from construction and landscaping to environmental restoration

.

Climate rational for the technology

Erosion control: Geobags are extremely effective soil erosion barriers. They work by trapping sediments and preventing them from being blown away by water or wind. Geobags assist in preserving the integrity of landscapes, shorelines, and embankments by limiting the migration of soil particles. This vital function protects natural habitats by ensuring that valuable topsoil is protected and erosion is minimised.

Slope stabilisation: Geobags are crucial in improving the stability of slopes and embankments. They considerably reduce the likelihood of landslides and erosion-induced damage by distributing weight and providing resistance to gravitational forces. This not only protects property and infrastructure but also improves environmental safety, especially in hilly or mountainous areas prone to slope instability.

Flexibility: One of the most notable benefits of Geobags is their extraordinary flexibility. These bags are easily moulded and positioned to meet the precise requirements of a project. Geobags may adapt to the geometry of the location, whether it's a curved shoreline, varied terrain, or special landscaping requirements. Because of their malleability, they may be precisely customised to meet a wide range of landscapes and construction circumstances.

	Cost-effectiveness: Geobags are a cost-effective alternative to standard construction methods such as concrete retaining walls. The savings are due to more cost effective material prices, simplified installation procedures, and decreased labour costs. As a result geobags are a popular choice for a wide range of projects **Rapid installation:** Geobags are valued for their simple and quick installation. This speed can be a game changer in time-sensitive building and repair projects. Geobag installation efficiency results in significant savings in both time and labour expenses. Furthermore, early deployment can assist in minimising erosion or stabilising slopes, reducing the danger of damage during bad weather or catastrophes.
2.3 Technology Characteristics/ Highlights: Few bullet points, i.e., low/high cost; advance technology; low technology	• Geobags have proven to be efficient erosion control and slope stabilisation techniques in a variety of sectors. Because of their adaptability, environmental benefits, and low cost, they are a popular choice for many projects. Whether you're a contractor, landscaper, or environmental enthusiast, investing in geobags can make a huge difference in preserving the natural landscape and protecting essential infrastructure. • Wall Tag provides an extensive selection of high-quality geobags are innovative solutions which ensures the best solutions for slope stabilisation and erosion control projects **Technology brief descriptions** • Medium cost technology and easy to apply • Not require intensive training • Geobags are constructed from a range of materials, including polypropylene, polyester, and nylon. The material of the bag will influence its strength, durability, and cost. • As geobags can be heavy, it is critical to select a bag that is sturdy enough to sustain the weight of the material it will contain. • Geobags can range in price and it is determined by its size, material, and features.

2.4 Institutional and Organizational Requirement:	• Work can be supervised by local bodies such as Island Council and people in the communities • The Ministry of Infrastructure and Sustainable Energy (MISE) will oversee the technical implementation of the project
3.0 Operations and maintenance	
3.1: Endorsement by Experts:	• **Basic physical and chemical functions** The Geobags has good physical and chemical functions, such raw materials can resist ultraviolet corrosion, and the geotextile of this material will not have any adverse effects on the substances in the soil, nor will it degrade, and can well resist insects. corrosion, even aging • **Non-toxic, harmless, friendly and energy-saving** The reason why the Geobags is welcomed by everyone is that it has the function of energy-saving and environmental protection. Now the country pays special attention to the environmental protection of all walks of life, and the Geobags is in line with environmental protection standards. Geobags do not have any toxic effects, and are acid and alkali resistant, corrosion-resistant, and impermeable to the soil, but can penetrate water quality, which is more suitable for plant maintenance and can play a role in beautifying vegetation. • **Geobags can replace other geotechnical materials** Geo bags can be a good substitute for other geotechnical materials, such as cement. The cost of cement is high, and the use of Geobags can reduce costs and achieve the same effect. The Geobags is water permeable, but not permeable to the soil, so it has good protection and stability
3.2 Adequacy for current climate: Are there negative consequences of	• Fits well for both the current and future expected climate change solutions for coastal erosions across the country.

the adaptation option in the current climate? Some adaptation may be targeted at the future climate but may have costs and consequences under the current climate	• Since the forecasts are predicting future SLR with increasing intensity and frequency of storm surges which may cause further coastal erosion and washing away of beaches, • sandbag seawall technology plays a pivotal role to protect • identified vulnerable locations around the island that would be beneficial to the communities at large.
3.3 Size of beneficiaries group: Technology that provides small benefits to larger number of people will often be favoured over those that provide larger benefits, but to fewer people.	**Beneficiaries of such Technology** • Beneficiaries include the household sectors, business houses, government departments, schools, health, and private sectors. • The sandbag seawalls would ensure the general community at large is protected. • There will be no individual or group of people who would be primary beneficiaries of such developments. • While homes located closer to the identified locations may directly benefit from such undertakings, the positive externality to the community at large is immeasurable. • The benefits are distributed and shared among almost everyone on the Islands.
4.0: Cost	
4.1	Kiribati has never invested in this technology, therefore costs associated with the adoption of the technology came from other countries where the technology has been in use for so long.

<table>
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<td>This cost however, is extracted as an example from Kingscliff Beach project, Australia.

A 300m seawall at Kingscliff Beach cost between AUD$ 3-5 millions (inclusive of materials, labour, transportation etc)
Design and Engineering cost AUD$ 8,000
Final cost is depending on scale and location but typically range between thousands to millions for larger projects
The costs associated with maintenance and operations include the following factors:

Site location and accessibility – remote or difficult-to-access sites increase transportation and labour cost. Proximity to material sources can also impact expenses
Soil and Environmental conditions – soil type affects construction complexity; rocky or unstable soil increases costs due to specialized equipment or materials
Design specifications – the height, slope and length of the seawall significantly impact material volume and labour requirement. Taller or steeper walls require more geo bags and structural reinforcement
Material cost – Geo bag prices vary based on size, quality and supplier. Transporting materials over long distances adds to cost
Labour and construction – Skilled labour for filling, placing, and securing geo bags is essential. Labour cost rise with project complexity or urgency
Maintenance needs – Lower initial cost may lead to higher long-term maintenance if material degrade faster or if the design is less durable.

If Kiribati invests $3 million to build a 300-meter sea wall, the cost of $10,000 per cubic meter is significantly lower than the usual costs</td>
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	associated with similar projects. For instance, the KAP III project in Kiribati, which is funded by the World Bank, has a cost of $15,400 per cubic meter, while the LDS Church project costs $17,400 per cubic meter. This only covers material and labour cost. Normally, the maintenance cost will always come from the Government budget which will base on the type of damage to be maintained. Therefore an annual budget of $4,000 is sufficient to cover for the travel cost for Engineers, hire of casuals and material cost. The main task to be performed is to patch up most affected areas and replace broken geobags.
4.2 Additional costs to implement adaptation option, compared to "business as usual"	• The Government standard rate applies.
5.0: Benefits	
5.1 Development impact, indirect /benefits	• The new initiative would reduce coastal erosion and bring confidence in the communities along the coastal areas that their properties are relatively safe and can continue with development initiatives at these sites. Below are some of the major benefits for implementing this technology. • Safety and security of the community along the coastlines: it is the primary motivator for the implementation of the sandbag seawalls, meaning more households/ public depends on the secure and safer environment from coastal erosion. • Contributing to food security by households participating in backyard gardening since they now have access to safer land, growing some of their basic crops supplementing their budgets. • There wouldn't be disruptions on major infrastructures such as roads, electricity and perhaps water supply manual distribution on the Island.

	• More funding will spend on economic development by the government rather than just building a seawall or barriers which would be seen uneconomical to this cash trapped nation.
5.2 Economic benefits: Employment – Jobs Investment – Capital requirements	• Investment into coastal area geobag seawall at selected areas across the country would create tens or hundreds of jobs for the next 12 to 16 months. • This will ensure that locals participate in landfilling during the implementation and maintenance stages of the technology. • The general community will continue to live and operate their business at the coastal areas thus contributing to the economic growth of the country. • The locals that participate in this technology would earn the income and support their families to meet school fees and other livelihood expenses.
5.3 Social benefits: Income: Income generation and distribution Education – Time available for education Health – Number of people with different diseases.	• The Social benefit of this technology on the households is that they are secured and protected from impact of SLR and coastal erosion. • The little money they earn could now be invested in other income generating activities to improve their livelihood rather than worrying about the coastal erosion. • The coastal areas which are vulnerable to coastal erosion and SLR will now have some protection against • acute salt water intrusion. The responsible authorities must ensure that primary and secondary schools across the island are safe and secure from such impact of SLR. This will ensure the youths and the weak are protected from the SLR and soil erosion. • Subsequently, health and gender issues will be considered and filtered through every process of decision making in this project.

5.4: Environment benefits: Reductions in GHG emissions, local pollutants, Ecosystem degradation etc.	• Coastal erosion caused by sea level rise will be controlled and managed at these sites because of sandbag seawalls etc. • Replanting of vegetation mainly at the reclaimed coastal area at these sites may also contribute towards reduction of the GHG and pollution into the atmosphere. • It will also improve the beach environment and ecosystem and directly strengthen soil aggregating hence, reduce the soil loss due to erosion.
6.0: Local context	
6.1 Opportunities and Barriers: Barriers to implementation and issues such as the need to adjust other policies.	**Opportunities** • Geobag seawalls is a technology that can be employed in conjunction with other adaptation measures such as coastal zone management • Locally managed marine area including coastal replanting as barriers is possible etc. In the case of Kiribati there must be a lot of investment and commitment into these options to make them viable. • Geobag seawalls would increase the opportunities for improving resilience with different purposes (domestic, agriculture use, etc. **Barriers** • Barriers include lack of access to finance to invest in land fillings along the vulnerable coastal areas, • Lack of policies by the National government surrounding management of beaches and awareness by communities on the devastation impact of climate change etc. • This option would be relatively cheaper compared to other adaptations options. Technical requirements such as V&A, EIA and structural design may increase implementation and maintenance costs. • Although geobags seawalls may be accruing some initial costs, it is cheaper on the longer run. A low level of public awareness is critical to support the technology.

6.2 Status: Status of technology in the country	**Technology Status** • Certain communities have already participated in programs design to protect coastal soil erosion within the country. • However, the rate of soil erosion is worrisome and thus calls for prioritizing of this technology at selected vulnerable sites across the Islands. • Timeframe is continuous
6.3 Timeframe: Specify timeframe for implementation	36 months
6.4 Acceptability to local stakeholders: Where the technology will be attractive to stakeholders	Yes

Adaptation Technology 5: Groyne	
Sector	Coastal Resources
Sub-Sector	Coastal Zone Management
Technology Characteristics	
Introduction	Groynes are wooden structure but can also be made of concrete and/or rock barriers or walls perpendicular to the sea. Beach material builds up on the updrift side, where littoral drift is predominantly in one direction, creating a wider and a more plentiful beach, therefore enhancing the protection for the coast because the sand material filters and absorbs the wave energy. However, there is a corresponding loss of beach material on the downdrift side, requiring that another groyne to be built there.

	Groynes are extremely cost-effective coastal defence measures, requiring little maintenance, and are one of the most common coastal defence structures. Groynes are common in The Gambia and have done well in the past. Lack of wood for their construction has limited their use but this can be overcome with the use of concrete, which is relatively more expensive.
Technology characteristics/Highlights	Groynes are cross-shore structures designed to reduce long-shore transport on open beaches or to deflect near-shore currents within an estuary. On an open beach they are normally built as a series to influence a long section of shoreline that has been nourished or is managed by recycling. They trap beach material and cause the beach orientation to change relative to the dominant wave directions. Sand is carried in temporary suspension during higher energy wave or current conditions and will therefore tend to be carried over or around any cross-shore structures. They mainly influence bedload transport and are most effective on shingle or gravel beaches. Groynes can also be used successfully in estuaries to alter nearshore tidal flow patterns. In an estuary they may be single structures. Rock is often favoured as the construction material, but timber or gabions can be used for temporary structures of varying life expectancies (timber: 10-25 years, gabions: 1-5 years). Groynes are often used in combination with revetments to provide a high level of erosion protection. Groynes along a duned beach must have at least a short "T" section of revetment at their landward end to prevent outflanking during storm events. The revetment will be less obtrusive if it is normally buried by the fore-dunes. Beach recycling or nourishment is normally required to maximize the effectiveness of groynes. On their own, they will cause down-drift erosion as beach material is held within the groyne bays.
Institutional and Organization requirements	Monitoring of the coastal environment is the responsibility of the Coastal Working Group at the National Environment Agency. Design, construction and management of coastal defense structures are the responsibilities of the Technical Services Department of the Ministry of Works and Infrastructure Development. At the municipality level, Mayoral offices of Banjul and Kanifing are involved in the decision making.

Operation and maintenance	The residual life of a groyne on a sand beach is approximately 20-25 years. Maintenance equipment has become more specialized with time and is worth about £25,000. Groynes which reach 25 years need to be dismantled and assessed. Groyne piles need to be replaced every 25 years and planks every 15-20 years.
Endorsement by experts	Experts at the Ministry of Works and the municipalities have long endorsed groyne systems as they have saved the city of Banjul for more than 30 years. Lack of materials to replace broken timber made the systems to collapse. Use of rock and concrete will solve this problem.
Adequacy for current climate	Groynes are adequate for current climate and for the projected climate in The Gambia. Adequate supply and appropriate materials (timber or rock) are required.
Scale/size of beneficiary group	The Gambian shoreline is in a highly dynamic sandy coast and groynes can be installed all along the coast.
Advantages and Disadvantages	Rock groynes have the advantages of simple construction, long-term durability and ability to absorb some wave energy due to their semi-permeable nature. Wooden groynes are less durable and tend to reflect, rather than absorb energy. Gabions can be useful as temporary groynes but have a short life expectancy. They are good on exposed shorelines with a natural shingle upper beach. Can also be useful in estuaries to deflect flows. Unlimited structure life for rock groynes. Disadvantages include disruptions in natural processes and public access along upper beach; causing downdrift erosion as they starve beaches further down the coast of sediment which can result in coastal erosion; and the resultant down-drift erosion could destroy buildings or private land and lead plummeting of housing prices in the region making it difficult for affected homeowners to move out. They are also quite expensive.
Capital Costs	
Cost to implement adaptation technology	Cost of installation of groynes is moderate but must include for recycling or nourishment. Construction costs are mainly dependent on structure dimensions but can be heavily influenced by the availability of suitable rock (or other material), transport and the associated costs of recycling or

	nourishment. Rock structures can be assumed to have an unlimited life with respect to economic assessments. Cost can be zero if a family build theirs from stones available at no cost
Development Impacts, direct and indirect benefits	
Direct benefits	Groynes reduce dependency on regular recycling or nourishment, and therefore reduce future disturbance of the shoreline environment. Localized accumulations of beach material will encourage new dune growth. If constructed in conjunction with a revetment, recycling, fencing and transplanting will help to keep the revetment sections buried, thereby enhancing habitat regeneration. Groynes encourage upper beach stability and reduce maintenance commitment for recycling or nourishment.
Indirect benefits	
Reduction of vulnerability to climate change impacts	Coastal erosion is reduced as sediment is trapped by the groyne.
Economic benefits: employment, growth and investment	As groynes trap sediment from long-shore drift the beach builds up supports tourism, and creates a positive multiplier effect on the local economy (good for retail, catering and transport jobs).
Social benefits: Income	
Environmental benefits:	Timber used for groyne construction should be derived from sustainably managed forests. Fencing and transplanting should be undertaken to establish a new line of fore-dunes along the stabilized upper beach. These dunes will enhance the coastal landscape, provide additional erosion protection and re-establish a natural succession of dune habitats from the shoreline to the backshore.

Local context	
Opportunities and Barriers	Groynes have a significant impact on the landscape and can create barriers to the recreational use of the upper beach. They often cause down-drift erosion unless there is a long term management commitment to beach recycling or nourishment. Downdrift erosion may well lead to pressure for further defence works.

	Timber groynes must be built from hardwood to endure the harsh shoreline environment. Much hardwood comes from tropical sources, making it both costly and potentially environmentally unacceptable. Timber groynes tend to reflect, rather than absorb, wave energy making them significantly less effective than rock on exposed coasts. They are also more likely to structural failure due to formation of scour channels around their seaward ends.
Market potential	The groyne systems in The Gambia have been constructed out of matured rhun palm trees with do well in saline conditions. There is acute shortage of these trees in The Gambia but there is abundant supply in neighbouring Senegal and Guinea Bissau. Business entities can take advantage of the market potentials. Concrete groynes also provide business entities with potential to procure concrete materials from the construction of the groynes.
Status	Both timber and rock groynes have performed very well in The Gambia. As a general rule, groynes should not be built on an open beach unless construction is accompanied by a commitment to regular recycling or nourishment. Without this commitment the groynes are likely to cause down-drift erosion as the upper beach becomes starved of sediment.
Timeframe	Because of salinity levels along the coast of The Gambia, rock and timber groynes stay longer before repairs are required. Beach recycling or nourishment is normally required to maximize the effectiveness of groynes.
Acceptability to local stakeholders	Coastal stakeholders have accepted groynes.