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Pacific Regional Ridge to Reef International Waters Project

Site Diagnostic Analysis Report for Bonriki & Buota in South Tarawa, Kiribati

Pacific R2R Ridge to Reef

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UNDP Empowered lives. Resilient nations

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Abbreviations

ACP	African Caribbean and Pacific Group of States
CBD	Convention on Biological Diversity
DLT	Dry Litter Technology
EC	European Commission
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIWA	Global International Waters Assessment
IW	International Waters
KBA	Key Biodiversity Area
MEA	Multilateral Environmental Agreement
MELAD	Ministry of Environment, Land and Agricultural Development
MICS	Multiple Indicator Cluster Surveys
MISE	Ministry of Infrastructure and Sustainable Energy
MLD	Mega litres per day
PA	Protected Area
PICs	Pacific Island Countries
PUB	Public Utilities Board
R2R	Ridge to Reef
SDG	Sustainable Development Goals
SIDS	Small Islands Developing States
SPREP	Secretariat of the Pacific Regional Environment Programme
STWSP	South Tarawa Water Supply Project
STAR	System for Transparent Allocation of Resources
TDA	Transboundary Diagnostic Analysis
UNCDF	United Nations Capital Development Fund
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
WASH	Water, Sanitation and Hygiene

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Executive Summary

The regional International Waters Ridge to Reef project aims to test the mainstreaming of climate-resilient approaches to integrated land, water, forest, and coastal management in Pacific Island countries through strategic planning, capacity building and piloted local actions to sustain livelihoods and preserve ecosystem services.

The International Waters Ridge to Reef project in Kiribati focuses on building local capacity to manage waste through effective community engagement, testing of sustainable dry-litter technology for nutrient offload and contamination reduction, and improved data management and community awareness in support of sustainable animal waste management.

This report presents the Site Diagnostic Analysis for the Bonriki/Buota water reserve site on Kiribati's densely populated atoll of South Tarawa. This is the main water reserve on the island, and it supplies approximately 52.9 per cent of the country's population. The environmental Issues identified were mainly extracted from meeting papers and from presentations during Parliamentary sessions. Identified issues were water issue; marine issue; ecosystem destruction; decline in marine resources and land issue. The analysis identified two priority issues for the Bonriki site: water issues related to brackish water and coastal erosion. A problem tree analysis identified the root causes and determined potential intervention options.

Broadly, the ridge to reef concept and its principles provides for better integrated management of natural resources, thereby increasing community resilience and improved livelihoods. This includes support for policy reforms and action that ensures clean and sustainable water, land-use, and marine resources.

1 Introduction

The overall goal of an initial diagnostic analysis for the Bonriki/Buota Water Reserve in South Tarawa, Kiribati is to provide a precise characterisation of the site in relation to the International Waters Ridge to Reef objectives and programme of activities. As such, the diagnosis also provides a baseline against which the effectiveness and efficiency of the project can be evaluated and monitored over time. The collection and assessment of tempo-spatial data are useful to better assess the impact of the R2R intervention in reducing nutrient offloads into the environment.

The site diagnostic process provides a structured approach to identify, understand, and prioritise key issues impacting on the ecosystem goods and services in an area. A range of risk assessment tools such as problem-tree and causal links analysis are available to the operator. The diagnostic analysis will scale the relative importance of source and causes (from the 'immediate' to the 'root') of the problems within the ridge to reef platform and to identify potential preventive and remedial actions.

1.1 The IWR2R Project in Kiribati

The Regional International Waters Ridge to Reef (IWR2R) project aims to test the mainstreaming of climate-resilient approaches to integrated land, water, forest, and coastal management in Pacific Island countries through strategic planning, capacity building and piloted local actions to sustain livelihoods and preserve ecosystem services.

The IWR2R project in Kiribati focuses on building local capacity to manage waste through effective community engagement, testing of sustainable dry-litter technology for nutrient offload and contamination reduction, and improved data management and community awareness in support of sustainable animal waste management.

The demonstration site for the Kiribati IWR2R project is South Tarawa, where large population migration has resulted in increased pressures on drinking water. A large population also corresponds to increasing levels of waste causing pollution and contamination to underground water. A large desalination plant with a daily capacity of 6.0 MLD (Mega-litres per day) has been proposed to address the shortage of drinking water and would be implemented as part of the ongoing South Tarawa Water Supply Project. The project would also include the rehabilitation of water supply systems with new pipes and storage tanks as well as the extension of services to Buota and other areas around the Bonriki water reserve to enable a 24-hour water supply system.

The Kiribati IWR2R project is expected to result in the reduction of waste thereby minimising risk of polluting and contaminating groundwater lenses, and the protection of coastal seawater from land-based contamination activities. The introduction of dry litter technology at Bonriki and Buota offers a cost-effective option for reducing water pollution, as it contains waste from existing pig pens and therefore prevents percolation of waste into underground water and nearby coastal areas.

Following the success of the project in controlling the contamination of groundwater lenses and coastal areas, these activities will be replicated in other parts of South Tarawa and then in Kiribati as a whole, as well as low-lying coral atoll islands in the region with similar geological settings.

The result framework comprised of the following components:

1. **Local capacity for sustainable on-site sanitation management stimulated through community engagement and training.** These community engagements were inclusive of women, youth and all members of communities. This component was partially implemented as part of the South Tarawa Sanitation Improvement Sector project, which included the installation of on-site sanitation toilets on South Tarawa and Betio. Dry and wet designed toilets were in the original planning stage but the project opted to focus only on wet designed toiletsThe Ministry of Infrastructure and Sustainable Energy (MISE) will be responsible to continue monitoring the impact of the project's wet designed toilets into the future. There are no other sanitation management networks that can take up the role of monitoring performance and conduct training on construction wet designed toilets. It is possible that another project on water and sanitation can continue further trial of constructing new toilet units In the country.

2. **Demonstration of innovative approaches to sanitation management.** Improving access and use of on-site sanitation using locally accepted methods is not feasible. This includes ow-cost sanitation such as pit latrines which is observed to be inappropriate and contaminate the groundwater. The use of a centralised sewerage system seems to be a solution, but it is very expensive. The more appropriate compost toilet could be a solution, but it is currently not socially accepted.
3. **Information management and community awareness increased in support of national Integrated Coastal Management.** With the recent completion of the South Tarawa Sanitation Improvement Sector project in 2019, raw sewage is now disposed of at the three sites at a depth of some 30 m below mean sea level – and below the thermocline. There are minimal risks of waste discharged below the thermocline resurfacing to shallow waters and impacting biodiversity and reef systems. The screening of sewage prior to discharge removes solids at the outfall pump station. This means that sewage effluent is no longer discharged at the reef's edge, causing reef damage, but rather at a depth of 30 meters, causing minimal reef damage. The effluents are released through a horizontal diffuser with several ports installed where the sewage plumes are ejected. Since the flushing media for the sewerage system is seawater, plumes are not expected to move up to the water surface but stay at the bottom of the seabed at some 30 m below mean sea level. At this depth, very few marine lives can survive.

In parallel with the IWR2R project, Kiribati is implementing the national Global Environment Facility STAR project. The STAR R2R project is in operating in Butaritari, North Tarawa and Tabiteuea North. The table below presents brief details of the STAR R2R project in the country focusing on some aspects of IW as well other GEF focal areas such as biodiversity and land degradation.

Table 1: Summary of the components and outcomes of the Kiribati National STAR project.

R2R Resilient Islands, Resilient Communities	
Improve biodiversity conservation and landscape management to enhance socio-environmental resilience to climate variability and change.	
Component 1: Strengthened national network of Protected Areas	
Outcome 1.1	National Protected Area system expanded to include priority KBAs
Outcome 1.2	Strengthened capacity of PA managers and communities to sustain PA management
Component 2: Promote sustainable and integrated landscape management	
Outcome 2.1	Integrated landscape management plans implemented in selected urban areas and outer islands
Outcome 2.2	Improved management of priority mangrove areas as part of broader land and marine use plans
Component 3: Knowledge management, dissemination of best practices, and monitoring and evaluation	
Outcome 3.1	Lessons learned from project identified and shared with national and regional partners

1.2 Scope of baseline assessment

The expected output of the baseline assessment is the establishment of changes that occur between the start and the middle or endpoint of the project. For instance, the changes in the level of nitrate/nitrite in the Bonriki borehole water over a certain period. If the trend continues, it will be necessary to identify the source of pollution and devise methods to eliminate it. If pollution is caused by human habitation, for example, it must be removed. The public must be informed that a cemetery located within the Bonriki restricted water reserve is not to be used.

The limitation of the assessment can be caused by several factors. In the case of Kiribati, the physical size of the site is quite large. Data can now be transmitted over the internet, but internet technology is still in its infancy, with issues such as satellite links and island coverage. Another limitation of the evaluation is the lack of previously gathered data. The data is always kept in written form, and it may be lost during storage. Another issue is data confidentiality, and ministries' unwillingness to share data with third parties.

2 Methodology

2.1 Description of study site

Kiribati is located in the central and western Pacific between 4o North and 3o South and 172o East and 157o West. It consists of 32 low-lying coral islands and one raised coral island in the three main group of islands; the Gilbert, the Phoenix, and the Lines group. Eleven islands are currently unoccupied, and most islands are usually not more than 2 km wide. The country has a population of 119,940 with 52.9 per cent of the population concentrated in South Tarawa, the capital of Kiribati, in the Gilbert group (Kiribati National Statistics Office 2020).

The Bonriki and Buota water reserves are the only current sources of reticulated safe drinking water for South Tarawa. These islands support the livelihood of more than 80 per cent of local communities and supply 52.9 per cent of the country's population. The reserves support more than 80 per cent of national development and are a very high government priority, with extremely high potential for degradation originating from both human and natural causes. South Tarawa, the densely populated capital of Kiribati, is nearing the end of its sustainable freshwater supply. Groundwater sources on these low-lying coral atoll islands are extremely vulnerable. Rising sea levels as a result of global climate change and variability, storm surges and encroachment, pollution, and overuse are all serious concerns.

Geographically, the Bonriki and Buota Water Reserves are separate, but they are close together. South Tarawa has the Bonriki Water Reserve, while North Tarawa has the Buota Reserve. South Tarawa is separated from North Tarawa by a narrow channel that allows for the exchange of water mass between the lagoon and the ocean. As a result, the two reserves do not necessarily share the same aquifer and underground water lens characteristics. The communities living on the periphery or close to both reserves are also different (Sauni and Biko 2020).

Figure 1 Map of South Tarawa showing the Bonriki and Buota areas. (Source: Google Earth).

2.2 Data collection

2.2.1 Literature review

The collection of baseline data is the process of gathering and measuring information in an established systematic manner that enable one to answer research questions and evaluate outcomes. The collection of data is integral to completing a project. Data collection is a demanding job, which needs proper planning, hard work, and patience to be able to complete the task successfully (Muhammad and Kabir, 2016). In the case of Kiribati, the collection of data from all islands of Kiribati is quite challenging given the vast distance between islands. In this case, one has had to depend on data that has been collected from previous visits to the islands and questions raised during the sitting parliament, as preliminary collected data.

2.2.2 Marine habitat assessment

There is overpopulation and uncontrolled urban drift experienced in Kiribati, especially within the capital of Tarawa. Consequently, the demand to consume natural resources has increased, and some resources are overexploited. This includes the overexploitation of fisheries resources (e.g., seaweeds, finfish, bêche-de-mer, crabs and lobsters, shellfish, corals, and other marine invertebrates) whose use was formerly restricted for local subsistence consumption but is now rapidly expanding to commercial production for local and export markets. Overexploitation is often associated with the use of more efficient and modern fishing technologies (i.e., better motorised boats, improved spear guns and line fishing methods, improved refrigeration and distribution, more efficient nets, and night spear fishing using SCUBA or hookah).

2.2.3 Terrestrial habitat assessment

Kiribati is plagued with limited land area and terrestrial resources. However, the resources provided by its limited land and terrestrial biodiversity are also central to the Kiribati way of life. The coconut, swamp taro, breadfruit, etc. are the main food crops, but are now not popular compared with imported rice, which is becoming a staple carbohydrate in the diet. Despite the poor soil fertility, Kiribati people are using organic farming techniques to grow cabbages, cucumbers, sweet pepper, and other green leafy vegetables for both subsistence and commercial activities.

2.2.4 Water quality assessment

The salinity (EC) of the potable water supplied by the Public Utilities Board never exceeds 1000 microsiemens/cm, indicating that it is always fit for drinking according to Kiribati standards. Human activities and climate change, on the other hand, have already contaminated the water in the villages of South Tarawa. Rainwater is used as a supplementary water source by almost everyone who has a rainwater tank. During long droughts, there is heavy reliance on stored rainwater. Large rainwater tanks can sustain these communities during the drought. Groundwater on some islands can have an EC of over 3 micro-siemens/cm or even 5000 microsiemens/cm, but people are used to drinking water with high EC values, which can be dangerous to small children. Kiribati's water is quite saline, with a maximum allowable drinking level of 2500 microsiemens/cm. Even though this value is quite brackish, it is still safe to bathe in and drink.

There is no surface water except for a few freshwater ponds on some islands, but these are not good for drinking. The ponds tend to become salty during long periods of drought. The occurrence of long drought in Kiribati is quite common, meaning that there is always a need to use an alternative water source. There is a desalination plant installed on South Tarawa but is not always fully functional due to technical difficulties such as the low availability of spare parts.

2.3 Diagnostic analysis in Bonriki and Buota

The diagnostic analysis for the Ridge to Reef Programme is derived from the Global International Waters Assessment (GIWA), GEF Transboundary Diagnostic Analysis (TDA), and Pacific IWRM Diagnostic Analysis methodologies. Due to the broader ecosystem context of the Ridge to Reef Programme, the methodologies have been adapted according to these changes (IW: LEARN 2021).

In identifying and prioritising the environmental problems, participants were encouraged to come up with a list of problems in country. Once the list was compiled, it was refined, and participants were asked to prioritise and focus on the real environmental problems (as opposed to things categorised as governance causes or impacts).

Four major issues were identified by the participants i.e., water issues, marine issues, ecosystem destruction and land issues.

2.3.1 Water Issues

A press release by the World Bank (2019) states that Tarawa, the capital of Kiribati, has limited water resources due to its small size, lack of storage capacity, and limited land area. Water scarcity is being exacerbated by the combination of limited freshwater resources, climate variability, and overcrowding. Under the water issue category, the working group identified three environmental issues which are listed in Table 2.

Table 2: Water issues identified by the participants.

Issues		Impacts and Problem	Root Causes
1	**Water in some parts of islands in Kiribati becomes brackish after the long drought and do not have sufficient fresh groundwater to meet the growing demand due to increase in population**	Impacts on the plants will affect food security	Caused by climate change – seawater overtopping and high evapo-transpiration
		Impacts on health due to drinking water with excessive salt content	Water withdrawal is greater than sustainable yield causing saltwater intrusion
		Reduce revenue from sales of vegetable and fruits	Long drought period causes shrinkage of the water lens and low rainwater tank storage
			Sufficient fresh groundwater cannot meet water demand
			High and excessive water usage
2	**Water in village areas of Kiribati becomes contaminated due to human activities**	Causes diarrhoea and other water-related diseases such as skin diseases	Lack of WASH programmes
		Increase in the cost of water treatment	Use of pit latrines and other toilets with poor waste storage
			Lack of hygiene practices in households, which allows for contaminants to infiltrate freshwater wells
3	**Water is insufficient to meet growing water demands to some villages in rural Kiribati**	Low water pressure would lead to unequal water distribution	Low water pressure would lead to unequal water distribution
		The more vulnerable groups in the community will find it harder to get access to potable water sources	Lack of policy enforcement
			Lack of WASH programmes
			Lack of sanitation policies
			Water conservation is not widely practised

2.3.2 Marine issues

The marine ecosystems are of global importance and their ecological health is increasingly threatened by largely anthropogenic-led pressures of pollution from land-based sources (Hodgson et al. 2019). The Republic of Kiribati is the world's largest small island developing state in terms of ocean territory, despite having a landmass of only 811 km2, however, its coastal marine environment faces pressure, including increasing population and limited infrastructure to manage pollution (Duvat et al. 2013, Mallin 2018).

Kiribati is heavily dependent on the marine environment. Climate change, coastal pollution, overfishing, and the destruction of coastal habitats are all threatening the long-term availability of marine resources. Under the marine issue category, the working group identify three environmental issues, its problem/impact and its root causes which is listed in the table below.

Table 3: Marine issues and its impacts and root causes identified by the participants.

Issues		Impacts and Problem	Root Causes
1	Coastal pollution	Decrease in marine resources	Dumping of rubbish into the ocean
		Disturbance of marine food web and ecosystems	Erecting pig pens near the coastline
		Increase in the use of tinned imported sources of protein	Open defaecation on the beach
		Increase in non-communicable diseases	
2	Ecosystem destruction	Decrease in marine food supplies	Building of seawalls would slowly cause erosion in areas not protected
		Decrease in land space especially at the beach front	Building of recreational areas on the coast
		Shifting of fish species away from Bonriki site due to change in marine habitat	Beach sand and gravel mining would also increase erosion and decrease land area
		Decrease in the number of seagrass due to destruction of habitat	
3	Decline in marine resources	Poor health due to the shortage of fresh protein source	The use of inappropriate fishing gears and methods used by fishermen
		Heavy reliance on imported food	Increase in the population means higher fishing pressures in certain areas
		With decline of edible marine life in the reef area people would move out into the ocean beyond the reef to fish	Climate change causes bleaching of coral reefs resulting in the destruction of fish habitat
			Removing of rocks for building seawalls

2.3.3 Ecosystem destruction

An increase in population in the Tarawa area has resulted in rapid exploitation of land resources, resulting in their overuse. Pollution of land, water and air has caused problems, and over-exploitation of natural resources has resulted in the loss of biodiversity, resulting in the reduction of valuable fruit trees and plants.

Sea level rise also plays a significant role. Massive waves cause seawater flooding and erosion, destroying valuable plants, buildings and infrastructure. Sea walls are built to help mitigate this effect. The use of dead corals for their construction will rid the coast of coral pieces and stones. There is a high demand for raw material for infrastructure development. The rate of sand mining activities along coastal areas is increasing, despite the regular inspections carried out by relevant authorities (MELAD 2007). Under the ecosystem destruction category, the working group identified the issue, its impact and problems and its root causes, which are listed in Table 4.

Table 4: Ecosystem destruction and its impact and root causes identified by the participants.

	Issue	Impacts and Problems	Root causes
1	**Ecosystem destruction**	Decrease in marine food supplies. Decrease in land space especially at the beach front. Shifting of fish species away from the study site due to change in habitat. Decrease in seagrass cover due to destruction of suitable habitats.	Building of seawalls would slowly cause erosion in areas not protected Building of recreation areas on the coastal area would encourage destruction of trees that would help to stabilise the coast. Sand and gravel mining would also increase erosion and decrease land area.

2.3.4 Decline in marine resources

The coastal fisheries of Kiribati are typically artisanal and local. The rapid expansion of the human population has put a strain on these resources, as evidenced by the decline of targeted species like goatfish, clams, and other finfish. Overharvesting and increased fishing capacity are the result of increasing population and the development of the cash economy. These factors, when combined with destructive fishing methods, pollution, and habitat destruction, contribute significantly to the decline in fish populations (Commonwealth Blue Charter 2021). Under the category on 'decline in marine resources', the working group identified the issue, its impact and problems and its root causes (Table 5).

Table 5: Decline in marine resources, its impacts and root causes as identified by the participants.

	Issue	Impacts and Problems	Root causes
1	**Decline in marine resources**	Poor health due to shortage of fresh protein source. People would rely on imported tinned fish. With the decline in edible marine life on the reef, people would move into outer waters to fish.	The use of inappropriate fishing gear and methods. The use of chemicals such as chlorine powder to kill fishes. The increase in the population means a lot of people going fishing in one area causing depletion of fish population. Climate change causes bleaching of coral reefs resulting in the destruction of fish habitat and food chain. Removing of rocks for building seawalls would also result in the destruction of habitat and food for the fish.

2.3.5 Land Issues

Land resources in Kiribati are very limited. In Tarawa, the government has been leasing land for infrastructure, which is preceded by clearing and levelling of land. This tends to rid the area of ground cover, thus exposing it to erosion. Under the land issues category, the working group identified the issues, its impact and problems and its root causes (Table 6).

Table 6: Land issues identified and documented by the participants.

Issues		Impacts and Problem	Root Causes
1	**Coastal Erosion**	Living with stress and uncertainty	Land degradation due to the poorly designed seawalls
		Displacement which can cause overcrowding on lands	Clearing trees near the coasts
		Political and social tensions over the use of the land	Beach sand and gravel mining
		Social inequality	Lack of policy enforcement on sand mining
		Loss of land	
2	**Plastic Pollution**	The uncontrolled disposal of plastics will contaminate the groundwater	Plastic wrappers from imported foods
		Disposed plastic can be ingested by marine organisms	Shops providing plastic shopping bags
		Plastic would get into our food systems	Lack of awareness on the threats of plastic
		Chemical or toxic waste is a burden on the environment	
3	**Open Defaecation**	Increase in water borne diseases	Unavailability of proper toilets
		Water contamination	Unemployment
		Unpleasant smell	Increase in household population leads to resorting to open defaecation
		Affects human and health of animals	Lack of awareness
		Increase in vector borne diseases	
		Gender based violence	
4	**Uncontrolled Animals**	Increase in the number of stray animals	Animals are not registered
		Increase in animal waste	No control of pets
		Degradation of land and water sources	Lack of enforcement of policies regarding animals
		Increase in diseases	

2.4 Prioritise the issue using risk assessment and problem-tree analysis

The problems of water becoming brackish, coastal erosion and decline in marine resources, are best solved by attempting to correct, address or eliminate root causes as opposed to addressing the immediate apparent symptoms. This strategy lessens the probability of a recurrence of the problem.

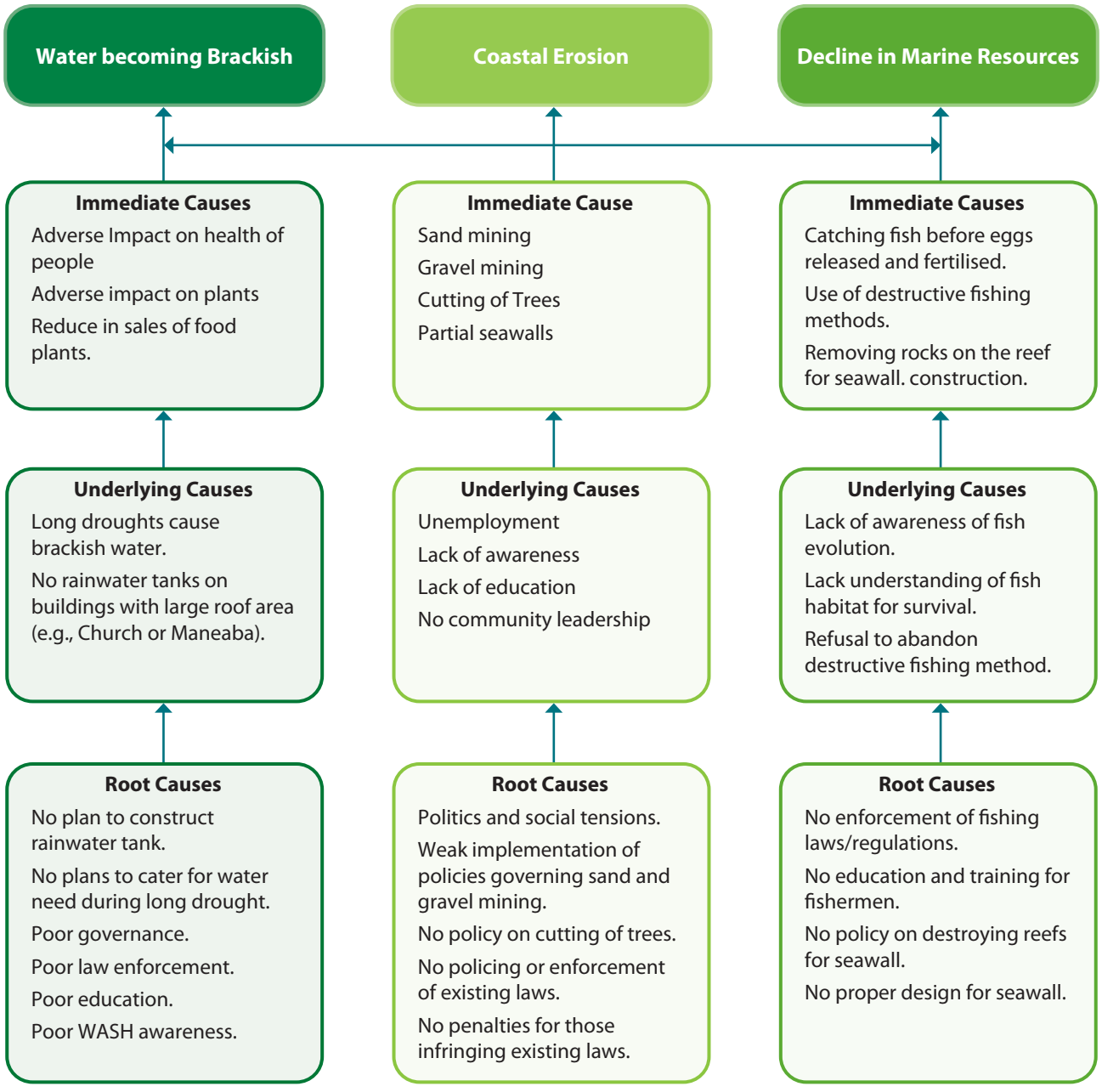

Figure 2: Diagnostic workshop outcomes on priority problems, immediate causes, and root causes.

2.5 Develop priority systems and plans for actions and interventions

Based on the prioritisation criteria, the most pressing issues that were frequently raised in Parliament over the years were 1) water issues related to brackish water; and 2) coastal erosion.

On the water issue, the problem with brackish water only occurred on islands where there was a long drought and if the freshwater lens was very thin. On the island of South Tarawa, the freshwater lenses at Bonriki and Buota can survive the long drought of more than two years. However, in some parts of South Tarawa, some villages could experience brackish water after just a few months of no rain. This is similar to what is occurring in a number of remote islets of Kiribati such as Aiwa in Tabiteuea North and Abamakoro on Nonouti islands in the northern and central Gilbert group.

The water issue should be considered as "everyone's business". The simple solution is for every household to have a simple roof catchment to collect rainfall. Community buildings such as the maneaba (meeting halls) and church buildings should all contain rainwater catchment systems. The rainwater storage from these community building should be accessible to everyone living in the community in times of drought.

A rainfall analysis needs to be conducted to determine the volume of tank that can sustain the longest drought period. One is available for South Tarawa, and this programme can be adapted to be used by all islands in Kiribati, provided monthly rainfall data is collected and stored for use.

The use of the desalination technology in the outer islands cannot be sustained due to the high energy requirement to run the plant and the cost of maintaining the system on a remote island. The experience on Banaba can be used as an example. The desalination plant on Banaba had been running for a number of years since early 2000. The plant continued to malfunction on quite a number of occasions due to the lack of spare parts. A brand-new desalination plant was acquired but continues to malfunction due to lack of spare parts and local skills to maintain the plant. It is therefore wise to choose the simple rainwater catchment system.

To reduce the issue of coastal erosion, it would be quite costly to build a concrete retaining structure to protect the coastal area and could be a significantly large investment of millions of dollars to protect all islands that have been identified with this issue. Alternatively, the use of sheet piling to protect the coast is also quite costly, therefore a cost benefit analysis on various coastal protection options is suggested at this stage to be able to identify and determine the least costly option weighed with its benefits.

3 Legislation and Policy Framework

3.1 Regional legislation

Multilateral Environmental Agreement (MEA) is a generic term for protocols, conventions and treaties and other binding instruments related to the environment and is usually applied or referred to as instruments of a geographic scope wider than that of a bilateral agreement (Secretariat of the Pacific Regional Environment Programme 2021).

During the 1992 United Nations Conference on Environment and Development (UNCED), which was held in Rio de Janeiro, Brazil, five key documents on sustainable development were produced. Two of these were "hard law" – the Convention on Biological Diversity[1], and the Framework Convention on Climate Change[2] – and three were "soft law" – the Rio Declaration[3], Agenda 21[4,5], and Forest Principles[6].

The African Caribbean and Pacific Group of States (ACP), European Commission (EC), Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP) and the Secretariat of the Pacific Regional Environment Programme (SPREP) have a partnership known as the ACP MEAs Programme. This programme aims to build capacity to support ACP States to meet obligations as parties to MEAs and thus, to tackle environmental issues that they face, such as management of chemicals and waste (seen in agriculture), MEAs relating to biodiversity, strengthening implementation of the Regional Seas Convention in the ACP States, and reinforcing compliance and enforcement of measures. Phase 1 and Phase 2 has been completed and currently the Programme is in Phase 3 (2020 – 2024) (also known as ACP MEAs 3 Programme).

Table 7: Multilateral Environment Agreements to which Kiribati is a signatory.

Multilateral Environmental Agreement	Website
Convention on Biological Diversity (CBD)	https://www.cbd.int/
Basel Convention on the control of transboundary movements of hazardous wastes and their disposal	https://www.brsmeas.org/
Stockholm Convention	https://www.brsmeas.org/
Minamata Convention	https://www.mercuryconvention.org/
Convention to ban the importation into Forum Island Countries of hazardous wastes within the South Pacific Region (Waigani Convention)	https://www.sprep.org/convention-secretariat/waigani-convention

Table 8: Sustainable development goals.

Goal 1 No Poverty	Goal 2 Zero Hunger
Goal 6 Clean water and sanitation	Goal 12 Responsible consumption and production
Goal 13 Climate action	Goal 14 Life below water
Goal 15 Life on land	Goal 17 Partnerships for Goals

1 https://www.cbd.int/doc/world/ki/ki-nbsap-v2-en.pdf (Summary: https://www.cbd.int/nbsap/about/latest/#ki)

2 https://unfccc.int/resource/docs/natc/kirnc1.pdf

3 https://www.sprep.org/att/IRC/eCOPIES/Countries/Kiribati/13.pdf

4 https://documents-dds-ny.un.org/doc/UNDOC/GEN/N92/836/55/PDF/N9283655.pdf?OpenElement

5 https://openresearch-repository.anu.edu.au/bitstream/1885/158076/1/082_south-pacific.pdf

6 https://www.are.admin.ch/dam/are/de/dokumente/statement_of_forestprinciples.pdf.download.pdf/statement_of_forestprinciples.pdf

3.2 National and local legislation and policy

Table 9: Kiribati's' National and local legislation and policy.

Name of legislative instrument	Year	Functional coordination	Operations strategy	Financial Strategy	Monitoring and reporting	Enforcement of regulations
Coastal Management Plan	1998	Y	Y	N	N	N
Environment Act	2007	Y	Y	Y	Y	Y
Public Utilities Ordinance	1999	Y	Y	Y	Y	Y
Squatters Act	2005	N	N	N	N	N
Fisheries Act	2010	Y	Y	Y	Y	Y
National Disaster Act	1993	Y	Y	Y	Y	Y
Building Code	2010	Y	Y	Y	Y	Y

Name of Plans/Guidelines	Year	Functional coordination	Operations strategy	Financial Strategy	Monitoring and reporting	Enforcement of regulations
Coastal Management Plan	1998	Y	Y	N	N	N
National Biodiversity Strategy and Action Plan	2007	Y	Y	Y	Y	Y
National Roadmap on Water and Sanitation	2011	Y	Y	N	N	N
National Action Plan Land for Degradation and Drought	2007	Y	N	N	N	N
Waste Management and Pollution Control	1998	Y	Y	N	N	N

3.3 Traditional governance and tenure system

Kiribati is a unitary republic with two levels of government, national and local. South Tarawa is home to the national government, while the outer island is home to the local government. There is also a local government in the urban area for the Betio Town Council and the Teinainao Urban Council, both of which are in South Tarawa.

The power of the traditional elite, particularly the power of the unimane (the old men who are traditional leaders of I-Kiribati society), is one of the most important mechanisms for maintaining accountability in the political process. Since leadership was traditionally exercised by men, women seldom speak in public meetings and over the years, only three women have ever been elected to parliament (Macdonald 1996). Today, women and youth are more vocal in community meetings because of their participation in women's and youth groups. Women, youth, and vulnerable groups are now included in the development of community policies.

The land tenure system is passed from father to sons. All land on South Tarawa is privately owned by families, but quite a lot of land is leased by government under the 99 years land lease agreement. Most lease agreements have already expired, and leased extension would be done with new landowners. However, with an increase in population, landowners are now demanding more compensation, but government can always apply the land acquisition Act for the public interest.

3.4 Communities and other stakeholders

Table 10: Communities and stakeholders involved.

Category	Stakeholder	Role
Village	Community-based group	Decision making body for village development
	Faith-based group	Different church group – spiritual growth and assistance to the congregation
	Private businesses	Serving villagers needs – business
Informal settlement	Health Group	WASH related activities
District	Local council	Oversee development needs of village

4 Description of the IWR2R Site

4.1 Socio-economy

Given the migration rate of people to the main island, the population has fluctuated since independence. South Tarawa had a population of 50,182 people in 2010, up from 40,311 in 2005, according to the 2010 census. This represents a nearly 10,000-person increase in the given timeframe (Teiwaki 2005). As of 2020, the population count stood at 63,439 people. Compared with other islands in Kiribati, South Tarawa is by far the most densely populated island, with a population density of 3184 people per square kilometre (based on the 2010 census). Almost all the population growth between 2005 and 2010 occurred in South Tarawa, which increased by 9781 people.

Kiribati is one of the poorest and most remote Pacific Island nations, classified as a low-income country by the World Bank and a least developed country by the United Nations. It has the lowest GDP among Pacific Island countries, and its standard of living is significantly lower than that of most other countries in the region. South Tarawa is Kiribati's economic hub, housing the majority of the country's state-owned and private businesses. The potential for a stable export market is severely limited due to a lack of resources. The only important cash crop is copra, which is grown primarily on small family plots. Tuna is also processed for export at a fish processing plant. Imports far outnumber exports, and the majority of the population is reliant on government employment and remittances from abroad (ADB 2014).

Unemployment and underemployment are a serious problem in Kiribati, especially in South Tarawa. In 2010, only 34 per cent of people in Tarawa were engaged in cash work. The remaining two thirds were either out of the labour force, unemployed or engaged in subsistence activities. In the 2015 census, unemployment rate was estimated to be 37.8 per cent and 43.5 per cent for females. The number is expected to increase as more people move into the island seeking better opportunities.

In 2018, a Social Development Indicator survey was carried out by the Kiribati National Statistics Office in collaboration with the Ministry of Health and other government ministries as part of the global Multiple Indicator Cluster Surveys (MICS). The survey collected data on domestic violence with the objective to measure the prevalence of physical, sexual, and emotional violence against women and girls from their partners. The survey showed that approximately 60 per cent of the women in Kiribati face some form of violence in their lifetime. Kiribati also faces major environmental challenges, including climate change, as well as public health issues from Communicable and Non-Communicable Disease (Burkot, 2015).

4.2 Cultural heritage

In the mid-1990s, Thomas (2009) conducted ethnographic and ethno-archaeological research on atolls in the Gilbert Islands, supplementing his findings with data from historical ecological collections and archaeological excavations. Wood charcoal from swamp taro pit mounds in North Tarawa was radiocarbon dated and revealed evidence of human activity around 1800 BP. There appear to be ancient migration links between Polynesian islands, such as Samoa, because of similarities in certain words and aspects of traditions (Thomas, 2009). The Samoans are also thought to have introduced the maneaba concept to the Kiribati people, influencing the development of specific socio-cultural norms.

Kiribati has a rich cultural heritage developed ever since the islands were inhabited during prehistoric era. Cultural heritage comprises of traditional chanting, traditional dances in the standing or sitting position as well as oral traditions and rituals. Kiribati's current governance incorporates elements of both contemporary and traditional systems, which are overseen by elders in the maneaba and it plays an important role in social cohesion and community resilience, particularly in the southern outer islands. Through a traditional system, chiefly families previously controlled the central and northern outer islands. This system has now changed with the establishment of island councils and village community groups.

According to Thomas (2009), archaeological research in Kiribati has recently focused on cultural history, with the establishment of settlement chronologies becoming a recent research goal. To date, no archaeological research has been published on significant sites such as World War II relics on Betio.

4.3 Geology and geomorphology

Kiribati's islands are mostly atolls made up of skeletal carbonate material and are in the tropical zone, where the temperature, water clarity, and organic productivity are all favourable for coral growth. Due to the submarine volcanic ridge that forms the islands' base, the islands are elongated in a north-west direction. Gravels dominate the seaward reef flats and make up a significant percentage of some islets, whereas sands make up most of the islet and lagoon reef flat deposits. Sediments differ primarily depending on depth and proximity to reefs. It is worth noting that Foraminifera are found almost everywhere, and some beach deposits are almost entirely made up of them.

4.4 Hydrology

Hydrology is the study of water. In terms of environmental measurements, hydrology refers to the physical movement of a body of water, including changes in water level, flow and other dynamic processes. However, groundwater and hydrogeological projects can be included in the hydrology subject, particularly with aquifer applications.

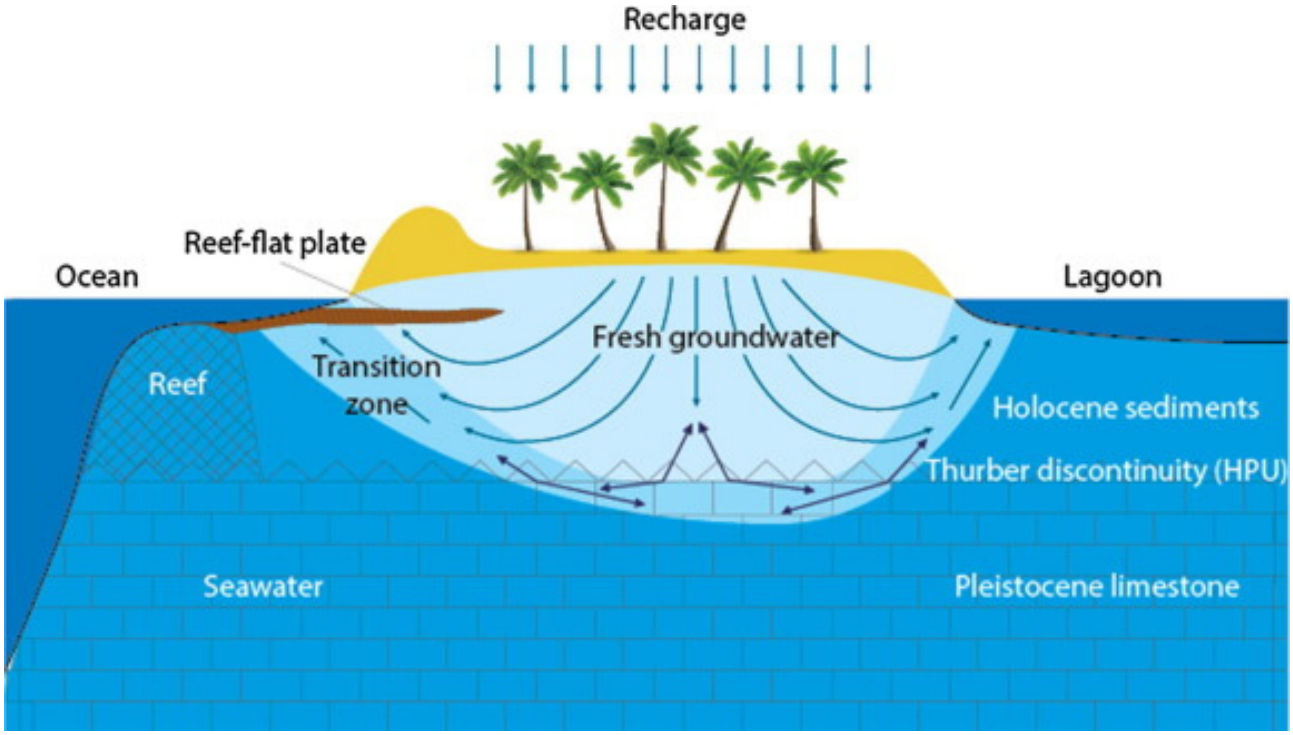

Figure 3: Freshwater lenses on atoll islands. (Source: sciencedirect.com)

On coral atoll islands, fresh groundwater occurs as a buoyant lens-shape body surrounded by saltwater derived from the sea, forming the main freshwater source for island communities. The rainfall recharges the freshwater lens, which continuously loses water through outflow into the sea by gravity, evapotranspiration by plants and extraction through pumping. The pumping rate should not exceed the sustainable yield to avoid saltwater intrusion, which can damage the lens. The lens can only recover with heavy rain in the long-term.

4.5 Coastal processes

The general findings of a survey conducted in 1993 (Gillie 1993) found that the cause of coastal erosion fall into two main categories: natural and anthropogenic causes. Natural causes include locations with a high variability of shoreline position such as depositional split complexes at the southern end of atolls, along lagoon shorelines and where the shoreline forms the inter-islet channels. Coastal erosion takes effect in years with higher-than-average sea level and westerly winds.

The anthropogenic causes include the deleterious effects of causeway construction across inter-islet channels which have cut off the supply of sand from the ocean reef to the lagoon, plus other built structures such as harbour and associated mole construction, dredging of the lagoon sediments and creation of borrow pits near to shores and land reclamation (Kiribati National Statistics Office and the SPC Statistics for Development Programme 2013).

In 2005, the South Pacific Applied Geoscience Commission (SOPAC)[7] carried out an assessment of the areas along Tarawa to identify areas vulnerable to storm surges and erosion and to assist in the development of coastal protection guidelines. Based on their report, wave over topping and erosion were of major concern for sites such as Bonriki airport and Tungaru hospital.

4.6 Marine ecology

Kiribati has one of the largest exclusive economic zones in the world, with globally important tuna stocks. Many of the uninhabited atolls in the Line and Phoenix Island group are home to globally significant populations of seabirds and have exceptional examples of healthy coral reefs free of anthropogenic stressors. Recent deep-sea research reveals that benthic ecosystems below 200 feet (60.9 metres) have a high richness, with numerous species previously unknown to science.

Tarawa is a triangular atoll with a wide rim on the eastern and southern sides bearing a near-continuous chain of islets, and a largely submerged reef forming the west side. Its benthic habitats can be divided into four major categories: 1) the intertidal to shallow subtidal sand flats that fronts the lagoonal sides of islets and passages along the southern and eastern sides of the atoll; 2) the lagoon slope and floor that cover much of the lagoon interior; 3) the patch and reef shoals that rise from the lagoon bottom; and 4) the submerged barrier reef that forms the western atoll rim (Paulay 2000).

According to Paulay (2000), the lagoons harbours the richest benthos documented for any Pacific atoll. This is strongly influenced by its setting in the equatorial upwelling zones, the unusual geomorphology of the atoll and the fact that Tarawa has the largest human population of any Pacific atoll. These attributes impose a strong influence on all aspects of the lagoon. However, over the years, Tarawa has experienced extremely rapid population growth as people tend to relocate form outer islands to take advantage of education and employment opportunities. This led to the improper discharge of waste materials, which in turn, contributes to the poor water quality in the lagoon and in the coastal ocean around Tarawa (Devlin 2019). The survey carried out by Cefas (Centre for environment, fisheries and aquaculture science) and the Ministry of Environment in early 2019 reveal dangerously elevated concentrations of bacterial tracers of sewage and evidence of the negative impacts of eutrophication.

7 Currently renamed the Geoscience, Energy and Maritime Division (GEM) of the Pacific Community (SPC)

4.7 Terrestrial ecology

Terrestrial biodiversity in Kiribati is not particularly rich or endemic and whatever exists is threatened by human development and expansion activities across the limited land area. Its indigenous land-based flora and fauna are limited and among the poorest on earth. Much of this has to do with its soil quality as it is composed mainly of alkaline coral with high porosity. As reported in the Kiribati 5th National Report, there is a decline in the number of some traditional staple food crop species. The declining traditional staple food crop includes the pandanus (*Pandanus tectorius*), breadfruit (*Artocarpus mariennesis, A. altilis, A. mariennesis*), giant swamp taro (*Cyrtosperma merkusii*), native fig (*Ficus tinctoria*) and coconut (*coco-nucifera*). Other important plants observed to have declined are te kiaiai (*beach hibiscus*), te ukin (beach almond), te uri (*Guettarda*), te ren (*tree and beach heliotrope*) and te mao (ECD 2005).

4.8 Water and wastewater management

The MISE is responsible for water and wastewater management. The MISE's Public Utilities Board (PUB) is solely responsible for water and wastewater management in South Tarawa. The Water and Sanitation Engineering unit of MISE looks after water supply and sanitation in the outer islands. The Ministry of Lines and Phoenix Development looks after water and wastewater management on Kiritimati Island and the two outer islands Tabuaeran and Teraina.

There is no official data available for water and sanitation services in the country. In South Tarawa, a little over 70 per cent of the population has access to the water supply, however, access to the saltwater flush sewerage system is limited to residents of Betio, Bairiki and Bikenibeu. There are additional outfall pump stations for the three locations, where the sewage is merely treated for solids before being dumped into the ocean at a depth of 30 metres below mean sea level. However, most people in South Tarawa who live in semi-urban areas do have access to water supply and some sort of toilet facility ranging from septic tanks to simple pit latrines.

Almost every residence on South Tarawa has access to a water supply house connection, and water is delivered every other day for one or two hours. The water quality monitoring for *E. coli* and faecal coliform is the responsibility of the Ministry of Health and Medical Services. The monitoring is done monthly on the PUB's water and at a few private wells on South Tarawa. A Bonriki & Buota Water Quality Monitoring Plan is also part of the Kiribati IWR2R project.

4.9 Natural vulnerabilities

Sea-level rise, coastal erosion and inundation, droughts, saltwater intrusion, and ecological degradation are seen as major threats to low-lying atoll nations like Kiribati (World Bank n.d.).

Storm surges, coastal erosion, droughts, and pandemics have been cited as having the greatest influence on the country in recent years. The only disasters reported for Kiribati in the last 50 years of world data are the coastal effects of Cyclone Bebe in 1972, the 1977 cholera outbreak, and the drought from May 1998 to March 1999. During the consultations, several stakeholders hold the view that these three large catastrophes do not reflect the perceptions of the people of Kiribati, such that frequent disasters are having a more regular impact on islands and communities, and that the country is considerably more disaster-prone.

Natural threats include extended droughts (Scott et al. 2003). Low-lying islands are vulnerable to partial or complete overwash from storm waves or storm surges, particularly associated with major tropical cyclones (Terry 2007, Spennemann 2006). There are major concerns of frequency of enhanced cyclone activity, rising means sea levels, increased frequency of drought and increased risk of island overtopping (Ali et al. 2001). Droughts are linked to El Nino and La Nina occurrences in the Pacific (White et al.1999, Scott et al. 2003), with droughts affecting Kiribati during La Nina periods (White et al. 2007). Drought events cause the fresh groundwater lens to contract. Seawater inundation from storm surges and storm waves causes salination of fresh groundwater on low-lying islands (Richards 1991, Oberdorfer and Buddemeier 1984). Droughts and overwashing of seawater are only temporary, while rising sea levels result in lasting change. Erosion of the edges of an island, which reduce the island area, also decreases the volumes of the freshwater lenses. Due to increase in population, whether through natural growth or migration to urban centres, threats to freshwater lenses involve the over-abstraction of groundwater and pollution from animal, human and industrial wastes.

The increase in ocean temperature leads to coral bleaching, which leaves the coral physiologically compromised (Wild et al. 2011). There is also the possibility of increased mortality rates, weakening of carbonate structure, increased susceptibility to disease and compromised productivity of corals (Spalding and Brown 2005). As a result of the consequences, coral reef rugosity is diminished, and reefs' ability to disperse waves is weakened, resulting in poorer coastal defences (Eliff and Silva 2017).

Reefs affected by climate change would also affect the fisheries and agriculture sectors and the natural biodiversity in Kiribati. More extreme droughts would put higher pressure on people to conserve water and use alternative sources of water. Earthquakes and tsunami are not of a high threat and are not expected to cause any significant damage. A tsunami caused by an earthquake was last seen in 1899 and caused moderate losses. Efforts to develop disaster risk resilience in Kiribati have been extensive. The multi-sectoral goals and linkages to policies and international goals and frameworks are listed in Table 11.

Table 11: Policy frameworks related to natural resource management in the Republic of Kiribati.

Sectoral Aim	Policies with Linkages to Sendai Framework for Disaster Risk Reduction	Policies with Linkages to Sustainable Development Goals	Policies with Linkages to the Paris Climate Agreement for Environment
National Development	Kiribati Development Plan 2016-2019	Kiribati Development Plan 2016-2019	Kiribati Development Plan 2016-2019
	Kiribati 20-Year Vision 2016-2036	Kiribati 20-Year Vision 2016-2036	
	Kiribati Joint Implementation Plan for Climate Change and Disaster Risk Management (2014-2023)		
Environmental Protection	Kiribati Integrated Environment Policy (2013)	Kiribati Development Plan 2016-2019	Kiribati Development Plan 2016-2019
Disaster and Climate Risk Reduction	National Adaptation Program of Action (2007)	National Adaptation Program of Action (2007)	National Adaptation Program of Action (2007)
	Kiribati Joint Implementation Plan for Climate Change and Disaster Risk Management (2014-2023)	Kiribati Climate Change Policy	Kiribati Climate Change Policy
Vulnerability Reduction	National Disaster Risk Management Plan (2012)	National Adaptation Program of Action (2007)	National Adaptation Program of Action (2007)
		Kiribati National Disability Policy and Action Plan (2018-2021)	
		Kiribati Approach to Eliminating Sexual and Gender Based Violence in Kiribati. Policy and National Action Plan (2011-2021)	Kiribati Climate Change Policy
Land Use Policy	Kiribati Development Plan 2016-2019	National Adaptation Program of Action (2007)	Kiribati Integrated Environment Policy (2013)
	National Adaptation Program of Action (2007)	Kiribati 20-Year Vision 2016-2036	

5 History of Interventions

The interventions in the water supply and sanitation sectors started in the late 1960s with the construction of Water supply and sanitation initiatives began in the late 1960s with the construction of the South Tarawa water supply system, which was funded by the Gilbert and Ellice Island Colony administrations. Following that, the South Pacific Commission supplied financing and the Ministry of Health provided construction supervision for the installation of water delivery systems and on-site sanitation systems in the outer islands. Windmill-fed water delivery systems, diaphragm hand pumps, and pit latrines were delivered to all families in the southern Gilbert group as part of the project.

In the 1980s the water supply systems in the outer islands were replaced with solar-powered pumping water supply systems and some windmill pumps were also refurbished, with funding from the Australian Government and through the supervision of the then Public Works Department under the Ministry of Works and Energy (now MISE). There was also major funding provided by the United Nations Capital Development Fund (UNCDF) in the late 1990s, which covered 75 villages on 13 outer islands in the Gilbert group. Depending on the distance from the village's good water source, the communities received either several hand pump systems or solar-powered water supply systems. The policy was that if the distance between the water source and the hamlet was less than 750 metres, a multi-hand pump system would be installed; if the water supply was more than 750 metres away, a solar pump would be installed. The UNCDF project took more than 10 years to complete because the target beneficiaries were expected to provide free labour, resulting in very slow implementation.

Following the cholera outbreak in 1977/1978, the Australian Government through its Department of Housing and Construction, funded the saltwater flushing sewerage systems for the three main centres on South Tarawa, which are Betio, Bairiki and Bikenibeu, each with sewer lines, pump stations and outfall pump stations. Upon completion of the sewerage project, the water supply project started in 1983 to improve the old system that was constructed in the early 1970s. The water supply project, which covered all South Tarawa, was completed in 1988 with all government residential buildings provided with metered house connections. Table 12 provides more recent interventions since the year 2000.

Table 12: Interventions as of the year 2000.

Name of Project	Implementing Agency	Outcome	IWR2R Linkage
Sanitation Public Health and Environment Project (SAPHE) 2002–2005	Funded by the Asian Development Bank and implemented by the Ministry of Infrastructure and Sustainable Energy	Improve in the South Tarawa Water supply and Sewerage systems, plus construction of landfills at Nanikaai, Bikenibeu and Betio.	Improve water supply, sewerage services and landfill development.
South Tarawa Sanitation Improvement Sector Project 2012-2019	Funded by the Asian Development Bank and implemented by the Ministry of Infrastructure and Sustainable Energy	Improvement of sewage disposal at the Betio, Bairiki and Bikenibeu. Sewage – solids removed before discharge at about 30 m below means sea level at three different sites.	Protect reef from destruction as sewage is discharged 30 m below sea level. Improve sanitation situation at Betio, Bairiki and Bikenibeu.
Modelling Sea-level and inundation effect of freshwater lens 1997–2014	Secretariat of the Pacific Community with MISE	Improve understanding of: Potential for wave overtopping of Bonriki water reserve. Probability of inundation of Bonriki Water Reserve is relatively low. Over-abstraction and low rainfall at Bonriki water reserve are more critical than inundation.	Improve knowledge on inundation due to climate change.

Name of Project	Implementing Agency	Outcome	IWR2R Linkage
Solar photovoltaic systems connected to PUB's grid 2015 – 2016	United Arab Emirates – 500 kW solar arrays installed at Bonriki, plus others 400 kW by Japan and another 516 kW by World Bank	Result in PUB saving US$800,000 in fuel cost as the result of some 1.4 MW solar array capacity connected to PUB's grid.	
Protection of freshwater sources and freshwater supply at the cost of US$10.8 million	Funded by the World Bank through the KAPIII and MISE.	Replacement of gallery pump with variable speed pump and installation of pilot 24/7 water supply system in Tanaea, part of Eita village and Nanikaai villages on South Tarawa.	
Future Projects			
South Tarawa Water Supply Project 2020	Funded by Green Climate Fund, Asian Development Bank, World Bank US$58 million	Water supply would run 24/7 including water system to Bonriki and Buota water reserve resident.	Improve water supply by installation of 6.0 Mega litre of water per day Reverse Osmosis Desalination Plants to supplement Bonriki and Buota water sources.

6 Key Findings

6.1 Diagnostic Analysis

The diagnostic analysis for the Kiribati IWR2R project demonstration site was made possible from data collected by Members of Parliament during a survey to identify environmental issues in all islands of Kiribati resulting from climate change in the years 2016 to 2017. Four main environmental issues were identified: 1) Coastal Erosion; 2) Adverse impacts on drinking water; 3) Adverse impacts on food crops; and 4) Decline in marine resources. Coastal erosion, impact on drinking water and the decline in marine resources were treated as priority and therefore investigated in the report.

The three prioritised environmental issues were further analysed using the problem tree analysis to determine the immediate causes, underlying causes and finally, the root causes. The ideas for reform and intervention were then derived based on the root causes. There is no easy way to solve issues such as coastal erosion (which will involve a huge investment to build a permanent seawall) or the drinking water issues. It is recommended that there is a need to conduct a feasibility study on the best option to tackle coastal erosion, while the drinking water issue can be tackled with installation of rainwater catchment systems for every household and the use of large community buildings such as church buildings, maneaba and other public buildings as catchments to fill large water tanks that can be used during the long drought. It is also suggested that rainfall for each island is collected and stored for rainfall analysis to determine the suitable tank volume and roof area.

6.2 Opportunities

Some of the factors that exist in Bonriki and Buota that can be harnessed for successful implementation of the GEF IWR2R project include:

1. The feasibility study on the design of an appropriate seawall to protect the coastline. These include concrete retaining structure and sheet piling.
2. The introduction of home gardening in the outer islands so households can grow cabbage, cucumbers, tomatoes, and watermelons using modern farming techniques using compost from a. Dry-Litter piggery system or from composted organic material. This would mainly be for households' consumption and providing a balanced diet or for sale.
3. The use of a properly designed rainwater catchment systems that can last during the drought period. This will involve the analysis of rainfall data over a period to enable calculations to determine minimum storage for a particular roof area.
4. For the decline in marine resources, it is important to spread awareness of the importance of sustainable fishing methods and enforcement of the prohibition of less destructive methods.

6.3 Risks

Some of the risk factors for the successful implementation of the GEF IWR2R project at the Bonriki and Buota site include:

1. The donors may not be interested in financing the coastal protection work proposal due to the very high costs when one considers the long distance of the coasts that are proposed to be protected.
2. The home gardening proposal may not be attractive to most I-Kiribati in the outer islands due to intensive labour requirements for farming work. This will require change in behaviour, which can be a challenge and will take time to take effect.
3. The issue with rainwater catchment systems is that most houses in the outer islands use thatched rooves which are not suitable for catching rainfall. There may be a need for all households to have at least one building in their yard that is built with a roof suitable for rainwater harvesting. A simple house with permanent roofing material, guttering and downpipe and a tank of approximately 500 litres capacity is quite sufficient to store rainwater for the duration of the rainy season.

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