CLIMATE CHANGE, WATER SECURITY, AND WOMEN

A Study on Water Boiling in South Tarawa, Kiribati

ADB

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ASIAN DEVELOPMENT BANK

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PREFACE

Kiribati is one of the most remote and least developed countries in the world. The capital, South Tarawa, is dependent on groundwater, which is seriously threatened by climate change-induced inundation and prolonged drought. The ongoing South Tarawa Water Supply Project is building two desalination plants, rehabilitating and expanding the water supply network, and building a solar photovoltaic system. These investments will provide the population with safe and climate-resilient water supplies.

The Asian Development Bank (ADB) supported the government to access climate financing from the Green Climate Fund for the project. This publication presents the results of a household survey conducted in relation to the Green Climate Fund (GCF) funding proposal. The survey measured the type and amount of fuel used by households to boil water and provided an estimate of greenhouse gas (GHG) emissions that could be avoided by the delivery of clean water through the project. The publication also details further notable survey findings including economic costs and benefits, and gender, health, and environmental considerations surrounding water boiling practices. The implications for the design of future projects are discussed in this report.

ADB works with developing member country governments and utilities in the Pacific region to improve access to essential services including water supply and electricity. This publication has links to four of the seven operational priorities (OPs) under ADB's Strategy 2030: (i) addressing remaining poverty and reducing inequalities (OP 1); (ii) accelerating progress in gender equality (OP 2); (iii) tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability (OP 3); and (iv) making cities livable (OP 4). It also links to the Sustainable Development Goals on water, energy access, climate change, and gender.

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ABBREVIATIONS

A$	Australian dollar
ADB	Asian Development Bank
CO_2	carbon dioxide
CRVA	climate risk and vulnerability assessment
GCF	Green Climate Fund
GHG	greenhouse gas
PUB	Public Utilities Board
WASH	water, sanitation, and hygiene

WEIGHTS AND MEASURES

kg	kilogram
km^2	square kilometer
L	liter
m^3	cubic meter
MW	megawatt

INTRODUCTION

The Republic of Kiribati consists of 32 atolls and one coral island, with a total land area of 810 square kilometers (km^2) spread over 3.5 million km^2 of the Pacific Ocean. South Tarawa, the nation's capital, lies on the Tarawa atoll. It has a land area of around 16 km^2, and at its highest point is only 3 meters above sea level. It is highly urbanized with a population of about 65,000, growing at 2.4% per year (Table 1).

Table 1: Key Statistics on Kiribati and South Tarawa

Kiribati		Remarks
Land area	810 km^2	Comparable to Singapore (700 km^2)
Ocean area	3.5 million km^2	Comparable to India (3.3 million km^2)
Population	113,000 (2018)[a]	
South Tarawa		
Land area	16 km^2	1/4 the size of Manhattan
Population	65,102	Projected from 2015 census
Population density	4,000/km^2	Almost entirely at ground level (no high-rise buildings)

km^2 = square kilometer.
[a] ADB Data Library. Kiribati, Key Indicators. https://data.adb.org/dataset/kiribati-key-indicators (accessed 29 March 2020).
Source: Author.

Former bridge between islets near Buota, South Tarawa (photo by ADB).

Water Supplies

South Tarawa's water resources are highly stressed due to the capital's small land area, lack of natural water storage, competing land uses, and densely populated urban environment. Two groundwater lenses[1] are the only freshwater sources suitable for drinking water, with an estimated combined sustainable yield of no more than 2,000 cubic meters (m^3) per day.

The Public Utilities Board (PUB), a state-owned water and electricity utility, operates South Tarawa's centralized water supply scheme. Water is extracted from the lenses, undergoes basic treatment, and is then supplied through a transmission main approximately 30 kilometers long, which stretches from east to west across South Tarawa and which supplies several small storage tanks and the distribution network.

While the transmission main was rehabilitated through a project that closed in 2018, leakages from the distribution network are estimated at 67%, so only about 700 m^3 per day, or around 10 liters per person per day, is available for consumption from the public supply. This amount is far below the 50 liters per person per day recommended to meet minimum health requirements.[2] The public water supply is rationed to 2 hours every 2 days, and delivery pressure is low. Projected population growth means that, without intervention, the gap between supply and demand will continue to widen.

Existing aeration system for sulfur removal and water storage tank at Bonriki (photo by ADB).

[1] A groundwater lens is a convex layer of less dense fresh water floating atop denser saltwater.

[2] G. Howard and J. Bartram. 2003. *Domestic Water Quantity, Service Level and Health.* Geneva: World Health Organization. http://www.who.int/water_sanitation_health/diseases/WSH0302.pdf.

Households have developed strategies to manage water demands using other sources to supplement the public supply. Rainwater harvesting is used to some extent, but its total contribution is marginal, and it cannot be relied upon during the periodic droughts that affect Tarawa. Groundwater in urban areas is harnessed to some extent through private, shared, and communal shallow wells. However, the groundwater is generally brackish and contaminated bacteriologically by animal and human waste, as the catchment in urban areas is unprotected. In most cases, PUB water, harvested rainwater, and groundwater show high levels of bacterial contamination.[3]

Collecting water in South Tarawa. A woman collects water supplied from the distribution network. The supply pressure is low, so water is often collected from below ground level (photo by Josh Chappelow).

[3] ADB. 2014. Economic Costs of Inadequate Water and Sanitation: South Tarawa, Kiribati. *Pacific Studies Series. Manila.* https://www.adb.org/sites/default/files/publication/41796/economic-costs-inadequate-water-sanitation.pdf.

Climate Change Vulnerability

Kiribati already faces significant challenges from oceanic and meteorological conditions, all to be exacerbated by climate change. Sea level rise is of particular concern. Sea water overtopping will increasingly threaten the fresh water stored in the groundwater lenses, and sea level rise will also exacerbate existing seasonal conditions such as heavy rains and king tides[4] that affect access to safe water (Box). Fresh water resources may also be increasingly threatened by extreme weather events such as droughts. Climate phenomena such as heatwaves may also lead to increased demand for fresh water.

The available literature on gender dimensions of climate change suggests that vulnerability is a key concern, and women bear a disproportionate burden of the impacts of extreme weather events and disasters. Sea level rise will intensify competition over scarce resources including land, resulting in conflicts in which women suffer most. Inequitable access to resources undermines women's capacities to cope and bounce back after disasters.

Box: Fragility of Water Resources[a]

"What is particularly disturbing in these vulnerable low-lying communities is how rapidly the conditions and positive efforts of the behavioural change program can be affected by external factors such as climatic changes and poor local planning. These communities are severely affected by a mixture of climate change, poor community resilience and lack of community development priorities and supports.

For example, Ketemwane, Tebwanimwaneka Kamwengaraoi and MNC had been gradually improving with support from the CM team.[b] However, poor community practices around accessing the limited water supply combined with the exceptionally high king tides in January 2019 significantly affected the positive achievements of these two communities for a period of time. The water supply became polluted with sea water and became unpotable. Constant heavy rain since December has added to the environmental concerns with considerable flooding affecting other communities also. Clean water was carted into households and its scarcity contributed to deteriorating hygiene practices and a subsequent diarrhoeal outbreak in March 2019 affecting children in particular, who play in the flooded areas. It is important for these communities to build their resilience to external shocks by securing appropriate equipment such as above ground water tanks, collecting rain-water run-off and managing flood waters whilst also managing their hygiene.

As voiced by one CM: '... as we gradually lose our lands to rising sea level and tides, space is becoming scarce and so to build a toilet is seen as a waste of space and so the beach becomes a toilet for many. As unhygienic as this may seem, this is the best option for many who have lost a portion of their land to rising sea level and sadly this poses health risks.'"

CM = community mobilizer, MNC = Mwengaraoi Nanikai Community.
[a] This is an extract from South Tarawa Sanitation Improvement Sector Project - Community Engagement Program Final Report.
[b] Ketemwane, Tebwanimwaneka Kamwengaraoi, and MNC are communities in South Tarawa.
Source: ADB. Final Report of the STSISP Behavioural Change Program. Consultant's report. Manila. Unpublished.

[4] King tides are tides just after a new or full moon, when there is the greatest difference between high and low water.

The houses in South Tarawa are exposed to storm surges and king tides (photo by ADB).

Public Health

Kiribati faces a double burden of disease, with both communicable and noncommunicable diseases leading to high morbidity and mortality. High-density housing and overcrowding in urban areas in South Tarawa facilitate the transmission of infectious diseases. In addition to inadequate water supplies, access to sanitation is limited (around 22% of South Tarawa's population practices open defecation), while only around 64% of households have a handwashing facility on the premises with soap and water.[5] Inadequate water, sanitation, and hygiene (WASH) infrastructure and behaviors, as well as poor food handling and storage, contribute to the high number of diarrheal, respiratory, eye, and skin infections. In 2016, 10% of recorded deaths of children under 5 were attributed to "diarrhoea and gastroenteritis of presumed infectious origin," and 3% to "volume depletion," which can be triggered by dehydration through vomiting and/or diarrhea commonly associated with gastroenteritis.[6] Kiribati's under-five mortality rate is among the highest in the Pacific at 61 per 1,000 live births, more than double the rate in most Pacific island countries (footnote 5).

[5] Kiribati National Statistics Office. 2019. *Kiribati Social Development Indicator Survey 2018-19: Survey Findings Report*. South Tarawa. https://asiapacific.unfpa.org/sites/default/files/pub-pdf/kiribati_mics_sdis_2018-19_survey_findings_report_english.pdf.

[6] ADB. South Tarawa Water Supply Project – Project Preparatory Technical Assistance Inception Report. Consultant's Report. Manila (TA 9200-KIR). Unpublished.

Energy Access

The PUB provides grid-connected electricity to South Tarawa with an installed capacity of 7.1 megawatts (MW). Reliance on diesel for electricity generation has resulted in electricity costs among the highest in the Pacific. Available diesel capacity (instantaneous diesel power available) after derating is 4.8 MW, compared with a peak demand of 5.5 MW. Contributions from solar photovoltaic, which accounts for 9% of the generation capacity, make up a portion of the difference, although this can require feeders to be disconnected at times when demand exceeds supply. A lack of back-up generation assets results in regular load shedding. Around 72% of South Tarawa households have access to electric lighting, but that lighting is often insufficient, inefficient, and expensive. Biomass and kerosene are typically used for cooking, although the sandy soil of the atolls and unreliable rainfall mean biomass supplies are difficult to rely on.[7]

Impact of Inadequate Water, Sanitation, and Hygiene and Energy Access on Women

Women, children, the elderly, and the most disadvantaged households often bear a disproportionate share of the burden of inadequate WASH infrastructure and behaviors. In South Tarawa, women tend to be responsible for a larger share of water-related household tasks such as cleaning, washing, and caring for infants and elderly family members, and spend significant amounts of time fetching well water for these purposes.[8] The challenge of ensuring adequate water availability for family use can also increase stresses on relationships within the household, creating potentially violent situations. The necessity for both men and women to obtain water when it becomes available due to intermittent supply in South Tarawa leads to household disruptions and may contribute to absenteeism.[9] Inadequate WASH facilities can also magnify the challenges faced by women and girls in managing menstrual hygiene. Private sanitation and hygiene facilities with clean water and disposal facilities for menstrual hygiene materials may be unavailable in households, schools, and workplaces, with resultant impacts on absenteeism as well as women's and girls' ability to manage menstrual hygiene with dignity.

Women are disproportionately affected by energy poverty. Women-led small home-based businesses, microenterprises, and informal livelihood activities—such as

7 International Renewable Energy Agency. 2015. *Kiribati Integrated Energy Roadmap (KIER) Renewable Energy.* Working Draft. September. https://irena.org/-/media/Files/IRENA/Agency/Publication/2017/Jul/Kiribati_Integrated_Energy_Roadmap_2017.pdf.

8 World Bank. 2019. *Implementation Completion and Results Report.* For the Kiribati Adaptation Program – Phase III Project. http://documents1.worldbank.org/curated/en/100741561139747493/pdf/Kiribati-Third-Phase-of-Kiribati-Adaptation-Program-Project.pdf.

9 Personal communication reported in ADB. 2017. *South Tarawa Water Supply Project – Poverty and Social Analysis.* Consultant's report. Manila (TA 9200-KIR).

handicrafts, food processing and sale, small retail, ice block making for sale of fish, participation in social institutions, etc.—are often dependent on a regular electricity supply. Without such access, women suffer from energy poverty, which perpetuates economic poverty as meager incomes do not meet livelihood needs. Such trends are worse for economically poor households headed by women who struggle to access electricity, clean water, and other development services.

The fuel and technology (e.g., type of stove) used for water boiling, cooking, lighting, and heating have different impacts on men and women given the unequal gender division of labor within the household. Sustainable Development Goal 7 indicator 7.1.2 relates to the use of polluting fuels such as firewood and kerosene, which typically have a disproportionate effect on women responsible for cooking in the home.[10]

In 2016, the World Health Organization declared household air pollution a global health emergency responsible for premature deaths, mainly causing noncommunicable diseases such as stroke, heart disease, and lung cancer.[11]

Dried fish seller. A woman sells dried fish in South Tarawa (photo by ADB).

10 United Nations Statistics Division. 2021. Metadata for SDG Indicator 7.1.2: Proportion of Population with Primary Reliance on Clean Fuels and Technology. https://unstats.un.org/sdgs/metadata/files/Metadata-07-01-02.pdf.

11 World Health Organization. 2016. *Burning Opportunity: Clean Household Energy for Health, Sustainable Development, and Wellbeing of Women and Children.* Geneva. https://apps.who.int/iris/bitstream/handle/10665/204717/9789241565233_eng.pdf;jsessionid=59BF0738E2A116B3D177822B081510DC?sequence=1.

Clothes drying. Clothes are dried under the sun and trees in South Tarawa (photo by ADB).

SOUTH TARAWA WATER SUPPLY PROJECT

The Asian Development Bank (ADB) approved the South Tarawa Water Supply Project in 2019. The $62 million project, with cofinancing from the Green Climate Fund (GCF), the World Bank, and the Government of Kiribati, will combat factors that result in the high incidence of waterborne diseases in South Tarawa through the delivery and effective management of new and rehabilitated climate-resilient water supply assets and improved hygiene practices.

Two seawater reverse osmosis desalination plants, with a total capacity of 6,000 m^3/day, will be constructed to provide a reliable, climate-resilient source of fresh water for the capital (Map 1). Several earlier studies concluded that desalination was a viable option for South Tarawa.[12] The technology can improve resilience to water quality degradation and diversify existing water supplies independent of rainfall, thus offering a climate-resilient water resource.[13] The desalination plants' energy consumption will be offset by a 2.5 MW solar photovoltaic system and a 2 MW battery.

The water supply network will be rehabilitated to minimize leakages in the distribution network and expanded to add new metered household connections to piped water supplies, ensuring a 24/7 supply of safe water to households. Both the desalination plants and water supply network will have 5-year operation and maintenance contracts attached to the works and funded by the project.

A 5-year WASH and climate change awareness campaign will run in parallel to these works. A public education center will be constructed and colocated with the desalination plant to educate visitors about climate change, desalination and water resources management, and how they are connected to topics such as water conservation, disaster risk management and renewable energy. The project will also support the project management unit under the Ministry of Infrastructure and Sustainable Energy to ensure the project is managed efficiently and effectively.

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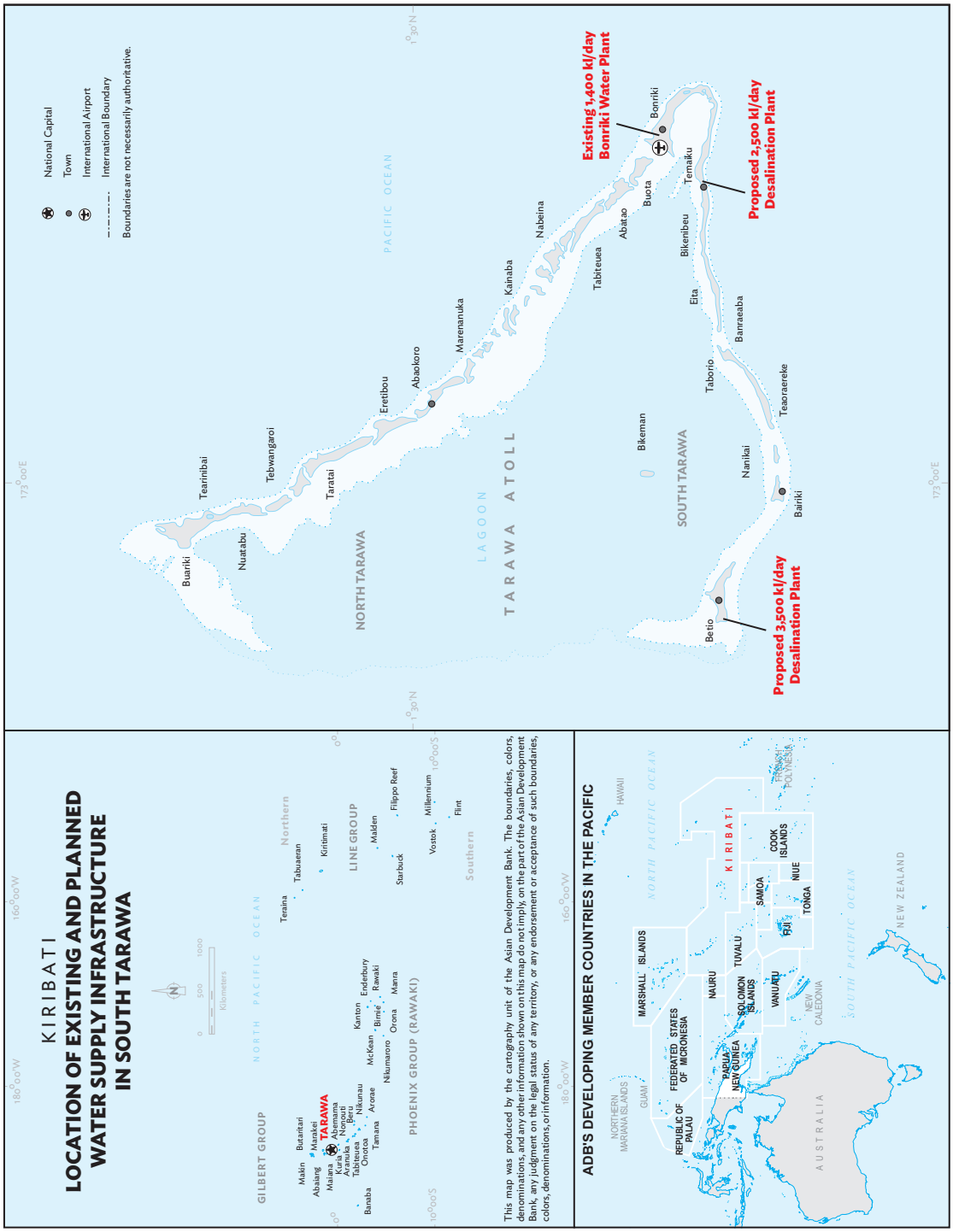
12 I. White. 2010. *Tarawa Water Master Plan*. Pacific Region Infrastructure Facility (PRIF). Sydney. https://www.theprif.org/document/kiribati/water-wastewater-and-sanitation/tarawa-water-master-plan; Fraser Thomas Partners. 2012. *Water and Sanitation Roadmap 2011–2030*. Volume 1. PRIF. Sydney. https://www.theprif.org/document/kiribati/water-wastewater-and-sanitation/south-tarawa-water-and-sanitation-roadmap-2011; Fraser Thomas Partners. 2012. *South Tarawa Water Supply Options Assessment: Desalination Feasibility Study*. PRIF. Sydney. https://www.theprif.org/sites/default/files/documents/desalination_fs_report_appendices.pdf; and Pacific Infrastructure Advisory Centre. TA-7359-KIR South Tarawa Water Supply Desalination Feasibility Study: Peer Review Report. Unpublished.

13 M. Elliot et al. 2011. *Technologies for Climate Change Adaptation – The Water Sector*. Roskilde: UNEP Risø Centre on Energy, Climate and Sustainable Development.

Map 1: Location of Existing and Planned Water Supply Infrastructure in South Tarawa



Source: ADB.

Climate Financing

The Government of Kiribati requested ADB to support the preparation of a project proposal to GCF. In parallel to the project's design process, which covered technical, financial, social, and other due diligence in line with ADB requirements, a climate risk and vulnerability assessment (CRVA) was undertaken. The CRVA defined the project's climate characterization and identified modifications to the project design necessary to ensure that it would be adapted to projected climate change. The CRVA also involved assessing and recommending measures to reduce greenhouse gas (GHG) emissions and thus mitigate climate change. The key elements of climate change adaptation and mitigation are summarized in Table 2 and Figure 1.

Table 2: Elements of Climate Adaptation and Mitigation in the Project

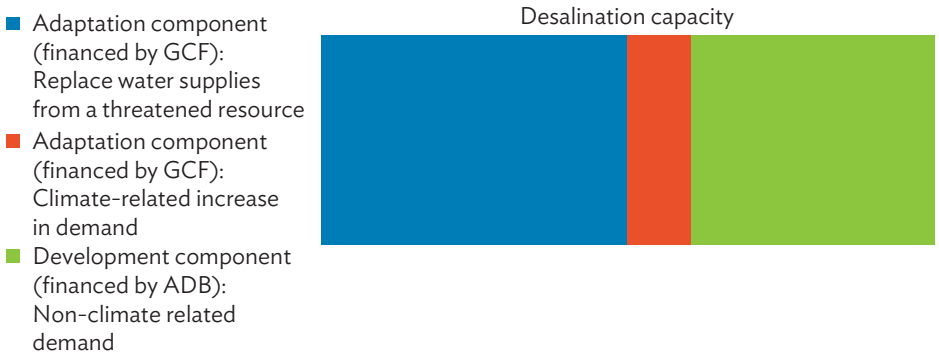
Area	Elements

Climate adaptation	• Desalination plant with sufficient capacity[a] to
	  • replace water supplies from a resource threatened by climate change (i.e., groundwater lenses)
	  • provide for climate-related increased demand (population growth due to climate-driven in-migration from outer islands, and increased per-capita demand due to temperature increase)
	• Solar energy infrastructure to offset the adaptation component of the desalination plant[b]
	• Related operation and maintenance, institutional strengthening, and project management activities
	• Information, awareness-raising, and education for South Tarawa's population

Climate mitigation	• Reduced need for households to boil water using kerosene due to improved quality of water delivered to households • Climate mitigation-related community engagement and institutional strengthening activities Mitigation co-benefits (no GCF financing sought): • Replacing diesel generators with solar to provide energy demand for water production and distribution (only the balance solar capacity not already captured under climate adaptation above, to avoid overlap) • Reduced need to pump and treat water due to reduced physical losses from the water supply network

GCF = Green Climate Fund.
[a] A significant proportion of the costs of the desalination plant were included in the proposal to GCF for climate financing. A distinction was made between the adaptation component (or capacity) of the plant, to be funded by GCF, and the development component of the desalination costs, to be funded by the Asian Development Bank.
[b] Funding for solar power infrastructure associated with the desalination plant's adaptation component (footnote a) was included in the GCF proposal as adaptation (not mitigation) financing.
Source: ADB.

Figure 1: Adaptation and Development Components of the Desalination Plant



ADB = Asian Development Bank, GCF = Green Climate Fund.
Notes: The adaptation component of the desalination plant capacity was distinguished from the development capacity (e.g., capacity required due to natural population growth) to identify costs eligible for climate financing. Figure not to scale.
Source: Author.

The mitigation assessment hypothesizes that households will burn less fuel to boil water once safe water supplies are available. To develop this hypothesis, ADB supported the government to commission a household survey on water boiling practices to obtain the required data. The results ultimately contributed to the project justification and selected design elements. The ADB project team worked closely with GCF to ensure the climate components described in Table 2 were substantiated in the GCF proposal document. GCF approved a grant of $28.6 million in October 2018.[14]

Women boiling water in South Tarawa (photo by ADB)

[14] GCF. 2018. Funding Proposal: FP091: South Tarawa Water Supply Project. https://www.greenclimate.fund/document/south-tarawa-water-supply-project.

WATER BOILING PRACTICES

This publication presents the findings of a comprehensive survey conducted in January 2018 on water boiling practices of South Tarawa's households. However, before that survey, several sources provided qualitative information to suggest that water boiling before consumption is well-established in South Tarawa. These sources include the following:

(i) **Public Utilities Board Pilot Water Improvement Zone Project.** The Pilot Water Improvement Zone information, education, and communication strategy, with incorporated behavior change strategy, included the key message "Your health and safety is our priority—our goal is to make water safe to drink straight from the tap but for now we recommend boiling it for 1 minute."[15] The pilot included three communities in South Tarawa, and activities were funded through the third phase of the Kiribati Adaptation Program Project (closed in 2018) (footnote 8).

(ii) **South Tarawa Sanitation Improvement Sector Project.** The project's Community Engagement Program implemented household health data boards as a tool for monitoring health and sanitation practices in communities. Households in a community would assess their level of health against a set of indicators, one of which included "Boiled Drinking Water and [solar disinfection] SODIS: All households should have access to the (boiled) PUB water, or boiled rainwater, or SODIS for their family members."[16] The South Tarawa Sanitation Improvement Sector Project closed in 2019.

(iii) **South Tarawa Water Supply Project.** Assessments conducted during the project preparatory technical assistance found that at the primary school level, students are taught WASH activities such as handwashing, face washing, and boiling water for drinking.[17] "Although the PUB water is chlorinated, customers are advised to boil water as testing has revealed high levels of bacterial contamination. This has been attributed to a number of factors including unsafe water storage practices, contamination of supply from external pollution sources due to the intermittent

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15 Communicate to support 24/7 safe & reliable water at home. Public Utilities Board Pilot Water Improvement Zone (PWIZ) Project's Information, Education & Communications (IEC) Strategy with Incorporated Behaviour Change Strategy (BCS). South Tarawa. Unpublished.

16 ADB. South Tarawa Sanitation Improvement Sector Project. Final Report of the STSISP Behavioural Change Program. Consultant's report. Manila. Unpublished.

17 ADB. 2018. *Project Preparatory Technical Assistance for the South Tarawa Water Supply Project*. Final Report. Consultant's Report. Manila.

> unpressurised nature of the system and the tampering with pipes, and high organic content in storages."[18]

The effectiveness of microbiological disinfection depends on the temperature and the length of time spent boiling water. It has been noted that, due to other nonmicrobiological contaminants, even boiled well water may not be potable in South Tarawa (footnote 16). For example, boiling does not treat nitrates, which may be found in groundwater. Excessive levels of nitrate pollution in well water used to mix infant formula are linked to infant methemoglobinemia, commonly called "blue baby" disease.[19] Blue baby cases have been reported in South Tarawa (footnote 3).

Survey

In January 2018, ADB supported a survey to estimate the type and amount of fuel used by households to boil water and other related practices. This survey was designed to provide the data required to estimate avoided GHG emissions should households no longer boil water due to interventions through the South Tarawa Water Supply Project. These estimates could then be used to substantiate one of the arguments presented in the GCF funding proposal, i.e., that improved water supplies could reduce GHG emissions, and thus associated activities might be eligible for climate mitigation financing. The survey was also designed to support (i) an estimation of potential future economic costs, such as fuel expenditures, time spent boiling water, and carbon dioxide (CO_2) emissions associated with using kerosene to boil water, to factor into the project's economic analysis; and (ii) an assessment of the gender elements related to boiling water for consumption.

Methodology

The survey was undertaken over 5 days by a team of four surveyors with previous experience conducting surveys. The survey team received a half-day training before starting the surveys. Of 16 villages in South Tarawa, the eight largest were selected: Ambo, Bairiki, Betio, Bikenibeu, Bonriki, Eita, Teaoraereke, and Temaiku (Map 2). A total of 200 households were surveyed. The sampling size was selected proportionately to the number of houses in each village. As a household list of each village was not available during the survey, households were randomly selected by each surveyor by sectioning off areas of the village participating in the surveys and selecting every fifth household. A random adult among those present at the time of visit was interviewed. Where an adult was not available to participate in the survey, or the house was vacant at the time of the visit, the surveyors moved to the next available household. Map 2 presents the survey areas and Table 3 the characteristics of the surveyed households.

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[18] Kiribati Water and Sanitation Sector Situational Analysis and Scoping Mission - Situational Analysis and Needs Assessment. Prepared for Ministry of Foreign Affairs and Trade. Consultant's Report. Unpublished; Chlorine dosing estimated to be around 3.7mg/L. ADB. Project Preparatory Technical Assistance for the South Tarawa Water Supply Project. Inception Report. Unpublished.

[19] L. Knobeloch et al. 2000. Blue Babies and Nitrate-Contaminated Well Water. *Environmental Health Perspectives*. 108 (7). pp. 675–678.

Map 2: Survey Areas in South Tarawa

Source: Water Boiling household survey report.

Table 3: Characteristics of Households Surveyed

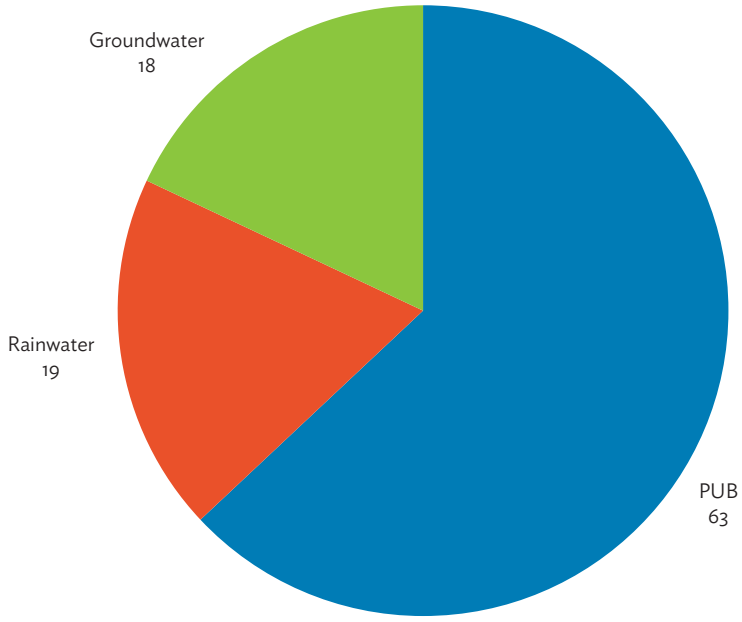
Characteristics	No.
Number of households surveyed	200
Average household size	8
Average number of adults (>18 years) in households	5
Average infants in households (0–5 years)	1
Average children in households (5–18 years)	3

Source: Author.

Survey Results

(i) **Sources of water.** Households use water from three main sources: PUB (municipal supply), rainwater, and groundwater (Figure 2). More than 60% of surveyed households responded that their primary water source was the PUB network. No household in the survey purchased bottled water or water from the PUB tanker service. Also, no households were paying for water, which is unsurprising given that PUB stopped charging domestic customers for water in 2013, following widespread discontent from customers for the poor service.[20]

Figure 2: Primary Source of Water (%)

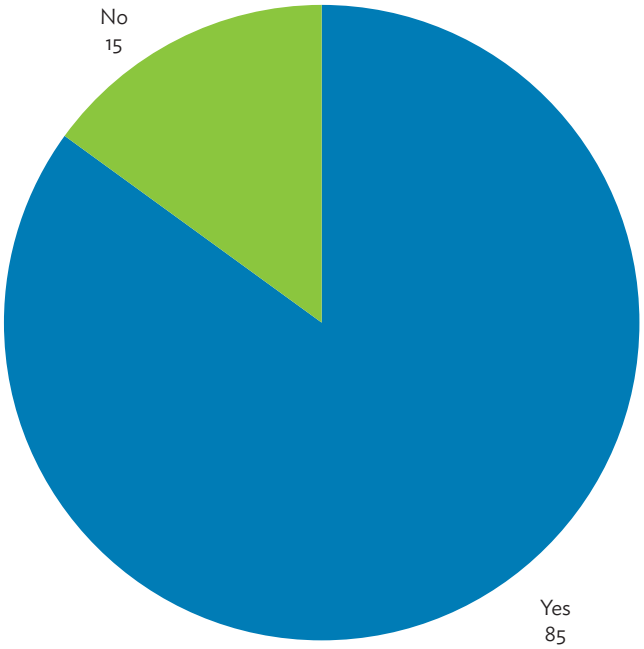


PUB = Public Utilities Board.
Source: Author.

(ii) **Water boiling practice.** Figure 3 shows that 85% of households had boiled water in the preceding 7 days. For those that had not, their main reason was that they thought the water was clean enough to drink. In some cases, respondents mentioned that they boiled the water in their households for infants and children only.

[20] In 2018 the government approved a volumetric water tariff for selected pilot zones funded by the Kiribati Adaptation Program – Phase III Project (Footnote 8). As part of the South Tarawa Water Supply Project, a socially inclusive and regulated tariff will be designed and regulated. The government has made commitments to tariff reform and to furthering its policy on community service obligations.

Figure 3: Households That Boiled Water in the Previous Week (%)



Source: Author.

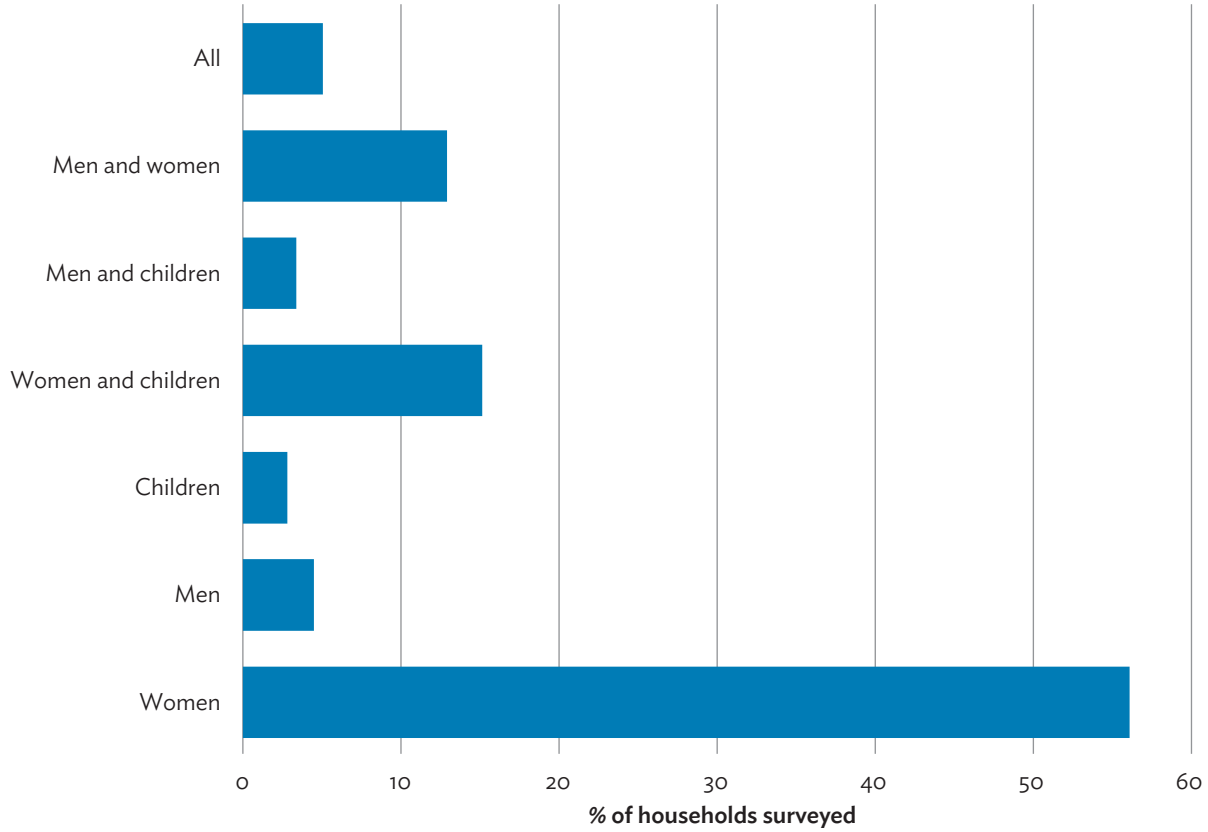
(iii) **Responsibility for water boiling.** The survey result shows that women were primarily responsible for boiling water in households (Figure 4). In more than 50% of households, women are exclusively in charge of boiling water. In 89% of households, women are involved (either exclusively or collectively with other household members) in water boiling.

The survey did not include questions on who collected fuel, but informal responses suggested that both men and women collected firewood.

(iv) **Frequency and volume of water boiled.** Among the 85% of households that boiled water in the preceding 7 days, 85% boiled water every day, indicating that about 70% of households (i.e., 0.85 × 0.85) boil water every day. On days that households boiled water, 45% boiled water once, 53% boiled water 2–3 times, and 2% boiled water 4 times per day (Figure 5).

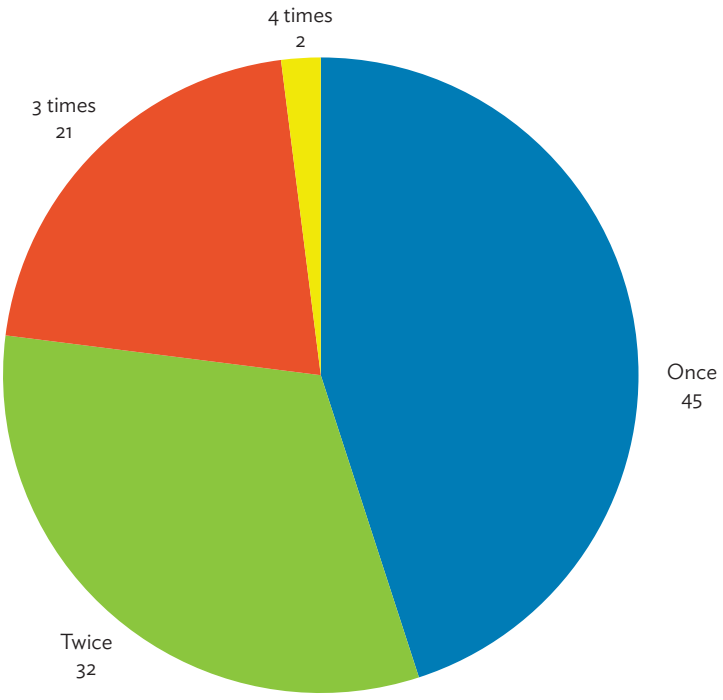
Each time the households boiled water, about 40% of them boiled 5–10 liters (L) of water, about 30% boiled 1–5 L, about 20% boiled 10–15 L, and about 10% boiled more than 15 L of water (Figure 6). On average, the households boiled 8.2 L of water each time.

Figure 4: Responsibility for Water Boiling



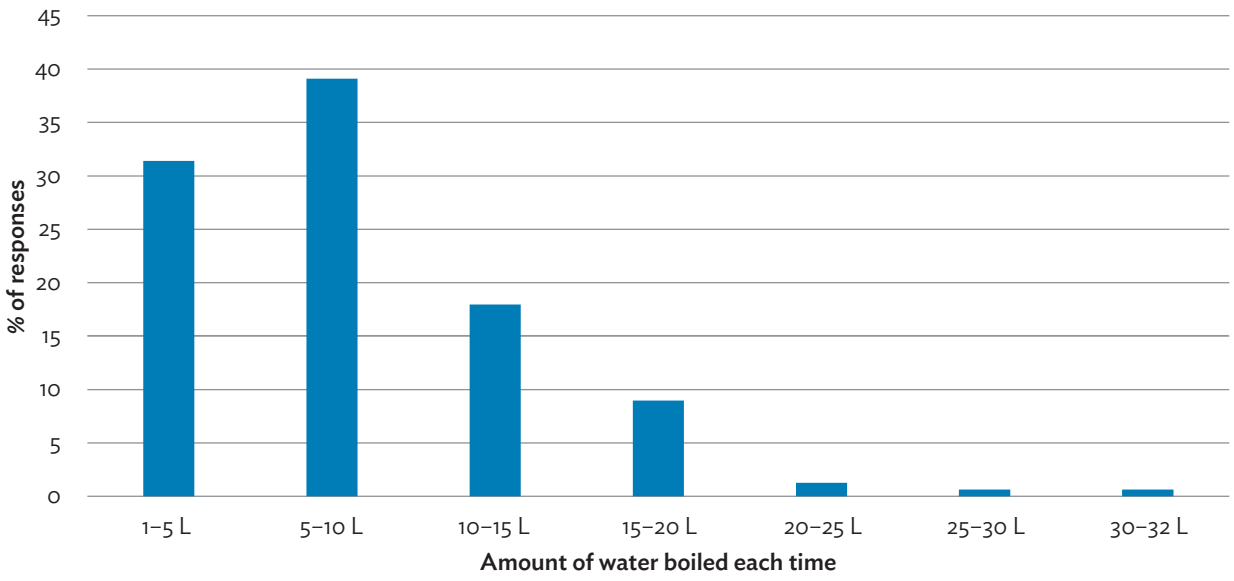
Source: Author.

Figure 5: Number of Times Water Boiled per Day (%)



Source: Author.

Figure 6: Proportion of Households Boiling Different Water Volumes per Boil



L = liter.
Source: Author.

(v) **Fuel sources and collection.** Survey results suggested that the most commonly used fuels to boil water in South Tarawa are wood, kerosene, gas, and copra (Figure 7). The type and volume of fuel used depend on the locations of households and villages.

(a) Wood is the most commonly used fuel, but its use is dependent on the availability of wood in and around the village, the space for the fire outside the household, and the weather. Most of this wood (93%) is sourced locally in and around the village at no cost. This wood can be a combination of coconut husks, small to medium-sized tree branches collected from the ground, or branches chopped into firewood. While the survey did not capture specific data on the type of wood gathered, it is reportedly from trees near the houses or within common areas in and around the village (such as the beachside). Like many natural resources in South Tarawa, wood for burning is scarce. Although it was not specifically captured in the survey results, there is an understanding within the households about which trees can be used for firewood. For example, large trees bearing fruit such as breadfruit were not used for firewood. For those households that primarily use wood as fuel, the average weight of wood used per boil is 4.2 kilograms (kg).

Coastal housing in South Tarawa (photo by ADB).

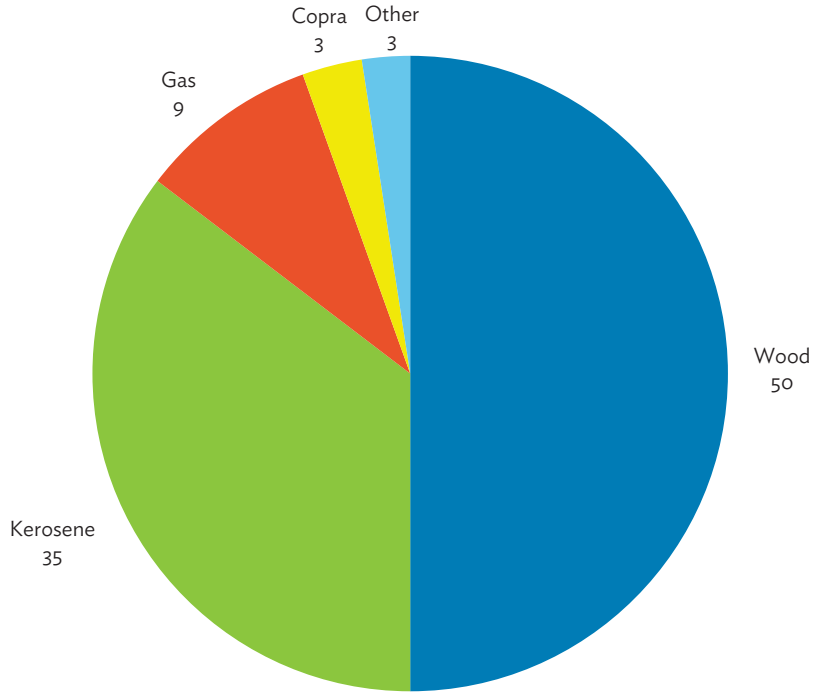
(b) Kerosene is the second most commonly used fuel source for boiling water, with about 35% of households reporting it as their primary fuel. About 0.9 L is used per boil. The typical kerosene container holds 1.5 L and fits into a commonly used model of stove found in the villages.

(c) Gas is the primary fuel for 9% of households surveyed. These households had cylinders of 11–13 kg, which cost approximately

A$42 per cylinder. The volume of gas used could not be calculated from the survey results.[21]

(d) Copra (dried coconut kernel) is considered a cheap and reliable fuel source for cooking and boiling water, although it is more labor-intensive than gas and kerosene. While the size of the vessel differed across houses, each household referred to using either cups of about 250 grams or coconut shells to heap copra onto the fire to boil water. The general cost of copra is up to A$10 per bag, which contains 11–12 kg of copra—a third of a "green bag" (commonly used for waste collection in South Tarawa) or three large scoops or spades.

Figure 7: Fuel Used for Water Boiling (%)



Source: Author.

(vi) **Time spent boiling water.** The survey also collected data on the amount of time each household spends boiling water. The time varied greatly, both for a given fuel and between fuels. Table 4 presents the broad estimate of the average boiling time for each fuel type. It is noted that these estimates

(a) do not include the time spent for fuel preparation such as collecting firewood or purchasing fuel,

(b) do not make assumptions about whether the person boiling water was undertaking other tasks in parallel, and

[21] Recent data (footnote 5) suggest that 18% of households in South Tarawa use clean fuels and technologies for cooking.

(c) include the time taken to bring water to the boil (with large bubbles on the surface of the water) and the duration of time the water was left to boil.

Table 4: Time Households Spend on Boiling Water

Fuel Source	Minutes/Boil
Wood	28
Kerosene	18
Gas	10
Copra	50

Notes: Responses were recorded as 0–5 minutes, 6–10 minutes, 11–15 minutes, 16–20 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hours, and 3 hours. A bracket of 0–5 minutes was counted as 2.5 minutes on average, 6–10 minutes was counted as 7.5 minutes, etc. to calculate the average time spent.
Source: Author.

While not measured within the survey, observations made as part of this exercise indicated space restrictions within some of the villages visited, such as Betio, where the amount of wood that can be stockpiled around the house is restricted.

(i) **Household spending on boiling water.** Survey results suggest that the daily spending per household on fuel to boil water ranges from A$0.25 (gas) to as much as A$15 (wood). However, the costs reported were only for purchasing the fuel itself. The survey did not consider the cost of time required to procure the fuel, particularly wood, which may be available for free but must be gathered, or equipment to use it, e.g., stoves that may pose a significant up-front household expense and preclude the use of gas.

Greenhouse Gas Emission Calculations

Data from the household survey results were then used to estimate current and projected GHG emissions. The results are summarized in Table 5. Only GHG emissions associated with households using kerosene to boil water were estimated. The use of wood and copra biomass for boiling was excluded to simplify the calculation because, unless proven otherwise, they are considered "sustainable" fuels with no net GHG emissions.[22] Gas was also excluded because few households use it, and thus overall emissions resulting from gas are expected to be low. These exclusions tend to lower the estimate of GHG emissions and therefore provide lower estimates of the project's GHG benefits.

Over the project life of 20 years, it is estimated that avoiding the burning of kerosene mitigates around 106 kilotons of CO_2. This figure can be considered conservative because (i) it neglects emissions due to the use of gas to boil water (volumes of gas

[22] It is assumed that for each piece of wood cut and burned (and therefore CO_2 emitted), a new piece of wood will grow, thereby absorbing the equivalent CO_2 from the atmosphere. Hence, there are no net emissions. This is in line with the methodology guidance of the United Nations Framework Convention on Climate Change. It is also a conservative approach and avoids overestimating benefits.

could not be accurately estimated based on the survey results); (ii) it only considers the fuel most commonly burned by households (e.g., if a household mostly used wood and occasionally used kerosene, its kerosene use was not counted); (iii) it does not consider the possibility that households will switch fuels (e.g., from wood to kerosene due to wood shortages, which may increase as the population grows, i.e., new households are less likely to have access to wood); (iv) it does not account for increased water demand due to warmer temperatures caused by climate change, or that household water use is already lower than demand due to rationing; and (v) it only considers avoided emissions when all new plant and equipment are online (projected in 2027), whereas project infrastructure will be phased and some areas will have access to project benefits before 2027.

Table 5: Summary of Greenhouse Gas Emission Calculations

Ref	Year	Item	Value	Reference
A		Number of boils per day per household	1.66	Household survey
B		Kerosene volume per boil (L)	0.93	Household survey
C		Kerosene per day per 200 households (L)	89.2	Calculated (A x B x 58 households). Only 58 households out of 200 use kerosene; hence the result represents the kerosene burned per 200 households.
D		Kerosene per year for 200 households (L)	32,543	Calculated (C x 365)
E		Density of kerosene (kg/L)	0.8	World Health Organization. 2018. International Programme on Chemical Safety. Kerosene. http://www.inchem.org/documents/icsc/icsc/eics0663.htm
F		Net calorific value of kerosene (TJ/1,000 ton)	43.8	A. Garg, K. Kazunari, and T. Pulles. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Table 1.2, page 1.18. http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf.
G		CO_2 emission factor for kerosene (ton CO_2/TJ)	71.9	A. Garg, K. Kazunari, and T. Pulles. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Table 1.4, p. 1.23. http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf.
H		Estimated household size	7.16	2015 census[a]
I	2020	Population	65,102	Projected from the 2015 census
J		Total households	9,094	Calculated (I/H)
K		Total kerosene burned per year (ton)	1,183	Calculated (D x E x J/200/1,000)
L		Emissions from kerosene burning (ton CO_2)	3,728	Calculated (K x F x G/1,000)

(continued)

Table 5 (continued)

L	2047	Population	102,812	Projected from the 2015 census. Growth rates are not fixed and range approximately 1.5%–2.3%.
M		Total households	14,362	Calculated (L/H)
N		Total kerosene burned per year (tons)	1,870	Calculated (D x E x M/200/1,000)
O		Emissions from kerosene burning (ton CO_2)	5,888	Calculated (N x F x G/1,000)
P		Total emissions from kerosene burning (2027–2047) kilotons	106.3	Cumulative emissions from 2027 to 2047 (assumes all new infrastructure are in operation in 2027). Annual emissions for this period were calculated using the same approach as above, using the projected population.

CO_2 = carbon dioxide, kg = kilogram, L = liter, TJ = terajoule.
[a] In 2015, the population of South Tarawa was 56,388, comprising 7,877 households. National Statistics Office. 2016. *2015 Population and Housing Census*. Bairiki. http://www.mfed.gov.ki/statistics/documents/2015_Population_Census_Report_Volume_1final_211016.pdf.
Source: Author.

Other Greenhouse Gas Emissions Savings

The project's 2.5 MW solar photovoltaic system will offset GHG emissions that would otherwise have been generated due to the operation of the new desalination plants and water supply network. Other emissions savings (described in Table 2) include the reduced need to treat and pump water due to reduced physical losses from the water supply network. However, the savings from reduced pumping are not significant compared to those associated with reduced water boiling. Further details can be found in the GCF proposal document (footnote 14).

Limitations on the Survey Methodology and Lessons for Future Surveys

The survey was planned at short notice and had strict time constraints, given the need for data to be available in time for the GCF proposal submission deadline. The assessment of the planning, implementation of the survey, and analysis of its results reveal the following lessons for future surveys:

(i) improvements to survey tool:
  (a) allow improved quantitative responses (e.g., on the length of time households spend boiling water)
  (b) collection of photos and videos as evidence of various practices and behaviors

(c) capturing other fuels (not just the primary fuels) used by households for boiling water

(d) collection of further indicators or knowledge of household air pollution

(e) collection of information on health and hygiene practices (e.g., menstrual hygiene management) in the absence of clean water

(f) geo-positioning of data collected

(g) recording information on the meteorological and climatic conditions during data collection

(h) collecting further socioeconomic and demographic data from households surveyed (e.g., by age group, gender, and household income) to allow disaggregation of results

(i) ask households to keep a diary to collect data on boiling practices (although this adds to the complexity and duration of the study)

(j) capturing qualitative information on the privacy and dignity of women

(k) capturing information on gendered roles and household work;

(ii) verification of costs of fuel (e.g., gas) from local stores;

(iii) collection of information on factors influencing the choice of fuel (e.g., affordability[23] and ease of access);

(iv) survey to cover a larger and/or more diverse geographic area, noting

(a) considerable differences in access rates to freshwater resources (due to rainfall, proximity to groundwater wells, water quality of wells, vulnerability of potable water supplies due to king tides and flooding), which may affect boiling practices; and

(b) considerable variability in demographic indicators across different communities (e.g., a recent survey in Nanikaai, South Tarawa showed that 30% of households were headed by women (footnote 8) compared with 26.5% in Kiribati overall (footnote 5).

[23] The government targets to have 75% of households in urban centers using liquefied petroleum gas for cooking and 80% using improved cookstoves by 2020 (Government of Kiribati, Ministry of Works and Public Utilities. 2014. *Kiribati Cooking for Life Strategy*. Suva: Secretariat of the Pacific Community. http://prdrse4all.spc.int/node/4/content/kiribati-cooking-life-strategy). However, there are likely to be issues with affordability since liquefied petroleum gas is more expensive than other fuels.

Coastal maneaba (traditional meetinghouse) and other housing are susceptible to storm surges and king tides (photo by ADB).

IMPLICATIONS OF REDUCED BOILING DUE TO IMPROVED WATER SUPPLIES

An improved water supply that reduces the need to boil water has several implications:

(i) **Avoided greenhouse gas emissions.** The survey results suggest that if safe drinking water is delivered to all households, there may be a reduced need for households to boil water using kerosene and gas, and thus GHG emissions may be avoided.

(ii) **Time saving.** Women's time poverty will be reduced on account of a reduction in the time spent fetching water, boiling water, and collecting wood for fuel. The survey results suggest that most households boil water every day, sometimes several times a day. The time spent boiling water each time varies but typically ranges 10–50 minutes per boil. Time saving through the project will stimulate women's involvement in productive activities, translating into women being able to afford more time (than currently possible) for entrepreneurship and employment. It will also provide girls more time and energy for the pursuit of education. Drudgery will also be reduced and women will have more time for leisure.

(iii) **Health.** Although not explored through the survey, reduced fuel burning is expected to reduce environmental health risks associated with exposure to household air pollution, particularly for women who play a primary role in water boiling and cooking. Household air pollution has been linked to premature deaths due to noncommunicable diseases such as heart disease, stroke, chronic obstructive pulmonary disease, and lung cancer; indoor air pollution is also responsible for many acute respiratory illnesses in children.[24]

(iv) **Decreased care work of women.** Since it is primarily women who are responsible for taking care of sick members of the family, a decrease in the incidence of diseases will substantially reduce the burden of unpaid care work on women.

(v) **Costs.** Although not explored comprehensively through the survey, households (i) are expected to realize cost savings from avoided fuel purchases for water boiling, and (ii) may avoid medical costs for respiratory ailments due to air pollution. This is in addition to avoided medical costs for diseases associated with inadequate water supplies.

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[24] World Health Organization. 2014. *Clean Household Energy Can Save People's Lives*. March. https://www.who.int/features/2014/clean-household-energy/en/.

HOW SURVEY RESULTS WERE FACTORED INTO PROJECT DESIGN

Survey results were factored into the project design as follows:

(i) **Greenhouse gas emissions calculations.** Estimates of potential avoided CO_2 emissions were included in ADB's project approval documentation and the GCF funding proposal, the latter helping to mobilize climate mitigation financing for the project. Results will be monitored during implementation and an end-line survey conducted to measure and report against the project's GHG emission targets.

(ii) **Economic analysis.** The economic analysis considered the cost savings from the avoided household-level treatment (i.e., water boiling) before the consumption of water, as well as the value of avoided CO_2 emissions related to this activity. Other potential cost savings—e.g., avoided health-related costs due to exposure to household air pollution, and loss of productivity due to the time spent by households boiling water and collecting fuel for boiling—were not quantified but may be considered in future projects.

(iii) **Gender analysis.** The project's gender action plan includes a target to collect qualitative data over the project's life to measure positive impacts on women's daily lives and health benefits resulting from 24/7 access to safe water.[26] Household burning of fuels may be considered as one of the areas reported against this indicator. Gender-sensitive materials developed as part of the WASH and climate change awareness program may consider water boiling roles and practices.

(iv) **Consideration in water, sanitation, and hygiene awareness campaigns.** Household practices surrounding water boiling can be considered through the community outreach campaigns to be rolled out through the project. In addition, the WASH and climate change visitor education center, which will be built at the site of one of the desalination plants, may include information surrounding water boiling practices, GHG emissions, and climate mitigation. Any change in the current advice for households to boil water will only occur after the new water supply system's quality at the tap is guaranteed and sustained, and will require constant monitoring by PUB to eliminate any potential negative health impacts on consumers that do not boil unsafe water. Training communities, women, and students in water quality testing may be considered through the project.

(v) **Environment assessments.** The initial environmental examination captures the reduced need to boil water as a socioeconomic benefit and notes the relationship with GHG emissions in the Environmental and Social Management Plan.

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[25] ADB. 2019. *South Tarawa Water Supply Project: Gender Action Plan.* Manila. https://www.adb.org/projects/documents/kir-49453-002-gap

LESSONS AND BROADER IMPLICATIONS OF RESULTS BEYOND THE SOUTH TARAWA WATER SUPPLY PROJECT

Beyond the South Tawara Water Supply Project, there are other lessons and broader implications:

(i) The study has highlighted a range of economic, social, gender, environmental, and climate change aspects, which may be considered in future projects that influence household-scale water treatment practices.

(ii) The survey has highlighted that benefits in terms of avoided GHG emissions and cost and time savings (particularly for women) associated with the delivery of improved water supplies may be significant. Further studies should be undertaken, using strengthened approaches to surveys and data collection, to enable a more accurate estimation of benefits. Assessments will need to be carried out early in the project design phase to allow results to be factored into the due diligence (particularly economic analysis, climate change assessments, gender analysis, and environmental assessments) conducted for projects.

(iii) This study did not consider wood burning as a source of GHG emissions. Where wood is used in other geographic locations for water boiling, it is recommended to further explore the sustainability of wood burning, noting it may be used in large quantities (as was the case in South Tarawa).

Climate Change, Water Security, and Women:

A Study on Water Boiling in South Tarawa, Kiribati

This publication summarizes the results of a household survey on water boiling practices in South Tarawa, Kiribati. The survey results were used primarily to estimate greenhouse gas emissions that could be avoided by the delivering of clean water through the South Tarawa Water Supply Project, and supported the mobilization of climate financing for the project. The publication also highlights economic, gender, health, and environmental implications of water boiling practices, and discusses considerations for the design of future projects.

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