COUNTRY HYDROMET DIAGNOSTICS

Informing policy and investment decisions for high-quality weather forecasts, early warning systems, and climate information in developing countries.

October 2023

Kiribati Peer Review Report

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SOFF Systematic Observations Financing Facility

WORLD METEOROLOGICAL ORGANIZATION

Alliance for Hydromet Development

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List of acronyms

ASOS	Automated Surface Observing System
AWOS	Automated Weather Observing System
AWS	Automatic Weather Station
BIP-M	Basic Instruction for Meteorologists
CHD	Country Hydromet Diagnostics
COSPPac	Climate and Oceans Support Programme in the Pacific
CREWS	Climate Risk and Early Warning Systems
ECMWF	European Centre for Medium-Range Weather Forecasts (model)
EEZ	Exclusive Economic Zone
FMS	Fiji Meteorological Service
GBON	Global Basic Observing Network
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GUAN	GCOS Upper-Air Network
ICT	Information and communications technology
KMS	Kiribati Meteorological Service
KNEG	Kiribati National Expert Group on Climate Change and Disaster Risk Management
LDC(F)	Least Developed Countries (Fund)
MICT	Ministry of Information, Communications and Technology
NMHS	National Meteorological & Hydrological Service
NDRMO	Kiribati National Disaster Risk Management Office
NOAA	United States National Oceanic and Atmospheric Administration
NZ	New Zealand
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
QMS	Quality Management System
RESPAC	UNDP Disaster Resilience for Pacific Small Island Developing States project
RSMC	Regional Specialised Meteorological Centre
SIDS	Small Island Developing States
SOFF	Systematic Observations Financing Facility
SOP	Standard Operating Procedure
SOPAC	South Pacific Applied Geoscience Commission (Pacific Community, SPC)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UKMO	United Kingdom Meteorological Office
WIGOS	WMO Integrated Observing System
WMO	World Meteorological Organization

Executive Summary

Kiribati is a geographically large and dispersed nation straddling the equator in the central Pacific, with much of the population in small, isolated coral island communities, but over half concentrated in South Tarawa. Kiribati has a largely subsistence economy and is extremely vulnerable to both high impact weather and water events and to the longer-term effects of climate change. A particular concern for Kiribati is coastal inundation from tidal, storm surge and tsunami events.

In this context, the services of the Kiribati Meteorological Service (KMS) alongside partner agencies are vital. However, KMS is challenged by the overall level of resourcing (although that has been rising), an insufficient observations network spread over a vast area, staff training resourcing hurdles, a relatively low level of product development, an inability to currently provide the full range of expected services including aviation and marine, and poor communications networks in-country, which limit their capacity to reach remote users. There are also strong needs to strengthen relationships with the water resources sector, as rainfall forecasts and monitoring will be of ever-increasing importance to Kiribati during extreme weather and climate events (such as a recent severe drought).

Kiribati has recently produced a strategic plan that details four sensible strategic goals for improving weather, water and climate services for the benefit of i-Kiribati. This has been further bolstered by the prompt development and passing of a Meteorological Services Act in support of KMS' functions.

The implementation of this plan and Act will need long-term, well considered institutional partnership support from the global community. Programs such as the Climate and Oceans Support Program in the Pacific (COSPPac) and the WMO Severe Weather Forecasting Programme demonstrate the value that can be provided through these long-term mechanisms. The Systematic Observations Financing Facility (SOFF) has considerable potential to improve Kiribati's observational situation, but will not cover all requirements (particularly marine observations) at this stage, and additional investment will be required. The development of Kiribati-specific forecasts and warnings, underpinned by appropriate numerical weather modelling and observations, and within a quality managed impact-based multi-hazard early warning system, will also need partnership support. Quality management systems for other key areas, such as aviation and marine services, will also require support.

Summary of assessed ratings for Country Hydromet Diagnostics elements

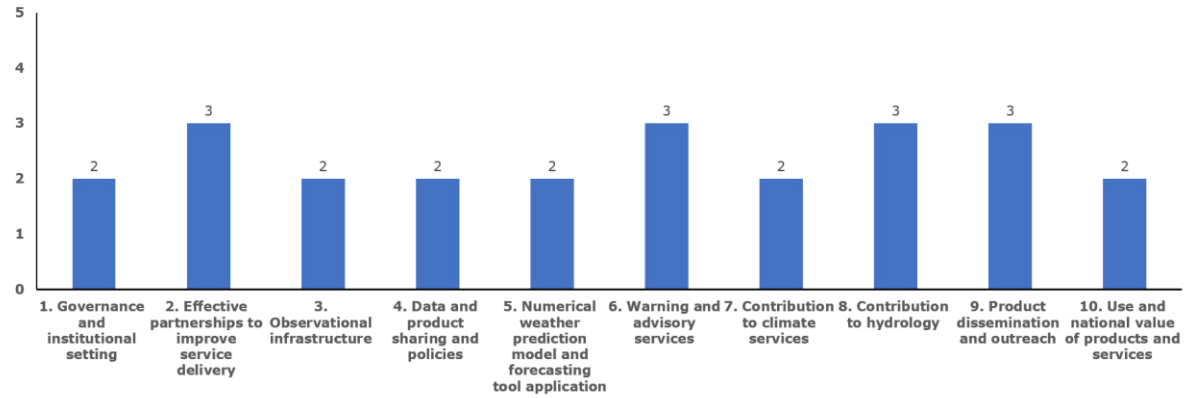

Figure 1 - Summary of assessed ratings for the ten Country Hydromet Diagnostics elements. Each rating is out of five, with five reflecting a relatively high degree of maturity.

Element	Maturity level score
1. Governance and institutional setting	2
2. Effective partnerships to improve service delivery	3
3. Observational infrastructure	2
4. Data and product sharing and policies	2
5. Numerical weather prediction model and forecasting tool application	2
6. Warning and advisory services	3
7. Contribution to climate services	2
8. Contribution to hydrology	3
9. Product dissemination and outreach	3
10. Use and national value of products and services	2

Table 1 - As for Figure 1, in tabular form

Chapter 1: General information

Introduction

Kiribati (pronounced kɪrɪˈbæs) is an independent republic straddling the equator in the central Pacific, with a population of approximately 130,000, all of whom live within 1 km of the coast. More than half of the population live in the capital South Tarawa, but the rest are spread over the 32 coral atolls and one raised coral island (811 km^2 of land in total) within 3.5 million km^2 of ocean. Kiribati has the 12th largest exclusive economic zone (EEZ) in the world, and the largest in the Pacific. The maximum elevation is 81m above mean sea-level, but the great majority of land is very low lying. Outside South Tarawa, there are 169 villages with an average population of 310 people.

Kiribati has three main groups of islands, including the isolated Banaba (Ocean Island) in the far west of the Gilbert Islands Group (Figure 2). Kiribati has few natural resources and has a relatively low per capita GDP of USD $1989 (IMF estimate, 150th in the world).

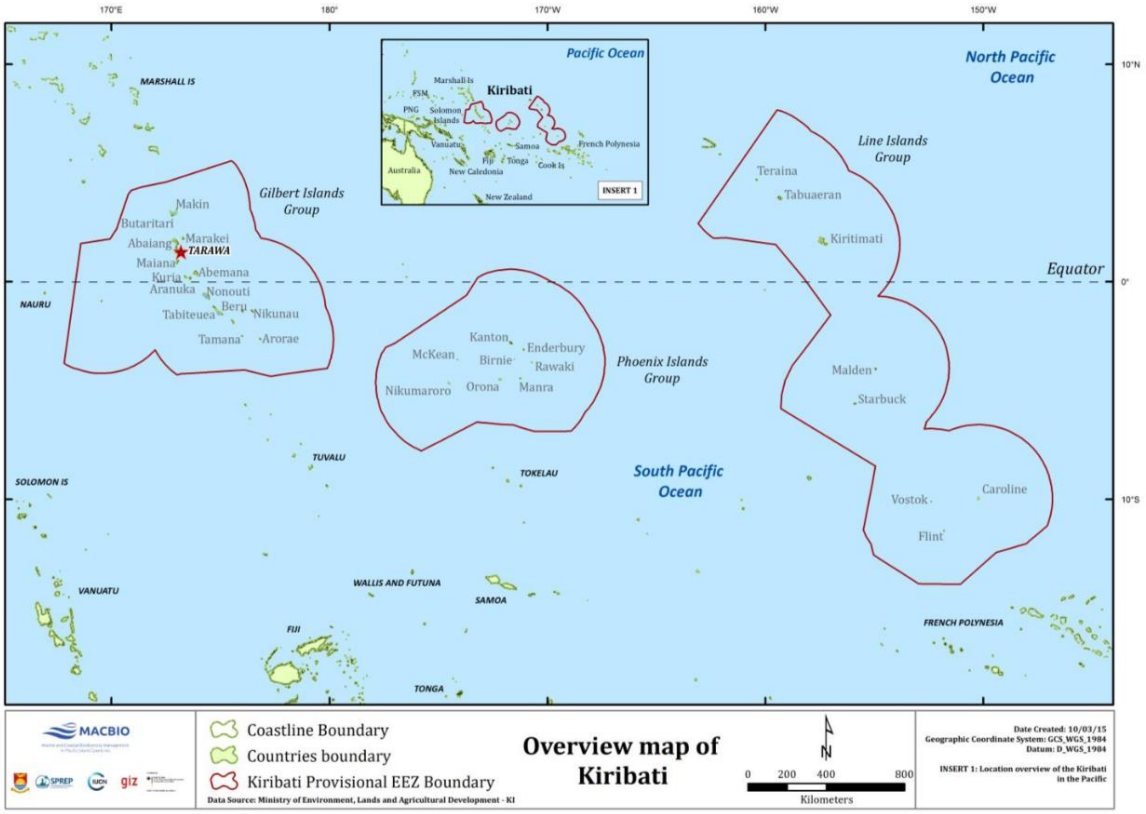

Figure 2 - Island groups and EEZ of Kiribati (source: Macbio project, derived from Govt Kiribati data). Banaba is located near Nauru, in the western part of the Gilbert Islands Group. Caroline Island (marked in the SE) is now called Millennium Island, due to its location well east of the 180 Meridian but west of the International Dateline. The distance between the western part of the Gilbert Islands Group and the SE of the Line Islands Group is approximately 4,600 km (similar to, for example, the distance between Lagos and Johannesburg in Africa, or Vancouver and Miami in North America).

There are no rivers in Kiribati. Soils are thin with low water-holding capacity and nutrient content, making ground-water management critical. Kiribati is also very highly exposed to climate variability and climate change. In June 2022, Kiribati declared a State of Disaster due to drought, with consecutive La Niña events greatly affecting water availability. The low-lying topography means that sea-level rise will affect soil and water

salinity and land availability, and exacerbate the impact of flooding events, including from La Niña, spring tides, and tropical cyclone-generated swells to the south.

Although tropical cyclones do not directly transverse Kiribati, there have been many instances of severe damage being caused by heavy swells, from both the north and south. One recent example was from the combined effects of Severe Tropical Cyclones Bevi and Pam in 2015, where swells caused inundation, erosion, major impacts to food crops, water sources, homes and infrastructure over many islands around Western Kiribati[1].

Kiribati is also vulnerable to tsunamis, which could be generated from any part of the Pacific Ring of Fire. The closest areas of major seismic activity are to the south and southwest, near Tonga, Vanuatu, and Solomon Islands.

CHD methodology

This report has been prepared using the methodology described in the 2022 update of the Country Hydromet Diagnostics, and in combination with other activities under the Systematic Observations Financing Facility initiative. An initial desktop review was performed, using information supplied from Kiribati, WMO, and other partners. An in-country visit to Tarawa was then undertaken to allow direct discussions with KMS and stakeholder discussions. This visit was supplemented by information from co-incident visits to the islands of Kanton and Kiritimati performed by other officers from the Australian Bureau of Meteorology, and other site information provided by KMS.

[1] Source: Kiribati Meteorological Services post-event report

Chapter 2: Country Hydromet Diagnostics

Element 1: Governance and institutional setting

1.1 Existence of Act or Policy describing the NMHS legal mandate and its scope

A new Meteorological Act (2021) in Kiribati provides a mandate and outlines the functional responsibilities for Kiribati Meteorological Service (KMS). The Act clearly outlines the functions and accountability of KMS:

> (a) the taking and recording of meteorological observations and other observations required for the purposes of meteorology;
>
> (b) establishing and maintaining meteorology stations and other observation and research stations, and all other necessary technical installations and equipment;
>
> (c) forecasting weather, and monitoring the state of the atmosphere;
>
> (d) advising the Government on matters related to meteorology and supporting the roles and responsibilities of the Kiribati National Expert Group on Climate Change and Disaster Risk Management and the Climate Change and the Disaster Risk Management Unit;
>
> (e) making arrangements to secure the safety and welfare of staff of the department who are performing their duties during times of disaster or potential disaster;
>
> (f) collecting, collating, archiving, and making available meteorological data and information required under this Act including archiving of such data and information;
>
> (g) providing information, data, products and services relating to currents, sea surface temperatures, tides and ocean related measurements and wave activity including for maritime transport and monitoring activities;
>
> (h) publishing meteorological reports, bulletins, advisories, and data;
>
> (i) promoting the effective use of meteorological information, and arranging for programs of public awareness and education;
>
> (j) developing. facilitating and providing training and instruction for persons whose duties and responsibilities concern matters relating to meteorology;
>
> (k) promoting the advancement of meteorological science, by means of meteorological research, investigation, and by any other means;
>
> (l) providing general advice on meteorological and climate matters, and providing meteorological data and advice in support of specific national development projects and other important weather sensitive economic activities;
>
> (m) setting and applying standards for all observations used for aviation, maritime, and other general forecasts (and where such observations are used for legal purposes), and ensuring that all such standards conform to appropriate international specifications;
>
> (n) implementing policies, international conventions, programmes, projects and initiatives in accordance with Part 3;
>
> (o) co-operating with the authorities administering the meteorological services of other countries. and with the World Meteorological Organization, the International Civil Aviation Organization, and any other relevant international organisations in relation to any of the functions and powers stated in this Part, and in particular, supporting the principle of free and unrestricted exchange of meteorological data between national meteorological services;
>
> (p) subject to government contracting procedures, entering into contracts or arrangements with any department, agency, or person in Kiribati or outside Kiribati to compile, record, or disseminate meteorological reports and information;

(q) developing, facilitating, and providing training and instruction for persons whose duties and responsibilities concern matters relevant to meteorology or climate;

(r) promoting the understanding and recognition of traditional practices and knowledge related to weather and climate through the observation of weather indicators occurring in nature, and by other means;

(s) assessing and advising on the impact of weather related hazards and other hazards to vulnerable and marginalized groups and remote communities;

(t) developing an effective communications strategy to ensure that advisories, bulletins, warnings, and alerts, and general meteorological information are broadcast and disseminated; and

(u) doing any other act which contributes to the capacities within Kiribati to provide effective and applicable meteorological and climate services, and to diminish the risks arising from adverse weather conditions.

In addition to this comprehensive list of functions, the Act specifically gives strong and exclusive powers for warning issuance for hydrometeorological and geohazard events.

The Disaster Risk Management and Climate Change Act (2019) also acknowledges and defines the Kiribati Meteorological Service as:

"the authoritative source of information on weather, climate and ocean conditions, and for advising KNEG (National Expert Group on Climate Change and Disaster Risk Management) on related hazards including extreme spring tides, tropical cyclones, tsunami, and droughts of sufficient severity to be considered a disaster".

KMS falls under the strategic plan of the Office of the President, the Beretitenti, who has overall responsibility for protection of people and places in Kiribati from disasters and climate change, acting upon advice of the Cabinet.

1.2 Existence of Strategic, Operational and Risk Management plans and their reporting as part of oversight and management.

Kiribati has recently developed and published its Strategic Plan & Framework for Weather, Climate and Oceans Services 2021-2025, with assistance from WMO, the Climate Risk and Early Warning Systems (CREWS) project, and Environment Canada. It sets four long-term goals:

Strategic goal 1: Ensure that the Kiribati Meteorological Service has an enabling policy and institutional environment;

Strategic goal 2: Strengthen the Kiribati Meteorological Service's infrastructure capacity for delivery of effective weather and climate services;

Strategic goal 3: Strengthen partnerships with stakeholders to improve service delivery, increase the use of meteorology, hydrology, marine and climate products, and ensure successful risk communication; and

Strategic goal 4: Strengthen the Kiribati Meteorological Service's human capacity, performance management, and operational efficiency.

Operational and risk management plans exist, but mainly for specific activity areas such as aviation, which has been receiving more of a focus due to quality management plans.

1.3 Government budget allocation consistently covers the needs of the NMHS in terms of its national, regional, and global responsibilities and based, among

others, on cost-benefit analysis of the service. Evidence of sufficient staffing to cover core functions

KMS's annual core budget has been rising (Figure 3), although it is still low by world standards. Although it may cover staff salaries, it does not allow KMS to completely cover equipment or consumables such as radiosondes, or to support significant staff training or operational funds. For this, Kiribati relies to some degree on international assistance.

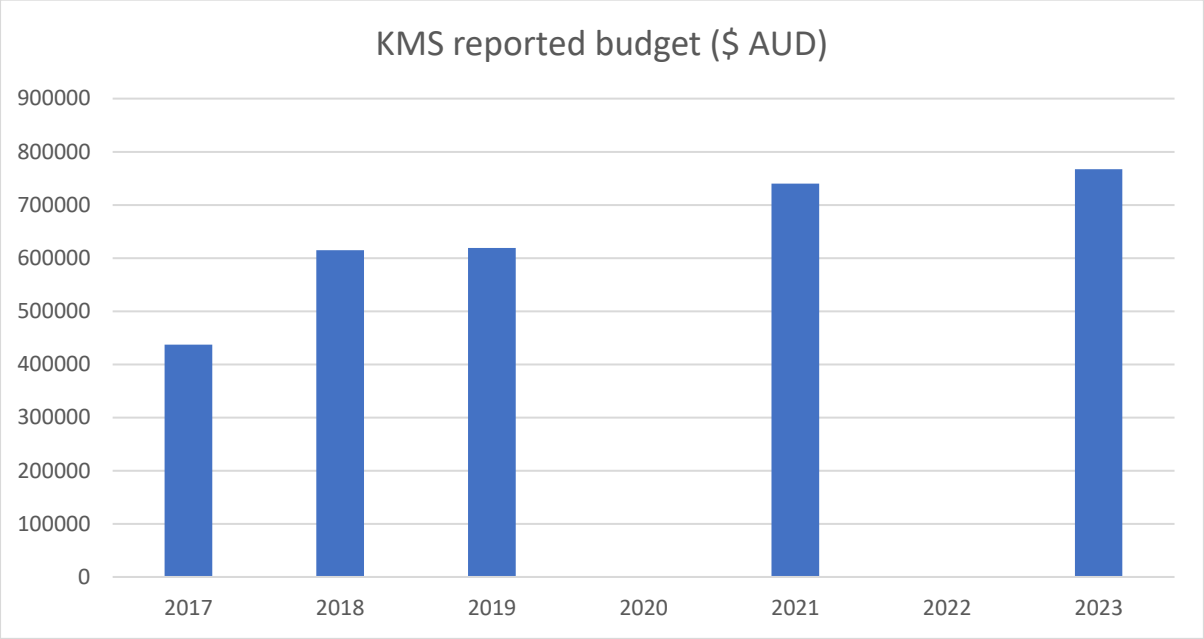

Figure 3 - Reported annual budget for KMS, in Australian/Kiribati Dollars (1 Kiribati dollar equals 1 AUD). Data source: KMS Report to Pacific Meteorological Council, 2023. Dollar amounts were not reported for 2020 or 2022.

There is no formal cost-benefit analysis in place yet for KMS. However, there is a proven process for improving resourcing, as demonstrated recently through a cabinet paper process. In recent years, this has resulted in the recruitment of a senior forecaster, quality assurance officer, ICT specialist, and oceanographer. The Government is regarded as reliable in terms of budget allocations and due process.

1.4 Proportion of staff (availability of in-house, seconded, contracted- out) with adequate training in relevant disciplines, including scientific, technical, and information and communication technologies (ICT). Institutional and policy arrangements in-country to support training needs of NMHS.

Table 2 shows the staffing education profile reported as part of the Weather Ready Pacific proposal. The total number of staff positions is now 33. The profile indicates that there are many staff with some relevant education. According to the Weather Ready Pacific proposal:

"KMS staff undergo basic meteorological training (regional or in-house) that is generally provided by the Pacific International Training Desk (in Hawaii). A very small number of staff have undertaken advanced meteorological training (BIP/M(T) training) such as that provided by the Bureau of Meteorology, PAGASA and the NZ Met Service. Occasionally, a Fijian training officer will go to Kiribati to provide training for observers, for example, or KMS will send staff to Fiji. In these circumstances, KMS will always seek support from Partners to fund the required training.

The Bureau and NZ Met Service provide training in their own countries but KMS attendance to this is highly dependent on the availability of funds and scholarships to send staff for external, international training. KMS currently does not have a budget for external training. WMO have indicated that they would expect KMS to identify staff with suitable skills and/or academic qualifications and put them forward for post graduate sponsorship."

In response to this, KMS has initiated a strategy to establish senior forecaster positions through projects, aiming to attract individuals holding BSc qualifications to join the KMS and undergo training, with an intent to transition the project-funded positions into permanent roles.

KMS also actively supports short term training secondments where possible, and has embraced online training opportunities.

Branch	Doctorate/ MSc/BIP-M	BIP-MT	Bachelor/Diploma	Other	Total
Administration	1		1	2	4
Forecast and warning	1	2	2		5
Climate			1	1	2
Hydrology, Oceanography			1		1
Observations			1	12	13
Engineering			4	1	5
ICT			1		1
General services				2	2
Total	2	2	11	18	**33**

Table 2 - Staffing profile of KMS. Source: Weather Ready Pacific Proposal, Pacific Meteorological Council 2021, updated to account for new positions discussed in 1.3 above.

Like other agencies in the region, KMS has a male-dominated workforce, but the disparity is not as strong as in some other nations. In 2018, Kiribati had 20 male staff and 8 female staff. Kiribati has particularly high female representation in climate and oceanography areas.

1.5 Experience and track record in implementing internationally funded hydromet projects as well as research and development projects in general.

As an LDC and SIDS, and one of the most exposed to climate change in the world, Kiribati has access to various international capacity building projects, as described under Element 2. In most cases, this would be as the junior partner, with staff capacity for leading such projects relatively limited.

Staff do not generally get involved in research activities unless as part of externally funded projects.

Summary score and recommendations for Element 1

Kiribati is assessed as being at **Maturity Level 2** for this element, corresponding to 'Effort ongoing to formalize mandate, introduce improved governance, management processes and address resource challenges.'

The strategies for improving this maturity level are well captured in the Strategic Plan as described above. KMS's placement in the Office of the President is an appropriate and unusually centralised position, reflecting the high priority of disaster and climate management in Kiribati. The rapid development and passing of the 2021 Meteorological Act, good agency relationships, and institutional placement bode well for KMS' future maturity in this area.

However, it should be emphasised that the budgetary position reported, whilst stable and positively increasing, is not compatible with the financial challenge of running an observational network and related services across a region with approximately the width of the continental United States. Rather, the government placement and budget stability is a positive signal for those wishing to work with Kiribati in long term partnerships, and noting both Kiribati's high exposure to climate hazards, and importance in terms of central Pacific weather observations.

Element 2: Effective partnerships to improve service delivery

2.1. Effective partnerships for service delivery in place with other government institutions.

As noted earlier, KMS sits in central government within the key Office of Te Beretiteni, which includes the Climate Change Coordination Unit, and Disaster Risk Management Unit. Relationships with these units are strong. KMS has good relationships with other agencies, although not necessarily to a very deep level. The evaluation mission observed amicable working arrangements with climate, emergency services, water, transport and aviation services, and also the working relationships of team members at Bonriki International Airport, where KMS operates an observing office on aviation premises.

The Meteorological Act (2021) explicitly mentions participation in international arrangements. KMS receives support from Nadi Regional Specialised Meteorological Centre (RSMC) under WMO arrangements. Nadi assists with aviation and marine forecasts as well as Tropical Cyclone warnings. KMS also is a member of the regional Severe Weather Forecasting Programme, which has participants across the SW Pacific. Kiribati receives geostationary satellite data from Japan.

2.2. Effective partnerships in place at the national and international level with the private sector, research centres and academia, including joint research and innovation projects.

KMS has limited time and resources for private sector and research collaborations, but does so on occasion, usually in the context of international development projects.

2.3. Effective partnerships in place with international climate and development finance partners.

There is extensive evidence of international partnerships and support, including with the CREWS project and other projects, regional met services including FMS, UKMO, NZ & the Bureau of Meteorology. Projects include the GCOS Upper-Air Network (GUAN), Seismic Support Fund, UNDP-LDCF Food Security Project, UNDP Disaster Resilience for Pacific Small Island Developing State (RESPAC) Project, and the Climate and Oceans Support Programme in the Pacific (COSPPac) programme. An Australian-funded programme is looking at improving observations for the aviation industry.

2.4. New or enhanced products, services or dissemination techniques or new uses or applications of existing products and services that culminated from these relationships.

COSPPac supports KMS in providing climate and ocean monitoring and prediction services, and ocean predictions (tide, currents, wind and waves) that support fishing, tourism and shipping.

Summary score, recommendations, and comments for Element 2

For this element, Kiribati is assessed as **Maturity Level 3**, which is expressed as: *Moderately effective partnerships but generally regarded as the weaker partner in such relationships, having little say in relevant financing initiatives.*

This rating reflects that KMS is highly dependent on international aid to achieve goals, with limited agency in initiating projects.

KMS has expressed through the Weather Ready Pacific initiative that all projects should be prefaced by a needs assessment, conducted by partners prior to starting projects. In

the past this has not been the case. Integrated assessments have been carried out as part of climate change initiatives. However, other projects have not had such assessments. Adherence to this request will help Kiribati manage and benefit from projects. The implementation of the Strategic Plan will further support strong and lasting partnerships.

Element 3: Observational infrastructure

3.1. Average horizontal resolution in km of both synoptic surface and upper-air observations, including compliance with the Global Basic Observing Network (GBON) regulations.

With its surface area of 3.5 million km^2, Kiribati would require approximately 4 upper air stations and 14 surface observations to meet GBON requirements, although moderated by practical considerations due to the relative lack of power, communications, and access to many locations.

In fact, Kiribati has one operational upper-air station (reporting once per day), supported by the international community (and particularly the United Kingdom) through the Upper Air GUAN project due to the criticality of the observations, giving a station resolution of 3.5 million km^2, once per day.

There are seven staffed synoptic stations (Betio, Bonriki, Kiritimati, Butaritari, Beru, Arorae, Kanton) that are staffed but reporting at a lower frequency than GBON requirements (3 hourly as opposed to 1 hourly). Two additional synoptic stations (Banaba, Fanning) are closed. There are an additional 3 Automatic Weather Stations reporting data, and 3 that are not reporting. A map of stations is shown in Figure 4.

In-country discussions suggested that the quality of manual stations is subject to communications, staff availability, and instrumental maintenance, including calibration. However, the manual sites are on the whole much more reliable than automatic weather stations, which are frequently installed in the Pacific region under country development arrangements, but typically come with no ongoing funding for maintenance, calibration, communications and site upkeep. The ideal solution is seen as having collocated manual and AWS equipment, with the site observer responsible for manual reports and first in maintenance as well as site upkeep, and the AWSs providing 24/7 observations when the observer is not on-duty. This situation still requires ongoing communications costs to be covered, but is likely to be the most successful in terms of reliability and data availability.

3.2. Additional observations used for nowcasting and specialized purposes.

Kiribati hosts a tide gauge in Betio, Tawara, that is funded by COSPPac and maintained by the Australian Bureau of Meteorology. There are also 7 tipping-bucket rain gauges.

An important area for network expansion is in sea level observations, due to Kiribati's exposure to coastal inundation from sources to the north and south, such as tropical cyclones, tsunamis, and mid-latitude cyclones.

In March 2021, KMS deployed a wave-buoy in collaboration with the country's Fisheries Division. The wave buoy was located on the western side of the Tarawa Lagoon and was designed to provide KMS, its stakeholders, and local communities potentially threatened by westerly waves, with real-time wave data. However, in August, the buoy was found to have been drifting from its position. KMS was able to track its position and charter a speedboat to rescue the valuable sensor. The buoy was found aboard a local wooden fishing boat, and restored to its location. Discussions in-country suggest that this will be a continuing challenge.

A possible area of investigation is the greater use of the Tropical Atmosphere Ocean (TAO) moored buoy array supported by the USA and Japan (marked 'as NOAA buoy' in Figure 4). The array was built over the 1985-94 period. In April 2023, a refurbishment

and upgrade was announced[2]. The refurbishment will include the inclusion of barometric pressure, rain, and solar radiation measurements across the array, transmitted at 10-minute intervals, and a subset of buoys capable observing real-time ocean current data at the surface and at depth, with an entire current profile from 11 to 315 metres.

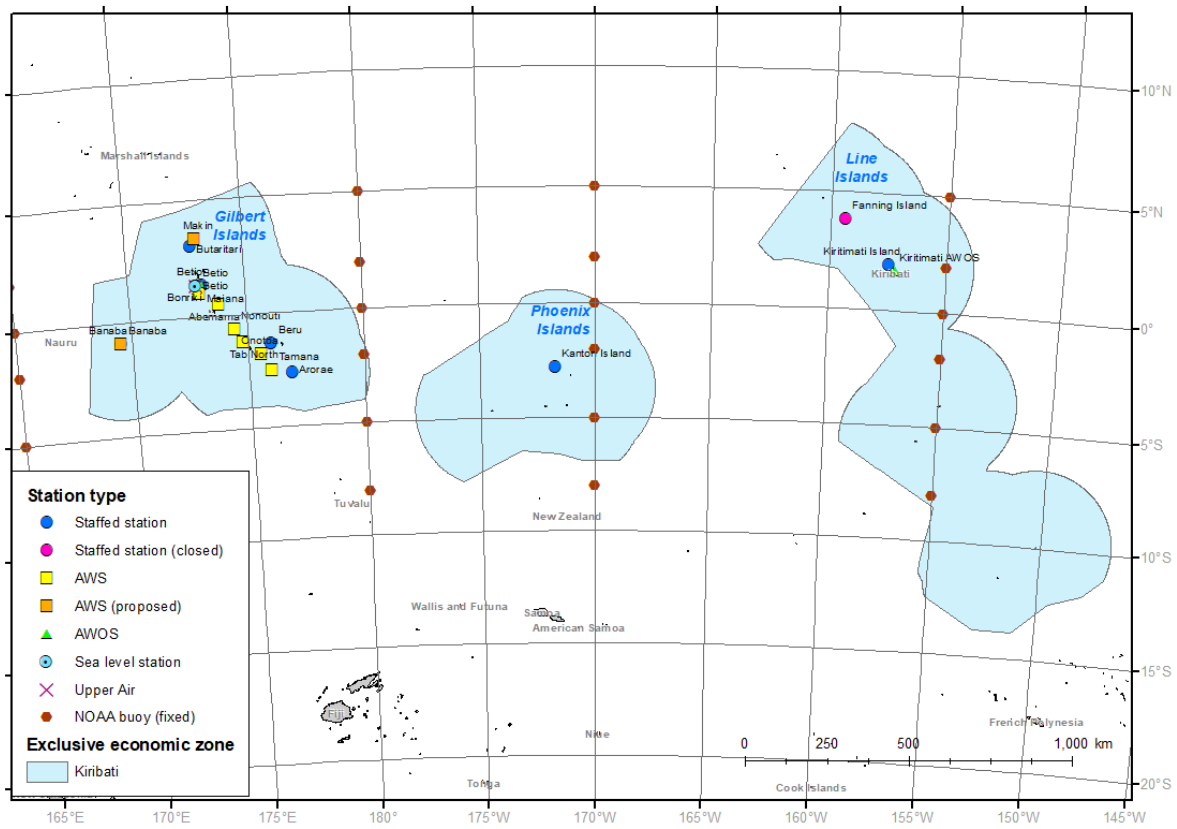

Figure 4 - Combined observations network for Kiribati (taken from the GBON Gap Analysis)

3.3. Standard Operating Practices in place for the deployment, maintenance, calibrations and quality assurance of the observational network.

KMS has a small engineering team and limited funds to routinely maintain instruments but has some training and technical knowledge. The extent of formal Standard Operating Procedures appears to be relatively limited.

3.4 Implementation of sustainable newer approaches to observations.

The most sustainable approach to observations in Kiribati is likely to be a combination of manual and automated observations, as discussed above. Automatic-only stations might be discouraged unless they are shown to be sustainable in the long term.

3.5. Percentage of the surface observations that depend on automatic techniques.

Approximately 25% of working sites have automatic weather stations.

Summary score, recommendations, and comments for Element 3

The vast size of Kiribati and lack of resourcing makes running a network extremely challenging. Kiribati is assessed as being **Maturity Level 2** for this element, reflecting

[2] https://www.climate.gov/news-features/climate-tech/landmark-buoys-across-tropical-pacific-ocean-get-makeover

'Basic network, large gaps, mostly manual observations with severe challenges and data quality issues'

As indicated earlier, long-term partnerships are critical for maintaining observations over such a large area of the Pacific. The UK Support for the upper air station in Tarawa is such an example.

In May 2023, the Australian Bureau of Meteorology and KMS announced a $2.5 million aviation-focused partnership over three years to provide new weather observing infrastructure, delivering training for weather forecasters and supporting peer-to-peer support. Component 1 of the plan is to repair AWOS stations at Bonriki and Cassidy airports (Tarawa and Kiritimati), build a new AWOS station at Kanton Airport, and install Metar terminals at each location.

Aside from these initiatives, the long-term improvement of Kiribati's maturity in this area can be assisted through the planned introduction of aviation cost recovery, together with support from the international community through the SOFF Programme.

Element 4: Data and product sharing and policies

4.1. Percentage of GBON compliance – for how many prescribed surface and upper-air stations are observations exchanged internationally. Usage of regional WIGOS centres.

No stations are GBON compliant, due to reporting frequency (currently 3 hourly for synoptic stations and once per day for the single upper air station). Regional WIGOS centres are still in development in the Pacific, with Fiji and Australia actively assisting SIDS in the region.

4.2. A formal policy and practice for the free and open sharing of observational data.

KMS is a WMO Member and shows evidence of free and open sharing of observational data as per GBON requirements. KMS strongly desires to share its data with the global community. At this stage, there is no national WIGOS partnership agreement, but there is no opposition to data sharing.

4.3. Main data and products received from external sources in a national, regional and global context, such as model and satellite data.

KMS has basic model and satellite data access through the Severe Weather Forecasting Programme MetConnect site and other sites. Data is displayed in web browsers, with no local data manipulation capability. There are no relevant national models, and regional models are very limited in application given Kiribati's large size and low topography.

Summary score, recommendations, and comments for Element 4

Kiribati is assessed as being at **Maturity Level 2** for this element, reflecting *'A limited amount of GBON compliant data is shared internationally. The existing data sharing policies or practices or the existing infrastructure severely hamper two-way data sharing.'*

In this case, the issue is infrastructure rather than policies. To improve this situation, long-term partnerships are vital, building on the strong relationships in the Pacific region and the global community. The SOFF programme is an excellent opportunity to build data availability across the region, and Kiribati's specific situation is known to have significantly influenced the development of innovative new approaches in this area.

Element 5: Numerical model and forecasting tool application

5.1. Model and remote sensed products form the primary source for products across the different forecasting timescales.

In the equatorial tropics, persistence-driven day-to-day forecasts are appropriate in many situations, and used heavily by default by the public (the assumption that today will be similar to yesterday). KMS produces short-term forecasts, but also produces 5-day public weather outlooks for key locations, informed by numerical modelling. The forecasters rely heavily on public web sources to produce these and a range of other basic products, supplemented by advice through the NZ-hosted Met Connect website of the Severe Weather Forecasting Programme, and using model data from ECMWF, Australia, UK, US and others. The forecasters have no ability to manipulate numerical weather prediction forecast data in their system.

Climate outlook products are produced using a mixture of statistical and dynamical techniques.

5.2. a) Models run internally (and sustainably), b) Data assimilation and verification performed, c) appropriateness of horizontal and vertical resolution.

There is no internal numerical modelling capability, nor would it be sustainable to attempt this in Kiribati. KMS has only one ICT officer, unreliable power, expensive communications, and very little ICT infrastructure. A regional partnership solution would be the most appropriate for the implementation of Kiribati-specific models.

The vast size and very limited topography of Kiribati means that high resolution deterministic modelling is probably of less importance than for some other countries. However, one priority for Kiribati-specific modelling would be the marine modelling necessary to support island-specific inundation forecasts, as the marine environment is much more complex from a forecasting perspective than the atmospheric environment, for which global modelling approaches probably suffice. A Kiribati Wave and Inundation Forecast System is being developed under the CREWS project.

5.3. Probabilistic forecasts produced and, if so, based on ensemble predictions.

Short-term forecasts are not produced probabilistically. Some climate products produced through COSSPac use ensemble techniques.

Summary score, recommendations, and comments for Element 5

Kiribati is assessed as **Maturity Level 2** for this Element, reflecting a *Basic use of external model output and remote sensed products in the form of maps and figures, covering only a limited forecast time range.*

As part of the improvement of appropriate model support, one strategy may be to work with others to develop Kiribati-specific and KMS branded numerical forecasting and related products for public release, in order to provide the maximum possible public benefit and to maintain KMS' role as a central authority. It is not recommended to greatly seek to strengthen KMS' High Performance Computing capabilities, except for the strengthening of model manipulation within forecasting systems.

Element 6: Warning and advisory services

6.1. Warning and alert service cover 24/7.

KMS does not have human resources to cover 24/7 operations with trained forecasters on a consistent basis. Forecasts are issued twice a day, and rosters allow for a substantial period during morning hours where urgent matters are covered by technical officers and the KMS management team, with forecasters covering afternoon and overnight shifts. In this way, a basic 24/7 service is provided. A submission is under development to have two more positions approved through a Cabinet submission, with initial funding provided through an aviation capacity building project.

6.2. Hydrometeorological hazards for which forecasting and warning capacity is available and whether feedback and lessons learned are included to improve warnings.

As noted earlier, KMS is the authoritative source of information on weather, climate and ocean conditions, and for advising KNEG on related hazards including extreme spring tides, tropical cyclones, tsunami and other geohazards, and droughts of sufficient severity to be considered a disaster. Its actual capacity to provide warnings is relatively limited, but its social media posts show warnings for seas & swell, strong winds, heavy rainfall, spring tides, below average rainfall, coral bleaching, and tsunamis (relaying Pacific Tsunami Warning Centre messages). The records suggest that KMS takes the warning role seriously and seeks continuous improvement in their processes, despite their limited resources.

Feedback during user consultation strongly suggests that coastal inundation is an urgent priority for further development of warning services. Transport incidents (aviation, road and marine) are also a significant concern. In January 2018, a domestic ferry sank in Kiribati due to a combination of weather, safety and operator factors, with the loss of 95 lives.

6.3. Common alerting procedures in place based on impact-based services and scenarios taking hazard, exposure and vulnerability information into account and with registered alerting authorities.

Impact-based warning services are in their very early stages of development. Common alerting procedures are not yet in place.

Summary score, recommendations, and comments for Element 6

Based on the evidence available, KMS is assessed at **Maturity Level 3** for this element, reflecting a *weather-related warning service with modest public reach and informal engagement with relevant institutions, including disaster management agencies.*

This rating is considered more appropriate than the next lower level (*Maturity Level 2 - Basic warning service is in place and operational but with limited public reach and lacking integration with other relevant institutions and services*) because KMS' central institutional placement allows a higher degree of integration and influence than would otherwise be the case.

KMS's capacity in this area will likely improve with the further implementation of the Strategic Plan, and also through the ongoing work of projects such as CREWS and under the Early Warnings For All initiative. It is likely that long-term partnership development assistance such as these will be required to continue to make strong progress on the design and implementation of end-to-end impact based early warning systems, which ideally should be supported by improved forecasting systems, observations, staffing, and

agency partnerships, and which must be supported by improved country-communications to the outer islands. This is a long journey, but KMS's active presence in the community and commitment to warning output is a good starting point.

Element 7: Contribution to Climate Services

7.1. Where relevant, contribution to climate services according to the established capacity for the provision of climate services.

KMS is housed in central government with good links to climate governance, and is a Member of the National Expert Group on Climate Change and Disaster Risk Management. KMS has a relatively strong orientation towards low onset hazards, such as climate variability, and has long-term participation in the COSPPac program.

KMS is also achieving good engagement with the community with climate products. For example, an online climate outlook forum held in association with COSPPac on 11 May 2023 attracted a very good range of participants including critical officers such as island community Mayors, as shown in Table 2.

Table 3 - attendees at online climate outlook forum, 11 May 2023. Courtesy COSPPac.

Stakeholder	Total Number of Participants	Number of male	Number of female
Government and Non-Government Organizations and public subscribed to the products.	118	45	73
National Media and KMS Staffs	53	23	30
Island Council Mayors and clerks, KMS staff	52	30	22
High Schools	6	3	3

Climate outlooks are issued regularly in English and i-Kiribati, and cover expected atmospheric and ocean conditions, supported by statistical and dynamical modelling. The climate services section is well staffed.

Despite this strong engagement, KMS still has to grapple with poor observational infrastructure, communications and technological limitations, and relatively low staff numbers. At time of writing, there are also no climate products available on the KMS website due to site redevelopment, so products are transmitted through email. There is also no monitoring of the socio-economic benefits of climate services, and KMS is limited in its ability to service country capacity development needs.

This means that, while Kiribati has good climate governance and user engagement, Kiribati scores relatively poorly in other areas.

Summary score, recommendations, and comments for Element 7

Kiribati is assessed as being at **Maturity Level 2**: Basic Capacity for Climate Services Provision. The further development of climate services is a high priority area for improvement, given the criticality of climate issues for Kiribati.

Element 8: Contribution to hydrology

8.1. Where relevant, standard products such as quantitative precipitation estimation and forecasts are produced on a routine basis according to the requirements of the hydrological community.

Kiribati does not have rivers. Flooding issues are associated with localised flash floods and potential pollution of the ground-water lens, and also with coastal inundation. Rainfall monitoring and forecasting, including at seasonal time-scales as well as day-to-day forecasting is very important for this effort. Rainfall-focused climate outlooks consistently refer to the potential impacts of higher or less than average rainfall.

At this stage, quantitative rainfall forecasting is difficult due to the convective nature of tropical rainfall and the lack of high-resolution modelling or radar observations. Satellite rainfall estimates without ground-truthing are not currently feasible. Qualitative outlook products are available from KMS to service this need..

8.2. SOPs in place to formalize the relation between Met Service and Hydrology Agency, showing evidence that the whole value chain is addressed.

According to the KMS Strategic Plan, KMS has previously had weak coordination and overlapping mandates with the Department of Water Resources, which is under a different Ministry. The indication from in-country discussions and stakeholder feedback is that coordination much improved, although the data exchange is mostly focused on rainfalls recorded rather than forecast expectations. The partnership is now described as a 24/7 relationship.

In user consultations, Water Resources indicated that climate products currently only have minimal influence on their daily decision-making, with their focus more on rainfall observed. However, when questioned further about the hypothetical availability of *high confidence* rainfall forecasts, the response was that the Water Resources team would work with the disaster relief office on measures to put in place to address water shortages.

There are no technical standard operating procedures, although data is shared as described below.

8.3. Data sharing agreements (between local and national agencies, and across international borders as required) on hydrological data in place or under development.

Data sharing arrangements and systems are in place. Water technicians are used in the outer islands to collect rainfall data, which is shared freely.

8.4 Joint projects/initiatives with hydrological community designed to build hydrometeorological cooperation.

Available project documents do not indicate a strong connection between KMS and water projects, but the working relationship is sound. KMS provide essential input towards the assessment of drought conditions, as salinity and rainfall conditions are essential in this process.

Summary score, recommendations, and comments for Element 8

Kiribati is assessed as **Maturity Level 3**, expressed as '*There is a moderately well-functioning relationship between the meteorological, hydrological and water resources communities but considerable room for formalizing the relationship and SOPs'.*

Noting that Kiribati does not have rivers, and has few expressed needs from the hydrological community, this is a mid-range assessment based on the depth of the relationship being primarily about rainfall recorded rather than more sophisticated precipitation estimates and dynamic policy variations based on those. Should stronger hydrological needs be articulated, Kiribati will need external support in meeting them.

Element 9: Product dissemination and outreach

9.1. Channels used for user-centred communication and ability to support those channels (for example, does the NMHS operate its own television, video or audio production facilities? Does it effectively use cutting-edge techniques?).

As for many other SIDS, media availability in Kiribati is limited. There has been a gap in the domestic TV service until the recent launch of 'Wave TV', which broadcasts some local content. There are two radio stations, which do not operate 24/7, and two weekly newspapers, as well as social media (mainly Facebook). Approximately half of the population uses the Internet, although noting that such statistics tend to favour the more urbanised communities.

KMS uses these channels to some degree, including with regular Facebook posts that include available graphics. The KMS Facebook page has 2.8K followers, which is relatively small[3]. Because many of the main dissemination channels are based nearby to KMS, KMS staff can deliver products manually if necessary and use personal relationships to emphasise the importance of messages.

The KMS website is under redevelopment, but contains a mixture of current short term and longer term forecasts. This includes forecasts, warnings, and the current ocean and climate outlooks, including predictions of extreme tides, coral bleaching and sea surface temperatures. These products are available in English and i-Kiribati.

However, in-country discussions indicated that proactive media engagement strategies with radio and television are still relatively limited, even allowing for the circumstances. Media have been reluctant to give KMS airtime except on a fee for service basis, which is highly unusual. Weather and climate content is potentially premium content for media outlets in a highly exposed country such as Kiribati. There is definite scope to improve staff media training, increase the use of press briefings around major weather events, and arrange for dedicated on-air time to discuss these.

9.2. Education and awareness initiatives in place.

Education resources exist[4], and KMS engage where possible with relevant projects and initiatives. The statistics shown above in relation to climate outlooks show some direct school engagement, which is impressive given the many demands on the time of teachers.

Regular school tours are given of the KMS sites, which serve to introduce students to key ideas about weather and climate and the importance of the KMS role. Education is also done through social media.

9.3. Special measures in place to reach marginalized communities and indigenous people.

The overwhelming majority of the Kiribati population are indigenous. Many i-Kiribati are marginalised in terms of their vulnerability to climate change and short-term hazards. Remote residents are strongly disadvantaged by the difficulties and costs of communications. KMS has a people-centred culture and seek to do their best for them, in combination with the National Disaster Management Office. Specific programs such as COSPPac include social inclusion components as part of their process.

[3] By comparison, the Tonga Meteorological Services have 33K followers with a smaller population, although many of these followers may come from the large Tongan diaspora in the Pacific.

[4] Eg 'Learning about climate change the Pacific way – A guide for Pacific teachers – Kiribati. Secretariat of the Pacific Community, 2013' https://kiribati-data.sprep.org/system/files/Kiribati.compressed.pdf

Summary score, recommendations, and comments for Element 9

Kiribati is assessed as **Maturity Level 3:** *'A moderately effective communication and dissemination strategy and practices are in place, based only on in-house capabilities and supported by user-friendly website'.*

This rating is considered more appropriate than the next lower level (Maturity Level 2), expressed as *'Traditional communication channels and a basic dedicated website is used to disseminate forecasts and basic information'* because of KMS' use of social media. In other respects though, KMS' communications are close to a Level 2 rating.

The maturity rating can be particularly improved through consideration of media strategies, including media skills training of staff, and direct engagement with media outlets on the understanding that meteorological content is generally broadcast for free as a public service and attracts wide audiences in most parts of the world. Further development of the KMS website will also benefit users.

Element 10: Use and national value of products and services

10.1. Formalized platform to engage with users in order to co-design improved services.

KMS's strategic plan demonstrates a high level of consultation with users, although there is not necessarily a formalised process for every improved service. There are no regular user forums, although relevant opportunities are used when possible.

There is also a plan to make climate outlook consultations more regular.

Feedback from user consultations indicates that KMS is well respected in the country. As already noted, their national reach is limited by real-time communications and infrastructure issues across a vast maritime country.

10.2. Independent user satisfaction surveys are conducted, and the results used to inform service improvement.

At present, independent surveys are not conducted. A user interface platform is planned under the strategic plan, incorporating user feedback mechanisms.

10.3. Quality management processes that satisfy key user needs and support continuous improvement.

Quality management processes are at their developmental stages, with the most advanced being in aviation. KMS's Quality Management programme is linked to a broader effort championed by the Australian Bureau of Meteorology.

QMS implementation and certification for aviation services is identified as a priority in the Strategic Plan, and there is also an active aviation project with the Bureau to improve services. Following this, climate and marine services quality management will be implemented.

Summary score, recommendations, and comments for Element 10

Kiribati is assessed as **Maturity Level 2** for this criterion, reflecting that *Service development draws on informal stakeholder input and feedback.*

To improve this rating, given the extraordinary challenges that Kiribati faces as a nation, long-term partnership arrangements would be very useful in driving steady progress in quality management. The experience of other countries demonstrates that quality management is a continuous effort and is quite demanding, but it is critical for driving service delivery improvements.

Annex 1 Consultations (including experts and stakeholder consultations)

3 July 23, Tarawa, Kiribati

Visit to Office of Te Beritítenti (Office of the President)

Discussions with KMS Staff

Visit to Australian High Commission

4-5 July 23, Tarawa, Kiribati

Discussions and consultations with KMS Director Ueneta and senior staff, sectional tours

Visits to observations infrastructure at Betio (KMS headquarters), at Port of Betio, and at Bonriki International Airport

5 July 23, Tarawa, Kiribati - stakeholder workshop

Attendees:

- Andrew Tupper, Rob Braaten, Justin Wood, Bureau of Meteorology
- Miriam Kataunati, Oceanographer, KMS
- Tita Mokeaki, Acting Forecaster, KMS
- Tebatibunga Kongotao, Senior Meteorological Observer, KMS
- Roonga Iabeta, Station Technical Officer KMS
- Mwata Keariki, Assistant Climate Officer, KMS
- Tidan Tennaki, Information Technology, KMS
- Buatua Michael, Planning Officer, Ministry of Information, Communications and Technology (MICT)
- Takena Redfern, National Disaster Relief Management Office, Acting Director Climate Change Disaster Relief Management
- Tekimwau Ofiawa, Senior Climate Change Officer, Climate Change Unit, NDRMO
- Tiamur Teaiwh, Aviation and Aerodrome Inspector, Aviation Services, MICT
- Tepepe Tawrwaannang, Water Foreman, Ministry of Infrastructure and Sustainable Energy

Debrief with Australian High Commission

Annex 2 Urgent needs reported

During the team-visit to KMS, power was not available to KMS headquarters (including forecasting, climate, and observations teams) for almost an entire day due to power load shedding. This is a critical issue. It is understood that the Australian Government intends to fund a back-up generator as part of a Bureau-led aviation project.

Annex 3 Information supplied through WMO

- WMO Monitoring System Data
- WMO EW4All Rapid Assessment for Pillar-2
- WMO Hydrology Survey
- Data from Checklist for Climate Services Implementation

Annex 4 List of materials used

Bureau of Meteorology, Australia, internal visit reports

Weather Ready Pacific – A Decadal Program of Investment. Pacific Meteorological Council, May 2021

Kiribati Meteorological Service reports for Severe Weather Forecast Demonstration Project (multiple severe weather event reports)

Kiribati Meteorological Service Country Report, Pacific Meteorological Council, 2019

Kiribati Meteorological Service Country Report, Pacific Meteorological Council, 2023

Kiribati Meteorological Service Strategic Plan & Framework, 2020

Kiribati Joint Implementation Plan for Climate Chane and Disaster Risk Management 2019-2028

Kiribati Climate Risk Country Profile. World Bank & Asian Development Bank, 2021

National Integrated Water Resource Management Diagnostic Report, Kiribati SOPAC Miscellaneous Report 638 (2007)

National Water Resources Implementation Plan - Sustainable Water Resource Management, Use, Protection and Conservation. National Water and Sanitation Committee, November 2008

Strategic Roadmap for Emergency Management in Kiribati 2020-2024

WMO Guidelines on High-resolution Numerical Weather Prediction (WMO-No. 1311, June 2023 Available at https://library.wmo.int/doc_num.php?explnum_id=11654

WMO Guidelines on the Role, Operation and Management of National Meteorological and Hydrological Services. 2017 edition (WMO-No. 1195). Available at https://library.wmo.int/doc_num.php?explnum_id=4221