COUNTRY HYDROMET DIAGNOSTICS

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

December 2025

Tonga Peer Review Report

Reviewing Agency: Meteorological Service of New Zealand and Earth Sciences New Zealand

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List of acronyms

ADB	Asian Development Bank
AWOS	Automated Weather Observing System
AWS	Automated Weather Station
BIP-M	Basic Instruction for Meteorologists
BIP-MT	Basic Instruction for Meteorological Technicians
BMKG	Agency for Meteorology Climatology and Geophysics, Indonesia
BOM	Bureau of Meteorology, Australia
BUFR	Binary Universal Form for the Representation of meteorological data
CHD	Country Hydromet Diagnostics
CIEWS	Climate Information Early Warning System
CIS-Pac5	Enhancing Climate Information and Knowledge Services for resilience in the 5 island countries of the Pacific Ocean
COSPPac	Climate and Oceans Support Programme in the Pacific
CREWS	Climate Risk and Early Warning Systems
DFAT	Department of Foreign Affairs and Trade (Australia)
ECMWF	European Centre for Medium-Range Weather Forecasts (model)
EEZ	Exclusive Economic Zone
FMS	Fiji Meteorological Service
GBON	Global Basic Observing Network
GCF	Green Climate Fund
GDP	Gross Domestic Product
ICT	Information and Communications Technology
LDC	Least Developed Country/ies
JICA	Japan International Cooperation Agency
MACRES	Tonga Mobile Applications Community MHEW and Response System
MetService	Meteorological Service of New Zealand
METAR	Meteorological Aerodrome Report
MFAT	Ministry of Foreign Affairs and Trade (NZ)
MHEWS	Multi Hazard Early Warning System
MPWIELMD	Ministry of Public Works, Infrastructure, Environment, Labour, Meteorology and Disaster
NCOF	National Climate Outlook Forum
NDC	National Disaster Committee
NDMO	National Disaster Management Office
NFWCOS	National Framework for Weather, Climate and Ocean Services for Tonga 2023-2032
NMHS	National Meteorological and Hydrological Service
NOAA	National Oceanic and Atmospheric Administration
NIWA	National Institute of Water and Atmospheric Research (NZ)
PIMS	Pacific Islands Meteorological Strategy
PMC	Pacific Meteorological Council
RESPAC	UNDP Disaster Resilience for Pacific Small Island Developing States project
RSMC	Regional Specialised Meteorological Centre
SIDS	Small Island Developing States
SPC	Secretariat for the Pacific Community
SOFF	Systematic Observations Financing Facility
SOP	Standard Operating Procedure
SPREP	Secretariat of the Pacific Regional Environment Programme
SWFP	Severe Weather Forecasting Programme
TAF	Aerodrome Weather Forecast (historically Terminal Area Forecast)
TMS	Tonga Meteorological Services
UKMO	United Kingdom Meteorological Office
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USP	University of the South Pacific

WIGOS	WMO Integrated Observing System
WMO	World Meteorological Organization
WRP	Weather Ready Pacific Decadal Programme

Executive Summary

Tonga is a Small Island Developing State comprising 169 islands spread across a vast Exclusive Economic Zone of more than 650,000 km². The country is highly exposed to hydro-meteorological hazards, including tropical cyclones, storm surge, coastal flooding, high seas, heavy rainfall, drought and tsunami. These hazards pose significant risks to lives, livelihoods, infrastructure and economic activity, particularly given Tonga's dispersed geography, reliance on rainwater and groundwater resources, and concentration of population on low-lying islands.

The Tonga Meteorological Service (TMS), operating within the Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC), is the nationally mandated authority for the provision of weather, climate and ocean services under the Meteorological Services Act 2017. TMS plays a critical role in safeguarding communities and supporting national development, including aviation, marine operations, agriculture, fisheries, tourism and disaster risk management.

This Country Hydromet Diagnostics (CHD) assessment finds that TMS demonstrates **solid core capability and strong commitment**, but remains constrained by **limited financial, human and technical resources**, resulting in uneven maturity across the ten CHD elements. Overall, TMS performs at Level 2–3 maturity across most elements, with particular strengths in product dissemination and outreach (Level 4) and operational forecasting and warning services (Level 3).

Key strengths identified include:

- A clear legal mandate and well-articulated strategic direction through the TMS Strategic Development Framework 2023–2027;
- Strong national and regional partnerships, particularly with neighbouring National Meteorological Services and development partners;
- A well-maintained surface observation network, including recent investment in automatic weather stations and the installation of a national weather radar;
- A 24/7 warning service with high population reach, supported by effective use of radio, social media and mobile-based dissemination platforms; and
- Advanced communication and outreach practices that position TMS as a regional exemplar.

Key gaps and challenges include:

- Insufficient and highly constrained core funding, resulting in heavy reliance on externally funded projects;
- Lack of GBON-compliant upper-air observations and limited automation of surface observations for international exchange;
- Weak data sharing infrastructure, including the absence of WIS 2.0 implementation and modern data encoding practices;
- Limited integration with hydrology services and the absence of formal SOPs and data-sharing agreements; and
- No systematic measurement of user satisfaction or socio-economic benefits to inform service improvement and investment decisions.

TMS is well placed to deliver significant improvements in national hydromet capability if targeted investments are made in sustainable observations, data exchange systems, impact-based warning services, institutional coordination (particularly with hydrology and disaster management agencies), and mechanisms to demonstrate the national value of meteorological and climate services.

Summary of assessment ratings for CHD elements

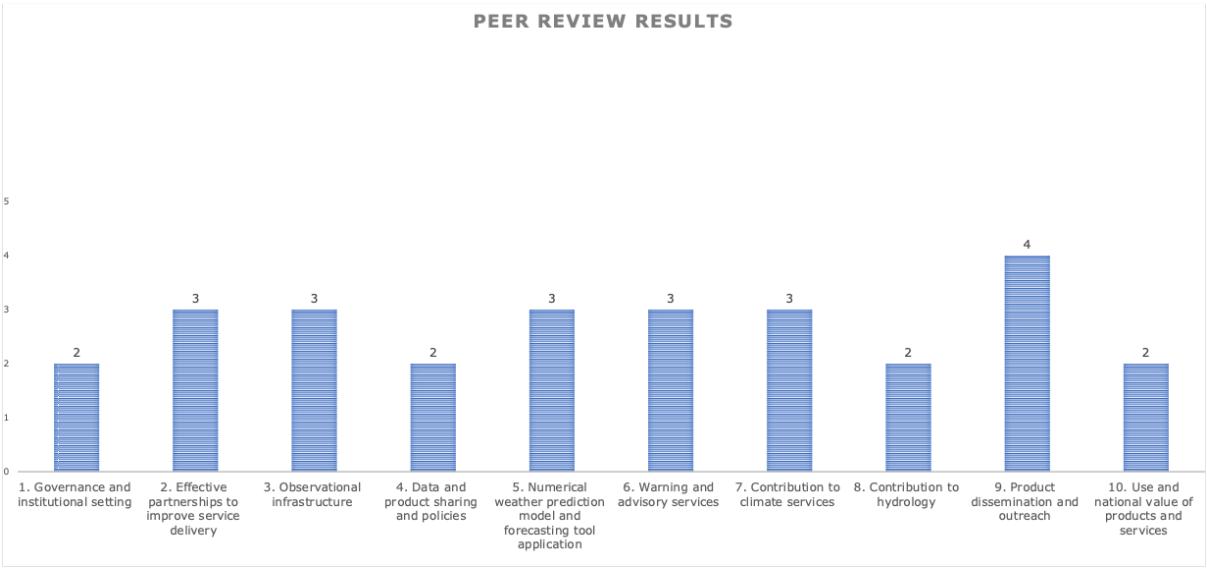

Figure 1: Summary of assessed ratings for the ten Country Hydromet Diagnostics elements. Each rating is out of five, with five reflecting a relatively high degree of maturity.

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

Table 1: As for Figure 1, in tabular form

Chapter 1: General information

Introduction

Tonga is a small independent nation consisting of 169 islands, 36 of which are inhabited. The total land area is 747 square kilometres with an EEZ of more than 650,000 square kilometres. The EEZ is the 40th largest in the world.

Tonga has a total population of around 107,000, with around one quarter living in urban areas. Approximately 75-80% of the total population of Tonga lives on the island of Tongatapu, which is home to the capital, Nuku'alofa.

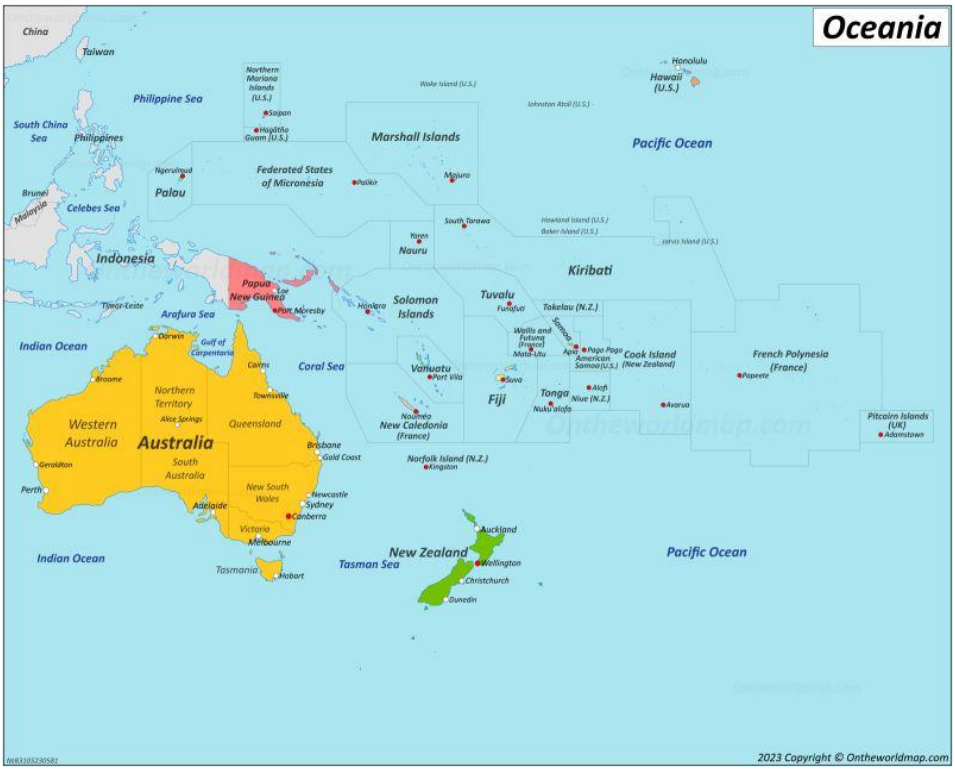

Figure 2: Map of Oceania (source: https://ontheworldmap.com/oceania/)

In 2022-23, the GDP per capita in real prices amounted to T$10,410[1] ($4,360 USD). Tonga is classified as a Small Island Developing State[2]. Tonga's economy is relatively small and heavily reliant on a few key sectors, with agriculture, fisheries, remittances, and tourism being the primary drivers. There is some agricultural export.

Tonga's topography is characterized by a combination of mountainous islands, low-lying coral atolls, and volcanic landscapes. Tongatapu (the largest island) is relatively flat and low-lying with some rolling hills and coastal plains.

Tonga has a tropical maritime climate, and receives significant rainfall, especially during the wet season. Annual precipitation can be 1,500 mm to 2,000 mm, with some variation between islands. The country has two distinct seasons—a wet season from November to April and a dry season from May to October. Even in the dry season, rainfall is normally more than 100 mm per month. Tonga is partially reliant on rainwater

[1] *https://finance.gov.to/sites/default/files/2024-10/GDP_Bulletin-2022-23_final.pdf*
[2] *https://www.un.org/ohrlls/content/list-sids*

as there are no sources of fresh water on the reefs and atolls. The larger islands have groundwater.

Tonga is between 13° and 23° south of the Equator, with Nuku'alofa around 2350 km south of the equator. A such, Tonga is very susceptible to tropical cyclones and has been impacted multiple times in the past decade, most notably by Cyclone Gita in February 2018. This was a Category 4 storm that caused widespread destruction in Tongatapu and 'Eua, damaging infrastructure and homes.

The services of the Tonga Meteorological Services (TMS), alongside partner agencies, are vital to the safety and economic activity of Tongan citizens, and this has been recognised by the Government of Tonga which, in recent years, has provided additional resourcing to support the observation network. Overall, resourcing remains a challenge.

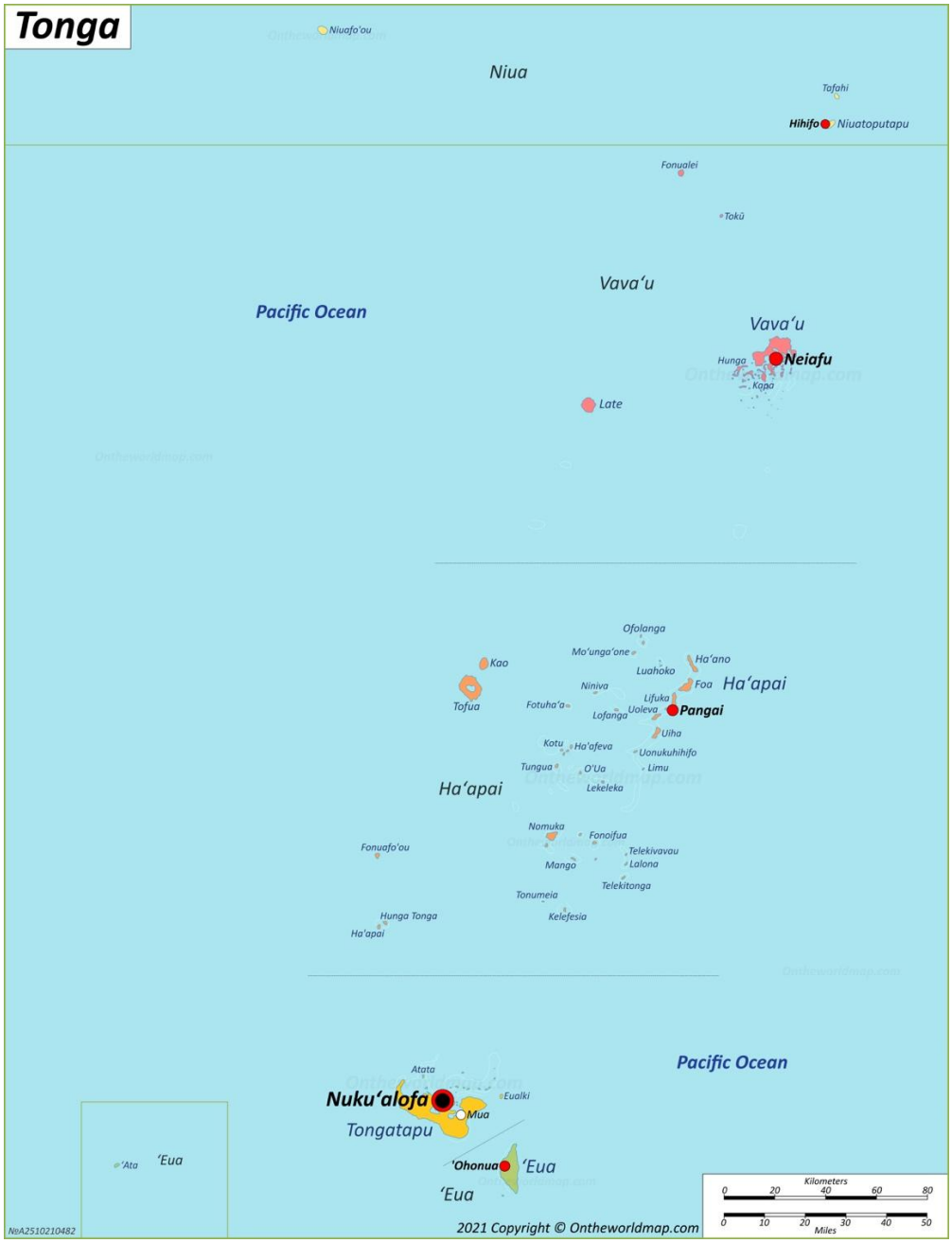

Figure 3: Map of Tonga (source: https://ontheworldmap.com/tonga)

The priority hazards for Tonga are tsunami, storm surge and coastal flood, tropical cyclones, thunderstorms and high seas.

CHD methodology

This report has drawn on multiple sources, but primarily on-site visits and interviews with TMS staff and other stakeholders. The initial site visits and interviews were undertaken in late 2023, with the report updated and completed in April 2025.

The Tonga Meteorological Service *Strategic Development Framework and Implementation Plan 2023-2027* provided very useful insights around the current state and future direction of TMS. Also referenced is the *Design of Impact-Based Multi Hazard Early Warning System (DT 2-1 & DT 3-1) Report*, prepared by Deltares in 2019.

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

The Tonga Meteorological Service (TMS) is a Department of the Tonga Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC). Its stated mission, from the *Tonga Meteorological Service Strategic Development Framework and Implementation Plan 2023-2027*, is "A more resilient Tonga by 2030 to socioeconomic consequences of extreme meteorological, ocean and other environmental events; and support its sustainable development through the best possible services."

The Meteorological Services Act 2017 designates TMS as the national authority for the provision of official meteorological and ocean information and services. The Act clearly defines the mandate and responsibilities of TMS, establishing it as the authoritative voice on weather, ocean and climate services in Tonga. Hydrology is not specifically mentioned in the act.

Hydrological services come under the Natural Resources Department within the Ministry of Lands and Natural Resources, with a focus primarily on water supply and groundwater. Rainfall measurement and forecasting is the responsibility of TMS. Public Works Department and mostly limited to ground water and saltwater intrusion.

For aviation services, TMS provide METARs for Nuku'alofa and Vava'u international aerodromes. Procurement of AWOSs for both these sites in progress under the Partnerships for Aviation project, funded by DFAT. Fiji Met Service continues to prepare the TAF and SIGMETs. Aviation Meteorological Observer and Aviation Meteorological Forecaster competency training is also scheduled for delivery by Partnerships for Aviation.

For MHEWS, the regulating Act is the Disaster Risk Management Act 2021. This details the responsibilities and requirements for each department, including that of the TMS, and the organisational arrangements for disaster prevention, mitigation and response.

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

The *Tonga Meteorological Service Strategic Development Framework and Implementation Plan 2023-2027 (TMS Strategic Plan)* was developed under the umbrella of the Tonga Strategic Development Framework II 2015-2025. It sets out five mid- to long-term goals:

- Goal 1: to provide an enabling environment for TMS to enhance performance, strengthen stakeholder confidence and improve its ability to effectively respond to external changes
- Goal 2: to better detect changes in atmosphere, ocean and the environment and provide quality data required to predict future changes
- Goal 3: to reduce vulnerabilities and improve preparedness and response to extreme meteorological, ocean and other environmental events
- Goal 4: to strengthen the capability of the TMS to sustainably meet its goals and objectives

- Goal 5: to enhance products and services that meet the users' needs

There is no formal risk management framework or plan in place; however, TMS have internal processes in place to manage risks such as staff shortages and absences for the key observation and forecasting roles with all staff receiving cross-training in observation and forecasting activities. The TMS Strategic Plan demonstrates a good understanding of risk management principles, and these are applied throughout the document.

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.

TMS received an annual operating budget of 1,400,000 Tongan Pa'anga (USD 590,000) in 2023-24, and this base level budget has been stable over the past three years. In addition, over the past two years, the Tongan Government has separately appropriated 150,000 TPA for the maintenance of the AWS network. It is understood that this supplemental budget will be maintained in future years and rolled into the bas budget. With a total staff of 38, around 75 per cent of the budget goes to personnel costs.

The budget allocation, whilst similar to other countries in the region, is insufficient to cover all core activities and, as a result, TMS is very dependent on donor programs, with the Asian Development Bank (ADB), Australian Department of Foreign Affairs and Trade (DFAT), New Zealand Ministry of Foreign Affairs and Trade (MFAT), and World Bank among the major contributors and implementers.

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.

TMS has a 38 full-time staff (31st July 2025), including the director. A breakdown is provided in Table 2.

Classification	Staff	Staff with degree
Professional	15	14
Technical	23	

Table 2 - Staff positions and qualifications

There are 31 male and seven female staff. 15 staff are classed as professional, and the remaining 23 as technical staff.

Staffing challenges identified in the TMS Strategic Plan include: inadequate staff numbers in Climate Services, Quality Management and Customer Support, and Capacity Development Divisions; lack of professional staff within the Maritime Radio Division; and inadequate staff numbers in the outer island meteorological offices.

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

Tonga has benefited significantly from internationally-funded hydrometeorological projects. As with many countries in the region and more broadly, the challenge has been to sustain the capability, systems and infrastructure after project completion, largely due to budget limitations. Recognising this need, as previously mentioned, the Tongan

Government has provided budget supplementation specifically to support the network of AWS that was funded by the Asian Development Bank.

Some major projects include the already mentioned 21 AWS funded by the Asian Development Bank, the PREP project funded by the World Bank, PARTneR and PARTneR-2 funded by MFAT and COSPPac funded by DFAT.

Summary score and recommendations for Element 1

TMS are assessed as **Level 2** for Element 1 of the CHD. This is defined as 'Effort ongoing to formalize mandate, introduce improved governance, management processes and address resource challenges.'

Element 1: Governance and Institutional Setting				Description: The level of formalization of the NMHS mandate and its implementation, oversight, and resourcing.
Level one: Weakly defined mandate; serious funding challenges; essential skills lacking; little formalized governance and future planning.	Level two: Effort ongoing to formalize mandate, introduce improved governance, management processes and address resource challenges.	Level three: Moderately well mandated, managed and resourced and clear plans for, and sufficient capacity to address operational gaps.	Level four: An effective service but with a few shortcomings related to its mandate, governance, and resourcing and in the process to address the gaps.	Level five: Strong and comprehensive mandate, highly effective governance, secure funding, and readily available skills base.

TMS provide an effective service that has a clear mandate and is very well-managed. For an organisation of its size, TMS has good governance practices and has a clear future direction outlined in the TMS Strategic Plan. The key limiting factor, and what prevents TMS attaining a higher rating, is insufficient financial and human resources for its ongoing operations. It is also noted that realisation of the goals in the TMS Strategic Plan will require significant external resources.

Recommendations

To improve its performance in this area, it is recommended for TMS to:

- Undertake a risk assessment and develop a risk management plan;
- Work with the Tongan Government to secure stable ongoing funding sufficient to support operations; and
- Work with donors to undertake a cost-benefit analysis to support additional investment in TMS.

Element 2: Effective partnerships to improve service delivery

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

TMS is part of a broader government ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change, and Communications (MEIDECC). The location within the one ministry drives close collaboration between the departments. TMS also has proactive and functional relationships with other departments in government including the Division of Natural Resources within the Ministry of Lands and Natural Resources, which contains the Water Resources Division and the Geohazards Services Section.

The National Disaster Risk Management Committee is established under the Disaster Risk Management Act 2021. Whilst the Minister for responsible for TMS and the CEO of the Department are members of the committee, the Director of TMS is not a formal member. However, when the Committee meets to discuss meteorological and related events, the TMS Director is invited to attend.

In 2024, a National Working Group on Multi Hazard Warning Systems was established and approved by the National Cabinet. The TMS Director is leading this group.

Overall, connections between the different functions of government work well, reflecting the small size of the country and the value of close personal relationships.

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.

The small size of the country, the maturity of the market for meteorological services and the effectiveness of TMS work together to create a situation where there is effectively no private meteorological sector.

In terms of engagement across sectors, TMS plays a central role in the National Climate Outlook Forum (NCOF), serving as the lead agency for climate monitoring, forecasting, and communication. As part of the forum, TMS provides seasonal climate outlooks based on regional and global climate models, helping stakeholders understand potential rainfall, temperature, and cyclone patterns for the coming months.

There are limited opportunities for TMS to participate in or undertake its own research, although a dedicated research facility and partnerships with academia are proposed in the TMS Strategic Plan. At the current time, TMS does not have any formal linkages academia; however, as key stakeholders, TMS maintains good relationships in the sector and plans to establish memorandum of understandings with key academic institutions in the near future.

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

TMS has well established partnerships with key regional partners such as the Australian Bureau of Meteorology (BOM), Meteorological Service of New Zealand Ltd (MetService), National Institute of Water and Atmospheric Research Ltd (NIWA) of New Zealand, other National Weather Services in the region, the Secretariat for the Pacific Community (SPC), the Secretariat of the Pacific Regional Environment Programme (SPREP), and WMO. The Director of TMS is a member of the Pacific Meteorological Council (PMC).

Tonga also has well-established partnerships with finance partners, in particular DFAT, MFAT, the Asian Development Bank and the World Bank.

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.

A number of new services have arisen from development projects. In particular, COSPPac has supported the delivery of climate services through access to climate outlooks, weather forecasts, and other climate-related data to support decision-making in various sectors.

Summary score, recommendations, and comments for Element 2

The Tonga Meteorological Service is assessed as **Level 3** for this element of the CHD. This is defined as 'Moderately effective partnerships but generally regarded as the weaker partner in such relationships, having little say in relevant financing initiatives'.

Element-2: Effective partnerships to improve service delivery			Description: The level of effectiveness of the NMHSs in bringing together national and international partners to improve the service offering.	
Level one: Works in isolation and does not value or promote partnerships. .	Level two: Limited partnerships and mostly excluded from relevant finance opportunities	Level three: Moderately effective partnerships but generally regarded as the weaker partner in such relationships, having little say in relevant financing initiatives.	Level four: Effective partnerships with equal status in most relationships and approaching relevant funding opportunities in a coordinated manner.	Level five: NMHS is regarded as a major national and regional role player. It has extensive and productive partnerships and is viewed as an honest broker in bringing parties together and provide national leadership on relevant finance decisions.

TMS has effective partnerships nationally and plays a very active role in the region. It is seen as a regional leader but internally, as a department within the Ministry, TMS could play a more leading role in funding initiatives.

Recommendations

To improve its performance in this area, it is recommended for TMS to:

- Establish a formal MOU with a relevant local research institution to further the goals of the strategic plan
- To continue contributions and support role in the National Disaster Risk Management Committee
- To effectively involve and utilize the established Tonga National Working Group on Multi-Hazard Early Warning Systems (TNWG-MHEWS) to enhance effective partnerships and service delivery.

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.

As a highly distributed island country, Tonga has limited land locations on which to place weather stations. The islands are scattered geographically with large areas of open ocean in between. There are currently five synoptic surface stations in Tonga, with an average distance between synoptic stations of approximately 235 km, in addition to 21 AWSs. The stations are shown in Figure 4 and summarised in Table 3.

Currently none of the stations are fully GBON compliant.

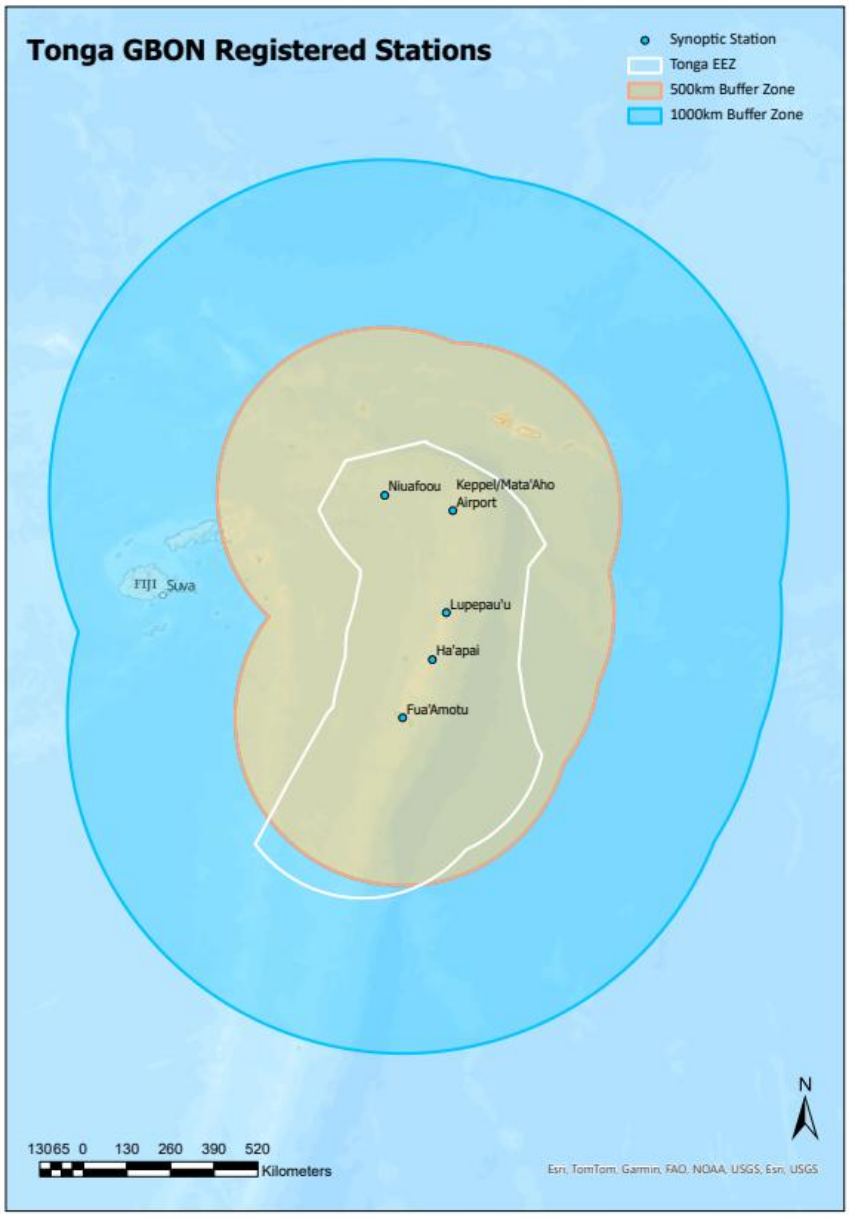

Figure 4 - Synoptic stations in Tonga

Station name	Observations Taken	Frequency
FUA'AMOTU	Synoptic observations (temperature, humidity, pressure, rainfall and wind at 10 metres)	3-hourly
HAAPAI	Synoptic observations	6-hourly
KEPPEL/MATA'AHO AIRPORT	Synoptic observations	6-hourly
LUPEPAU'U	Synoptic observations	3-hourly
NIUAFOOU	Synoptic observations	Station silent

Table 3 - Synoptic stations in Tonga

At the four operating synoptic stations, manual surface observations are taken 3-hourly or 6-hourly and shared internationally. There are currently no staff at the Niuafo'ou MET Office, but TMS is planning to fill this position by Dec 2025. The remote stations communicate their observations to the TMS Office by email, radio, phone or Chatty Beetle. Observations are emailed to NZ MetService who share the observations internationally.

There were 21 AWS installed across the country in 2019 under an Asian Development Bank project, as shown in **Error! Reference source not found.**. Five of these are installed at the synoptic stations listed above. These are an excellent example of a tiered network with some meeting full WMO standard for exposure, and others providing situational awareness. These AWS currently do not supply coded messages for international exchange but do have the potential to do this. At the time of writing, all stations are operational. Data are transmitted to TMS HQ via the mobile network (primary) with satellite communications as a backup.

There are three sea level stations installed which provide verification data for tsunami services as well as information on sea-level rise.

TMS does not operate any upper-air station, which would be required to become GBON compliant. Tonga operated a pilot balloon program up to the early 2000s, but this was discontinued due to the high cost of importing gas cylinders.

Figure 5 - AWS in Tonga

3.2. Additional observations used for nowcasting and specialized purposes.

In August 2024, a weather radar was installed at Fua'amotu International Airport on Tongatapu along with training for staff in the maintenance and use of the system, and software for visualisation of the data. The radar technology provides detailed information on location and intensity of rainfall, thunderstorms, and tropical cyclones that affect Tonga.

Forecasters have access to geostationary satellite imagery from Himawari via internet and also make use of real-time satellite rainfall products from JAXA.

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

TMS operate a good maintenance and sensor exchange programme. Transfer standards, used to verify or calibrate sensors on site, are in use. However, in terms of calibration, there are no calibration facilities available and workshop space is limited. Instruments, including transfer standards, need to be sent offshore for calibration, usually to Earth Science New Zealand (formerly NIWA).

The more remote islands are accessible by light plane, which facilitates site visits and maintenance. Currently, the AWS sites are visited quarterly. The AWS project also provided a good supply of spares and calibration kits.

Regional calibration facilities are available through the Regional Instrument Centres (RIC) in Australia, and the RIC currently under construction in Fiji. Calibration support is also available from New Zealand.

Radar maintenance is being carried out by TMS with support from the vendor and NZ MetService. Currently, no additional financing or human resources have been made available.

TMS has one staff member who has received OSCAR Surface training and is registered as a station contact.

3.4 Implementation of sustainable newer approaches to observations.

There is no WIGOS implementation plan in place but, as there are few observations taken by other parties, this is not a high priority.

Mercury in glass measuring equipment is in the process of being phased out.

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

Currently, synoptic observations are all manual.

As noted, there have been 21 AWS installed through funding from the Asian Development Bank. Many of these sites are co-located with manual observing sites and there is, therefore, an opportunity to fully automate observations in the future.

Taking into account labour costs, maintenance costs and the complexity of automated systems, any investment in upper air observations should be in manual systems.

Summary score, recommendations, and comments for Element 3

The Tonga Meteorological Service is assessed as **Level 3** for this CHD element. This describes a moderate network with some gaps with respect to WMO regulations and guidance and with some data quality issues. The lack of an upper air system is noted.

Element-3: Observational Infrastructure			Description: The level of compliance of the observational infrastructure and its data quality with prescribed WMO regulations and guidance.	
Level one: No or limited, basic surface observations and no upper-air observations.	Level two: Basic network, large gaps, mostly manual observations with severe challenges and data quality issues.	Level three: Moderate network with some gaps with respect to WMO regulations and guidance and with some data quality issues.	Level four: Comprehensive mostly automated network providing good traceable quality data fully compliant with WMO regulations and guidance.	Level five: Comprehensive and highly automated advanced network including additional measurements and remote sensing platforms providing excellent data fully compliant with WMO regulations and Guidance.

The current network is fairly comprehensive and well-maintained. The main issue is in data transmission, both back to TMS and also for international exchange.

Recommendations

To improve its performance in this area, it is recommended for TMS to:

- Establish a manual upper air system with sustainable long-term funding supporting two flights per day
- Fully automate observations at GBON stations with staff remaining on site to provide maintenance and basic fault finding and rectification
- Transition from manual to automated observations at staffed sites
- To establish effective cost recovery frameworks for the observation network and infrastructures of TMS

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.

Observations from the synoptic stations operated by TMS are shared internationally. The observations, however, do not meet the GBON requirements for temporal frequency and so, cannot be considered to be GBON compliant. There are no upper air observations at the current time.

TMS has no direct connection to the GTS and its synoptic observations are emailed to MetService (New Zealand) and BOM (Australia) for input into the GTS. Obsolete code forms are used for this transfer. There are no WIS2.0 protocols used.

A potential challenge for TMS, and other NMHS in the region is the ability to encode and decode BUFR messages. An important requirement for TMS is to still be able to receive bulletins in traditional synoptic code.

The information available from the Regional WIGOS Centre is also not used.

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

There is no formal policy for the free and open sharing of observational data, however, the Meteorological Act is specific on the functions of the Meteorological Service, which include:

- *'exchange of meteorological data with Meteorological Services of other jurisdictions, free and unrestricted, in accordance with the Convention of the World Meteorological Organization for the purpose of meteorology'*

The Act also specifies that, *'subject to any intellectual or copyright laws of the Kingdom, the Department shall have copyright over all meteorological and ocean related data collected, generated and archived, including all works developed or published by the Department or by any person authorised to do such works for and on behalf of the Department.'*

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

Staff at TMS access a range of data and products from external sources. The primary source of forecast and guidance material is the NZ MetService 'MetConnect' site. The main products used are observations bulletins, forecast and analysis charts and satellite imagery. Other sources of information include JMA forecasts (via the SatAID server), UKMO and ECMWF charts (via internet) and streamline analysis using the 'Windy' website.

Satellite data are used for real-time monitoring of large-scale weather events and situational awareness. Meteorology staff are well trained in the use of satellite data for monitoring priority hazards. Forecasters have access to geostationary satellite imagery from Himawari via internet and also make use of real-time satellite rainfall products from JAXA.

Internet connectivity to the headquarters has relatively high bandwidth (55-60 Mbps) via cable but is subject to periodic outages.

Summary score, recommendations, and comments for Element 4

The Tonga Meteorological Service is assessed as **Level 2** for this CHD element, which is defined as 'A limited amount of GBON-compliant data is shared internationally. The existing data sharing practices and the existing infrastructure severely hamper two-way data sharing.'

Element-4: Data and Product Sharing and Policies			Description: The level of data and product sharing on a national, regional and global level.	
Level one: No observational data is shared internationally, either because not available to be shared or due to the lack of data sharing policies or practices, or the existing infrastructure does not allow data sharing.	Level two: 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.	Level three: Moderately well mandated, managed and resourced and clear plans for, and sufficient capacity to address operational gaps.	Level four: Fully meeting GBON data sharing compliance with a data policy and practices and infrastructure in place. These support free and open sharing of data nationally and, for some products, regionally or internationally as well as the in-house use of external data.	Level five: Exceeding GBON data sharing compliance and additional data (marine, radar, etc.) contributing to regional and international initiatives with policies that promote free and open two-way sharing of data and products

It is expected that in future, the provision of data will be from a mix of manual and automated observations. The installation of a WIS2.0 node, either nationally or regionally, would address many of the issues around two-way data exchange.

The internet connectivity is a constraining factor in terms of both its reliability and bandwidth.

Recommendations

To improve its performance in this area, it is recommended for TMS to:

- Develop a data policy for the exchange of observational and other data
- Implement a WIS2.0 node to facilitate the international exchange of observational data and the reception of additional modelling, satellite and data products
- Explore the possibilities of sharing observations from its AWS network internationally. This will increase the skill of models in the local 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 terms of service delivery, TMS provides:

- daily weather forecasts out to 10-days
- detailed 3-hour forecasts
- severe weather warnings
- strong wind warnings, swell warnings
- tsunami warnings
- rainfall and ocean outlooks
- tides forecasts

Underpinning these services, TMS access a range of products. Data sources include Regional Climate Centres at the BoM, FMS, BMKG, NOAA, NIWA, the RSMCs in Nadi, Wellington, World Meteorological Centres at BoM and NOAA.

The main products accessed are charts, satellite images, text forecasts and observations, extended outlooks and seasonal forecasts. Forecast products are updated twice daily and accessed via the MetConnect platform hosted by NZ MetService.

Forecasters in TMS have received training from New Zealand MetService as part of the SWFP programme. Remote sensing data, primarily from Himawari, is accessed via the internet-based SatAID system, which has its own dedicated data display system.

TMS generate their own forecasts based on the different data types available to them.

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

TMS has no capability to internally run models and there is no additional processing of externally-sourced models and forecasts.

TMS staff face a problem that is common to smaller meteorological services of having to view each data stream in a separate interface and with no way of integrating forecast and analysis information.

Forecast verification is performed routinely, but primarily in a qualitative manner and with limited scope to affect changes to systems or procedures.

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

There is no use of probabilistic forecast information and no post processing of ensemble predictions.

Summary score, recommendations, and comments for Element 5

The Tonga Meteorological Service is assessed as **Level 3** for this CHD element ‘Prediction is based mostly on model guidance from external and limited internal sources (without data assimilation) and remoted sensed products in the form of maps, figures and digital data and cover nowcasting, short and medium forecast time ranges.’ Forecasts are produced internally based on available information.

Element-5: Numerical Weather Prediction Model and Forecasting Tool Application			Description: The role of numerical weather prediction model output and other forecasting tools in product generation. Whether local modelling is sustainably used to add value to model output from WMO Global Data-processing and Forecasting System (GDPFS) centres.	
Level one: Forecasts are based on classical forecasting techniques without model guidance and only cover a limited forecast time range.	Level two: Basic use of external model output and remote sensed products in the form of maps and figures, covering only a limited forecast time range.	Level three: Prediction based mostly on model guidance from external and limited internal sources (without data assimilation) and remoted sensed products in the form of maps, figures and digital data and cover nowcasting, short and medium forecast time ranges.	Level four: Digitized model output from internal (with data assimilation) and/or external (regional) sources and remote sensed products and data used and value-added through post-processing techniques extended into longer ranges.	Level five: Optimal combination of global, regional and local models, remote sensed data, post-processing techniques and automated probabilistic product generation over weather and climate time scales with minimal human intervention supported by up-to-date verification statistics.y sharing of data and products

At Level 3 for this element, Tonga is one of the more capable meteorological services in the region. Given the size of the service and the resource constraints, it is not likely to be able to progress beyond level four.

Recommendations

To improve its performance in this area, it is recommended for TMS to:

- Implement a visualisation and forecast generation platform to facilitate the use of gridded data products
- Implement a formal forecast verification process

It is not recommended for TMS to implement its own local modelling system at this point of time. As AI-based systems continue to evolve, this recommendation may change at some time in the future.

Element 6: Warning and advisory services

6.1. Warning and alert service cover 24/7.

The TMS Office is staffed 24/7 by operational forecasters and the warning service is provided 24 hours per day, every day of the year.

A bulletin including a two-day forecast is issued each morning and evening with the evening forecast providing more detailed information and the morning forecast providing an update. These are issued in English and local Tongan language.

Daily updates of 10-day outlooks are provided for rainfall, wind, temperature, sea swell and sea state.

Warnings are produced locally based on available information, including tsunami warnings.

The weather forecasts, warnings and outlooks are made available on TMS Website (https://met.gov.to/), the TMS Facebook page and broadcast on the marine radio service operated by TMS. Information is also sent via email to focal points in ministries, television stations and radio stations. Given that most of the populated areas have mobile coverage, and taking into account the radio service for marine and coastal users, warnings and alerts cover the majority of the population (90-95%).

All remote stations are equipped with redundant communication systems consisting of HF radio, Chatty Beetle systems with sirens and internet.

Multi-Hazard Early Warning Systems are under development.

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

The TMS provides warnings and alerts for tsunami, storm surge and coastal flood, fog, drought and dry spell, wind, tropical cyclone, thunderstorms and squall lines, high seas and rogue waves, extreme high tide and heavy damaging swells, heavy rain, flash-floods and tsunamis.

In terms of feedback and lessons learnt, there is a seasonal survey after extreme events. The website also has a feedback form. The ongoing review of the effectiveness of the MHEWS has led to improvements, in particular a cell-based warning service in partnership with the telecommunications provider.

Systems testing is undertaken with daily checks of the communications systems and monthly exercises. Standby power is available at the headquarters, but procedures require review.

Forecasts and warnings are archived, both physically and electronically.

Guidance products from RSMCs are used for tsunami, tropical cyclones, thunderstorms and high seas warnings.

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.

Alerts in CAP format were previously produced using the SmartMet system, installed in 2014 under a Finnish-Pacific project spanning a number of countries. The system is no

longer performing this function at the time of writing; thus, CAP warnings are no longer being issued.

There are standard operating procedures in place for some hazards, but not all, and this is an area for future investment.

Some forecasting staff have been trained in impact-based forecasting but there is currently no capability within TMS to do this. The TMS Strategic Plan has, as one of its objectives, to implement impact-based multi-hazard warning systems following the WMO MHEWS guidelines.

Summary score, recommendations, and comments for Element 6

The Tonga Meteorological Service is assessed as **Level 3** for this CHD element. TMS operates a weather-related warning service with modest public reach and informal engagement with relevant institutions, including disaster management agencies.

Element-6: Warning and Advisory Services			Description: NMHS' role as the authoritative voice for weather-related warnings and its operational relationship with disaster and water management structures.	
Level one: Warning service not operational for public preparedness and response.	Level two: Basic warning service is in place and operational but with limited public reach and lacking integration with other relevant institutions and services.	Level three: Weather-related warning service with modest public reach and informal engagement with relevant institutions, including disaster management agencies.	Level four: Weather-related warning service with strong public reach and standard operational procedures driving close partnership with relevant institutions, including disaster management agencies.	Level five: Comprehensive, impact-based warning service taking hazard, exposure and vulnerability information into account, with strong public reach. It operates in close partnership with relevant national institutions, including disaster management agencies and registered Common Alerting Protocol alerting authorities.

The main gaps are around the implementation of standard operating procedures, and the development and production of impact-based forecasts, both of which are addressed in the TMS Strategic Plan.

Recommendations

To improve its performance in this area, it is recommended for TMS to:

- Fully integrate the weather radar into its warning services
- Improve mechanisms for obtaining feedback on the accuracy and effectiveness of warning services
- Develop and implement impact-based warnings
- Implement warnings in CAP format

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.

For ranking climate services, the Country Hydromet Diagnostics uses a six-point rating scale, ranging from 'Not Applicable', through 'Less than Basic', 'Basic', 'Essential', 'Full' and 'Advanced'. The scale is applied across six categories, in alignment with the WMO Checklist for Climate Services Implementation.[3]

Climate Services Governance

The Meteorological Act clearly defines the role of the TMS in monitoring the climate and also includes climate within the broader definition of meteorology. TMS is the national provider of climate services.

The climate section of TMS comprises four staff: Climate Scientific Officer, Climate Prediction Officer, Database Officer and Communication Officer

There is a Climate Change Department within the Ministry (MEIDECC) with responsibility for policy, planning, finance, and international obligations. The location within the same ministry, and the small size of the country, mean that climate activities are well coordinated within Tonga. TMS has the legislated mandate to provide climate services within the framework. Taking all into consideration, Tonga's capacity is ranked as 'Essential' in this area.

Basic systems

As discussed in the previous sections, the overall climate observing network is mainly weather and hydrology focused and has a number of challenges around resourcing. Data management is adequate but there is no clear data strategy and currently no quality management system. A number of climate products and outlooks are produced, and data is made available on request. Taking all of this into account, Tonga's climate services are assessed as 'Essential'.

Some data rescue activity is underway but ongoing effort is required.

User Interface

There are several mechanisms for interacting with climate data, both internal and external. These include CliDE and CliDEsc. The TMS website has a range of climate products available including outlooks. As such, Tonga is assessed as 'Essential'.

Provision and application of Climate Services

As mentioned, TMS provide a range of climate services via the website, including a Tonga climate summary and local summaries, rainfall outlook in English and Tongan, ocean outlook in English and Tongan. Climate data requests can be made by submitting a web-based email form.

Taking these factors into account, Tonga is ranked as 'Essential' in this area.

Monitoring and evaluation of the socio-economic benefits

[3] *https://extranet.wmo.int/edistrib_exped/grp_has/_en/Archives%202011_2022/Archives%202020/18582-2020-S-CS-Checklist_en.pdf*

TMS has currently no capacity to measure the socio-economic benefits of its climate services. This is addressed in the Strategic Plan. As such, Tonga is assessed as 'Less than Basic' in this area. Development projects do measure their benefits.

Capacity Development
TMS does not conduct any formal capacity development of other agencies or departments. Some workshops and training have been provided through development projects. TMS is rated as 'Basic' for this criterion.

Summary score, recommendations, and comments for Element 7

The Tonga Meteorological Service is assessed as **Level 3** for this CHD element. It has an essential capacity for climate services provision.

Element-7: Contribution to Climate Services				Description: NMHS role in and contribution to a national climate framework according to the established climate services provision capacity.
Level one: Less than basic Capacity to provide Climate Services	Level two: Basic Capacity for Climate Services Provision	Level three: Essential Capacity for Climate Services Provision	Level four: Full Capacity for Climate Services Provision	Level five: Advanced Capacity for Climate Services Provision

Key gaps are around monitoring and evaluation and capacity development.

Recommendations

To improve its performance in this area, it is recommended for TMS to:

- Develop methods to measure the socio-economic benefits of its climate services
- Assist in outreach and capacity development activities for other agencies and departments in relation to the understanding and application of climate services
- To establish and recruit more staff into the climate services of TMS

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.

Tonga has some surface and groundwater, with the population partially dependent on rainfall harvesting. There is some surface hydrology on the larger islands[4] but Tonga does not have any major rivers. The islands of Eua and Niuatoputapu do have creeks.

The weather radar has provided the capability for real time precipitation information over Nuku'alofa. Apart from this, TMS has no capability to provide quantitative precipitation estimation or forecasts.

All of the AWS installed across the country measure real time rainfall and this is the primary source of rainfall observations across Tonga. In addition, there are manual rain gauges at each of the staffed observing stations, providing a check on the automatic measurements.

Water supply and hydrology is the responsibility of the Natural Resources Department, whose main focus is groundwater. TMS do provide the Natural Resources Department with rainfall data and outlooks, which assist with managing the water supply.

Coordination does occur during tsunami and volcanic eruptions as the CEOs of both ministries are on the National Disaster Management Committee.

There is a lack of real-time stream gauging on the island of 'Eua and, as a result, TMS is not able to effectively warn of riverine flooding events which impact downstream populations and infrastructure.

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

There are no formal standard operating procedures between the TMS and the Natural Resources Department (which is in a separate Ministry). There are no committees in place for hydrology management.

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

Rainfall observations data and rainfall outlooks are provided to the Natural Resources Department on an ad hoc basis, but there are no formal agreements in place.

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

There are currently no joint projects designed to build hydrometeorological cooperation.

Summary score, recommendations, and comments for Element 8

The Tonga Meteorological Service is assessed as **Level 2** for this CHD element, reflecting: 'Meteorological input in hydrology and water resource management happens on an ad hoc basis and or during times of disaster.'

[4] https://www.sprep.org/publications/the-hydrology-and-water-supply-of-the-kingdom-of-tonga

Element-8: Contribution to Hydrology				Description: NMHS role in and contribution to hydrological services according to mandate and country requirements.
Level one: No or very little meteorological input in hydrology and water resource management.	Level two: Meteorological input in hydrology and water resource management happens on an ad hoc basis and or during times of disaster	Level three: There is a moderately well-functioning relationship between the meteorological, hydrological and water resources communities but considerable room for formalizing the relationship and SOPs.	Level four: The meteorological, hydrological and water resources sectors have a high-level formal agreement in place and an established working relationship and data sharing take place, but institutions still tend to develop products and services in isolation.	Level five: The meteorological, hydrological and water resources sectors have robust SOPs and agreements in place to work closely in developing new and improved products and providing seamless and advanced services.

There is some room for improvement, and the priorities should be the establishment of formal standard operating procedures and data sharing agreements with the Natural Resources Department.

Recommendations

To improve its performance in this area, it is recommended for TMS to:

- Establish formal standard operating procedures between itself and the Natural Resources Department
- Establish formal data sharing arrangements for hydrological data

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?).

TMS has made a significant investment in its communication capabilities. Services are provided via the website, social media, live radio crosses, pre-recorded forecasts sent send to television stations for broadcast, VHF radio and HF radio for coastal users.

Facebook is heavily used by TMS to communicate directly with the public. The TMS Facebook page has 48,000 followers, within a total population of approximately 100,000 people.

Recent developments have included the Tonga Mobile Applications Community MHEW and Response System[5] (MACRES), a mobile phone app developed with the assistance of CREWS that delivers cell-based warnings even when there is no data connectivity. The system also allows for two-way communication of reports from communities to allow the authorities to receive both hazard and damage information for quick and targeted response.

9.2. Education and awareness initiatives in place.

Public education and awareness activities in Tonga are delivered through a combination of Ministry-led national campaigns, project-based initiatives, and communications products developed by the Tonga Meteorological Services (TMS). While TMS does not operate a formal education programme, it contributes to broader public outreach by providing hazard information, seasonal climate updates, and preparedness messages that feed into awareness activities and disaster preparedness efforts.

A key initiative supporting early-life awareness is Tonga's use of the Community-Oriented Preparedness and Education (COPE) children's book series, produced with WMO support and translated into Tongan. These illustrated storybooks are used in schools, community meetings and local awareness campaigns to build hazard literacy among children and families, and they provide an accessible way for teachers and community leaders to reinforce key preparedness messages.

Additional education and outreach activities occur through national climate and disaster awareness weeks, sector-specific workshops for agriculture, fisheries and tourism, and community sessions organised under donor-funded resilience and early warning projects. These events often feature TMS presentations or information packs on seasonal outlooks, cyclone preparedness, marine hazards and the interpretation of warnings.

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

Given Tonga's dispersed island geography and high vulnerability, targeted communication measures are essential to ensure equitable access to warnings and preparedness information. While TMS does not operate specific programmes dedicated solely to marginalised groups, several systems and practices are designed to improve reach to remote, low-connectivity or high-risk communities. These include the use of multiple parallel dissemination channels — radio, SMS, VHF and HF marine networks, siren-enabled devices, and community focal points — ensuring that warnings can be received even when internet services are disrupted.

[5] *https://wmo.int/media/news/tonga-boosts-early-warnings-through-smartphones*

MACRES enables two-way reporting from villages during hazard events. This significantly improves access for communities on outer islands, and for those without smartphones capable of high-bandwidth applications. With national mobile coverage reaching over 90 per cent of inhabited areas, MACRES has become a critical tool for bridging geographic and socio-economic barriers.

TMS also relies heavily on Tonga's established community structures, such as church networks, and village disaster committees, to disseminate warnings to people who may have limited access to formal channels. These networks play a central role during cyclones, tsunami alerts and volcanic events, ensuring that elderly people, persons with disabilities, isolated households and those in informal settlements receive timely information.

Summary score, recommendations, and comments for Element 9

The Tonga Meteorological Service is assessed as **Level 4** for this CHD element. A large fraction of the population is reached using various communication techniques and platforms, in collaboration with partners, and a user-friendly and informative website and apps. Outreach and education activities occur regularly.

Element-9: Product Dissemination and Outreach			Description: The level of effectiveness of the NMHS in reaching all public and private sector users and stakeholders.	
Level one: Dissemination using only limited traditional channels such as daily newspapers and the national broadcaster and with little control over messaging and/or format.	Level two: Traditional communication channels and a basic dedicated website is used to disseminate forecasts and basic information.	Level three: A moderately effective communication and dissemination strategy and practices are in place, based only on in-house capabilities and supported by user-friendly website.	Level four: A large fraction of the population is reached using various communication techniques and platforms, in collaboration with partners, and a user-friendly and informative website and apps. Outreach and education activities occur regularly.	Level five: Advanced education, awareness and communication strategy, practices and platforms in place using various technologies tailored to reach even marginalized communities and in close cooperation with several partners.

TMS have a high level of maturity in this area and can be seen as an exemplar for the region in terms of their service offerings and communication of critical information.

Recommendations

To improve its performance in this area, it is recommended for TMS to:

- Continue its work on education and outreach with a focus on those populations in isolated communities, with limited cellular coverage and including GEDSI component of service delivery and dissemination
- Ensure that future development projects invest in this area

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.

TMS provides a suite of weather, climate and ocean products that are widely used across government agencies and key economic sectors, including agriculture, fisheries, tourism and marine transport. These products range from daily forecasts to seasonal outlooks, depending on the sectoral need. Although there is no formal framework for co-design with users, TMS maintains regular informal contact with sectoral partners, who rely on its guidance for operational and planning decisions.

The primary committee for dealing with disasters is the National Disaster Management Committee, established under the Disaster Risk Management Act 2021. TMS is not formally listed as a member of this committee but is represented by the CEO of the Ministry.

TMS have developed a range of tailored services for agriculture, aviation, marine, tourism and fisheries. However, there is no established formal mechanism for the continued co-design and/or co-production of tailored products and services.

No studies specific to Tonga have been undertaken on the social and economic benefits (SEB) of weather, climate and water hydrological services in the last 10 years.

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

There have been no formal, independent user satisfaction surveys in recent years, and no systematic assessment of the socio-economic benefits of TMS products at the national level. This limits TMS's ability to quantify the value of its services, identify service gaps, or make evidence-based cases for investment. However, a number of development projects have undertaken periodic evaluations of their climate and early warning components, offering some useful insights into how meteorological information is applied in practice.

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

TMS has some internal capacity in quality management, with several staff trained in QMS auditing, but there is no formal quality management system in place to guide continuous improvement or ensure that user needs are consistently addressed.

Summary score, recommendations, and comments for Element 10

The Tonga Meteorological Service is assessed as **Level 2** for this CHD element. Service development draws on informal stakeholder input and feedback.

Element-10: Use and National Value of Products and Services			Description: Accommodation of public and private sector users and stakeholders in the service offering and its continuous improvement.	
Level one: Service development lacks any routine stakeholder feedback practice.	Level two: Service development draws on informal stakeholder input and feedback.	Level three: Services development draws on regular dialogue with major stakeholders.	Level four: Service development draws on survey data and regular dialogue based on formal relationships with major stakeholders to ensure continuous improvement.	*Level five: Strong partnerships, formal and objective survey and review processes exist with all major stakeholders enabling service co-design and continuous improvement.*

It could be expected that, with modest investment in this area, the maturity of TMS could be raised to Level 3 in a relatively short timeframe.

Recommendations

To improve its performance in this area, it is recommended for TMS to:

- Implement a regular stakeholder forum to assist in the design of sectoral and specialised services
- Conduct formalised and repeatable user satisfaction surveys to ensure that service quality is improving over time
- Continue to implement quality management systems, in particular for aviation services and to establish a quality management system for the entire TMS in all aspects

Annex 1 Consultations

(including experts and stakeholder consultations)

- Director of NMHS
- TMS staff
- MetService and NIWA experts with experience working in Tonga
- Bureau of Meteorology staff in relation to *Partnerships for Aviation*

Annex 2 Urgent needs reported

No urgent needs were identified.

Annex 3 Information supplied through WMO

- Data from WMO metadata systems (OSCAR-Surface)
- Data from WMO monitoring systems (WDQMS)
- Data from WMO Country Profile database

Annex 4 List of materials used

- Tonga Meteorological Service, Country Report, presented to the Fifth Pacific Meteorological Council (PMC-5) meeting held in Apia, Samoa from 7-9 August 2019
- Weather Ready Pacific, A Decadal Program of Investment, 2021
- Weather Ready Pacific, Implementation Plan, 2023
- Tonga Disaster and Risk Management Act, 2021
- Tonga Meteorological Act, 2017
- Tonga Meteorological Service Strategic Development Framework and Implementation Plan (TMSSDF) 2023–2027
- General Consultant / System Integrator Early Warning Preparedness for Tonga, Deltares, 2019