

COUNTRY HYDROMET DIAGNOSTICS

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



December 2023

Nauru Peer Review Report

Reviewing Agency: Bureau of Meteorology, Australia



Australian Government
Bureau of Meteorology

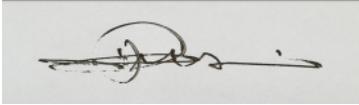


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Authorisation for release of this report has been received from the Peer Reviewing Agency and the Country NMHS.

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Table of Contents

ACKNOWLEDGEMENTS	II
TABLE OF CONTENTS	III
LIST OF ACRONYMS.....	IV
EXECUTIVE SUMMARY	1
Summary of assessment ratings for CHD elements	2
CHAPTER 1: GENERAL INFORMATION	3
Introduction	3
Country Hydromet Diagnostics methodology.....	4
CHAPTER 2: COUNTRY HYDROMET DIAGNOSTICS	5
Element 1: Governance and institutional setting	5
Element 2: Effective partnerships to improve service delivery	10
Element 3: Observational infrastructure	12
Element 4: Data and product sharing and policies	14
Element 5: Numerical model and forecasting tool application.....	16
Element 6: Warning and advisory services	18
Element 7: Contribution to Climate Services	20
Element 8: Contribution to hydrology	22
Element 9: Product dissemination and outreach.....	23
Element 10: Use and national value of products and services	24
ANNEX 1 CONSULTATIONS (INCLUDING EXPERTS AND STAKEHOLDER CONSULTATIONS)	25
ANNEX 2 URGENT NEEDS REPORTED	25
ANNEX 3 INFORMATION SUPPLIED THROUGH WMO	26
ANNEX 4 LIST OF MATERIALS USED	26

List of acronyms

CHD	Country Hydromet Diagnostics
CLiDE	Climate Data for the Environment
COSPPac	Climate and Oceans Support Program in the Pacific
CREWS	Climate Risk and Early Warning Systems
DMO	Disaster Management Office
GBON	Global Basic Observing Network
GTS	Global Telecommunication System
ICAO	International Civil Aviation Organization
ICT	Information and communications technology
METAR	Meteorological Aerodrome Report (an aviation observation)
NDRM	National Disaster Risk Management
NMHS	(Nauru) National Meteorological & Hydrological Service
NWP	Numerical Weather Prediction
SPECI	Special Report of Meteorological Conditions (an aviation observation)
SOP	Standard Operating Procedure
SPREP	Secretariat of the Pacific Regional Environment Programme
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
WIGOS	WMO Integrated Global Observing Network
WMO	World Meteorological Organization

Executive Summary

The Republic of Nauru (population approximately 13000) is a small, single island 40 km south of the Equator in the SW Pacific, with its arable land and population concentrated in a thin strip of low-lying land on the coastline. The country is not heavily exposed to tropical cyclones due to its latitude close to the Equator, but is still vulnerable to tsunamis, flash flooding, strong winds and coastal inundation as 'short fuse' hazards, and drought as a seasonal hazard. Nauru is also highly exposed to climate change.

The Nauru National Meteorological & Hydrological Service (NMHS) was established in 2015 with one officer, and now has fourteen staff, including two climate/weather forecasters, and eight weather observers. Most staff, including the forecasters, have high school qualifications. The NMHS sits within the Department of National Emergency Services and shares a small and inadequate building with the Departmental headquarters and Rescue and Fire Services. The NMHS has little in the way of equipment or non-staffing budget at this stage. Plans for a new headquarters building for the Department, including for the NMHS, have been prepared and land set aside through extensive negotiations with landholders, but funding has not yet been obtained for construction.

Nauru is rated towards the lower end of most maturity elements in the Country Hydromet Diagnostics, although noting the growth in staffing numbers, a favourable organisational placement within the structure of Government, the ongoing development of threshold-based warning services, and the recent launch of a new Early Action Rainfall Watch product. The existence of a Short Message Service broadcasting system capable of reaching virtually the entire population is also a favourable capability for the potential ability for NMHS to assist the National Emergency Services in anticipating and responding to severe events.

The continued development of the NMHS could be guided through the development of an agency-focused Strategic Plan that specifically considers the NMHS country context and what a sustainable future operating model would look like in support of the needs of National Emergency Services as well as the broader economy. Suggested priorities that could be considered within that context include the finalisation of governing legislation, continued growth in community partnerships and product development, an upgrade of observational practices and climate record-keeping, including transmission of surface observations into the WMO Integrated Global Observing System, the establishment of an upper air station, and continued training of staff, including in observations, forecasting, and maintenance practices. If Nauru is able to establish the ability to maintain 24/7 meteorological operations, consideration could also be given to issuing aviation forecasts in-country (currently they are issued from the National Weather Service in Papua New Guinea).

Many of these capacity development and operational activities are potentially most suitable for occurring in the context of long-term peer relationships with partner agencies in the region, and within the context of longer-term programmes such as the Systematic Observations Financing Facility and Weather Ready Pacific. International partnership arrangements are particularly important in meteorology, including in the context of sharing observations, benefitting from atmospheric and ocean forecasts made using high performance computing facilities in other countries, and operating a sustainable service model for warnings and other critical services.

Summary of assessment ratings for CHD elements

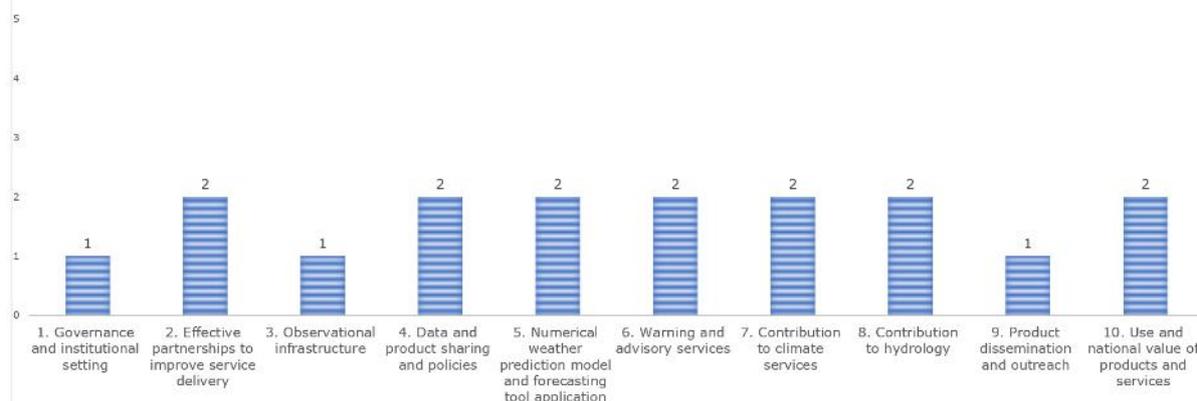


Figure 1 - Summary of assessed ratings for the ten Country Hydromet Diagnostics elements. Each rating is out of five, with five reflecting a relatively high degree of maturity.

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

Table 1- As for Figure 1, in tabular form

These ratings are discussed below.

Chapter 1: General information

Introduction

Nauru, one of the smallest countries in the world, is a single coral island of only 21 km², with approximately 13000 residents, 90% of whom are indigenous Nauruan. The country has two distinct topographic areas – the elevated and largely mined out ‘Topside’ area (up to 65 metres above sea-level), covering almost 90% of the island, and the low lying ‘Bottomside’ coastal area, which has the only fertile areas. Nauru is a Small Island Developing State with few marketable resources, isolation from major markets and high economic vulnerability. Nauru has an Exclusive Economic Zone area of approximately 309,000 km².

Nauru is located only 47 km south of the equator and is not directly at risk from tropical cyclones, which cannot form so close to the equator due to the weakness of the Coriolis Effect. As it is surrounded by reef and with some inland topography, it is slightly protected from coastal inundation events. Nauru is also in a relatively seismically stable area of the SW Pacific, with the nearest active fault lines and volcanic areas located in the Solomon Islands approximately 1100 km to the southwest. However, Nauru is still exposed to tsunami risk, with even small tsunamis potentially impacting the country strongly due to the population virtually all living on the coast¹.

Nauru is also exposed to strong winds, seas and swell, severe thunderstorms, flash flooding, and longer-term events such as drought and heat waves. Annual rainfall variability is very large². Of these hazards, the four most important in the short term are tsunamis, flash flooding, strong winds, and storm surges (or other sources of coastal inundation). Drought is also a significant ‘long-fuse’ hazard for Nauru, due to having very low water security and little ability to import water. Much of Nauru’s key infrastructure, including the national hospital, is located on its coasts, with little habitation or industry possible inland.

Climate change is expected to affect Nauru through an increase in precipitation and number of extreme rainfall events, increase in sea-level, decrease in drought frequency (although with low confidence) and an increase in marine and land heat waves³. Climate change analysis and forecasting for Nauru is limited partly due to poor observations, and there is a broad range of possible outcomes for rainfall.

The Nauru National Meteorological & Hydrological Service (NMHS) is very new in global terms, having been established in May 2015 with one officer. By 2019, a workforce of 10 had been approved, enabling 24/7 observations operation, and Nauru was also announced as the 193rd member of WMO in May 2019.

¹ Australian Government Bureau of Meteorology 2009, SOPAC Member Countries National Capacity Assessment: Tsunami Warning and Mitigation Systems, Republic of Nauru, 24-26 February 2009, research report compiled by C. Stitz-O’Brien, Australian Government Bureau of Meteorology, Melbourne.

² CSIRO and SPREP (2021). ‘NextGen’ Projections for the Western Tropical Pacific: Current and Future Climate for Nauru.

³ Climate Risk Country Profile: Nauru (2021): The World Bank Group.

Country Hydromet Diagnostics methodology

This report has been prepared using the methodology described in the 2022 update of the Country Hydromet Diagnostics. A desktop review of available materials was first performed, followed by an in-country visit and face-to-face discussions, and then report finalisation. The relatively recent establishment of NMHS should be considered when considering the report results, since it would be unusual for a National Meteorological and Hydrological Service to achieve elevated levels of operational maturity in such a brief period.

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 Nauru NMHS was established on 11 May 2015 under the Department and the Ministry of the National Emergency Services (Figure 2). Under the National Disaster Risk Management (NDRM) Act (2016), the department of the National Emergency Services consists of the following offices and services:

- Nauru National Disaster Risk Management Office
- Nauru Rescue & Fire Services
- Nauru Ambulance Services
- Nauru Lifeguard Services, and
- Nauru Meteorology Services

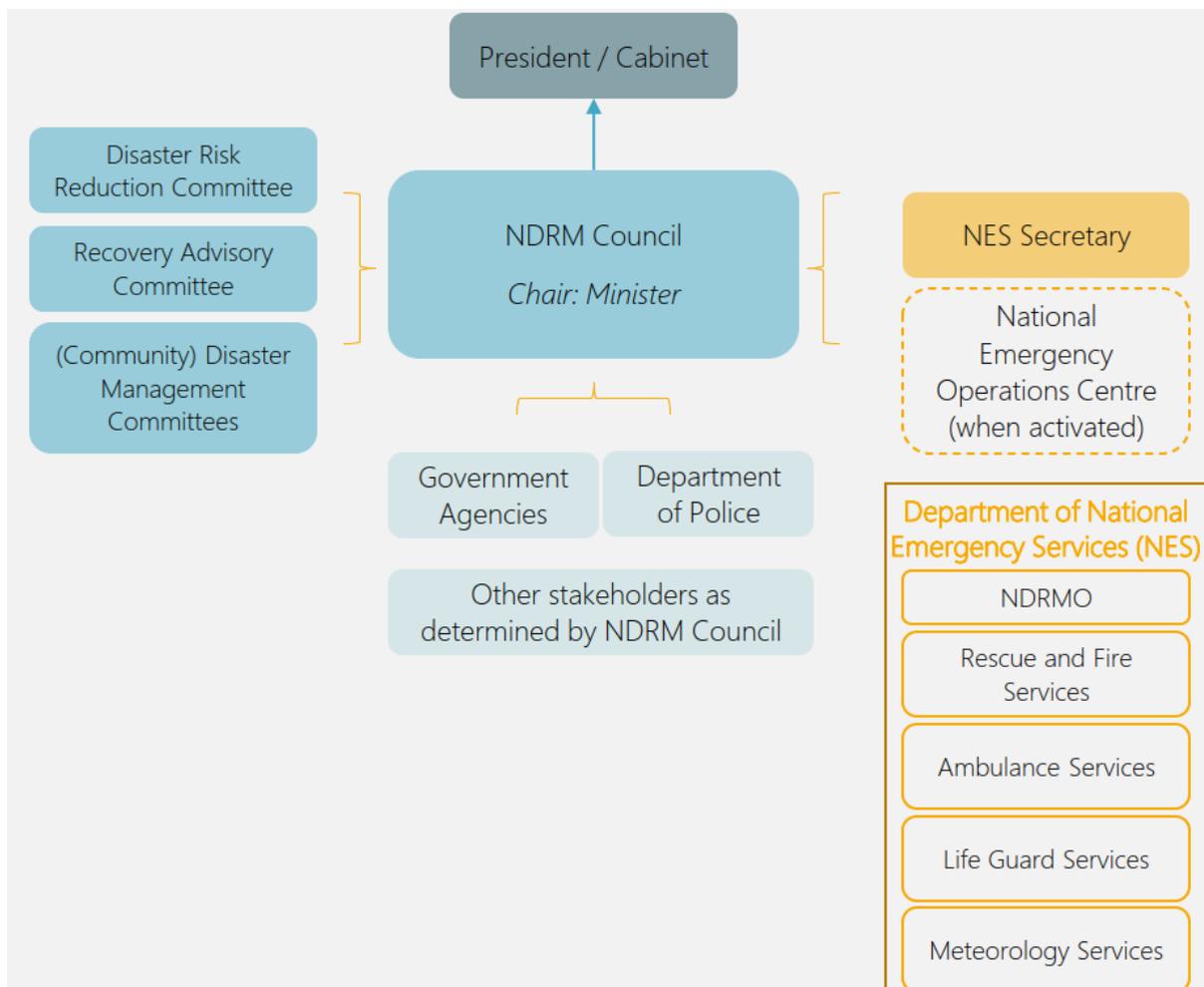


Figure 2 - Departmental structure for Emergency Services (source: Government of Nauru)

The Act requires that the Department provide issuance of early warning messages of potential threats and establishes a National Disaster Risk Management Council. Events mentioned in the Act include cyclones, earthquakes, floods, storms, storm surges, king tides, droughts, fires, tsunamis or other natural or human induced occurrences, and climate change induced occurrences.

Other than early warnings, the usual functions of a national meteorological service (e.g. weather forecasting, observations management, climate services, marine and aviation services) are not mentioned in the NDRM Act. This would generally be regarded as a concern for a national meteorological service, as meteorological and hydrological functions generally extend well beyond the portfolio functions of their parent department (for example, to aviation, marine and climate services), and so a stand-alone meteorological act is generally especially useful for more closely defining agency functions and how all users will be serviced seamlessly.

Meteorology is also mentioned in the earlier Civil Aviation Act (2011), which states that the *“Civil Aviation Authority must ensure the provision of a national weather service to provide public weather forecasting and meteorological warning services in a timely and efficient manner”* and that the Authority may make arrangements with any person to provide such a service. However, this is not reflected in the NDRM Act.

In this light, a 2022 UNDRR Assessment⁴ recommended several priority actions for Nauru, including a Meteorology Act: *“It is essential to develop a strategy to maintain longer term records of data and cascading hazard events. It is essential to draft a Meteorology Act defining the roles and responsibilities of the Nauru Meteorological Service to improve the service delivery.”*

At this stage, drafting of such an Act is in progress, in collaboration with the Justice Department. Depending on how this progresses, Nauru may need further assistance in progressing the Act to completion.

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

Nauru has a Strategic Roadmap for Emergency Management 2021-2023, which is focused on high level considerations for the NDRM Council and Department. The Roadmap sets four goals:

1. Disaster management arrangements and incident management system in place
2. Disaster Risk Management Arrangements are supported by integrated and operational emergency management communication strategies
3. Nauru has a disaster management training and skills development strategy to guide DRM skills development
4. Nauru has established Disaster Management Committees

The operations of the NMHS are most aligned with Goal 2, but also encompass broader support for climate, agricultural, marine and aviation services and economic development in general for Nauru.

There are no stand-alone plans for the NMHS. There is currently no risk management plan for the NMHS.

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

⁴ UNDRR (2022). Disaster Risk Reduction in the Republic of Nauru: Status Report 2022, United Nations Office for Disaster Risk Reduction (UNDRR), Sub-Regional Office for the Pacific.

The NMHS is still in its setup phase. The budget commitment for 2022-23 was published as only AUD \$17000⁵, but noting that staffing costs and office accommodation costs are covered by the parent Department, which provides a small (two room) office within a building largely allocated to fire services. Staffing numbers have been increasing (with 14 staff now employed). Some services are being provided, but the service has little visibility. The NMHS needs a fully operational building, observations equipment, office equipment, a website, strategic planning processes and operations processes. It could not be reasonably said that core functions are covered at this stage, although the increasing staffing is a positive indicator.



PERSPECTIVE

NTS



LOCALITY PLAN

NTS



VICINITY PLAN

NTS

Figure 3 - Artist visualisation and site location for planned new operations building for Department of Emergency Services, including NMHS (source: Government of Nauru)

⁵ The overall budget for the NMHS including staffing costs is estimated at AUD \$200-250K.

The current office is quite small in relative terms. A site has been identified, plans prepared, and costings obtained for a new operations building for the Department, with space for the NMHS (Figure 3). The site identification and approval process were conducted through very extensive consultation with local landholders, who have approved the use of the land specifically for this purpose. The site is appropriately located 'topside', away from coastal inundation zones but conveniently close to the critical airport facility, where observations are currently taken. At time of writing, a funding source has not yet been confirmed for the building, but undertaking these works would likely be of substantial benefit to Nauru and to the NMHS and Emergency Services.

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.

Nauru has eight observer staff. There are also two forecasting staff, a hydrological officer, an ICT manager, an administration officer, and the Director. Two of the fourteen staff are women. Of these staff, one (the ICT manager) has a Master's degree in his discipline. In general staff otherwise have high school qualifications.

Nauru has been assisted in various training activities, particularly through Fiji, Japan, and Australia.

Nauru is one of the smallest countries in the world, with little in-house training capacity. The most recent training needs assessment in the region, the 2018 UNDP Feasibility Study for a Pacific-based WMO Regional Training Centre⁶, noted that it would be expected that Nauru would have similar needs to other small meteorological services in the region, but was unable to provide further insights.

In-country discussion confirms that training for staff is indeed a high priority and would be expected to remain so for a considerable period, suggesting the importance of long-term engagement. One of the priority training actions is to train the observer staff to BIP-MT (Basic Instruction Package Meteorological Technician) level as per ICAO requirements, to assist in supporting aviation services. Nauru's preference is for training to occur in-country where possible to maximise the degree of staff engagement.

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

NMHS is only eight years old and with a small, but growing staff cohort. The team actively work with external partners to build services for Nauru. However, the work is in its early stages, with little in the way of training, facilities, ICT infrastructure, observations or forecasting equipment to work with. There are no substantial research or development projects, although Nauru recently developed and launched an Early Action Rainfall Watch bulletin following in-country training and a stakeholder workshop with the Australian Bureau of Meteorology.

Summary score and recommendations for Element 1

As a fledging NMHS, NMHS is rated as Maturity Level 1, which is expressed as 'Weakly defined mandate; serious funding challenges; essential skills lacking; little formalized governance and future planning.' This is not intended as any reflection on the staff of

⁶ UNDP (Love, Mamaeva and Wilson), 2018, Feasibility Study for a Pacific Based WMO Regional Training Centre, 266 pp

NMHS, but on their situation in setting up a service and without most of the essential elements of NMHS operations.

Element 1: Governance and Institutional Setting		<i>Description: The level of formalization of the NMHS mandate and its implementation, oversight, and resourcing.</i>		
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.

To accelerate the development of NMHS’ capacity, long-term partnership arrangements are most likely to be effective, particularly with peer agencies in the region. Within this context, it will still be important to carefully consider the strategic vision for what a sustainable national meteorological service will look like in the Nauru context, and to ensure that legislation, facilities, staffing, training and equipment are well aligned with that vision. In this light, the development of standalone legislation and a specific strategic plan and operational implementation plan for meteorological services would likely be helpful.

Element 2: Effective partnerships to improve service delivery

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

NMHS has in-country partnerships within its parent agency (National Emergency Services) and with agriculture, fisheries, transport, utilities and health agencies. As a small country, NMHS has relatively easy access to other agencies.

However, as a recently established agency, these partnerships are relatively immature, and it is difficult to judge effectiveness. Some other partner agencies are still adjusting to the possibilities arising from the existence of NMHS and are beginning to engage. According to staff, the recent workshop for the Early Action Rainfall Watch was very helpful in this respect.

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 private and academic sectors in Nauru are limited, and there is little in the way of active private or academic partnerships.

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

Nauru benefits from the COSPPac program for climate services, as discussed in greater detail later in this report. Various other programs and entities have collaborated with Nauru, including the Australian Bureau of Meteorology, Papua New Guinea National Weather Service, Fiji Meteorological Service, and the Japan International Cooperation Agency. Nauru is involved in the Climate Risk and Early Warning Systems (CREWS) 2.0 Small Island Developing States project and the Climate Services and Related Application Programme (ClimSA).

Of the UN agencies, only UNDP has an office in-country, which can make cooperation at this level more challenging. On the other hand, the compact nature and small population of Nauru means that, if external relationships are well coordinated (including efforts by external partners to coordinate and collaborate), this is strong potential to achieve positive outcomes.

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.

As noted, an Early Action Rainfall Watch bulletin has recently been introduced. The other partnerships noted have also been helpful in developing the daily weather bulletin that is issued.

Summary score, recommendations, and comments for Element 2

Nauru is assessed as **Level 2** for the CHD. This is defined in the CHD template as 'Limited partnerships and mostly excluded from relevant finance opportunities', however the description is not fully reflective of NMHS' situation, given that the NMHS has only been recently established.

Element-2: Effective partnerships to improve service delivery		<i>Description: The level of effectiveness of the NMHSs in bringing together national and international partners to improve the service offering.</i>		
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.

The next higher level of the CHD maturity scheme for this element is defined as 'Level three: Moderately effective partnerships but generally regarded as the weaker partner in such relationships, having little say in relevant financing initiatives.' It is not felt appropriate to assign Level 3 at this stage due to the relative immaturity of the relevant partnerships and lack of evidence of sustained outcomes.

The trajectory for Nauru in this area is strongly positive. In order to keep improving the CHD maturity level for this element, it will be useful to continue to prioritise internal and external engagement, whilst noting the relatively limited staff numbers and the ongoing importance of coordination amongst external partners (as any uncoordinated partnerships risk placing an unsustainable workload on the beneficiary country).

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.

Nauru has been working to build up to GBON compliance. A 2019 press release noted that new equipment had been provided from the Secretariat of the Pacific Regional Environment Programme (SPREP) through the Finnish-Pacific Project (FINPAC) to help vulnerable island communities build resilience through enhanced Met services. It was announced that since December 2018, Nauru was providing information hourly to aviation.

Currently, Nauru has one partially compliant weather station, which is situated at the airport. This staffed station has a complement of manually read monitoring equipment, including temperature probes in Stevenson Screen (recording and displaying wet bulb, dry bulb, max, min); barometer; rain gauge and anemometer. There are currently 8 observing staff at the airport which enable this station to operate 24 hours a day with a target of hourly observations. Due to siting and maintenance challenges, some of the instruments provide unreliable data, requiring the observers to estimate or omit parameters. From these instruments, NMHS prepares aviation-format METAR and SPECI messages, which are transmitted via email to key contacts, including to Fiji and Papua New Guinea NMHSs. These messages can then be retrieved through aviation databases.

Unfortunately, the aviation messages are not currently forwarded into the WMO Integrated Global Observing Network (WIGOS), meaning that Nauru is 'invisible' to numerical models, and also not GBON-compliant. This situation could be improved through setting up automatic switching of observations, and further improved by Nauru issuing hourly synoptic observations directly in addition to the aviation format messages.

An automatic weather station is currently in storage awaiting installation 'Topside', having been obtained through an aid program in 2021. Nauru does not have the expertise or resources to install the station, and so requires assistance.

There is no operational upper air station, following the cessation of high-quality observations from the US Atmospheric Radiation Measurement program operations in September 2013⁷. Nauru would be willing to host an upper air station, although would require assistance in training and maintenance as well as operational costs.

3.2. Additional observations used for nowcasting and specialized purposes.

Nauru hosts one tide gauge, maintained by Australia, which is not currently operational due to relocation works at the port. It is expected that the relocation works would be complete by 2024. The Tropical Atmosphere Ocean (TAO) moored buoy network, supported by the USA and Japan, provides a supplementary source of data for NWP and has a presence in the west of the Nauru EEZ.

⁷ An account of the upper air site history at Nauru can be found at <https://www.arm.gov/news/facility/post/23404>. The article notes that the 15-year operation of a technologically advanced upper air research station at Nauru, together with a similar site at Manus Island in Papua New Guinea, demonstrates that such site operations are possible even with limited local infrastructure, given sufficient external support. The site was serviced by an Australian Bureau of Meteorology team based in Darwin, Australia.

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

NMHS has limited expertise in deployment, maintenance, calibration and quality assurance, but has recently recruited staff who are available for training. No observations logbooks have been maintained since 2019, making it difficult to establish a quality assurance chain. A daily list of basic observations is kept in a spreadsheet in the office.

3.4 Implementation of sustainable newer approaches to observations.

A sustainable approach to observations in Nauru would likely consist of a mixture of manual instruments, that can be manually read and maintained, and automated, high quality instruments that are regularly serviced by third parties, and with some local spare parts available for first-in troubleshooting. A highly automated network in Nauru would increase Nauru’s dependence on international parties for maintenance, so it is recommended that some manual instrumentation be maintained.

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

No automatic observations are being taken at this stage, other than from a non-compliant automatic weather station situated on top of the NMHS roof. Discussions are underway regarding the potential for an aviation-quality Automated Weather Observing System (AWOS) station to be installed at the airport, and (as noted earlier) the deployment of an already-purchased automatic weather station ‘topside’ in the elevated interior.

Summary score, recommendations, and comments for Element 3

Nauru is rated as ‘**Maturity Level 1**’ for this Element, reflecting *No or limited, basic surface observations and no upper-air observations.*

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.

This rating is considered slightly more appropriate than Level Two, described as ‘*Basic network, large gaps, mostly manual observations with severe challenges and data quality issues*’, due to the combined effect of basic facilities and training, limited quality processes, lack of upper air station, and lack of procedures to transmit observations to the GTS. Once again, this reflects the early stage of operation of NMHS and a relative lack of capacity in Nauru.

Without quality observations that are being shared internationally in real time, any users requiring real-time observations will be limited in their use of NMHS’ services, and NMHS itself will only be able to receive generalised model guidance from NWP that cannot ‘see’ Nauru properly. It is recommended that a high priority be given to improving the observations situation, both for surface synoptic and upper-air observations, but with particular attention given to the long-term sustainability of any proposed solutions. One potential ‘quick win’ would be to reconfigure observations transmission of aviation METARS and SPECIs to also include the transmission of synoptic observations to the GTS.

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.

There are no internationally reporting stations in GBON terms, although surface observations are issued in METAR and SPECI format for aviation purposes. These observations are received in Fiji (a regional centre) and from there are made available to aviation users. The observations are also received regularly in Port Moresby, Papua New Guinea, for Papua New Guinea National Weather Service forecasters to use when preparing the Terminal Aerodrome Forecast for Nauru (this was verified in person in Port Moresby by the review team).

There is no upper air station at present.

Because surface and upper air observations are not currently received on the WMO Global Telecommunication System (GTS), the percentage of GBON compliance is currently rated as zero. However, this could be relatively easily improved through a change in communications practices.

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

Nauru has intent to share data internationally, consistent with WMO principles, and demonstrates this through the email sharing of observations in aviation format. There are no formal policies to implement this intent currently for observations being transmitted to the GTS.

NMHS has access to a cloud version of the Climate Data for the Environment (CliDE) database. CliDE was developed by the Australian Bureau of Meteorology under the International Climate Change Adaptation Initiative. It provides data entry, storage, basic visualisation and extraction tools for weather and climate data. It can process data in near-real-time.

The NMHS version was hosted on a NMHS server at their Yaran head office, but this is no longer functional. The cloud version of CliDE for Nauru is functional and accessible from their office. Data from the staffed station is currently not entered by NMHS staff into CliDE from the METAR messages recorded by observers, and SYNOP messages are not currently being recorded.

Observations taken in Nauru are not generally available to the public.

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

NMHS use the NZ MetConnect website to gain broad scale modelling and severe weather guidance, alongside the free 'Windy' site, which is used extensively as the main forecasting tool. Nauru is also able to access observations from the local tide gauge.

Summary score, recommendations, and comments for Element 4

Nauru is assessed as **Maturity Level Two** 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.*'

Element 4: Data and Product Sharing and Policies		<i>Description: The level of data and product sharing on a national, regional and global level.</i>		
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

This rating could be quickly improved through sharing hourly synoptic observations in addition to the aviation observations, supported by standard procedures and processes.

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.

Nauru can access broad scale products through the NZ MetConnect and 'Windy' websites. Fiji Meteorological Service also produces a broad scale forecast for Nauru (Figure 4). However, these products are all limited in their specificity for Nauru, with the limited availability of international observations being a contributing factor. The forecast guidance from Fiji, for example, does not contain forecast temperatures. While interfaces such as 'Windy' can give quantitative guidance, they are not dynamically calibrated against observations.

Nauru would also benefit from the installation of a standalone 'HimawariCast' system (operated by Japan), which would provide an independent method for accessing geostationary satellite data and numerical modelling data in the event of an Internet failure. HimawariCast systems operate successfully in many small meteorological services in the region.

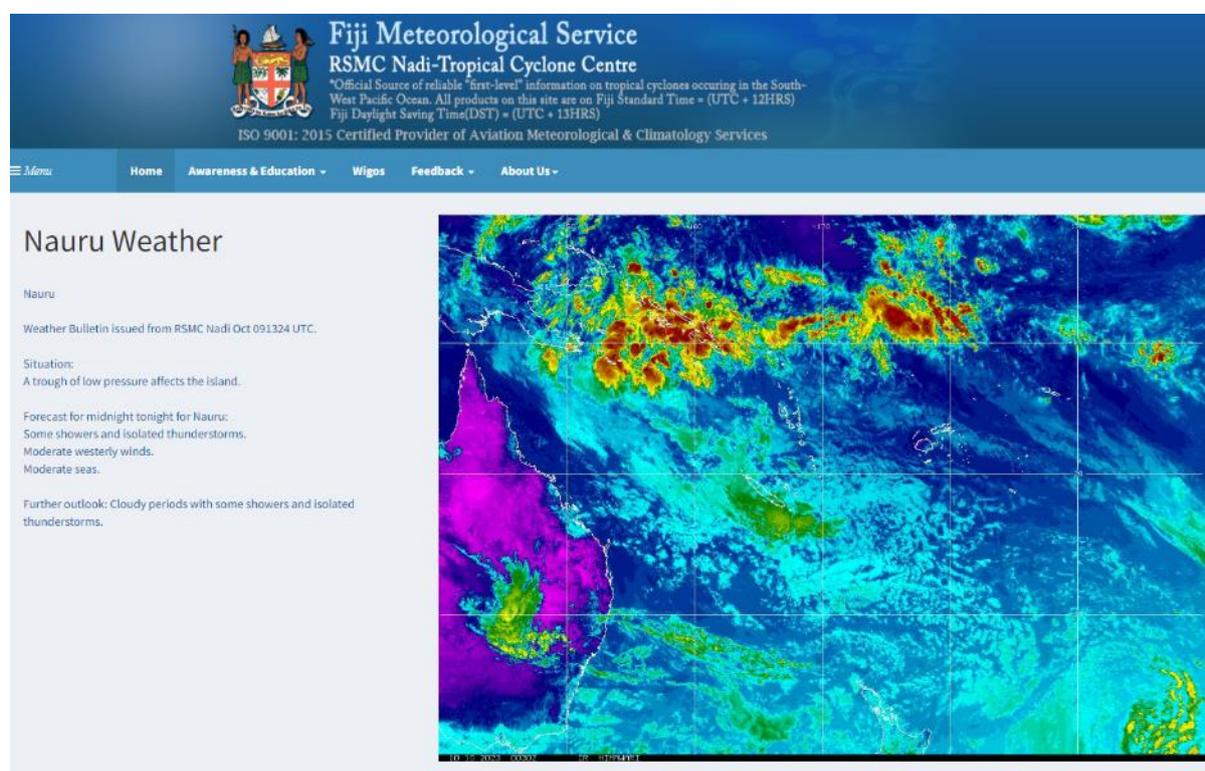


Figure 4 Example forecast for Nauru provided by Fiji Meteorological Service.

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

Nauru does not have capacity to run models sustainably, in terms of ICT infrastructure, training, or scientific expertise. The use of a multi-model display tool such as 'Windy' is appropriate for the level of technology and training available to Nauru. Transmission of surface synoptic observations and upper-air observations would assist model accuracy for Nauru and the surrounding area.

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

Broad scale probabilistic forecasts form part of the seasonal forecasting support provided through COSPPac, although again with the limitation of the lack of local observations.

Summary score, recommendations, and comments for Element 5

Nauru is assessed as **Level 2**, 'Basic use of external model output and remote sensed products in the form of maps and figures, covering only a limited forecast time range.'

Element 5: Numerical Weather Prediction Model and Forecasting Tool Application		<i>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 (GDPPFS) centres.</i>		
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.

This is an area that can steadily be improved as the capacity of NMHS staff to use numerical prediction forecast grows, and as observations flow externally to help improve model specificity and skill.

As noted above, Nauru does have any source of numerical weather prediction or satellite data that is independent of Internet functionality, and it may be useful to install a satellite-based system such as the Japanese 'HimawariCast' system to provide improved resilience for receipt of basic guidance.

Element 6: Warning and advisory services

6.1. Warning and alert service cover 24/7.

NMHS has observer staffing to cover 24/7 services, but has only two forecasters at this stage, neither of whom have had formal forecasting training. Out of hours support during a warning situation can be provided by off-duty staff, as well as the Director and the Departmental Secretary, who has authority for warning issuance through the island-wide text message network.

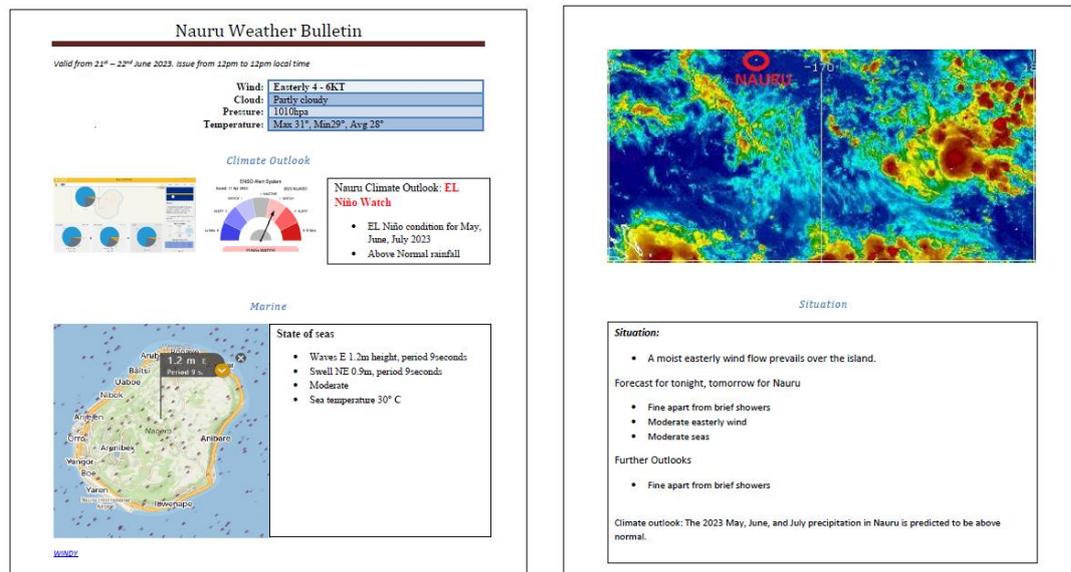


Figure 5 - Example Daily Nauru Weather Bulletin, the principal daily product of the NMHS, issued by email. Courtesy NMHS

The main daily product of the NMHS is the Nauru Weather Bulletin (Figure 5), which contains a summary of current conditions, the climate outlook, and the weather outlook. It is distributed by email to key users.

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

NMHS is in its initial stages of establishing a multi-hazard early warning capacity.

The 2022 UNDRR assessment noted that '*Communication infrastructure used for early (tsunami) warnings is old. The service does not include warnings for other hazards such as early onsets of droughts, fires and storms.*'

The assessment also recommended that '*More attention is required for further development of key components of early warning systems, namely risk knowledge (risk informed early warning systems), monitoring (hydrological monitoring systems), forecasting and warning and cross-cutting theme of governance (risk informed policies and plans, financing and sustainability).* It is recommended to introduce an impact-based forecast and warning system for all natural hazards, which would evolve the focus from information about the hazard to information about the impact of the hazard. This would help the public to understand what actions to take to reduce the risk to lives and livelihoods.

Also, the flash flood monitoring and forecasting systems needs to be improved, which requires the implementation of hydrological observing network and the addition of new

technologies, including weather radar (i.e., Doppler). Promoting usage of advanced models to improve climate adaptation adoption and service delivery is also needed.'

Since that assessment, Nauru has progressed further in its journey to implement services. As discussed under climate services, an early action rainfall watch bulletin has been introduced. Threshold criteria have been drafted for wind, intense rainfall, and wave warnings, and forecasters have begun trialling these criteria, using model output displayed using the 'Windy' interface. A flash-flood event occurred in early October, just prior to the visit from the report team, resulting in flooding at the hospital and at the power utility. Staff noted that broad scale guidance through the WMO Severe Weather Forecasting Program had not captured this specific possibility, which could be studied further in a case study (the Severe Weather Forecasting Program includes a system of country contributed case studies around severe weather events, to help participants and supporting agencies continuously improving the system).

Nauru's small population and compact physical environment means that, once greater capability is established, warning services may progress relatively quickly.

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.

Common alerting procedures are not yet in place. Training on this capability was expected at time of writing to occur in Fiji later in 2023, with two officers from Nauru planning to attend.

Summary score, recommendations, and comments for Element 6

Nauru is assessed as **Level 2**, '*Basic warning service is in place and operational but with limited public reach and lacking integration with other relevant institutions and services.*'

Element 6: Warning and Advisory Services		<i>Description: NMHS' role as the authoritative voice for weather-related warnings and its operational relationship with disaster and water management structures.</i>		
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.

This assessment can be improved by continuing to develop impact-based warning thresholds, working with the parent Department and other stakeholders and implementing standard operating procedures in support of these thresholds, continuing to recruit and train forecasting staff, and introducing Common Alerting Protocol based warnings for automated transmission through mobile networks and social media, in combination with appropriate media strategies. This is a journey of incremental improvement and it is pleasing to see that threshold criteria are already being trialled based on model forecasts.

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 core data points, in alignment with the WMO Checklist for Climate Services Implementation⁸.

Climate Services Governance

The climate service section of the NMHS was only established in 2021, meaning that services are in their initial stages of development. Climate services are provided by the two forecasters.

Nauru's national governance for climate services is quite basic, considering that there is no defining legislation, few staff, no website, and limited services available. The climate record is held in a set of spreadsheets that capture historical data and does not appear to be held in any internationally available database. Nauru's capacity is ranked as 'Less than Basic' in this area.

Basic systems

For the reasons discussed in previous sections, the overall climate observing network, data management, monitoring and forecasting systems for Nauru's climate services are assessed as 'Less than Basic'.

User Interface

With no website or another mechanism for users to interact with data, but with evidence of recent user engagement, Nauru's user interface is ranked as 'Basic'.

Provision and application of Climate Services

Through the support of COSPPac and others, the NMHS can provide basic services. As mentioned earlier, in June 2023, the first major training activity for staff and stakeholders was held in Nauru, supported by COSPPac. The training focused on the provision of long-term rainfall outlooks, noting the relative skill of seasonal forecasting models for the region based on sea-surface temperature patterns, and the importance of La Niña and El Niño in that process. Shortly after the training, the NMHS issued the first Early Action Rainfall Watch (Figure 6), giving a clear El Niño-related outlook, with sector specific information. For this reason, Nauru is ranked as 'Essential' (i.e. higher than 'Basic') in this area.

Monitoring and evaluation of the socio-economic benefits

There is no monitoring of the socio-economic benefits of climate services for Nauru, and accordingly Nauru is ranked as 'Less than Basic' in this area.

Capacity Development

No formal capacity development of other agencies is performed by NMHS, although the recent workshop activities indicate potential for this to happen. Nauru is still rated as 'Less than Basic' in this area.

⁸ [https://etp.wmo.int/pluginfile.php/25832/mod_resource/content/1/Checklist for Climate Services Implementation.pdf](https://etp.wmo.int/pluginfile.php/25832/mod_resource/content/1/Checklist%20for%20Climate%20Services%20Implementation.pdf)



Nauru National Meteorological & Hydrological Service

Early Action Rainfall Watch

The Early Action Rainfall Watch provides sector managers with a brief summary of recent rainfall patterns, particularly drought and the rainfall outlook for the coming months.

Current El Niño-Southern Oscillation (ENSO) status: The ENSO Outlook is at El Niño ALERT. There is 70% chance that El Niño developing in 2023. Nauru usually experiences wetter than normal conditions during El Niño events.



Status summary:
On the past 3, 6 and 12 month time scale there has been **no extreme** weather conditions which means normal weather. However on the 1 month time scale Nauru experienced wetter than normal condition.

Outlook summary:
For July there is a very high chance of very wet conditions for Nauru. Then on July to September there is still a very high chance of very wet conditions.

This in combination with the status conditions suggest that the chance of wetter than normal condition in Nauru is improving.

Impacts
After the specified period of below or above average rainfall, the following primary agricultural and hydrological variables and secondary socio-economic and health variables may be impacted. Note the periods are estimates only. Allow for uncertainty associated with island size, topography, geology and soil type. Contact the relevant sector offices for further information on impacts.

Very Dry to Seriously Dry conditions				
Sector	1-month period most relevant for	3-month period most relevant for	6-month period most relevant for	12-month period most relevant for
Water	Small water tanks (5000ml), small creeks and streams (if present) Increased water demand	Small wells, small streams (if present) Desal plant unable to meet water demand	Boreholes, deeper wells, large water tanks	Large water sources (e.g. rivers, artesian wells if present) Groundwater depletion?
Agriculture and Food Security	Shallow rooted crops (e.g., chillies, cherry tomatoes, and eggplants)	Deeper rooted crops (e.g., bananas and guavas)	Small trees (including fruit trees e.g., breadfruit, pawpaw, sugarcane)	Large trees (including fruit trees e.g. coconut, and breadfruit), Lime trees, Native trees, Soil quality.
Health		Diarhoea outbreak asthma, skin rash	Diarhoea outbreak asthma, skin rash	Heat stroke, dehydration and conjunctivitis.

Very Wet conditions				
Sector	1-month period most relevant for	3-month period most relevant for	6-month period most relevant for	12-month period most relevant for
Fisheries			Reduced tuna catches	
Socio-economic			School closure	Increase household expenses on food
Agriculture and Food Security	Reduced mangoes	Increased pig diseases due to poor shelter Soil quality (if shading nets poorly located)	Soil erosion Pandanus root rotting	
Health	Increased incidences of dengue, gout	Increased incidences of dengue, flu, pneumonia, gout	Increased incidences of dengue, flu, pneumonia, gout	Increased incidences of dengue, flu, pneumonia, gout
Fisheries	Increased tuna catches			
Socio-economic	Frequent road flooding Roof leaking Disrupts communication (increased cloud coverage) Wet laundry Mental health (stuck indoors)	Frequent flooding Disrupts phosphate mining Frequent electricity outage (solar) Increases and frequent shipping and flight delays (affects food supplies) School closures due to leaking roofs Mental health (stuck indoors)	Frequent flooding Disrupts phosphate mining Frequent electricity outage (solar) Increases and frequent shipping and flight delays (affects food supplies) School closures due to leaking roofs Mental health (stuck indoors)	Frequent flooding Disrupts phosphate mining Frequent electricity outage (solar) Increases and frequent shipping and flight delays (affects food supplies) School closures due to leaking roofs Mental health (stuck indoors)

Figure 6 - Extracts from July 2023 Early Action Rainfall Watch, a new product issued after stakeholder consultations during 2023.

Summary score, recommendations, and comments for Element 7

Nauru is assessed as **'Level two: Basic Capacity for Climate Services Provision'** overall for this area, with weight given to the recent product introduction and user consultations.

Element 7: Contribution to Climate Services		Description: NMHS role in and contribution to a national climate framework according to the established climate services provision		
Not Applicable: Climate Services provided by another party	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
Level one: Less than basic Capacity to provide Climate				

The prompt development and issuance of the Early Action Rainfall Watch following stakeholder engagement in June 2023, with the assistance of the COSPPac program, shows that Nauru has strong potential to continue to develop services with external support.

This assessed rating can be improved over time by further recruitment of climate staff, modernisation and publication of the climate database, including on a website, further engagement with other agencies and other key users, and further product development.

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.

NMHS is unable to provide quantitative precipitation estimation and forecasts at this stage, except as direct model output. The main users would be in terms of flash flooding warning needs and future rainfall assessment. There are no rivers in Nauru, and so there are no requirements related to riverine flooding.

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

NMHS has a single hydrologist position, although to date the officer has been deployed assisting with tide gauge 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.

No formal data sharing agreements exist, although there is not a strong context for doing so.

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

There are no joint projects underway.

Summary score, recommendations, and comments for Element 8

Nauru is assessed as **Maturity Level 2**, or 'Meteorological input in hydrology and water resource management happens on an ad hoc basis and or during times of disaster' for this element. This reflects that hydrological services are mostly around rainfall outlooks and flash flooding warning. Because Nauru does not have rivers, hydrological services are not as high a priority as some other functions.

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.

One obvious deficiency in terms of flash flood assessment is that NMHS appears to have no real-time automatic rain gauges, meaning that rainfall rate observations cannot be taken. Although numerical models produce rainfall predictions, tropical rainfall intensity is notoriously difficult to forecast given its highly convective and spatially limited nature. Automated rain gauges reporting from key locations may help verify model predictions in real time and assess the severity of imminent flooding.

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?).

NMHS has no website and limited communications channels. It has no social media presence to speak of, although it is currently seeking permission to run an official Facebook page (as opposed to sharing information through a more general government page) to communicate with users more directly.

On the other hand, the small population is relatively easy to reach. It is particularly notable that Nauru has a national process to distribute Short Messaging Service (SMS) text messages to virtually the entire population if there is a strong need (for example, a tsunami).

9.2. Education and awareness initiatives in place.

No specific awareness or education initiatives are known. Sometimes the NMHS is visited by school groups. The office of the NMHS is small, and there is also no budget for education, or formal communications strategy.

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

90% of the population is indigenous, and a quarter of the population live below the poverty line. In this sense, the 'mainstream' Nauru population is to a degree disempowered, and this is the focus of the NMHS. Understanding of English is widespread, and this is the primary language for NMHS communications.

Summary score, recommendations, and comments for Element 9

Based on the information available, Nauru is rated as '**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.'

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.

This rating could be easily improved through developing a social media presence and supporting website. In terms of the various challenges that NMHS faces, this is a relatively straightforward one, as a stronger community presence can be established without much investment. The small size of the Nauru community should allow the NMHS to effectively reach the entire community through more diverse communication channels and the reinforcing effects of 'word of mouth'.

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.

There is no global platform, but user consultations have occurred, for example in June 2023 when a joint workshop was held with early rainfall warning product users (as discussed earlier). These consultations were well received, and staff commented in-country on the potential use of this approach in the future.

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

No user satisfaction surveys are conducted. Realistically, with a population of only 13,000, such surveys would not necessarily be a high priority if strong personal relationships and consultative relationships were in place.

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

No quality management processes are in place at this stage. It was noted that, in terms of observations, use of surface observations logbooks had been discontinued, making it more difficult to verify the quality of individual observations. Quality control procedures around the issue of warnings and daily weather bulletins were not observed.

Summary score, recommendations, and comments for Element 10

Nauru was assessed as '**Level two: Service development draws on informal stakeholder input and feedback**' for this criterion. Further development of processes around all operational products is recommended, together with regular user consultation and proactive relationship building.

Element 10: Use and National Value of Products and Services			Description: Accommodation of public and private sector users and stakeholders in the service offering	
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.

As for the previous Element, there are some relatively straightforward ways for NMHS to improve this rating. Regular, scheduled user consultations would help drive relationships, visibility, and product improvement, in turn assisting with assessing the value of hydrometeorological services to the government and community. Quality control procedures can be strengthened with moderate levels of training and without introducing recent technologies. These would be excellent long-term activities for the NMHS and partners.

Annex 1 Consultations (including experts and stakeholder consultations)

- Staff and Director of NMHS
- Secretary of Department
- Civil Aviation Authority

Annex 2 Urgent needs reported

NMHS has little in the way of facilities, training, or operational budget. These are all urgent needs, but 'quick fix' solutions are not likely to be effective, and long-term partnership approaches are recommended as the preferred option.

Staff expressed training needs in the following areas:

- Information dissemination
- Standard Operating Procedures
- Communications
- Community outreach
- Early Warning Systems

It should be noted that while 'short-course' style training will be useful for NMHS, particularly when accessible by staff in-country, it will also be necessary to support longer-term graduate training in these fields, as meteorology is a highly specialised area.

In terms of facilities, as noted in the text of the report, land has been set aside for the building of a new headquarters for Nauru Emergency Services, including the NMHS, and this would be of great benefit for emergency management, and weather and climate forecasting in Nauru. A short-term action could be to explore this further, given the large investment of time in seeking and obtaining consent from landholders for use of the site for that purpose.

An additional short-term action could be to explore how aviation-format METAR and SPECI observations can be switched through to the GTS, so that Nauru's basic data is received in global modelling systems.

Lastly, approval for an external website and social media pages could be a timely way of allowing the enhancement of communications, given the presence of an ICT manager and staff who are able to provide content.

Annex 3 Information supplied through WMO

- WMO Monitoring System Data
- Data from Checklist for Climate Services Implementation

Annex 4 List of materials used

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