COUNTRY HYDROMET DIAGNOSTICS

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

November 2024

Trinidad and Tobago Peer Review Report

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IDB Inter-American Development Bank

Alliance for Hydromet Development

TTMS TRINIDAD AND TOBAGO METEOROLOGICAL SERVICE

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

WORLD METEOROLOGICAL ORGANIZATION

SOFF Systematic Observations Financing Facility

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The findings, interpretations and conclusions expressed are those of the named authors alone and do not necessarily reflect those of the agencies involved.

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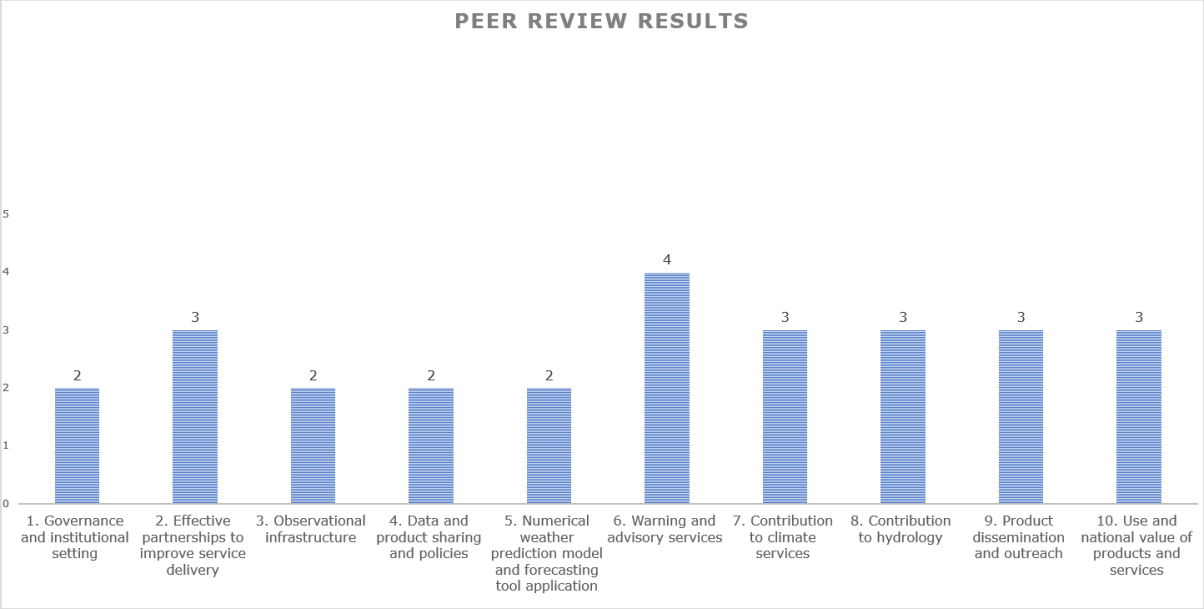
Abbreviations

AWS	Automatic Weather Station
CAP	Common Alerting Protocol
CARICOF	Caribbean Climate Outlook Forum
CARICOM	Caribbean Community
CAST	Central Administrative Services
CCCCC	Caribbean Community Climate Change Centre
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CHUAS	Cooperative Hurricane Upper Air Stations
CIMH	Caribbean Institute of Meteorology and Hydrology
CMO	Caribbean Meteorological Organization
CREWS	Climate Risk Early Warning System
EMA	Environmental Management Authority
FMI	Finnish Meteorological Institute
GBON	Global Basic Observation Network
ICAO	International Civil Aviation Organization
ICT	Information and Communication Technologies
IDB	Inter-American Development Bank
NAP	National Adaptation Plan
NCOF	National Climate Outlook Forum
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
ODPM	Office of Disaster Preparedness and Management
QMS	Quality Management System
SIDS	Small Island Developing State
SOFF	Systematic Observations Financing Facility
TTMS	Trinidad and Tobago Meteorological Service
UCAR	University Corporation for Atmospheric Research
WMO	World Meteorological Organization
WASA	Water and Sewerage Authority
WRA	Water Resources Agency

Executive Summary



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

The TTMS is successfully operating the national weather and climate observation networks and providing forecasting and warning services for the public and a large group of public and private stakeholders. Over the years, the TTMS has made investments in needed infrastructure, tested out new technologies and tools, and continuously strives to improve the capacity of its staff. To support TTMS's development, some key improvements in its operating environment and remaining capacity gaps need to be made.

The following critical gaps have been identified:

- **Legislation:** Currently there is no Hydrometeorological legal framework, act or regulation in Trinidad and Tobago. A draft meteorological bill has been developed and it is recommended to pursue the ratification of the bill. Including cost-recovery mechanisms in the framework is recommended to improve the long-term financial sustainability of the TTMS. A socio-economic benefit analysis is recommended to

be conducted to provide support and visibility for the urgency of establishing the required legislation.

- **Budget:** The annual budget needs to be increased to include investments in additional staff for critical positions, needed spare parts, sensor replacements and calibration services. Establishing cost-recovery mechanisms will improve the financial sustainability and encourage the TTMS to develop new services.
- **Cooperation:** As there are two meteorological services: Trinidad Meteorological Service Division and Tobago Meteorological Service Department that are governed by different Ministries, there is a risk of communication breakdowns and differences in strategical weighing of the services. Due to such risks, it is recommended to improve the cooperation between the services. It is also recommended to formalize key partnerships, e.g. with Memorandums of Understanding (MoUs). Identified partnerships that would benefit from such formalization are the Water Resource Agency (WRA) and the Office of Disaster Preparedness and Management (ODPM).
- **Stakeholder engagement:** it is recommended to increase annual interaction with stakeholders and to engage them in the co-creation and tailoring of services.
- **Observation network:** The manual SYNOP stations are recommended to be automatized. Marine network is recommended to be improved, and the coverage increased. Additionally, there is no lightning detection network and ceilometers in the national network.
- **Data management:** It is recommended to upgrade the data management system and tools to support effective data and quality management utilizing automated quality control methods and to support modern data dissemination and metadata management. Data rescue efforts should be continued.
- **Maintenance:** It is recommended to update maintenance plans and draft lifecycle plans, increase spare part stock and the annual budget for maintenance work. It is recommended to support the regional calibration capabilities or to establish new service contracts to support a healthy annual calibration cycle.
- **Staff capacities:** Human capacities in data management, ICT skills, data quality control and assurance, quality management and metadata management are recommended to be strengthened and more staff trained in the fields. Additional staff to support climate services is recommended.
- **Forecasting:** it is recommended to upgrade the forecasting and visualization software to a solution that supports full utilization of available gridded NWP data and observation data with tools to support automatic dissemination of tailored services and products. The selected solution is recommended to be an open-source code and license free solution to improve the financial viability and to enable independent maintenance of the system. The TTMS is recommended to continue with the impact-based forecasting development and to initiate operational forecast verification processes.
- **QMS:** the TTMS is recommended to develop and expand the QMS processes to cover all essential services it provides.

Chapter 1: General information

Introduction

Trinidad and Tobago is a Small Island Developing State and vulnerable to extreme weather events and the adverse effects of climate change. Due to its location, tropical cyclones rarely make direct contact with the country making them a low-probability, high-impact hazards. More frequent meteorological hazards are flooding, lightening, landslides, tides, fires and high wind events. Hazards related to excessive rainfall such as landslides, riverine flooding and flash floods, are especially frequent and difficult to mitigate damages. Conversely, low-rainfall hazards cause drought periods. Such periods are expected to increase in frequency as the average precipitation has reduces significantly during the recent decades. Threatening climate change impacts are increases in temperature, changes in precipitation, sea level rise, changes in rainfall patterns, inland and coastal flooding, stronger hurricanes and loss of coastal ecosystems. Climate threats are especially pronounced in the country's coastal zone that captures 70% of the population and 81% of all economic activity.

The Trinidad and Tobago Meteorological Service (TTMS) is responsible for the provision of weather and climate forecasts, services and warnings for the country. The TTMS services are widely used by national stakeholders, both public and private, as well as and the citizens. The TTMS's vision is to improve the quality and expand the variety of services they provide to advance the science of meteorology and to provide meteorological information and advice consistent with international standards towards the pursuit of national, scientific, social, economic and cultural goals and support sustainable development.

The TTMS has been systematically improving its capabilities with investments to necessary infrastructure, new technologies and improving the human capacity to provide services for a wide user base including public and private stakeholders. The TTMS development activities have been guided by the 10-year Development Strategy and national and regional projects and collaborations.

Adapting to climate change and mitigating its negative impacts is a national priority that has been highlighted in the National Adaptation Plan, the National Development Strategy, the National Climate Change Policy, the Carbon Reduction Strategy, the Nationally Determined Contribution to the Paris Agreement and the Long-term Strategy for Low Emissions Development. In all of these efforts the role of the TTMS is critical in providing national climate data and forecasts and actively participating in the national discussions and planning as well as educating both stakeholders and the citizens.

CHD methodology

The Country Hydromet Diagnostics (CHD) work was done as a Readiness output for the Systematic Observations Financing Facility (SOFF) project in Trinidad and Tobago and was preceded by preparation of the National GBON Gap Analysis and Contribution Plan.

During the SOFF project's Readiness Phase the following activities were organized:

- Remote workshop for the kick-off for the SOFF work.
- A fact-finding mission to Trinidad and Tobago focusing on discussing the observation network status, gaps and plans, including a trip to survey the GBON surface weather station in Port of Spain. The mission focused on the information required for the Gap Analysis report and the National Contribution Plan document.

- A mission focusing on the Country Hydromet Diagnostics. Workshop with the TTMS to assess and evaluate all line-items on the CHD template. A half day key stakeholder engagement to collect input from the users. Invitees included representatives from the following agencies and institutes:
    - Ministry of Public Utilities
    - Water Resources Agency
    - Water and Sewerage Authority
    - Trinidad and Tobago Electricity Commission
    - Environmental Management Authority
    - Institute of Marine Affairs
    - Ministry of Planning – Environment Policy Planning Division
    - Caribbean Meteorological Organization
    - Officer of Disaster Preparedness and Management
    - Ministry of Education
    - Ministry of Tourism
    - Ministry of Rural Development and Local Government
    - Ministry of Works and Transport – Drainage Division
    - Ministry of Energy
    - Ministry of Health
    - Trinidad and Tobago Civil Aviation Authority
    - Airport Authority of Trinidad and Tobago
    - Caribbean Airlines
    - Port Authority of Trinidad and Tobago
    - Ministry of Agriculture
    - Agricultural Society of Trinidad and Tobago
    - University of West Indies
    - Fishing Association
    - Caribbean Gas Chemical Limited
    - EcoEngineering
    - Atlantic LNG
    - CNC 3
    - CCN TV6
    - TEMA
- Consultation with the US National Oceanic and Atmospheric Administration National Weather Service Office of Observations regarding the Cooperative Hurricane Upper Air Stations program.
- Two visits to the Caribbean Meteorological and Hydrological Institute (CIMH) to discuss regional network support and plans and the capacity of the regional calibration centre.
- Consultation with the Caribbean Meteorological Organization on the regional collaboration aspects.
- Several remote meeting to prepare and comment on the findings and documents.

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 Trinidad and Tobago Meteorological Service (TTMS) traces its origins to the British Caribbean Meteorological Service. Following the country's independence, the Government of Trinidad and Tobago established the TTMS in 1963, formalizing its membership in the World Meteorological Organization (WMO) and aligning its responsibilities with WMO conventions. However, there is no specific legislation that defines the TTMS's mandate and responsibilities. Despite this lack of formal legal framework, the TTMS is widely recognized as the national authority responsible for weather, climate services, and warnings. The 1963 Cabinet note establishing the TTMS remains the primary legal document outlining its responsibilities.

In 2019, a committee was established to explore options for transforming the TTMS, resulting in a report advocating for official legal status. Due to Trinidad and Tobago's two-island structure, there are separate meteorological offices for Trinidad and Tobago, with each governed by different entities. The Trinidad Meteorological Office operates under the Ministry of Public Utilities, while the Tobago Meteorological Office is managed by the Central Administrative Services Tobago (CAST), which falls under the Office of the Prime Minister. The TTMS central office is located at Piarco International Airport and The Tobago Meteorological office at Crown Point.

A draft bill for the TTMS was developed based on a model provided by the Caribbean Meteorological Organization (CMO) and submitted for government review in 2009. However, due to subsequent changes in government, the bill did not advance. In 2013, the Cabinet approved a restructuring plan for the TTMS and authorized the revision and resubmission of the draft bill and policy for legislative review. The absence of specific national legislation for TTMS operations is a significant gap, and the formalization of its mandate remains a priority.

An inter-agency committee, including representatives from the Ministry of Public Utilities, CAST, and the CMO, is currently working on developing an appropriate legal framework to support TTMS operations. The findings and recommendations from this committee will be presented to the Permanent Secretary for Cabinet consideration (Source: Cabinet Minutes).

The TTMS also operates in alignment with various national regulations, including the Civil Aviation Authority Law, the Airports Authority Act, the Disaster Measures Act (covering hurricanes), the Water and Sewerage Authority Act (addressing water and flood management), and the Environmental Management Authority Act, as well as numerous national policies that address meteorological concerns.

The TTMS consists of the following units:

- Operational Meteorology Unit in charge of main synoptic and forecast office
- Administration Unit Rawinsonde Unit operating the upper air station
- Equipment Repair and Maintenance unit
- Applied Meteorology and Support Services Unit in charge of climatological and technical office unit
- Trinidad Weather Radar Station

The Tobago Meteorological Service Division consists of the following units:

- Meteorological Service Office in charge of observing stations and forecasting unit
- Tobago Weather Radar

Although the services are separated, there are daily briefings, hourly observation sharing and monthly reviews between them. Communication is done with a low threshold using telephone, face-to-face meetings, online meetings, email and instant messaging. The

communication between the services is as of now very good, but as they are governed by different Ministries there is a risk of communication lag or breakdown, different prioritizing and different weighing on the strategy.

The TTMS, while lacking a formal legislative mandate, effectively fulfills all responsibilities outlined in the WMO Convention for national meteorological services, including weather, climate, warnings, air quality, and hydrology. In addition to its core duties, the TTMS collaborates with other agencies on shared responsibilities, particularly in areas of risk mitigation:

- Tsunami warnings are jointly managed with the Office of Disaster Preparedness and Management (ODPM).
- Air quality monitoring is shared with the Environmental Management Authority (EMA); EMA handles monitoring, while TTMS provides forecasting.
- Water management and flood warnings are coordinated with the Water and Sewerage Authority, specifically its Water Resources Agency.
- Disaster risk reduction efforts are coordinated with the Disaster Management Authority.
- Climate action initiatives are coordinated with the Ministry of Planning and Development.

Responsibilities between the TTMS and the Tobago meteorological division are shared as the following:

- The Tobago service provides weather observation from the Crown Point Meteorological Observing Station directly in Tobago and shares these with the TTMS. The TTMS is in charge of international distribution for all observations from Trinidad and Tobago. The Tobago office also provides METARs and SPECIs but these are distributed via the TTMS.
- The Tobago office is only responsible for issuing the Tobago Tourism Forecast, all other weather forecasts, warnings and climate outlooks are issued by the TTMS.
- The TTMS is responsible for operating the main Forecast office for Trinidad and Tobago which includes responsibility for the Piarco Flight Information Region, upper- air station (part of the Cooperative Hurricane Upper Air Stations network).
- The Tobago office is part of the Tobago Disaster Management Committee and Aerodrome Safety and Security Tobago Committee meetings
- Tobago office conducts tours, participates in career days and other outreach activities for the Tobago community whilst the TTMS performs such duties for Trinidad community
- Tobago office supplies Tobago climate data to the TTMS. The TTMS climate section processes all climate requests and service provision.

The TTMS also contributes to the review of Environmental Impact Assessments (EIAs).

Although a Disaster Measures Act exists, there is currently no overarching legislation for a multi-hazard early warning system. Proposals for such a policy have been submitted but are not yet adopted. Work is underway as part of the Climate Risk Early Warning System (CREWS) initiative, and multi-hazard risk assessment guidance is available from the Caribbean Tourism Organization, an entity within the Caribbean Community (CARICOM).

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

The TTMS has a strategic development plan covering a 10-year period from 2015 to 2024. The plan is up-to-date and aligned with relevant national, regional and international plans. The TTMS plans to update the strategy within the CREWS2 project scope. The strategy identifies nine long-term strategic objectives as main priorities. Identified objectives are:

- Become a national and regional reference in weather forecasting, climate seasonal prediction and provision of climate services.
- Offer high quality products and services to assist the real needs of users and stakeholders, meeting WMO and ICAO standards.
- Enhance and operate meteorological observation systems according to TTMS needs.
- Develop and operate modern and appropriate infrastructure for storage, processing and dissemination of data, weather and climate products and services meeting current and future demands.
- Establishment of a proper building with adequate space for the various technical units some with common space for staff responsible for development of weather and climate services for stakeholders.
- Develop and keep a technical team well trained, encouraged and proactive.
- Strengthen the communication strategy to reach stakeholders and public effectively and get recognition of TTMS by society, public and private institutions.
- Promote development and consolidation of synergic partnerships with stakeholders at national level and with NMS and related institutions at international level.
- Consolidate TTMS as a dynamic, flexible and open institution oriented to results.

The strategy includes corresponding actions for each objective, indicators, targets, and an implementation plan for the activities.

The Ministry of Public Utilities has approved TTMS's strategy and reviews the annual implementation reports during budget negotiations.

The TTMS is mentioned in the 2023 National Adaptation Plan for the Republic of Trinidad and Tobago[1]. The plan outlines the following climate risk management responsibilities for the TTMS:

- Continuous monitoring and sharing of robust, high-quality climate data.
- Climate change research and projections for climate variability.
- Develop, produce, and disseminate climate risk products to each sector.
- Undertake education and awareness campaigns on climate change hazards and risks.
- Provide climate data, projections, and modelling to the Knowledge Management System.

Risk matrixes are currently under development as part of ongoing Quality Management System (QMS) development.

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

[1] National Adaptation Plan for the Republic of Trinidad and Tobago, 2023

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

The TTMS total annual budget estimate for 2024 is around 34.5 million TTS$. The main budget items have been laid out in the table below.

Table 1 Budget breakdown for TTMS budget in 2023 and 2024.

Item	2023 revised estimate	2024 estimate
Construction of a new building for the Meteorological Service division	10 000 000	5 000 000
IT upgrade	-	1 000 000
GOES receiver procurement	-	2 000 000
Weather radar tower refurbishment	1 800 000	-
S-band weather radar procurement	1 300 000	-
Personnel expenditure	5 633 790	6 027 000
Goods and services	8 441 600	13 704 000
Minor equipment purchases	1 275 000	775 000
CMO membership	1 129 000	1 129 000
CIMH membership	9 192 276	4 624 000
WMO membership	436 800	212 000
Total:	**29 208 466**	**34 471 000**

The current budget covers the costs of constructing of a new building for the Meteorological Service division, which is a very costly investment that is only done once. The TTMS has been successful in receiving investment budget for a weather radar (during 2023) and GOES satellite receiver (for 2024). These high-price items are a rare addition to the annual budget that typically consists of mainly personnel expenditure and expenditure to goods and services. Overall, the budget has little room for new sensor replacements or investments in spares. The budget trend has been slightly decreasing in the past years, although there is year-by-year variation based on the investments.

The TTMS's annual budget is received from the Government. Project-based funding is not directly contributing to the TTMS's budget, instead it is typically received in the form of equipment and training.

To enhance the financial sustainability of the TTMS, it is recommended to increase its national recognition and dedicated funding. To that effect, conducting a socio-economic benefit analysis would provide valuable evidence and justification to the Government to support such an increase.

The TTMS is providing some of its services to the private sector for a fee, but these are collected to the consolidated fund in the Ministry and are not reflected in the TTMS's annual budget as revenue. To improve the financial sustainability and flexibility of the TTMS and to provide incentives for more customer-focused service creation, it is recommended to establish cost-recovery mechanisms that bring revenue directly to the TTMS budget. This is recommended to be included in the meteorological bill. Since the TTMS already has experience of providing cost-based services of tailored products for the private sector, mainly the oil and gas industry, and based on their stakeholder interactions, it would be a logical step for the TTMS to expand its service portfolio if the mechanisms allow. Although the commercialization of the services is still in the incubation stage, the TTMS has estimated the potential amount of revenue they could recover from services provided to to the aircrafts traversing the Piarco Flight Information Region.

Such a cost-recovery policy would be in line with World Meteorological Organization (WMO) and International Civil Aviation Organization (ICAO) guidelines and recommendations. The sum has been estimated to approximately TT$13,000,000,recoverable from the Trinidad and Tobago Civil Aviation Authority. Funds are also potentially recoverable from the Airports Authority of Trinidad and Tobago but have not been assessed accordingly. The Public Management Consulting Division, Ministry of Public Administration, is of the view that the TTMS has the capability to become a revenue generating entity and consideration should be given to developing and implementing the necessary legislation to promote it as the meteorological authority of Trinidad and Tobago.

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.

The total number of staff in the TTMS in the meteorological office in Trinidad is 52, approximately half of the staff is working as permanently employed and half as contract workers. The Tobago meteorological office has 10 meteorological staff and 7 staff in administrative and supporting positions.

The male to female ratio in the TTMS staff 3:4.

Table 2 Number of staff and established positions in TTMS.

Staff position	Established positions	Contract staff
Director	1	
Assistant Director	1	
Meteorologist IV	1	
System Admin	0	
Chief Climatologist	1	
Climatologist	1	
Meteorologist III	2	
Meteorologist II	3	4*
Meteorologist I	3	
Equipment Repairmen Supervisor	1	
Equipment Repairmen	3	2 **
Senior Meteorological Assistant	2	
Meteorological Assistant	7	10
Communication Manager	1	1
Web Specialist		1
ICT Technician		2
Database Administrator		1
GIS Specialist		1
Radar Compound Watchman		2
Sanitation Officer		1
Office Attendant	1	
Total:	27	25

Grand total:	52

** weather forecaster ** electrical engineer and technician*

The TTMS has a Competency Assessment framework in place (Manual WI 620-02, 2016/02/10) for the competency standards for Aeronautical Meteorological Personnel. And there is a training plan for the staff.

The overall training level of the staff is good overall, and many of the meteorologists have been studying in the University of West Indies and the Caribbean Institute for Meteorology and Hydrology's joint meteorological programs. As a member of the CIMH, the TTMS can utilize the offered training courses in specific topics e.g. system maintenance training. Additionally, several staff members have participated in internship programs with the Caribbean Catastrophe Risk Insurance Facility (CCRIF).Technical staff have attended meteorology-specific sensor maintenance and operation training courses for the different acquired technologies and systems, typically offered by the systems manufacturers.

Overall major gaps in the staff capacity are mostly related to ICT, data management, data processing, and programming skills. The field is very competitive, and recruiting for such positions is difficult. Other key shortcomings related to staff capacity is the concentration of key skills to only one person e.g. QMS knowledge, and the lack of staff for climate services. The TTMS is keen to expand their capability and portfolio to provide climatological services and products to answer to growing national needs, but will need more investments to the required positions to cover these new tasks.

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

The TTMS has extensive experience in both national and regional projects, many of which have involved a wide range of national stakeholders and focused on enhancing national processes and plans. Recent national projects include:

- Community Flood Early Warning System project, as part of the Global Environmental Facility CReW+ project, executed 2021-2023.
    - Project partners included the TTMS, WRA, Ministry of Rural Development & Local Government, Ministry of Works and Transport and Tobago Emergency Management Agency and implemented by Ministry of National Security – ODPM.
- Integrated Water Resources Management project, supported by local funding.
- Metrology to Meteorology, funded by BTB Germany.
- Development of a Dry Season and Drought Management Plan, led by WASA with local funding. Environmental Impact Assessment for ports, supported by local funding.
- National Disaster management project
- National Emergency Operational Centre
- Inter resilience project
- Climate index for Caribbean, funded by WMO.
- National Climate Reports (co-authors)
- Project with solar-parks

- Project with highways
- Projects with local schools, including monitoring and outreach initiatives.

Recent international projects further include:

- Funding from CCRIF to increase the coverage of automatic surface weather stations (non-GBON compliant stations). Project ongoing.
- Risk Platform for risk information exchange developed by UNDRR.
    - Project included developing risk mitigation methods and practices.
- CREWS Caribbean projects
- CHUAS cooperation with upper-air soundings with the UC NWS.
- CCCCC EU funded project for two automatic weather stations.
- National Adaptation Plan created with the support of Global Environment Facility and UNDP.

Summary score and recommendations for Element 1

The summary score for the element is 2 "Effort ongoing to formalize mandate, introduce improved governance, management processes and address resource challenges."

It is strongly recommended to establish a legal framework and status for the TTMS. It is **recommended to pursue the ratification of the developed meteorological bill** and to **include cost-recovery mechanisms in the framework** to ensure sustainability in the financing for the TTMS operation. To strengthen the annual budget allocated by the Government, it is **recommended to conduct a socio-economic benefit analysis** to provide strong proof and justification for increased national investments. The strengthening of the budget is needed to improve the capacity to **procure replacement and spare parts to the infrastructure and to expand the staff for the needed positions.** Staff shortage is most urgent in ICT, data management and processing skills and for climatological services.

Since the two meteorological services, Trinidad Meteorological Service Division and Tobago Meteorological Service Department, are governed by different Ministries, there is a risk of communication breakdowns and differences in strategical weighing of the services, due to such risks **it is recommended to improve the cooperation between the two services.**

Element 2: Effective partnerships to improve service delivery

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

The TTMS has very effective yet mostly unofficial partnerships with its key stakeholders.

Airport authorities are one of the key users of TTMS services as weather affects ground operations, flight control and the fuelling of planes. A Memorandums of Understanding in place with the Airports authority and there is a long history of mutually beneficial service delivery.

Other key stakeholders include the Water Resource Agency (WRA), Water and Sewerage Authority (WASA) and Office of Disaster Preparedness and Management (ODPM). The TTMS and WRA are sharing rainfall information from each other's network. The sharing is

done free of charge, but it is not done in real-time nor is there any guarantees on the data quality. The cooperation is not governed with any formal agreement.

Another example of close engagement with key governmental sectors is the daily weather brief done to ODPM, North Coast, Air Guard and Coast Guard.

ODPM[2] has the strategic disaster management coordination responsibility in Trinidad and Tobago. They lead the National Disaster Prevention and Preparedness Multi-sectoral Committee. As part of this committee, the TTMS works with fire brigades, civil aviation, agriculture/farmers, fisheries, electricity/energy sector, ODPM, Tourism, WRA, Water authority, airports authority, media, CMO, IMA, local government, health, ministry of works and transport, UWI, Ministry of Education. Key activities for the committee are to review and update the Multi-Hazard Early Warning Systems in Trinidad and Tobago, improve preparedness and response actions, improve public information and community outreach, mitigation planning and research.

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 TTMS is a member of the Caribbean Meteorological Organization (CMO). CMO has a critical role in leading the efforts of increased collaboration and synergy benefits in the region. CMO is a specialized agency of the Caribbean Community that coordinates the joint scientific and technical activities in weather, climate and water related sciences in the sixteen English-speaking Caribbean countries. As part of the CMO resolution 1[3], Trinidad and Tobago is responsible for the forecasts and warnings not only for the islands and coastal water of Trinidad and Tobago, but it also holds responsibility for tropical cyclone warnings for Grenada and its dependencies. The TTMS is also working as the backup for Barbados with respect to the islands and coastal waters of Barbados and St. Vincent and the Grenadines, and as secondary backup to Barbados with respect to Saint Lucia.

The TTMS is also a member in the Caribbean Institute of Meteorology and Hydrology (CIMH), that hosts the regional training and research centre assisting in improving and developing meteorological and hydrological services and enhancing awareness of the benefits of such services for the economic well-being of its Member States. CIMH is the main provider of technical operation and maintenance training, hosts the regional calibration laboratory, runs a regional numerical model, and hosts the Caribbean Climate Outlook Forum.

The TTMS is also part of the Cooperative Hurricane Upper Air Station (CHUAS) network program supported by the US National Oceanic and Atmospheric Administration (NOAA). The program's aim is to provide upper-air sounding data for hurricane forecasts from the most important regions in the hurricane tracks and formation area. The cooperation is longstanding and based on a Memorandum of Understanding signed in 1983.

The TTMS is working with the academic sector, mainly by providing weather and climate information for research, but also on an ad-hoc basis by participating in research. In 2020 a research paper was published through the regional EURECA research project. Follow-up for the study has been scheduled for 2024-2025. Besides providing information, the TTMS has an arrangement on internships with the CCRIF.

The TTMS has been working with the University Corporation for Atmospheric Research (UCAR) to manufacture and deploy a network of locally 3D-printed automatic weather

[2] ODPM website
[3] CMO resolution 1

stations. The collaboration's leading idea is to develop a concept for low-cost, easy-to-make stations to improve the coverage of stations.

The TTMS has no formal partnerships with the private sector but is producing specialized services including tailored products for private sector stakeholders, mainly in the oil and gas industry. Private sector entities have in very few cases participated in providing local observations, e.g. Brighton marine station shares wind data with the, although without the legitimacy of any formal agreements or contracts. Other than the few cases the private sector has not been keen on participating in providing observations or local services in Trinidad and Tobago, and the only players providing competitive services are large global actors such as Accuweather and the WeatherCompany.

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

The TTMS has benefited from several projects by international climate and development finance partners but does not have direct connections with the financing partners. The TTMS is mainly engaging in these projects via regional organizations e.g. CARICOM community, CMO and CIMH, or other implementing entities for the projects. Most support received through such collaboration is in the form of equipment or training. Successful partnerships have been with CCRIF, CCCCC utilizing EU funding and CREWS (see section 1.5).

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.

Most new innovative ways for products and services have stemmed from different projects and regional collaborations. The newest advancement being the use of Common Alerting Protocol (CAP) for warning dissemination, which was achieved in the CREWS project.

Summary score, recommendations, and comments for Element 2

The summary score for the element is 3 "Moderately effective partnerships but generally regarded as the weaker partner in such relationships, having little say in relevant financing initiatives".

The TTMS has very good, although mostly unofficial, connections to all its key stakeholders and the provided products and services are highly appreciated. **Formalizing the key partnerships with e.g. MoUs or agreements is recommended**. Identified partnerships that would benefit from such formal relationship are the Water Resource Agency (WRA) and the Office of Disaster Preparedness and Management (ODPM).

To improve engagement with the private sector stakeholders, it is **recommended to establish cost-recovery mechanisms for the TTMS to build proper customer relations and project portfolio**. Besides improving services for the private sector, the TTMS is recommended to **increase stakeholder engagement to improve the dialogue between different user groups, and to co-create and tailor services** to better fit the needs of the different users. To support both efforts the TTMS needs to **strengthen active portfolio and customer management by improving related human capacity.**

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.

Currently there is one upper-air sounding station in Trinidad and Tobago, which is adequate according to the WMO GBON density criteria. The station is located at the Rawinsonde Office in Piarco. The station is part of the Cooperative Hurricane Upper Air Stations (CHUAS) network and supported by the US NOAA. The cooperation provides the sounding equipment and consumables for the TTMS and the TTMS provides the facilities and manpower to operate the soundings. Typically, soundings are operated twice a day, but in case of approaching hurricanes the NWS may ask for additional soundings. Due to staff number limitations, the TTMS has had difficulties in the past to operate the soundings twice a day.

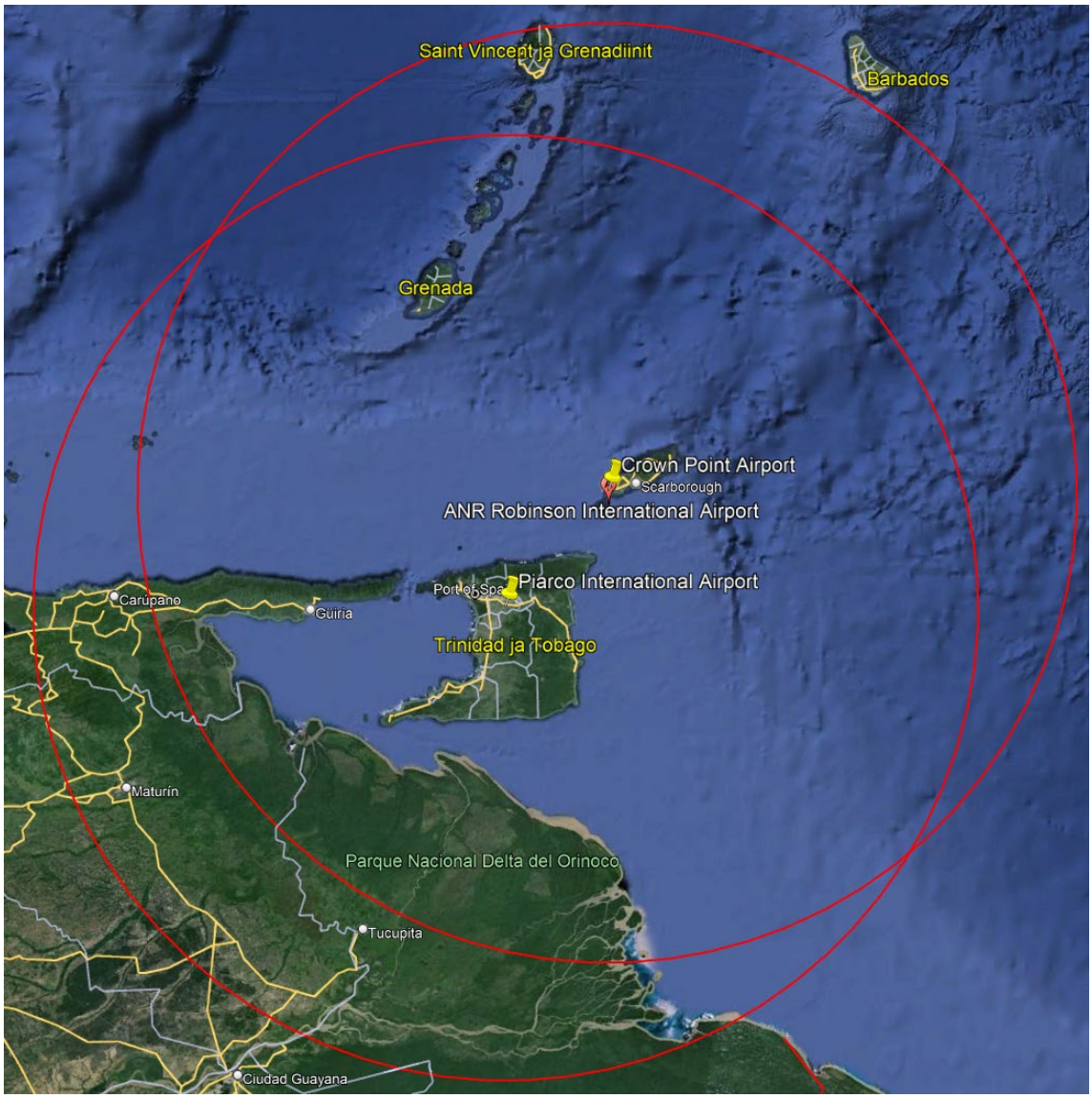


Figure 1 Map of GBON nominated surface and upper-air stations in Trinidad and Tobago. Circles indicated for the stations with 500km diameter.

Trinidad and Tobago has two manual SYNOP surface weather stations reporting observations hourly. Both stations are located in airports: Piarco International Airport and Crown Point Airport and are registered as GBON stations to the WDQMS GBON database. The distance between the stations is less than 100km, thus fulfilling the GBON requirements for the high-density networks and exceeding the required 200 km set for SIDS. Both stations are recommended to be updated to automatic stations with the SOFF project support.

Besides the SYNOP stations the TTMS is operating 24 automatic weather stations (AWS) in Trinidad and 10 in Tobago (including climatological and agrometeorological stations), two automatic weather observation stations on the airports and a network of 3D printed 3D-PAWS[4] stations (not WMO compliant and mainly used as a back-up and additional input for agrometeorological services). Many AWSs are not working properly since there has been a shortage of spare parts, and the sensors have not been regularly calibrated, thus decreasing the reliability of the observations.

The network consists of stations from many different manufacturers, which causes an additional burden in the maintenance and calibration of the sensors, as each stations needs separate spares, maintenance and calibration procedures, and the support for the stations are spread across these different suppliers. The TTMS estimates that around 60% of the stations are not working properly.

Currently, the main gaps in the surface weather observation network are the low coverage in high altitudes and the lack of marine stations. Trinidad and Tobago is surrounded by large marine areas with very active marine sector and increasing marine observations is one of the priorities to improve in the national observation network. This would improve the overall situational awareness on prevalent and approaching weather and enable tailored weather services to the marine sector.

3.2. Additional observations used for nowcasting and specialized purposes.

The TTMS operates a S-band weather radar that provides coverage over both islands. Previously there has been issues with the radar operation, which causes major problems as there is no back-up systems or redundancy in the network. Besides the S-band radar, there is one X-band weather radar located in Tobago.

[4] UCAR 3D-PAWS Manual

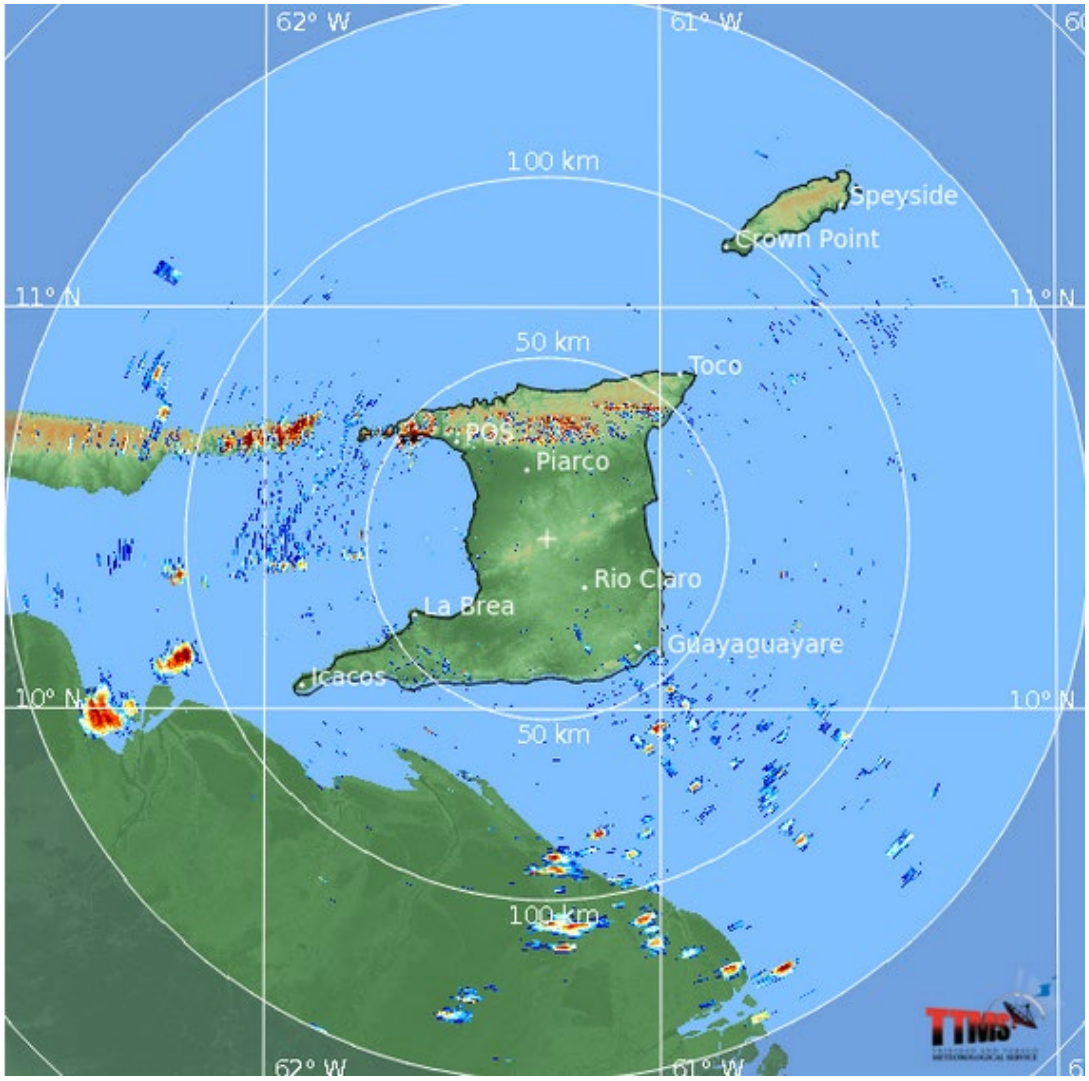


Figure 2 Snapshot from weather radar imaginary (surface rainfall intensity) shared on TTMS website[5].

[5] TTMS website radar imagery

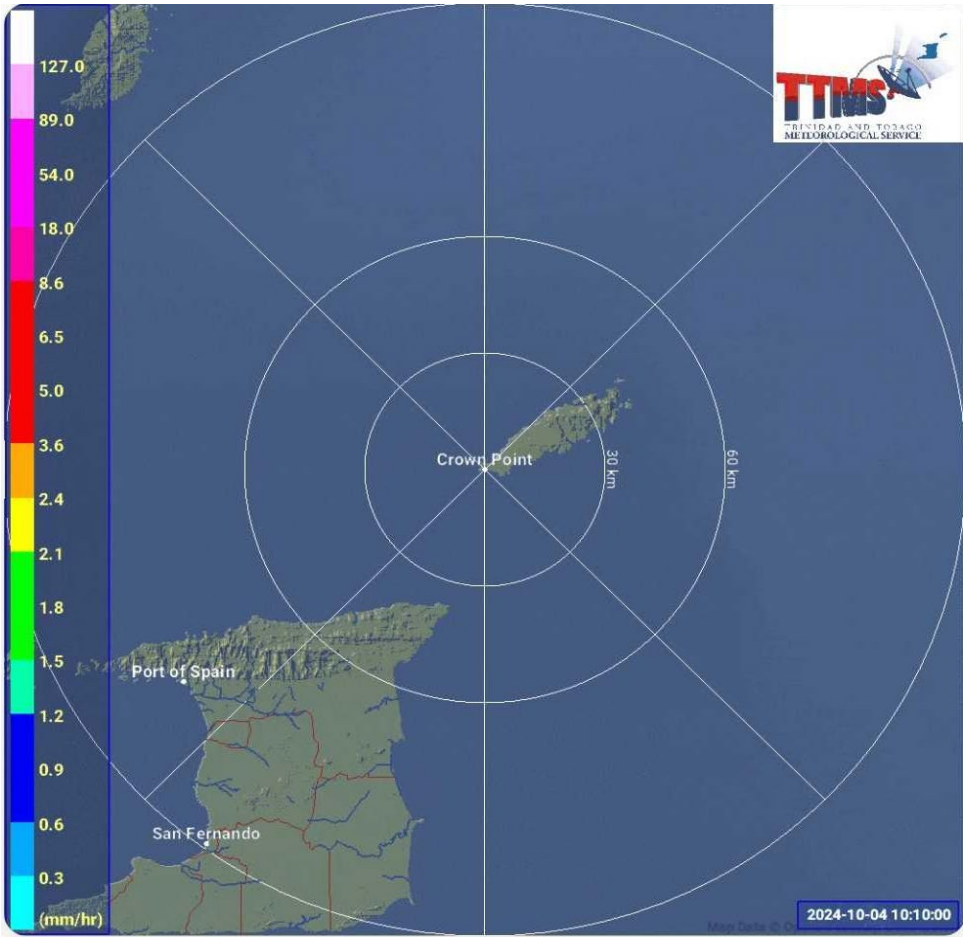


Figure 3 Snapshot from X-band weather radar imaginary (rain rate in mm) shared on the TTMS mobile app.

In addition to the weather radar observations, Trinidad and Tobago would benefit from lightning detection observations to provide more information on storm formation and monitoring. Establishing a lightning detection network – be it national or regional – is recommended.

The TTMS has newly installed a GOES-16 satellite receiving system.

To complement the airport weather observation systems, there is also observation systems to detect low level wind shear on both airports, although the system in Trinidad is currently not working. The main issues are the lack of spare parts and the limited access to the site, which is located inside the airport area, even for maintenance purposes. The TTMS is recommended to improve the collaboration with the airport authority regarding maintenance access and to increase the spare part stock for the LLWAS sensors.

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

The TTMS have SOPs in place for several observation systems. It is recommended to review and update SOPs when new systems are procured, or new technologies are introduced.

The TTMS operates a maintenance unit with good capabilities to do onsite maintenance and troubleshooting. Main limiting factors for the work is the lack of spare parts and sensor replacements and lack of field tools or limitations in reaching the observation sites.

Currently there are large issues with the lack of calibration laboratories that can service the TTMS and a lack of annual budget to outsource the calibration to a commercial provider. The Regional Instrument Centre with its calibration laboratory is located in CIMH in Barbados. CIMH has not had the capacity to provide the calibration for the GBON sensors for some time and the service is currently limited to only the calibration of pressure sensors. Previously when their capabilities also included the calibration of temperature and humidity, another limiting factor was CIMH's decision to only support certain manufacturers' sensors. The TTMS has initiated the process to find some other potential partner, and have had talks with the Bureau of Standards in Trinidad and Tobago and with INSMET Cuba. It is recommended to reinstate CIMH's calibration capabilities (with special emphasis on increasing the capabilities to support all regional GBON stations), or for the TTMS to form a contract with another calibration facility and to include the annual calibration costs in the yearly budget.

Quality management duties and expertise has been concentrated to a key staff member and the knowledge should be passed on to other staff members. Currently QMS has included only aviation-related processes and should be expanded also to other TTMS duties.

3.4 Implementation of sustainable newer approaches to observations.

The TTMS has been collaborating with UCAR in manufacturing and deploying of locally 3D printed automatic surface stations called 3D-Paws[6]. The approach is to have low-cost easy-to-make stations that can be used as supplementary to SYNOP stations and to provide higher spatial density of observations. The initiative was launched by UCAR and the US NWS International Activities Office, with support from the USAID Office of U.S. Foreign Disaster Assistance. The TTMS is monitoring the data quality and the ease of operation and maintenance of these stations and the added value they bring to the forecasting process and stakeholders, mainly the agricultural sector. The advantages in the 3D-Paws approach regarding sustainability is the ease to locally print replacement sensors and spare parts for the systems.

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

Most the surface weather network consists of automatic techniques. The two remaining manual stations are those nominated to GBON and proposed to be upgraded to automatic ones with the SOFF financing.

Summary score, recommendations, and comments for Element 3

Summary score for the element is 2 "Basic network, large gaps, mostly manual observations with severe challenges and data quality issues".

Although the network of surface weather stations has mostly been automatized, there is severe lacks in the maintenance of the network and the key high-quality SYNOP stations registered for GBON are both still operated manually. **The TTMS is recommended to automatize both GBON stations with the assistance of SOFF funding**.

To improve the sustainability of the network the **TTMS is recommended to update maintenance plans and draft lifecycle plans, to increase spare part stock and to ensure adequate annual budget is allocated to spare parts, sensor replacements and calibration.**

[6] 3D- Paws project homepage

A key shortcoming in the current network is the unreliable connection between Trinidad and Tobago. The connection is recommended to be strengthened or switched to a more reliable form of connection to be able to effectively share the observations from both of the islands.

Network plans for future investments should consider how to integrate new systems with the existing network and utilizing synergy benefits. Such benefits can be a spare part stock that services a large part of the network, instead of many different manufacturers all with different spares, having systems with same maintenance and calibration procedures, and having only a limited number of supplier contacts for the service requests. The TTMS has received many of the systems through different projects and convincing the implementing entities to consider legacy systems may be difficult. CIMH has been developing a regional standard to assist in tendering for systems and in the homogenisation of the networks for improved maintenance and calibration support. The effort is interesting and **the TTMS is recommended to actively participate in the development to have their national considerations included**.

In addition to the network maintenance, the calibration of sensors should be significantly improved. Currently the largest issue is the lack of calibration laboratories that can provide the service to the TTMS and a lack of annual budget to outsource the calibration to a commercial provider. **It is recommended to reinstate CIMH's calibration capabilities** (with special emphasis on increasing the capabilities to support all regional GBON stations) **or for the TTMS to form a contract with another calibration facility and to include the annual calibration costs to the yearly budget.**

Currently, the main gaps in the surface weather observation network are the low coverage in high altitudes and the lack of marine stations. **Improving the marine station coverage is recommended. The TTMS is recommended to investigate and develop potential partnerships with marine sector and stakeholders for mutual benefit of marine observations.**

Other large gaps in the current observation network are the lack of a lightning detection network, ceilometers and air quality monitoring. The lightning detection network is needed for the monitoring and forecasting of thunderstorms that have a major impact on sectors such as aviation. Ceilometers would also benefit these same stakeholders. Air quality monitoring would be of large importance in the cases when large amounts of Saharan dust is dispersed on the islands.

For both the lightning network and marine stations, a regional approach could be beneficial since these gaps are shared with the majority of the other Caribbean countries.

Besides the recommended investments in observation equipment, staff capacities to operate and maintain systems, data management, data quality control and assurance, quality management and metadata management needs to be strengthened. **Human capacity building on all these areas is recommended.** Adequate number of staff should be trained with the skills, including new staff and senior staff to decrease dependency on single individuals. **The TTMS is also recommended to invest in new staff positions for key tasks that have to little staff resources**. Besides training, investments in the data management system and its features may be needed, including allocation of annual budget for its operation, to efficiently serve the TTMS.

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.

Based on the WDQMS database, all GBON nominated stations (two surface weather stations and one upper-air sounding station) are reporting internationally at the required temporal frequency. The upper-air sounding station has had issues with operating at the required twice a day frequency, but lately the systems has been operated successfully.

Sharing for the surface weather observations is done partially with WIS2.0 protocol using the WIS2Box software. WIS2Box has been in testing phase and the upper-air sounding information has not yet been included in the solution.

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

Currently, no formal agreements or policies govern the open sharing of observational data, except for a Memorandum of Understanding (MoU) between the TTMS and the Civil Aviation Authority. Despite the lack of formalized agreements, the TTMS actively cooperates in freely sharing data with various stakeholders, including the WRA and EMA. Additionally, a governmental policy supports open data sharing with the Caribbean Meteorological Organization (CMO).**4.3. Main data and products received from external sources in a national, regional and global context, such as model and satellite data.**

Satellite data is extensively used in developing forecasting and warning services. This data is accessed through web-based services and a GOES-16 satellite receiver, acquired in 2024, which serves as the primary satellite resource for the TTMS.

The TTMS also utilizes several global and regional models, including GFS, ECMWF, ICON, GEM, and CIMH WRF. These models are primarily accessed as ready-made chart and text products delivered via the internet.

The TTMS has some previous experience in downloading and using model data in gridded format to use for visualization in a forecasting software. They have experience in using the SmartMet weather forecasting and service creation software (open-source code software developed by the Finnish Meteorological Institute), but this solution has not been in operation for the past several years. A Visual Weather workstation (by Campbell) had been utilized to visualize GFS data, but the system is not currently working reliably due to high license fees and a lack of maintenance.

Summary score, recommendations, and comments for Element 4

The summary score for element four is 2 "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".

The TTMS is recommended to continue the WIS2Box implementation to fully include both surface weather and sounding observation dissemination and to support automatic weather station data transfer.

The TTMS has recently upgraded the GOES-16 satellite receiver and would benefit of **additional training on new satellite products and their use in operational work.**

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.

The TTMS is using ready-made chart and text-based products available from different Regional Centres. Such products are:

- tropical cyclone advisories from the National Hurricane Centre
- model data products by GFS (13km resolution), ECMWF (9km resolution), ICON (13km and ICON Hi-Res with 2.2km resolution), GEM (regional resolution at 10km), CIMH WRF
- World area forecast centre products
- Climatological outlooks/forecasts from CariCOF

Model data is viewed by the duty forecasters when creating forecast and warning services and products for the different delivered timescales. Forecasts are provided for two days and extended forecast for four days. Beside short-term weather forecasts the TTMS provides extended range forecasts on sub-season (weeks 3 and 4 ahead) and seasonal climatological forecasts.

The TTMS utilizes available satellite products via internet and has a ground receiving station for GOES-16 data (mainly channel 1 and 2 visible, channel 3 and 5 near-IR ranges, channels 4,6 and 16 near-IR and IR ranges), which is the main satellite input used.

To improve the efficiency of utilizing model and remote sensed products, the TTMS is recommended to start utilizing available gridded model data and to visualize the data jointly with observations in a centralized platform. This is necessary to effectively comparing the different models with each other and the observations, thus improving the forecasts and reducing the potential of human error that stem from using multiple separate viewing platforms that are visually compared to each other.

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

No models are run internally.

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

The TTMS is using readymade probabilistic NWP products from the global models GFS and ECMWF. Currently there is no capabilities to produce probabilistic forecasts independently or to post-process NWP and run ensemble prediction system products.

Summary score, recommendations, and comments for Element 5

The summary score for element five is 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"

In order to strengthen the forecasting and warning capabilities and possibilities to serve an expanding user base with tailored products, the **TTMS is recommended to upgrade their weather forecasting and visualization software** to a solution that supports a versatile use of gridded model data, other observation sources (both local observations e.g. weather stations, radar and soundings, regional e.g. weather radar composite and regional WRF, and global e.g. satellite) and has the tools for automatic product generation and dissemination. The selected solution **is recommended to be an open-source code and license free solution** to improve the financial viability and to enable independent maintenance of the system.

Element 6: Warning and advisory services

6.1. Warning and alert service cover 24/7.

The TTMS is providing warning and alerting services on a 24/7 basis with a multi-hazard early warning system in place. They have the capability to monitor and report on multiple hazards simultaneously including the cascading impact e.g. in a case with heavy precipitation and potential flooding.

Before issuing public warnings, the information needs to go through the TTMS Director, Permanent Secretary and line Minister before it is published.

Warnings published by the TTMS will be forwarded to OPDM and then on to TV channels, mobile phones via text messages and social media. At least 70% of the population is estimated to have access to the warning and alert services.

The TTMS has different lead times for different types of hazards, the typical being 24-hours lead time, while the lead time for tropical cyclones is longer (48-h and less).

The operation of the service has some inbuilt redundancy for the systems and facilities. Also, the Trinidad office and Tobago office are the backup offices for each other.

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

The TTMS is producing warning products in CAP format. CAP guidelines are used in the forecasting office to assess the weather risk based on certainty/probability and severity to create colour-coded risk levels. Besides CAP guidelines, the forecasting office uses alert response cards that stipulate the issuance time, validity period, area of interest, information required and contact and dissemination details for the different covered phenomenon. Covered phenomenon include thunderstorms, tropical cyclones, strong winds, localized flooding, landslides, drought and dry spells, dust storms and turbulent and agitated seas.

The TTMS uses a specialized alerting tool, "Metapp", that includes the following events: hazardous seas, adverse weather, tropical storm, hurricane, tropical depression, flood, hot spell, rainfall deficit and high winds.

Public surveys on the usefulness of the warnings are made annually and feedback on warnings received through social media channels are addressed. A review on the TTMS performance in relations to MHEWS is conducted in the National Climate Outlook Forum (NCOF). After each hurricane season ODPM conducts a hurricane and wet season review with its stakeholders, to whom the TTMS belongs. New products have been developed based on the feedback received from the NCOF review.

The TTMS maintains a warning and forecast archival system where CAP files are backed up together with other products in the network drive and backed to a server.

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.

Warnings are issued in CAP format and include information on impacts and instructions for the citizens how to minimize these. Impacts are estimated by the forecaster based on their subjective analysis. As background information for the analysis, the TTMS has reports from ODPM (not shared in real-time) and the possibility to access Disaster Management Units records on the previous impacts (not in real-time, information has to be requested). Additionally, the TTMS forecasters have some experience on the exposure and vulnerability information from discussion with stakeholders. Most of these interactions are ad-hoc. No GIS data on the exposure and vulnerability is utilized.

Public Warning

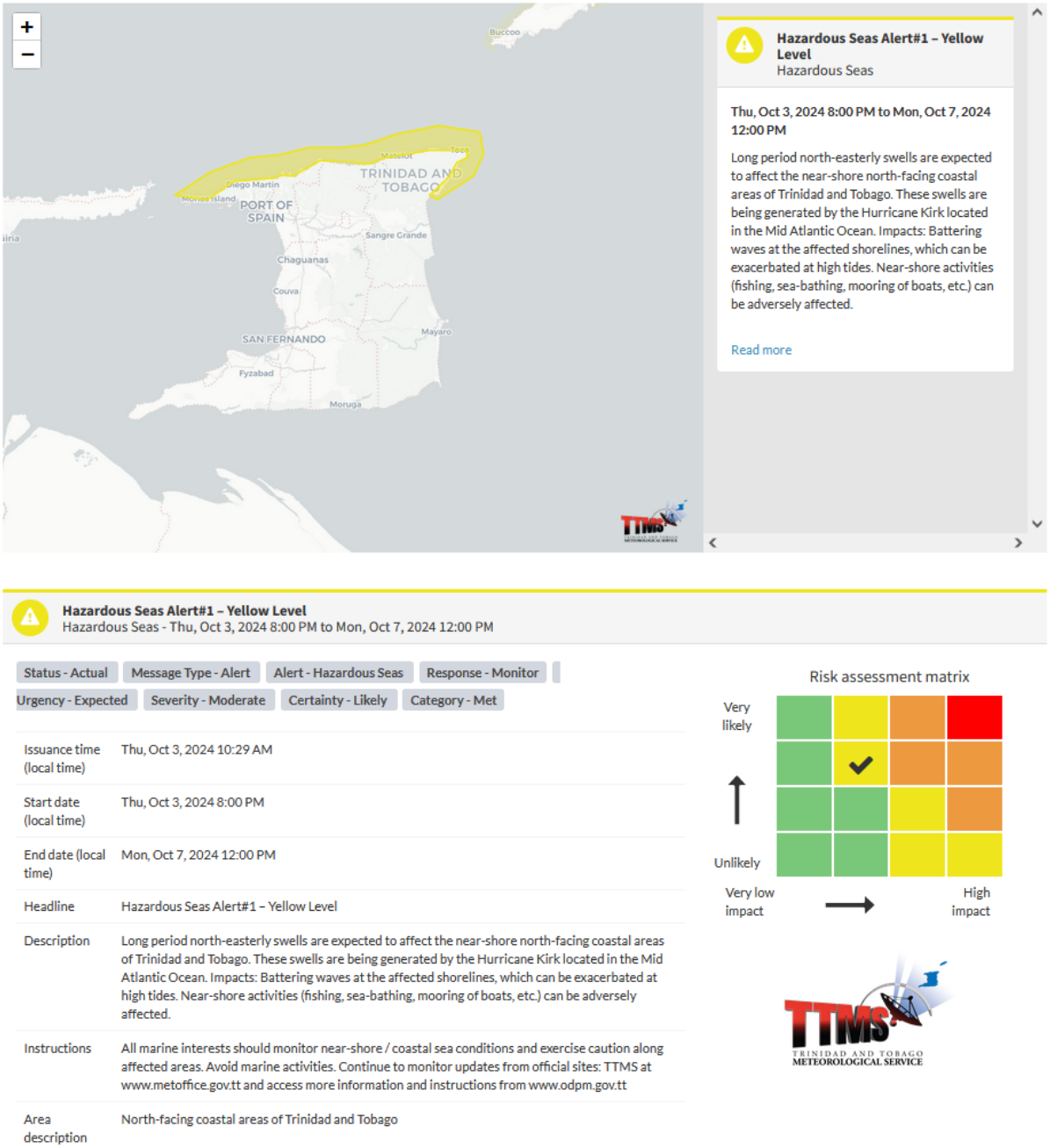


Figure 4 Example of a Public Warning for hazardous seas. Warning shared through the TTMS website.

ttmetservice High Winds Alert #1- YELLOW LEVEL

Start date (local time) Mon, Jun 24, 2024 10:00 PM
End date (local time) Tue, Jun 25, 2024 12:00 PM

Issuance time (local time) Mon, Jun 24, 2024 3:16 PM

Description: There is a high potential (70%) for wind gusts in excess of 55km/h especially in the vicinity of showers overnight into tomorrow. These strong winds may be brief but are capable of displacing unsecured roofs, loose outdoor objects and can even topple trees and weak structures. Sea conditions are expected to be additionally agitated with waves reaching above 2.5 m in open waters and choppy in sheltered areas.

Instructions: Secure loose outdoor objects and livestock. Marine interests should exercise extra caution during this period. Follow the instructions of lifeguards. Monitor official news sources and weather updates from www.metoffice.gov.tt.

Figure 5 Example of a high wind alert including the description of the event and its possible impacts and instructions for citizens. Alert shared on the TTMS social media (Instagram)

ttmetservice Hurricane Warning #5 for Tobago - RED LEVEL

Updated Issuance time #10 (local time) Sun, Jun 30, 2024 8:11 PM

End date (local time) Mon, Jul 1, 2024 12:00 PM

Description: A Hurricane Warning is in effect for Tobago. This means there is a higher potential for hurricane conditions, including sustained winds in excess of 118 km/h, within the warning area, in this case within the next 12 - 18 hours. As of 8 pm, Hurricane Beryl was located near 11.2°N 57.3°W, approximately 360km east of Tobago, moving west - northwest near 30 km/h. Tobago can expect a gradual deterioration in conditions, beginning with periods of showers and gusty winds in excess of 70km/h near midnight. From 11 pm tonight, there is a high chance (80%) of hazardous seas with large, battering waves. Mariners should expect wave heights to increase significantly, posing a danger to small craft, coastal and offshore activities. Strong currents and choppy seas will make navigation hazardous. The next update will be at 11 pm (Sunday 30th June 2024) or earlier if necessary.

Instructions: Take immediate actions to protect their lives, livelihoods, and property. Shelter in place or evacuate to a safe location if your home is unsafe or vulnerable to flooding or wind damage. Secure food, water and medicine for at least 7 days in waterproof containers. Outdoor drains should be clear and loose objects secured by now. Sandbags should be near all entrances to your home. Monitor official news sources and weather updates from www.metoffice.gov.tt. Follow instructions of government officials.

Figure 6 Example of a hurricane warning including the description of the event and its possible impacts and instructions for citizens. Warning shared on the TTMS social media (Instagram)

TRINIDAD AND TOBAGO
METEOROLOGICAL SERVICE
SYNOPTIC BRANCH
Telephone: 1-868-669-4392 ext. 120/121 | Fax: 1-868-669-4727
Email: synop@metoffice.gov.tt Website: www.metoffice.gov.tt

F 852-24

PUBLIC WARNING MESSAGE

Date:	2022/11/27	**Issuance Time:**	07:45 AM
Event:	Adverse Weather	**Message Type:**	Update
Headline:	**ADVERSE WEATHER ALERT #3 - ORANGE LEVEL**		
Area Description:	Trinidad and Tobago and offshore marine areas		
Start Date/Time:	2022/11/27 07:45 AM	**End Date/Time:**	2022/11/28 06:00 PM
Urgency:	Expected	**Response:**	Prepare
Severity:	Severe	**Certainty:**	Observed
Description:	Rainfall and/or showers of varying intensities are expected to continue throughout the course of today, especially during the afternoon (Sunday 27th November). There is still a 70% - 80% (high) chance of heavy showers and thunderstorms. Impacts: * Rainfall greater than 25mm and in excess of this amount in isolated areas. * Gusty winds in excess of 55 km/h may be experienced especially in the vicinity of heavy showers/thunderstorms. * Street/flash flooding and localized ponding are also likely in heavy downpours. * Seas can become agitated at times in sheltered areas. * Landslides/landslips are also possible in areas so prone.		
Instructions:	Do not wade or drive through flood waters. Secure loose outdoor items and livestock. Monitor weather conditions and official updates. More information: www.metoffice.gov.tt; www.odpm.gov.tt		
< END >			

GREEN	*YELLOW*	*ORANGE*	*RED*
Take no action	*Monitor conditions*	*Secure yourself/property*	*Take shelter/evacuate*

Figure 7 Public warning message for adverse weather alert including the description of the events and its possible impacts and instructions for citizens. Alert shared on the TTMS social media (X)

Summary score, recommendations, and comments for Element 6

The summary score for the element is 4 "Weather-related warning service with strong public reach and standard operational procedures driving close partnership with relevant institutions, including disaster management agencies."

The TTMS is recommended to continue with the progress on developing impact-based forecasting capacity.

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.

The TTMS is the organizer for the National Climate Outlook Forum (NCOF). NCOF is the operational activity to link climate information that is generated by the TTMS with national stakeholder institutions and their decision-making processes to improve application of climate information, particularly the seasonal climate outlooks. The TTMS is also involved in committee work when the National Adaptation Plan[7] (NAP) is updated and participates in the consultation for the Ministry for Planning and Development.

The NAP 2023 identifies the climate risk management responsibilities for the TTMS as the following:

- Continuous monitoring and sharing of robust, high-quality climate data
- Climate change research and projections for climate variability
- Develop, produce, and disseminate climate risk products to each sector
- Undertake education and awareness campaigns on climate change hazards and risks
- Provide climate data, projections, and modelling to the Knowledge Management System

The TTMS is operating the essential observation network for climatological purposes and a database with Clidata database and management system (upgraded in 2024). The GIS department produces different products based on the observation and climate data and utilize some of the database system built-in production capabilities. The TTMS had started a data rescue project in the past in collaboration with the University of West Indies. However, the project has ended, and data rescue is currently done only sporadically. The TTMS is recommended to continue with the data rescue work.

The TTMS is a member of the Caribbean Climate Outlook Forum (CARICOF), the regional climate outlook forum for Caribbean, sponsored by WMO and hosted by CIMH. The TTMS is sharing nationally collected climate data with CARICOF and in return receives the climate outlooks for the area. These outlooks are one of the main inputs in the climate service work done at the TTMS. CARICOF hosts a bi-annual regional meeting, where TTMET is invited and participating. These events include training on products and creating of regional outlooks.

Public users and different stakeholders have access to the climate products through the TTMS's website[8]. The produced products are:

- Description on the climate in Trinidad and Tobago, including records on average and extreme values
- Drought policy
- Information on climate: variability, climate change, trends, projections and ENSO monitoring update
- Rainfall and temperature wet/dry season outlook for 3 months

[7] UN site to access National Adaptation Plan 2023
[8] TTMS website

- Dryness/drought indicator, monitor and outlook for 3 months

The TTMS is adopting a National Sustainable Initiative for members of the general public. As a result of this initiative, members of the public have access to historical climate data from the Piarco and Crown Point stations by creating an account in the interface. Monthly climate data for the same sites is shared through the TTMS website.

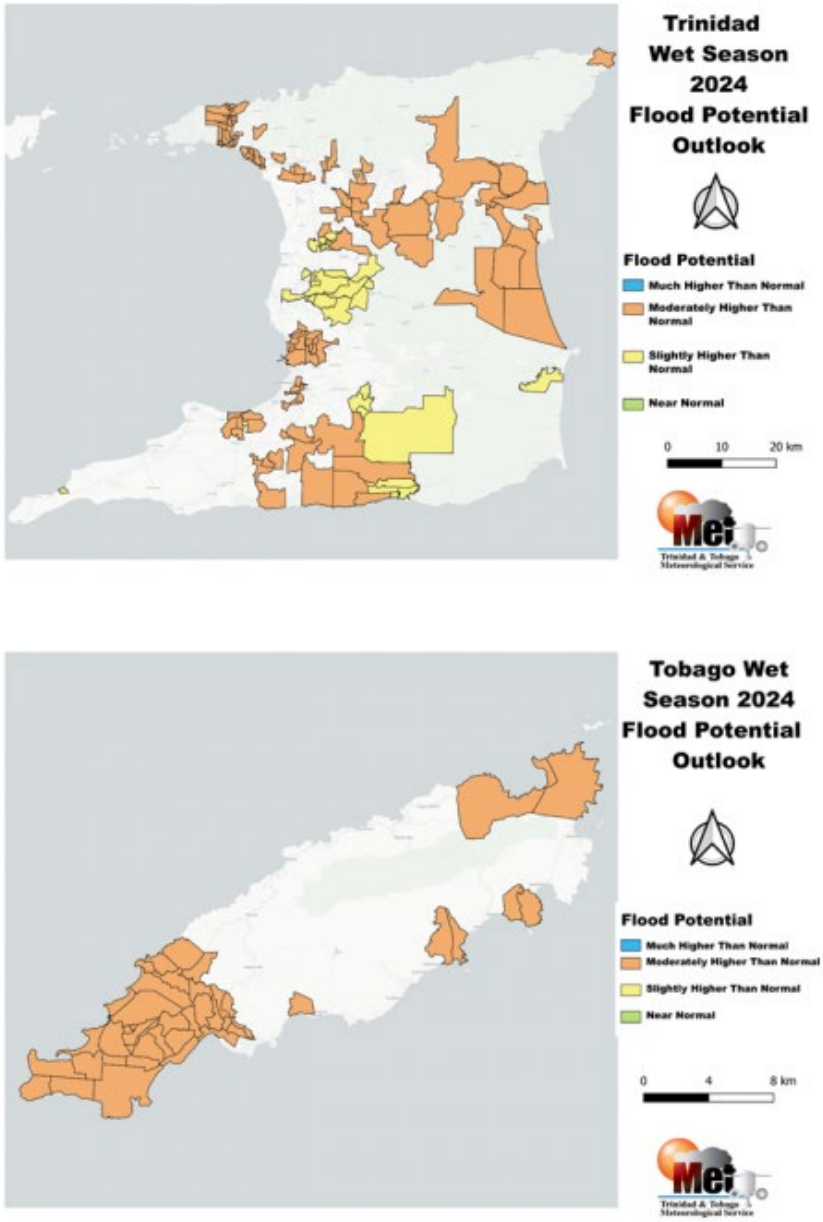


Figure 8 Flood potential outlooks from the rainfall and temperature wet/dry season outlook. Shared though the TTMS website.

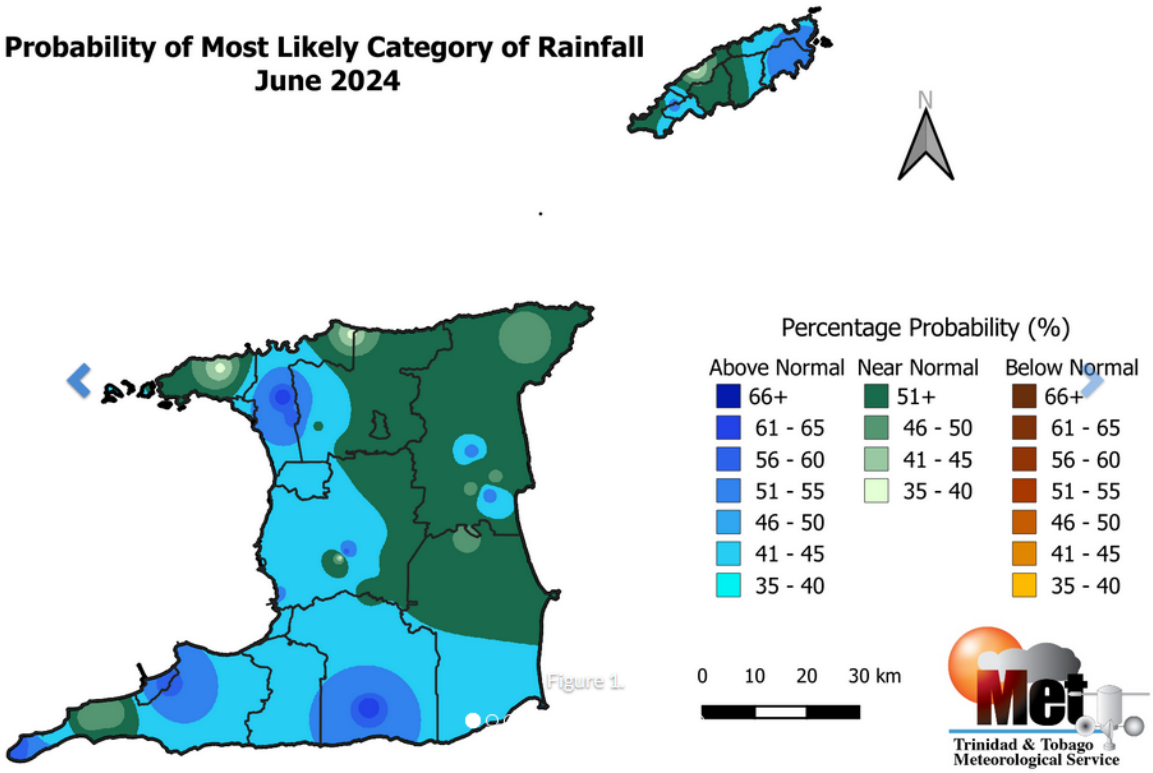


Figure 9 Probability of most likely category of rainfall for the month of June from the rainfall and temperature wet/dry season outlook. Shared though the TTMS website.

Meteorological Services Division Climatic Data at Selected Stations for August 2020 **Issue Date: 10/09/2020**

	TEMPERATURE														SUNSHINE					RAINFALL				
PLACE	Mean Maximum (°C)	Difference from 1981-2010 average (32.2°C at Piarco ; 30.9°C at Crown Point)	Mean Minimum (°C)	Difference from 1981-2010 average (23.6°C at Piarco ; 24.5°C at Crown Point)	Highest maximum (°C)	Date (s)	Lowest maximum (°C)	Date (s)	Number of days with maximum temperatures ≥ the 95th percentiles for 1981-2010 (≥ 34.1°C at Piarco ; ≥ 32.3°C at Crown Point)	Lowest minimum (°C)	Date (s)	Highest minimum (°C)	Date (s)	Number of warm nights with minimum temperatures ≥ the 95th percentiles for 1981-2010 (≥ 24.9°C at Piarco ; ≥ 26.2°C at Crown Point)	Total for month (hours)	% of 1981-2010 average (213.1 hrs at Piarco ; 243.3 hrs at Crown Point)	Maximum duration (hours)	Date (s)	Days with no sunshine	Total for month (mm)	% of 1981-2010 average (264.6 mm at Piarco ; 164.8 mm at Crown Point)	Max. fall in 24 hours from 0800 am (mm)	Date (s)	Number of dry days (≤ 1.0 mm rain)
Piarco	32.8	+ 0.6	24.1	+ 0.5	34.6	15th	28.8	31st	5	22.7	18th & 22nd	25.4	12th & 28th	3	218.8	103	11.6	13th	1	443.9	168	89.3	7th	12
Crown Point	31.9	+ 1.0	25.1	+ 0.6	33.4	27th	28.4	31st	10	23.1	22nd & 23rd	27.0	3rd	2	236.5	97	11.5	11th	2	236.3	143	43.6	17th	12

Figure 10 Climatic Data Monthly at selected stations from the TTMS website.

Currently users have access to the different products mainly through the TTMS website, but this communication is limited to informing citizens and stakeholders and have no built-in feedback mechanisms. The only regular forum to receive input on products and services and opportunities for co-creation and tailoring of the products is the NCOF itself.

The TTMS is providing decision-support product and services for some of its key stakeholders. These are e.g. Environmental Impact Assessments for construction

planning, monthly rainfall forecast tailored for the WRA planning and optimization process, and in some cases specific products for agriculture and tourism.

Currently the largest obstacle hindering the TTMS from regularly providing services and products beyond the daily/monthly products is the lack of staff. The TTMS has plans to invest in more dedicated staff for climate services as the demand for applied services has been increasing, as well as to support the priorities outlined in the NAP. On that note, besides climatological knowledge, stakeholder and product management skills will be required to successfully expand the services, especially if cost-recovery principles can be applied to the tailored services.

Summary score, recommendations, and comments for Element 7

The summary score for the element 7 is 3 "Essential Capacity for Climate Services Provision".

The TTMS is recommended to invest in additional staff dedicated for providing climate services and products. Additional staff is needed to cover all tasks mentioned in the NAP and to meet the increasing demand of different users. **Once the staff base has been increased, the TTMS is recommended to prioritize creating new climate services to offer decision-support for key stakeholders and sectors**. This will benefit from increased engagement with the users and stakeholders to co-create services and products. With cost-recovery methods, the tailoring of such products can be increased, thus increasing the benefits for the users.

The TTMS is also **recommended to continue with the data rescue efforts** that were previously initiated.

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.

In Trinidad and Tobago, the Water Resources Agency (WRA) is responsible for the management of the country's water resources and the conservation, development, and protection of the resources for sustainable use. WRA is governed by the Water and Sewerage Act and is a department of the Water and Sewerage Authority (WASA). WRA is responsible for the operation of a hydrological monitoring network that consists of rain gauges, streamflow, and groundwater measurements as well as evaporation and water quality monitoring. WASA prepares the national dry season plans and has been the main driver in developing the Dry Season and Drought Management Plans.

The TTMS has a close relationship with WRA. The relationship is informal, and it is recommended to formalize it with a Memorandum of Understanding or other agreements. The main mode of cooperation between the TTMS and WRA is data and forecast sharing. The TTMS is sharing precipitation data and monthly precipitation forecast, and WRA shares its rain gauge information (not received in real-time). The TTMS also has access to WRA river gauge data. Based on the observations, the TTMS makes rainfall and flood forecasts that it shares with WRA and the Ministry of Works. No hydrological models are used in the TTMS.

The TTMS also shares precipitation data and forecast with the Ministry of Works.

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

No SOPs exists between the TTMS and WRA. Both entities have internal SOPs that they follow.

The formal platform for the TTMS and WRA to coordinate activities is the NCOF, which is arranged by the TTMS. At the national disaster risk reduction level, the coordinator is ODPM, and there is a risk platform currently being developed by the UNDRR where both entities feed information on events and related risks.

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

Data sharing is done on a routine basis free of charge between the TTMS and WRA. The TTMS is also sharing climatological observations with the CARICOF and receives in return the seasonal climate outlooks, including the rainfall forecasts. The TTMS uses this information when providing the monthly precipitation forecasts for the WRA.

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

Some examples of the joint projects/initiatives with the hydrological community in recent years are:

- Community Flood Early Warning System project as part of the Global Environmental Facility CReW+ project. Project executed in 2021-2023.
    - Project partners included the TTMS, WRA, Ministry of Rural Development & Local Government, Ministry of Works and Transport and Tobago Emergency Management Agency and implemented by Ministry of National Security – ODPM.
    - The project included installation of stream gauges, training in flood modelling and mapping, setting up a website to display stream gauge and rainfall station information, public education and awareness campaign, and human capacity building.
- Integrated Water Resources Management project.
    - The project goal was to build awareness concerning issues impacting local watersheds and facilitate the participation of public and private sector entities in sustainable and holistic projects to improve the status of rivers and watersheds.
- Development of Dry Season and Drought Management Plan.
    - This project was led by WASA.

Summary score, recommendations, and comments for Element 8

The summary score for the element 8 is 3 "There is a moderately well-functioning relationship between the meteorological, hydrological and water resources communities but considerable room for formalizing the relationship and SOPs."

The TTMS is recommended to formalize its relationship with WRA and to consider developing joint SOPs.

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?).

The TTMS is using a variety of dissemination channels to reach out to the public and private users. Key channels are the TTMS website, TTMS app, email threads, on-call meteorologist service, several social media channels (Instagram, Facebook, YouTube, X), as well as providing information to local TV and radio broadcasts.

A key channel is the TTMS dedicated website (https://www.metoffice.gov.tt/). The website includes the following products:

- Observations
  - weather radar
  - satellite images
  - surface weather stations (Piarco, Caroni, Penal and San Fernando)
- Forecasts
  - General public weather forecast up to 3 days
  - Five-day weather forecast bulletin
  - Agro-meteorological forecast for 15-day period
  - Sub-seasonal (week 3 and week 4 ahead) rainfall prediction
  - Dust index forecast
  - Tobago tourism weather forecast (3 day forecast including tidal information)
- Warnings
- Outlooks and bulletins (maps and text)
  - Rainfall and temperature wet/dry season outlook
  - Rainfall and temperature outlook
  - ENSO monitoring
  - Agro-met bulletin and assessment
  - Dryness/drought indicator, monitor and outlook
- Climate: baseline climate information, climate trends and projections for Trinidad and Tobago. Interface for climatological daily database.

A new addition to the dissemination portfolio is the dedicated TT Met Office mobile app that provides similar information as the website but in an optimized mobile phone format.

Local television channels are integrating data provided by the TTMS. In Port of Spain the TV company owns a weather station that is also used as added value for the TV products.

TTMS has a social media presence in the following channels (follower amounts from October 2024):

- Facebook with 135 thousand followers. Used to post public weather forecasts (link to webpage), weather outlooks, official statements, and disaster preparedness awareness. The site is actively used with daily postings and active engagement of followers.

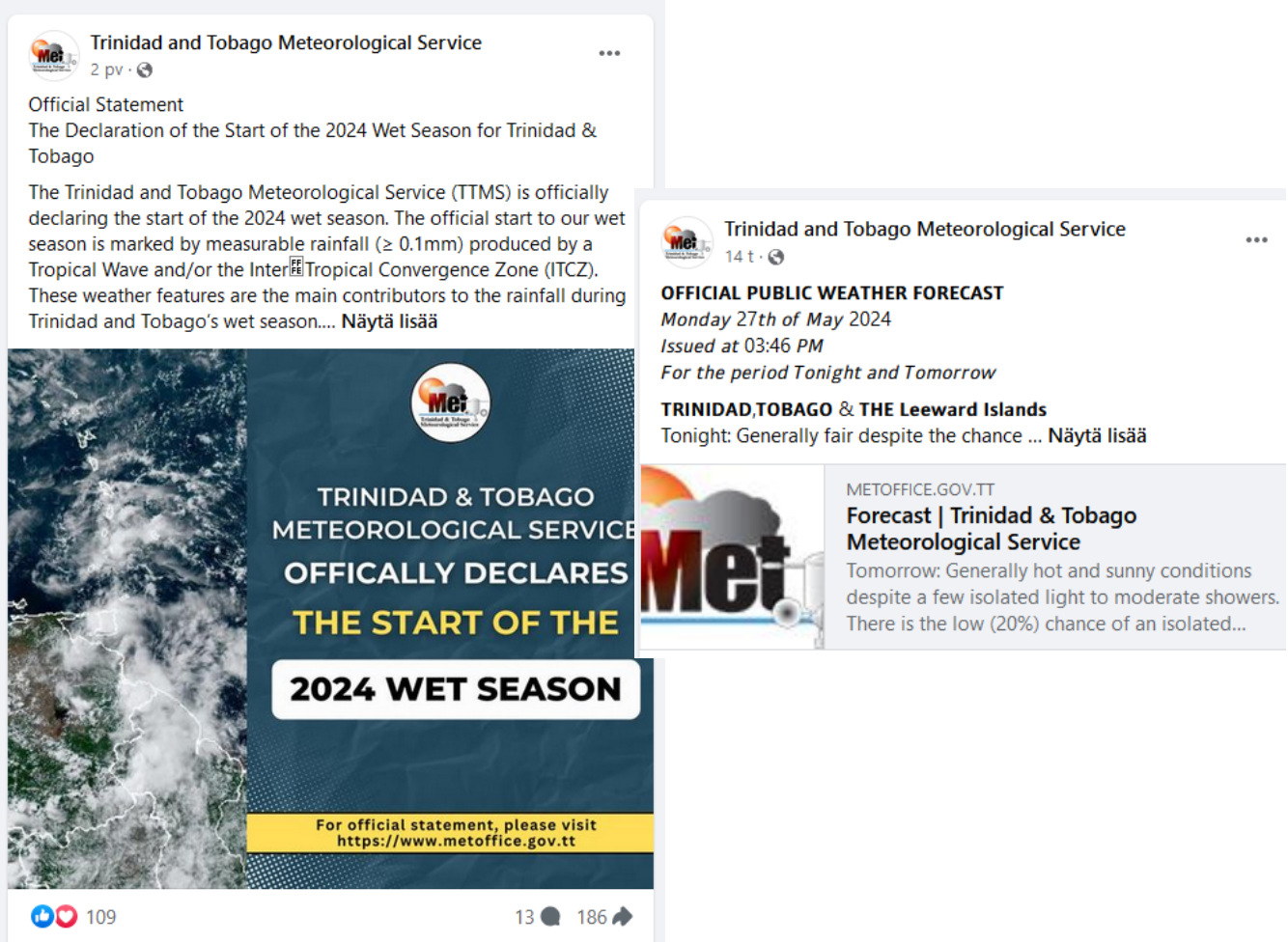


Figure 11 Examples of TTMS Facebook products.

- X with 34,5 thousand followers. Shared content is similar to Facebook.
- YouTube with 1.22 thousand subscribers. The channel has been inactive in recent years but was previously used to share hurricane or seasonal outlooks.
- Instagram page has 3781 followers. Shared content is similar to Facebook but in a more visual format.

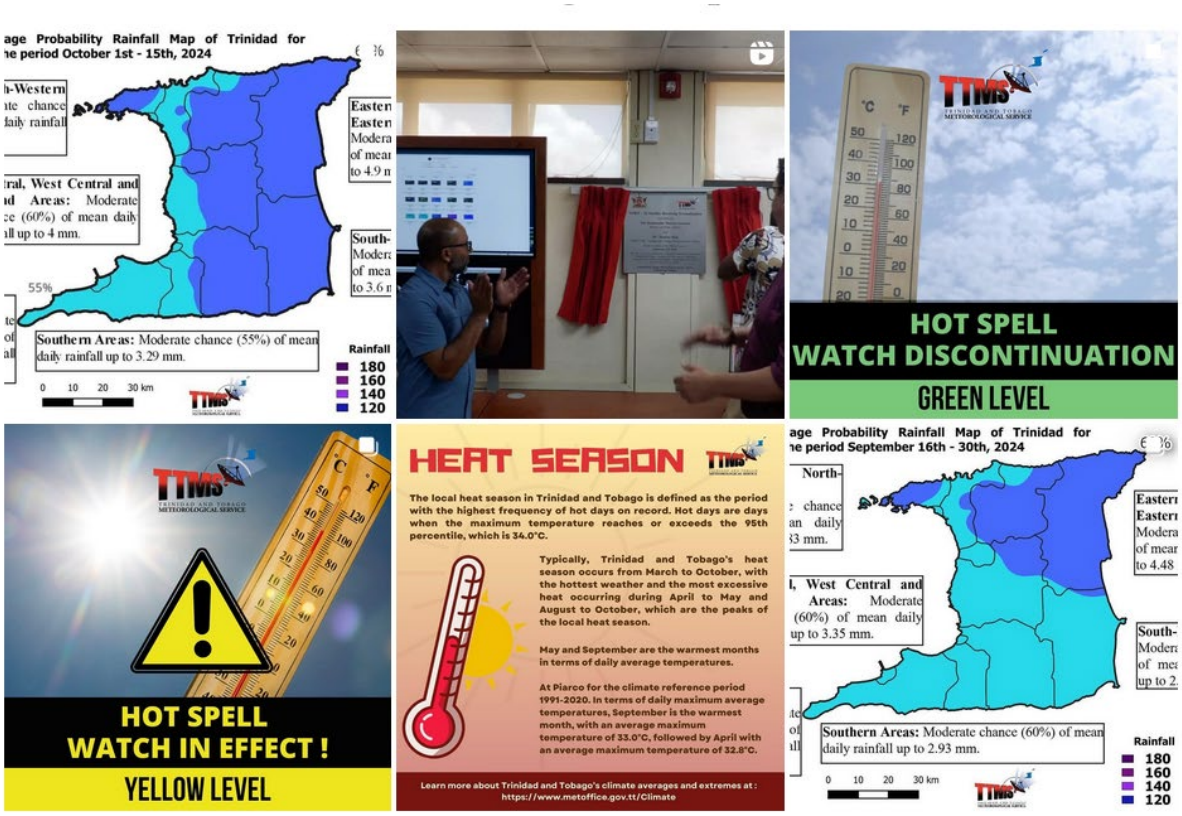


Figure 12 example products from the TTMS Instagram page.

- TikTok with 7399 followers. Shared content as in Facebook and Instagram but in video format.

The importance of social media presence has been increasing in the recent years and TTMS has started to do a three-month performance report on the data on social media.

9.2. Education and awareness initiatives in place.

The TTMS participates actively in hosting school visits or visiting schools when requested. On the World Meteorological Day, there is an open doors day for visitors to come to the TTMS premises. Each May there is a Public Awareness month when the TTMS experts participate in several different events such as lectures and school visits. The activities are supported by educational content in the form of booklets and brochures, or social media content targeted to reach the youth.

The newest National Adaptation Plan sets the task or "Undertake education and awareness campaigns on climate change hazards and risks" under the responsibility of the TTMS. The task requires proactive communication from the TTMS side using a variety of dissemination channels to reach all of the public. Already now, the TTMS website has educational information on the climate, climate change, trends and expected impacts on Trinidad and Tobago for the citizens.

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

No specific measures are currently in place.

Besides broadcasts on TV and radio, warnings are disseminated via text format which is important in getting through to people with impaired hearing. The UNDP is currently

working with the Spanish Blinds Association to create improved services for hearing impaired citizens.

Maintaining a broad portfolio of social media channels helps to keep up with the shifting behaviour of the youth.

The population is estimated to have good availability of internet and smartphones, which improves the effectiveness of using the website and mobile app as the main communication channels.

Summary score, recommendations, and comments for Element 9

The summary score for the element 9 is 3 "A moderately effective communication and dissemination strategy and practices are in place, based only on in-house capabilities and supported by user-friendly website."

The TTMS is recommended to continue using a versatile portfolio of different dissemination channels for effective outreach to citizens and stakeholders. It is **recommended to follow the performance and user traction of the channels** in order to target efforts to the most effective ones. Engaging end users to give their feedback on the products and services and to participate in co-creation of new services is encouraged. Considerations to the accessibility of information should be made when developing new products and services or selecting new ways of dissemination.

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.

The National Climate Outlook Forum (NCOF) is the main platform for the TTMS to interact with stakeholders in regard to provided climate services. The NCOF is arranged by the TTMS and organized three times a year (before dry, wet and hurricane season) with all relevant stakeholders and user sectors such as agriculture, fishers etc.

The national disaster risk reduction activities are coordinated by ODPM and the Ministry of National Security. The TTMS is a member of the national DRR committee, which is covered by a MoU to set the collaboration framework.

The TTMS is collaborating with private sector and government institutions, but on the whole this collaboration has not been formalized by agreements or MoUs. Indeed, these interactions and discussions happen on an ad hoc basis, when specific requests or issues arise. Examples of such collaboration is with the oil and gas companies for which the TTMS is providing tailored services. Targeted products for the agriculture and tourism sectors are also created routinely and shared though the TTMS website.

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

No independent user satisfaction surveys are done due to a llack of financial resources. The TTMS conducts a satisfactory survey themselves as part of the QMS process for the aviation services. The TTMS has also conducted a similar survey on the warning services provided.

Looking ahead, the intention is to extend the QMS process to include meteorological, hydrological and climate warning services.

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

The TTMS is only applying quality management processes for the aviation services. They are implementing the QMS ISO9001:2015 standard, but the TTMS has not yet been certified to the protocol. The timeline for certifying the QMS is two years.

Summary score, recommendations, and comments for Element 10

The summary score for element 10 is 3, "Services development draws on regular dialogue with major stakeholders".

Considering NCOF activities, the TTMS is very well connected with its main stakeholders, with frequent engagement and opportunities for feedback, discussion and co-creation of services and products. To strengthen the dialogue between the TTMS and its key stakeholders, more targeted interactions (e.g. sector specific stakeholder events or surveys) could in cost-effective way improve the possibilities of targeted co-creation of products and services. The **TTMS is recommended to start conducting an annual survey for key contacts and following metrics on the satisfaction level**. Based on the survey results, targeted actions can be made. In case additional funding is available, conducting an independent user satisfaction survey is recommended. In order to collect the satisfaction information, it is important for the TTMS to keep records on the stakeholders and contacts.

The TTMS is recommended to develop and expand the QMS processes to cover all essential services.

Annex 1 Consultations (including experts and stakeholder consultations)

The CHD was developed as part of the SOFF Readiness Phase. During this time FMI conducted two missions in Trinidad and Tobago. The following stakeholders were consulted during this work:

- Staff and Director of the TTMS
- The following stakeholders participated in CHD workshop:
    - Ministry of Public Utilities
    - Water Resources Agency
    - Water and Sewerage Authority
    - Trinidad and Tobago Electricity Commission
    - Environmental Management Authority
    - Institute of Marine Affairs
    - Ministry of Planning – Environment Policy Planning Division
    - Caribbean Meteorological Organization
    - Office of Disaster Preparedness and Management
    - Ministry of Education
    - Ministry of Tourism
    - Ministry of Rural Development and Local Government
    - Ministry of Works and Transport – Drainage Division
    - Ministry of Energy
    - Ministry of Health
    - Trinidad and Tobago Civil Aviation Authority
    - Airport Authority of Trinidad and Tobago
    - Caribbean Airlines
    - Port Authority of Trinidad and Tobago
    - Coastal Protection Unit
    - Ministry of Agriculture
    - Agricultural Society of Trinidad and Tobago
    - University of the West Indies
    - Fishing Association
    - CGCL- Caribbean Gas Chemical Limited
    - EcoEngineering
    - Atlantic LNG
    - Media
- Consultation with the US National Oceanic and Atmospheric Administration National Weather Service Office of Observations regarding the Cooperative Hurricane Upper Air Stations program.
- Two visits to the Caribbean Meteorological and Hydrological Institute (CIMH) to discuss regional network support and plans and the capacity of the regional calibration centre.
- Consultation with the Caribbean Meteorological Organization on the regional collaboration aspects.
- Several remote meetings to prepare and comment on the findings and documents.

Annex 2 Urgent needs reported

The TTMS is successfully operating the national weather and climate observation networks and providing forecasting and warning services for the public and a large group of public and private stakeholders. Over the years, the TTMS has made investments in needed infrastructure, tested out new technologies and tools, and continuously strives to improve the capacity of its staff. To support TTMS's development, some key improvements in its operating environment and remaining capacity gaps need to be made.

The following critical gaps have been identified:

- **Legislation:** Currently there is no Hydrometeorological legal framework, act or regulation in Trinidad and Tobago. A draft meteorological bill has been developed and it is recommended to pursue the ratification of the bill. Including cost-recovery mechanisms in the framework is recommended to improve the long-term financial sustainability of the TTMS. A socio-economic benefit analysis is recommended to be conducted to provide support and visibility for the urgency of establishing the required legislation.
- **Budget:** The annual budget needs to be increased to include investments in additional staff for critical positions, needed spare parts, sensor replacements and calibration services. Establishing cost-recovery mechanisms will improve the financial sustainability and encourage the TTMS to develop new services.
- **Cooperation:** As there are two meteorological services: Trinidad Meteorological Service Division and Tobago Meteorological Service Department that are governed by different Ministries, there is a risk of communication breakdowns and differences in strategical weighing of the services. Due to such risks, it is recommended to improve the cooperation between the services. It is also recommended to formalize key partnerships, e.g. with Memorandums of Understanding (MoUs). Identified partnerships that would benefit from such formalization are the Water Resource Agency (WRA) and the Office of Disaster Preparedness and Management (ODPM).
- **Stakeholder engagement:** it is recommended to increase annual interaction with stakeholders and to engage them in the co-creation and tailoring of services.
- **Observation network:** The manual SYNOP stations are recommended to be automatized. Marine network is recommended to be improved, and the coverage increased. Additionally, there is no lightning detection network and ceilometers in the national network.
- **Data management:** It is recommended to upgrade the data management system and tools to support effective data and quality management utilizing automated quality control methods and to support modern data dissemination and metadata management. Data rescue efforts should be continued.
- **Maintenance:** It is recommended to update maintenance plans and draft lifecycle plans, increase spare part stock and the annual budget for maintenance work. It is recommended to support the regional calibration capabilities or to establish new service contracts to support a healthy annual calibration cycle.
- **Staff capacities:** Human capacities in data management, ICT skills, data quality control and assurance, quality management and metadata management is recommended to be strengthened and more staff trained in the fields. Additional staff to support climate services is recommended.

- **Forecasting:** it is recommended to upgrade the forecasting and visualization software to a solution that supports full utilization of available gridded NWP data and observation data with tools to support automatic dissemination of tailored services and products. The selected solution is recommended to be an open-source code and license free solution to improve the financial viability and to enable independent maintenance of the system. The TTMS is recommended to continue with the impact-based forecasting development and to initiate operational forecast verification processes.
- **QMS:** the TTMS is recommended to develop and expand the QMS processes to cover all essential services it provides.

Annex 3 Information supplied through WMO

Peer adviser acknowledges the material and templates provided by SOFF throughout the Readiness phase.

Annex 4 List of materials used

In addition to WMO guides, the following materials were utilized:

- TTMS web page
- Material shared by the TTMS about their organization:
    - TTMS Strategic Development Plan 2015-2024
    - Competency Assessment Manual for TTMS
    - Cabinet Minutes
    - Budget and staff reports
- online material included as reference to this document