COUNTRY HYDROMET DIAGNOSTICS

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

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Guyana Peer Review Report

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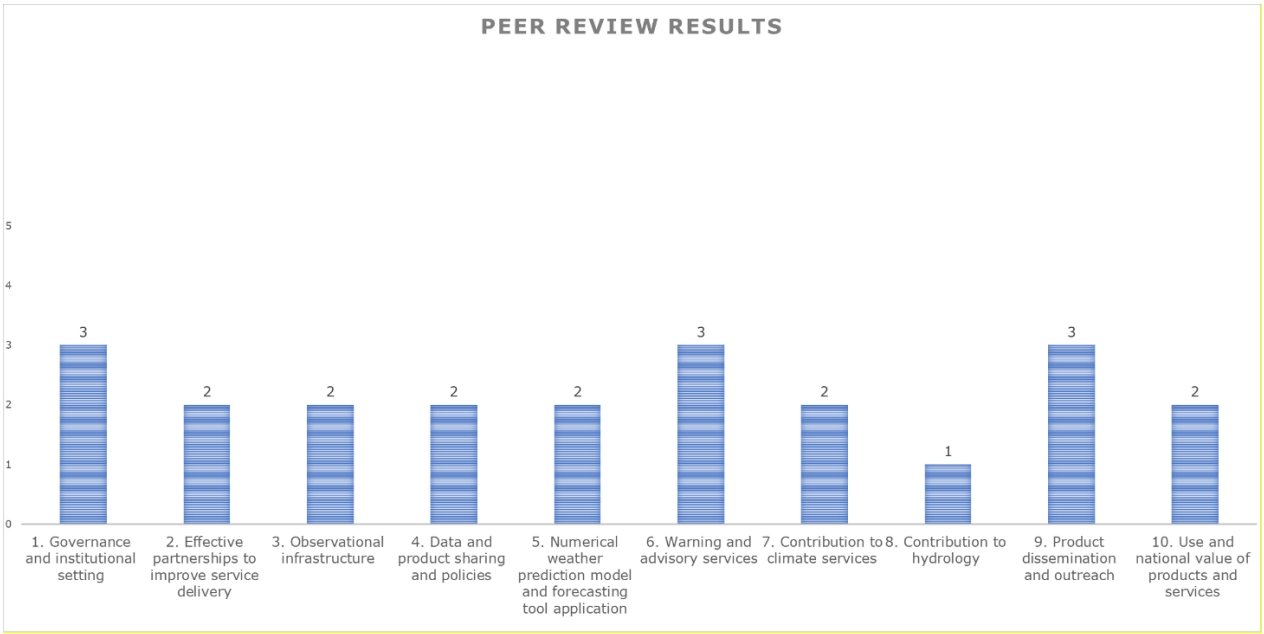
Executive Summary

The Guyanese Hydrometeorological Service (or the Hydrometeorological Service of the Cooperative Republic of Guyana, GHMS) is the national Hydrological and Meteorological Service of the Republic of Guyana, being a department under the Ministry of Agriculture and operating under the Water and Sewerage Act, 2002. The GHMS provides services and products to most of the agencies of the Guyanese government, especially for the Aviation Authority, Ministry of Agriculture, the Emergency Department, regional councils and more.

GHMS currently faces a number of challenges that can be summarized as follows:

a. An insufficient and too narrow formal mandate – the Water and Sewerage Act does not cover many of the most vital fields of activities of a modern National Meteorological and Hydrological Services (NMHSs) – Disaster Risk Reduction (DRR), aviation and marine services, Climate Services, etc. A new draft legislation was prepared several years ago, but it has never been taken to the Guyanese Parliament.
b. Salaries – the applicable staff salary scales of GHMS are not competitive in comparison with comparable job opportunities offered nationally and regionally. This issue causes strong staff rotation and a constant brain, experience and knowhow drain.
c. Human resources limitations – most of the sections within the GHMS are heavily understaffed. Moreover, education and training in the different specialized areas of hydrometeorology can only be found outside of Guyana (including at the Caribbean Institute for Meteorology and Hydrology (CIMH) in Barbados), it continues to be challenging for the existing staff to stay up-to-date with the developments in the worlds of meteorology, hydrology and the allied sciences.
d. Limited observational capacity – the current weather and hydrological monitoring network of Guyana is too small, providing data in much less than an hourly base, with extended gaps and mostly not on a real-time basis. A donation of a considerable number of AWSs turned out to be rather counter-productive, as all of the stations were delivered with manufacturer's defects, and despite large efforts in recovering them, these stations can be considered obsolete.
e. Lack of centralized data management system – most employees of the GHMS do not have easy and comfortable access to the data. Moreover, large parts of the historical data are still not digitalized.
f. Lack of communication with stakeholders – exchange is limited and happens mostly on an ad-hoc basis.
g. Limited outreach – since most of the country has only limited, if any, internet, TV or radio coverage, it remains extraordinarily challenging to reach out to faraway communities.

The peer reviewed results are presented in the Figure I below.



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

Figure I. the maturity level scores for the GHMS, according to the CHD Methodology

2 General information

Introduction

Guyana

Guyana, officially referred to as the Co-operative Republic of Guyana, is an independent state located in the northeastern corner of South America. It lies between latitudes 1° and 9°N, and longitudes 56.8° and 61.2°W. The country gained its independence from the United Kingdom in 1966, becoming a republic on 23rd February 1970, but remaining a member of the British Commonwealth. Its capital and largest city is Georgetown. Guyana is bordered by the Atlantic Ocean to the north, by Suriname to the east, by Brazil to the south and southwest, and by Venezuela to the west. The country has an area of approximately 215,000 km^2 (plus an Exclusive Economic Zone in the Atlantic Ocean with an additional area of approximately 135,000 Km^2) and a population of approximately 800,000 inhabitants[1][2]. Hence, the overall population density is very low.

The large majority (about 90%) of Guyana's population lives along a narrow coastal strip that ranges from a width of 16 to 64 km inland and makes up approximately 10% of the nation's total land area. According to the EU/JRC GHSL (Global Human Settlement Layer), large parts of the country are almost unpopulated[3].

Inform Risk Index

The country has an Inform risk index of 3.6 (scale 0-10, 0 is optimum) and is thus positioned in the risk class "Medium". This means that the country is at a medium risk of a humanitarian crisis in case of natural or man-made disaster. The coping capacity of the country is medium as well[4]:

Hazard and exposure: 2.4 [0-10]

Vulnerability: 4 [0-10]

Lack of coping capacity: 4.7 [0-10]

Topography

The country can be divided into four (4) natural regions:

a. A narrow and fertile marshy plain along the Atlantic coast (Coastal Plain).
b. A white sand belt further inland (Hilly Sand and Clay Region).
c. The dense rain forests (Forested Highland Region) dominating the interior part of the country.
d. The drier savannah areas in the south-west along the Guyana/Brazil border – Interior Savannah.

Climate

The dominant climate in Guyana is a tropical rainforest climate. The rainfall patterns in Guyana are characterized by bimodal patterns in the northern part and unimodal in the south. Here is an overview of these patterns:

1. Long Wet Season (May to August for the South and May to July in the North): During this season, Guyana receives the bulk of its annual rainfall. This period corresponds to the northern hemisphere's summer months when the Intertropical Convergence Zone (ITCZ) shifts northward, bringing moist air from the Atlantic

[1] https://en.wikipedia.org/wiki/Guyana
[2] https://www.britannica.com/facts/Guyana
[3] https://ghsl.jrc.ec.europa.eu/
[4] https://drmkc.jrc.ec.europa.eu/inform-index/

Ocean to the region. This results in frequent, partly persistent, intense, at times heavy, rainfall, often causing flooding in low-lying areas.

2. Short Wet Season in the North (Mid-November to January): Though shorter, higher occurrences of extreme rainfall are observed during this period. During some La Nina years, this seasonal rainfall can extend to the south during the mid-November to January period, typically with very little impacts.

3. Dry Season: The dry season in Guyana usually extends from September to April for Southern Guyana; February to April and September to Mid-November in the North. During this time, the ITCZ moves southward, taking the heaviest rainfall away from the region. The dry seasons are characterized by reduced rainfall and lower humidity levels. While there may still be occasional showers, the amount of precipitation decreases significantly compared to the wet seasons.

It is important to note that these general patterns can vary from year to year based on factors such as El Niño and La Niña events, which can influence weather patterns and rainfall amounts in the region. Additionally, local geographic features can also influence microclimates and rainfall distribution within the country.

The specific amount of rainfall and the exact timing of the wet and dry seasons can vary depending on the location within Guyana.

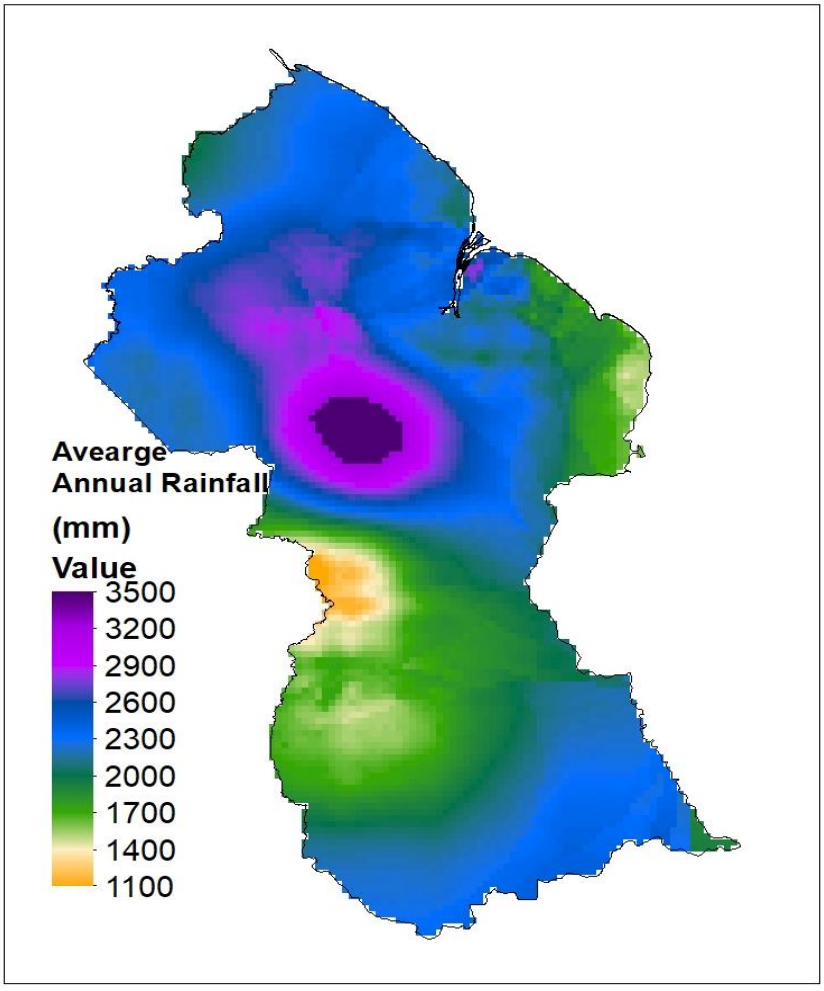


Figure 1. Average Annual Rainfall for Guyana (Source: GHMS)

Mean temperatures vary from 18 to 28°C, however, most of the country experience 25 to 28°C. Mean temperature is cooler during May to July and December to February. The warmest period is between September to November with the peak in October.

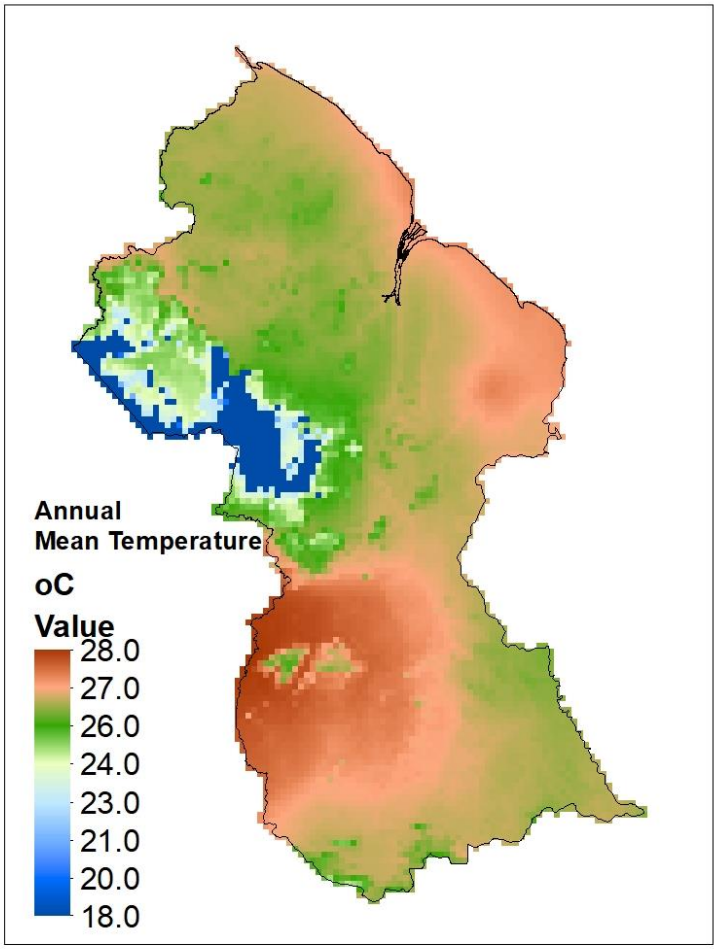


Figure 2. Annual mean Temperature in Guyana (source: GHMS)

The Guyana Hydrometeorological Service (the GHMS)

The Hydrometeorological Service was established on 5 October, 1965. Having been established under the Ministry of Public Works and Hydraulics, the Service changed hands to the Ministry of Agriculture in 1992, and since 2002, has been given a revised mandate under the Water and Sewerage Act (however, as further elaborated, the law does not cover some of the essential and basic responsibilities and activities of a modern NMHS). The collection of rainfall data began as early as the 19th Century, but this was done under the auspices of the various ministries of the British colonial administration and the sugar estates dominating the local economy at the time.

The Department's main responsibility is to monitor and evaluate the weather and water resources in Guyana and to support the government in disaster risk management and aeronautical, water, agriculture, engineering and other activities for socioeconomic development. It is practically the sole governmental provider of weather, water and climate information and related products and services in Guyana.

GHMS provides beneficial outputs to a variety of users, top of the list being agriculture, education and the aviation sector. It also contributes to the World Weather Watch and World Climate Programmes. Services such as climate and weather forecasts, water resources monitoring, high tide alerts, and daily weather forecasts are disseminated via radio, television, newspapers, internet, bulletins and facsimile, even though not covering all of Guyana's territory. GHMS has links with at least two regional institutions: CMO Headquarters' Unit and the Caribbean Institute for Meteorology and Hydrology (CIMH), both being part of the Caribbean Meteorological Organization (CMO).

On the international level, GMHS is well connected with the WMO. It also relates to the International Civil Aviation Organization on matters relating to operational meteorology for aviation. Local weather and monthly climatology are exchanged for international consumption and aviation on the Global Telecommunication System (GTS) and the Aeronautical Fixed Telecommunications Network coordinated by WMO and the International Civil Aviation Organization. In addition, the Hydromet Service is the focal point for the Vienna Convention and the Montreal Protocol through its National Ozone Action Unit.

Most of the employees of the GHMS are working at its headquarters in Georgetown, though the compound does not ideally fit with the number of employees, as well as with the different technical infrastructure GHMS controls.

CHD methodology

This report has been prepared using the methodology described in the 2022 update of the Country Hydromet Diagnostics. An initial desktop review was performed, using information supplied from the Hydrometeorological Service of Guyana, World Meteorological Organization (WMO), and other partners. An in-country visit was then undertaken, followed by report revision and approval. The in-country visit included meetings in the capital Georgetown (coastline), the Cheddi Jagan International Airport (Timehri) as well as visits to Regions 1 (Rainforest area) and 9 (Savannah area), their respective regional capitals, Mabaruma and Lethem, together with visits to several observation sites in these regions, representing different geographic, social and climatic sub-zones.

This document is intended to provide crucial information for the SOFF initiative implementation phase, in which Guyana's involvement is coordinated and supported by GeoSphere Austria together with the Inter-American Development Bank (IDB), as well as informing the ambitious EW4All initiative of the UN. The assessment by GeoSphere Austria has been facilitated by an on-site visit as well as various remote consultations. Following the CHD structure, this report is presented along the ten most critical elements of the hydromet value cycles with an indication of their respective maturity level and some high-level recommendations to help lift up that maturity level, and as mentioned above, with special emphasis on monitoring, forecasting, climate projection and warning systems for climate-related hazards, across timescales.

3 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 Guyana Hydrometeorological Service (GHMS) is a department established under the Ministry of Agriculture of the Co-operative Republic of Guyana. Despite being a part of the Ministry of Agriculture, the main law relevant to GHMS is the Water and Sewerage Act, 2002, in which the role of GHMS with respect to the agricultural sector is very limited. As the name of the law already suggests, it deals mainly with the role of the service in the management of the water resources of the country (thus, somewhat biased to hydrology rather than meteorology), and makes only brief reference to the other roles of a modern NHMS, including those with regard to agriculture. This lack of reference also applies to a great extent to Aviation, Marine, Weather, Climate and Environmental services.

A new and much more comprehensive law, including regulations related to disaster risk management and public weather and climate services, has been under consideration for a few years. Currently, it is still unclear when the law-making process will be concluded and when the bill could be passed on to the national parliament for a vote. Moreover, the current law foresees the creation of a national committee to coordinate and control the water resources management of Guyana, as GHMS as a permanent member, but this body has not been established since the legislation entered into force in 2002. This indicates a lack of law enforcement in a field relevant for GHMS, that comes on top of a dated legal framework for NMHS activities.

The GHMS is both the designated Meteorological Authority as well as the sole provider of meteorological services for the aviation sector in Guyana. It should be mentioned here that national air transportation, although the country is still not fully integrated into the international air traffic networks, is and remains to be an extremely vital, constantly expanding economic factor in the country. This is due to the lack of other transport modes. Moreover, due to the presence of vast underwater petroleum reservoirs in the ocean shelf of Guyana, it can be expected that the importance of the meteorological services for aviation and marine transportation will further increase mid- to long-term. However, the latter service market is still only partially regulated by the Guyanese government. In addition, there is currently no cost-recovery mechanism in place for the meteorological services provide to the aviation sector. In both areas, a regulatory framework is required to secure the needed long-term funding for the NMHS.

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

Currently, there is a strategic plan in action (for the years 2022 until 2026). Its main priorities include improvements of the managerial and institutional setup and arrangements, enhancement of the weather and climate services delivery and a strong focus on the education, training and the capacity building of the staff. A risk management plan exists, but is only partly enforced by the administration. There are annual reports produced regarding its implementation, but there are no fixed and regular meetings of the control committee, indicating a lack of evaluation in this regard.

1.3 Government budget allocation consistently covers the needs of the NMHS in terms of its national, regional, and global responsibilities and based, among others, on cost-benefit analysis of the service. Evidence of sufficient staffing to cover core functions.

The current budget of the GHMS amounts to $3,500,000 a year (last updated in 2022). The budget is covering the salaries of the employees (amounting to 35% of the available funds), the operational costs (50%), investments (1.5%) and others (13.5%, which

includes, among other things, the maintenance of the premises of the headquarters and the operational tower at the Cheddi Jagan International Airport).

A considerable part of the operational costs is dedicated to the operations and maintenance of the country's sole weather radar, located at the international airport. In past years, a large amount of money was spent, unfortunately in vain, in trying to operate and maintain dozens of faulty AWSs that were donated to GHMS. More recently, it was decided to abandon these stations and to start acquiring another type of AWSs, which proved to be much robust in the harsh local conditions prevailing in the hinterland.

However, due to the very limited budget allocated to investments, this endeavor will not be sufficient to solve the challenge of upgrading the station network, which is currently operated mostly manually, into a state-of-the-art automatic one. Additional funds, including those made available through the SOFF initiative, will be required.

While the current budget is sufficient to cover the costs of the salaries of the existing staff, the following observations were made:

a. The GHMS, as elaborated in the following paragraph, is currently heavily understaffed when taking into account its mandate and responsibilities.

b. The salaries offered are far from being competitive, not only in comparison with the local market, but even more with the general Caribbean Market, where Guyanese citizens are eligible to freely move and work. This is the biggest human resource obstacle the GHMS currently faces, since it not only causes a difficulty in finding new and well-qualified employees, but also makes it much harder to keep the experienced ones in-house. This leads to a high staff turnover and a constant loss of well-qualified and well-trained staff.

Taking this into account, the current budget can be qualified as insufficient to secure the needed human resources base.

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 GHMS has mostly well-trained and highly motivated staff. However, in each of the departments, there is a chronic lack of personel. There are only five (5) forecasters, where the minimum required staff should be closer to ten (10). There are nine (9) meteorological technicians, only three (3) hydrologists (for a country, which very name means "many waters"), and six (6) hydrological technicians (for both ground and surface water); there are twenty nine (29) employees for climate services (observers or quality check personel), and thirty-two additional staff (32) for administration, technical support, lab, IT, etc.

Despite the growing importance of the marine zone for Guyana, the GHMS does not have trained people dedicated to this field, as well as no staff available for R&D.

The abovementioned non-competitive salaries make it very hard to keep the existing experienced staff and therefore, there is a continuous issue of brain and experience drain out of the organization.

The only major institute producing these experts for GHMS is to be found outside of Guyana: CIMH in Barbados, of which the GHMS is a member. The CIMH is the main provider of Education and Training in the fields of Meteorology, Hydrology and Climatology in the Caribbean Region. No further educational or training possibilities exist in the country itself.

Currently, the organization has achieved gender balance, with 43 male and 49 female employees.

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

The GHMS was only involved in a handful of internationally funded projects in recent years, including a data rescue project funded by the World Wildlife Fund and completed in 2020, a component of the CREWS initiative completed in 2022, and the PICSA project (Participatory Integrated Climate Services for Agriculture) supported by Reading University, UK.

Overall, these projects did have a positive impact on the work of the GHMS. However, due to the very limited scope of GHMS' participation, there was certainly no sustainable impact of these activities on the whole organization. It is important that the level of engagement in external projects is increased in the medium-term.

Summary score and recommendations for Element 1

The CHD Element 1 score for the "Governance and Institutional Setting" assessed as Maturity Level 3 on the CHD scale, reflecting "Moderately well mandated, managed and resourced and clear plans for, and sufficient capacity to address operational gaps".

Though this score is medium, nevertheless a set of recommendations that should be both realistic and aligned with the current situation of the country should be followed, not only to improve the situation in the future, but also to keep it at least at the current level. Our recommendations are as follows:

a. The most important and urgent issue is working together with the government in substantially increasing the salaries offered to the employees to match local and regional market conditions.

b. To finalize the law-making process and to pass on the new legislation for approval by parliament as soon as possible.

c. To create, together with the government and the Aviation Authority, a cost-recovery mechanism ensuring higher income for the GHMS, as well as creating a better incentive for the GHMS to improve the services provided to aviation.

d. To start a sustainable process of increasing the staff resources, starting with the most urgent areas, namely forecasting and hydrology services, then moving to climate services and technical support, and eventually creating new capacities in the fields of R&D and Marine Meteorology. Better R&D support is a prerequisite for a larger engagement in external projects.

e. To dedicate part of the working time of a person from the administration (or even recruiting a new person for this position) for scanning the different websites of different international institutes for current opportunities of engagement into international projects.

Element 2: Effective partnerships to improve service delivery

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

The GHMS has partnership with different governmental intuitions, but mostly as the GHMS as a provider of forecasts, warnings, etc. and the other institutions function, mostly, as passive recipients of these services/products.

A good example might serve the partnerships with the state-owned cooperative company of Guyana Water Inc., the larger provider of drinking water in the country. Though the GHMS provides services to this company, their provision is not based on any formal arrangement between the two entities.

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

Currently, there are no such partnerships with the private sector. However, there is a wide spectrum of other potential partnerships with the private sector, beginning with the oil sector operating in the offshore oil fields, the public electricity company Guyana Power and Light (GPL), private aviation companies, large agricultural farms, mining companies and the constantly developing tourism sector.

As for a partnership with academia, the only continuous one is with the CIMH in Barbados, but with a single goal of providing training and education for the employees of the GHMS. Here, as well, there is a large potential for creating new partnerships with The University of the West Indies, different universities in the US and Brazil. A major obstacle here is, as already mentioned, the lack of a real R&D capacity inside of the GHMS.

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

Except participation in a few short and medium-term projects, mostly in small parts of them, there is no continuous partnerships of the GHMS with international climate and development finance partners.

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

As a result of the lack of any lasting partnerships, there are no sustained benefits of such partnerships.

Summary score, recommendations, and comments for Element 2

The CHD Element 2 score for the "Effective partnerships to improve service delivery" assessed as Maturity Level 2 on the CHD scale, reflecting "Limited partnerships and mostly excluded from relevant finance opportunities".

Recommendations:

i. Without a proper legal framework in place for GHMS, its responsibilities will not be properly defined and hence, it would be difficult to build upon them any effective partnerships.

ii. The GHMS should enact a proactive policy and initiate meetings with multiple potential governmental and private partners, formalize partnerships through MoUs and working groups, that will tailor specialized existing products. All of this should

be done irrespective of, but considering the currently limited resources and capacities of the GHMS. New partnerships may lead to a stronger political support in strengthening the GHMS, in terms of staff and funds. The GHMS should start from the already existing partnerships, seeking to deepen and strengthen them. Then approach other governmental entities and eventually turn its attention also towards the private market.

iii. Lateron, it is important to create and properly resource a dedicated R&D department, which would enable the development of future products as well as facilitate the establishment of effective partnerships with research institutes inside and outside of Guyana.

iv. To dedicate part of the working time of one of the existing or new employees of the GHMS for scanning the websites of international partners as well as being the focal point for such potential future partnerships.

Element 3: Observational infrastructure

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

Currently, the observational network of Guyana consists of six (6) manual stations and fifty-four (54) AWSs. Taking into account the GBON low-resolution for the country, Guyana should share data from, at least, seven automatic stations. In this regard, the number of stations alone is rather misleading.

Out of the 6 manual stations, only 1 operates 24/7 (the Timehri International Airport Station), a second one operates on a hourly base, but only during daytime (OGLE International Airport), the rest only during daytime and provide observations only once every four hours. With regard to the AWSs, most of which originated from an international project, 45 were of poor quality, became inoperable and are unsalvageable, while 5 are currently non-operational, but salvageable. Only 4 of these stations are currently functional, but they are not located in the most populated areas and do not rely on the original equipment (the original parts had to be replaced by spares from the same vendor).

The reason for this situation is that all of the donated stations were delivered, as it was learnt afterwards, with a technical defect, which, despite all of the efforts and resources invested, remained unresolved. Eventually, the GHMS has decided to abandon these stations and started installing stations from a different producer, which were installed purposely in some of the more difficult locations, in order to assess their longer-term sustainability and operability. The new equipment was found to cope well with the local conditions. However, due to the high costs of these stations and the very limited budget of GHMS for investments, only four were acquired and installed to date. These new stations were installed in different locations from the 6 manual stations, in some of the more rugged locations in the country, in order to assess their ability to cope with the harsh environmental conditions.

In summary, the current observational network of the GHMS is not GBON compliant, except for the Timehri Station. Ogle station, though providing hourly observations, does it only during daytime. Moreover, the GHMS does not operate any upper-air station, although the Service has considered such a station in the future, resources permitting.

3.2. Additional observations used for nowcasting and specialized purposes.

The GHMS has been operating a Doppler S band radar at its facilities at the Cheddi Jagan International Airport since 2009. However, it does not cover the entire country.

Almost no hydrological measurements are established in the country, though water is abundant with rivers and underground water and annual precipitation rates high in most areas.

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

Despite Guyana being non-GBON compliant, the GHMS has established well developed SOPs for the deployment and maintenance of AWSs. GHMS' staff has learnt quite quickly how to deploy, operate and maintain the new AWSs. With adequate funding, the staff is certainly well prepared to continue deploying such stations all over the country. In addition, the GHMS is about to procure a central data management system, which will allow the reception, storage and sharing of data coming from stations. With additional funding (for a calibration lab) and training, the current staff would also be able to calibrate the measurement equipment – as the regional calibration lab at CIMH is not equipped to calibrate the new AWSs in Guyana. As for quality checks, the GHMS has proven capability

for performing QC for its manual stations. With additional training, there should not be a problem to move towards a proper QC for data coming from AWSs.

It should be added that Guyana faces exceptional challenges with its observational network. Most of the country is unpopulated, and it is difficult, sometimes even impossible, to access these large areas, let alone that there is no other infrastructure available. Furthermore, the environmental conditions in most of the country are particularly harsh, and many types of stations available on the market cannot be sustained under these conditions.

With regard to an upper-air station, it needs to be noted that the current staff of the GHMS do not have any experience in operating such a station. However, due to the high professional level of the employees and assuming that there will be adequate training, there should be no irrecoverable issue to operate such stations in the future.

3.4 Implementation of sustainable newer approaches to observations.

None.

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

This question is difficult to answer, as all the AWSs, which were installed in the locations of the old manual (and international stations) were never operational. Most of the other AWSs were never operational and the operational 4 AWSs represent only some parts of the country.

Summary score, recommendations, and comments for Element 3

The CHD Element 3 score for the "Observational Infrastructure" assessed as Maturity Level 2 on the CHD scale, reflecting "Basic network, large gaps, mostly manual observations with severe challenges and data quality issues.".

Recommendations:

a. Currently, the GHMS lacks the funds for a substantial expansion of its Surface Network. In the event that funds become available (perhaps through initiatives such as SOFF, CREWS, etc.), the GHMS should continue acquiring and deploying the current type of stations, already proven to cope with the particular conditions in Guyana.

b. With additional funds, it would be possible to build an adequate calibration lab at the GHMS headquarters that might also serve neighboring countries and regions (such as Suriname, Northern Brazil, etc.)

c. All these steps should be followed with adequate training for the engineers, technicians as well as the staff working on the QC of the data.

d. The same recommendation is made with regard to the single upper-air station required within the country.

e. However, without an adequate visualization tool, available for the entire relevant staff of GHMS (forecasters, climatologists, hydrologists and agrometeorologists) and an easy access to future centralized data management system for all of them, there will be no true on-site benefit of expanding the observational network of the GHMS. Therefore, proper in-house data access and handling needs to be established.

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 centers.

Currently, 6 out of the 8 manual surface stations provide all the required standard parameters, and their data is exchanged internationally (albeit only one of them is operational on a hourly base and 24/7, a second operates on a hourly base, but only daytime and the others only on 4-hourly base and only during daytime). Two additional manual stations (also working on a 4-hourly base and only during daytime) provide all the required standard parameters, except pressure.

Nevertheless, since most of the stations do not work 24/7 and on a hourly base, Guyana is fully non-GBON compliant. No upper-air observations are currently being performed.

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

None.

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

The forecasters use the SmartMet forecaster's station that was especially developed for the GHMS. Through it, they have access to satellite imagery, but also through the websites of NASA and EUMETSAT. They also have access to global models, through their respective websites, but not in their gridded formats. There is also a regional model, based on WRF, run for the GHMS and accessible for the forecasters through the forecaster's station.

Summary score, recommendations, and comments for Element 4

The CHD Element 4 score for the "Data and Product Sharing and Policies" assessed as Maturity Level 2 on the CHD scale, reflecting, "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".

Recommendations:

a. Taking into account the recommendations from the previous element, together with the procurement of a centralized data management system, would ensure that Guyana becomes fully GBON-compliant.

b. In a later step, in case a real R&D capacity would be built up at the GHMS, not only the downloading of the grid files of the global models will become possible, but also their full exploitation for the benefit of the entire relevant staff of GHMS. This could be done through better display options, extrapolation and interpolation of the models' data, post processing of the data and perhaps even operating a nowcasting model, which is quite important under the climatic conditions of Guyana, together with a wave model with a high-resolution.

c. All the relevant staff of the GHMS should have full and easy access to the real-time data as well as the historical data, stored on the central data management system.

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 forecasters of the GHMS have access to the different products of the S-band Doppler Weather radar, as well as the visual results of the runs of global models (GFS, ECMWF) and a regional model (WRF-based, run by CIMH).

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

None.

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

Such forecasts are produced only for aviation purposes, based on the TAFOR code.

Summary score, recommendations, and comments for Element 5

The CHD Element 5 score for the "Numerical Weather Prediction Model and Forecasting Tool Application" assessed as Maturity Level 2 on the CHD scale, reflecting, "Basic use of external model output and remote sensed products in the form of maps and figures, covering only a limited forecast time range."

Recommendations:

a. Further capacity building is required in order to increase the benefits from the already existing products accessible to the forecasters, but this should not be limited only for forecasters, but also provided to any relevant staff members of the GHMS (Hydrologists, climatologists, etc.)

b. If the GHMS hires researchers, it could start developing more advanced post-processing products, based upon the global and regional models, satellite imagery as well as radar imagery.

c. There is no need for pushing towards running models internally, except for: Nowcasting, Marine and especially hydrological models for the main rivers (based upon the runs of the global and regional models).

d. To foster capacity building related to longer-term forecasting and prediction models (monthly and seasonal predictions), which are highly important for a tropical country like Guyana that is affected by sea surface temperature changes and El Nino/La Nina conditions.

Element 6: Warning and advisory services

6.1. Warning and alert service cover 24/7.

The GHMS does operate a fully functioning warning system, but it is mostly limited to certain meteorological hazards (not including hydrological, geological or anthropogenic, for example). The warnings are produced in a standard CAP format and are distributed by email, phone, RSS, and with the help of the media.

However, due to the insufficient number of forecasters and despite their relative high level of expertise, there might be situations, in which, due to a high workload or a long series of shifts, the forecasters (one per shift) is at danger of not recognizing all the possible hazardous situations. Moreover, due to the very limited observational network (and especially, since most of the observations are not provided on an hourly basis, with a longer delay and mostly during daytime), much of the essential immediate data required for issuing accurate warnings is either missing or made available too late.

Another challenge, perhaps of a more evident impact, is associated with the problems revolving around outreach in a country with many very sparsely populated areas, which are not fully covered by telecommunication networks. Thus, the warning might be accurate, issued on time, but it might simply not reach its audience in time.

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

The weather parameters addressed by the abovementioned early warnings are heat waves, drought/dry spells, wind, thunderstorms/squall lines, high seas/rogue waves, rain/wet spells, lightning and a potential for flash floods. Unfortunately, due to lack of staff, these warnings are not passing any verification or validation (except the ones for aviation, but also on a partial scale). Moreover, no information is gathered systematically from the end users regarding their level of satisfaction regarding the warnings, unless it is made per event and ad hoc.

In addition, due to the limited observational network, no sufficient hydrometeorological data could be collected to be verified against the warnings issued.

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.

None.

Summary score, recommendations, and comments for Element 6

The CHD Element 6 score for the “Warning and Advisory Services” assessed as Maturity Level 3 on the CHD scale, reflecting "Weather-related warning service with modest public reach and informal engagement with relevant institutions, including disaster management agencies”.

Recommendations:

a. Like elsewhere, it is mandatory to upgrade the observational network (both meteorological and hydrological), so that it could provide real-time accurate hourly observations, both for forecasts/warnings as well as their post-event verification and validation.

b. Without enlarging the number of forecasters, additional hazards or multi-hazard advice could not be dealt with properly.

c. An additional, dedicated person should be hired for verification/validation.

d. The Hydrological department (especially for surface water) should be significantly strengthened, so that it could provide much more information regarding hydrological hazards, which are by far the most relevant hazards for Guyana in terms of impact (including measurements, but also hydrological models for the basins of the main water systems of Guyana, including a verification system for these).

e. The forecasters should undergo additional capacity building and training, enlarging their use of the different already available tools provided by the Global and Regional Centres.

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 current climate services of the GHMS are solely based on the data from the eight (8) manual stations, out of which seven (7) are operational only during daytime and six (6) with observation intervals of 4 hours. Thus, these stations do not provide an accurate description of the diurnal change. Moreover, large parts of the country are not properly or not at all represented by these stations. The historical data is partially still found only in paper form, which makes it much less accessible for its immediate users.

The GHMS produces basic climatological products, as well mapped rainfall, temperatures, wet days, wet spells, dry spells, Heat Indices and drought climate products. In addition, there are gridded rainfall, temperatures and drought information. All of these were performed without a special treatment of extreme values, although considering homogenization issues.

As for future climate, the GHMS does issue seasonal forecasts since 2017 and is planning to commence producing climate predictions in the near future, through an on-going project with the Cuban Meteorological Service. However, its main client, the national committee for climate change, meets quite rarely and its information requests from the GHMS are done only on an ad-hoc basis.

Summary score, recommendations, and comments for Element 7

The CHD Element 7 score for the "Contribution to Climate Services" assessed as Maturity Level 2 on the CHD scale, reflecting " Basic Capacity for Climate Services Provision".

Recommendations:

1. The central data management system, based on Clidata, should be strengthened, with easy access to all of the climatologists, together with modules for QC and homogenization.
2. The entire data archive should be digitalized and fed into this system.
3. The system should also be able to host the AWSs data archive, to be kept separately from the manual network.
4. The relevant staff should have further training regarding this system, so they could exploit its benefits fully.
5. The climatological department should become more pro-active and initiate contact with potential long-term partners. The aim is to establish properly formalized and effective partnerships with them.
6. With a gradual upgrade of the stations network to AWSs, working 24/7 on a hourly base, with time, a more representative picture of Guyana's climate could be created, especially these climatic parameters related to the diurnal cycle.

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.

Though Hydrology is also established under the GHMS umbrella (as its name implies), the capacity of this department is quite low. There is a lack of adequate personnel (the existing personnel has relatively little experience with hydrology), no specialized hydrological measurement equipment, no rain gauges, to name the most important deficits. Though Guyana has a large number of rivers and other water bodies, the current knowledge level about its different rivers, water bodies and ground water aquifers is still extremely limited.

One positive exception is the Water Quality lab of the GHMS, which has started in the last few years to perform periodical water quality tests in fixed places. As the Guyanese Water management relies mostly on usage of surface water, these tests might provide a valuable contribution to the wellbeing of the citizens of the country.

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

As abovementioned, Hydrology and Meteorology sit under the same umbrella. However, in addition to the low capacity of the hydrological unit, the unit has limited access to the meteorological observational data, and does not receive data on a real-time basis. As for the forecasting department – due to the current low capacity of the hydrology department, the latter cannot contribute much to developing additional tools for flooding forecasts.

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

As Hydrology sits under the same umbrella, there should be a full access established for the entire data base for all of the experts at GHMS, which is not the case now. Thanks to WMO assistance, a MCH database was installed at GHMS and is in full use. Though it seems that some other entities in Guyana do operate some measurements (though mostly not on a continuous basis), there is no official agreement for such an exchange, though it might occur from time to time, due to personal and informal contacts.

As for international exchange – there were already discussions within the region for a data exchange in the framework of the countries sharing the Amazonas basin, especially with Brazil (having the more advanced hydro-meteorological network), but due to different reasons, this did not mature into a formalized agreement and moreover into a continuous practice.

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

Except the abovementioned initiative under the Amazonas Basin countries framework, there was no other related project or initiative. The GHMS has collaborated with the National Drainage and Irrigation Authority on a number of projects for the instrumentation of the East Demerara Water Conservancy (EDWC) and canals around Georgetown. All of the instruments installed under such projects have been handed over to the GHMS for its operation and maintenance. These stations are in the EDWC and around Georgetown.

Summary score, recommendations, and comments for Element 8

The CHD Element 8 score for the "Contribution to Hydrology" assessed as Maturity Level 2 on the CHD scale, reflecting " Meteorological input in hydrology and water resource management happens on an ad hoc basis and or during times of disaster".

Recommendations:

a. As mentioned above, there are two acute challenges that GHMS has to tackle – expanding the surface stations network based on AWSs, as well recruiting and preserving a staff to carry these tasks. Currently, the Hydrology Department is much understaffed.

b. The hydrologists should undergo a comprehensive capacity building and training program, allowing them, first of all, to learn how to maximize their use of internationally available data sources.

c. Slowly and gradually, it is essential to start expanding the hydrological observational network, starting from the main river, the Essequibo river. At a later stage, together with adequate advisory, start implementing hydrological models for these rivers.

d. An additional capacity training is required, providing the Guyanese Hydrologists with sufficient tools and know-how to create the basic hydrological products, which are extremely important in this water-rich country.

Element 9: Product dissemination and outreach

9.1. Channels used for user-centered 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 GHMS uses multiple channels to communicate its products, especially forecasts and warnings. The GHMS has a fully dedicated press officer, who is working hand-in-hand with the different TV and Radio governmental and private, national and regional stations. Though the GHMS does not operate its own radio/TV production facility, it is quite visible at the different media channels, including social media. However, due to the very limited forecaster's staff, it is virtually impossible to send them to present the GHMS in the media, so the actual number of people from the GHMS who are available for media broadcasts is quite limited.

At the same time, the GHMS disseminates products and warnings through SMS, dedicated WhatsApp and Viber groups and through local government authorities, email and phone. However, one should keep in mind that large parts of the country are experiencing only a partial to very limited access to internet, TV, radio or even basic cellular networks. Then the GHMS makes use of words of mouth, megaphones, very localized radio transmissions, local information agents and so on. This situation causes very often substantial delays of critical information, which simply does not arrive on time to the relevant public or users.

9.2. Education and awareness initiatives in place.

Education and awareness initiatives are generally performed on an ad-hoc basis. A good exception is the PICSA project, in which the Agrometeorology department of the GHMS has worked together with a selected group of farmers to strengthen their understanding of the benefits arriving from a proper use of meteorological and agrometeorological information. This group (and other groups) has benefited much from this initiative, but due to budgetary and especially staff constraints, it could only cover a limited number of farmers.

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

There are some initiatives, especially related to education of the indigenous population of Guyana, but due to multiple reasons (the staff is mostly located in Georgetown, the targeted population in remote areas, lacking sufficient internet networks), lack of sufficient staff and funding limitations, such initiatives are only short-term and on an ad-hoc basis.

There are also school visits to the facilities, but since many schools are located far from the headquarters, they are mostly limited to schools located in and around Georgetown. No current outreach to the Spanish-speaking minority, which numbers are growing due to the situation in neighboring Venezuela. In addition, mostly in the hinterland, reside citizens belonging to 9 indigenous nations with 9 separate languages – these do not receive services in their respective language, currently. The same goes to the population requiring sign language.

Summary score, recommendations, and comments for Element 9

The CHD Element 9 score for the "Product Dissemination and Outreach" assessed as Maturity Level 3 on the CHD scale, reflecting, "A moderately effective communication and dissemination strategy and practices are in place, based only on in-house capabilities and supported by user-friendly website.".

Recommendations:

a. An increase in the number of forecasters is required to adequately respond to the needs of the media.

b. Other dissemination methods should be explored, such as cell broadcasting.

c. A Spanish-speaking person should be recruited, to provide support with dissemination of the information in the Spanish language. Also, people able to provide support with the indigenous languages as well as with the sign language.

d. Perhaps together with CIMH in Barbados, GMHS could initiate an education program through which teachers from all around Guyana could be brought to Georgetown or one of the regional capitals for dedicated short-term workshops. In such workshops, the experts from GHMS and others could strengthen their knowledge in relevant topics, which might be later added to the education programs, especially in anything related to DRR.

e. Additional, sustainable funding should be found for PICSA so that this initiative could be expanded.

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 GHMS is a member of a national committee coordinating DRR activities. However, this committee becomes active only during and after major events, but much less dealing with preventive activities. Apart from this committee, there are basically no other formalized platforms for user engagement, which is being performed only on an ad-hoc basis, through personal contacts and communication, social media or irregular meetings with different entities.

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

Such were performed in the past, but not anymore. Partially, it was done in the past through the PICSA project.

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

The GHMS is developing a QMS for aeronautical meteorology, conforming to ISO 9001:2008 standard, but not in any other field it is engaged in, or as a whole, as an organization.

Summary score, recommendations, and comments for Element 10

The CHD Element 10 score for the "Use and National Value of Products and Services" assessed as Maturity Level 2 on the CHD scale, reflecting, "Service development draws on informal stakeholder input and feedback".

Recommendations:

a. The different heads of the different departments should become more involved in the national committee for DRR activities, according to the different events dealt with. Moreover, they should be encouraged to initiate creation of additional platforms (and later to formalize them) with different stakeholders by connecting them directly. They should report on a monthly basis, during management meetings, about the feedback they got in these platforms. At a later stage, it would be advisable to engage more of the professional staff in these platforms. In cases, when such platforms are non-sustainable, to constantly initiate meetings with stakeholders from the different sectors. As more stakeholders will be invited and more often, some of them are likely to become more engaged in providing the GHMS with beneficial feedback.

b. One person from the administration should be dedicated to user and customer relations, conducting yearly general surveys and specialized surveys and to communicate on a constant base and in a structured way with the main stakeholders. The more such structured exchanges will happen, the more information will be derived.

c. To contact CARICOM (the Caribbean Community Regional Organization for Standards and Quality) with the request of supporting the GHMS in becoming fully an ISO-certified institute.

Annex 1 Consultations (including experts and stakeholder consultations)

GHMS:

Name	Unit	Role
Garvin Cummings	Management	Chief Hydromet. Officer
Dwayne Lanferman	Agrometeorology	Agrometeorologist/Head
Komalchand Dhiram	Climatology	Specialist Meteorologist
Sharonda Agard	Water Quality Laboratory	Hydro-Chemist/Head (ag.)
Colis Allen	Surface Water Department	Specialist Hydrologist
Frank Grogan	Groundwater Department	Specialist Hydrologist
Haymawattie Danny	Management	Deputy Chief Hydromet Officer/ GIS Manager
Ron Deonandan	Telecommunications Department	Electrical Engineer (Automatic Weather Station Network)
Gavin Williams	Telecommunications Department	Electrical Engineer (Radar)
Satesh Nanlall	National Weather Watch Center	Meteorologist
Kezra Boyal	Management	Public Relations Officer

Stakeholders:

Title	Name	Organization	Role
Lt. Col. (Ret'd)	Egbert Field	Guyana Civil Aviation Authority	Director General
Mr.	Troy Clarke	Maritime Administration Department	Hydrographic Surveyor/ Acting Ports Director
Ms.	Tiffany Hoenkirk	Maritime Administration Department	Legal Advisor
Mr.	Nigel Kamrouz	Maritime Administration Department	Director of Finance
Captain	John Flores	Maritime Administration Department	Operations Officer
Ms.	Delma Nedd	Ministry of Agriculture	Permanent Secretary

Mr.	Adrian E. Bassier	Guyana Civil Aviation Authority	Director Aviation Safety & Security
Ms.	Denise Woolford	Guyana Water Incorporated	Manager of Water Resources and Climate Change Adaptation
Ms.	Angela White	Guyana Water Incorporated	Hydro Engineer
Dr.	Narine Singh	Ministry of Health	Chief Medical Officer
Lt. Col.	Hubbard Rodney	Guyana Defence Force	Head of Financial Department
Mr.	Damion Shiwcharan	Guyana Energy Agency	Hydropower Support Engineer
Mr.	Jagnarine Singh	National Agricultural Research and Extension Institute (NAREI)	Chief Executive Officer
Dr.	Dwight Walrond	Guyana Livestock Development Authority (GLDA)	Chief Executive Officer
Mr.	Badrie Persaud	Guyana Rice Development Board (GRDB)	General Manager
Mr.	Sasenarine Singh	Guyana Sugar Corporation Inc	Chief Executive Officer
Captain	Learie Barclay	Roraima Airways Inc.	Director of Operations/ Pilot

Annex 2 Urgent needs reported

As mentioned in the executive summary:

a. Non-competitive salaries
b. The absence of a comprehensive law for the activities of GMHS (in process for quite a long time)
c. Insufficient number of weather stations, providing hourly quality observations
d. Almost non-existing hydrological observation network
e. A large potential for effective partnerships with governmental, international and private entities.

Annex 3 Information supplied through WMO

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

Annex 4 List of materials used

1. Country Hydromet Diagnostics, published by WMO, 2023
2. CHD Operational Guidance for SOFF, 2023
3. Guyana Hydrometeorological Service – National Strategic Plan & Framework for Weather, Water and Climate Service 2022 – 2026, December 2021
4. Guyana Water and Sewage Act, 2002
5. Different Bulletins (Agrometeorology, Drought, etc.), Forecasts and Warnings of the Hydrometeorological Service of Guyana from 2023

Annex 5 List of Abbreviations

Abbreviation	Full Name
ASL	Above Sea Level
AWS	Automatic Weather Stations
CHD	Country Hydromet Diagnostics
CREWS	Climate Risk and Early Warning Systems
ECMWF	European Centre for Medium-range Weather Forecasts
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
EW4all	Early Warnings for all
FAO	Food and Agriculture Organization
GBON	Global Basic Observing Network
GDPFS	Global Data processing and Forecasting System
GHMS	Guyana Hydrometeorological Service
GISC	Global Information System Centre
ICT	information and communication technologies
IDB	Inter-American Development Bank
NASA	The National Aeronautics and Space Agency (USA)
NCAR	National Center for Atmospheric Research
NMHS	National Meteorological and Hydrological Service
NWP	Numerical Weather Prediction
OECD	Organization for Economic Co-operation and Development
PICSA	Participatory Integrated Climate Services for Agriculture
RTC	Regional Training Centre
RTH	Regional Telecommunication Hub
SOFF	Systematic Observation Funding Facilities
SSCAA	Civil Aviation Authority of South Sudan
SSMS	South Sudan Meteorological Department
TAFOR	Terminal Aerodrome Forecasts
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
WFP	World Food Programme
WMO	World Meteorological Organization