Systematic Observations Financing Facility

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GBON National Contribution Plan of Ecuador

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Weather and climate data for resilience

GBON National Contribution Plan
Ecuador

SOFF beneficiary country focal point and institution	Bolivar Erazo, Executive Director Instituto Nacional de Meteorología e Hidrología "INAMHI", Ecuador
SOFF peer advisor focal point and institution	Leading Peer Advisor: Marcel Haefliger, Federal Office of Meteorology and Climatology MeteoSwiss, Switzerland (hereafter MeteoSwiss) Supporting Peer Advisor: Servicio Meteorológico Nacional Argentina (hereafter SMN)

Management Summary

The GBON National Contribution Plan for Ecuador outlines a detailed strategy to meet the Global Basic Observing Network (GBON) standards established by the WMO. Key components include:

1. **Current State Assessment**: Identification of existing gaps in the national meteorological network, highlighting deficiencies in data collection and infrastructure.
2. **Infrastructure Upgrades**: Plans to modernize and expand weather stations and related facilities to enhance data accuracy and coverage.
3. **Capacity Building**: Training programs aimed at improving the skills of meteorological staff and fostering institutional growth.
4. **Sustainability and Maintenance**: Strategies for ensuring the long-term functionality and upkeep of upgraded systems.
5. **Compliance and Integration**: Steps to align national observation practices with international standards and improve data sharing with the global meteorological community.

The plan emphasizes a comprehensive approach to strengthening Ecuador’s meteorological capabilities, ensuring robust and reliable weather and climate data collection.

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Module 1. National Target toward GBON Compliance

Ecuador is divided into three continental regions: the Costa (Pacific Coastal Region), Sierra (Andes Region) and Oriente (Amazon Region). In addition, there is one insular region: the Galapagos Islands. While there are a large number of stations in the Coastal and Andes regions, there are fewer stations in the Amazon region for logistical reasons. According to the results of the Global Core Observation Network Global Gap Analysis for Ecuador (ref. 18876/2022/I/WIGOS/ONM/GBON), and considering a land area of 256,370 km^2, Ecuador should have at least 7 surface stations (in a 200 km grid density scenario). In terms of upper-air observation stations, there should be at least two in operation in Ecuador. Considering the location of the Galapagos Islands, an additional surface station as well as an additional upper-air station are justified. This was acknowledged by the WMO Technical Authority (WMO TA), which has approved an additional surface and one upper-air Station. The Global Gap Analysis did not take into account the geographical separation of the Galapagos Islands from the mainland.

Table 1: GBON National Contribution Target

Type of station	WMO GBON Global Gap Analysis, June 2023				GBON National Contribution Target	
	Target	Reporting	Gap		To improve	New
			To improve	New		
	[# of stations]				[# of stations]	
Surface	7	0	7	0	7	1
Upper-air	2	0	2	0	2	1
Marine	*when applicable					

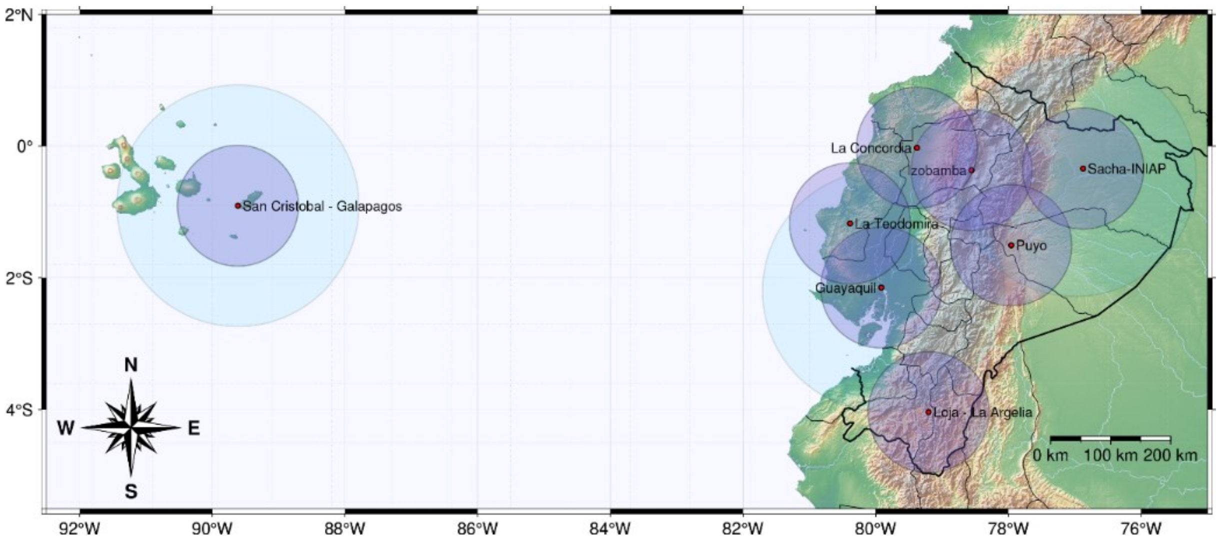

Figure 1: Map of existing and proposed surface and upper-air stations with 200 km/500 km (diameter) circles. The station Sacha-INIAP is a new location, all other stations are already existing.

Given the potential of the installed capacity, it is important to consider the future inclusion of additional surface stations in the GBON network as a possible scenario.

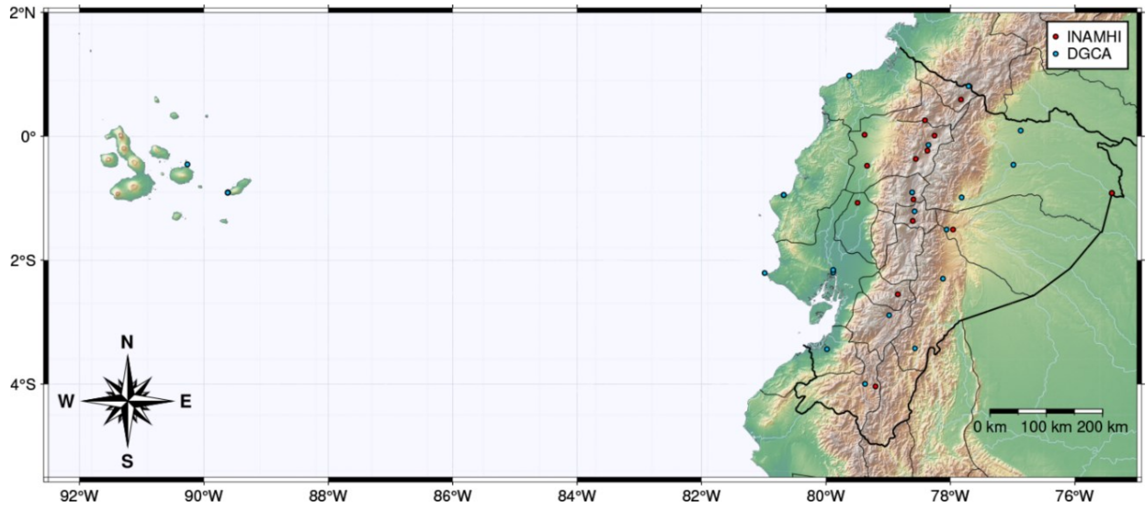

Figure 2: Existing surface observation and upper-air stations, some of which may be included in the GBON network at a later step in addition to the selected stations (see Module 3).

In order to achieve GBON compliance, it is recommended that the proposed actions be implemented in three steps. The first step is to upgrade the selected and already existing surface observation stations and to disseminate the data in the GBON network (using WIS2.0). In a second step, the construction of a new surface observation station (Sacha-INIAP) will be realized by INAMHI. Depending on the available human resources, this can be done in parallel to the first step.

The third step proposed is the construction and installation of the infrastructure of the three upper-air stations. This is likely to be the most resource-intensive phase of the activities. The reason for this is that some of the existing hardware is outdated and no longer operational and the stations need to be completely rehabilitated.

One goal is a quick win with the rapid realization of the distribution of data in the GBON network within one year. The second focus is on the construction and operation of the upper-air stations within 3 years. In addition, other already existing surface observation stations can also be integrated into the GBON network.

Module 2. GBON Business Model and Institutional Development

2.1. Assessment of national governmental and private organizations of relevance for the operation and maintenance of GBON

Ecuador is a member of WMO since 6 July 1951. INAMHI (Instituto Nacional de Meteorología e Hidrología) is the technical-scientific institution responsible for the production and dissemination of hydro-meteorological information in Ecuador. This information serves as a basis for the formulation and evaluation of national and local development plans, as well as for conducting its own research or that of other stakeholders. The services of INAMHI contribute to the daily lives of the population and the strategic sectors of the economy.

INAMHI is a governmental institution affiliated to the Ministry of Environment and Water and provides Public Weather Services based on the national law of the National Institute of Meteorology and Hydrology (Registro Oficial No. 839, May 25, 1979). It is the governing, coordinating and standardizing body of national policy in all matters related to meteorology and hydrology, and has to maintain and operate the basic network of hydrometeorological stations in Ecuador.

There exist partnerships with other government institutions for service delivery. There are numerous agreements signed with Decentralized Autonomous Governments and with Universities and Institutes (Corporación Eléctrica del Ecuador CELEC; Dirección General de Aviación Civil, DGAC) for the provision of services and exchange of information. INAMHI receives data from other government agencies that have their own observation infrastructure, such as data from hydrometeorological stations. Some of the agreements are out of date and need to be renegotiated.

Table 2: Governmental stakeholders in Ecuador who operate and acquire meteorological observations or have the potential to support the Global Basic Observing Network (GBON).

Stakeholder	Role	Potential GBON support
Instituto Nacional de Meteorología e Hidrología (INAMHI)	The national agency responsible for meteorological and hydrological observations, forecasts, and research.	Leading the implementation, operation, and maintenance of GBON stations.
Dirección General de Aviación Civil (Directorate General of Civil Aviation)	Technical institution that guarantees the safety and security of aviation by providing quality services for the sustainable development of air transport in the country.	Uses meteorological data for aviation meteorological services.
Ministerio del Ambiente, Agua y Transición Ecológica	Manages environmental policies, water resources,	Provides policy support, funding, and integration of

Stakeholder	Role	Potential GBON support
(Ministry of Environment, Water and Ecological Transition)	and ecological transition strategies.	meteorological data into environmental monitoring.
Secretaría de Gestión de Riesgos (Secretariat for Risk Management)	Responsible for disaster risk management, including monitoring natural hazards and coordinating emergency response.	Utilizes meteorological data for risk assessments and early warning systems, potentially funding and advocating for GBON.
Corporación Eléctrica del Ecuador CELEC - EP (Public Company Ecuadorian Electric Corporation)	Responsible for hydroelectric generation in the country.	Its different business units have meteorological observation networks. They have a budget to manage these stations. They require calibration services from INAMHI.
Ministerio de Agricultura y Ganadería (Ministry of Agriculture and Livestock)	Oversees agricultural policies, including climate-smart agriculture practices.	Incorporates meteorological data into agricultural planning and supports the installation of agrometeorological stations.
Ministerio de Transporte y Obras Públicas (Ministry of Transport and Public Works)	Manages transport infrastructure and public works projects.	Integrates weather data into infrastructure planning and maintenance, supporting GBON through collaborative projects.
Instituto Geofísico de la Escuela Politécnica Nacional (Geophysical Institute of the National Polytechnic School)	Conducts research and monitoring of geophysical phenomena, including seismic and volcanic activity.	Collaborates on integrated monitoring systems, sharing data and resources for enhanced observational capabilities.
Ministerio de Energía y Recursos Naturales No Renovables (Ministry of Energy and Non-Renewable Natural Resources)	Manages energy resources, including renewable energy initiatives.	Uses meteorological data for energy production optimization and supports the establishment of meteorological stations near energy projects.

In the long term, closer cooperation with universities like Universidad San Francisco de Quito (USFQ), Universidad Central del Ecuador (UCE) or Escuela Politécnica Nacional (EPN) should be intensified. Research collaborations, data analyses and educational programs that support meteorological observations are possible. The Corporación Eléctrica del Ecuador (CELEC) appears to be the most promising potential partner for closer, mutually beneficial cooperation.

To ensure effective collaboration and support for GBON, INAMHI could consider the steps in the following table.

Table 3: Steps for a collaborative approach with the governmental stakeholders.

Step	Action
Stakeholder Mapping and Engagement	Organize stakeholder workshops and meetings to discuss the GBON initiative and explore collaboration opportunities.
Memorandums of Understanding (MOUs)	Establish MOUs with key stakeholders to formalize commitments and define roles and responsibilities.
Integrated Data Sharing Platforms	Develop centralized data sharing platforms to facilitate the exchange of meteorological data among stakeholders.
Joint Funding Proposals	Collaborate on funding proposals to national and international funding bodies, leveraging the collective strengths of the stakeholders.
Capacity Building and Training	Conduct joint training programs to build technical capacity across institutions, ensuring the sustainability of the GBON network.
Public Awareness Campaigns	Raise awareness about the importance of meteorological observations (and the GBON initiative) through public campaigns and educational programs.

By engaging the governmental stakeholders and fostering a collaborative approach, INAMHI can enhance its meteorological observation network and effectively support the implementation and sustainability of GBON.

In addition to INAMHI, a few private companies also operate local networks. To satisfy quality specifications, they are obliged to comply with the established criteria for sensor calibration. A lack of resources on the part of both the private companies and INAMHI has resulted in the stations remaining unevaluated. As a result, it is challenging for private companies to support the GBON compliance strategy and contemplating a potential partnership.

2.2. Assessment of potential GBON sub-regional collaboration

ENANDES+ (Enhancing Adaptive Capacity of Andean Communities through Climate Services) is a regional initiative consisting of financial contributions from the Swiss Agency for Development and Cooperation (SDC, Spanish: COSUDE) and the Adaptation Fund (AF), and marks the scaling up of a previous successful national effort to the Andean region.

The SDC contribution (CHF 5.8 Mio. for 4 years) supports four Andean countries (Argentina, Bolivia, Ecuador and Peru) with targeted weather, water and climate services for better adaptation and increased resilience to climate variability and change, and thus directly contributes, among other, to the UN's Early Warning for All initiative, aimed at expanding access to early warning systems and facilitating proactive measures.

A key objective of ENANDES+ is to develop capacities and knowledge within regional networks that bring together local experts in the fields of meteorology, hydrology, climate, and training services. This endeavor is facilitated through a cutting-edge virtual platform known as the

"Núcleo Regional de Experticia" (NUREX). Importantly, NUREX is designed to seamlessly integrate with pre-existing regional networks.

The ENANDES+ long term objective is to support economies, productive sectors and communities of four Andean countries to better adapt and become more resilient to climate variability and change thanks to the use of improved weather, water and climate services and information. To reach this objective, interventions are planned to increase technical, institutional, socio-economic, and human capacities.

MeteoSwiss will enhance the technical capabilities of National Meteorological Services and Regional Climate Centres to produce and communicate weather, water, and climate information. It will improve institutional standing and co-design new tools to turn this information into actionable knowledge. The end goal is to strengthen National Meteorological Services to tackle the challenges posed by climate variability and change.

A functioning surface and upper-air observation network which mostly complies with GBON standards, is an important prerequisite and basis for ENANDES+.

2.3. Assessment of a business model to operate and maintain the network

The regular annual operating budget of INAMHI is approximately USD 2 Mio, which is consistent with the budgetary allocations of the previous four years. Furthermore, INAMHI has been promised an additional USD 1.2 Mio for investment projects in 2024 and 2025. It is not yet clear when and in what amounts this will be paid out.

This renders the planning and implementation of projects more challenging. In addition, important research and development work is carried out in the form of projects, which often leads to unsustainable solutions as no funding is provided for transfer into operations. Project staff are often only hired on a temporary basis, which can lead to a loss of knowledge and experience. Considerable additional resources are required to meet the requirements of the NCP and the national development plan "New Ecuador". INAMHI faces challenges to identify the shortfalls in funding for critical operations or projects and fill the funding gaps.

Besides government funding, additional resource fundings are possible:

- International grants and aid:
  - World Bank: Grants or loans for projects related to climate resilience and disaster risk management.
  - Inter-American Development Bank (IDB): Funding for regional meteorological projects and capacity building (SOFF funding).
  - Global Environment Facility (GEF): Financial support for environmental and climate-related initiatives.
  - United Nations Development Programme (UNDP): Support for sustainable development and climate adaptation projects.

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[1] See chapter 4 of the Operational Guidance Handbook on SOFF private sector archetypal business models

- Project specific funding:
    - International Partnerships: Collaborations with international meteorological organizations, universities, and research institutes that provide financial support for specific research and development projects.
    - Non-Governmental Organizations (NGOs): Funding from environmental and climate-focused NGOs for specific initiatives.
- Service fees and commercial revenue:
    - Consulting Services: Revenue from providing consulting services to private companies and government agencies.
    - Data Sales: Fees from selling meteorological data to businesses, researchers, and other stakeholders are not an option.[2]

In light of the reliability of existing government processes, the existing expertise of INAMHI, its legal mandate, and the lack of private sector operators in Ecuador, the optimal and recommended business model at the time is the public model (INAMHI as a public institute).

It is assumed that a public approach will ensure a more sustainable approach beyond SOFF activities, despite the lack of resources for some operational tasks and projects. However, there is a possibility that the private sector could play an important role in the future in supporting INAMHI's functions, but this needs further clarification.

Based on the SOFF business models for the private sector, a description of recommendations for a business model to operate and maintain the GBON infrastructure for INAMHI follows, including financial planning and identification of potential operators from the private sector.

Table 4: Public-Private Partnership (PPP) Model to Operate and Maintain the GBON Infrastructure

Description	Key Features	Recommendations
A Public-Private Partnership (PPP) is a cooperative arrangement between INAMHI and private sector entities for the operation and maintenance of GBON infrastructure. This model leverages the expertise and efficiency of the private sector while ensuring public oversight and strategic alignment with national priorities.	• Establish long-term contracts (10-20 years) with private operators to ensure continuity and sustained investment. • Implement performance-based payment structures where private partners are compensated based on meeting specific operational and service quality benchmarks. • Both INAMHI and private partners contribute to the initial investment and ongoing	• INAMHI retains ownership of the GBON infrastructure and sets strategic objectives, regulatory frameworks, and performance standards. • Private sector operators handle day-to-day operations, maintenance, and technological upgrades under a performance-based contract.

[2] With the proviso that the WMO Unified Data Policy regarding free access to core data should be respected. (see https://wmo.int/wmo-unified-data-policy-resolution-res1)

Description	Key Features	Recommendations
	maintenance costs, reducing the financial burden on the government.	

The following table gives an overview of examples of potential private sectors operators.

Table 5: Potential private sectors operators supporting maintaining a robust GBON network.

Private Sector Operators	Examples of Possible Companies present in Ecuador[3]
Technology and Infrastructure Companies	• Siemens AG: Expertise in smart infrastructure and IoT (Internet of Things) solutions for environmental monitoring. • Vaisala: Specializes in weather, environmental, and industrial measurement solutions, providing high-quality sensors and monitoring systems. • Sutron Corporation: Offers integrated systems for hydrological and meteorological data collection and analysis.
Telecommunication Companies	• Telefónica Ecuador: Capable of providing communication infrastructure for data transmission from remote GBON stations. • Claro Ecuador: Another major telecom provider that can offer robust and reliable connectivity solutions.
Renewable Energy Companies	• Acciona Energia: Expertise in providing renewable energy solutions to power remote monitoring stations sustainably. • Solaris Energy: Specializes in solar power installations that can ensure energy independence for remote meteorological stations.
Consulting and Engineering Firms	• AECOM: Provides comprehensive infrastructure and environmental services, including project management and technical consulting. • Arcadis: Specializes in sustainable infrastructure solutions and can offer consultancy on optimizing GBON infrastructure.

The next table gives an overview of a possible financial plan for operating the GBON compliant modernized infrastructure, considering following cost components[4]:

[3] These companies were found through a quick internet search. The author or MeteoSwiss have no relationship with these companies.

[4] World Bank, 2022. Charting a Course for Sustainable Hydrological and Meteorological Networks in Developing Countries. Washington, DC: World Bank. License: Creative Commons Attribution CC BY 3.0 IGO

- Initial Capital Expenditure (CapEx): Costs for setting up new GBON stations and upgrading existing ones, including equipment, installation, and commissioning.
- Operational Expenditure (OpEx): Ongoing costs for running and maintaining the infrastructure, including salaries, maintenance, energy, and communication expenses.
- Total Cost of Ownership (TCO): The combined cost of CapEx and OpEx over the lifespan of the infrastructure (typically 7-10 years for observation station, 20 years for upper-air).

Table 6: Possible Financial Plan for Operating the Modernized Infrastructure.

Planning steps	Financial Plan
Investment Phases	• Initial Phase: this phase is focused on meeting GBON compliance requirements, funded by IDB. This phase covers the initial setup and essential upgrades. • Operational Phase: Long-term operation and maintenance, funded through a combination of government budget allocations and IDB funds.
Revenue Streams	• Government Funding: Core funding from national budget allocations for INAMHI. • Service Fees: Fees from customized weather services. • Grants and International Aid: Continuous application for grants from international organizations like the World Bank, GEF, and UNDP. • Public – Public Partnership Revenue: Agreements with public companies in charge of hydroelectric generation and public water companies for basin monitoring, in which financial resources are transferred to INAMHI to operate stations and report these to GBON, to improve climate forecasts and estimates in the basins.
Financial Sustainability Plan	• Initial Setup (Years 1-5): Utilize SOFF financial support to cover up to 50% of CapEx, with the remaining 50% sourced from government funds and private investments. • Mid-Term (Years 6-15): Transition to full operational capacity with private partners handling maintenance under performance-based contracts. Generate additional revenue through service fees and consulting services. • Long-Term (Years 16-25): Ensure sustained financial health through diversified revenue streams, efficiency improvements, and regular updates to the infrastructure.

2.4. Assessment of existing national strategies and projects related to observing networks

As of February 16, 2024 Ecuador approved the 'Development Plan for the New Ecuador 2024-2025'. INAMHI is currently in the process of aligning its strategic plan with the national plan. INAMHI's services will contribute to the preservation of ecosystems, adaptability to climate change, extreme weather event, droughts, floods and other disasters. The aim of the National

Development Plan is to create sustainable food production systems and resilient agricultural practices that increase productivity and production by 2030.

A number of planned hydromet development projects aimed at enhancing environmental monitoring capabilities and fostering community resilience in Ecuador exist. Among them are following projects:

- Strengthening the National Multi-Hazard Early Warning System: This project seeks to mitigate the potential impact of natural disasters such as floods, landslides, tsunamis, and volcanic eruptions by providing accurate early warning information and fostering community resilience.
- Hydrology and Geodynamics of the Amazon Basin: Aims to support sustainable development by providing timely hydro-meteorological information and conducting research to enhance community safety and promote economic growth
- Improving Adaptive Capacity of Andean Communities through Climate Services (ENANDES+): This project enhances the resilience of Andean communities against hydroclimatic hazards by improving access to weather, water, and climate services.

It is important that INAMHI defines long-term strategic and sustainable goals that go beyond the year 2030. The vision should include the path to a sustainable organization and services as an elementary component. The formulation of the strategic goals include:

1. **Clarifying the vision**: defining INAMHI's long-term objectives (5 years). The vision can be ambitious, but should still be realistic.
2. **Analyzing the status quo**: assessing the current situation and resources. Since INAMHI is a project driven organization, a road map of the projects and their priorities is necessary which must be in line with the strategic objectives.
3. **Formulation of objectives**: setting measurable and achievable goals that contribute to the realization of the vision. It is also a first and important step towards a quality management system.
4. **Operationalization**: translation of strategic objectives into concrete operational goals that can be implemented in the short term (1-2 years). This should include the realization of a compliant GBON network.
5. **Agile planning**: adapting objectives and strategies to changing conditions.

Important strategic goals among others should be:

- Strengthening INAMHI's infrastructure capacity for delivery of effective weather and climate services;
- Strengthening INAMHI's human capacity, performance management, and operational efficiency;
- Strengthening and preparing the fundamentals for a quality management system.

The following recommendations are given for the realization of GBON-compliant stations:

- Setting up and commissioning WIS2.0
- The instrument and sensors to be purchased should be of the same vendor. This will optimize purchase options, maintenance and purchasing of spare parts.

- The data management system can also be dealt with as part of this project. It can be clarified in the first months of the investment phase.

Although some of the hydromet projects have secured financial commitments, the necessary resources to expand the measurement network and achieve GBON compliance remain unallocated. The IDB's commitment to financing the GBON stations in Ecuador can hopefully serve as a catalyst for further sources of financing.

2.5. Review of the national legislation of relevance for GBON

A comprehensive compilation of national legislation can be found in the appendix.

The Law of the National Institute of Meteorology and Hydrology (Ley del Instituto Nacional de Meteorología e Hidrología, INAMHI) outlines the responsibilities for measuring and providing weather observations in Ecuador. Key points related to the Global Basic Observing Network (GBON) include:

Objective and Functions:

- INAMHI is the main agency responsible for planning, directing, and supervising meteorological and hydrological activities nationwide.
- It coordinates with other institutions and sets regulations to ensure the effectiveness of meteorological and hydrological programs.

Data Collection and Dissemination:

- INAMHI is tasked with establishing, operating, and maintaining the necessary infrastructure for meteorological and hydrological observations.
- The institute collects, processes, publishes, and disseminates data related to weather, climate, and hydrology across Ecuador.

Coordination and Standardization:

- INAMHI is part of the National Network of Meteorological and Hydrological Stations, which includes both state and qualified private stations.
- All public and private entities that operate meteorological and hydrological stations must coordinate with INAMHI.

Regulatory Authority:

- INAMHI has the authority to regulate the installation and operation of meteorological and hydrological stations in Ecuador.
- It can declare necessary areas for station installations as public utilities and is exempt from certain import taxes for operational equipment.

Funding and Resources:

- The institute's funding comes from government allocations, service fees, and donations.
- It can seek international cooperation and support to enhance its capabilities.

Scientific Research and Training:

- INAMHI promotes scientific research in meteorology and hydrology and is responsible for training and specializing personnel in these fields.

This legal framework ensures that INAMHI maintains a comprehensive and coordinated approach to weather observations and data management in line with GBON requirements, supporting both national and international needs.

The legislation pertaining to the procurement, importation, and customs processes relevant to the activities and investments of INAMHI is also outlined in the law. Key points include:

Procurement:

- INAMHI must adhere to the national laws on bidding and procurement processes for acquisitions. This ensures transparency and competitiveness in obtaining goods and services required for its operations.

Importation and Customs Exemptions:

- INAMHI is exempt from paying customs duties on the importation of equipment, instruments, spare parts, materials, and products necessary for the operation of its meteorological and hydrological stations and laboratories.
- This exemption facilitates the acquisition of specialized equipment required for accurate weather observations and research, reducing operational costs and promoting efficiency.

Operational Autonomy:

- INAMHI can declare certain areas as public utilities for the installation of meteorological and hydrological stations. This provision ensures that the institute can effectively expand its infrastructure as needed for comprehensive weather monitoring and data collection.

These legislative measures ensure that INAMHI can procure and import the necessary equipment and resources, benefiting from customs exemptions and adhering to national procurement laws to support its meteorological and hydrological activities. However, implementing the Global Basic Observing Network (GBON) in Ecuador may face constraints related to the national legislation, particularly in procurement, importation, and regulatory compliance. Here are some recommendations to address these constraints:

Streamline Procurement Processes:

- Advocate for simplified and expedited procurement procedures specifically for meteorological and hydrological equipment. This could involve creating special provisions within existing procurement laws that recognize the urgency and specificity of GBON-related acquisitions.
- Establish framework agreements with pre-approved suppliers of meteorological and hydrological equipment to reduce time spent on individual procurement processes.

Facilitate Importation and Customs Clearance:

- Create dedicated customs clearance channels for scientific and meteorological equipment to expedite processing. Collaborate with customs authorities to ensure they understand the importance and urgency of GBON-related imports.
- Conduct training sessions for customs officials to familiarize them with the types of equipment used in meteorology and hydrology, emphasizing the need for prompt clearance.

Leverage International Cooperation:
- Form strategic partnerships with international organizations and donors who can provide technical and financial assistance. These partnerships can also help navigate and comply with local regulations more effectively.
- Seek technical assistance from international meteorological organizations to align local practices with global standards, ensuring smooth implementation of GBON requirements.

Enhance Regulatory Framework:
- Advocate for updates to the current legislation to specifically address the needs of GBON implementation. This could include provisions for fast-tracking approvals and reducing bureaucratic hurdles for meteorological projects.
- Work with policymakers to draft policies that explicitly support the objectives of GBON, ensuring legislative backing for all necessary activities and investments.

Optimize Funding Mechanisms:
- Establish special funding mechanisms or budget allocations dedicated to GBON implementation. This can ensure consistent and reliable financial support for necessary procurements and activities.
- Explore opportunities for grants and subsidies from international bodies or donor countries specifically earmarked for GBON-related activities.

Public and Private Sector Collaboration:
- Involve both public and private sector stakeholders in the planning and implementation process. This can help pool resources, share expertise, and ensure broader support for GBON initiatives.
- Seek sponsorships or partnerships with private companies interested in supporting meteorological and environmental initiatives, potentially easing funding and resource constraints.

Module 3. GBON Infrastructure Development

3.1. Design the surface and upper-air observing network and observational practices

To ensure a robust and comprehensive observing network, the following recommendations encompass the siting, instrumentation, and maintenance of new and rehabilitated stations for INAMHI. This design aligns with the principles of the Global Basic Observing Network (GBON).

Observing Network Distribution and Required New or Rehabilitated GBON Stations

After a field trip to Ecuador and the Galapagos 8 stations were identified (see Figure 1), which are going to be updated to GBON compliant automatic surface observations stations and 3 upper-air stations. One of the 8 stations is completely new (Sacha-INIAP) and includes an upper-air observation station. All other locations are being rehabilitated. Currently; none of the stations are fully GBON-compliant.

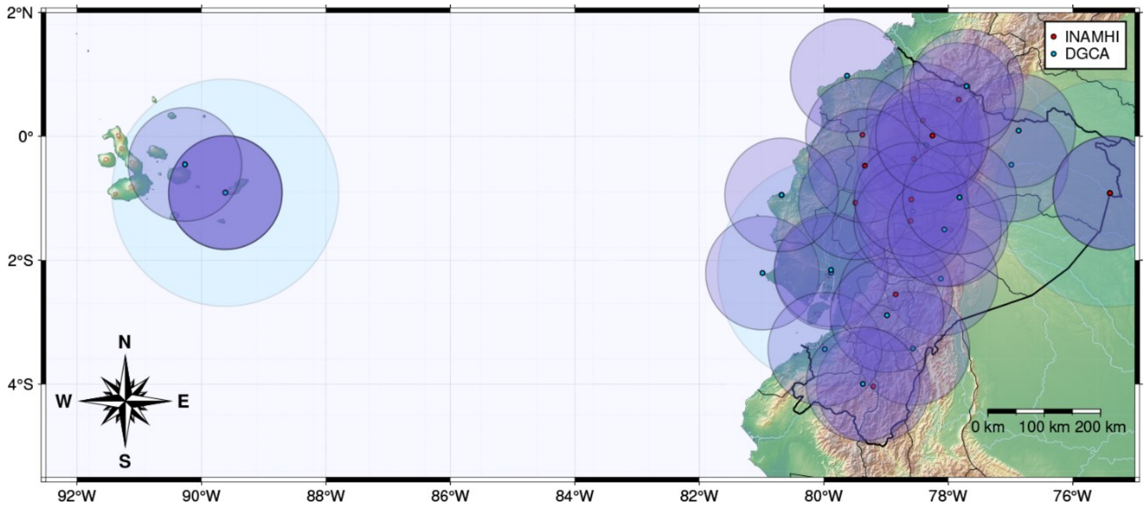

Figure 3: Map of existing observing network distribution with 200 km/500 km (diameter) circles

Using the method as described in Appendix A of the Gap Analysis of the Democratic Republic Congo from F. Vogt, MeteoSwiss, a horizontal resolution of 193.7 km is calculated (note: calculation is based on mainland Ecuador stations only without the Galapagos). The proposed network reaches a land coverage of 86.6% as can be seen in the following Figure.

The locations were chosen in a way, that all areas are adequately covered. Due to the accessibility of the remote regions the coastal area has a better coverage than the other regions.

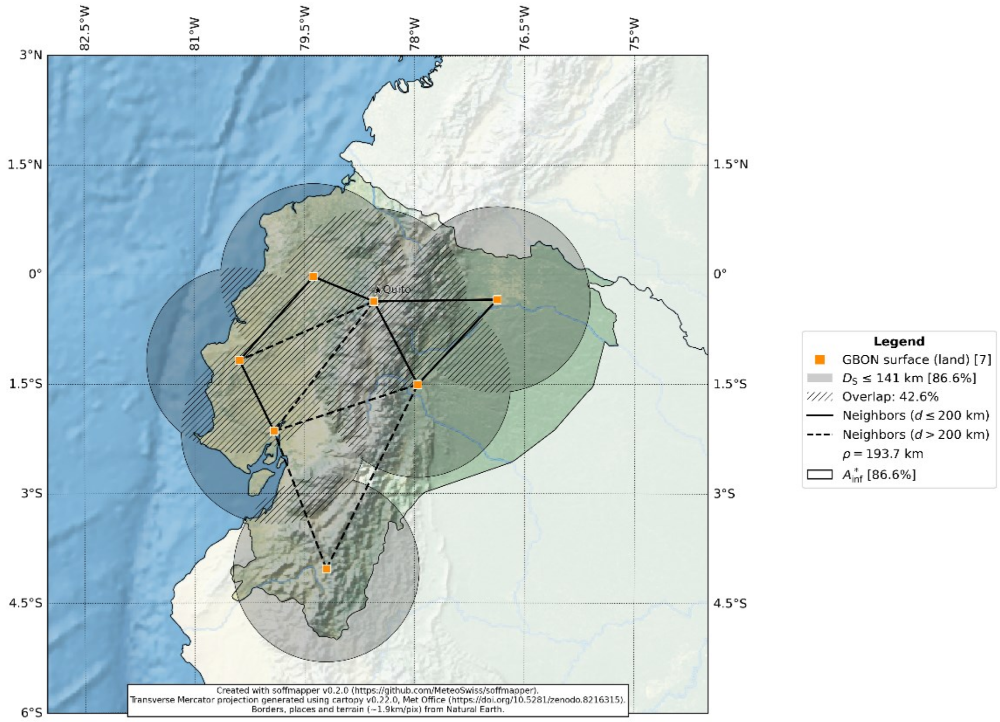

Figure 4: This map is based on the work of F. Vogt, MeteoSwiss, National Gap Analysis Democratic Republic of Congo, Appendix A. A radius of 141.4 km is used in this map.

More stations can be added in a further step to increase the number of GBON stations from the existing network.

Table 7: Recommended surface observation stations to be designated to GBON. All except one are already existing stations.

Station name	Station status	Planned GBON configuration
Guyaquil	Existing; AWS	Upgraded AWS
Izobamba	Existing; AWS; Observer	Upgrades AWS
Sacha INIAP	New location	New AWS
La Concordia	Existing; AWS; Observer	Upgraded AWS
La Teodomira	Existing; AWS; Observer	Upgraded AWS
Loja – La Argelia	Existing; AWS; Observer	Upgraded AWS
Puyo	Existing; AWS; Observer	Upgraded AWS
San Cristobal - Galapagos	Existing; AWS; Observer	Upgraded AWS

The following figures give an impression of some of the stations visited during the field trip.

Figure 5: The surface observation station Izobamba, a well-equipped and maintained station for GBON.

Figure 6: Puyo, one of the chosen sites for a GBON compliant station.

Figure 7: San Cristobal, Galapagos

Figure 8: Tena hda. Chaupishungo: challenges in a special environment, ants and fast-growing trees and bushes. This station is not a chosen GBON station.

Figure 9: Querochaca (left), Rumipamba Salcedo (right): two stations which could be added to GBON in a later stage.

All surface observation stations need to be equipped with sensors, according to WMO standards as described in the following documents:

- World Meteorological Organization, 2021: Guide to Instruments and Methods of Observation (WMO-No. 8). Geneva.
- World Meteorological Organization, 2010 (Updated in 2017): Guide to the Global Observing System (WMO-No. 488). Geneva.
- World Meteorological Organization, 2019: Manual on the WMO Integrated Global Observing System (WMO- No. 1160). Geneva.
- TT_GBON Deliverable 6.1 – GBON Tender Specifications for AWSs; approved by WMO Commission for Observation, Infrastructure and Information Systems, Task Team on GBON Implementation, June 2022

The next table shows a list of observation instruments and systems per site which are required in order to be GBON compliant.

Table 8: Instruments for planned GBON surface stations. Details can be found in WMO-No. 8

Parameter	Sensor Technologies	Installation Height	Accuracy/Range
Air Temperature	Electrical Resistance	1.25 – 2.0 m	±0.1°C/-80°C to 60°C

Parameter	Sensor Technologies	Installation Height	Accuracy/Range
Relative Humidity	Capacitive/Resistive/ Electrical Psychometric	1.25 – 2.0 m	±3%/0-100%
Wind direction & speed	Speed: Cup/Propeller Direction: Vane Both: Ultrasonic	10 m	5 degrees 0.5 m/s for WS = 5m/s, 10% for WS > 5 m/s 0-60 m/s
Precipitation	TBRG/Weighing/ Float Gauges	Local requirements	5% or 0.1 mm
Pressure	Variable Capacitive/Piezo-Resistive/Resonance	No Installation Height Requirement, protected from draughts and vibrations	0.15 hPa

Upper-air stations need to be completely newly equipped. The existing infrastructure isn’t operational anymore. The next table lists the chosen sites.

Table 9: Planned upper-air stations. All of them need new equipment.

Station name	Station status	Planned GBON configuration
Guyaquil	Non-functional;	New semi-automatic station
Sacha INIAP (New Station)	New location	New semi-automatic station
San Cristobal - Galapagos	Non-functional	New semi-automatic station

Figure 10: Old radio sounding infrastructure, San Cristobal, Galapagos. Due to the condition of the existing infrastructure, a complete renewal must be assumed.

The document "TT-GBON-Deliverable 6.2 - Requirement document to be used as input to tender specifications for radiosonde-related procurements" [5] provides comprehensive technical specifications and guidelines for the procurement of upper-air stations, particularly focusing on radiosonde systems. It provides a structured approach to procuring environmentally sustainable, reliable, and efficient radiosonde systems necessary for accurate upper-air observations.

Table 10: Key points form the requirement document of TT-GBON Implementation

Key Points	Summary
Technical Specifications	• Detailed specifications for meteorological radiosondes cover temperature, humidity, and wind measurements, as well as physical design and ground station requirements. • Specifications for meteorological balloons and hydrogen generation systems are also included, ensuring all components work seamlessly together.
Site-Specific Requirements	• The document highlights the need for adaptability to local environmental conditions and regulatory requirements, ensuring the systems are suitable for diverse operational contexts.
Safety and Standards	• Safety standards must be adhered to, including compliance with local electrical safety regulations and international standards such as IEC and ISO. • Emphasis on electromagnetic compatibility and the ability to withstand environmental shocks and vibrations.

[5] Approved by WMO Commission for Observation, Infrastructure and Information Systems, Task Team on GBON Implementation, July 2022

Key Points	Summary
Environmental Sustainability	• Instruments and packaging must comply with recognized environmental regulations and local jurisdictions where applicable. • Emphasis is placed on the use of recyclable and biodegradable materials, minimizing energy use, and designing for repair and recyclability.
Documentation and Training	• Comprehensive documentation and training are required for the operation, maintenance and safety of the radiosonde systems. • Suppliers must provide detailed project schedules, maintenance guidelines, spare parts lists and training for customer technicians.

For planning purposes, it is necessary to answer two questions about the infrastructure. Hydrogen, which is used for the ascent of the balloons, can be purchased from local providers or generated on-site. The second question concerns the operation of the radiosounding station: it can be operated manually or automatically. The following table lists some pro and cons.

Radiosounding System		
Decision	**Pro**	**Con**
Buy H_2 from provider	• Less infrastructure • No maintenance • Easier to handle	• Dependent of supplier
Generate H_2 on-site	• Independent of supplier	• Significant investment on infrastructure • Technical knowledge • Safety: explosive material • Maintenance • Needs energy
Manually operation	• System costs less	• Needs more personnel
Automatic operation	• No personnel needed for starts, just for preparation (advantage during the night)	• Maintenance more complex

Almost all routine radiosonde launches take place one hour before the official observation times of 00:00 UTC and 12:00 UTC, in order to centre the observation times during the approximately two-hour ascent.

In Ecuador the radisonde will have to be launched at 18:00 and 06:00 local time, respectively 17:00 and 05:00 local time on Galapagos. Recommended is a manual operation when local staff is available. An automatic operation needs local staff, too, but is more complex.

The following is a rough plan for investments and activities that are necessary for the installation of GBON compliant stations, as already outlined in Module 1. It is the intention of the IDB to provide financial support for these measures as the implementing entity. Furthermore, the utilization of IDB financing is intended to facilitate the assurance of sustainability (but needs to be discussed between SOFF and IDB).

Step 1

In view of the fact that many stations in the existing network are almost fully operational, it should be possible to improve the selected GBON stations within a year so that they become GBON-compatible. The first objective is to create the basis for capacity building and commissioning of the network. The following measures are required during this step:

- Initiate AWS procurement procedures:
  The procurement[6], led and financed by the implementing agency (IDB) and supervised by the peer advisor, should consider the possible acquisition of the same type of AWS that will facilitate station maintenance, training and use of spare parts.
- Install WIS2.0 as the basis for the dissemination of the data into GBON.
- Initiate the ICT and metadata/data management acquisition process with the corresponding vendor offers and quality control and assurance mechanisms.
- Once procurement is achieved for the 8 chosen stations, start deploying the equipment at the 7 existing stations (see Table 7).

Step 2

- Start the construction of the new surface observation station and initiate the procurement process for the 3 upper-air stations.
- Prepare the deployment plan for the upper-air stations.

Step3:

- Construction and installation of the infrastructure of the three upper-air stations.
- Start adding other existing surface observation stations to the GBON network.

The investments should include:

- 7 rehabilitated fully automatic surface observation stations and one completely new station. All including the Total Cost of Ownership approximation.

INAMHI has experience in maintaining the stations as well as the sensors and instruments. A major advantage of INAMHI is its own metrological laboratory, which is to be certified. INAMHI thus has the potential to become a metrological calibration center for other institutions in Ecuador and the entire Andean region (ENANDES+). There is a lack of sufficient resources for both the maintenance and operation of the laboratory. Due to the lack of personnel and funds to cover the costs of the necessary preventive and corrective maintenance work on the

[6] Procurement guidance can be found in this document: World Meteorological Organization, 2021: Generic Automatic Weather Station (AWS), Tender Specifications, Instruments and Observing Methods (WMO-No. 136). Geneva.

network's equipment and instruments, compliance with GBON quality requirements is difficult to achieve without financing by the implementing entity.

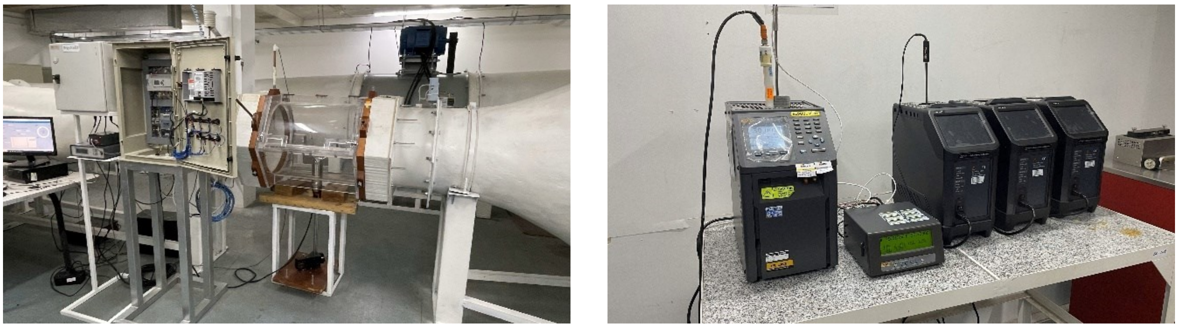

Figure 11: Wind channel in the metrology laboratory (left), calibration of sensors (right).

INAMHI should start or continue to describe their processes of their operations. This is an important step towards a quality management system. In view of the situation of resources at INAMHI, this is also a preventive measure against the loss of knowledge and experience due to employees leaving INAMHI. The ultimate goal could be a quality management system (QMS) in accordance with ISO 9001, which defines requirements for the quality of products and services. It defines a series of standards and best practices that help companies to establish and continuously improve quality standards.

A QMS focuses on customer orientation, continuous improvement, leadership involvement and a process-oriented approach. This standard serves as a guide to ensure that organizations provide products and services that meet the needs of their customers and comply with legal requirements.

3.2. Design of the ICT infrastructure and services

Designing an ICT infrastructure and services solution for transmitting data from an observing station to the national real-time data management system, requires careful consideration of various factors such as reliability, security, and compatibility with the WIS2.0 standard.

The ICT infrastructure should be designed with redundancy and scalability in mind to ensure reliability and accommodate future growth. It should consist of:

Observing Station Hardware:
Install reliable sensors and data collection devices at the observing station capable of capturing various environmental parameters such as at least atmospheric pressure, air temperature, relative humidity, precipitation, wind speed and direction.

Data Collection System:
Implement a robust data collection system that can efficiently gather data from the observing station and transmit it to the collection point. This system should include:

- Data loggers capable of storing and transmitting data securely.

- Communication equipment such as satellite modems, radio transmitters, or cellular modems for transmitting data over long distances.
- Backup power supply to ensure continuous operation in case of power outages.

Collection Point:
Set up a centralized collection point where data from multiple observing stations can be aggregated before being forwarded to the national data management system. This may involve deploying servers with sufficient storage and processing capabilities.

Real-time Data Management System:
Develop or utilize a real-time data management system capable of receiving, storing, quality checking and processing incoming data streams from the collection point. The system should support standards like WMO Information System (WIS) 2.0 and Global Telecommunication System (GTS) for seamless integration with other meteorological services.

Network Infrastructure:
Establish a reliable network infrastructure, including wired and wireless connections, to facilitate data transmission between the observing station, collection point, and data management system. Implement security measures such as firewalls, encryption, and access controls to protect data integrity and confidentiality.

The technical specifications for the data collection system from the observing station to the collection point should include:

Data Logger:
Use data loggers with sufficient memory capacity to store data locally in case of communication failures. Ensure compatibility with various sensor types and communication protocols. A data logger should be able to store data for at least 30 days and able to transmit the data automatically at least every 60 minutes; able to run in a low power mode and able to perform data compression before sending (especially if the network is below 3G)

Communication Equipment:
Select communication equipment based on the geographical location and availability of communication networks. Consider factors such as bandwidth, latency, and reliability when choosing between satellite, radio, or cellular communication.

A key element is the compatibility of the technical specifications of the data services with WIS2.0. It includes:

Data Format:
Adopt standard data formats such as XML or JSON to ensure compatibility with WIS2.0 requirements.

Metadata:
Include comprehensive metadata along with the data to provide context and facilitate interoperability with other systems.

Data Quality Control:
Implement data quality control procedures to identify and correct errors or anomalies in the incoming data streams.

Installation of the WIS2 box is done in one day, but configuration may take as long as needed. In particular sending the data to the WIS2 box can require configuration of other software or the loggers of the stations if you plan to send the data directly from stations. Registration of a WIS2 node in the WIS2 Global Services requires around a week.

Measures to ensure resilience and continuity of the full data processing chain are important for a reliable data stream. It includes:

Redundancy:
Where possible, implement redundant components at each stage of the data processing chain to minimize single points of failure. This includes redundant power supplies, communication links, and data storage systems as well as regularly backups.

Disaster Recovery:
Develop a comprehensive disaster recovery plan outlining procedures for data backup, restoration, and failover in the event of natural disasters or system failures. This is also part of a QMS.

Regular Maintenance:
Conduct regular maintenance and performance monitoring of the ICT infrastructure to identify and address potential issues proactively.

Training and Documentation:
Provide training to personnel responsible for operating and maintaining the data processing chain. Maintain up-to-date documentation outlining system configurations, procedures, and troubleshooting steps. Again, this is also an important step towards a QMS.

By following these recommendations, an ICT infrastructure and services solution can be designed that ensures seamless data transmission from observing stations to the national WIS2.0 compatible data management system, while also prioritizing resilience and continuity of operations.

3.3. Design the data management system

Designing a data management system (DMS) to meet the requirements of providing real-time access to operational data while also facilitating long-term archiving for a Climate Data Management System (CDMS) entails careful planning and consideration of various aspects.

For short-term data storage and access via the services and protocols required by applications for national and international operational activities, the following points must be observed:

- Implement a robust database system capable of efficiently storing and retrieving large volumes of data in real-time. Consider using a combination of relational and NoSQL databases to accommodate different types of data and access patterns.

- Develop application programming interfaces (APIs) that expose data access methods and protocols required by national and international operational applications. Support standard protocols such as RESTful APIs or web services to ensure interoperability.
- Design the DMS architecture to scale horizontally to handle increasing data volumes and user requests. Implement caching mechanisms and data partitioning strategies to optimize performance.

Acquisition of data to and from WIS/GTS; WIS2.0 and other national or international sources required for operational activities:

- Establish data exchange mechanisms to ingest data from sources such as WIS/GTS, WIS2.0, and other national or international data providers. Implement data transformation and normalization processes to ensure consistency and compatibility with internal data formats.
- Ensure compliance with relevant protocols and standards for data exchange, such as WMO Data Buoy Cooperation Panel (DBCP) protocols, WMO Core Metadata Profile (CMP), and WIS 2.0 standards.

Data delivery to the national Climate Data Management Systems (CDMS):

- Develop automated archiving workflows for transferring operational data from the short-term storage layer to the national CDMS for long-term archiving. Implement data validation and quality control checks before archival to ensure data integrity.
- Convert data formats as necessary to align with the requirements of the national CDMS. Include metadata and documentation along with the archived data to facilitate future discovery and retrieval. Again, this is an important step towards a QMS.

Finding and managing descriptive metadata:

- Adhere to standardized metadata schemas such as ISO 19115 for describing datasets and ISO 19139 for encoding metadata. Include descriptive metadata elements such as dataset title, abstract, keywords, spatial and temporal coverage, and quality information.
- Establish a centralized metadata repository where descriptive metadata records are stored and managed. Implement search and discovery functionalities to enable users to find relevant datasets efficiently.

Monitoring of data, processing, and services:

- Implement automated data quality monitoring processes to detect anomalies and inconsistencies in incoming data streams. Set up alerts and notifications for monitoring data processing pipelines and services.
- Deploy monitoring tools to track the performance and availability of the DMS infrastructure, including databases, servers, and network components. Monitor key performance indicators such as response time, throughput, and error rates.

Taking these points into account, in the best-case scenario, a robust data management system can be developed that meets the requirements of real-time access to operational data, while ensuring seamless integration with national and international data sources and facilitating long-term archiving for climate data management purposes.

3.4. Environmental and sustainability considerations

To ensure the environmentally responsible design and evolution of national networks to meet Global Basic Observing Network (GBON) requirements, pragmatic approaches and measures can be implemented across various stages. Here are some recommendations for several aspects:

Development and use of specifications that consider environmental sustainability for procurement of measurement instrument equipment:

- Incorporate environmental sustainability criteria into procurement specifications for measurement instruments. Consider factors such as energy efficiency, recyclability, use of environmentally friendly materials, and adherence to eco-certifications.
- Conduct life cycle assessments (LCA) of measurement instruments to evaluate their environmental impact from raw material extraction to disposal. Prefer instruments with lower environmental footprints throughout their life cycle.
- Collaborate with instrument suppliers to encourage the development of eco-friendly products and provide incentives for sustainable practices in manufacturing and distribution.

Integration of sustainability considerations for the management of operations of GBON stations:

- Implement energy-efficient practices in the management of GBON stations, including the use of renewable energy sources such as solar or wind power where feasible. Optimize energy consumption through efficient equipment selection and operational practices.
- Design GBON station infrastructure with sustainability in mind, incorporating features such as rainwater harvesting, green roofs, and native landscaping to minimize environmental impact and enhance biodiversity.
- Adopt sustainable transportation practices for station installation, calibration, and maintenance activities, such as using electric or hybrid vehicles and optimizing travel routes to reduce emissions.

Careful material selection for the development, shipping, and day-to-day operations of GBON stations:

- Prioritize the development and use of reusable measurement instruments that are durable, repairable, and upgradable to minimize waste generation. Consider modular designs that allow for component replacement rather than entire instrument replacement.
- Choose environmentally friendly packaging materials for shipping measurement instruments and station components, such as recyclable or biodegradable packaging materials. Minimize packaging waste through efficient packaging design and optimization.
- Phase out the use of single-use plastics in GBON station operations by replacing plastic components with sustainable alternatives or implementing reusable solutions. Promote plastic waste reduction initiatives such as recycling and waste segregation at stations.

By adopting these pragmatic approaches and measures, national networks can achieve GBON requirements while advancing environmental sustainability goals. Collaboration among stakeholders, including governments, instrument manufacturers, and research institutions, is essential to drive collective action towards a more environmentally responsible observing network.

Module 4. GBON Human Capacity Development Modul

4.1. Assessment of human capacity gaps

Summary of staff skills, education levels, and capacity gaps at INAMHI:

Technicians:

- **Skills:** Proficient in equipment maintenance, data collection, and basic troubleshooting.
- **Education Levels:** Typically have technical diplomas or vocational training in relevant fields such as electronics, meteorology, or instrumentation.
- **Capacity Gaps:** May lack advanced technical skills for specialized equipment maintenance or calibration. Training in emerging technologies and sustainable practices may be needed.

Experts:

- **Skills:** Possess specialized knowledge in meteorology, climatology, or related fields. Skilled in data analysis, forecasting, and research.
- **Education Levels:** Hold advanced degrees (master's or doctoral) in meteorology, atmospheric science, or related disciplines.
- **Capacity Gaps:** May require additional training in advanced data analysis techniques, numerical modeling, and remote sensing technologies. Collaboration with international experts could help fill knowledge gaps.

Management:

- **Skills:** Proficient in organizational management, strategic planning, and resource allocation. Skilled in policy development and stakeholder engagement.
- **Education Levels:** Often have degrees in management, public administration, or a related field, supplemented by experience in meteorological services.
- **Capacity Gaps:** May need training in modern management practices, including project management, leadership development, and change management. Capacity-building programs can enhance management skills.

Gender Balance and Gender Opportunities:

- **Gender Balance:** Assess and promote gender balance across all levels of INAMHI, including technicians, experts, and management positions. Implement policies and practices to encourage equal opportunities for career advancement and leadership roles for women.
- **Gender Opportunities:** Provide targeted training and mentorship programs to support the professional development of women in meteorology and related fields. Promote diversity and inclusivity in recruitment and retention strategies.

Overall, INAMHI should prioritize continuous professional development and capacity-building initiatives to address skill gaps, foster gender balance, and capitalize on emerging opportunities in meteorological services. Collaboration with national and international partners can enhance staff capabilities and strengthen the organization's capacity to deliver high-quality meteorological services.

Table 11: Staffing profile of INAMHI.

Branch	Doctorate/ MSc	Bachelor	Diploma (technique or technology)	High School Diploma	Total
Administration/ Management	7	16	2	4	29
Climate	2	4			6
Hydrological Technician	2	5		1	8
Hydrologist	1	1			2
Meteorological Technician		1		1	2
Meteorologist		7		2	9
Observations		9	2	4	15
Researcher	2				2
General Technician	2	12		1	15
ICT	1	1			2
General services		3	2	14	19
Total	17	59	6	27	**109**

The gender ratio is 63.9% male to 36.1% female.

4.2. Design capacity development activities for technical staff

To enhance the capabilities of technical staff at INAMHI in the areas of instrument and station maintenance, calibration and maintenance, network monitoring, and ICT system operations, it is essential to implement specialized training activities and targeted recruitment strategies. Here are detailed recommendations for each area:

Instrument and Station Maintenance at Site

Table 12: Training activities at maintenance site

Activity	Ojective	Content	Duration
Hands-on Workshops	Provide practical experience in maintaining meteorological and hydrological instruments.	Installation, troubleshooting, routine maintenance, and emergency repairs of instruments.	3-5 days
Vendor-Specific Training	Ensure familiarity with specific equipment used at INAMHI.	Training provided by manufacturers on the use, maintenance, and	2-3 days per equipment type

Activity	Ojective	Content	Duration
		troubleshooting of their instruments.	
Safety Training	Ensure the safety of technical staff working in various environments.	Electrical safety, working at heights, and handling hazardous materials.	1-2 days
Field Simulation Exercises	Prepare staff for real-world scenarios.	Simulated maintenance tasks under various environmental conditions.	2 days

The following aspects should be taken into account during recruitment:

- **Clear Job Descriptions:**
  Define Requirements: Highlight the need for technical proficiency, hands-on experience, and familiarity with meteorological instruments.
- **Technical Schools and Institutes:**
  Recruitment Focus: Partner with technical schools and institutes that offer relevant programs to attract skilled graduates.
- **Apprenticeship Programs:**
  Structured Learning: Develop apprenticeship programs to train new recruits under experienced technicians.
- **Industry Networking:**
  Expand Reach: Use industry conferences, trade shows, and professional networks to identify potential candidates.

Calibration and Maintenance at the Workshop

Table 13: Training activities at the workshop

Activity	Ojective	Content	Duration
Calibration Techniques Courses	Train staff in precise calibration methods for meteorological instruments.	Calibration standards, use of calibration equipment, and maintaining calibration records.	3 days
Advanced Technical Training	Provide in-depth knowledge of electronic and mechanical systems.	Electronics, sensor technology, and mechanical systems maintenance.	Weekly sessions over 2 months
Quality Assurance Workshops	Implement and maintain high standards of quality in calibration processes.	QA/QC procedures, documentation, and auditing.	2 days
Problem-Solving and Diagnostics	Enhance troubleshooting skills for complex technical issues.	Diagnostic techniques, common issues, and repair strategies.	2 days

Recruitment

- **Specialized Recruitment Channels:**
  Focus on Expertise: Target technical forums, job boards, and professional organizations related to calibration and instrument maintenance.
- **Technical Proficiency Assessment:**
  Evaluation: Conduct technical assessments and practical tests to evaluate candidates' calibration and maintenance skills.
- **Collaboration with Technical Schools:**
  Internships: Establish internships and cooperative education programs with technical schools to build a pipeline of trained technicians.
- **Industry Certifications:**
  Preferred Qualifications: Look for candidates with certifications in relevant areas, such as ISO calibration standards.

Network Monitoring

Table 14: Training activities for network monitoring

Activity	Ojective	Content	Duration
Network Monitoring Tools Training	Familiarize staff with network monitoring tools and software.	Training on used software and other network monitoring solutions.	2-3 days
Data Analysis and Interpretation	Enhance skills in analyzing network data to identify and resolve issues.	Data analytics, interpretation of network metrics, and performance tuning.	3 days
Cybersecurity Training	Ensure secure network operations and protect against cyber threats.	Network security principles, threat detection, and incident response.	2-3 days
Incident Management Workshops	Prepare staff to handle network incidents effectively.	Incident response procedures, root cause analysis, and recovery strategies.	1-2 days

Recruitment

- **Technical Job Fairs:**
  Recruitment Drives: Participate in job fairs focused on IT and network engineering to attract qualified candidates.
- **Detailed Job Specifications:**
  Requirements: Clearly outline the skills and experience required, including familiarity with specific monitoring tools and cybersecurity knowledge.
- **University Partnerships:**
  Talent Pipeline: Partner with universities offering programs in computer science, network engineering, and cybersecurity.
- **Professional Certifications:**
  Preferred Credentials: Seek candidates with certifications such as CompTIA Network+, CCNA, or CISSP.

ICT System Operations

Table 15: Training activities for ICT system operations

Activity	Ojective	Content	Duration
System Administration Courses	Train staff in managing and maintaining ICT systems.	Operating systems, server management, virtualization, and cloud services.	Weekly sessions over 2 months
ITIL Training (Information Technology Infrastructure Library)	Introduce ITIL best practices for IT service management.	Service strategy, design, transition, operation, and continual service improvement.	2-3 days
Database Management Training	Enhance skills in managing and maintaining databases.	SQL, database administration, backup and recovery, and performance tuning.	3 days
Disaster Recovery and Business Continuity	Prepare staff to ensure ICT systems' resilience and recovery.	Disaster recovery planning, business continuity strategies, and emergency response.	2 days

Recruitment

- **ICT Job Boards:**
  Recruitment Focus: Utilize job boards specializing in ICT roles to find qualified candidates.
- **Skill Assessments:**
  Evaluation: Use technical assessments and practical tests to evaluate candidates' proficiency in system operations.
- **Industry Certifications:**
  Preferred Qualifications: Look for candidates with certifications such as CompTIA A+, MCSE, or AWS Certified Solutions Architect.
- **Tech Meetups and Conferences:**
  Networking: Attend tech meetups and conferences to connect with professionals in the field and promote job openings.

By implementing these tailored training activities and strategic recruitment approaches, INAMHI can build over the years a highly skilled technical team capable of maintaining and enhancing its meteorological and hydrological monitoring capabilities.

4.3. Design capacity development activities for senior management

INAMHI could benefit greatly from specialized training and recruitment strategies to enhance its management in strategic and financial planning as well as project management. Here's a comprehensive recommendation for both training activities and recruitment:

Strategic and Financial Planning

Table 16: Training activities for strategic and financial planning

Activity	Ojective	Content	Duration
Workshops on Strategic Planning	Management must be enabled to set long-term goals, assess the internal and external environment and formulate strategies.	SWOT analysis, PESTEL analysis, vision and mission development, strategic goal setting, and implementation planning.	2-3 days
Financial Management Courses	Improve financial literacy and budgeting skills among managers.	Budgeting techniques, financial forecasting, cost-benefit analysis, financial reporting, and risk management.	Weekly sessions over 2 months
Scenario Planning Workshops	Prepare management for uncertain futures by exploring multiple potential scenarios.	Identifying key drivers of change, developing plausible scenarios, and creating strategic responses.	1-2 days
Balanced Scorecard Training	Introduce a performance measurement framework that adds strategic non-financial performance measures to traditional financial metrics.	Development of balanced scorecards, linking performance to strategy, and continuous improvement.	2 days
Executive Leadership Programs	Enhance leadership skills crucial for effective strategic and financial planning.	Leadership theories, decision-making, change management, and team building	Intensive programs over several weeks, possibly in partnership with local universities or international institutions.

Recruitment

- **Job Descriptions and Requirements:**
  Clearly define the roles, responsibilities, and qualifications required for strategic and financial planning positions. Emphasize experience in financial analysis, strategic management, and a strong understanding of the meteorological and hydrological sectors.
- **Targeted Recruitment Campaigns:**
  Utilize professional networks, industry conferences, and academic partnerships to find candidates with specialized skills. Leverage platforms like LinkedIn and industry-specific job boards.

- **Assessment Centers:**
  Implement assessment centers to evaluate candidates' strategic thinking, financial acumen, and leadership skills through simulations, case studies, and problem-solving exercises.
- **Incentive Programs:**
  Develop attractive compensation packages, including competitive salaries, benefits, and opportunities for professional development, to attract high-caliber talent.
- **Diversity and Inclusion Initiatives:**
  Promote diversity in recruitment efforts to bring a range of perspectives and experiences into the management team.

Project Management

Table 17: Training activities for project management

Activity	Ojective	Content	Duration
Project Management Professional (PMP) Certification	Certify managers in globally recognized project management standards.	Project initiation, planning, execution, monitoring, controlling, and closing.	Several weeks, with a final exam
Agile and Scrum Training	Introduce agile methodologies to enhance flexibility and responsiveness in project management.	Agile principles, Scrum framework, roles and responsibilities, sprint planning, and retrospective meetings.	2-3 days
Risk Management Workshops	Improve the ability to identify, assess, and mitigate project risks.	Risk identification techniques, risk assessment methods, risk response planning, and monitoring.	1-2 days
Project Management Software Training	Familiarize managers with project management tools like Microsoft Project, Trello, or Asana.	Software functionalities, project scheduling, resource allocation, and progress tracking.	1-2 days
Communication and Stakeholder Management Training	Enhance communication skills and stakeholder engagement strategies.	Communication planning, stakeholder analysis, conflict resolution, and reporting.	1-2 days

Recruitment

- **Job Descriptions and Requirements:**
  Define roles with a focus on project management skills, including experience with project management methodologies, software, and successful project delivery.
- **Professional Networks and Associations:**
  Recruit through project management professional associations such as PMI (Project Management Institute) and industry-specific forums.

- **Technical and Behavioral Assessments:**
  Conduct comprehensive assessments to evaluate technical project management skills and behavioral competencies such as leadership, communication, and problem-solving.
- **Internship and Graduate Programs:**
  Develop internship and graduate programs to attract young talent with potential for development into project management roles.
- **Career Development Pathways:**
- Offer clear career progression paths and professional development opportunities to retain top talent and encourage long-term commitment to INAMHI.

By implementing these training activities and recruitment strategies, INAMHI can build a robust management team capable of effective strategic and financial planning as well as efficient project management.

4.4. Gender and CSOs considerations

To ensure active participation of Civil Society Organizations (CSOs) and promote gender balance and gender opportunities in the implementation of INAMHI's plans, it is essential to engage in a range of activities, consultations, and collaborative efforts.

An internal quota for the SOFF activities will be sought to ensure as possible that at least 50% of the staff related to SOFF are female

The following tables list some recommendations.

Activities

Table 18: Activities to ensure active participation of Civil Society Organizations (CSOs)

Activity	Ojective	Content	Frequency
Awareness and Capacity Building Workshops	Increase awareness about INAMHI's initiatives and build capacity among CSOs, particularly those focused on gender issues.	Introduction to INAMHI's projects, training on how CSOs can contribute, and sessions on the importance of gender balance.	Quarterly
Gender Sensitivity Training	Promote gender sensitivity within INAMHI and its partners.	Workshops on gender equality, unconscious bias, and inclusive practices for INAMHI staff, CSO representatives, and other stakeholders.	Bi-annually
Community Engagement Activities	Ensure grassroots involvement and feedback.	Town hall meetings, focus group discussions, and community forums, especially in areas where meteorological and hydrological data is critical.	Monthly in different regions.

Consultations

Table 19: Consultations to ensure active participation of Civil Society Organizations (CSOs)

Activity	Ojective	Format/Members	Frequency
Stakeholder Consultation Meetings	Regularly consult with CSOs to gather input and feedback on INAMHI's plans and projects.	Roundtable discussions, virtual webinars, and surveys.	Bi-monthly
Gender Advisory Panel	Establish a panel of gender experts to advise on the integration of gender perspectives in INAMHI's projects.	Gender experts from academia, government, and CSOs.	Quarterly meetings with additional sessions as needed
Public Consultations	Collect broad public input on INAMHI's plans and the promotion of gender balance.	Online consultations, public comment periods, and workshops.	Annually, with additional consultations for major projects

Areas of Collaboration

Table 20: Areas of collaboration to ensure active participation of Civil Society Organizations (CSOs)

Activity	Ojective	Activities	Potential Partners
Partnerships with Gender-Focused CSOs	Leverage the expertise of gender-focused CSOs to enhance gender inclusivity in INAMHI's initiatives.	Joint projects, co-hosted events, and shared research.	Women's organizations, local gender advocacy groups, and international NGOs.
Collaborative Research and Data Collection	Conduct research to understand the gender-specific impacts of climate and hydrological changes.	Joint research projects, data sharing agreements, and collaborative publications.	Universities, research institutions, and CSOs specializing in gender and environmental studies.
Co-Design and Implementation of Projects	Ensure CSOs are actively involved in the design and implementation of INAMHI's projects.	Co-develop project proposals, joint implementation teams, and shared monitoring and evaluation.	Environmental NGOs, community-based organizations, and development agencies.

Specific Recommendations for Gender Balance and Opportunities

Table 21: Specific Recommendations for Gender Balance and Opportunities

Activity	Ojective	Actions
Gender Equality Policies and Practices	Institutionalize gender equality within INAMHI.	Develop and enforce gender equality policies, ensure gender balance in hiring and promotions, and create a gender task force.
Women in STEM Initiatives	Promote women's participation in meteorology and hydrology.	Scholarships and internships for women, mentorship programs, and partnerships with educational institutions to encourage young women to pursue STEM careers.
Gender-Responsive Budgeting	Ensure financial resources are allocated to promote gender equality.	Integrate gender considerations into budgeting processes, fund gender-specific initiatives, and regularly review and adjust budgets to meet gender equity goals.
Monitoring and Evaluation	Track progress on gender balance and opportunities.	Develop gender-sensitive indicators, conduct regular gender audits, and publish reports on gender outcomes.

By implementing these recommendations, INAMHI can ensure active participation from CSOs, promote gender balance, and create opportunities for women and underrepresented groups within its initiatives. This approach will not only enhance the effectiveness of INAMHI's projects but also contribute to broader social equity and inclusion goals.

Module 5. Risk Management Framework

5.1 Assess the risks of the observing network and propose mitigation measures

A proper management of risks is required during and after the SOFF investment phase to prevent potential setbacks and adapt as agile as possible to an emerging risk. To develop a robust Risk Management Framework for INAMHI, we can draw upon the principles of the SOFF (Systematic Observations Financing Facility) Risk Management Framework. The risk analysis should include

- a probability assessment to evaluate the likelihood of each risk occurring (e.g., rare, unlikely, possible, likely, almost certain);
- an impact assessment to evaluate the potential impact on INAMHI's activities (e.g., minor, moderate, significant, severe, catastrophic);
- a risk matrix for presenting risks in a matrix in order to prioritize them according to their probability and impact.

The following tables shows some identified risks.

Table 22: Risk Analysis

Identified Risk	Risk Level	Likeli-hood	Impact	Mitigating Measures	Responsable
Natural Risks: Extreme weather events, climate change impacts, earthquakes, and other natural disasters affecting meteorological and hydrological stations.	High	Likely	Major	- Develop and implement disaster preparedness and response plans. - Enhance infrastructure resilience against natural disasters. - Invest in backup power and data storage solutions.	Operations Manager, Infrastructure Team, IT Department.
Operational Risks: Equipment failure, data inaccuracies, insufficient maintenance, and cyber-attacks.	Medium	Possible	Moderate	- Regular maintenance and calibration schedules. - Implement robust data verification and validation processes. - Conduct cybersecurity audits and	Technical Maintenance Team, Quality Assurance Team, IT Security Team.

Identified Risk	Risk Level	Likeli-hood	Impact	Mitigating Measures	Responsable
				upgrade security protocols.	
Financial Risks: Budget constraints, funding fluctuations, and financial mismanagement.	Medium	Likely	Major	- Diversify funding sources and develop financial contingency plans. - Implement strict financial controls and regular audits. - Engage in proactive financial planning and forecasting.	Finance Department, Executive Management, Audit Committee.
Strategic Risks: Changes in government policy, regulatory changes, and shifts in organizational priorities.	Medium	Possible	Major	- Engage in continuous policy and regulatory monitoring. - Foster strong relationships with government and regulatory bodies. - Develop flexible strategic plans that can adapt to changes.	Strategic Planning Team, Government Relations Team, Executive Management.
Reputational Risks: Public perception, stakeholder trust, and media relations.	Medium	Possible	Moderate	- Implement a comprehensive communication strategy. - Engage proactively with stakeholders and the public. - Monitor media and social media to manage public perception.	Communications Team, Public Relations Officer, Stakeholder Engagement Team.
Human Resource Risks: Staff turnover, skill gaps, and lack of training.	Medium	Likely	Major	- Implement training and professional development programs.	HR Department, Training and Development Team, Executive Management.

Identified Risk	Risk Level	Likeli-hood	Impact	Mitigating Measures	Responsable
				- Develop retention strategies and career advancement opportunities. - Foster a positive workplace culture and address skill gaps.	

It is important to monitor and evaluate the risks. Regular reviews (quarterly or bi-annually) should be carried out, performance indicators should be determined and continuously monitored and the identified risks, their status and mitigation measures documented. Internal audits can be carried out to ensure compliance with risk management policies and procedures. A risk management governance structure could include a risk management committee (senior representatives from key departments) and a dedicated risk management officer.

By implementing this Risk Management Framework, INAMHI can systematically identify, analyze, mitigate, and monitor risks, ensuring resilience and stability in its operations and enhancing its capacity to fulfill its meteorological and hydrological mandates effectively.

Module 6. Transition to SOFF investment phase

The activities outlined in this National Contribution Plan will provide the basis for developing the Investment Proposal for INAMHI's National GBON Network. Further steps have to be planned in coordination with the beneficiary country and the implementing entity.

Summary of GBON National Contribution Plan

Components	Recommended activities
Module 2. GBON business model and institutional development	1. Engage with governmental stakeholders to identify synergies and cooperation for the investment and compliance phase.
	2. Establish MOUs or agreements with key stakeholders to formalize commitments and define roles and responsibilities.
	3. Establish a good information exchange with ENANDES+, identify common synergies.
	4. Finish vision and strategic plan.
	5. Draft a roadmap with initial project plan, including budget and financial plan.
	6. Raise awareness about the importance of meteorological observations (and the GBON initiative) through public campaigns and educational programs.
Module 3. GBON infrastructure development	1. Review existing and new equipment and facilities at the proposed surface observation stations to identify any items that need to be procured.
	2. Review existing and new equipment and facilities at the proposed upper-air stations to identify any items that need to be procured.
	3. Initiate procurement procedure led be the implementing entity (IDB).
	4. Develop centralized data sharing platforms to facilitate the exchange of meteorological data among stakeholders.
	5. Finish installation of WIS2.0 and start disseminating data into GBON.
	6. Start systematically documenting the work flows and processes.
Module 4. GBON human capacity development	1. Explore synergies and cooperation within ENANDES+
	2. Conduct joint training programs to build technical capacity across institutions, ensuring the sustainability of the GBON network.
Module 5. Risk Management	1. Identify and focus on the top 3 risks for INAMHI regarding a successful GBON implementation and implement relevant mitigating measures.
Module 6. Transition to SOFF investment phase	Coordinate between the implementing identity, the beneficiary country and peer advisor.

Annexes

National legislation

Pursuant to Supreme Decree No. 1446, published in Official Gazette No. 289 of August 15, 1961, the National Meteorology and Hydrology Service was created, attached to the Ministry of Development, headquartered in Quito.

INAMHI is a public law institution with legal personality, headquartered in the city of Quito and with jurisdiction throughout the national territory. It is the governing, coordinating and standardizing body of national policy in all matters related to meteorology and hydrology and has, among its functions, to maintain and operate the basic network of hydrometeorological stations of Ecuador, as established by Supreme Decree No. 3438, published in Official Gazette No. 839 of May 25, 1979, which establishes the Law of the National Institute of Meteorology and Hydrology, attached to the Ministry of Natural Resources and Energy;

Through Ministerial Agreement No. 472-a of May 28, 1985, published in Official Gazette No. 207 of June 14 of the same year, INAMHI's Organic Functional Regulations were issued.

Through Ministerial Agreement No. 1402 of August 3, 1987, published in Official Gazette No. 745 of August 7 of the same year, the amendments to the Organic Functional Regulations of INAMHI were issued.

Ministerial Agreement No. 1588 of January 29, 1988, published in Official Gazette No. 875 of February 18 of the same year, approved the Codification of the Organic Functional Regulations of INAMHI.

INAMHI is attached to the National Water Secretariat by virtue of the Third General Provision of Executive Decree No. 1088, published in Official Gazette No. 346 of May 27, 2008.

INAMHI is attached to the National Secretariat of Risk Management, by virtue of Executive Decree No. 391, published in the Second Supplement to Official Gazette No. 224 of June 29, 2010; and by Resolution No. DE-087-2010, published in Official Gazette Supplement No. 367, of January 20, 2011, the Reform to the Organic Statute of Organizational Management by Processes is issued.

By Executive Decree No. 709 INAMHI is attached to the Water Secretariat on March 28, 2019.

By Executive Decree No. 1007, INAMHI was attached to the Ministry of Environment and Water on March 4, 2020.

INAMHI is the technical-scientific entity of the State, which is responsible for generating and disseminating hydrometeorological information that serves as a basis for the formulation and evaluation of national and local development plans, support for risk management and the conduct of its own research or that of other actors.

List of Acronyms and Abbreviations

AWS	Automatic Weather Station
CDMS	Climate Data Management System
COSUDE	Swiss Agency for Development and Cooperation
CSO	Civil Society Organization
DGAC	Dirección General de Aviación Civil (Directorate General of Civil Aviation)
ENANDES+	Enhancing Adaptive Capacity of Andean Communities through Climate Services
GBON	Global Basic Observing Network
GEF	Global Environment Facility
GTS	Global Telecommunication System
ICT	Information and Communications Technology
IDB	Inter-American Development Bank
INAMHI	Instituto Nacional de Meteorología e Hidrología (National Institute of Meteorology and Hydrology)
ISO	International Organization for Standardization
ITIL	Information Technology Infrastructure Library
MOU	Memorandums of Understanding
NCP	National Contribution Plan
NGO	Non-Governmental Organization
NUREX	Núcleo Regional de Experticia
PESTEL	Political, Economic, Social, Technological, Environmental, Legal (Analysis Framework)
PMP	Project Management Professional
QMS	Quality Management System
SOFF	Systematic Observations Financing Facility
STEM	Science, Technology, Engineering, and Mathematics
SWOT	Strengths, Weaknesses, Opportunities, Threats (Analysis Framework)
UN	United Nations
UNDP	United Nations Development Programme
USD	United States Dollar
WIGOS	WMO Integrated Global Observing System
WIS	WMO Information System
WMO	World Meteorological Organization

Report completion signatures

Peer Advisor signature	Fontana Fabio Digitally signed by Fontana Fabio Date: 2024.12.13 11:05:23 +01'00'
Beneficiary Country signature	Firmado electrónicamente por: BOLIVAR ANDRES ERAZO MALDONADO
WMO Technical Authority signature