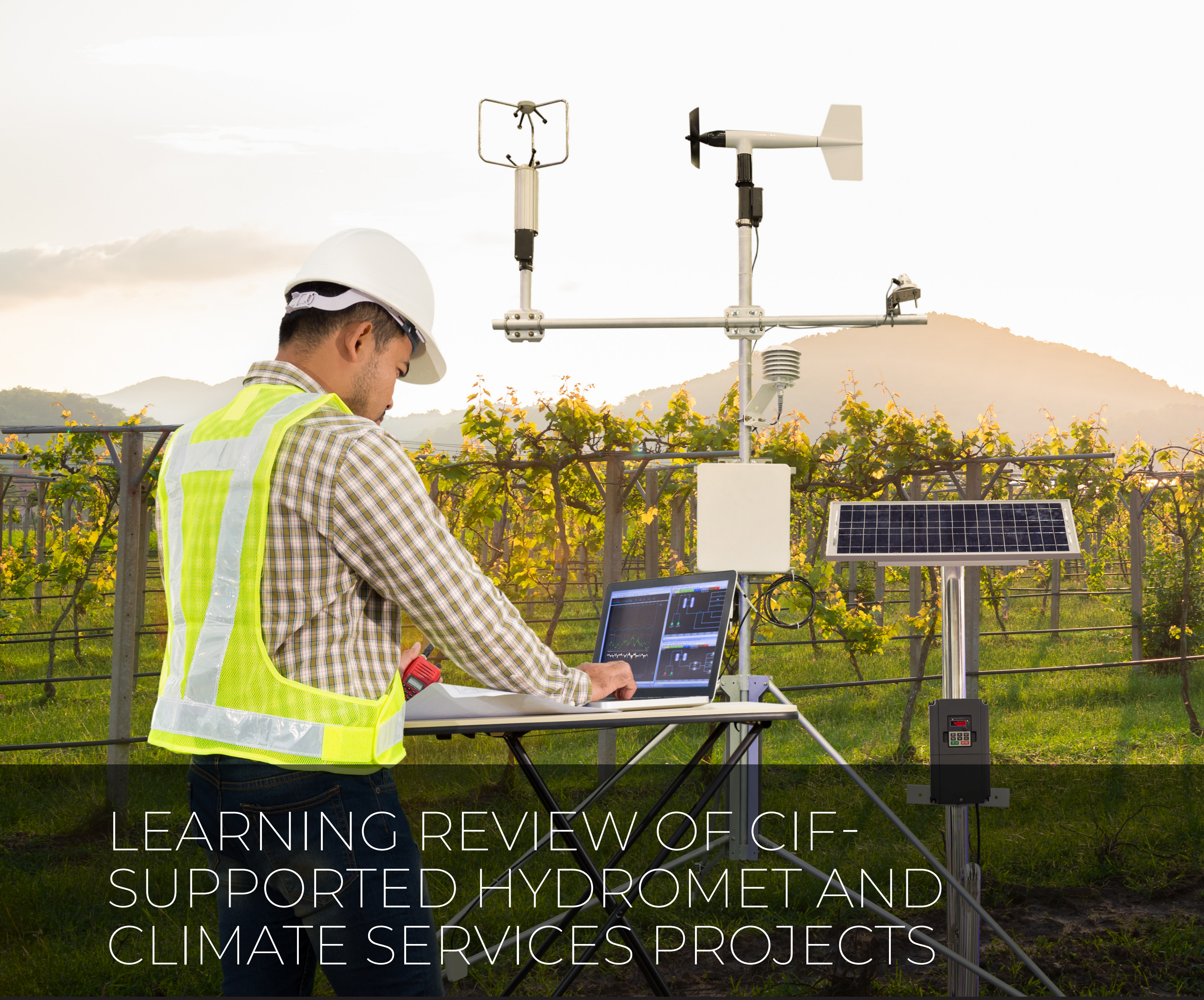

LEARNING REVIEW OF CIF-SUPPORTED HYDROMET AND CLIMATE SERVICES PROJECTS

NOVEMBER 2021

ATKINS

Member of the SNC-Lavalin Group

CIF CLIMATE INVESTMENT FUNDS

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DISCLAIMER

Contents

Acronyms

AfDB African Development bank

AI Artificial Intelligence

AMIS Agriculture Management Information System

ARA Regional Water Authority

AWS Automatic Weather Station

CAHMP Central Asia Hydrometeorology Modernization Project

CCCCC The Caribbean Community Climate Change Centre

CCORAL Caribbean Climate Online Risk and

Adaptation Tool

CCRIF Caribbean Catastrophe Risk Financing FacilityCHD Country Hydromet Diagnostics

CIF Climate Investment Funds

CIIFEN International Research Centre on El Niño

CIMH Caribbean Institute of Meteorology and Hydrology

CMIP6 Coupled Model Intercomparison Project Phase 6

COSMO Consortium for Small-scale Modeling

CRFM Caribbean Regional Fisheries Mechanism

CWSA The Central Water and Sewerage Authority

DHM Department of Hydrology and Meteorology

DNGRH National Directorate of Water Resources Management

DRM Disaster Risk Management

DVRP Disaster Vulnerability Reduction Project

E&L Evaluation and Learning

EBRD European Bank for Reconstruction and Development

ECMWF European Centre for Medium-Range Weather Forecasts

EWS Early-Warning System

FCDO/DFID UK Foreign, Commonwealth & Development Office/Department for International Development

FEWER Fisheries Early Warning and Emergency Response

FMA Finnish Meteorological Association

FMI Finnish Meteorological Institute

G2G Government-to-Government

GBON Global Basic Observing Network (WMO)

GCF Green Climate Fund

GFCS Global Framework for Climate Services

GIS Geographic Information System

GTS Global Telecommunication System

GWE Global Weather Enterprise

HMCS Hydromet and Climate Services

HPC High-Performance Computing

IBF Impact-Based Forecasting

ICDIMP Improving Climate Data and Information Management Project

ICIMOD International Centre for Integrated Mountain Development

ICT Information and Communication Technology

IDA International Development Association

IDB Inter-American Development Bank

IMO International Maritime Organization

INAM National Institute of Meteorology

LAM Limited Area Modelling LDCs Least Developed Countries

LiDAR Light Imaging Detection and Ranging

LQs Learning Questions

M&E Monitoring and Evaluation

MARNDR Ministry of Agriculture, Natural Resources and Rural Development

MDB Multilateral Development Bank

MDC Minister of Civil Defence

MDRyT Ministry of Land and Rural Development

MMAyA Ministry of Environment and Water

MHEWS Multi-Hazard Early Warning Systems

ML Machine Learning

MOP Ministry of Public Works

MoU Memorandum of Understanding

MSJ Meteorological Service of Jamaica

MTR Mid-Term Review

NaDMA National Disaster Management Agency

NARC Nepal Agricultural Research Council

NAWASA National Water and Sewerage Authority

NEMO National Emergency Management Organisation

NHS National Hydrological Service

NIWRMIS National Integrated Water Resources Management Information System

NMHS National Meteorological and Hydrological Service(s)

NMS National Meteorological Service(s)

NWP Numerical Weather Prediction

NWS National Weather Service(s)

NOAA National Oceanic and Atmospheric Administration NGO Nongovernmental Organisation

ODA Overseas Development Assistance

O&M Operation and Maintenance

O&M Observations and Monitoring

PCU Project Coordination Unit

PDIPC Climate Information Development and Forecasting Project in Niger

PIOJ Planning Institute of Jamaica

PMU Project Management Unit

PPCR Pilot Program for Climate Resilience

PROMOVARE Water Resources Mobilization and Development Project

PWS Public Weather Service

R&D Research and Development

RCC Regional Climate Centre

RCIIMS Regional Coastal Integrated Information Management System

SEARPI Water Channeling and Regularization Service of the Piraí River

SENAMHI National Service of Meteorology and Hydrology

SIDS Small Island Developing States

SLMS Saint Lucia Meteorological Service

SOFF Systematic Observations Financing Facility

SPCR Strategic Program for Climate Resilience

SPI Standardised Precipitation Index

STEM Science, Technology, Engineering, and Math

SVG Saint Vincent and the Grenadines

SVGMO Saint Vincent and the Grenadines Meteorological Office

TCFD Taskforce for Climate-Related Financial Disclosures

UGR Regional Units of Disasters Management

UHM Hydrometeorological Unit of Haiti

UN United Nations

USAID US Agency for International Development

WASCO Water and Sewerage Company

WB World Bank

WBG World Bank Group

WCIS Weather and Climate Information Services

WIGOS WMO Integrated Global Observing System

WMO World Meteorological Organization

Executive Summary

This learning review takes stock of the progress made to date under the Climate Investment Funds' (CIF) Pilot Program for Climate Resilience (PPCR) and contributes to global learning on the effective financing of hydromet and climate services (HMCS). The PPCR was designed to support vulnerable countries in increasing their resilience and ability to adapt to the impacts of climate change.

The review considered 12 HMCS projects, funded by the CIF with co-finance from the African Development Bank (AfDB), Inter-American Development Bank (IDB), and the World Bank with total PPCR funding of USD222 million (grants of USD122 million and loans of USD100 million). The projects, based in Bolivia, the Caribbean (Dominica, Grenada, Jamaica, Saint Lucia, Saint Vincent and the Grenadines), Haiti, Mozambique, Nepal, Niger and Tajikistan included some of the most vulnerable countries in the world, with high exposure to climate risks and hydromet-related natural hazards and a history of underinvestment in weather and climate services.

The approach to the learning review was based on considerable engagement with each project team, including 48 interviews and seven workshops to gather evidence from different stakeholders, and to test and validate findings throughout the study. The review was structured around six learning questions (LQs) covering the progress of the projects, as well as the priorities and opportunities for future investments in HMCS.

Progress delivered by PPCR projects

- Of the **12 selected projects**, seven have been completed, while five are ongoing.[1] Most of these projects are mainly focused on improving the capacities of the countries in the development and delivery of HMCS, with some only having components that aim to contribute to this objective. Although all projects will meet the majority of their objectives, they will also face significant challenges in delivering complex national infrastructure projects, and for some, their country's first major investment in hydrometeorological services.
- In the larger adaptation and climate resilience projects, HMCS components accounted for around 25 percent of the total investment, with most of the funding aimed at climate-resilient infrastructures. All the PPCR investments were designed to address the different components of the HMCS value chain—ranging **from observations and monitoring** to **data management;**

[1] Here, the Grenada project is counted as completed (June 2021), whereas the Saint Vincent and Grenadines (SVG) project is still considered to be ongoing due to the support provided following the La Soufriere volcanic eruption that delayed some civil works.

research and forecasting, and service delivery; as well as **capacity building** across the full-value chain.

- By design, the **primary focus** of HMCS projects was on **(1) observations and monitoring, (2) data and information management and (3) service delivery**. However, the greatest capital expenditure was in observations equipment (47 percent), with significantly less investments in service development and delivery (five percent) and capacity building (20 percent). The remaining two components of the HMCS value chain (data and information management as well as research, forecasting and modelling) each received 14 percent of the capital expenditure.
- The projects were most successful at extending and **upgrading observation networks** (for example, in Niger, Grenada, Nepal, and Tajikistan), **improving the management of data and information** [for example, the collection and sharing of Light Imaging Detection and Ranging (LiDAR) data in Dominica], and building capacity (for example, with more than 200 staff trained in Jamaica). There were also successes in **public engagement** on climate change and the **development of weather and climate services**, particularly in the water and agriculture sectors (for example, in Jamaica, Mozambique, and Nepal).

Common successes, challenges, and enablers emerging from PPCR projects

- A synthesis across the projects identified several **hallmarks of successful PPCR projects**:
    - A **clear vision, long-term strategy, and investment plan** for HMCS that are aligned with national development priorities;
    - **Strong partnerships** between national meteorological and hydrological services (NMHS), other ministries, universities, along with global and regional weather and climate centres;
    - **Customer focus** and a service delivery culture within the National Meteorological and Hydrological Service (NMHS) and other suppliers, which supports the cocreation of improved services;
    - **Feedback mechanisms**, including user surveys, social media and steering groups, that supported continuous improvements within projects and longer-term strategies.
- **Successful project components** were underpinned by **adequate core funding** from the governments to cover staff and other operational costs, **strong governance and management**, significant **improvements in information and communications technology (ICT) infrastructure,** along with **investments in government staff** (and in some cases, key individual experts), to deliver these major projects.
- **Typical project challenges** included **organisational capacity** and the ability to **retain skilled project staff** to see long projects through from inception to completion, the **procurement of**

specialist equipment and parts for maintenance, and the fulfilment of **ambitious objectives** through periods of political instability, natural disasters, and COVID-19 (since early 2020).

- **Enabling factors** that helped to navigate the challenges are identified here: (1) the use of **professional project management and procurement experts**, along with technical assistance from multilateral development bank (MDB) partners and international individual consultants; (2) **strong inter-ministerial collaboration** in the form of multistakeholder Project Steering Groups and Hydromet Working Groups, which enabled more effective data sharing and service development; as well as (3) **regional collaboration** with Regional Climate Centres (RCCs) designated by the World Meteorological Organization (WMO) and peers in the neighbouring NMHS that supported both the capacity building and the improvement of regional services.

Future priorities for PPCR countries

- There are **priority needs along the full HMCS value chain**, including some **further investments in observations as well as monitoring and data exchange**, along with a much **greater focus on service delivery** to improve weather and climate resilience in key economic sectors. All project countries recognised the foundations laid by the PPCR projects and the need to focus future projects on service delivery. This requires **targeted capacity building** and skills development to bridge the gap between improved observation networks and improvements in the delivery of weather and climate services.
- Despite significant investments in the rehabilitated, upgraded, and extended monitoring and observation networks, there are still **significant monitoring gaps** in many PPCR countries that can be attributed to the historic lack of investment and the capacity of the monitoring and observation infrastructure. Therefore, there is still some demand to **increase the density of networks** as well as **improve data availability** and access, which underpin effective weather and climate services.
- Strengthening partnerships and collaboration across government agencies, key sectors, and vulnerable communities through **demand-led** and **cocreated project designs** is strongly supported by all PPCR project-implementing agencies and beneficiaries.
- Investments that lead to **improved quality of services**,[2] particularly those that inform decision-making in priority sectors, are regarded as essential to securing and maintaining government

[2] As evidenced by customer or user feedback, in the form of user surveys and forums involving stakeholders from a range of sectors that make use of Weather and Climate Information Services (WCIS).

support. They can also support the aspirations for **private sector income** of the NMHS tasked with greater cost recovery.

- Overall funding for public Weather and Climate Information Services (WCIS) suppliers is regarded as **'adequate'** at best but **'insufficient'** in the majority of PPCR countries.[3] Further work is needed to **maintain basic services** and find **sustainable financing** to improve services. PPCR countries need to navigate different pathways to develop their weather and climate services, which may include developing **improved policies**,[4] **strengthening government partnerships**, as well as working with WMO centres and the private sector to secure **sufficient technical expertise** and **operational income** to deliver improved services.

Recommendations

A number of project design and implementation recommendations for CIF and the wider climate finance community were developed, based on the lessons learned from PPCR HMCS projects.

For project design:

- The design of projects must be aligned to a **national long-term strategy** for the modernisation of HMCS and include some **flexibility and contingencies** when working in politically unstable and highly vulnerable developing country contexts. The effective implementation of projects requires significant efforts in building teams with **suitable expertise** and essential **institutional relationships**. The need for longer-term, more **programmatic future investments** was emphasised by several project partners.
- Projects should be designed, based on **national economic, climate, and disaster risk reduction (DRR) priorities** and **user requirements** for weather and climate information, then **work backwards along the value chain,** to identify what investment is needed to improve specific services and products.
- Projects should be **codesigned** to allow active learning from users of weather and climate services, as well as allow feedback for improving product design and the delivery of services. This requires the **piloting of new services** and significant **stakeholder engagement** throughout the design, implementation, and learning stages.

[3] Based on feedback from interviews, gaining sufficient core government funding was a challenge, particularly post COVID.
[4] These may include policies linked to National Adaptation Plans, data and information for disaster preparedness, or broader open data policies.

For project implementation:

- The sustainability of HMCS investments, encompassing the following areas, should be made a core principle of implementation: **effective strategy** and **business planning**, **long-term partnerships** and **institutional arrangements**, as well as the **resilience of critical infrastructure systems** for impact-based forecasting (IBF).
- For NMHS, the careful **consideration of operational and maintenance (O&M) costs** is essential before embarking on the further expansion of observation networks. O&M costs were a common challenge across the PPCR projects, which echoes the long-term critique of grants and loans for purchasing hydromet stations and other equipment. However, in many cases, the PPCR projects were influential in securing further O&M funding from the government.
- NMHS should **invest in strategic and long-term planning** to make a strong business case for capital and operational funding. Public Weather Services (PWS) are essential for preventing severe damages and losses from extreme weather events and hydromet-related natural hazards, as well as supporting the economic growth of key economic sectors in developing countries.
- **The development of strong partnerships** with different government ministries, including obtaining **clear mandates** for the provision of meteorological and hydrological services, along with formulating data-sharing policies, ensures that HMCS are well targeted to meet user requirements, thereby avoiding additional costs due to the duplication of observation networks or competing services.
- In some countries, NMHS have been asked to recover costs, and in these cases, partnerships with the private sector to deliver value-added services are likely to be far more effective than focusing on data sales. In general, **open data policies** have been shown to deliver greater national socioeconomic benefits, thus generating a stronger case for government funding.[5]
- National governments need to **maintain the national capability in HMCS**, including retaining skilled staff. Support is needed to develop effective strategies to attract Science, Technology, Engineering, and Maths (STEM) graduates and technicians as well as provide a rewarding and sufficiently well-paid career path.

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[5] David P. Rogers, and Vladimir Tsirkunov, 2021, *Open Data: A Path to Climate Resilience and Economic Development in South Asia?* Washington, D.C.: World Bank, https://www.preventionweb.net/publication/open-data-path-climate-resilience-and-economic-development-south-asia.

1.0 Introduction

CIF was founded with the mandate to serve as a learning laboratory for scaled-up climate finance. The CIF Evaluation and Learning (E&L) Initiative is helping to fulfil this mandate through a range of strategic and demand-driven evaluations covering some of the most important and pressing challenges facing climate financiers and practitioners. Drawing on experience from across the CIF portfolio of investments in clean energy, forests, and resilience in 72 developing countries, the E&L Initiative uses evaluation to enable relevant and timely learning that can be used by both CIF and the wider climate finance sector to inform their decisions and strategies. This learning review was commissioned by CIF's E&L Initiative and focuses on learning from CIF's hydromet and climate services (HMCS) projects funded under the CIF's Pilot Program for Climate Resilience (PPCR).

In the context of global commitments on Climate Action (UN Sustainable Development Goal 13) and Disaster Risk Reduction (Sendai Framework for DRR 2015-2030), the international community is scaling up support in building resilience to climate and disaster risks, including through the strengthening of hydromet and climate services (HMCS). These include early-warning systems (EWS), seasonal forecasts for agriculture, and the development of national climate change projections. Improvements in these services require investments across the full meteorological and hydrological value chain—from observations and monitoring to service development and delivery (Figure 1-1). In developing countries, the challenges of sustainability, including capacity constraints, limits to public financing and effective operating models for HMCS, are well documented.[6]

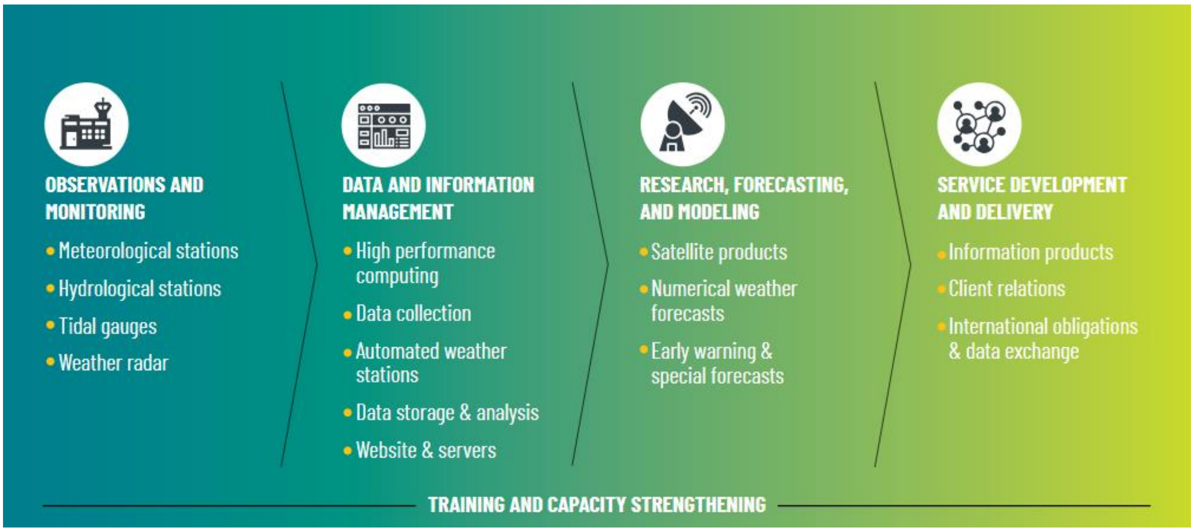
The economic rationale for investing in weather and climate services remains strong, with cost-benefit ratios typically in the range of 3 to 36:1.[7] Some research on regional flood forecasting systems makes the case for much higher cost-benefit ratios of 400:1[8] for the European Flood Awareness System.[9] The investment case is the greatest when the services provided deliver reliable and actionable information that can be used to

[6] David P. Rogers, and Vladimir V. Tsirkunov, 2013, *Weather and Climate Resilience: Effective Preparedness through National Meteorological and Hydrological Services. Directions in Development*, Washington, DC: World Bank, doi:10.1596/978-1-4648-0026-9.
[7] Based on studies cited in CIF, 2020, originally from WMO, World Bank GFDRR, and USAID, 2015, *Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services*, Geneva: WMO, WMO-NO.1153, https://library.wmo.int/doc_num.php?explnum_id=3314.
[8] Florian Pappenberger, et al., 2015, "The Monetary Benefit of Early Flood Warnings in Europe," *Environmental Science and Policy* 51: 278–91. https://core.ac.uk/download/pdf/82514981.pdf.
[9] The European Flood Awareness System provides probabilistic flood forecasting information to national authorities within Europe and the Emergency Response Coordination Centre of the European Commission, thus enabling local and national authorities to make informed decisions regarding flood risks.

inform decisions, avoiding significant harm and economic loss, whilst promoting sustainable economic development. In developing countries, this typically translates into providing improved services in impact-based forecasting (IBF),[10] thereby ensuring the safety of aviation, shipping and services for key economic sectors, such as agriculture. However, there are also a growing number of examples of high-impact weather services in health, energy and other sectors.[11]

The provision of weather information normally involves a country's National Meteorological and Hydrological Service (NMHS) working effectively with other national and international partners in the 'Global Weather Enterprise (GWE)[12]', which increasingly involves the private sector. The amount of investment required to create an effective NMHS is significant, and therefore, it is essential to target investments based on lessons learned from past projects, such as those under the Climate Investment Funds' (CIF) Pilot Program for Climate Resilience (PPCR), as well as by understanding emerging trends in the international weather and climate services sector.

Figure 1-1: HMCS value chain.



Source: CIF 2020.[13]

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[10] Impact-based forecasting (IBF) is the provision of information needed to support improved decision-making and planning to minimise the impact of weather, climate, and hydrological hazards.
[11] WMO, 2016, "Climate Services for Health," Climate Services for Health | World Meteorological Organization and Met Office, 2018, "Energy Industry Weather and Climate Services", https://public.wmo.int/en/media/news/climate-services-health.
[12] The global weather enterprise (GWE) is complex, involving global telecommunications and data suppliers, global and regional modelling centres, the National Meteorological and Hydrological Services (NMHS), public and private sectors, academics and the research community, along with a wide range of end-users across multiple governments and commercial sectors.
[13] CIF, 2020, *Strengthening Weather and Climate Information Services: Highlights from PPCR-Supported Projects Climate Investment Fund Knowledge for Resilience Series*, September 2020, https://www.climateinvestmentfunds.org/sites/cif_enc/files/knowledge-documents/ppcr_resilience_series_weather_and_climate_information_services.pdf.

PPCR was designed to support vulnerable countries and increase their resilience to the impacts of climate change. It has invested over USD200 million[14] of its USD1.2 billion of funding in activities to strengthen HMCS in selected countries.[15] As seen in Figure 1-1, PPCR addresses the full Weather and Climate Information Services (WCIS) value chain from (1) observations and monitoring, through (2) data and information management along with (3) research, forecasting, and modelling to (4) the development and provision of improved services, as well as the training and capacity building underpinning all four components.

Figure 1-2: Status snapshot of selected PPCR HMCS projects (as of August 2021).[16]

This learning review takes stock of the progress made to date on strengthening HMCS under PPCR and the lessons learned from these projects, with the view to contribute to global learning on the effective financing of HMCS. Apart from drawing lessons from the 12 projects in the PPCR HMCS portfolio, this learning review also focuses on assessing key gaps for future HMCS investments. To help move forward, the review identifies recommendations for the development of sustainable funding strategies for HMCS in order to address key

[14] Total investments in WCIS-focused projects under the PPCR includes USD221.69 million of PPCR funds and USD136.37 million of cofinancing from multilateral development banks (MDBs). This estimate is based on the budgets of projects, with a specific focus on improving the capabilities of countries in the development and delivery of weather and climate information services only.

[15] CIF, 2020, *Strengthening Weather and Climate Information Services: Highlights from PPCR-Supported Projects Climate Investment Fund Knowledge for Resilience Series*, September 2020, https://www.climateinvestmentfunds.org/sites/cif_enc/files/knowledge-documents/ppcr_resilience_series_weather_and_climate_information_services.pdf.

[16] Progress towards objectives is based on progress of project development objective indicators within relevant *Implementation Status & Results Reports*.

issues around the sustainability of services beyond donor funding. These recommendations are designed to be relevant to the wider HMCS community, including all stakeholders involved in the funding, design, and implementation of HMCS projects.

This report presents the findings from the learning review of PPCR HMCS projects, synthesising information from an extensive review of project documentation, interviews with key project staff, and seven workshops (including five participatory workshops and two final validation workshops).

The report is structured as follows:

- Section 2, organised around six Learning Questions (LQs) developed for the learning review, provides an overview of the scope and approach.
- Section 3 presents the results from the learning review: the focus of PPCR projects and their progress towards meeting their objectives, including a summary of achievements along the hydromet value chain presented in Appendix B (3.1); the challenges, successes, and good practices (3.2); along with priorities for future investments (3.3).
- Section 4 provides recommendations based on the experience of the PPCR projects.
- Twelve project learning briefs summarising key information and lessons learned are provided in Appendix A.

2.0 Scope and Approach

2.1. PPCR Projects Considered

In consultation with CIF, 12 PPCR projects are considered under this learning review. These include projects in 11 countries and one covering the Caribbean Region. Table 2-1 summarises some of the basic project information, the respective focus on each element of the WCIS value chain, and the sectors targeted. More comprehensive summaries are provided in the learning briefs for each project in Appendix A.

Table 2-1: PPCR projects selected for the learning review.

				Basic data				Value chain focus					Sectors			
No.	Multilateral Development Bank	Country	Project Name	PPCR Grant (US$M)	PPCR Loan (US$M)	Total PPCR Financing (US$M)	Co-financing (US$M)	Observations & Monitoring	Data & Information Management	Research, Forecasting & Modelling	Service Development & Delivery	Training & Capacity Strengthening	Agriculture	Water	Coastal	Multisector
1	World Bank	Bolivia	Climate Resilience - Integrated Basin Management Project (IBRM)	9.50	36.00	45.50	25.90	3	2	1	2	2	3	3	0	2
2	Inter-American Development Bank	Caribbean Region	Investment Plan for the Caribbean Regional Track	10.39	~	10.39	~	3	2	1	2	1	1	1	3	3
3	World Bank	Dominica	Disaster Vulnerability Reduction Project (DVRP)	12.00	9.00	21.00	18.50	3	3	1	2	1	3	1	3	2
4	World Bank	Grenada	Disaster Vulnerability Reduction Project (DVRP)	13.00	12.00	25.00	14.00	2	2	2	2	1	3	3	0	2
5	World Bank	Haiti	Strengthening Hydro-Meteorological Services Project	5.00	~	5.00	~	1	3	2	3	2	2	2	0	3
6	World Bank	Jamaica	Improving Climate Data and Information Management Project (ICDIMP)	6.80	~	6.80	0.70	3	2	1	2	2	1	3	3	3
7	World Bank	Mozambique	Climate Resilience: Transforming Hydro-Meteorolgoical Services	15.00	~	15.00	7.50	2	2	2	3	2	3	3	2	2
8	World Bank	Nepal	Building Resilience to Climate-Related Hazards	16.00	15.00	31.00	0.30	2	3	1	3	1	1	1	3	2
9	African Development Bank	Niger	Climate Information Development and Forecasting Project (PDIPC)	3.50	9.50	13.00	0.85	2	3	1	3	2	1	1	3	3
10	World Bank	Saint Lucia	Disaster Vulnerability Reduction Project (DVRP)	12.00	15.00	27.00	41.00	2	2	1	2	2	3	1	0	1
11	World Bank	Saint Vincent and the Grenadines	Disaster Vulnerability Reduction Project (DVRP)	12.00	3.00	15.00	12.92	3	2	1	1	2	2	2	3	3
12	World Bank	Tajikistan	Improvement of Weather, Climate and Hydrological Delivery Project	7.00	~	7.00	14.70	1	2	1	2	1	3	1	3	2
				122.19	**99.50**	**221.69**	**136.37**									

Key: Shaded coding indicates the relative focus on different parts of the value chain and different sectors (scored '0–3', with '3' being the highest focus). Some countries have no coastline, hence '0' in the coastal sector column. As expected in developing countries, agriculture is a primary focus, but PPCR also has a strong emphasis on water resources, floods, and droughts. Under PPCR, the Bolivia IBRM project was not categorised as a hydromet project, but it was included in this study because it has a component related to hydromet activities.
Source: Analysis of PPCR project documents.

2.2. Overview of Approach

This learning review combined consideration of relevant literature and project documentation, with significant engagement of project stakeholders in the form of workshops, interviews, and country case studies.

It is clear that project outcomes depend both on factors that are internal to the project and the wider HMCS context in which they are implemented. Therefore, in order to identify transferable good practices and lessons learned, the review focused on situating the learning from the PPCR projects in a broader context of learning from global weather services. This includes major relevant projects supported by a range of institutions including the World Bank (WB), the US Agency for International Development (USAID), as well as the UK Foreign and Commonwealth Development Office (FCDO).

The inception workshops carried out in December 2020 provided useful feedback on the proposed LQs, with rich discussions generated around how best to gather evidence for the different questions. The six LQs that were agreed upon are presented below:

Progress made under PPCR projects

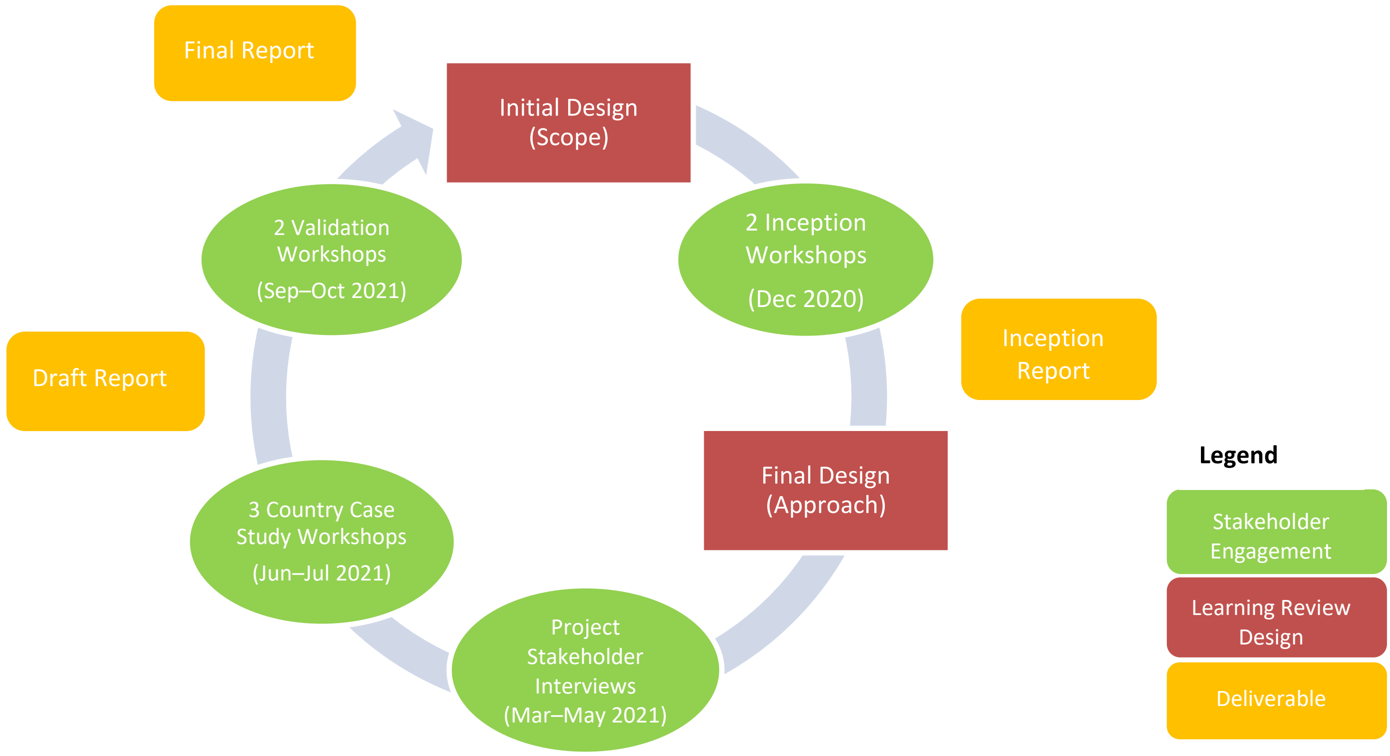
- LQ1: What motivated the PPCR investment in HMCS?
- LQ2: What are the key process features of the PPCR HMCS projects?
- LQ3: To what extent did investments meet objectives and contribute to key aspects of the overall HMCS value chain?
- LQ4: What are the top good practices or factors contributing to project successes that could be replicated elsewhere, including any lessons learned that could inform the design and/or implementation of similar future projects?

Priorities and opportunities for more effective investments in HMCS

- LQ5: What are the priority needs for further hydromet development within the PPCR HMCS project countries?
- LQ6: What are the key elements of a funding strategy for a sustainable and functional HMCS in developing countries?

The framework for the learning review allowed for three levels of feedback and validation, as highlighted in green in Figure 2-1 below. This iterative approach allowed the review to explore and integrate stakeholder views on the issues addressed through the different LQs, clearly identifying lessons learned, good practices, and operational recommendations for CIF and other potential financiers.

Figure 2-1: Iterative approach to learning review.

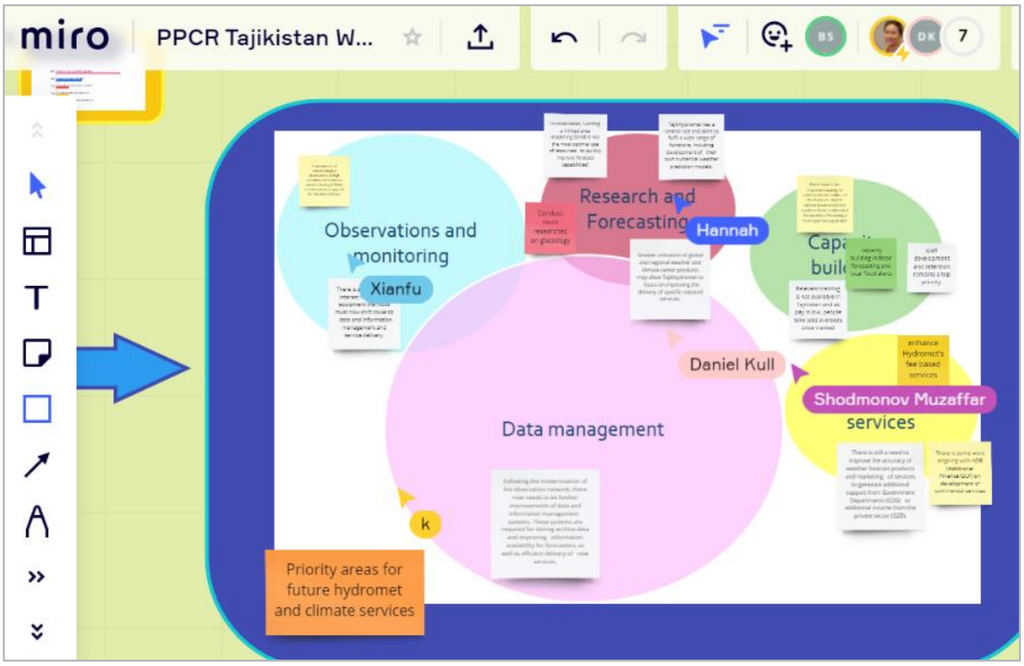


Early engagement in the project highlighted the importance of understanding the context in which the individual PPCR projects were implemented. As such, the learning review first developed a comprehensive understanding of the HMCS system in each country or region before engaging in interviews with the key stakeholders from international donors, PPCR project teams, and national meteorological services (NMS). Based on the combination of the document review and stakeholder engagement, an in-depth understanding of each project was developed, from which a set of preliminary answers to each LQ was developed. These were synthesised into short learning briefs for each country (11) and the Caribbean Region (see Appendix A). In turn, these learning briefs were shared with the engaged stakeholders as part of an initial validation process to test the understanding of the different projects and provide the stakeholders with an opportunity to provide feedback on initial findings. Three out of the 12 PPCR projects were selected, in coordination with the CIF, as case studies. They covered different regions and varying approaches to project focus and implementation, thereby enabling an deeper exploration of the specific challenges and lessons learned from the projects. These projects are listed below:

1) Niger—Climate Information Development and Forecasting Project (PDIPC)
2) St Lucia—Disaster Vulnerability Reduction Project (DVRP)
3) Tajikistan—Improvement of Weather, Climate and Hydrological Delivery Project

For each of these case studies, a virtual country learning workshop was held in order to gain a deeper understanding of the different projects and the context in which they were implemented. These workshops were structured using online whiteboards[17] that allowed participants to engage and comment on initial findings, as shown in Figure 2-2. Key lessons from each of the case study countries are presented throughout this report, with the full project learning briefs available in Appendix A.

Figure 2-2: Example of the virtual country learning workshop whiteboard (showing the relationships between project elements and how comments could be added).



The synthesis and validation phase of the learning review then comprised further analysis, the incorporation of the initial feedback, and the development of draft recommendations. The findings from the draft report were shared with stakeholders prior to the final validation workshops, thus providing an opportunity to gather further feedback on the main lessons learned and draft recommendations.

[17] Either Miro or Google's 'jamboard'.

Following the final validation workshops, final revisions that were made to the conclusions and recommendations were incorporated into the final learning brief for each project. Thus, the results and recommendations presented in this report are built on the extensive inputs from the PPCR project stakeholders, which have been developed and refined in an iterative learning process.

In total, the engagement with stakeholders for this learning review included the following components:

- Two inception workshops,
- 48 interviews,
- Three country learning workshops (Niger, Saint Lucia, and Tajikistan)
- Two final validation workshops.

Where the level of stakeholder engagement was limited, additional documentation, such as independent evaluations and studies, were reviewed to support the learning review.

Figure 2-3: Number of interviews carried out per project.

3.0 Key Findings

This section presents the key findings from this learning review. It is structured as follows:

- Section 3.1 summarises the progress made to date in the PPCR projects, including the main focus of the projects on the HMCS value chain, the key attributes of the project design, and a summary of the progress vis-à-vis the project objectives, including notable project successes.
- Section 3.2 highlights the key challenges encountered in the projects, as well as the enabling factors that contributed to successful outcomes and lessons learned. Table 3-2 provides a summary of the successes, challenges and enabling factors of the different projects.
- Section 3.3 summarises the key areas in need of future investments in the countries and region engaged through the learning review, in accordance with the stage of the HMCS value chain and within the wider literature on weather and climate services.

3.1. Progress delivered by the PPCR HMCS projects

3.1.1. Focus of the PPCR HMCS projects

The PPCR HMCS projects span a wide range of geographies, from the landlocked semi-arid Central Asia to tropical Caribbean islands and the arid conditions of the Sahel. The projects were funded in different ways. Some (for example, Haiti), entirely funded by PPCR, were fully focused on strengthening HMCS. In the case of larger projects [for example, Bolivia and the Disaster Vulnerability Reduction Projects (DVRPs) in the Caribbean], the HCMS investment, typically accounting for around 10–25 percent of the overall project investment, is just one component. Despite differences in the funding size, the geographic context, and the focus of the project along the WCIS value chain (as discussed further under LQ3), there are common themes that motivated the PPCR investments.

A key theme for the majority of the PPCR HMCS projects is that they are **implemented in countries or regions with high exposure and vulnerability to weather and climate hazards**, and in particular, to hurricanes, droughts, and flooding (highlighted in Table 3-1). Specifically, there is a common recognition that in order **to support national development objectives, there is a need to enhance the generation, uptake and application of weather and climate information so as to increase the resilience of key sectors**. Disaster-risk reduction is a key focus area for many projects. For several countries, the PPCR HMCS projects were linked to wider disaster risk reduction projects, such as the Disaster Risk and Vulnerability Reduction projects in the Caribbean, with a clear motivation to use the PPCR investment **to develop and improve early-warning systems (EWS), as well as create a stronger link between WCIS and infrastructure sectors.** Agriculture and water infrastructure are the other main sectors targeted by the PPCR HMCS projects. **A key driver of investment has been the need to modernise national meteorological agencies**, which in many cases, have been persistently underfunded, and as such, were not in a position to effectively deliver the weather and climate services needed to build resilience. Most national meteorological services (NMS) involved in the PPCR projects were providing 'basic' or 'less-than-basic' services, based on the WMO system of self-assessment and peer review. [18,19] Some of the larger Met Services were providing 'intermediate' services.

Table 3-1: Vulnerability and Exposure rankings for selected PPCR countries on the ND-GAIN Vulnerability Index[20] (🚩 indicates lower quartile of all countries surveyed, 🏳 indicates upper quartile). [21]

	Exposure Rank (n=192)	Vulnerability Rank (n=182)
Bolivia	107 🏳	120🏳
Dominica	46	88
Grenada	50	55
Haiti	94	152 🚩
Jamaica	107 🏳	96 🏳
Mozambique	88	140 🚩
Nepal	129 🏳	137 🚩
Niger	191 🚩	182 🚩
St Lucia	54	37
St Vincent and the Grenadines	73	N/A
Tajikistan	39	72

Source: Vulnerability rankings | ND-GAIN Index.

[18] A basic level of climate service provides a dataset that is the foundation for information products available in higher categories. There is limited interaction with users.

[19] WMO, 2011, *Climate Knowledge for Action: A Global Framework for Climate Services— Empowering the Most Vulnerable*, Geneva: World Meteorological Organization,https://library.wmo.int/index.php?lvl=notice_display&id=5439#.YUA9XxmSk2w.

[20] The ND GAIN Index, which combines multiple different indicators to summarise national-level vulnerability to climate change, includes aggregate indices on Exposure, Vulnerability, and Sensitivity.

[21] The Caribbean Regional project was not included, as the rankings are national; however, the Caribbean region as a whole is highly exposed to hurricanes and other disasters.

Figure 3-1: Relative focus on the HMCS value-chain components, as identified by project stakeholders.

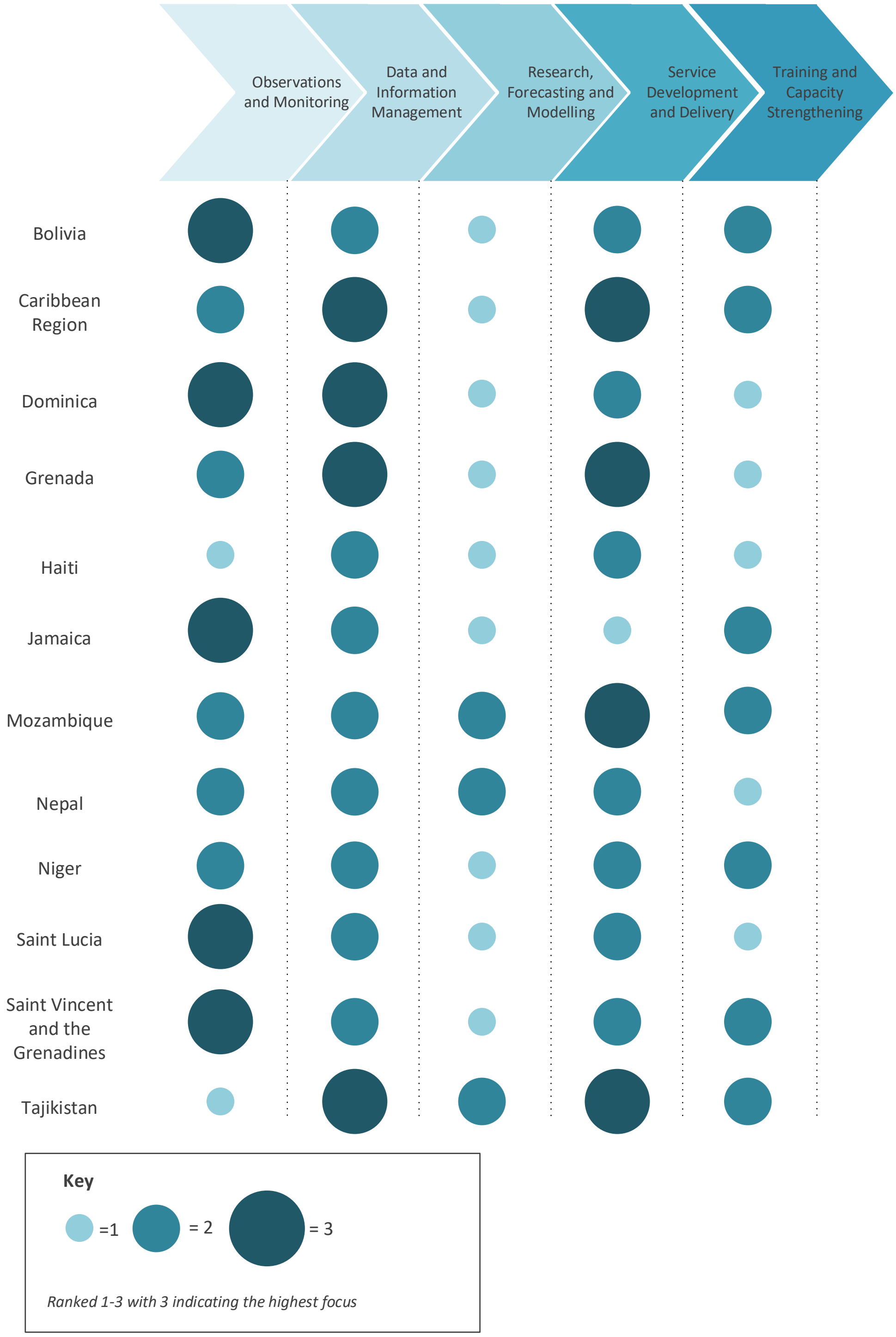
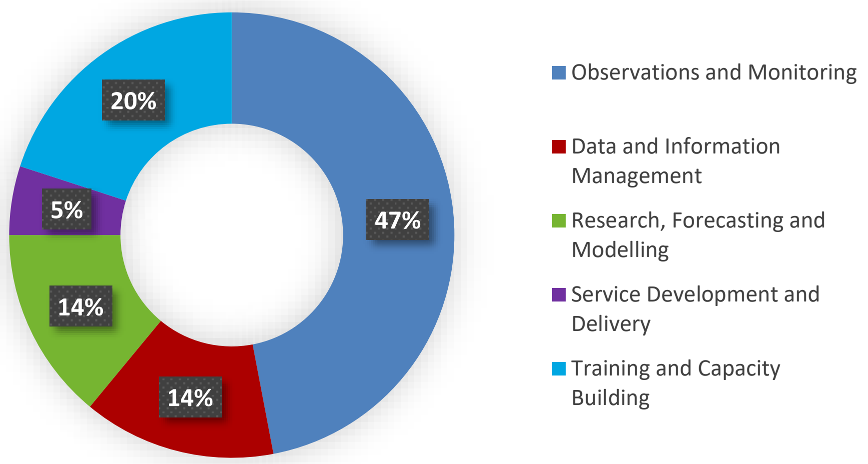


Figure 3-2 shows the split of PPCR investment at the different stages of the HMCS value chain. **In terms of money spent, investments in improving observations and monitoring dominate, representing nearly half of all the money spent (47 percent), with significantly less investments in service development and delivery (five percent) and capacity building (20 percent).** To some extent, however, this is a slightly misleading picture, as it is skewed by the fact that hydrometeorological equipment is, by its nature, a significant source of capital expenditure within a project, when compared to the operational activities that mainly require staff time and engagement, which are not fully accounted for in the project budgets.

Observations and monitoring are key underpinning components of weather and climate services. Without an effective observation network or historical record at the national level, the number and types of possible services can be limited. The comparison between the amount spent on training and the amount spent on the development of climate services, both of which require similar types of input, is, however, illustrative. **That four times the amount of money was spent on training and capacity building, compared to service delivery, shows that despite the intention to work across all stages of the value chain, as shown in Figure 3-1, many projects were not able to carry out service-related activities.**

Figure 3-2: Split of PPCR investments across the value chain.



Source: CIF 2020.[22]

[22] CIF, 2020, *Strengthening Weather and Climate Information Services: Highlights from PPCR-Supported Projects Climate Investment Fund Knowledge for Resilience Series,* September 2020, https://www.climateinvestmentfunds.org/sites/cif_enc/files/knowledge-documents/ppcr_resilience_series_weather_and_climate_information_services.pdf.

3.1.2. Key process features of the PPCR HMCS projects

The PPCR projects were initially identified and developed as part of the Strategic Program for Climate Resilience (SPCR) for each country. This was a multistakeholder and participatory process designed to ensure that the PPCR projects reflected national priorities and included inputs from community-based organisations, the private sector and vulnerable groups.

The projects are, therefore, the result of a participatory consultation and engagement process with key national stakeholders, including relevant government departments, the district or federal government where appropriate, representatives from potential intermediary users and end-users[23] of climate services, along with representatives from both the civil society and the private sectors. This means that the projects are clearly aligned with the national priorities for climate resilience and user-informed weather and climate services, as well as being rooted in the institutional hydromet context of the country. As such, these projects are central to modernisation efforts of the hydromet system, rather than an endeavour to create a separate set of institutional structures.

Several projects noted strong inter-ministerial coordination as a key factor driving the success of the project, building on relationships developed through SPCR and multistakeholder forums, such as hydromet commissions or working groups. Two examples are presented below:

- In Dominica, **inter-ministerial collaboration** has been key to the project design and implementation. All government ministries involved have been working together, sharing data and information towards a common goal. Institutional arrangements have been very clear from the outset of the project, with each institution knowing well its responsibilities and contributions to the project.
- In St Vincent and the Grenadines (SVG), extremely **strong engagement, mandates and data sharing between ministries** are viewed as exemplary in the region, with a particularly clear mandate in the Physical Planning department to share data. Although the Saint Vincent and the Grenadines Meteorological Office (SVGMO) is the custodian of hydromet data, there is smooth sharing between the

[23] Intermediary users are often partners of the NMHS and work to translate climate information into tailored weather and climate services for end-users. Examples of intermediaries include the Caribbean Community Climate Change Centre (CCCCC) and the International Centre for Integrated Mountain Development (ICIMOD). The final end-users of weather and climate services are those who often require a relevant, reliable, and useful advisory service or product that they can input into their decision-making. These final end-users can be farmers, fisherman, dam operators, construction workers, and vulnerable communities, as well as national and sub-national decision-makers and planners who need services or products at longer timescales (for example, decadal predictions and climate projections).

agencies. SVGMO has put significant effort into creating an open data platform to facilitate the sharing of data and data products.

Although the SPCR process laid the groundwork for strong collaboration within projects, there are examples from within the PPCR portfolio where a lack of coordination and collaboration was cited as a barrier to successful implementation (see section 3.2 for further detail).

Aided by the initial SPCR process, beneficiaries were generally viewed as having had a strong influence on project design, and to a slightly lesser degree, the implementation of the different PPCR projects.[24] Beneficiary participation tends to be, however, stronger for intermediary organisations (for example, other government departments and regional agencies) than for the ultimate end-users. Where projects have been able to develop effective weather and climate services, strong engagement between NMS, intermediaries and end-users has been seen as a key component of their successful implementation. An example is the development of climate projections in Jamaica, coupled with a public campaign on preparedness for climate change.

A consistent finding among projects is that processes to gather and incorporate beneficiary feedback for services were less developed than that for project design. However, there are exceptions. In Jamaica, the Improving Climate Data & Information Management Project (ICDIMP) captured user feedback on services through a web map on the Water Resource Authority's (WRA) webpage and social media, such as Facebook/Instagram/Twitter. In Grenada, the Ministry of Agriculture has been obtaining feedback from users on the open data platform in order to improve services.

This reflects, in part, the focus of many of the projects on the initial stages of the HMCS value chain (observations and monitoring and data and information management), as discussed below, with fewer examples where user services have been developed. Feedback and learning processes within the projects, as opposed to the traditional log frame-based monitoring and evaluation (M&E) of projects, are, however, underdeveloped, relative to other elements of the projects. This is an area that could be strengthened in the design of future projects.

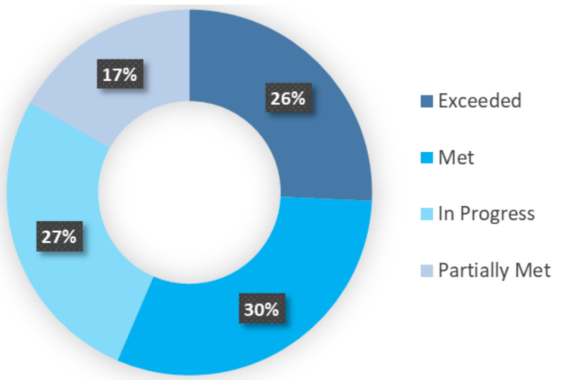
[24] Based on the semi-quantitative data gathered during interviews and supported by the ranking exercises carried out during the interviews, using the interactive Menti software.

Another hallmark of the PPCR projects has been the clear ambition to design projects that invest across the HMCS value chain, as highlighted in Figure 3-1. Although priorities shifted for some projects during implementation, as discussed in Section 3.3, most projects were designed to both strengthen the observation and monitoring system as well as develop weather and climate services. The attempt to design projects to span the different stages of the HMCS value chain had the effect of inadvertently introducing dependencies and bottlenecks. **Projects tended to be designed in such a way that delays to initial activities caused subsequent delays across the whole project; in some cases, this led to an effective pause in most project activities until the initial delay was resolved.** For example, the need to first procure equipment and strengthen meteorological observation and monitoring networks along with data management processes, before activities related to climate service development and delivery could be carried out, meant that any delays to the initial activities had knock-on effects for the whole project.

3.1.3. Progress towards meeting project objectives

Overall, projects have made good progress in meeting their objectives, although a significant number of deliverables remain in progress, as shown in Figure 3-3. Interviews with project stakeholders revealed that for many of the projects, the investments in strengthening observation and monitoring networks were considered among the key successes for the project. For example, in Niger, despite initial delays to the project, a smooth procurement process, aided by technical assistance from the African Development Bank (AfDB), has meant that a total of 34 synoptic weather stations, 39 agro-meteorological weather stations, and 1,658 rain gauges were installed—all of which significantly improved the quality and coverage of the network in the project's area of focus. Even where procurement was highlighted as a problem, projects were, in the end, generally able to install equipment successfully.

Figure 3-3: Progress on project objectives.



Source: Based on progress of project development objective indicators within relevant Implementation Status & Results Reports.

3.1.4. Notable project successes

Figure 3-4 synthesises the words commonly used in the 'project successes' sections of each project learning brief, with words sized according to frequency. Although qualitative, it is an interesting way of exploring the key elements highlighted as successes, with 'Data', 'Network', 'Monitoring', and 'Hydromet' all prominent, as well as 'Share' in relation to data sharing and management. The importance of stakeholder engagement in facilitating project successes is confirmed. 'Service' was also highlighted, relating both to the development of services and the standard of service.

Figure 3-4: Common terms used to describe project successes.

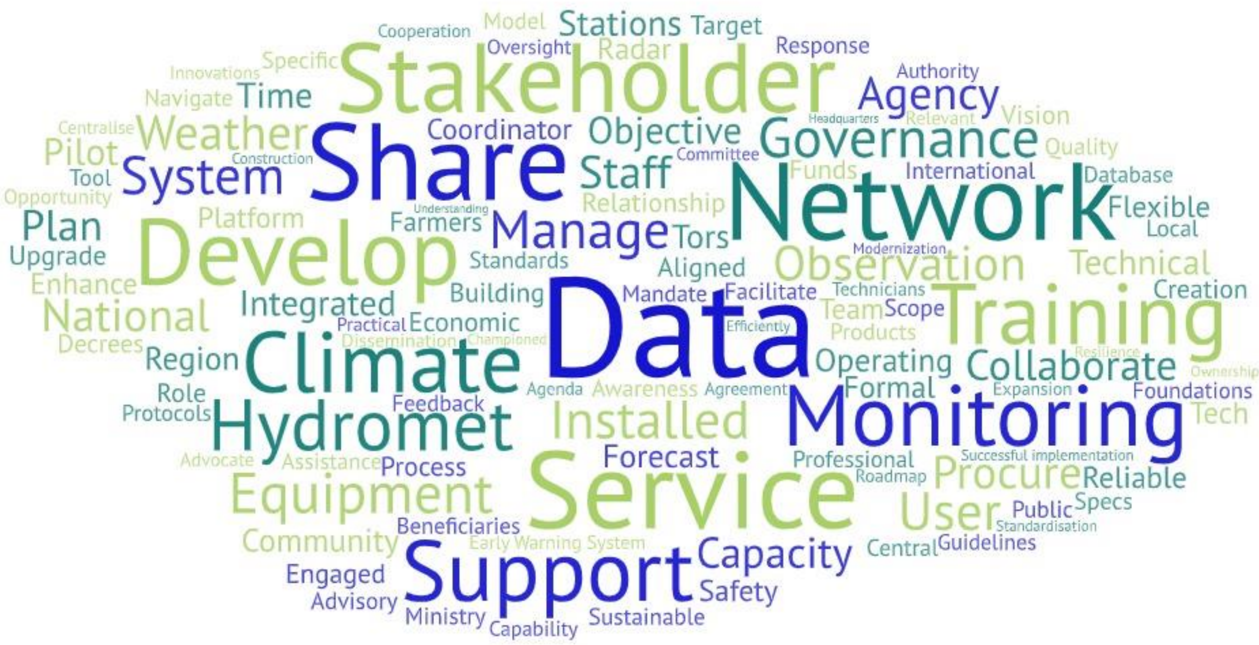
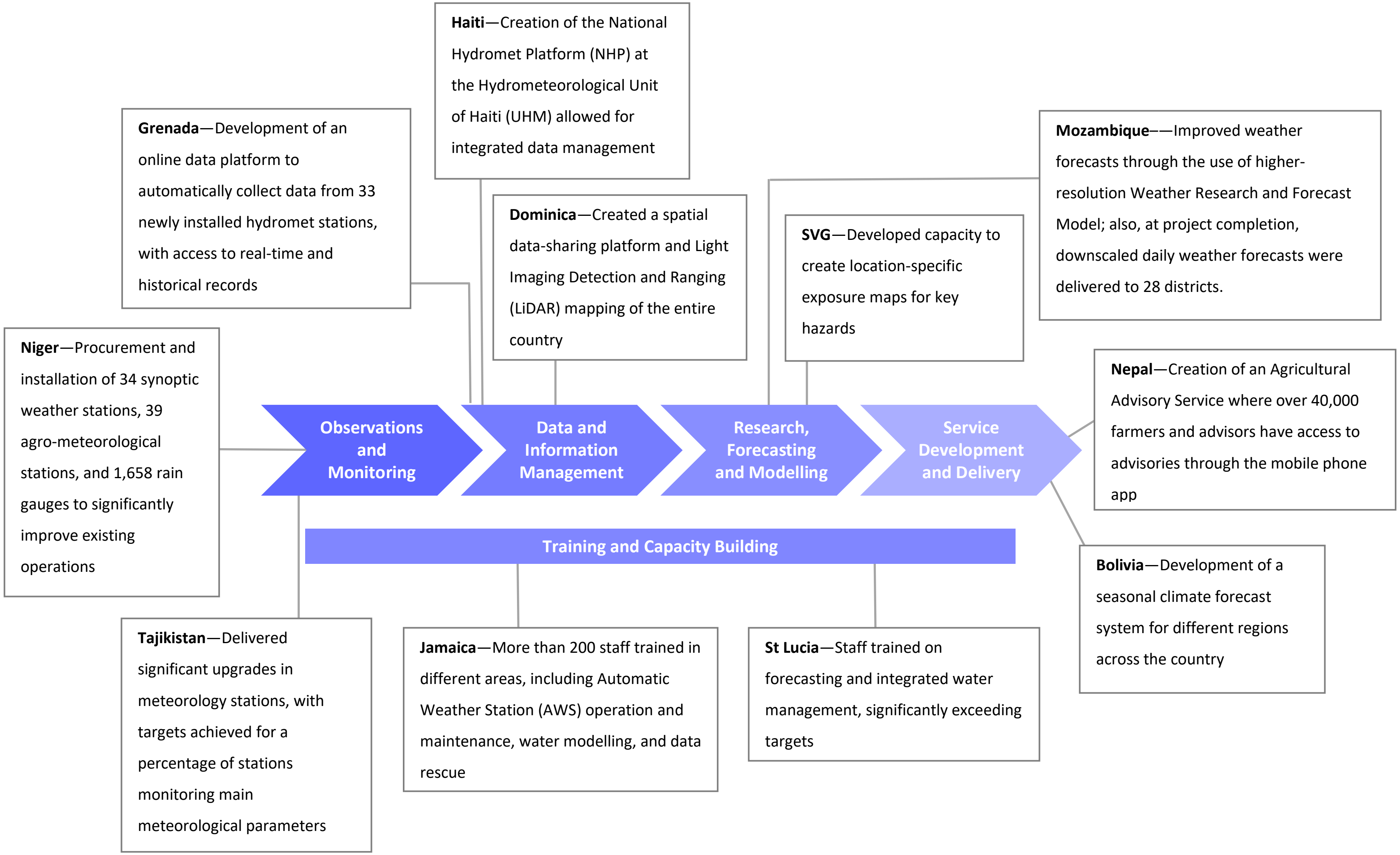


Figure 3-5 presents a number of highlights selected from across the portfolio of projects to represent a selection of achievements at different stages in the HMCS value chain, with a more detailed summary provided in Appendix B.

Figure 3-5: Selected examples of project achievements.



3.2. Challenges, enabling factors and good practices of PPCR HMCS projects

3.2.1. Challenges

Across the portfolio of PPCR projects, there are a number of issues that were identified as challenges to the successful implementation of the overall project. Figure 3-6 synthesises in a word cloud the challenges noted in each project's learning briefs and some of the key issues are discussed below.

Figure 3-6: Common terms used to describe project challenges.

3.2.1.1. *Staff retention and succession planning*

Retaining key staff after they have been trained was highlighted as a recurring challenge across projects. Keeping hold of highly skilled staff who have been trained in a variety of digital skills that are very transferrable to the private sector is a challenge common to NMHS around the world; the PPCR projects are no exception. Clear career pathways within meteorological services, along with budgets that can accommodate remuneration packages closer to those available in the private sector, are important in order to reduce staff turnover and increase/retain institutional capacity. In addition, in smaller NMHS, significant expertise is held by a small number of individuals. This can be lost without succession planning. Both of these points suggest that capacity building, which is more of a continuous process of professional development (not just in the form of one-off training courses), is important in ensuring a pipeline of skilled staff.

3.2.1.2. *Procurement*

Procurement was highlighted as a factor causing significant delays across the majority of projects. In several of the projects, the initial plan was for a single procurement contract to cover all equipment needs for the project, including very specialist and technically complex equipment. This created overly complex procurement processes that were very difficult to implement and led to long delays, as a delay to any single component meant the whole procurement process was held up. In several cases, the need to align with both national and international procurement processes[25] also introduced additional delays and complexities. In addition, the specialist nature of much of the equipment being procured meant that it was difficult to carry out a truly competitive process in some regions due to a very limited number of suppliers.

3.2.1.3. *Maintenance and Technology*

The lack of both the financial and technical capacities to ensure the regular maintenance of both the station network and computing equipment was seen as a significant barrier, with concern expressed that in the absence of suitable capacity for maintenance, some of the gains made would be lost. Limited capacity in information and communications technology (ICT), as well as outdated technology, was highlighted as a constraint for several projects. Basic issues, such as unreliable internet connections for accessing data servers and receiving data from automatic weather stations (AWS) and global climate centres, were commonplace. In some cases, this has meant that the stations installed are not able to provide real-time data reliably. Maintenance is a particular issue for stations installed in the more remote areas of PPCR countries. In many cases, these are also areas where station coverage is most limited, meaning that there is little redundancy in the network; so if a station goes offline, it cannot be easily replaced.

3.2.1.4. *Multistakeholder coordination*

While some projects highlighted inter-ministerial coordination and collaboration as a key enabling factor, interviewees for several other projects highlighted weak inter-ministerial coordination and a lack of clarity on inter-agency mandates and responsibilities as a significant barrier to project progress. In particular, in countries with a less stable political environment, the challenge of establishing and maintaining relationships with several different ministries in a rapidly evolving political situation, along with the uncertainty over the remit of different agencies, added complexity to the project implementation. This was highlighted in a number of cases as a cause of delays. Thus, although the SPCR process served to lay the groundwork for

[25] For example, following the procurement rules of the World Bank (WB) or other multilateral development banks (MDBs).

coordination and collaborative working between different stakeholders, the degree to which collaboration was an enabling factor or barrier varied. An appraisal of the overall success requires a context-specific understanding of the institutional and political context of the hydromet system within a country (more on this in Section 3.2.2. below).

3.2.1.5. *Project Design*

There is evidence that the initial design of some PPCR projects was ambitious relative to the capacities, funding, institutional and political contexts, as well as project timeframes. For various reasons, including COVID-19, political instability, project delays due to procurement, institutional coordination, or natural disasters, many of the PPCR projects required a combination of extensions and reorientations to focus on a smaller number of objectives.

Although these adjustments are an important part of effective project management, the focus of projects frequently shifted towards investments in meteorological infrastructure and data management. More ambitious objectives related to service delivery were dropped from project activities, as reflected in the differences between original project aims and the reported project focus. This has allowed the foundations for sound hydrometeorological systems that conform to international standards to be laid, but it has also meant that there has been more of a focus on strengthening observational networks rather than service development and delivery. Even in cases where service development was relatively successful, such as with the development of the Agriculture Management Information System (AMIS) in Nepal, there were additional activities in both service development and capacity building that could not be carried out as originally planned due to time constraints and the delays experienced by the project.

3.2.2. Enabling factors and good practices in the HMCS project design and implementation

A number of important lessons can be drawn from the experience of the PPCR HMCS projects, ranging from project design to operational issues, such as procurement and the role of collaboration in project design and implementation. Key lessons learned are summarised below:

3.2.2.1. *Procurement*

Procurement was highlighted as a factor causing significant delays across many projects. There are, however, examples where procurement processes were seen to have been effective and successful; in fact, they were rated as a contributing factor to the eventual success of the project. In Jamaica, the initiative adopted effective project management and systematic procurement processes, assisted through the recruitment of a highly skilled project manager. This enabled it to proceed quickly with the direct procurement of equipment, based on well-researched and developed specifications to allow integration into the existing networks. In Niger, the role of technical assistance from AfDB was highlighted as a key factor in helping the project navigate complex international procurement requirements and purchase equipment smoothly to strengthen the observations and monitoring network. Several projects noted that once initially complex procurement processes were simplified and split into separate lots, equipment could be procured quickly. The experience of the PPCR projects highlights the need for the following features:

- **Simplified procurement processes** wherever possible;
- **Professional project management and procurement processes**;
- **Additional technical assistance** to support project teams in navigating procurement processes; and
- **Recognition of likely delays in procurement and measures to mitigate** the effect of these delays on the rest of the project.

3.2.2.2. *Strong inter-ministerial coordination and buy-in*

Several projects emphasised inter-ministerial coordination and buy-in as a key factor in contributing to project success. The role of multistakeholder project design processes, initiated under SPCR, was singled out as having been a key component in building trust among different stakeholders and establishing the relationships that were then able to drive projects forward. This created the conditions for strong collaboration between government departments, including providers and users of weather and climate information.[26] In some cases, this was integrated into project governance via mechanisms such as multistakeholder project steering groups or the creation of a Hydromet Working Group,[27] as in Jamaica. It is important to note that while all PPCR HMCS projects emerged from SPCR processes, the role of collaboration between departments varied from being a strong enabler to a significant challenge and cause of delays. In attempting to understand these differences in outcomes, the following factors have been identified:

- **Political stability**: An obvious point perhaps, but the political context in which PPCR projects have been implemented has a significant impact on whether institutional arrangements and project governance is an

[26] For example, apart from the implementing agencies of the Jamaica Met Service and the Water Resources Authority (WRA), others involved in these groups included Weather Risk Management Association (WRMA), the Climate Change Division, the Ministry of Agriculture and Fisheries, the Ministry of Health and Wellness, groups representing vulnerable stakeholders/groups from the nongovernmental organisation (NGO) sector and academia, as well as communication specialists.

[27] The working group is able to coordinate activities across the agencies to prevent the duplication of activities, improve data sharing, maximise the government's resources to benefit each entity, and improve the entities' awareness of the information available to them from WRA (and the Meteorological Office when it is able to share their data freely online).

enabling factor or a barrier to progress. In several PPCR countries, there has been significant political unrest, along with rapid turnover in government and staff in key departments. It is much more difficult to retain clear roles and responsibilities with rapidly changing conditions that can, in effect, require a project to react to new agendas and start building trust and relationships afresh.

- **Technical capacity:** Collaboration is far more effective if there is strong technical capacity within both the project team and the staff within other government departments who have a technical understanding of the weather and climate services arena. Retaining this capacity once built is a common challenge; there is a clear need for greater investment not only in staff training but also in developing career pathways that are attractive to skilled staff and succession planning to replace key staff if they leave.
- **Clear budgets and responsibilities:** Unclear or overlapping responsibilities with regards to HMCS were seen as a barrier contributing to the lack of collaboration in certain projects. This was particularly the case when coupled with limited budgets, thus leading to conflicts over resources between departments. In contrast, cooperation appeared to be much more successful when there was a consensus on the roles of the different partners that have been integrated into project governance processes.

3.2.2.3. *Project design appropriate for national context*

Given concerns raised about designs being ambitious relative to the national circumstances in which they were implemented, projects focusing on specific value-chain elements may be more appropriate in countries where conditions for project implementation are more challenging. The Niger team, for example, was highly positive about the model adopted by two projects—the Climate Information Development and Forecasting Project (PDIPC) and the Water Resources Mobilization and Development Project (PROMOVARE). Working very closely with each other, they had different but complementary responsibilities: while PDIPC focused on the observation network and data management aspects, PROMOVARE worked on services and applications. The common project management structure benefitted both projects, and the strong relationship between the two, along with the clear split in focus and responsibilities, was highlighted as key to their abilities to achieve their respective objectives.

3.2.2.4. *Flexibility*

A consistent finding was that flexibility in project management and direction allowed projects to readjust as necessary and find solutions to problems that caused delays. Funders need to acknowledge that the nature of these projects may require changes to activities and objectives in order to achieve their overall intended outcomes. For the Haiti project, for example, a significant streamlining and refocusing of activities ultimately allowed progress to be made under very challenging circumstances, including natural disasters and political instability.

3.2.2.5. *Regional Collaboration*

The development of close working relationships between regional NMHS as well as between national and regional HMCS providers was seen as a strong enabling factor, thus supporting capacity building and the delivery of successful regional climate services. For example, work in the Caribbean on data standards has helped to integrate data from individual NMHS into regional products. Collaboration between NMHS within both Central Asia and the Caribbean has been successful for capacity building, enabling technical experts to learn from peers facing similar operational challenges. Clearly defining roles and budgets to support regional climate centres and regional collaboration, as in the Caribbean Regional Track project, has supported strengthening regional collaboration overall because it has prevented competition between institutions for limited resources.

Table 3-2 summarises the successes, barriers and enablers of the reviewed PPCR projects. Common elements are shown in Figure 3-7 as hallmarks of successful projects. The most successful projects or project components are linked to the following factors:

- **A clear vision, a long-term strategy, and an investment plan for HMCS** required to modernise and improve services. These three aspects should be aligned with national priorities, while taking into account the coordination of investments in the full range of systems and capacity building. In Jamaica, the project went one step further, compared to other PPCR HMCS projects, in increasing the reach of climate information, by including a major education and awareness campaign, 'Smart and Steady, Get Climate Ready'. This initiative, aligned with the goals of the National Development Plan Vision 2030, provided more information on climate change and wider capacity building, which benefitted the communities using weather and climate services, such as farmers and fishers.[28]
- **Strong partnerships between NMHS and other ministries, universities, along with global and regional weather and climate centres,** which enabled joint projects, data sharing and access to the best available global and regional forecasting products. Regional cooperation and collaboration between the five agencies in Central Asia were key in Tajikistan.[29] As the agencies possess a wide range of capabilities, this provided the opportunity for knowledge sharing

[28] PIOJ (Planning Institute of Jamaica), 2009, *Vision 2030*, https://www.pioj.gov.jm/policies/vision-2030-jamaica-the-national-development-plan/.

[29] Namely, Kaz Hydromet, Kyrgyz Hydromet, Tajik Hydromet, Turkmen Hydromet, and Uz Hydromet

between countries. For example, professional colleagues in Kazakhstan were able to assist their colleagues in Tajikistan with training support.

- **Strong support and engagement from key stakeholders.** In Mozambique, local authorities and beneficiaries in selected pilot communities were involved from the beginning. This example of active stakeholder involvement in the project planning stage enabled the easy transfer of monitoring responsibilities to the five Regional Water Authorities (ARAs) and the district governments when the project was finished.
- **Integrated approach across the value chain.** In Bolivia, for example, approaching climate change at the river basin-scale facilitated an integrated approach to developing the HMCS value chain with an ultimate common goal. By improving equipment and forecasting models, more accurate data has led to more informed decision-making on priority infrastructure investments, such as riverbank protection, irrigation, water supply and forestry.
- **Customer focus and a service delivery culture within the NMHS and other suppliers,** which support the cocreation of improved services and provide information that can be used to support decision-making in key sectors.
- **Feedback mechanisms, including user surveys, social media, steering groups, and performance indicators,** that support continuous improvements within projects and longer-term strategies.

There are also some foundational elements around governance, funding and capacity that are critical to effective project implementation. These are discussed further in Section 3.3 below.

Figure 3-7: Hallmarks of successful PPCR HMCS projects.

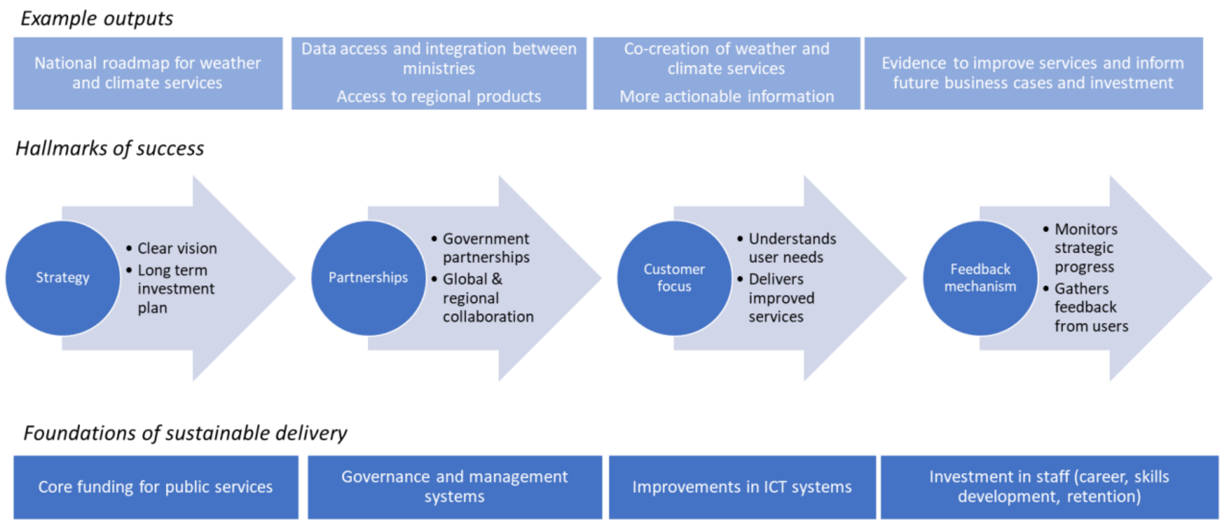


Table 3-2: Summary of selected project successes and the main barriers and enabling factors.

	Highlighted successes	Key barriers to progress	Key enablers of progress
Bolivia	- Development of a seasonal climate forecast system for different regions across Bolivia - Development and monitoring of an Early Warning System (EWS)	- Technology, such as old computers, obsolete equipment, and the use of different software - Lack of clarity and guidance of operational costs - Mechanisms to transfer the operation and maintenance of equipment were not established	- Inter-institutional collaboration and a clear governance structure from the outset of the project - Flexibility during project design and implementation; for example, EWS was not originally planned, but was approved during the project as it was aligned with the overall project objectives.
Caribbean Region	- Acquisition of the Scientific Platform for Applied Research and Knowledge Sharing (SPARKS) - Development of the Fisheries Early Warning and Emergency Response (FEWER) tool	- Low staff retention	- Clear division of roles and responsibilities - Strong influence from beneficiaries to create a user-oriented service
Dominica	- Creation of strong institutional relationships and inter-ministerial collaboration - Construction of new Met Office headquarters	- Low retention and high turnover of staff, especially senior managers - Ambitious design with regards to the number of stations and data collection tasks - Difficulties with the procurement of equipment for a highly automated network	- Strong inter-ministerial collaboration during project design and implementation - Clear institutional arrangements from the outset of the project.
Grenada	- Extent of the automatic data collection network exceeded expectations - Establishment of the real-time hydromet data portal	- Lack of institutional capacity - Limited awareness of project outputs and services among potential beneficiaries	- Highly engaged stakeholders with a good technical understanding - Strong political will to collaborate and efforts to ensure succession planning - Good alignment and standardisation with regional bodies

	Highlighted successes	Key barriers to progress	Key enablers of progress
Haiti	- Creation of the National Hydromet Platform (NHP) at the Hydrometeorological Unit of Haiti (UHM) - Strengthened visibility and profile of UHM at the national level	- Overly ambitious project design given the political context and existing level of capacity in Haiti - Delays to the start of the project caused by significant procurement issues. - Institutional challenges, such as in the case when UHM was not fully established, causing early delays	- Redirection of the project following the mid-term review (MTR) allowed a small team to focus on delivering key objectives
Jamaica	- Upgraded observations and monitoring networks, exceeding the project objectives for the number of automatic weather stations (AWS) and hydrological stations installed - Publication of national climate change scenarios in 2015	- Staff retention and succession planning - Ensuring that weather forecasting services reach the most vulnerable groups	- Professional management and procurement - Good collaboration between government departments, including suppliers and users of weather and climate information
Mozambique	- Use of real-time meteorological information for air traffic control and airline flight plans - Access to improved, reliable, and timely hydromet information for local communities, farmers, and fishers in pilot areas - Modelling linked to the project used by the National Institute of Meteorology (INAM) to develop the response actions to Cyclone Idai (2019)	- Lack of procurement and fiduciary capacity in key organisations - Changes in key management positions [in World Bank (WB) and INAM] - Communication with users, including language used to communicate agro-meteorological information, and the mechanisms used to communicate it	- The development of protocols, such as the Memorandum of Understanding (MoU), and decrees for inter-agency data sharing - Clear quality standards and monitoring guidelines
Nepal	- Upgraded observation/monitoring networks - Raised profile of weather and climate services, along with their social and economic benefits for Nepal, contributing to a government commitment to	- Technical barrier relating to a lack of ICT knowledge at DHM	- Good collaboration between DHM and agricultural intermediaries and users in the development of the Agricultural Advisory Service

	Highlighted successes	Key barriers to progress	Key enablers of progress
	increase the budgets of the Department of Hydrology and Meteorology (DHM)	- Very limited staff availability including staff (excluding consultants) not being able to solely focus on the project and high turnover of personnel	
Niger	- Significant increase in the number of farmers and communities being able to access agro-climatic information - Development of regional climate scenarios	- Major delays early in the project caused by challenges with ministerial coordination - Very limited information available at the start of the project, in terms of baseline data and studies to support project activities - Difficulty in recruiting and retaining staff	- Successful procurement process, especially the role of African Development Bank (AfDB) in helping the project to navigate international procurement processes - The strong relationship between the Climate Information Development and Forecasting Project (PDIPC) and the Water Resources Mobilization and Development Project (PROMOVARE)
Saint Lucia	- Training outcomes exceeding expectations, in terms of number of people trained - Significant improvements made to the hydromet network	- Lack of in-house capacity (technical knowledge and staff numbers) - Protracted procurement processes	- Good inter-agency communications and data sharing - Engaged Flood and Drought Committee.
St Vincent and the Grenadines	- All objectives related to investment in observation and monitoring met - Progress in incorporating user feedback systems into activities exceeding expectations	- Protracted procurement processes - Lack of existing technology for communications and data management	- Strong collaboration between ministries - Supportive WB team - Good alignment between government and project objectives
Tajikistan	- Delivery of a major upgrade to the observation and monitoring network - Promotion of greater regional cooperation between the five meteorological agencies in Central Asia	- Staff retention and low capacity of IT systems - Institutional challenges in switching to a more user-focused approach for the delivery of services	- Adoption of a country-specific approach, in the form of SPCR, helped multiple development partners work together and align climate resilience projects

3.3. Priorities for future investment

The PPCR projects have provided a foundation for the further development of HMCS within each country and region. This section discusses priority needs and provides recommendations for future investments from CIF and other climate finance institutions.

3.3.1. Priority needs for further hydromet investments in HMCS in PPCR countries

It is widely recognised amongst PPCR countries and key development partners that the modernisation of weather and climate services is a long-term undertaking (10–25 years). Even in PPCR countries where there have been significant investments in observations and monitoring equipment, **there are clear infrastructure and operational gaps that need to be addressed to improve the delivery of services.**

Some key infrastructure gaps in PPCR countries include:

1) the density of both ground observations and upper air measurements for the Global Basic Observation Network (GBON), particularly the number of sites with data that are shared globally;[30]
2) systems integration, data management systems and effective service delivery platforms for national weather services; and
3) more resilient information and communication technology (ICT) systems that include robust satellite telecommunications, along with sufficient backup and redundancy, to maintain operations during extreme events.[31]

Key operational gaps are more country-specific, but may include the following areas:

1) a lack of capacity and capability (for example, budgets and skilled staff) to provide the long-term maintenance of observation and monitoring assets;
2) Insufficient training in new software systems, particularly related to complex observation equipment (for example, radar); and
3) Effective 'user interface platforms' and systems integration to deliver tailored services to multiple sectors.

[30] Data shared globally as evidenced on the WMO Data Quality Management System and, therefore, available for use by global and regional centres; see WDQMS (wmo.int) that shows that there are still data availability issues in countries with significant PPCR investments.
[31] Several PPCR countries have placed a heavy reliance on mobile telephone communications that may fail in tropical cyclones or extreme flood conditions. This issue was highlighted in the context of Caribbean islands and the impacts of Hurricane Maria in 2017 that devastated Puerto Rico.

Project stakeholders interviewed[32] were asked directly about the priority needs for further hydromet development along the WCIS value chain. The findings were context-specific and depended significantly on whether that country had already expanded its observation networks through PPCR or whether its project is focused on upgrading the existing network only. Figure 3-8 uses data gathered through interviews with project stakeholders to show the relative importance given to different parts of the value chain during the current projects, as well as the views on where the focus for future investments should lie.

For almost all the current projects, it is clear that the initial stages of the value chain—observations and monitoring as well as data management—were a strong focus. In contrast to the initial project design and stated objectives shown in Figure 3-1, **there are only a limited number of countries for which service development and delivery was assessed to have been a major focus in the project**. This was partly due to the linear design of projects where improved services followed investments in observations, so any delays primarily impacted the subsequent service delivery parts of the project. **There is a need to focus more strongly on service delivery in future projects.**

Reflecting on the infrastructure and operational gaps that remain**, there is a clear consensus that investments in observations and monitoring are still required in the future, particularly for specialist equipment and the availability of data to the regional and global climate centres.** It is important to note that much of the PPCR investment in hydrometeorological observations and monitoring has been focused on basic meteorological networks, with hydrological observations systems comparatively rare. This gap has been acknowledged through the responses from many of the projects, such as the Strengthening Hydro-Meteorological Services Project in Haiti, which highlights increased hydrological monitoring and modelling as an important area for future investment.

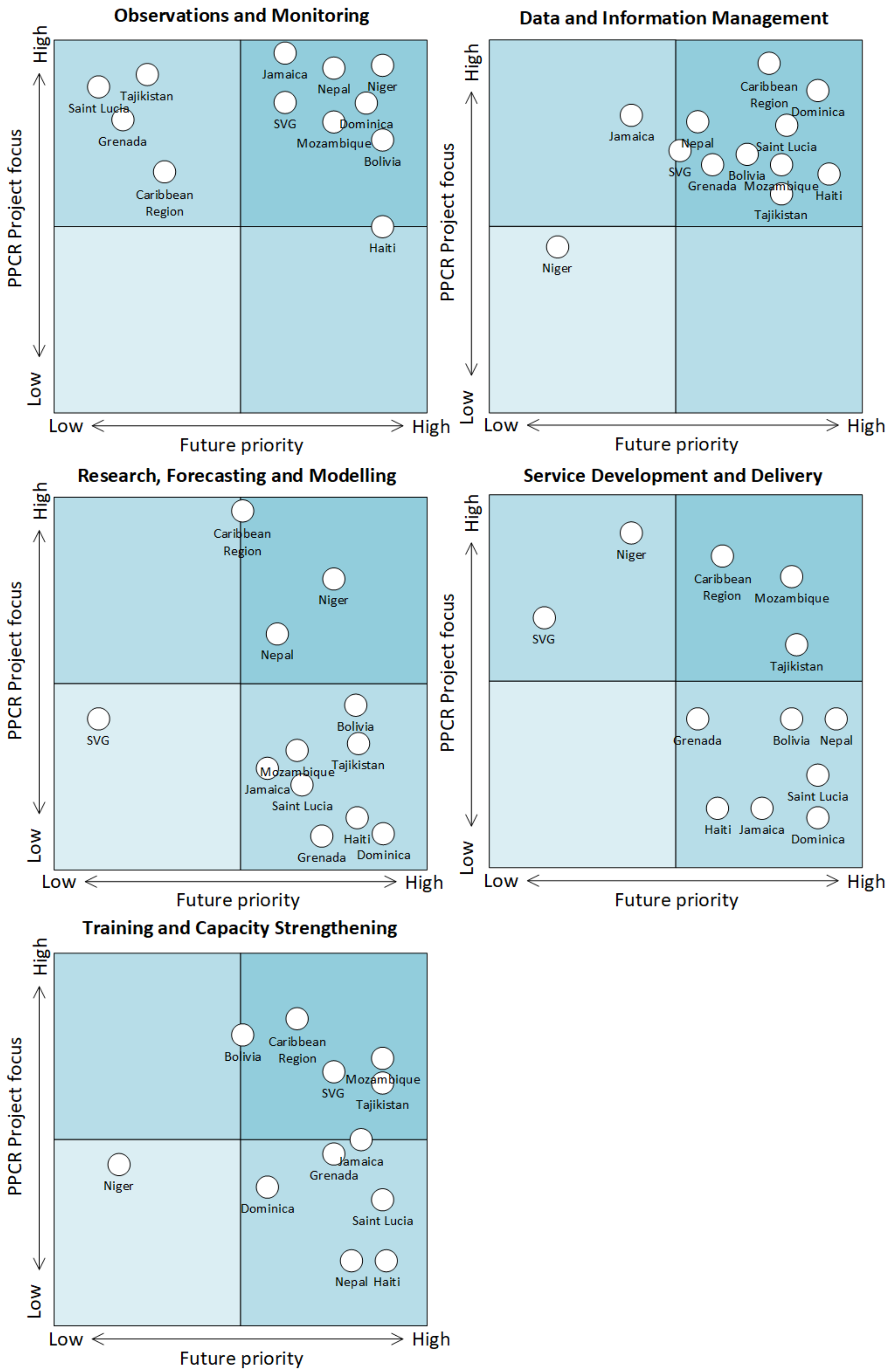
Data and information management is an integral part of most of the PPCR HMCS projects. Efforts to continue to rescue historical data in hard copy, integrate different data sets, and improve data exchange, both nationally and with the Global Weather Enterprise (GWE), are expected to feature in future projects.

[32] The questionnaire responses were primarily from project beneficiaries, particularly the suppliers of WCIS, rather than a wider range of users of WCIS.

Research, Forecasting, and Modelling did not feature strongly in the PPCR HMCS projects, but is regarded as being increasingly important for researching, testing, piloting, and evaluating new ways of forecasting that make use of global and regional numerical weather prediction (NWP), remote sensing and other innovations, such as machine learning (ML) and artificial intelligence (AI). Capacity building continues to be important for most countries, and most countries value long-term support from WMO, regional centres, and other sources.

The clear message across almost all projects is that the development of user-driven climate services needs to be a priority in the future—a point that will be further discussed below.

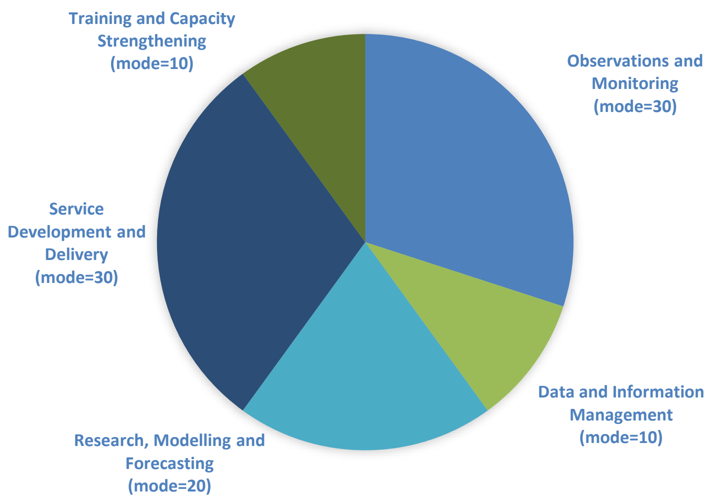
Figure 3-8: PPCR country stakeholder perspectives on their PPCR projects' <u>relative</u> focus and future focus areas.



In general terms, **the relative focus on future investments along the WCIS value chain** has a much greater emphasis on outputs related **to improved service delivery** that ensure forecasts and other information products are actively received, understood and acted upon.

A proportion of respondents quantified future budget priorities (N=18), with service delivery and observations and monitoring regarded as the top two priorities (Figure 3-9). For the latter, the priority need was typically specialist equipment, such as upper air measurements or high-altitude climate stations, rather than the standard AWS; nevertheless, there is still interest in further network extensions even in countries where the operational environment and the sustainability of large networks are clearly challenging. The country perspectives of each component of the WCIS value chain are presented in Appendix C. Capacity building was regarded as an underpinning enabler of all components, but it was not prioritised by all PPCR countries.

Figure 3-9: Modal response of future funding priorities.



Note: Seven countries, 18 interviewees.

3.3.2. Key considerations

- The **future direction and pace of HMCS investment** need to respond to:
  - The global context and changing development partner agendas, currently focused on the recovery from COVID-19 and the transition to Net Zero,[33,34] as well as trends in global weather and climate; some of the relevant ongoing and proposed initiatives are summarised in Figure 3-12, while the potential HMCS-related components in the CIF program areas are presented in Figure 3-13;
  - The national and regional context of developing countries, particularly the Least Developed Countries (LDCs) and Small Island Developing States (SIDS), and emerging user requirements for weather and climate services, such that they are inclusive of sectors that have not been a major focus to date, as in the case of health; along with
  - The lessons learned and priority needs identified in the learning briefs for each project.
- Despite the greater vulnerability and potential loss and damage due to extreme weather in LDCs and SIDS, **investments in WCIS have been very low in these countries**, that is, below USD1 per capita, compared to the approximate USD25 of high-income non-OECD countries.[35] This has created **a large infrastructure gap** that will still take time to fill.
- There are **priority needs along the full WCIS value chain**, including some further investments in observations and monitoring as well as data exchange, and a **much greater focus on service delivery** to improve weather and climate resilience in key economic sectors.
- Despite significant investments in rehabilitated, upgraded, and extended monitoring and observation networks, **there are significant monitoring gaps in many PPCR countries** that can be attributed to the historic lack of infrastructure investment and capacity. There is a demand to increase the density of networks, as well as improve data availability and access, which underpins effective weather and climate services.

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[33] Foreign, Commonwealth & Development Office and The Rt Hon Dominic Raab MP, 2021, "UK Official Development Assistance (ODA) Allocations 2021 to 2022: Written Ministerial Statement," https://www.gov.uk/government/speeches/uk-official-development-assistance-oda-allocations-2021-to-2022-written-ministerial-statement.
[34] World Bank Group, 2021, *World Bank Group Climate Change Action Plan 2021–2025 : Supporting Green, Resilient, and Inclusive Development*, https://openknowledge.worldbank.org/handle/10986/35799.
[35] Lucien Georgeson, Mark Maslin, and Martyn Poessinouw, 2017, "Global Disparity in the Supply of Commercial Weather and Climate Information Services," *Science Advances* 3 (5): e1602632, https://www.science.org/doi/pdf/10.1126/sciadv.1602632.

- **Demand-led and cocreated project designs** involving partnerships, that is, working closely with multiple government agencies, key sectors or vulnerable communities, are strongly supported by all PPCR project-implementing agencies and beneficiaries, and viewed as a key enabler of progress.
- Investments that lead to the **improved quality of services**,[36] particularly those that inform decision-making in priority sectors, are regarded as essential to securing and maintaining government support. They can also support the aspirations for private sector income for those NMHS tasked with greater cost recovery.
- Overall funding for public WCIS suppliers is regarded as **'adequate'** at best but **'insufficient' in the majority of PPCR countries**.[37] Further work is needed to maintain basic services and secure sustainable financing to improve services. PPCR countries need to navigate different pathways that may include developing policies,[38] strengthening government partnerships, as well as working with WMO centres and the private sector to secure sufficient operational income.
- The **Alliance for Hydromet Development** and initiatives, such as the **GWE Forum,** aim to promote broad partnerships and coordinate investments to increase their effectiveness and sustainability beyond the lifecycle of individual projects. The existing PPCR projects have been embedded in country programmes and focused on the whole value chain, with most investments in observations and monitoring equipment.

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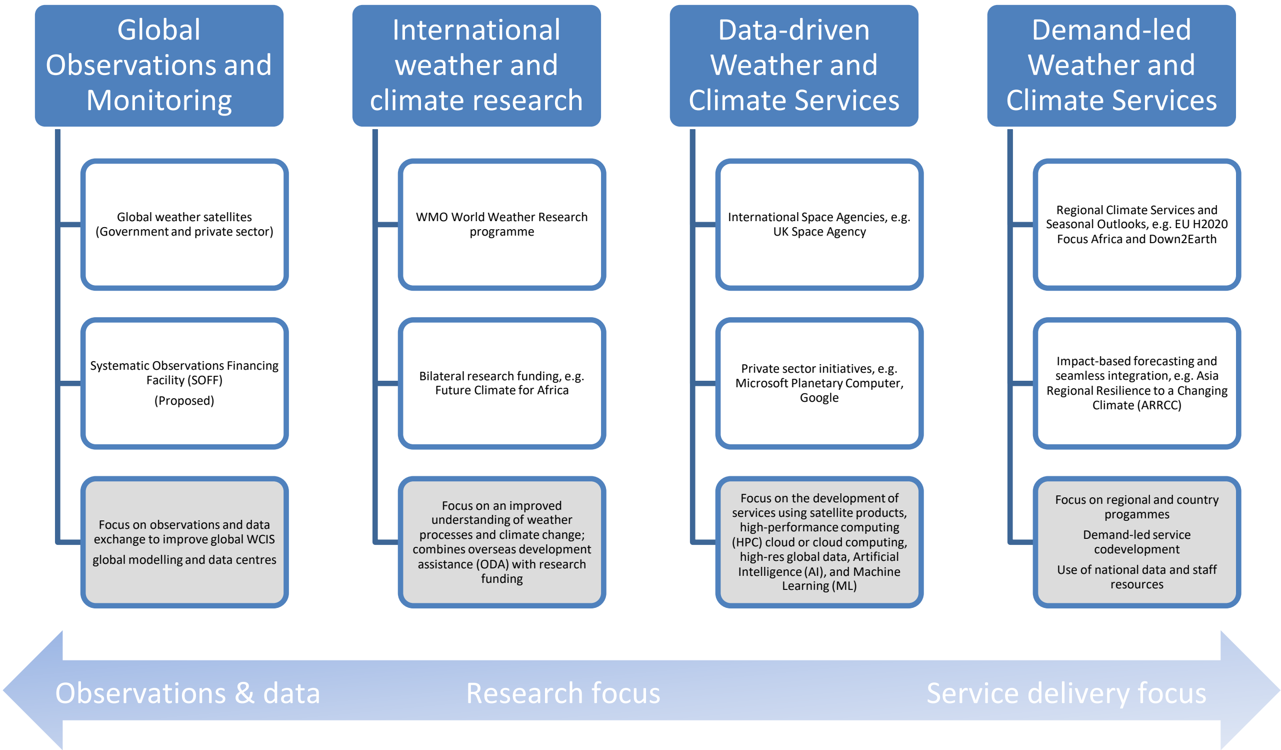
[36] As evidenced by customer or user feedback in the form of user surveys and forums that include stakeholders from a range of sectors making use of WCIS

[37] Based on feedback from interviews conducted for this study, gaining sufficient core government funding was a challenge, particularly in the post-COVID situation.

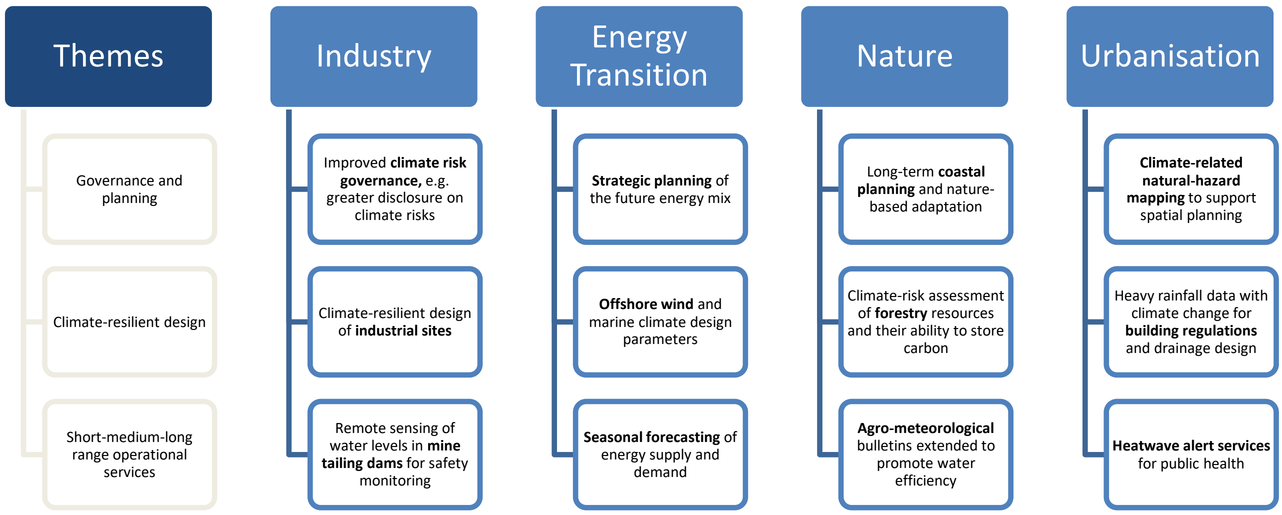
[38] These may include policies linked to National Adaptation Plans, data and information for disaster preparedness, or broader open data policies.

Figure 3-12: Examples of existing and proposed weather and climate services initiatives and their primary focus.



Note: Different sources of funding have a primary focus on specific parts of the WCIS value chain that focus on a range of different timescales for forecasting and climate predictions, for example, weather prediction (one to 14 days), sub-seasonal to seasonal (S2S) (two weeks up to 60 days), seasonal (one month to six months), interannual to decadal prediction, as well as future climate projections.

Figure 3-13: Examples of potential weather and climate services components in CIF's priority areas.



Notes: Based on a review of CIF's proposed programmes from April 2020. Under the 'Energy Transition' heading, 'Renewables' is a CIF theme and the 'Accelerating Coal Transition Program' is a funded programme.

3.3.3. Key elements of a funding strategy for a sustainable and functional HMCS in developing countries

Most PPCR countries face challenges with respect to the funding of their activities, in terms of capital and operational expenditures. A long-term critique of grants and loans to purchase hydromet stations and other equipment is that there is often insufficient long-term operational funding to maintain the equipment. This is a well-known issue that was considered in the design of the PPCR projects.[39] In the near future, government spending is likely to be under increased pressure during recovery from COVID-19, with increased priority given to economic recovery, the health sector, and the building of community resilience. The current situation, therefore, is unlikely to improve.

During the implementation of several PPCR projects, NMHS were successful at increasing their government funding to cover the operational costs of the extended and upgraded observations and monitoring networks, as well as improving their own long-term strategic planning. Some PPCR countries considered their funding as 'adequate', but the majority of PPCR countries still defined funding levels as 'insufficient' to improve services. In this context, there is further work needed to establish sustainable funding models for maintaining basic services as well as increasing funding for partnerships and collaborations to improve services in the PPCR countries.

Based on the feedback from country interviews, the key elements for funding sustainable WCIS include the following elements:

- Development of a **long-term strategy** and clear business case for further investments in national capability. In Saint Lucia, the cocreation of a **national roadmap for weather and climate services**[40] helped to align investment needs with country priorities and acknowledge the inter-connected roles of suppliers, intermediaries, and users of services. The economic rationale for investing in weather and climate services remains strong, with benefit-cost ratios typically in the range of 3:1 to 36:1.[41] However, the case is strongest when made by users of climate services alongside suppliers.

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[39] With increased packaging of extended warranties and operational support as part of the capital expenditure, along with capacity building on how to maintain observation networks

[40] *Strengthening Operational Weather, Water, and Climate Services: Road Map for St. Lucia,* https://www.doaslu.govt.lc/wp-content/uploads/2021/04/Roadmap-May-24.pdf.

[41] Based on studies cited in CIF, 2020, originally from WMO, World Bank GFDRR, and USAID, 2015, *Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services*, WMO-NO.1153, https://library.wmo.int/doc_num.php?explnum_id=3314.

- Implementation of a **Hydromet Law** (or a similar law), alongside regulations and standards that work towards improving services, is important for many PPCR countries. Hydromet laws typically define the roles and responsibilities of NMHS, provide some legal mechanisms for cost recovery, and a framework for regulating activities, such as the delivery of government EWS. **Standards**, such as WMO standards[42] and ISO standards like ISO14091 on climate risk assessment, can help suppliers and users of WCIS ensure products and systems, including those developed in the private sector, are fit for their purposes.[43]
- **Developing strong partnerships** is essential: this includes research partnerships and service delivery partnerships. The PPCR projects included examples of cocreated services, such as the Nepal Agro-Meteorological Bulletin, which were successful, thus leading to the beneficiary departments taking on the ownership and coverage of the costs of new weather services. Research partnerships can work to improve services, increase collaborations, as well as help provide skilled staff and continued professional development.
- The consideration of **commercial services** to generate revenue, which includes the potential to sell data or deliver bespoke services to sectors that will pay for tailored products. The feasibility of commercial income was highly variable and regarded as very low priority in the Caribbean and other countries, but it was actively sought in Tajikistan as part of Tajikhydromet's Business Plan. The provision of commercial services by government agencies can be challenging because it distorts the 'level playing field' and can become a barrier for data sharing between departments or stifle the private sector. Government, research, or private-sector partnerships may be a more effective pathway for rapid improvements in services, as they are likely to introduce greater innovation and access to additional technology and data sets. Several PPCR countries have engaged with private and NGO suppliers as potential partners in service provision, but a number of barriers have prevented some initiatives from gaining traction and acceptance. Piloting potential partnerships and learning how they can work technically and commercially would be a way of overcoming such difficulties.
- **Improving data policies** related to **open data** that is shared freely to government departments and the private sector, along with any **managed data** or **operational data** that may be subject to restrictions or require some form of payment to recover costs. The **WMO Congress in Resolution 40**

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[42] WMO, 2021, "Standards and Recommended Practices," https://public.wmo.int/en/resources/standards-technical-regulations.
[43] For an overview of climate-related ISO standards, see ISO and climate change. Note that a standard for weather and climate services is under development as part of the research programme of the UK Met Office Strategic Priority Fund Climate Resilience.

(Cg-XII) explicitly affirms the WMO commitment to the principle of the free and unrestricted exchange of meteorological and related data and products, particularly on matters linked to the safety and security of society, economic welfare, and the protection of the environment. The consensus within the wider hydromet community is that open data policies deliver far greater socioeconomic benefits than data sales. This stance should thus contribute to a 'virtuous circle', whereby governments and development partners reinvest a larger proportion of tax revenue/grant funding into fundamental observations and PWS as a global public good. In Europe, the opening up of the products of the European Centre for Medium-Range Weather Forecasts (ECMWF) to all research and commercial partners has allowed many new entrants into the climate services market to deliver services that require a deep understanding of specific sectors, such as offshore wind, energy pricing, and climate-risk screening for banks. The Copernicus Climate Services model of grant funding to support weather and climate services start-ups, as well as established companies to develop services using ECMWF data, could be used to develop services to deliver socioeconomic or commercial benefits that flow back to NMHS.

- **Leveraging the role of WMO**, its network of global and regional centres, as well as trusted advisors with specific expertise, to manage NMHS. Learning from case studies of how other services are funded, how they maintain sufficient incomes to deliver improved services, and how they work with government and private sector partners is beneficial. Working at a regional scale to deliver services that require specific modelling expertise is generally supported as long as NMHS maintain their designated roles. There are also opportunities for peer-to-peer learning between meteorological and hydrological services within regions and between regions.

The Alliance for Hydromet Development and SOFF

Within the Alliance for Hydromet Development,[44] and specifically, the Systematic Observations Financing Facility (SOFF),[45] a strong argument is emerging for improved public and private sector partnerships to collect observations as a global public good, make data more widely available, and enable the improvement of both PWS and commercial services in the private sector. The aim of SOFF[46] is to contribute to strengthening climate adaptation and resilience through improved weather forecasts, EWS, and hydromet services. In compliance with GBON, SOFF will contribute to this aim by supporting the sustained collection and international collaboration for the exchanging of high-quality surface-based weather and climate observations. SOFF will provide its support in three phases:

1. **Readiness:** Countries will be supported in their assessments of their hydromet status and gaps through the Country Hydromet Diagnostics (CHD) in order to develop a plan to close the GBON gap. CHD provides a set of 10 standardised elements for assessing national meteorological and/or hydrological services that are grouped into four categories: enablers; observation and data processing systems; service and product development and dissemination; along with user and stakeholder interactions that can help to identify the support required. It provides a maturity index based upon the 10 elements on a scale of '1 to 5', where '5' indicates the greatest maturity.
2. **Investment**: LDCs and SIDS will receive support through capital investments in the GBON infrastructure, and most crucially, in developing the capacity to operate and maintain such networks. SOFF will work through multilateral development banks (MDBs) and UN organisations (part of the Hydromet Alliance) to blend their resources and integrate SOFF into their larger country hydromet investment operations (at the country or a sub-regional level).
3. **Compliance**: Most importantly, LDCs and SIDS will receive support to sustain compliance with GBON in the long term, such as contributions to operational and maintenance (O&M) costs and incentives to encourage data sharing.

[44] WMO, 2021, "Alliance for Hydromet Development," Alliance for Hydromet Development | World Meteorological Organization (wmo.int).
[45] WMO, 2021, "Systematic Observations Financing Facility," Systematic Observations Financing Facility | World Meteorological Organization (wmo.int).
[46] Alliance for Hydromet Development, 2021, *Hydromet Gap Report 2021: Overview*, GAP Report - Alliance for Hydromet Development (alliancehydromet.org).

In Europe, a highly complex WCIS 'ecosystem' is emerging and the research community is advocating (i) greater public-private partnerships and different ways of delivering hydromet services; (ii) open data policies and monitoring as well as the post-evaluation of hydromet service use; along with (iii) mandatory climate risk reporting in the finance and infrastructure sectors and adequate assurance mechanisms.[47]. The latter issue is creating a large demand for climate risk-related products in the global market, as international companies and national governments align investments with the recommendations of the Taskforce for Climate-related Financial Disclosures (TCFD) and similar initiatives. As investors, asset managers, and corporations place a greater emphasis on physical climate risks than before, developing countries, particularly LDCs and SIDS, will need to scale up their climate change governance, including their own national risk assessments and adaptation plans. This, in turn, creates a demand and opportunity for HMCS suppliers to deliver improved climate information services to government partners.

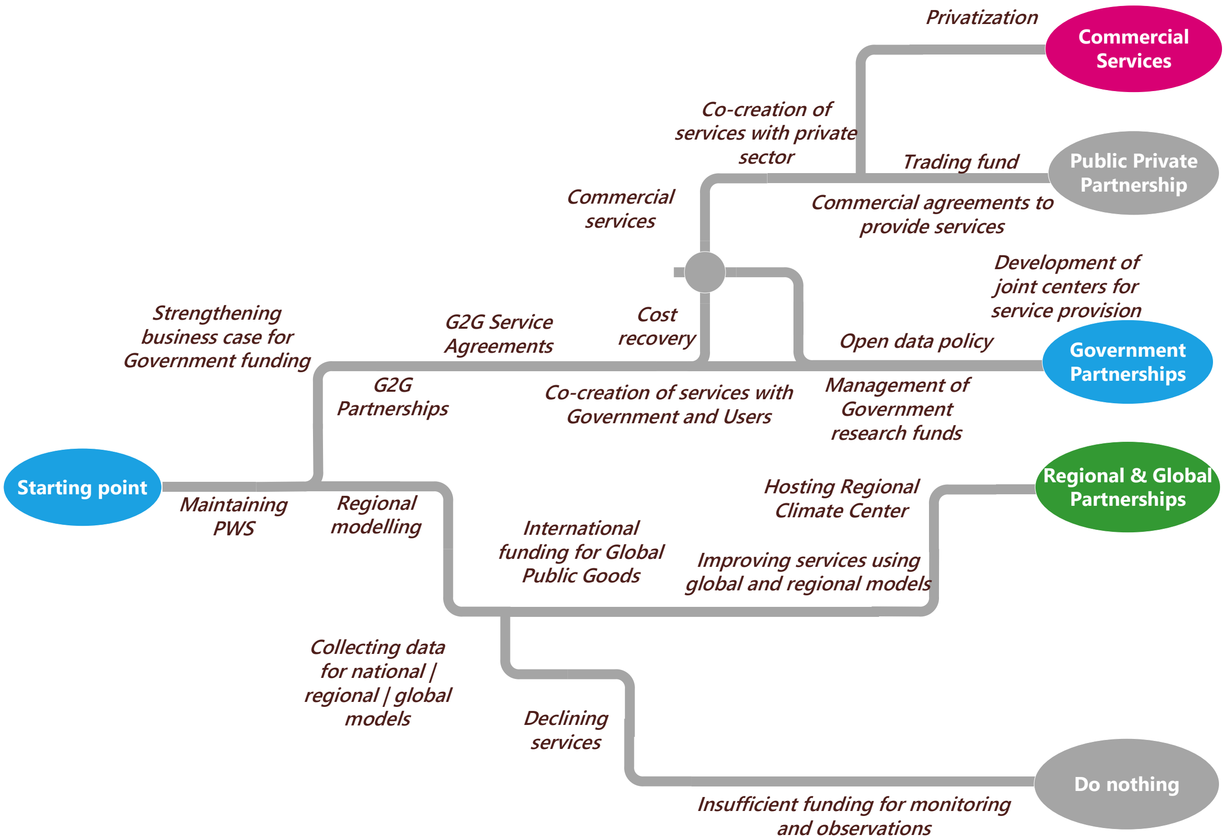
PPCR countries need to navigate different pathways for achieving sustainable funding to maintain and improve weather and climate services. These include working towards:

- Stronger partnerships and service provision to secure long-term government support and continued funding;
- Regional partnerships to share data and secure access to regional NWP and seasonal predictions, along with climate projections and technical assistance, to deliver improved regional services; and
- In some cases, delivering specialist data or information services to allow cost recovery by using innovative mechanisms and partnerships with the private sector.

Figure 3-14 illustrates some potential pathways for weather and climate services providers. These pathways are not mutually exclusive: most countries will need to adopt a twin-track or blended approach based on the country context, such as improving their PWS, based on partnerships and the improved use of global and regional modelling products. None of the PPCR countries considered privatisation to be its long-term goal, although examples, such as New Zealand, demonstrate that this is a possible outcome of a commercially driven approach.

[47] Thanh-Tâm Lé, Driaan Perrels, and Jörge Cortekar, 2020, "European Climate Services Markets—Conditions, Challenges, Prospects, and Examples," https://doi.org/10.1016/j.cliser.2020.100149.

Figure 3-14: Illustrative pathways towards the development of improved HMCS.



4.0 Moving forward

4.1. Synthesis of key findings

This learning review considers 12 selected CIF PPCR projects, of which seven have been completed and five are ongoing. The projects have faced significant challenges related to staff retention, procurement, political instability, natural disasters and a global pandemic. However, they have delivered notable successes in observations and monitoring, data management, capacity building and service delivery.

The features of successful PPCR projects have been identified to include **a clear long-term strategy and investment plan** for HMCS that is aligned with national development priorities; **strong partnerships** between NMHS, other ministries and stakeholders; a **service-oriented focus**; and the opportunity for **incorporating feedback mechanisms** to enable continuous improvements. Project successes are underpinned by **adequate core funding** from governments to cover staff and operational costs, **strong governance and management, significant improvements in ICT infrastructure** and **investments in government staff** (and, in some cases, key individual experts).

Future priorities and lessons learned from these PPCR HMCS projects include **strengthening collaboration** across government agencies, key sectors, and vulnerable communities using **demand-led and co-created project designs**; **investments in improving the quality of services**,[48] particularly those that inform decision-making in priority sectors; the **maintenance of basic services**; and the **securing of sustainable financing** for the improvement of WCIS. PPCR countries need to navigate different pathways that may include developing policies,[49] strengthening government partnerships, as well as working with WMO centres and the private sector, to secure sufficient operational income.

[48] As evidenced by customer or user feedback in the form of user surveys and forums that include stakeholders from a range of sectors making use of WCIS

[49] These may include policies linked to National Adaptation Plans, data and information for disaster preparedness, or broader open data policies.

4.2. Recommendations

Based on the progress made in the PPCR projects as well as the challenges and future priorities identified, there are a number of recommendations for development partners,[50] involved in the financing and design of projects, as well as for NMHS and other national agencies in charge of the delivery of improved weather and climate services.

Design for results:

- ***Development partners* should align hydromet projects with a national long-term strategy** for the modernisation of HMCS, while incorporating some flexibility and contingencies when working in developing country contexts that are politically unstable and highly vulnerable.
- ***Development partners* should design hydromet projects, based on national economic, climate and DRR priorities, along with national user requirements for weather and climate information**, then work backwards along the value chain to identify the investments needed to improve specific services and products.
- ***Development partners, NMHS and national agencies* should put significant effort into building effective teams with suitable expertise, as well as the required institutional relationships**. The need for longer-term, more programmatic future investments was emphasised by several projects. Interviewees were concerned that in the absence of clear follow-up investments, the gains achieved through the PPCR projects might be lost as technical capacity and institutional relationships dissipate, and limited maintenance budgets lead to a gradual deterioration in equipment.
- **A longer time period for similar projects in the future would enable sufficient implementation time,** along with the provision of trial periods for new systems to enable testing and learning before full implementation. This could also allow for a more explicit focus on the experimentation and trialling of different approaches in service design and delivery, with a more explicit focus on encouraging innovation and learning. When a programme was compressed, some new systems were delivered with very little time for training and handover, which made them more difficult to use and undermined the realisation of their benefits.

[50] Development partners include MDBs, such as WB, the European Union, and governments that provide bilateral Overseas Development Assistance (ODA), international nongovernmental organisations (INGOs), WMO, along with global and regional weather and climate centres. Collectively, these institutions provide grant funding, along with loans and technical assistance to improve HMCS in developing countries. Private sector manufacturers or consultants may also be development partners, though they are typically contracted on a project-by-project basis.

- ***Development partners*** **should adopt contingency plans and a more flexible approach to deal with project disruptions associated with hydromet-related natural hazards[51] and political instability that impact the programme**. In some cases, more 'realistic' objectives are needed, including project design with fewer dependencies between components, so that they are less sensitive to knock-on effects where initial delays push back subsequent activities and can ultimately lead to certain activities being abandoned.
- ***Development partners*** **should adopt a more user-centric approach in the design of future projects**. There are important lessons related to the development of climate services, which draw on experience from across the PPCR where, overall, investments in the early stages of the HMCS value-chain have been more prominent, and to some extent, prioritised. A more user-centric approach should start with scoping and assessing what services are needed, before working backwards along the value chain to identify what additional investments in data, modelling, and observations, if any, are needed in order to deliver timely and effective services; and
- ***Development partners, NMHS, and national agencies*** **should prioritise demand-led projects** that **involve partnerships** between suppliers and users **to improve services**. This approach would maximise the value of existing data and products, thus providing a cost-effective way of achieving tangible climate resilience benefits. There is a clear desire among NHMS in many of the PPCR countries to further strengthen observations and monitoring; however, adopting a more **service-oriented approach to project design** could allow for more balanced investments across the HMCS value chain. It also has the clear advantage of drawing users into the codesign and coproduction processes from the very start of a project, thereby increasing user inputs and the salience of services.

[51] A natural hazard is any natural geophysical and biological event that negatively impacts people and the environment. For the purpose of this learning review, it exceeds what has been considered in the context of climate change; and so the term, 'hydromet-related natural hazard', is used to cover climatic, hydrological, and meteorological events.

Design for learning and experimentation:

- **In designing projects, *development partners* should allow active learning from users of weather and climate services**, thus generating feedback that can improve product design and the delivery of services.
- ***Development partners* should build greater capacity in service development and delivery. The need for the development of weather and climate services is clearly recognised by the stakeholders interviewed. However, with limited resources to invest in HMCS activities, there is a tension between the desire to move towards service delivery and the expressed needs around the further strengthening of the observation and monitoring network**. The observation and monitoring network, along with data management processes, needs to reach minimum technical standards so that it is able to support the development of reliable and usable services or products. As much as data-generation and processing capabilities need to be strengthened, however, there is also a need to build greater capacity around service development and delivery.
- ***Development partners and NMHS* should consider piloting impact-based forecasting services and other information products in order to initiate the iterative process of HMCS coproduction. Effective coproduction, including setting up mechanisms for gathering feedback and iteratively improving the services provided, is not a simple task.** They require a specialised set of skills that an NHMS may not necessarily have in-house already. Viewing the development of weather and climate services as a long-term iterative process in which both producers and users learn about how to create and use services can lead to tangible increases in resilience.
- Given the experience from across the portfolio of PPCR projects, ***development partners* should consider strengthening the development of climate services in future projects, and potentially, structure them separately from projects seeking to strengthen the hydrometeorological infrastructure**. This would ensure that service development is given a greater priority during project implementation. The model used in Niger, with two complementary projects operating closely together but focusing on different aspects of the value chain, could be a helpful example from which to learn.

For project implementation:

- ***NMHS and national agencies*** **should make the sustainability of HMCS investments a core principle**, including effective strategy and business planning, long-term partnerships and institutional arrangements, along with the building of resilient critical infrastructure systems for impact-based forecasting (IBF).
- ***NMHS and national agencies*** **should invest in strategy and long-term planning,** which can be used to make a strong business case for capital and operational funding. PWS are essential to the prevention of severe damage and losses from extreme events and hydromet-related natural hazards; thus, they are vital for supporting economic growth in key economic sectors in LDCs.
- ***NMHS and national agencies*** **should develop strong partnerships with different government ministries**, including setting clear mandates for the provision of meteorological and hydrological services and data-sharing policies, thus ensuring that HMCS are well-targeted to meet user requirements and preventing additional costs due to the duplication of observation networks or competing services. In some cases, a hydromet law may be required to clearly set out roles and responsibilities, including any regulation or mechanisms for cost sharing or recovery.
- ***NMHS,*** **when asked to recover costs, should develop partnerships with the private sector** to deliver value-added services, which are likely to be more effective than data sales. In general, **open data policies**, which can generate a stronger case for government funding, have been shown to deliver greater national socioeconomic benefits.
- ***National governments*** **should *maintain the national capability of HMCS, including retaining skilled staff.*** Support is needed to develop effective strategies that attract STEM graduates and technicians, along with providing a rewarding and sufficiently well-paid career path. Strong relationships with universities and other research partners can provide a supply of staff and some opportunities for scientific career progression in the region, which may slow the 'brain drain' experienced in some regions, with staff moving to the US, Europe, or Australia.
- ***Development partners and NMHS*** **should carefully consider O&M costs before embarking on the further expansion of observation networks.** O&M costs were a common challenge across the PPCR projects, which echoes the long-term critique of grants and loans to purchase hydromet stations and other equipment. In many cases, the PPCR projects were influential in securing further government O&M funding. However, long-term future funding is not guaranteed; so project financiers and beneficiaries should design networks and systems with low operational costs and use grant-funded projects to review and rationalise networks periodically against an agreed set of criteria.

Appendix 1. Learning Brief on Hydromet and Climate Services Project: Bolivia

The learning review aims to take stock of the progress made to date on the lessons learned from strengthening hydromet and climate services (HMCS) under the Climate Investment Funds' (CIF) Pilot Program for Climate Resilience (PPCR) and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews.

This learning brief that focuses on Bolivia forms part of the HMCS project's final learning review.

It has been informed by interviews with representatives from the National Service of Meteorology and Hydrology (SENAMHI), the Ministry of Environment and Water (MMAyA), the Pilot Program for Climate Resistance (PPCR) Unit in Bolivia and the World Bank. (WB).

Project Overview

Brief country context

Bolivia is one of the most vulnerable countries to climate change in Latin America due to its geographical location and high level of poverty. Despite the country being one of the world's richest in water resources, nearly half of Bolivia's territory and more than half of the population is concentrated within arid and semi-arid areas characterised by high water deficit levels and frequent severe droughts. As a result, Bolivia is extremely exposed to the impacts of hydrometeorological extremes, with drought and floods being frequent and costly indicators of those extreme situations.

An improved understanding of the hydrological cycle and its reliable prediction are key to managing water resources. River basins are typically selected as the geographical unit on which hydrological cycles are defined. They are also the spatial unit selected for the planning and management of water resources, climate change adaptation, and disaster event preparation.

Bolivia is one of the pilot countries under CIF's PPCR. With its focus on the protection and rationalisation of water resources, the Bolivian government has proposed integrated, participatory plans to improve water resource management. PPCR has aligned with this national priority to approach planning for climate change adaptation from the perspective of integrated river basin management (IRBM). This project is one of the case studies covered in this learning review.

A graphic showing the stakeholders involved in Bolivia's HMCS can be found at the end of this document.

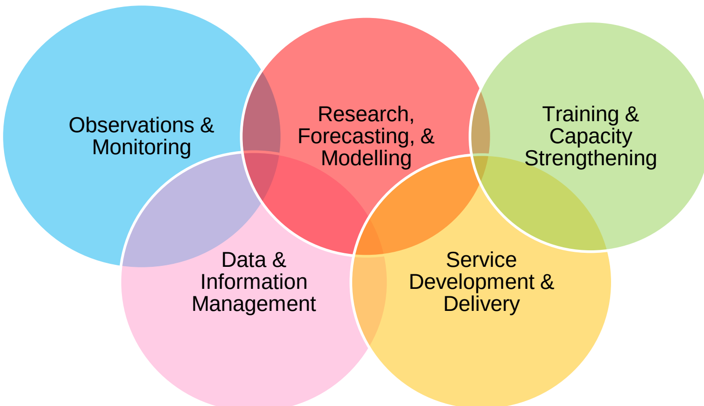
PPCR project overview

Name of project	Climate Resilience - Integrated Basin Management Project (IBRM)
Implementing multilateral development bank (MDB)	World Bank
MDB approval date	July 2014
Closing date	December 2020
PPCR financing	USD45.5 million (including grant of USD9.5 million and non-grant of USD36 million)
Objectives	To support the implementation of Bolivia's strategy for climate resilience by 1) strengthening the institutional capacity to define the IRBM approach to climate change adaptation, and 2) supporting its implementation in three pilot sub-basins in the Rio Grande river basin.
Project components	1) Strengthening the national capacity for climate change adaptation; 2) Strengthening the capacity for adapting to climate change in the Rio Grande River Basin; along with 3) Designing and implementing sub-projects in the Piraí, Mizque, and Rocha sub-basins to improve climate resilience in the Rio Grande river basin.

Relevance for the HMCS Value Chain

The provision of a modern and robust hydrometeorological information system enables the improvement and strengthening of data management and climate forecasting. Activities cover the rehabilitation and installation of stations, the centralisation of weather and climate databases, the development of an Early

Warning System (EWS), and the training of staff from national and regional/local institutions—all of which are aspects of the HMCS value chain. The focus placed on each element of the value chain is indicated by the size of the circles in the diagram below.



Stage of value chain	Project activities
1. **Observations and monitoring**	• Improvement of the observation and monitoring network at the local/regional levels, including the provision of new equipment and rehabilitation • Agreement between the National Service of Meteorology and Hydrology (SENAMHI) and the municipalities to install equipment in areas where monitoring stations are safer and less prone to vandalism, such as schools and utilities' facilities
2. Data and information management	• Centralised and publicly accessible platform of HMCS database managed and hosted by SENAMHI, also developed in collaboration with other relevant institutions including the Ministry of Environment and Water (MMAyA), the Ministry of Civil Defence (MDC), the Ministry of Land and Rural Development (MDRyT), municipalities, and regional authorities

Stage of value chain	Project activities
	• Development of data-exchange protocols to be integrated with the SENAMHI database in order to inform decision-making and the planning of climate-sensitive activities, including an agreement with the Civil Aviation Authority to share weather data, which is more accurate for the airport's operations
3. Research, forecasting, and modelling	• Development and implementation of a drought EWS in the Cochabamba region • Improvement of forecasting and modelling systems to release seasonal weather bulletins, with SENAMHI's forecasting and modelling system complemented by the use of satellite data
4. Service development and delivery	• Delivery and dissemination of monthly and quarterly user-friendly weather bulletins, including rainfall and temperature forecasts to the relevant authorities, such as MDC, MDRyT, and MMAyA, for distribution to the states (*departmentos*)/regional authorities, and, in turn, to the municipalities within their respective jurisdictions
5. Training and capacity strengthening	• Training and capacity building occurred at all aspects of the HMCS value chain (1, 2, 3, and 4 above), as well as the national- and regional-/local-level institutions.

Key Findings

Main project successes

The project was successful in modernising the observation network and data management processes to enhance the services provided by SENAMHI. The main successes highlighted by stakeholders include:

- The development and monitoring of **EWS** have benefitted multiple users—MDC, MMAyA, MDRyT, road associations, the Regional Units of Disasters Management (UGR), and the Ministry of Public Works (MOP)—by helping them to be better-informed in their decision-making and the planning of their activities. This tool that enables a variety of stakeholders and citizens to make use of reliable data has been highlighted as the project's greatest achievement.
- **Inter-institutional collaboration** has been key to the successful implementation of the project. Coordination between different stakeholders within a river basin, who share the same limited water resources, has been essential to ensure an integrated participatory approach to planning and management that include the HCMS services. This is a win-win solution that benefits multiple stakeholders and the wider community.
- **The capacity** of national and regional staff has been **strengthened**. The training program was successfully implemented. This project objective was satisfactorily met, even though some training sessions had to be undertaken online due to the COVID-19 pandemic restrictions.
- A **seasonal climate forecast system** for different regions across Bolivia was developed, with the support of the NGO, International Research Centre on El Niño (CIIFEN).[52] It did not adopt a time-bound approach and thus provided continuous technical support even after the contract had expired. By providing an extended guarantee on the forecasting tool, this flexible model has enabled the SENAMHI and MMAyA staff to work directly with the experts on a regular basis and receive technical support when needed.

Challenges

[52] CIIFEN, 2021, "Development of Implementation of the Seasonal Climate Forecasting System for Bolivia (PPCR Project)," https://ciifen.org/project/desarrollo-e-implementacion-del-sistema-de-pronosticos-climaticos-estacionales-para-bolivia/

- The project was delayed due to **COVID-19** and **unexpected national elections**. There was high turnover of government staff throughout the project, thus adversely affecting its continuity.
- **Technology**, such as old computers, obsolete equipment and technology, as well as the use of different software between organisations, **was a barrier**. While software technology issues have been overcome at the national level, it is still challenging with regards to regional collaboration since each country uses its preferred software.
- There is a **lack of clarity and guidance on operational costs**. Mechanisms to transfer the operation and maintenance of equipment have not been established. **Decentralisation is an ongoing process** in Bolivia: local authorities have neither the autonomy nor the capacity to manage the investments in equipment and its related operations.

Lessons Learned

- Undertaking a **river basin-scale approach** to climate and weather services has enabled the water and environment authorities to make informed decisions on planning, the prioritisation of needs and future investments, as well as the effective management of water resources at the regional level. This approach recognises the inter-linkages of water resources to enable the prioritisation process of investments in HMCS services and climate-resilient infrastructure.
- A **clear governance structure** from the outset of the project has allowed for collaboration and the integration of activities, as well as data exchanges between institutions to strengthen the information management system. The implementation of agreements with airports and aviation authorities, which collect and analyse their own data, has enabled the use of the resulting information for practical and operational benefits in real time.
- The project is **aligned with the Bolivian government's agenda** to approach water resources and climate change at the river basin level, as well as the river basin management measures.
- **Flexibility** has been a key factor to the successes. Although EWS was not originally planned, it was later approved as it was aligned with the overall project objectives. When the Water Channelling and Regularization Service of the Piraí River (SEARPI) did not agree with the initial conditions and dropped out of the project, no investments were then made in the Pirai river basin and the funds initially allocated to SEAPRI were redistributed to other PPCR activities.

- Approaching climate change at the river basin-scale has facilitated the ability to look at HMCS in a more integrated way with an ultimate common goal. Improved equipment, more accurate data, and improved forecasting models have led to more informed decision-making on priority infrastructure investments, such as riverbank protection, irrigation, water supply, and forestry.

Key Recommendations

HMCS priorities

While the modernisation and strengthening of the observation and monitoring system has progressed significantly, more products and better services are needed to enhance service and information delivery. The main priorities for future projects are:

Stage of value chain	Priorities for future projects
1. Observations and monitoring	• Although the products developed so far have improved the decision-making and planning process, increasing the number of monitoring stations in areas with limited coverage (instead of making assumptions based on satellite imagery) is key. Additional resources should be allocated to the installation of modern equipment and the rehabilitation of existing technology that can be made to fit in with it. • An effective network to monitor reservoir and river water levels should be established to complement the weather and climate services. WB is reported to have started to work on this: it is suggested that involving the national authorities as early as possible will enable them to effectively contribute to the design, development, and implementation of the resulting tool, as well as facilitate the integration with other products and services provided by SENAMHI.
2. Data and information management	• Automated and cloud-based data systems should be the next step once the monitoring stations are improved. Better synergy and integration of the different tools are needed, such as using tools that automatically take

Stage of value chain	Priorities for future projects
	weather data from stations to generate forecasts and feed into EWS, rather than doing it manually.
3. Research, forecasting, and modelling	• Future modelling and forecasting should use different local/regional scenarios (instead of global scenarios) in order to forecast at shorter timescales. Some universities have undertaken modelling by using local future scenarios; this could be tested at the river basin scale with better results for effective prediction. • Additionally, a bottom-up approach to integrate indigenous systems would be needed to strengthen the scientific forecasting system. The Rocha River Basin Master Plan has been highlighted as a successful case for integrating local indigenous knowledge into the planning and management of resources. It is important to acknowledge communities who have special bonds with their territory and the impact of the decisions affecting their livelihoods, both now and in the future.
4. Service development and delivery	• It has been recognised that an improvement in all value-chain services will lead to better service development and delivery. Service development and delivery cannot be addressed in isolation, but instead, as a combined outcome of better equipment, data management, modelling and forecasting, as well as improved capacity. • Communities, including farmers and ranchers, were taken into account in the design and planning of the PPCR project, but the dissemination of EWS to the community (as final users) is still recognised as a gap in the initiative. Reaching out—communicating and disseminating HCMS products to the local community—should be one of the next priorities. • The continuous improvement of service delivery through regular monitoring and evaluation (M&E) should be considered in the next steps. While interactions with related institutions have been successful, interactions with final users need to be included to ensure their comments are fed into the

Stage of value chain	Priorities for future projects
	system. Although a user feedback form exists, the M&E process that needs to occur on a regular basis could be integrated as part of the data management system.
5. Training and capacity strengthening	• Acquiring good practices and technical assistance, by working closely with international experts and learning from them, should also be considered as part of research and training programs. • Strengthening the capacity at national and regional levels should ensure the continuity of training programs over the longer term, thereby adding skills and flexibility to the system.

Achieving sustainable HMCS

Funding arrangements

HMCS services are generally funded by the Bolivian government. However, public funds tend to focus on the procurement and installation of infrastructure, with only a limited budget for the operation and maintenance of the network. Although an annual budgeting plan is undertaken every year, the funds allocated to O&M are lower than required. Donor budgets are also mainly focused on equipment.

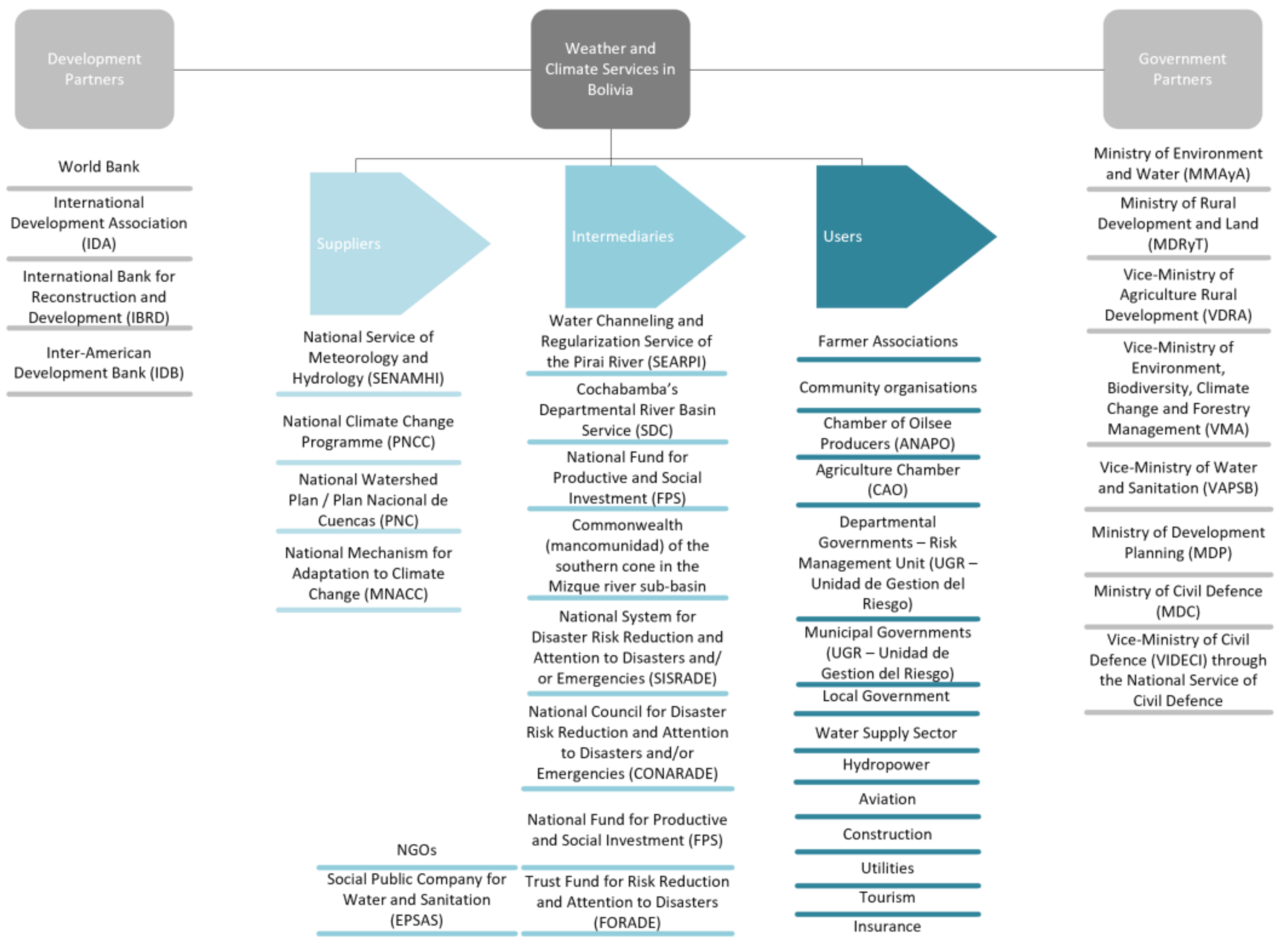
Commercial HMCS are not well-developed; nor are private operators available in Bolivia. Weather data is provided commercially at low cost, but there is no specific commercial model or strategy for commercial climate services. Public private partnership mechanisms are not established or operating in the country.

Before commercial services can be provided, there is a need to improve forecasting and modelling skills as well as reduce the uncertainty associated with the products. Market analysis and feasibility studies should be undertaken to better understand the benefits and advantages of commercial HMCS, including the diversification of potential funding sources.

Regional cooperation

Bolivia is participating in regional cooperation projects where transboundary services are key. Collaborations with Brazil, Peru, Uruguay, Paraguay, and Argentina at the river basin-scale has increased the socialisation of weather and climate products, as well as allowed useful feedback and learning from their counterparts. However, the differences in software and tools used have been a barrier when developing projects together. **CIIFEN** (International Research Centre on El Niño) has been a valuable partner in the region. It has an agreement with the national hydromet authorities in the west and south of Latin America to provide regional seasonal weather and climate forecasts.[53]

Key Stakeholder Map



[53] Regional Climate Centre for Western South America, 2021, https://crc-osa.ciifen.org/.

Appendix 2. Learning Brief on Hydromet and Climate Services Project: Caribbean Region

> The learning review aims to take stock of the progress made to date on the lessons learned from strengthening HMCS under CIF's PPCR and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews.
>
> This learning brief that focuses on the Caribbean Region forms part of the final learning review.
>
> It has been informed by interviews, with representatives from the Jamaican Meteorological Office and the Inter-American Development Bank (IDB) staff involved in the project.

Project Overview

Brief regional context

The Caribbean Region consists of 24 Small Island Developing States (SIDS) and low-lying countries. Vulnerability to climate change across the region is diverse due to variations in geographical and socioeconomic factors that determine each country's ability to withstand and adapt to the effects of climate change, such as increased exposure to hurricanes and sea-level rises. Such hazards impact tourism and commodity exports—the biggest economic activities in the region.[54] Regional efforts to tackle climate-related vulnerabilities benefit many SIDS by increasing the pool of knowledge and resources available.

The Caribbean Regional Track of PPCR is one of two regional tracks of PPCR and involves six Caribbean PPCR pilot countries: Dominica, Grenada, Haiti, Jamaica, St. Lucia, as well as St. Vincent and the Grenadines (SVG). The programme builds on the region's prior work that has focused on increasing capacity and producing key

[54] CCCCC, IDB, World Bank, 2012, *Caribbean Regional Strategic Programme for Climate Resilience*, caribbean_regional_track_spcr_cif_endorsed_final_0.pdf (climateinvestmentfunds.org)

products for use in policy and climate monitoring, along with disaster risk reduction, management, and adaptation.

A map of the stakeholders involved in the HMCS system can be found at the end of this learning brief.

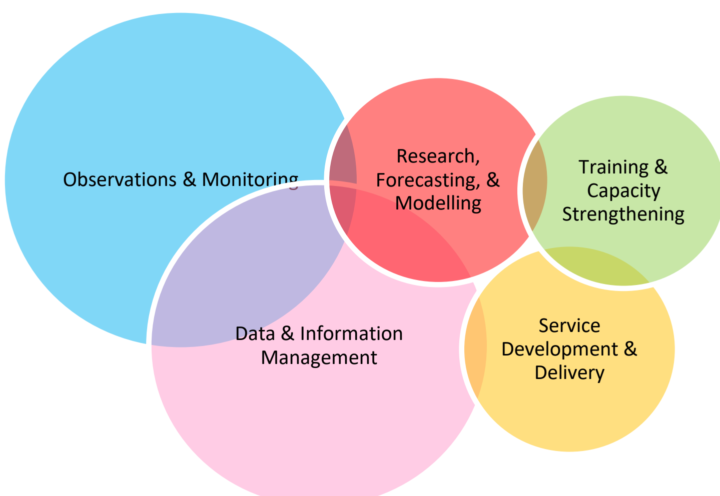
PPCR project overview

Name of project	Investment Plan for the Caribbean Regional Track
Implementing multilateral development bank (MDB)	Inter-American Development Bank (IDB)
MDB approval date	May 2015
Closing date	March 2021
PPCR financing	USD10.39 million (grant)
Objectives	**To implement the activities of the regional track of the Caribbean PPCR**: **improve the regional processes of climate-relevant data acquisition, storage, analysis, access, transfer, and dissemination, as well as pilot and scale up innovative climate resilient initiatives.** The project aims to **adopt a regional approach for generating data and developing information products and services that can be utilised at both the regional and national levels**. Six countries are involved in the Caribbean Regional PPCR project: Jamaica, Haiti, Saint Lucia, SVG, Grenada, and Dominica.

Project components	1) Improving geospatial data and management for adaptation planning, sea-level rises, and storm surge impact analysis; 2) Consolidating and expanding the regional climate monitoring network and global platform linkages; 3) Downscaling and expanding climate projection models, along with high-resolution maps; and 4) Applying adaptation initiatives. Communications strategy will cover all components and raise the profile of the Caribbean Regional PPCR track and its activities among decision-makers in the Caribbean.

Relevance for the HMCS Value Chain

The project contributed to the HMCS value chain through improved observation and monitoring, as well as data and information management. The focus placed on each aspect of the HMCS value chain is indicated by the size of the circle in the diagram below.



Stage of value chain	Project activities
1. Observations and monitoring	• Installation and improvements to weather stations
2. Data and information management	• Development of high-resolution topographic and bathymetric maps, along with land-use scenarios, for vulnerable areas in the PPCR countries • Ecological and socioeconomic impact assessments related to fisheries and monitoring systems undertaken to provide improved data and climate-smart fisheries planning and decision-making • Development of the Caribbean Regional Fisheries Mechanism (CRFM) portal, designed to provide broad user access to datasets, information and knowledge products, as well as storage of products from other major CRFM and national projects • Procurement of three Climate Data Storage and Redundancy Systems (one each in Barbados, Trinidad, and Belize) to expand regional climate monitoring networks and ensure data security • Development of the Regional Coastal Integrated Information Management System (RCIIMS) to support ongoing national PPCR programmes, climate analysis, and regional adaptation planning
3. Research, forecasting, and modelling	• Acquisition of the Scientific Platform for Applied Research and Knowledge Sharing (SPARKS)—a high-performance computing and storage system delivering improved access, storage, analysis, transfer, and dissemination of data. SPARKS is able to provide users with higher resolution and refined climate data by isolating geographical areas within countries. • Development of the Fisheries Early Warning and Emergency Response (FEWER) tool in SVG, Grenada, Dominica, and Saint Lucia, thereby enabling climate-smart fisheries planning, management, and decision-making. • Research into drought-tolerant varieties of sweet potatoes completed, with findings offering an income opportunity for regional producers

Stage of value chain	Project activities
4. Service development and delivery	• Refurbishment of seed storage bank facilities in Jamaica, including the upgrading of the seed storage facilities, the construction of a cold room, and the procurement of a seed batch dryer • Installation of rainwater harvesting systems in Grenada, Haiti, Jamaica, and St. Lucia. Haiti has been highlighted as benefitting from the capacity-building component of the rainwater harvesting: the manuals that have been developed will enable installation techniques to be replicated**.**
5. Training and capacity strengthening	• Training provided to 30+ male and female fishers from SVG on the use of the FEWER system • Training provided to 20 agricultural stakeholders from Jamaica, Barbados, Belize, Guyana, St. Lucia, SVG, along with Trinidad and Tobago, on Climate Resilience Advanced Crop Modelling in order to prepare farmers to better manage weather uncertainties associated with climate change • A Climate Services Toolkit (CST) workshop held to increase the utilisation of local climate data and the Climpact tool, as well as build capacity within the National Meteorological Service of Jamaica. With more officers trained in climate services, services can be expanded beyond the agriculture sector to additional climate-sensitive sectors. • National Sectoral Early Warning Information System Committee established to increase capacity for disaster risk management (DRM) and reduce the socioeconomic impacts of disasters across sectors • National Climate Products and Services Road Map for Jamaica created to guide national policy and planning • National fisheries officers introduced to statistical and Geographic Information System (GIS) software in order to improve analytical capabilities in the region • Training provided to the Jamaican government staff and other agencies in the use of the Caribbean Climate Online Risk and Adaptation Tool (CCORAL)

Stage of value chain	Project activities
	to be able to integrate climate resilience into the Caribbean decision-making processes and activities.

Key Findings

Main project successes

- **Improvements to the hydromet network** made across all six countries increased the coverage of the network, its reliability, and automatic data transmission.
- Progress has been made to **develop high-resolution coastal topographic and bathymetric maps**.
- **Improvements in data handling, processing, and sharing** have been made, which have increased access to accurate real-time data.
- The **clear division of roles and responsibilities** within the project has allowed for an efficient process.
- The **strong influence from beneficiaries** throughout the project design and implementation has helped to develop a tailored service, with beneficiary feedback having been a key part of the evaluation.

Challenges

- **Delays in procurement**, along with disruption to shipments caused by Covid-19, have slowed progress across all six countries.
- **Staff retention** has been difficult, thus limiting the technical capacity to complete key tasks.

Lessons Learned

- **Efficient procurement** is key to smooth project implementation so that delays do not impact progress of later project activities, such as improved service development and delivery, which is often out of necessity completed at a later stage in the project.
- There needs to be a **focus on users and services** so that the project can be designed with a clear vision of what is required for delivering a useful and sustainable HMCS system.

Key Recommendations

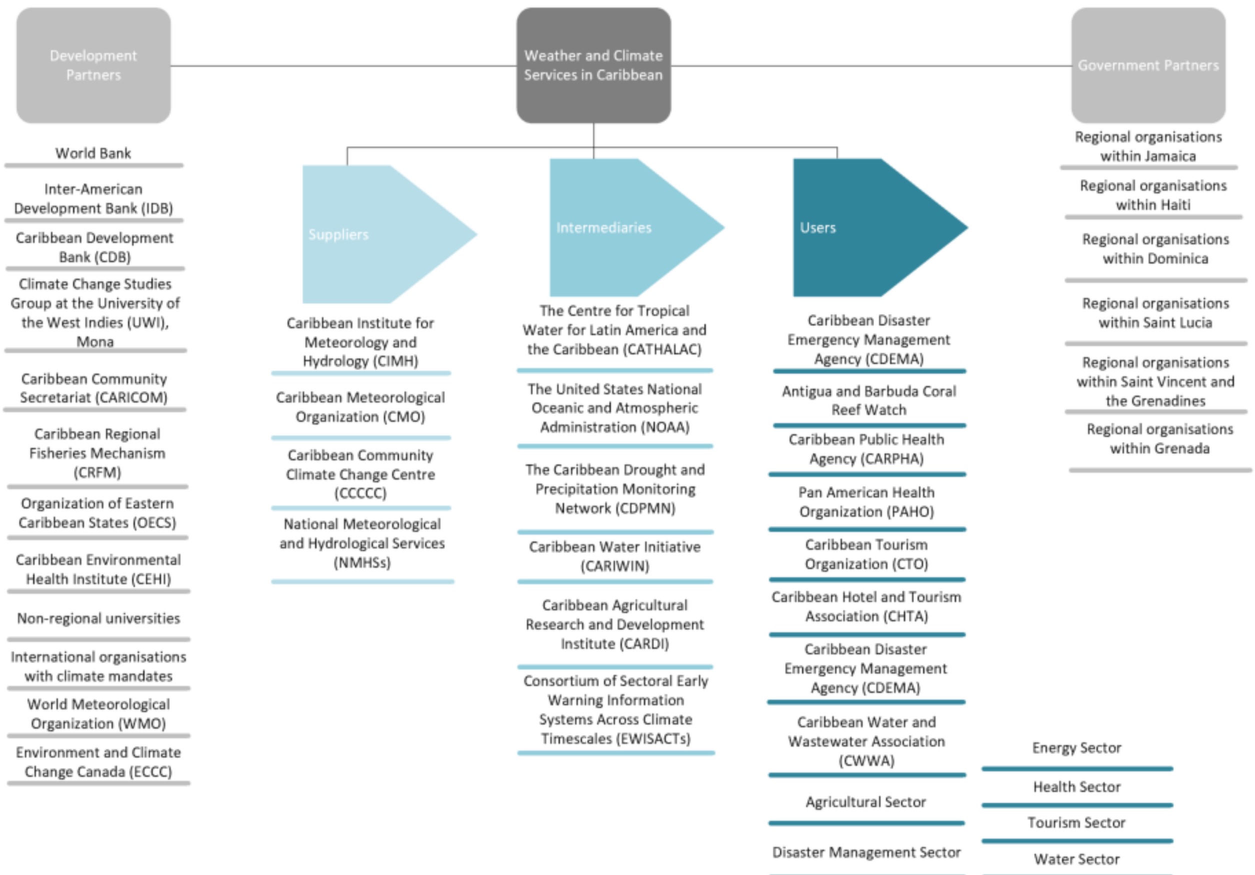
HMCS priorities

Stage of value chain	Priorities for future projects
1. Data and information management	• Data and information management has been identified as requiring focus in future activities.
2. Research, forecasting, and modelling	• The effects of climate change on fishing communities and livelihoods need to be explored further in order to build resilience in the communities themselves, as well as the environments, tools, and operations of fishers.
3. Service development and delivery	• FEWER should be integrated into existing national DRM and emergency response frameworks. • Rainwater harvesting should be expanded to more households through the promotion of smaller upgrades to existing systems, rather than new costlier systems. Focus should be placed on improving the water quality of the systems to enhance household water security.
4. Training and capacity strengthening	• Training to fishers should be expanded to increase the capacity to combat overfishing and illegal fishing in order to minimise the exacerbation of local extinctions due to the loss of habitats caused by climate change.

Achieving sustainable HMCS

- **Increased technical capacity** by attracting new and retaining existing staff is necessary to achieve sustainable HMCSs.
- **Allocated funding** to maintain the national observation networks is needed to prevent asset deterioration.

Key Stakeholder Map



Appendix 3. Learning Brief on Hydromet and Climate Services Project: Dominica

The learning review aims to take stock of the progress made to date on the lessons learned from strengthening HMCS under CIF's PPCR and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews.

This learning brief that focuses on Dominica forms part of the final learning review.

This learning brief has been informed by interviews with representatives from WB, the Dominica National Meteorological Office, the PPCR Unit in Dominica, and independent hydromet consultants.

Project Overview

Brief country context

Dominica is a small country island state in the Caribbean, located within the Atlantic hurricane belt. The island is highly exposed not only to meteorological risk (high winds, excess rainfall, hurricanes, and droughts) but also to geophysical (seismic, volcanic, and tsunamigenic) hazards. These have had significant negative impacts on its population and economic stability. A single hazard event can impact the entire population and economy of Dominica due to its small geographical location and population of 71,808 inhabitants.[55] Topographic conditions mean that more than 60 percent of the population is settled on the coastal plains, thereby increasing their vulnerability to climatic events.

[55] World Bank, 2019, "Dominica," Dominica | Data (worldbank.org).

In 2012, the country designed its Strategic Program for Climate Resilience (SPCR) in collaboration with WB, which has led to its Low Carbon Climate Resilient Development Strategy. This strategy is the government's top commitment to transformational change towards climate action.

An updated map of the stakeholders involved in the HMCS system can be found at the end of this learning brief.

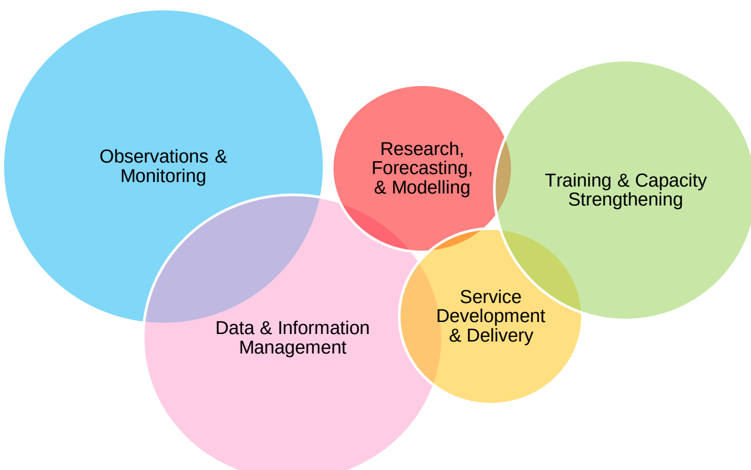
PPCR project overview

Name of project	Disaster Vulnerability Reduction Project (DVRP)
Implementing multilateral development bank (MDB)	International Bank for Reconstruction and Development (IBRD)
MDB approval date	May 2014
Closing date	June 2023
PPCR financing	USD21 million (including grant of USD12 million and non-grant of USD9 million-)
Objectives	The Dominica Disaster Vulnerability Reduction Project (DVRP) is one of several DVRPs in the Caribbean Region. It aims to **measurably reduce vulnerability to natural hazards and climate change impacts in Dominica**. This will be achieved through **investments in resilient infrastructure**, as well as **improved hazard data collection and monitoring systems**, to better inform future investment decisions.

Project components	1) Prevention and adaptation investments; 2) Capacity building and data development, along with hazard risk management and evaluation; 3) Natural disaster response investments; and 4) Project management and implementation support. The HMCS elements are part of a larger project that is building infrastructure driven by the National Meteorological Office.

Relevance for the HMCS Value Chain

The focus placed on each aspect of the HMCS value chain is indicated by the size of the circle in the diagram below.



Stage of value chain	Project activities
1. Observations and monitoring	• The design and deployment of a robust and modernised hydromet network including the construction of the Met Office HQ, the installation of 36 weather stations across the island, and the provision of reliable servers.
2. Data and information management	• The creation of a centralised spatial data management platform, including a high-resolution digital topographic and bathymetric model (based on Light Detection and Ranging (LIDAR)), soils survey maps and other key data sets. • Development of data exchange protocols.
3. Training and capacity strengthening	• Training and capacity building of government staff and community will also be undertaken; due to project phasing, this will be the last task.

Key Findings

Main project successes

DVRP is still ongoing (August 2021) and it is too early to determine if objectives have been fully met. So far, the achievements and outcomes noted below have been highlighted as successes:

- **Inter-ministerial collaboration** has been key to the project design and implementation. All government ministries involved have been working together—sharing data and information towards a common goal. Institutional arrangements have been very clear from the outset of the project, enabling each institution to understand its responsibilities and contributions to the project.
- The construction and provision of the **Met Office headquarters** has been praised as a big success. This has enabled the Met Office staff to centralise their operations, work efficiently as a team, and share experiences, as well as host hydromet servers and equipment.

Challenges

- The project was overly ambitious with regards to the number of stations and data collection tasks, and available funds only covered some of the initial tasks, which meant that prioritisation of work was required. The number of stations was reduced from 50 to 36 due to the lack of budget, with accessible areas prioritised. LIDAR modelling, forecasting, and the hydrological profile models were also discarded due to budget constraints.
- Project implementation has been delayed due to **COVID-19** and hurricane Maria. Although the equipment has been delivered, installation has been delayed due to the pandemic. Likewise, the training of the Meteorological Office personnel and other institutions is still pending due to travel restrictions. Online training was not pursued, as the NMHS staff had a strong preference for practical hands-on exercises on how the equipment operated and the maintenance requirements.
- There have been **low retention and high turnover of staff,** especially among senior managers. Ideally, there would be continuity of junior staff throughout the project lifecycle to provide support on key technical tasks so as to allow senior leaders to focus on strategic components.
- **Procurement of equipment** has proved to be difficult. The detailed specifications/requirements of a highly automated network have been difficult to fulfil; hence, cost estimates from bidders, including estimates for maintenance of equipment, have exceeded the budget allocated. The evaluation criteria of the bid process were mainly focused on cost, instead of quality or services.

Lessons Learned

- The logistics and management of installation of the equipment have been challenging for such a small country with limited capacity, and the **support from technical experts has been highly appreciated**. This has been an opportunity for the government to work closely with international experts and benefit from international good practice.
- **Allocating funds realistically** from the outset of the project would have prevented the need to change the scope of the design and remove key HMCS value-chain activities, such as forecasting and modelling.

  It is important to ensure that the **warranty of the equipment has not run out before the equipment is installed**. The warranty should commence once the equipment is installed, instead of on its delivery date. In the case of the Dominica DVRP, the installation of the equipment that had been delivered started after more than a year due to COVID-related travel restrictions.

Key Recommendations

HMCS priorities

Any future HMCS funding should prioritise the tasks that were not covered due to the limited budget. The priorities presented below came from stakeholder feedback:

Stage of value chain	Priorities for future projects
1. Observation and monitoring	• Weather stations that were cut due to budget constraints and difficult topographic conditions and terrain should be provided for and installed in the more remote areas in the island. While remote stations can be difficult to maintain, collecting some observations at higher elevations and across the island is regarded as beneficial.
2. Data and information management	• A more detailed spatial database, including on-the-ground surveys to complement the digital models and LIDAR modelling, should be created to enable the extension of the profiles of river cross-sections in order to support hydraulic modelling.

Stage of value chain	Priorities for future projects
3. Research, forecasting, and modelling	• Improved EWS should be a key priority. Similarly, more research on micro-climate models is needed due to the variable changing conditions in the Caribbean.
4. Training and capacity strengthening	• Real-time services delivery should be the next step once equipment is installed and operational. Communities should be involved to provide and disseminate information as well as engage in future project design.

Achieving sustainable HMCS

Funding arrangement

Public weather services have not been a priority for the country: historically, it has been under-funded, as there had been other urgent areas to address on the island.

Commercial HMCS are not feasible; only data requests by private companies (for example, engineering contractors) are paid at a very low cost. Dominica is not yet ready or willing to pay for commercial HMCS services.

Only construction is covered as part of PPCR, with no budget allocated for operational expenditure. The government does not have resources to support maintenance either. Contractual arrangements for a private outlet to provide maintenance of equipment on a remote island are expensive. Alternative options, such as a partnership with the private sector and sales of services to marine communities, should be considered to ensure sustainable HMCS.

Continuous improvement to achieve sustainability

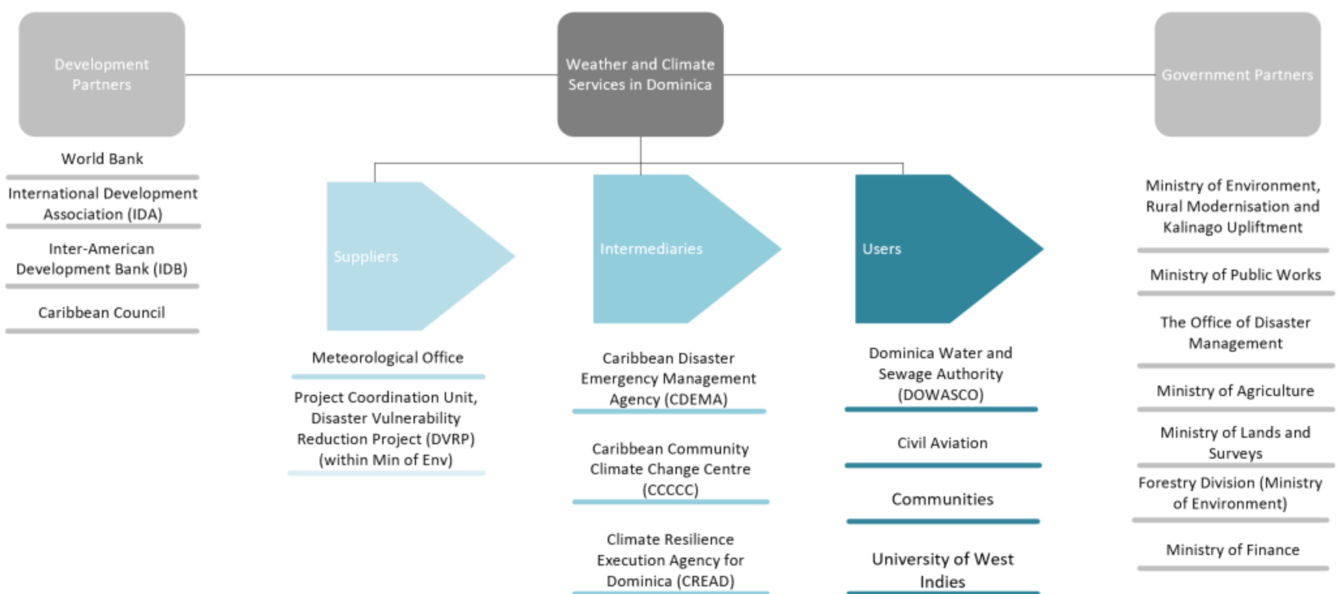
There are no plans to address asset deterioration. Therefore, it will be important to provide guidance on discharging equipment when needed, and a monitoring census should be undertaken with regular frequency.

The project has not focused on improving services at this stage; therefore, gathering user feedback has not been considered yet. The next steps should be to capture feedback through customer/user feedback satisfaction forms in order to ensure the continuous improvement of the hydromet services.

Regional collaboration

It will be beneficial to widely collaborate with the region, but the approach and conditions need to change. Individual countries need to be consulted before regional authorities can proceed.

Key Stakeholder Map



Appendix 4. Learning Brief on Hydromet and Climate Services Project: Grenada

The learning review aims to take stock of the progress made to date on the lessons learned from strengthening HMCS under CIF's PPCR and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews.

This learning brief that focuses on Grenada forms part of the final learning review.

It has been informed by interviews with representatives from WB and the Independent Hydromet Consultant (employed by the Government of Grenada). Representatives from the Department of Agriculture were unavailable for interviews within the learning review programme timeframes.

Project Overview

Brief country context

The Grenada Meteorological Department is directed by the Grenada Airports Authority (a statutory body) under the Ministry of Civil Aviation and Tourism. Although its primary responsibility is to the users in aviation, it also plays a role in the provision of early warnings for PWS.[56] The Met department works closely with the National Water and Sewerage Authority (NAWASA) that sits within the Ministry of Communications, Works, Physical Development, Public Utilities & ICT services.

[56] Grenada Airports Authority, 2020, https://gaa.gd/.

There is a well-established Hydromet Committee in Grenada that was created prior to DVRP. The committee includes representatives from several agencies and stakeholders, including NAWASA, the Met Department, the Ministry of Environment, Foreign Trade and Export Development, the Ministry of Agriculture, and the Ministry of Public Works.

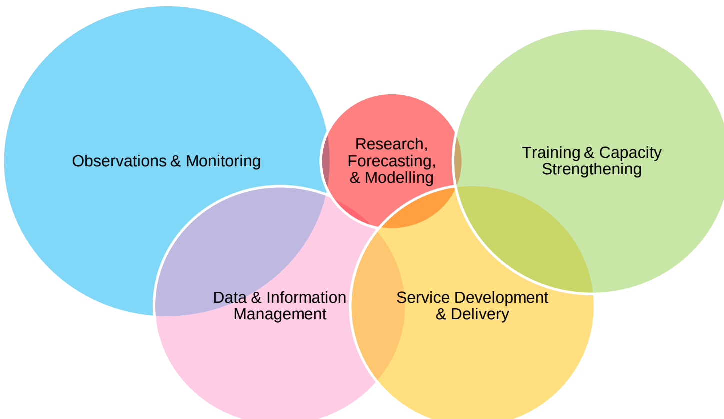
A map of the stakeholders involved in the HMCS system can be found at the end of this learning brief.

PPCR project overview

Name of project	Disaster Vulnerability Reduction Project (DVRP)
Implementing multilateral development bank (MDB)	International Bank of Reconstruction and Development (IBRD)
MDB approval date	June 2011
Closing date	June 2021
PPCR financing	USD25 million (including grant of USD13 million and non-grant of USD12 million)
Objectives	**Climate-proof key infrastructure, increase the capacity of the National Disaster Management Agency, and improve the capacity of the Physical Planning Unit to conduct climate monitoring and hazard planning**
Project components	1) Prevention and adaptation investments; 2) Regional platforms for hazard and risk evaluations, as well as applications for improved decision-making; 3) Natural disaster response investments; 4) Project management and implementation support; 5) Payment of the Caribbean Catastrophe Risk Financing Facility (CCRIF) Insurance Premium. HMCS activities, which formed a relatively small part of the overall scope, were predominantly driven by the Land Use Division within the Ministry of Agriculture (the implementing agency), NAWASA, and the Meteorological department.

Relevance for the HMCS Value Chain

The focus placed on each aspect of the HMCS value chain is indicated by the size of the circle in the diagram below.



Stage of value chain	Project activities
1. Observations and monitoring	• 35 functional hydromet stations now providing data to a shared platform • Two new tidal stations • 40+ manual rain gauges
2. Data and information management	• LiDAR mapping for the entire territory of Grenada completed and available on a shared platform
3. Service development and delivery	• The Ministry of Agriculture obtaining feedback from users on the open data platform to try and improve services
4. Training and capacity strengthening	• Capacity building and associated data collection and management tools provided to the Physical Planning Unit within the Ministry of Works and the National Disaster Management Agency (NaDMA).[57] This component focused on linking up regional data management and risk analysis platforms and using them in policy making.

[57] World Bank, n.d., *Project Appraisal Document for the Disaster Vulnerability and Climate Risk Reduction Project*, Report No: PAD1227.

Key Findings

Main project successes

What have the major achievements been?

- The installation of the hydromet network exceeded objectives in that the **automatic data collection network is now more extensive than initially expected**. As specifications were developed and the need became clearer, project funds were made available to enable greater expansion.
- The **establishment of the real-time hydromet data portal was a great success**, but the portal still needs further development to improve it and ensure its sustainability going forward. All the maintenance and ownership of this portal sit in the Land Use Division. Training and capacity building of the Land Use Division on servicing equipment, maintaining the database, introducing the web portal to users, and so on were delayed due to COVID-19, but they will take place before the project's completion.

Which factors were highlighted as playing supportive or key roles in these successes?

- **Beneficiaries were very engaged** and aligned, demonstrating a good understanding of the context.
- Institutional governance within the relevant parties was a key enabler of this project. There was **strong political will to collaborate,** coupled with the good technical capacities of all levels of staff. This was largely down to the individuals involved, rather than formal remits. Efforts were made to ensure that junior staff were fully integrated into the process to help with succession planning.
- Good **alignment and standardisation with Caribbean Community Climate Change Centre (CCCCC)** helped with the development of databases.

Challenges

- Lack of **capacity in-house** to specify and manage the procurement of the Emergency Communication Network.
- **Project delays** meant that the LiDAR data was not incorporated into the data and information management systems as intended.
- The rollout and **awareness of the project outputs** and HMCS services have not been promoted widely enough for all potential users and beneficiaries to be aware of what is available (for example, the open access data platforms).

- Immediate and **longer-term HMCS institutional needs** were assessed in the project. While short-term needs were well understood after an MoU was developed and clear roles and responsibilities were defined, the longer-term plan was not mapped out sufficiently under this project. Another project tried to address this in December 2020, but faced similar challenges; this issue is still outstanding.

Lessons Learned

- **Realistic project objectives/scope**: When the project was being defined, the ambition was extremely optimistic and extensive. Not all aspects of the scope were aligned with the existing technical HMCS capacity or the defined project programme. Objectives need to be more focused and realistic by factoring in the project environment.
- **Longer project durations**: The project duration was too short to achieve the desired sustainable improvements in HMCS. HMCS programmes need to be longer to enable field support post installation, such as a minimum of a two-year warranty period and technical support. Attempting to achieve this within shorter project timeframes is very challenging, and paying for ongoing support upfront limits commercial incentives for suppliers to fulfil their duties.
- **Focus on users and services**: The project could have been more effective if it had started by scoping what the system as a whole required to improve the overall quality of services. By starting at the end of the value chain and focusing on users and services, a more sustainable HMCS system could be developed to maximise the value of existing data and products.

Key Recommendations

HMCS priorities

Future HCMS priorities as raised by stakeholders are shown in the table below.

Stage of value chain	Priorities for future projects
1. Data and information management	• There is a need to institutionalise monitoring and data collection between the ministries and make a longer-term plan for HMCS management in general. Although each party has a different focus, there are common data and information needs that need to be linked with the Land Use Division, the primary custodian of the majority of the HMCS data, and NAWASA that owns the majority of the handheld sampling equipment. • The wider sharing of data could improve and create more analytical products, such as rainfall depth duration curves.
2. Research, forecasting, and modelling	• This is a current area of weakness, with very little in the way of modelling being carried out at a national level. To address this area, improvements to Stage 5 are necessary.
3. Service development and delivery	• In general, the ambition to provide good services and customised products for different clients is there. However, to improve in this area, significant focus is needed in Stages 2 and 3 described above.
4. Training and capacity strengthening	• The findings of the short- and long-term institutional needs assessments need implementing. A greater focus on hydromet services is required with a ring-fenced budget line.

Stage of value chain	Priorities for future projects
	• Staff need to be trained (for example, through college/university courses) to improve their technical capacity, and positions that utilise the necessary skills need to be created. This will not only improve in-house capabilities, but will also enable the better management of Technical Assistants providing support in the field.

Achieving sustainable HMCS

Regional Collaboration

There are clear advantages to regional HMCS collaboration, especially in the Caribbean's small island states. Within the Caribbean, there are a number of key organisations supporting regional collaboration in HMCS:

The Caribbean Institute for Meteorology and Hydrology (CIMH) is a training and research organisation that aims to improve the meteorological and hydrological services and assist in promoting the awareness of the benefits of these services for the economic well-being of the countries.

CCCCC is a regional entity whose work is focused on SIDS in the Caribbean, with a focus on improving the region's framework for activities that address climate change.

The mandate for CIMH and CCCCC in supporting Grenada is not clear to all stakeholders; hence, formalising this mandate and/or raising the awareness about it would be advantageous. Approaches and ambitions of regional organisations need to be aligned with national strategies. By integrating regional services and projects into the national HMCS strategy, collaboration could be further improved and the relevant agencies/departments would be better able to maximise the benefits and opportunities presented by regional bodies.

It is understood that there are significant differences between the maturity of the relationship between regional organisations and the member states. While the relationships are very strong with neighbouring countries (for example, SVG), there are more challenges working with Grenada; thus, CIF's funding of regional projects may have varied impacts across the region.

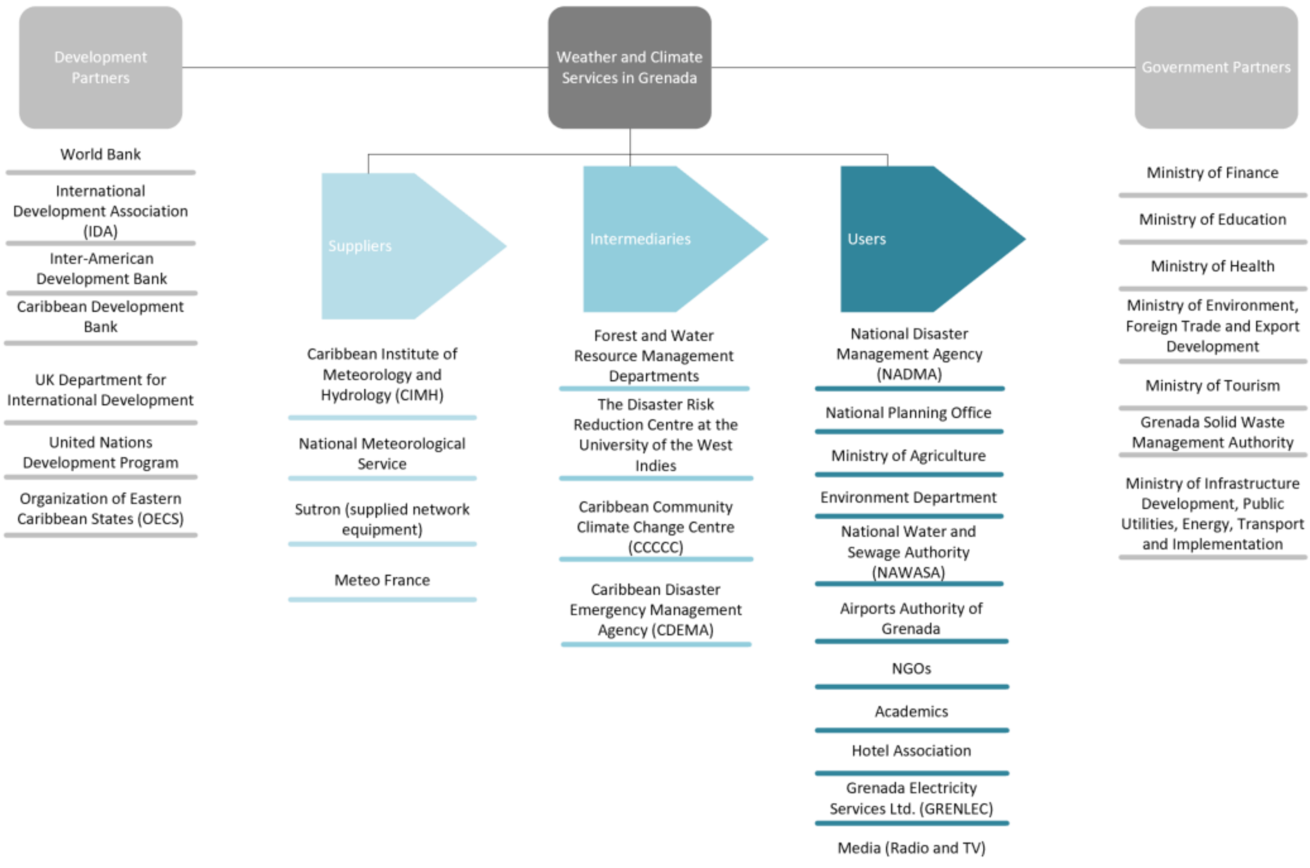
Funding Arrangements

In general, the stakeholders engaged with felt that agencies working in HMCS in Grenada are under-funded. A key factor for this is the reliance on the central government's funding process that is not meeting their needs. Suppliers and intermediaries jointly funding HMCS projects or resources is not commonplace at present, but this collaboration has potential where the joint benefit is clear, such as obtaining geospatial data of use to many agencies/users. This is discussed within the MoU drafted under this project.

Commercialising HMCS

It is perceived that there is an interest, for example, from airport fuelling and shipping companies along with tourism operators, among others, in paying for quality data if it is available for purchase. However, there is a concern that the private sector partners would ultimately gain an unfair profit in their roles as intermediaries by repackaging and selling data. This has been witnessed regionally in telecoms.

Key Stakeholder Map



Appendix 5. Learning Brief on Hydromet and Climate Services Project: Haiti

The learning review aims to take stock of the progress made to date on the lessons learned from strengthening HMCS under CIF's PPCR and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews.

This country learning brief that focuses on Haiti forms part of the final learning review.

It has been informed by interviews with representatives from WB, the Hydrometeorological Unit of Haiti (UHM), the Ministry of Agriculture, Natural Resources and Rural Development (MARNDR), as well as independent consultants involved in the project.

Project Overview

Brief country context

Haiti is a small Caribbean country that shares the Island of Hispaniola with the Dominican Republic. With a long history of political violence and instability, it has suffered from severe environmental degradation, which has increased its vulnerability to climate change. In addition to earthquakes, which pose a major threat to the country, Haiti is highly exposed to hydro-meteorological hazards, including hurricanes, landslides, flooding, and droughts. The 2010 earthquake is estimated to have killed more than 220,000 people, leaving more than six million Haitians unable to meet basic needs and causing huge damage to the country's infrastructure. In the recovery from the 2010 earthquake, strengthening the response to disasters was a strategic priority and improving the country's capacity to use and generate meteorological data were recognised as key considerations for building resilience. This PPCR project followed the 2012 SPCR.

As this report was being finalised (August 2021), Haiti was again struck by an earthquake, closely followed by Tropical Storm Grace. News reports identified that improved hydro-meteorological services meant emergency services could tell where the weather conditions would be at their worst. Nonetheless, the damage to infrastructure caused by the earthquake hampered attempts to deploy equipment to provide the necessary shelter and support.

A map of key stakeholders involved in HMCS in Haiti has been included at the end of this learning brief.

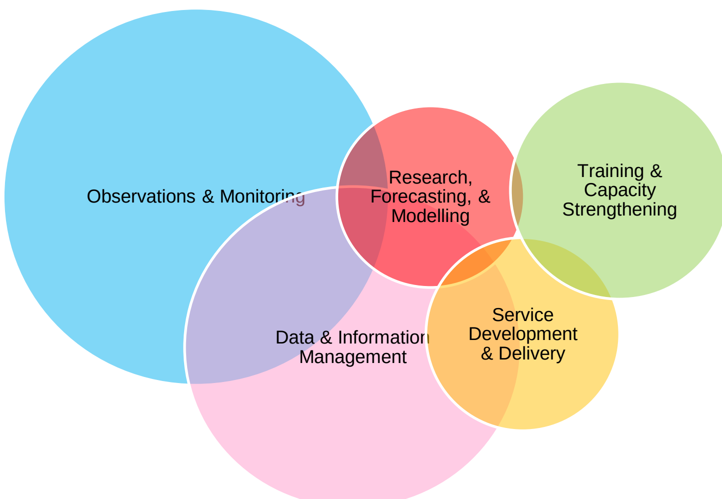
PPCR project overview

Name of project	Strengthening Hydro-Meteorological Services Project
Implementing multilateral development bank (MDB)	International Bank of Reconstruction and Development (IBRD)
MDB approval date	June 2015
Closing date	October 2020
PPCR financing	USD5 million (grant)
Objectives	**Strengthen the government of Haiti's institutional capacity to provide hydro-meteorological and climate information services that are customised to the needs of the civil protection and agriculture sectors** in order to contribute to increasing disaster and climate resilience.
Project components	1) Integrate existing hydromet data collecting networks into a national data platform and strengthen capacity for data archiving, validation, and analysis; 2) Identify hydro-meteorological and climate services' requirements for select end-users (including agriculture and civil protection); and 3) Develop information services to support decision-making.

Relevance for the HMCS Value Chain

The original focus of the project was reoriented following the mid-term review (MTR). As such, activities were strongly focused around Observation and Monitoring as well as Data and Information Management. Service Development and Delivery activities were the original targets for the project, but they could not be undertaken due to delays and a need to first focus on building the foundations for a strong hydro-meteorological system.

The focus placed on each aspect of the HMCS value chain is indicated by the size of the circles in the diagram below.



Stage of value chain	Project activities
1. Observations and monitoring	• The project procured an additional 28 stations, but only two were installed successfully under the project due to COVID-related and procurement delays. The remainder are currently being installed under a separate project.
2. Data and information management	• A National Hydromet Platform (NHP) was established, with data obtained from 35 stations and five sub-networks.
3. Training and capacity strengthening	• Some training was carried out through the project on the use of the Platform; however, there is a clearly identified need for more.

Key Findings

Main project successes

- **The creation of the National Hydromet Platform (NHP)** at UHM was consistently highlighted as a major achievement. The data management platform that is operational is receiving data; its installation allows for a central system where previously there had been none. While not all stations procured could be connected, NHP will be able to receive data from these stations once installed.
- The project played an important role in **building the visibility and profile of the UHM** at the national level. The project helped UHM to become fully operational, and interviewees felt that it laid the foundations for the further strengthening of UHM and the climate services system.
- Despite experiencing major delays, and operating under very challenging circumstances, the eventual **successful procurement of 42 stations** was seen as a success, even if these could not be installed under the project. They are now being installed under a separate agreement and will strengthen the national observational network.
- All stakeholders highlighted the importance of the **redirection of the project following the MTR**, which allowed a smaller team to establish good working relationships and produce some concrete results as highlighted above, despite a very challenging political and economic context.

Challenges

- **The design of the project was too ambitious, given the political context** and the existing level of capacity in Haiti. In particular, stakeholders noted that creating user services was not a realistic goal, given the need to first improve observations and monitoring, and then create a data management system.
- **Institutional challenges** caused delays early in the project. In particular, UHM was not fully established when the project started (only becoming properly operational in 2018), with major implications for the work of the project and coordination with key stakeholders.
- **Significant delays in procurement** caused delays to the start of the project. The political and security situation severely limited the number of firms that could work in the country and the quality of work. The context meant that the market could not supply the skills needed (for example, some procurement processes had one bidder only), and there was a lack of understanding of how to work in the Haitian context.

Lessons Learned

Stakeholders highlighted a series of lessons related to the difficulties of working in politically and economically fragile countries such as Haiti. Some key lessons are presented below:

- **Context-appropriate project design needed.** The project design was seen to be overly ambitious given the political context and level of capacity in the country, with limited contingency planning for what would happen in the event of a worsening political situation. The view is that it was designed in a rare window of political stability and became far too complex, particularly once the situation began to deteriorate. Where capacity is limited and the HCMS system is starting from a low base, the focus should be on building the foundations for effective climate services, rather than attempting to work along the whole value chain to deliver services. In countries where delays are likely, project design should, where possible, avoid too many dependencies among components. Big delays to early activities can otherwise cause major delays to the whole project.
- **Budget flexibility and maintenance.** Money needs to be available for basic maintenance and monitoring. Examples were given in the project where the lack of money for petrol and a per diem meant that stations could not be inspected as planned. A small amount of money ring-fenced to be flexibly programmed to respond to urgent needs could help to avoid unnecessary delays.
- **Longer-term engagement.** Stakeholders noted that in countries like Haiti, where the conditions for HMCS projects are challenging and initial capacity is low, there would be significant value in a longer-term approach to engagement and programming. It takes time to create good technical teams and establish working relationships with the government and other key stakeholders. In the absence of longer-term engagement, opportunities can be lost and it is difficult to maintain the structures needed and the technical capacity that was built. This was a clearly expressed frustration among all stakeholders interviewed.

Key Recommendations

HMCS priorities

Stage of value chain	Priorities for future projects
1. Observations and monitoring	• The stations procured in the project are being installed. However, there is still a need to **further strengthen the observational network** and improve the coverage of hydrological monitoring stations in particular.
2. Research, forecasting, and modelling	• Delays in the project meant that planned activities around building the modelling capacity could not be carried out. **Improving modelling capability** at UHM, but also within the research community, is seen as an important precursor to the development of user-oriented services.
3. Service development and delivery	• There is a clear need to build on the project's investments in observations and data management, as well as **develop processes for the development of user-oriented services**. A first step would be greater exploration of the services that can be offered to other government departments, but there is also a clear view that services are needed to reduce the vulnerability of the agriculture sector in particular. The development of a clear user engagement platform would facilitate the development of user-oriented services.

Achieving sustainable HMCS

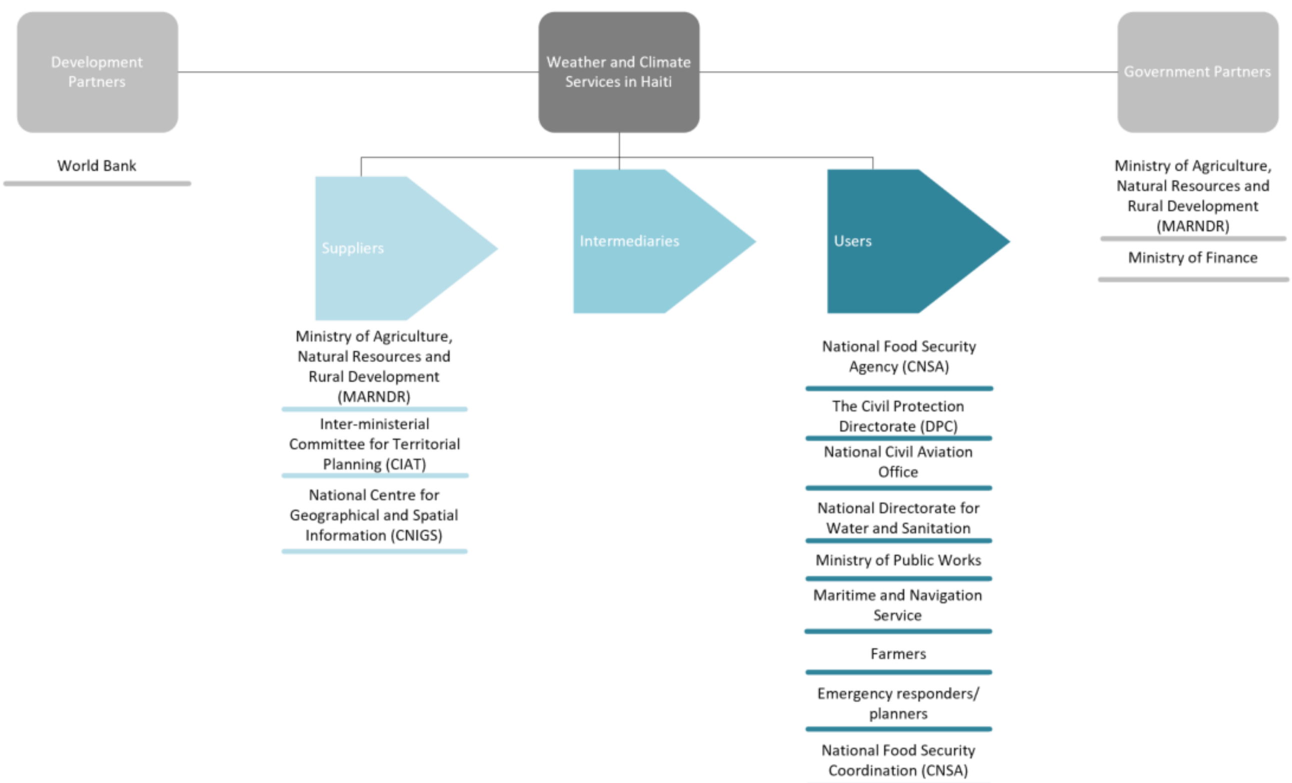
Despite advances under the project, there are major challenges to the development of a sustainable HMCS system in Haiti. In particular, these relate to:

- **Budget and resources for UHM**. UHM currently has no dedicated budget, though it clearly understands the need to generate its own revenue streams. In addition to technical support, UHM also needs assistance in developing a business plan to clearly set out the nature of services that could be offered, potential clients, sources of revenue, and strategies on how it could develop user-oriented services.
- **Technical capacity**. UHM has identified a clear problem with regards to human resources and technical capacity. There is a large amount of technical knowledge held by senior staff members who

are close to retirement, but there are no staff possessing a similar level of technical capabilities, who will be able to replace them, once they are gone. Without a strategy to attract, train, and retain key technical staff, there will not be enough capacity for a sustainable HMCS system.

- **Autonomy**. UHM, which currently sits under the Ministry of Agriculture, is not an autonomous body. This lack of autonomy was noted as a factor limiting its ability to make quick decisions and follow a consistent strategy.

Key Stakeholder Map



Appendix 6. Learning Brief on Hydromet and Climate Services Project: Jamaica

The learning review aims to take stock of the progress made to date on the lessons learned from strengthening HMCS under CIF's PPCR and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews.

This learning brief that focuses on Jamaica forms part of the final learning review.

This learning brief has been informed by interviews with representatives from WB, the Planning Institute of Jamaica, the Meteorological Service of Jamaica (MSJ), and the Water Resources Authority (WRA).

Project Overview

Brief country context

Jamaica, the third-largest island in the Caribbean, has the fourth-largest population with over 2.9 million inhabitants.[58] The island is vulnerable to natural disasters, primarily flooding and hurricanes, but the risks from droughts and sea-level rises are present and increasing.[59] Tourism and agriculture are two of the most important economic sectors in the country, both of which could be threatened by increased physical risks from climate change. Improving weather and climate information services in Jamaica is thus necessary to manage the impacts of climate variability and climate change, particularly for socially and economically vulnerable groups. A large proportion of such groups live in rural upland areas and rely on climate-sensitive small-scale agriculture.

[58] UN, 2019, "World Population Prospects 2019: Jamaica," World Population Prospects - Population Division - United Nations.

[59] World Bank, 2020, "Climate Change Knowledge Portal: Jamaica," https://climateknowledgeportal.worldbank.org/country/jamaica.

The Planning Institute of Jamaica (PIOJ) set out a strategic roadmap for national development in its *Vision 2030 Jamaica* document that includes national outcomes on hazard risk reduction and climate change adaptation.[60] SPCR, which was aligned with the goals of Vision 2030, scoped three investment programmes—the first of which was the Improving Climate Data and Information Management Project (ICDIMP). In addition, PPCR supported investment programmes on mainstreaming climate change adaptation and financing mechanisms for public and private sector adaptation initiatives.

A map of key stakeholders involved in HMCS in Jamaica has been included at the end of this learning brief.

PPCR project overview

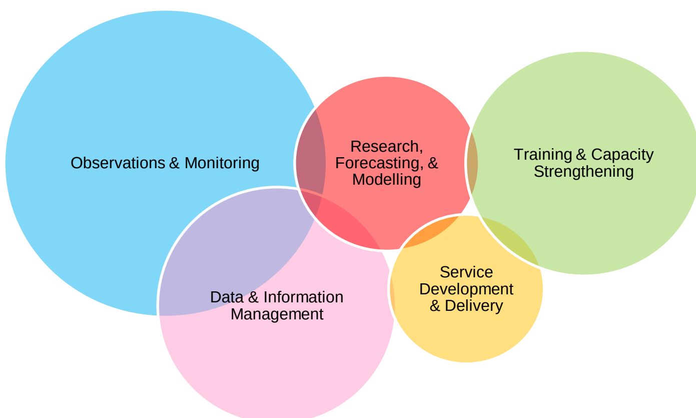
Name of project	Improving climate data and information management project (ICDIMP)
Implementing multilateral development bank (MDB)	International Bank for Reconstruction and Development (IBRD)
Approval date	July 2015
Closing date	April 2022
PPCR financing	USD6.8 million (grant)
Objective	**To improve the quality and use of climate-related data and information for effective planning and action at local and national levels.**
Project components	1) Upgrade hydro-meteorological data collection, processing, and forecasting systems; 2) Improve climate-resilient planning and hydro-meteorological information services; and 3) Support climate change education and awareness for behaviour change.

Relevance for HMCS Value Chain

[60] PIOJ, 2009, *Vision 2030*, Vision 2030 Jamaica - National Development Plan - The Planning Institute of Jamaica (pioj.gov.jm)

Although the whole value chain was addressed in the project, observations and monitoring, as well as data and information management, were the strongest[61] elements. These elements were supported by the successful **capacity building and training** of MSJ and the Water Resource Authority (WRA) staff, along with more than 100 rain gauge partners collecting data in the field. Research, forecasting, and improved services were also part of the project, but they had a lower priority during implementation.

The focus placed on each aspect of the HMCS value chain is indicated by the size of the circle in the diagram below.



Stage of value chain	Project activities
1. Observation and monitoring	• One of the main focus points of the project, this area exceeded its objectives for the number of meteorological, hydromet, and agro-met stations reporting data in real time.
2. Data and information management	• This stage was also a key focus, with improvements made to data handling and processing.
3. Research, forecasting and modelling	• This stage was a lower priority during implementation, but progress has been made, including the development of high-resolution national and sectoral climate change scenarios.

[61] Based on feedback from four interviews

Stage of value chain	Project activities
4. **Service development and delivery**	• Improvements have been made to the quality of weather forecasts.
5. **Training and capacity strengthening**	• The project included a major education and awareness campaign, "Smart and Steady, Get Climate Ready", which made this component more significant in this project's design than those of other PPCR HMCS projects. The campaign included the provision of more information on climate change and wider capacity building that benefitted communities using weather and climate services.

Key Findings

Main project successes

The Jamaica ICDIMP has been a successful project, exceeding several objectives related to the modernisation of the observation and monitoring networks. In fact, it was granted an extension by WB to procure more equipment by utilising cost savings throughout the project. It has benefitted from strong governance, professional project management, and effective procurement. The main project successes are presented below:

- **Good collaboration** between government departments, including suppliers and users of weather and climate information,[62] starting in the design phase of the project, was reflected in project governance through a **multistakeholder project steering group** and the creation of a **Hydromet Working Group.**[63] User feedback on services provided has been captured through a web map on WRA's webpage and through social media such as Facebook/Instagram/Twitter.

[62] As well as the implementing agencies of the Jamaica Met Service and WRA, others involved in these groups included WRMA, the Climate Change Division, the Ministry of Agriculture and Fisheries, the Ministry of Health and Wellness, groups representing vulnerable stakeholders/groups from the NGO sector, academia, and communication specialists.

[63] The working group has been able to coordinate activities across the agencies to prevent the duplication of activities, improve data sharing, maximise the government's resources to benefit each entity, and improve the entities' awareness of the information available to them from WRA (and the Meteorological Office when it is able to share their data freely online).

- **Upgraded observations and monitoring networks**, exceeding the project objectives for installing AWS and hydrological stations (rainfall, soil moisture, and streamflow) with real-time reporting of data. The networks include some design innovations to protect solar panels from theft and vandalism.
- **Professional management and procurement** enabled the project to proceed quickly, with some direct procurement of equipment based on well-researched and developed specifications to allow for integration with the existing networks.
- **Improved data handling and processing**, including progress on data sharing, has allowed WRA to provide hydrological reports and updates much more quickly than before the project.
- The **publication of national climate change scenarios in 2015**, coupled with education and awareness campaigns, has raised the awareness of weather hazards and climate change risks, as well as provided products that can be used by sectors for adaptation decision-making.

Challenges

While the project has been a success, it has faced a number of challenges—some common to other HMCS projects and others that are specific to the island context. Some of these challenges are presented below:

- **Delays in procurement**. Despite a generally successful procurement, delays were experienced with complex and failed procurements of very specialist items (for example, radar), uncertainties around import taxes, and problems with COVID, as some equipment was sourced from China at the beginning of the pandemic.
- **Staff retention and succession planning.** In common with other NMHS around the world, staff retention has been difficult, particularly for highly skilled staff with digital expertise; the proximity of Jamaica to more attractive professional job markets in the US, Canada, and even Europe means that it is difficult to retain bright young staff. In addition, in smaller NMHS, significant expertise held by a small number of individuals can easily be lost without succession planning.
- **Reaching the most vulnerable groups.** Ensuring that weather forecasting services reach the most vulnerable groups has been challenging; further work is still needed to meet the project objective—'targeted vulnerable groups having access to early warning messaging'.

Lessons Learned

A number of lessons have been learned in relation to the design and implementation of a large hydromet project, particularly in a Caribbean island context. These are relevant for future Jamaican projects, other projects in the region, and other island states seeking investments in HMCS.

- **Cocreated project design supported by preparation grants.** The well-developed design of the project, both as part of SPCR and involving a number of government departments, benefitted the project at its implementation stage. The project started with a clear view of the roles and responsibilities of two implementing agencies and provided opportunities for input from users through several groups.
- **Effective procurement approaches.** The alignment of national and MDB procurement processes, along with the overall burden of large volumes of procurement, was challenging with many hydromet projects. The earlier procurement of 'big-ticket items', such as radar, would have been highly beneficial; however, for this to be successful, technical assistance is required for the early development of high-quality technical specifications. Single-source procurement was possible on this project, and when this can be justified, it saves a significant amount of time.
- **Management of major infrastructure projects.** Hydromet projects are providing critical national infrastructure that is needed to reduce the loss of life and economic damage. The same high-quality management of these projects is required as other national infrastructure projects. Therefore, recruiting skilled management and procurement staff and adequately resourcing Project Management Units (PMUs) is important, as well as providing access to regional or international experts in meteorology and hydrology.
- **Refinement of AWS design for the local context.** One of the key issues was the theft of items, such as solar panels, from the stations. WRA that has designed a new robust AWS station box has shared the design with PIOJ and CIMH. Since this new design was adopted, there has been no equipment lost.
- **Increased emphasis on improvement in user services required,** as well as data supply and management, to ensure improved delivery across the entire HMCS value chain. Future projects are likely to place a greater focus on user requirements and service delivery to ensure that the benefits of improved observations and forecasting are realised in all economic sectors.

Key Recommendations

HMCS priorities

Stage of value chain	Priorities for future projects
1. Observation and monitoring	• **Filling the gaps in automatic recording and specialist observations.** Following on from the project, there are still several ungauged stations and some that do not use real-time data. In addition, there is a demand for improved groundwater monitoring, including a desire to install automatic systems in some karstic limestone areas, as well as intensity rain gauges in areas where there is no surface water.
2. Service development and delivery	• The main focus of the future work is likely to be focused on improving service delivery, including research, forecasting, and better data management, for example, through service delivery platforms. • **Improving community DRM plans.** The project has not yet achieved its target for providing vulnerable groups with access to EWS. However, it has begun a programme of activities to address this area, including the upscaling of community DRM plans across Jamaica and starting a project to develop improved early warning messaging systems.
3. Training and capacity strengthening	• **Improving regional collaboration.** CIMH plays an important role as a WMO Regional Climate Centre (RCC) and the project maintains good links with CIMH. However, there is still limited collaboration between the individual islands, unless a regional workshop is organised. Regional cooperation is likely to be supported by the Jamaican government, and it would be beneficial for the region to share knowledge and learn from the respective islands' experiences.

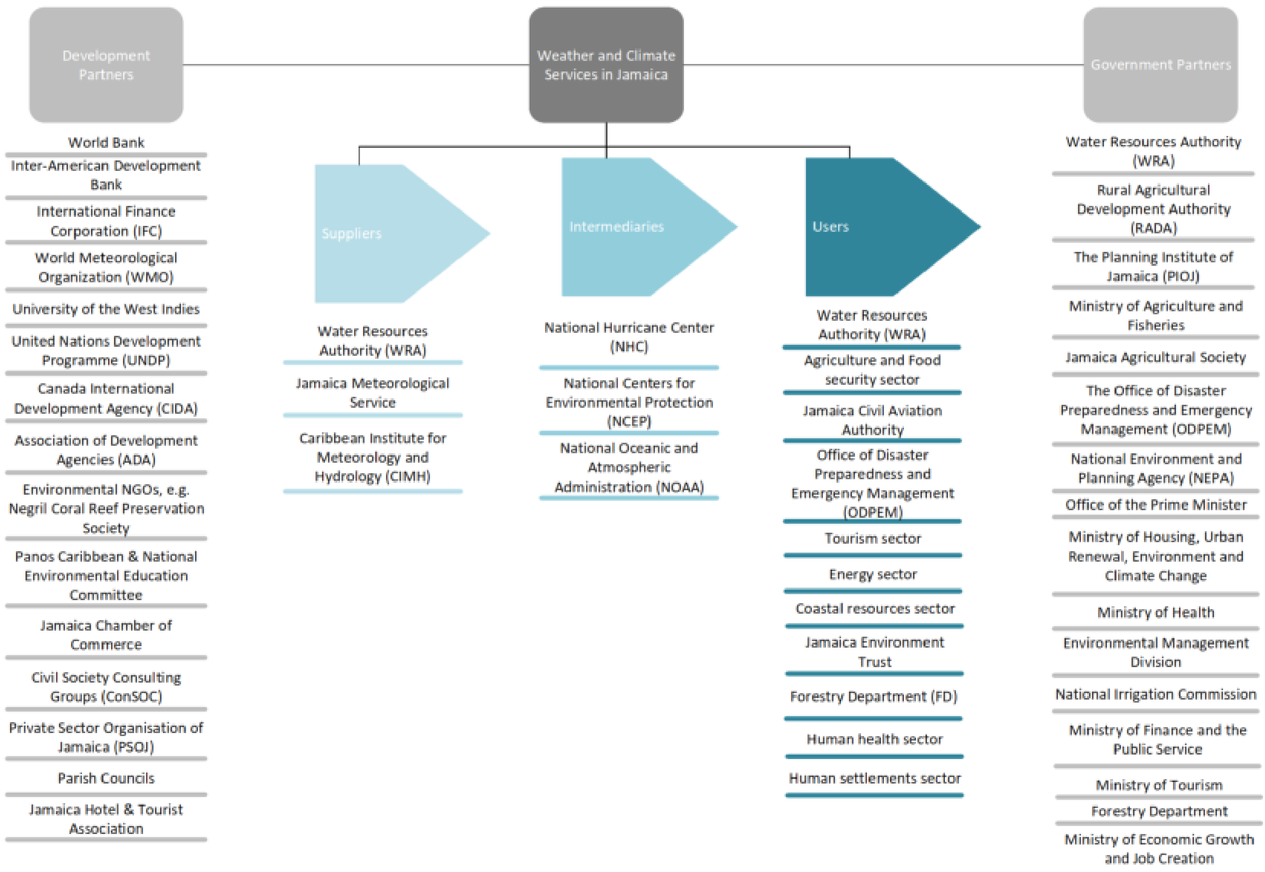
Achieving sustainable HMCS

The weather and climate services sector in Jamaica remains underfunded, and there is the feeling that they are remembered only when droughts or floods impact the island, or when there are more general water distribution problems. The Meteorological Office is the main HMCS in the country, but it does not make all information freely available, whereas WRA acts as a regulatory body and provides free access to its own hydrological data.

Due to the country's high climate vulnerability, **increased funding is important to maintain basic services and develop more advanced services**. There are currently no nongovernment sources of funding available outside of projects, such as PPCR, although there is the possibility of receiving direct research grants, subject to PIOJ and other approvals. The local market for commercial weather and climate services has limited potential, and therefore, government-to-government (G2G) collaboration. Partnerships and making a business case for more government funding may be more successful than selling services into the private sector.

Maintaining sufficient staff headcount, including skilled scientists and engineers, is essential. PIOJ and WRA face difficulties with high staff turnover, which has been a barrier throughout the project, as it has slowed progress. WRA has difficulties maintaining staff because of competition with higher salaries elsewhere. High rates of staff turnover could be managed by maintaining a larger group of officers and also including the development of a larger community of practice and the engagement of staff in other divisions and government departments to work on improving HMCS.

Key Stakeholder Map



Appendix 7. Learning Brief on Hydromet and Climate Services Project: Mozambique

The learning review aims to take stock of the progress made to date on the lessons learned from strengthening HMCS under CIF's PPCR and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews. This learning brief that focuses on Mozambique forms part of the final learning review. It has been informed by interviews with representatives from WB and the Salomon Environmental Consultancy.

Project Overview

Brief country context

Mozambique is vulnerable to climate change and needs to be able to supply reliable and timely climate information to industries, service providers, and local communities in order to maintain livelihoods and support economic development. This requires improved institutional coordination and data sharing for forecasting and early warning; strengthened technical capacity for monitoring, modelling, and forecasting; the improved functioning of hydromet monitoring stations; and strengthened financial sustainability.

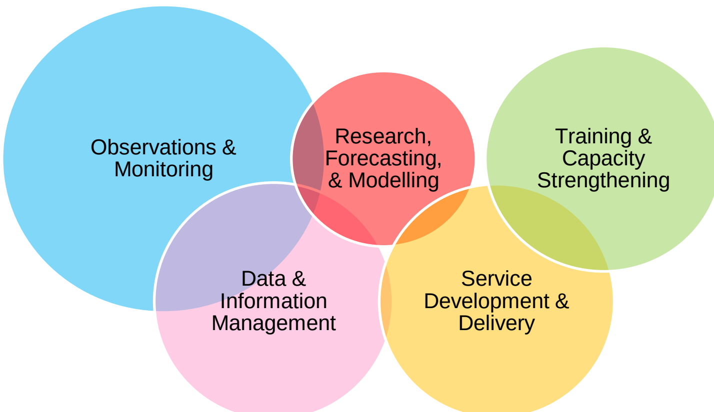
A map of key stakeholders involved in HMCS in Mozambique is included at the end of this learning brief.

PPCR project overview

Name of project	Climate resilience: transforming hydro-meteorological services
Implementing multilateral development bank (MDB)	International Bank for Reconstruction and Development (IBRD)
MDB approval date	April 2013
Closing date	December 2019
PPCR financing	USD15 million (grant)
Objectives	**Piloting climate services to specific, targeted communities**, for example, • subsistence farmers to **support decision-making**, for example, on irrigation and harvesting; • aquaculture & fisheries sectors, which need **timely weather forecasts to avoid working in storms**; and • transport, specifically improving the **safety for the aviation industry**, which needs data at a specific resolution.
Project components	1) Strengthening hydrological information management; 2) Strengthening weather and climate information management, including strengthening monitoring networks; improving quality control and standards enforcement; improving data management, modelling, forecasting, early warning systems, and ICT; 3) Piloting resilience through the delivery of improved weather & water information, including the creation of pilot interventions to enable end-to-end delivery of hydro-meteorological information.

Relevance for the HMCS Value Chain

The project worked on all parts of the HMCS value chain. The focus placed on each aspect of the HMCS value chain is indicated by the size of the circle in the diagram below.



Stage of value chain	Project activities
1. Observations and monitoring	• Expansion of weather and hydro monitoring equipment
2. Data and information management	• Real-time transmission, the development of National Integrated Water Resources Management Information System (NIWRMIS), along with open-source and cloud-based services for data storage
3. Research, forecasting, and modelling	• For example, the expansion of the hydromet modelling and prediction capacity, as well as improved weather forecasting
4. Service development and delivery	• For example, the piloting of tailored hydromet services for local farmers, along with fisher and transport communities
5. Training and capacity strengthening	• For example, technical skills and capacity strengthening of staff in equipment installation, forecasting, and development of tailored products

Key Findings

Main project successes

- Coordination of data systems across the National Institute of Meteorology (INAM) and the National Directorate of Water Resources Management (DNGRH) and organisational support for new systems to ensure sustainability;
- Capacity strengthening of INAM and DNGRH staff across the HMCS chain: for example, in equipment installation and monitoring, the management of data integration tools/platforms, along with modelling, forecasting, and the dissemination of targeted products; as well as
- Good stakeholder involvement in project planning: for example, beneficiaries in selected pilot communities and local authorities were involved from the beginning, which enabled the easy transfer of monitoring responsibilities to the five Regional Water Authorities (ARAs) and district governments when the project was finished.

Specific outcomes highlighted (Vaughan, 2020):[64]

- **Increased safety of maritime navigation**, thus enhancing economic opportunities in the coastal areas of Mozambique
- **Air traffic control and airlines** now using real-time meteorological information for flight plans that are compliant with international safety-airspace navigation standards
- **Local communities, farmers, and fishers** in the pilot areas now having access to improved, reliable, and timely hydromet information for decision-making
- **Weather prediction modelling** linked to the project used by INAM to develop the response actions to Cyclone Idai (2019), thus reducing potential social and economic impacts

[64] Catherine Vaughan, 2020, "Pathways for Transforming Weather, Water, and Climate Services in Mozambique," unpublished draft report, based on an evaluation for World Bank.

Factors that supported project successes

Cross-agency coordination has been helped by the following factors:

- The development of protocols, for example, the Memorandum of Understanding (MoU) and decrees for inter-agency data sharing;
- Clear quality standards and monitoring guidelines; and
- The formal designation of INAM as the oversight agency charged with ensuring the monitoring of quality standards.

Challenges

- **Lack of procurement and fiduciary capacity in key organisations:** DNGRH managed the procurement processes on behalf of both delivery organisations. INAM was thus dependent on DNGRH for procurement, which contributed to significant delays in implementation, particularly during the severe flooding in the Limpopo Basin when DNGRH's priorities shifted to recovery activities.
- **Changes in key management positions (in WB and INAM) added to modest implementation at times:** This included a restructuring of DNGRH, which affected implementation support.
- **Communication with users**: Barriers exist in both the language in which agro-meteorological information is communicated and the mechanisms used to communicate it, resulting in a need to use trusted intermediaries, such as the Red Cross, to communicate forecast information to local populations.

Lessons Learned

Specific innovations

- The MOU between INAM and DNGRH for data sharing, which was critical to project success, could be extended to adopt the WMO Integrated Global Observing System (WIGOS) standards to further increase efficiency and effectiveness.
- Protocols and guidelines following internationally recognised standards, such as ISO-9001-2015, were produced.
- Working with trusted intermediaries, like the Red Cross, to communicate messages to community leaders, so as to explain probabilistic forecasting and build local confidence in the forecasts and early-warning messages, should be encouraged.

Three main lessons

- Separate procurement budgets for INAM and DNGRH: this arrangement would have enabled INAM to recruit qualified staff and strengthened institutional capacity for procurement for the future.
- Skills and capacity strengthening in M&E, such as identifying more specific and measurable indicators and capacity for progress reporting; more consistent mentoring in M&E is still needed for key staff, as well as the consolidation of monitoring frameworks across implementing agencies to enhance M&E effectiveness.
- Linking key organisations: The MOU between INAM and DNGRH contributed to significant improvements in the coordination of activities between the institutions, but challenges remain. Some stakeholders believe that INAM and DNGRH should become one organisation to enable easier sharing of data, along with the management and integration of hydro and met data.

Key Recommendations

HMCS priorities

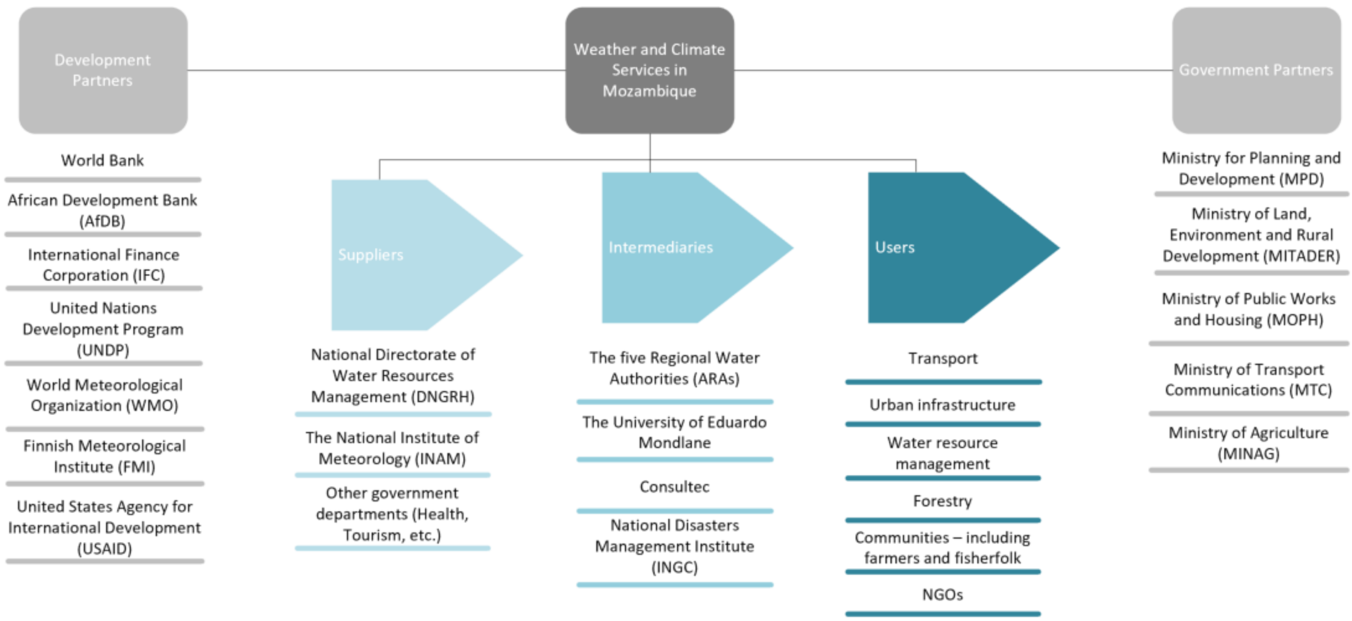
Stage of value chain	Priorities for future projects
1. **Observations and monitoring**	• **Continued need for greater density of observation**, that is, investments in more monitoring stations and instrumentation, as forecasts need to be very localised if they are to build trust in their accuracy and usability for purposes, such as planting and harvesting that have significant implications on livelihoods; • Continued support for capacity strengthening in data collection.
2. **Data and information management**	• **Continued improvement to the effective integration of weather and water data resources**: Despite progress, challenges remain. For example, observation data are collected by both INAM and DNGRH, using different standards and procedures; common standards and procedures would make this more efficient.
3. **Research, forecasting, and modelling**	• **Tailoring and scale of the forecast:** Information is reaching the district, but not tailored to particular users. • **Improving the ways in which HMCS communications are presented** (for example, choice of language, visualisations, and mechanisms used to reach certain communities). As trust in the value of the forecast can be low in some communities, trusted intermediaries, such as extension officers, community radio presenters, or local NGOs, could provide contextualised products in a local language and diverse forms, like visuals, stories, and focused events.
4. **Service development and delivery**	• **Improving design and delivery of services, including reaching out to new sectors**: a number of sectors, such as health and tourism, as well as populations remained underserved by weather, water, and climate services.

Stage of value chain	Priorities for future projects
	• **Providing opportunities for user evaluation and feedback** to support ongoing service improvement and improve trust in and use of HMCS services
5. Training and capacity strengthening	• **Improving national coordination capacity** and continued strengthening of the collaboration between INAM and DNGRH • **Strengthening evaluation capacity**. Developing internal capacity in IMAN and DNGRH by funding staff positions for HMCS evaluations, or by working with external organisations, for example, the WMO Regional Climate Centres for Southern Africa or other boundary organisations (for example the University of Cape Town's Climate Systems Analysis Group) • **Improving staff retention**: Although INAM and DNGRH are continually investing in training, they are not benefitting from increased capacity, as people leave once they are trained. Strategies are needed to improve staff motivation, salaries, career progression, and job security. The provision of good supervision and support in using the equipment needed for the work, such as computers, will also help with staff retention, and ultimately, the ability to plan for succession of staff whilst retaining institutional knowledge and experience. • **Developing closer relationships with communities**. DNGRH is fostering collaborative arrangements (possibly with MOUs), whereby communities hosting weather stations can feel a sense of ownership, understand the services provided, and obtain direct benefits from taking care of the stations.

Achieving sustainable HMCS

- Revenues from information services provided to the aviation sector (about three percent on average) financially support INAM in part, thus allowing it to allocate resources for Observations and Monitoring (O&M).
- Some ARAs and provincial governments have the fiscal capacities to allocate budgets for annual O&M to support the hydrological network, but this is not the case for all. The allocation of an adequate budget to maintain investments at decentralised levels is not done efficiently (Vaughan et al., 2020).
- Local governments, where pilots were implemented further, indicated that budget allocations would be made available for O&M. Securing both O&M and the training for the technical capacity development of staff have been identified in INAM's forthcoming Business Plan, including a clear structure for recovering operational costs or obtaining financial assistance.
- Government subsidies and donor financing may continue to be necessary as a short-term measure to support the financial stability of INAM and ARAs.
- Private sector partnerships are needed to integrate with the public sector infrastructure. For example, a financial model for improved and delivered hydromet services could help reduce financial sustainability gaps.
- INAM and DNGRH have different cost-recovery strategies: INAM charges for its data, while DNGRH has structured its cost recovery around water resources themselves, not the data. As a result, there are different controls on these different data sets; this situation can act as a constraint on HMCS development.

Key Stakeholder Map



Appendix 8. Learning Brief on Hydromet and Climate Services Project: Nepal

The learning review aims to take stock of the progress made to date on the lessons learned from strengthening HMCS under CIF's PPCR and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews.

This learning brief that focuses on Nepal forms part of the final learning review.

It has been informed by interviews with representatives from the Department of Hydrology and WB.

Project Overview

Brief country context

Nepal is a landlocked country with a predominately mountainous topography. It is vulnerable to a number of hazards, including landslides, flooding, and droughts, all of which are projected to increase in frequency and intensity as a result of climate change. Those living in poverty, in remote areas and relying on small-scale subsistence agriculture, are disproportionately vulnerable to climate hazards, as they have limited capacity to adapt to the risks and recover from the damage caused.[65] Due to Nepal's high level of vulnerability, development partners have placed a strong focus on disaster risk reduction and climate change adaptation.[66]

A map of key stakeholders involved in HMCS in Nepal has been included at the end of this learning brief.

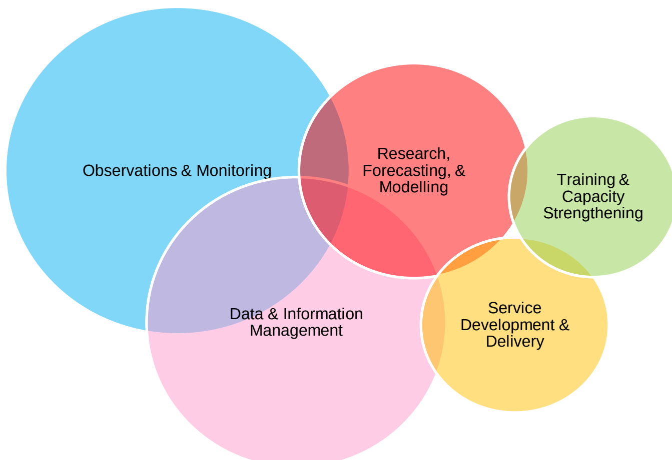
[65] World Bank, 2020, "Climate Change Knowledge Portal," https://climateknowledgeportal.worldbank.org/country/nepal.
[66] Nepal Earthquake Housing Reconstruction Program Multi-Donor Trust Fund, 2015, *Nepal Earthquake 2015. Post-Disaster Needs Assessment Volume A: Key Findings,* nepalhousingreconstruction.org.

PPCR project overview

Name of project	Building resilience to climate-related hazards
Implementing multilateral development bank (MDB)	International Bank for Reconstruction and Development (IBRD)
MDB approval date	January 2013
Closing date	November 2020
PPCR financing	USD31 million (including grant of USD16 million and non-grant of USD15 million)
Objectives	**Increase resilience to climate-related hazards** by: • **improving the accuracy and timeliness of weather and flood forecasts and warnings for vulnerable communities countrywide** and • **develop agricultural information management system services to help farmers mitigate climate-related production risks**. • The project aimed to establish multi-hazard information and EWS, upgrade the existing hydro-meteorological system and agricultural information management system, as well as enhance the capacities of users and suppliers of weather and climate information.
Project components	1) Institutional strengthening, capacity building, and implementation support of the Department of Hydrology and Meteorology (DHM); 2) Modernisation of observation networks and forecasting; 3) Enhancement of the service delivery system of DHM; and 4) Creation of an agriculture management information system (AMIS).

Relevance for the HMCS Value Chain

The focus placed on each aspect of the HMCS value chain is indicated by the size of the circle in the diagram below.



Stage of value chain	Project activities
1. Observations and monitoring	• This stage was a focus during project implementation when improvements were made to the surface hydrological and meteorological observation networks.
2. Data and information management	• Data and information management was the second priority during implementation, and good progress was made with the creation of an **Agriculture Management Information System (AMIS).**
3. Service development and delivery	• There has been increased adoption of AMIS tools by farmers and the associated **Agricultural Advisory Service**, with DHM working in collaboration with the Nepal Agricultural Research Council (NARC).[67,68] • Some activities were not completed due to delays and time restrictions.

[67] A. P. Timilsina, et al., 2019, "A Practice of Agro-met Advisory Service in Nepal," *Journal of Bioscience and Agriculture Research* 21 (2): 1778–85, https://www.journalbinet.com/uploads/2/1/0/0/21005390/217.02.21.19_a_practice_of_agro-met_advisory_service_in_nepal.pdf.

[68] A. Shrestha, and S. Shah, 2018, *Asia Hydromet Services: Pathways for Regional Collaboration* (summary slides), ShresthaAndShah-NEPAL-AgrometAdvisoryServices-002.pdf (worldbank.org).

Stage of value chain	Project activities
4. Training and capacity strengthening	• Time constraints, interruptions due to political changes, along with major earthquakes and floods, meant that some activities related to **capacity building** were only partially completed.

Key Findings

Main project successes

The project was successful in the installation of meteorological equipment and improved management of weather and climate data. This has led to some improvements in the services provided by the Department of Hydrology and Meteorology (DHM), and as a result, there is more confidence from users, both the government and public, in the DHM weather forecasts and other related services. The main successes highlighted by stakeholders include the following components:

- **Upgraded observations and monitoring networks**, including AWS (no. 81), streamflow monitoring stations (no. 62), upper air observations (no. 1), and new radar equipment. Due to the high terrain and weather variability in Nepal, there is still a need for further specialist equipment (for example, additional radar and high altitude AWS).
- **Improved government budgets.** The project has helped to raise the profile of weather and climate services, as well as their social and economic benefits for Nepal. This has contributed to a government commitment to increase DHM budgets to manage the larger observation network, including both capital expenditure and operating budgets.
- **Good collaboration** between DHM and agricultural intermediaries and users in the development of the **Agricultural Advisory Service.** This demonstrates how improvements in observations and forecasting can feed through to sectors to reduce risks and provide timely advice. Over 40,000 farmers and advisors have downloaded the advisory mobile phone app.[69]

[69] Based on the latest World Bank *Implementation Status & Results Report*

The project was extended by one year to November 2020 to allow for the completion of installation and integration of the remaining systems, training and additional resources at DHM, along with further work on the Hydromet Bill.

Challenges

Meeting the project programme of a major hydromet investment with **complex procurement procedures** and through a period of political instability was a significant challenge. The main challenges highlighted by stakeholders are presented below:

- **Project programme:** The monsoon season means that there is a limited window for the installation of equipment, particularly in remote locations. Slow procurement had impacts on installation schedules, and consequently, the project's overall progress. The project was extended by two years, but faced further challenges from major earthquakes and floods, as well as political events, which meant that it was unable to fully meet its objectives. As well as general COVID-19 impacts, travel restrictions meant that training in the operation of some systems was insufficient to enable effective service delivery.
- **Low capacity in ICT:** Moving from manual observations to automatic observations, systems integration, and the management of large data volumes for Numerical Weather Prediction (NWP) placed a tremendous burden on ICT staff. There was a technical barrier related to **a lack of ICT knowledge** at DHM, though consultants were available to provide technical assistance. Together with DHM staff, complex specifications and contract documents were prepared and refined. In the longer term, continued investments in ICT are required to maintain and develop improved services.
- **Availability of technical staff:** During the project, there was **very limited staff availability**, both in terms of the staff (excluding consultants) not being able to solely focus on the project, but also the high turnover of IT personnel and financial officers. The government did supply fixed financial officers when requested, which helped the project to move at a faster rate and solved difficulties surrounding institutional problems and evolving government mandates.

Lessons Learned

The implementing bodies have now gained experience in a major hydromet investment project and learned a number of lessons for future projects:

- **Detailed project planning, monitoring, and reporting are critical to its success.** This involves a clear implementation plan to outline the programme of activities and implications if the project deviates from it; clear delegation of responsibilities for each person, focal team, and government staff; as well as institutional clarity surrounding laws and mandates so that it is clear which procurement rules and regulations should be followed. In the case of this project, there were rules and regulations provided by both the government and WB, hence causing confusion about which set of rules and regulations should be adhered to.
- **Cocreation and close collaboration** between implementing agencies and other government partners delivers improved and more sustainable services. For example, the government has taken full ownership of the Agricultural Advisory Bulletin over the last two years (out of a total 4.5 years). This means that it has been producing the bulletin from its own budget, not that of the project.
- **Modernisation is a long-term project** (>10 years). A longer time period for similar projects in the future would enable sufficient implementation time and provision for trial periods to enable new systems to be tested and learning to take place before full implementation. With a squeezed programme, some new systems were delivered with very little training and handover, which made them more difficult to use. In addition, contingency plans and a more flexible approach are needed to deal with project disruptions that exert an impact on the programme (for example, natural hazards and political instability).

Key Recommendations

HMCS priorities

Stage of value chain	Priorities for future projects
1. **Observations and monitoring**	• Stakeholders from the supplier community still noted some remaining gaps in the observation and monitoring network. They advised that these gaps could be filled with targeted capital expenditure, for example, for additional radar stations. A few of the remote AWS installed have issues transmitting data. Some stations were not installed in high-altitude areas as was intended; so stations will need to be added in the future in order to provide a network that meets DHM's vision of a modern observation network.
2. **Service development and delivery**	• The main priority of future projects is the development and improvement of weather and climate services across several sectors. DHM recognises that its top priority is that the PPCR investment delivers its full potential to improve weather and climate services. This project made some good progress in the agricultural sector and future work should involve similar integration and service development in other sectors, including energy, aviation, or the specialist services that are part of disaster management, such as for mountaineering. These improved services will require coproduction with stakeholders to fully understand their requirements, develop suitable products, as well as improve the quality of both general weather forecasting services (accuracy, timeliness, and resolution) and specialist services providing actionable information for decision-makers.
3. **Training and capacity strengthening**	• Nepal needs to **develop institutional arrangements and partnerships to promote data and information sharing**, because this is regarded as key to the development of improved services. Although a Hydromet Bill has been prepared, it has been pending for the past three years. DHM is keen to have

Stage of value chain	Priorities for future projects
	access to all observations collected in Nepal[70] and participate in WMO global and regional initiatives for the sharing of data across the region. Regional cooperation is particularly useful for collecting data regarding glacial lakes in the northern Tibet area and transboundary water resources management in Tibet, Nepal, India, Bangladesh, and China. The installation of **EWS** was piloted in two river basins and the government of Nepal is keen to extend flood and landslide EWS.

Achieving sustainable HMCS

The **long-term sustainability of hydromet services is still a key concern**, for example, the availability of operational funding to maintain a modern observation network and skilled staff to contribute to improved weather and climate services in multiple sectors.

The Central Government is the main source of funding for weather and climate services in Nepal. Therefore, a **first step** towards sustainability is securing adequate government funds for providing a PWS and partnerships or funding for additional services in collaboration with other government departments. The project has already resulted in an increased budget from the Ministry of Finance for maintaining the equipment, as well as upgrading ICT and for other operational expenditure. The agricultural advisory service has been involved in a partnership with NARC, which proved successful, thereby attracting government funding. A similar model may work in other sectors with some pump-priming investments in a pilot service, followed by a commitment to extend and maintain the service.

The **second step** is to understand the demand for more commercial services. Suppliers believe that there is some potential in Nepal for the private sector to pay for good-quality services, for example, in the

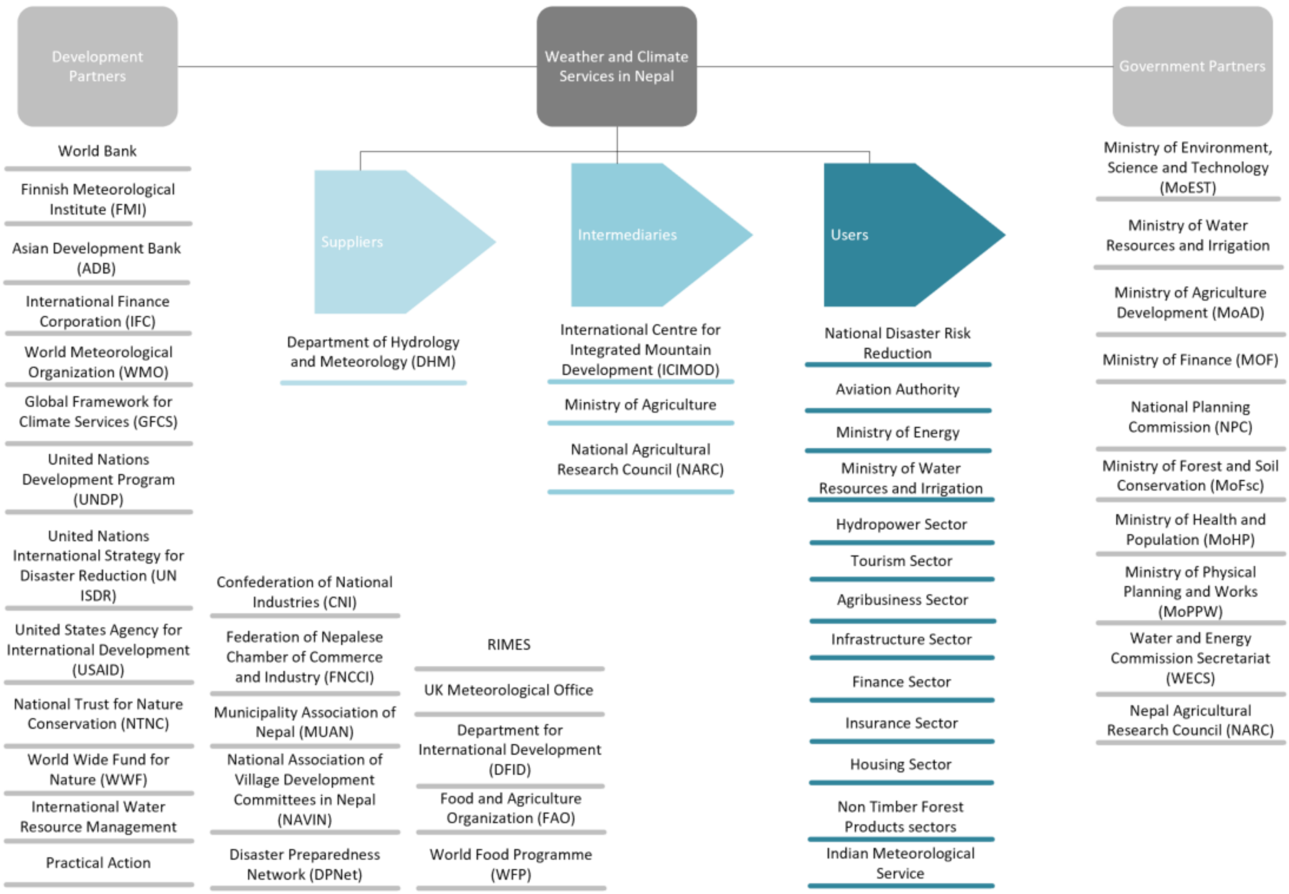
[70] Some suppliers expressed concern that the NGO, the International Centre for Integrated Mountain Development (ICIMOD), collects its own data from hydromet stations, but it is not legally required to share these data with the DHM, and therefore, its data do not contribute to the development of an improved national PWS.

mountaineering sector, energy sector (electricity power companies), and aviation. The further development of pilot services is needed to test such commercial arrangements.

A **third step** is to consider other sources of funding or partnership; for example, collaboration with the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES)[71] may be sought, which could strengthen ICT services, as well as improve systems integration and service delivery platforms. Gaining an agreement to share data with NGOs that operate their own observation networks, such as the International Centre for Integrated Mountain Development (ICIMOD), may save the duplication and costs of installing additional stations.

[71] RIMES, 2021, "rimes | Regional Integrated Multi-Hazard Early Warning System for Africa and Asia."

Key Stakeholder Map



Appendix 9. Learning Brief on Hydromet and Climate Services Project: Niger

The learning review aims to take stock of the progress made to date on the lessons learned from strengthening HMCS under CIF's PPCR and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews.

This learning brief that focuses on Niger forms part of the final learning review.

This learning brief has been informed by interviews with the representatives of Projet de Développement de l'Information Climatiques and WB staff involved in the project.

Project Overview

Brief country context

A land-locked Sahelian country with a hot and arid climate, Niger frequently experiences major drought episodes. As the north of the country is dominated by deserts, the majority of the 16 million population lives in the south, where climatic conditions are more favourable. Niger ranks 189/189 on the UNDP Human Development Index, with climate change posing a major risk to attempts to reduce poverty and create sustainable growth. The Agriculture, Livestock, and Water Resources sectors were identified as priorities for adaptation and resilience in Niger's Nationally Determined Contribution.

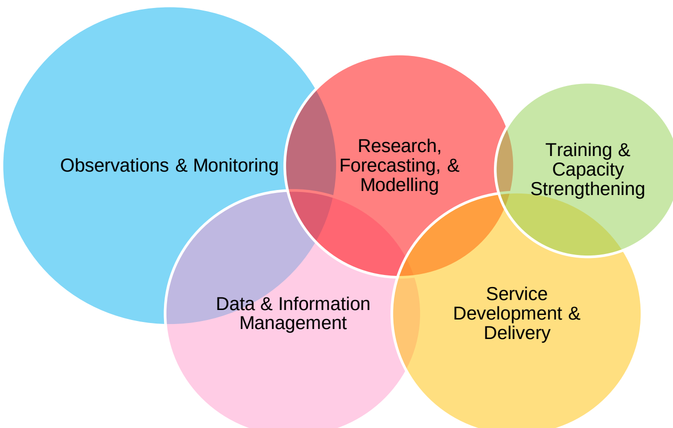
A map of key stakeholders involved in HMCS in Niger has been included at the end of this learning brief.

PPCR project overview

Name of project	Climate Information Development and Forecasting Project (PDIPC)
Implementing multilateral development bank (MDB)	African Development Bank (AfDB)
MDB approval date	September 2012
Closing date	December 2019
PPCR financing	USD13 million (including grant of USD3.5 million grant and non-grant of USD9.5 million)
Objectives	The Climate Information Development and Forecasting Project in Niger (PDIPC) is one of four projects arising from Niger's SPCR. It was designed to strengthen climate data and modelling capabilities as well as increase access to information on climate impacts in Niger. PDIPC was structured to work very closely with another project generated by SPCR—PROMOVARE (Water Resources Mobilization and Development Project), with the climate data and model outputs generated in PDIPC used to enhance the resilience of agricultural communities in the PROMOVARE project.
Project components	At the approval stage, the project's main objectives were: 1) Developing and disseminating climate scenarios and products to end-users; 2) Building capacity for mainstreaming climate products in development actions; 3) Preparing a vulnerability map of agro-pastoral activities in Niger's district councils; and 4) Scaling up the EWS to make it multihazard.

Relevance for the HMCS Value Chain

The focus of the project was on strengthening climate projection and modelling capabilities. Activities to improve the observation and monitoring network, along with data and information management systems, supported modelling for both developing regional climate scenarios for Niger, as well as a series of weather and climate services advisories or early warning bulletins. The focus placed on each aspect of the HMCS value chain is indicated by the size of the circle in the diagram below.



Stage of value chain	Project activities
1. Observations and monitoring	• Procurement and installation of 34 synoptic weather stations, 39 agro-meteorological weather stations, and 1,658 rain gauges to significantly improve existing observations
2. Data and information management	• New data centre created, with information from the observation network automatically fed in
3. Research, forecasting, and modelling	• Regional climate model developed for Niger and regional climate projections now available; EWS developed for four main climate risks: droughts, extreme heat, floods, and sandstorms
4. Service development and delivery	• National vulnerability atlas and climate risks platform developed; project data served as inputs for service development on other projects, with 64 communities benefitting from warnings and alerts

Stage of value chain	Project activities
5. Training and capacity strengthening	• Training of extension officers undertaken to assist in the dissemination of products created under the project

Key Findings

Main project successes

- The project has led to a **significant increase in the number of farmers and communities being able to access agro-climatic information**, with the target of 150,000 farmers met. A multihazard EWS now provides alerts for four main climate risks: droughts, extreme heat, floods, and sandstorms.
- **The strong relationship between PDIPC and PROMOVARE** was highlighted as a major success. It was instrumental in allowing the data and information produced through the PDIPC project to have a practical impact and increase the resilience of communities in the PROMOVARE project area. Both projects shared the same coordinator, thus allowing for strong collaboration between the two programmes.
- **Procurement** was highlighted as a successful process in this project. The role of AfDB was noted as having been critical in helping the project to navigate international procurement processes in a relatively smooth manner, which minimised delays with equipment and installation.
- The development of regional climate scenarios for Niger through the **project significantly improved the understanding of climate risks and vulnerabilities**, which supported the creation of the national climate risk platform and vulnerability atlas.

Challenges

- There was **very limited information available** at the start of the project, in terms of baseline data and studies, to support project activities. As a result, a large number of diagnostic studies had to be carried out in order to inform project activities, which caused significant delays to the project. An example highlighted was that there was no baseline information available to guide the siting of the 1,600+ rain gauges to be installed; so this had to be done from scratch.

- **Institutional challenges** caused major delays to the early part of the project, in particular in relation to inter-ministerial coordination and the processes for approvals and signatures.
- **The large number of different processes and procedures** that needed to be followed in relation to both the approval and reporting of project activities was highlighted as a challenge, and one that imposed additional burdens on the project. **A more streamlined or consistent approach** between the requirements of different parties involved would have simplified the process.
- The difficulty in **finding and retaining staff** with the requisite level of capacity was seen as a major challenge to the successful running of the project.

Lessons Learned

Stakeholders highlighted a series of lessons that can be taken from the experience of the PDIPC project. The key lessons are presented here:

- **Coordination between complementary projects.** The relationship and synergies between the work in PDIPC and the activities in PROMOVARE were emphasised as an important lesson to take away. In particular, having projects with a separate but complementary focus, managed by a single coordinator, was seen as having enabled greater impact across the two projects than if they had been run as separate projects.
- **Longer-term engagement.** Stakeholders noted that in countries like Niger, where the conditions for the HMCS project are challenging and initial capacity is low, there would be significant value in a longer-term approach to engagement and programming. Opportunities can be lost in the absence of longer-term engagement. It is difficult to maintain the structures needed and the technical capacity that was built. Staff will then move on and institutional memory will be lost. This was a clearly expressed frustration among the stakeholders interviewed.
- **Basic logistics are important**: Simple measures could improve the overall impact. For example, ensuring consistent internet or back-up internet is critical so that real-time data from the newly installed automatic weather stations is always available. Basic logistical issues can undermine the impact of the project as a whole.

Key Recommendations

HMCS priorities

Stakeholders highlighted several areas as priorities for investment in the HMCS system:

Stage of value chain	Priorities for future projects
1. Observations and monitoring	• **Further improvements to the station network**. Although good progress was made through the project on improving the number of weather stations and rain gauges, the density of observations remains well below WMO's recommendations, and there is a particular need to increase station coverage in more remote areas.
2. Research, forecasting, and modelling	• **Improved hydrological data.** In order to increase the understanding of key hydrological risks in the country, stakeholders noted the need for better monitoring, modelling for key catchments, along with research, to improve the understanding of catchments as a holistic system.
3. Service development and delivery	• **Scaling up the dissemination of weather and climate information**. Stakeholders noted that there is now a large amount of information being generated that could be of use to many more people than those currently receive this information. In particular, it was suggested that the community radio model, highlighted as being successful in the project, could be expanded and scaled up.

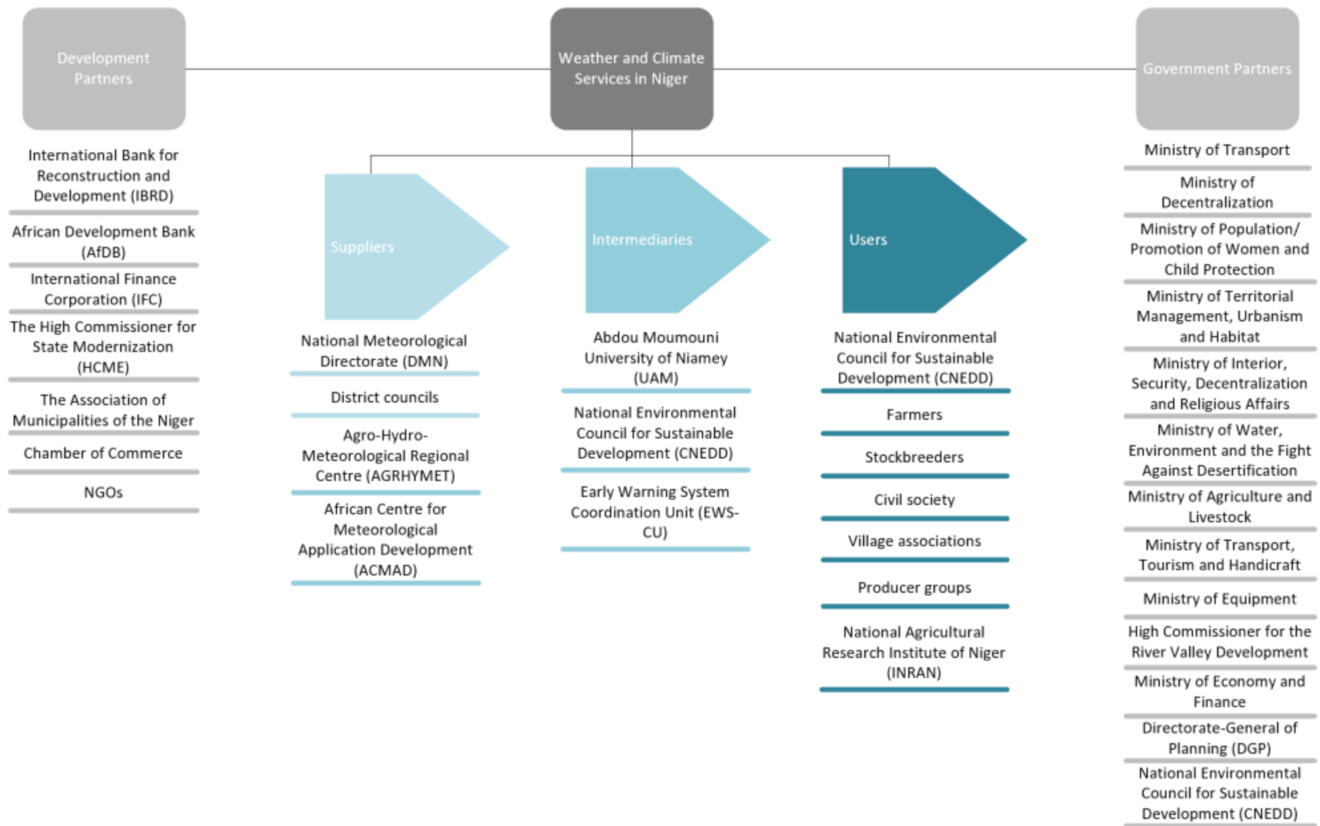
Achieving sustainable HMCS

Despite advances under the project, there are major challenges to the development of a sustainable HMCS system in Niger:

- **Consistent sources of funding.** There is a need for a long-term strategy on financing HMCS and creating consistent streams of funding and revenue that can be used to develop and scale-up effective climate services. Stakeholders were not clear about how to find revenue that would allow them to build on the achievements made in the project; as a result, there is a risk to the sustainability of improvements that have been made to the HMCS system.

- **Technical capacity**. High staff turnover was a significant challenge for the project and the issue of ensuring that capacity can be built and maintained over the longer term is an important one. Without a strategy to attract, train, and retain key technical staff, there will not be enough capacity for a sustainable HMCS system.
- **Maintenance**. The logistics of maintaining a functioning meteorological network in Niger are challenging, given the distances involved, the security situation in parts of the country, and harsh environmental conditions in many areas. In addition, the maintenance effort needed to ensure that the large number of gauges installed in the project continue to function will be high. There is a need for more qualified technicians who are capable of providing the maintenance needed, as well as clear budget lines dedicated to maintaining existing stations. In addition, improving the resilience of the network by providing backup internet connections would reduce the amount of down-time for automatic weather stations.
- Initial investments in observations and monitoring lay the foundations for **future demand-driven service development.** It is too soon for commercial climate services to the private sector be a realistic option; however, further investments in modelling could allow the development of useful services for other government departments.

Key Stakeholder Map



Appendix 10. Learning Brief on Hydromet and Climate Services Project: Saint Lucia

The learning review aims to take stock of the progress made to date on the lessons learned from strengthening HMCS under CIF's PPCR and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews.

This learning brief that focuses on Saint Lucia forms part of the final learning review.

This learning brief has been informed by interviews with representatives from WB, the Water Resource Management Agency (past and present employees), and the Hydromet Consultant (Government of Saint Lucia).

Project Overview

Brief country context

The Saint Lucia Meteorological Service (SLMS) classified itself as a 'Category 2' climate service provider offering a basic range of climate services and products along with climate predictions. The Met Service has been delivering climate information for 1–3 years. The organisation tailors one of the seven regional climate products for the national context, namely the 'Caribbean Standardised Precipitation Index (SPI) Outlook'. SLMS uses this to verify the national SPI Outlook. Other climate products available at the national level include the 'National Agrometeorological Bulletin'.[72]

SLMS works closely with the Water Resource Management Agency (WRMA) whose mission is to utilise the most appropriate technology and engage in participatory approaches and strategic partnerships to enhance

[72] CIMH, 2018, *Country Profile: Saint Lucia*, http://rcc.cimh.edu.bb/files/2018/06/Country-Profile-St-Lucia.pdf.

collaborations among public and private sector and civil society interests in promoting the sustainability of water resources[73].

An updated map of the stakeholders involved in the HMCS system can be found at the end of this learning brief.

PPCR project overview

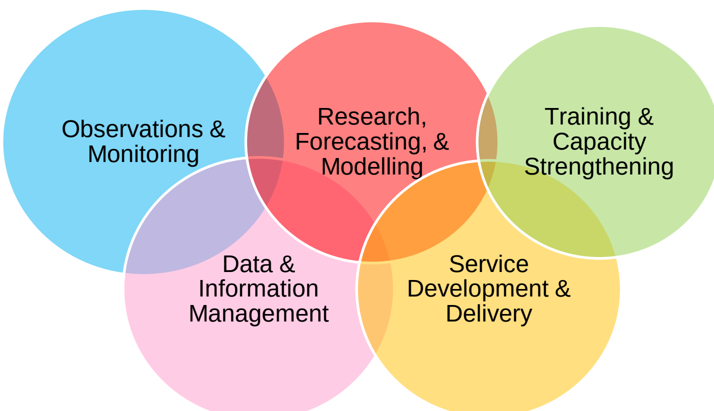
Name of project	Disaster Vulnerability Reduction Project (DVRP)
Implementing multilateral development bank (MDB)	International Bank for Reconstruction and Development (IBRD)
MDB approval date	June 2014
Closing date	December 2021
PPCR financing	USD27 million (including grant of USD12 million and non-grant of USD15 million)
Objectives	**To measurably reduce vulnerability to natural hazards and climate change impacts**. The St Lucia Disaster Vulnerability Reduction Project (DVRP) included a wide range of interventions to build infrastructure resilience and strengthen the institutional understanding of climate-related risks. HMCS activities that formed a relatively small part of the overall scope were predominantly driven by the WRMA.

[73] Government of Saint Lucia, 2021, 'Home Page (govt.lc).'

Project components	1) Risk reduction and adaptation measures; 2) Technical assistance for the improved assessment and application of disaster and climate risk information in decision-making; 3) Climate Adaptation Financing Facility (CAFF); 4) Contingent emergency response; and 5) Project management and implementation support.

Relevance for the HMCS Value Chain

The St Lucia DVRP scope spanned the entire HMCS value chain. The focus placed on each aspect of the HMCS value chain is indicated by the size of the circle in the diagram below.



Stage of value chain	Project activities
1. Observations and monitoring	• While little expansion of the existing network was carried out, significant improvements and maintenance were undertaken to improve reliability and improve automatic data transmission. Twenty-three meteorological or hydrological observational/monitoring stations were made functional, upgraded, or purchased under the Project, and tide gauges were installed for sea-level rise monitoring. A maintenance policy and strategy were developed.
2. Data and information management	The country's GIS analysis capacity to maintain risk and spatial data management system was strengthened through technical assistance,

Stage of value chain	Project activities
	training, and the procurement of equipment, which included the following aspects: ▪ Management of the National GeoNode—an open-source platform for sharing geospatial data and maps; ▪ Close collaboration with the DVRP sub-project, the Integrated Hydromet Platform Project, which improved data architecture and processing; along with ▪ Support of the Open Data Portal—a platform that hosts hydromet data.
3. Research, forecasting, and modelling	• Geonetcast—integration of satellite data for forecasting • Worked closely with the parallel Flash Flood Guidance System (FFGS) project to increase lead time and forecasting capabilities
4. Service development and delivery	• Worked closely with the DVRP's Integrated Hydromet Platform Project that developed a new portal/software platform with tailored products for users
5. Training and capacity strengthening	• Bespoke training on the above elements has been provided, with a detailed training plan developed by a consultant under this project (note that the implementation of this training is beyond the current project's scope)

Key Findings

Main project successes

- **Training was rolled out to more people than expected**: eight technicians received training from CIMH between 2016 and 2021. This was needed to both address staff turnover and enhance the technical capability of the SLMS. Additionally, 10 WRMA officers attended training on Integrated Water Resource Management at McGill University. The total number of 18 technicians who received training surpassed the initially planned two.
- In parallel with the DVRP project, the **Government of St Lucia developed an HMCS roadmap** that was extremely useful in clearly aligning the outcomes and needs to improve national HMCS capacity. While not strictly an achievement within this project scope, several stakeholders referred to it as a significant success.
- **Significant improvements were made to the hydromet network**, despite many delays and challenges.

A key message from stakeholders interviewed was that the personnel involved were pivotal to the project's success:

- **Strong advocate within the lead agency (WRMA)** who championed the project;
- **Flexible and supportive WB team** who facilitated programme extensions and responded positively and efficiently to changes to the terms of reference (ToR), technical specifications, and so on; and
- **Active and engaged flood and drought committee**, comprising stakeholders from national and local organisations and users, who meets once a month.
- The project spanned multiple agencies and government departments with differing capacities and experiences in HMCS. Good cooperation between these parties was essential for smooth project implementation. There is an MoU already in place to enable open data sharing; the terms of the MoU need to be expanded to include new services and equipment before project completion.

Challenges

Institutional/Personnel:

- Significant programme delays/interruptions due to COVID-19: limited/delayed travel of technical experts, including both consultants and LiDAR suppliers, as well as remote workshops with reduced attendees, and thus, engagement;
- Changes in key personnel in counterpart agencies with whom relationships had been established;
- Lack of clarity over the mandates of key ministries/agencies involved in HMCS. Saint Lucia is fortunate to receive a lot of external support, but this is sometimes duplicated, notably in the case of developing an EWS; along with
- Insufficient resources (in terms of numbers and technical capacity) to implement the project as intended

Technical/Procurement:

- Very protracted procurement of the network rehabilitation due to challenges in getting an agreement between the consultant and the Project Coordination Unit (PCU), as well as between the PCU and line agencies.

Lessons Learned

- Support the government to develop a detailed roadmap during project preparation to inform and scope activities. This should start with a focused review of user needs and work backwards through the value chain.
- Ensure that the roadmap is shared with all stakeholders working in the country—including regional organisations and bilateral partners—to avoid duplication.
- The DVRP was designed as a framework project with bucket allocations to tasks, but allowed the definition and detailed allocation to be made during implementation. This approach worked extremely well in Saint Lucia where the HMCS needs became more apparent as the project progressed.
- Embedding the WCIS investment within a larger infrastructure improvement project worked well for this DVRP project. The benefits of the work to the critical infrastructure were more widely

comprehended than stand-alone hydromet projects; thus, it helped the project gain traction and support.

- Procurement processes need to be simplified and/or better supported. The engagement of some services was inefficient due to ToRs being overly complicated and restrictive for consultancy, equipment, and construction. Had direct awards or national procurement been permitted for certain elements, this would have sped up the programme and saved money.

Key Recommendations

HMCS priorities

Future HCMS priorities as raised by stakeholders are shown in the table below.

Stage of value chain	Priorities for future projects
1. Data and information management	• DVRP ToR were directed at the development of specifications for the portal, not its implementation. New specifications have been developed. Data from both SLMS and WRMA are to be collated, stored, processed, and shared through the existing open data portal.
2. Service development and delivery	• Delivering information products to end-users is the next step. Although this is detailed in the road map, there is no clear funding mechanism in place to facilitate it. • The user feedback loop should be integrated into the web portal.
3. Training and capacity strengthening	• Training across all areas is needed, specifically in radar technology, flood forecasting, remote sensing, instrumentation repairs and general network maintenance, IT expertise, literary courses, funding applications, and GIS.

Achieving sustainable HMCS

Regional Collaboration

There are clear advantages to regional HMCS collaboration, especially in the Caribbean Small Island States. Within the Caribbean, there are a number of key organisations supporting regional collaboration in HMCS:

CIMH is a training and research organisation that aims to improve the meteorological and hydrological services and assist in promoting the awareness of the benefits of these services for the economic well-being of the countries. Saint Lucia has a good, established relationship with CIMH and feels well supported by them. WRMA feels that CIMH has been invaluable in developing the hydromet data portal, as well as providing technical support and mentoring. The alignment between the WRMA/SLMS equipment and that provided by CIMH is strongly encouraged: by utilising the same certified supplier (SUTRON), CIMH can provide the agencies with greater support in the training and maintenance of equipment.

CCCCC is a regional entity whose work is focused on SIDS in the Caribbean and the improvement of the region's framework for activities that address climate change.

The mandate for CIMH and CCCCC in supporting Saint Lucia is not clear to all stakeholders; formalising and/or raising awareness of this mandate would be advantageous. By integrating regional services and projects into the national HMCS strategy, collaboration could be further improved. SLMS/WRMA would thus be better able to maximise the benefits and opportunities presented by regional bodies.

It is understood that there are significant differences between the maturity of the relationship between regional organisations and the member states. While the relationships are good with Saint Lucia, they are more strained in other countries and, as a result, the CIF funding of regional projects may have varied impacts across the region.

Funding Arrangements

Securing adequate funding for HMCS from the central government has been a real challenge for the agencies and this is something they are very keen to improve.

WRMA has obtained several grants from overseas governments (for example, Kuwait, Korea, and Japan); however, the funding that is fed into a consolidated fund at the ministry level is often not allocated to HMCS activities as expected.

Suppliers and intermediaries jointly funding HMCS projects is not commonplace at present. However, this has potential when the joint benefit is clear. However, in small Caribbean island states, it is currently thought to be more likely that intermediaries or other suppliers will operate services in partnerships with regional HMCS providers (for example, CIMH), rather than national providers.

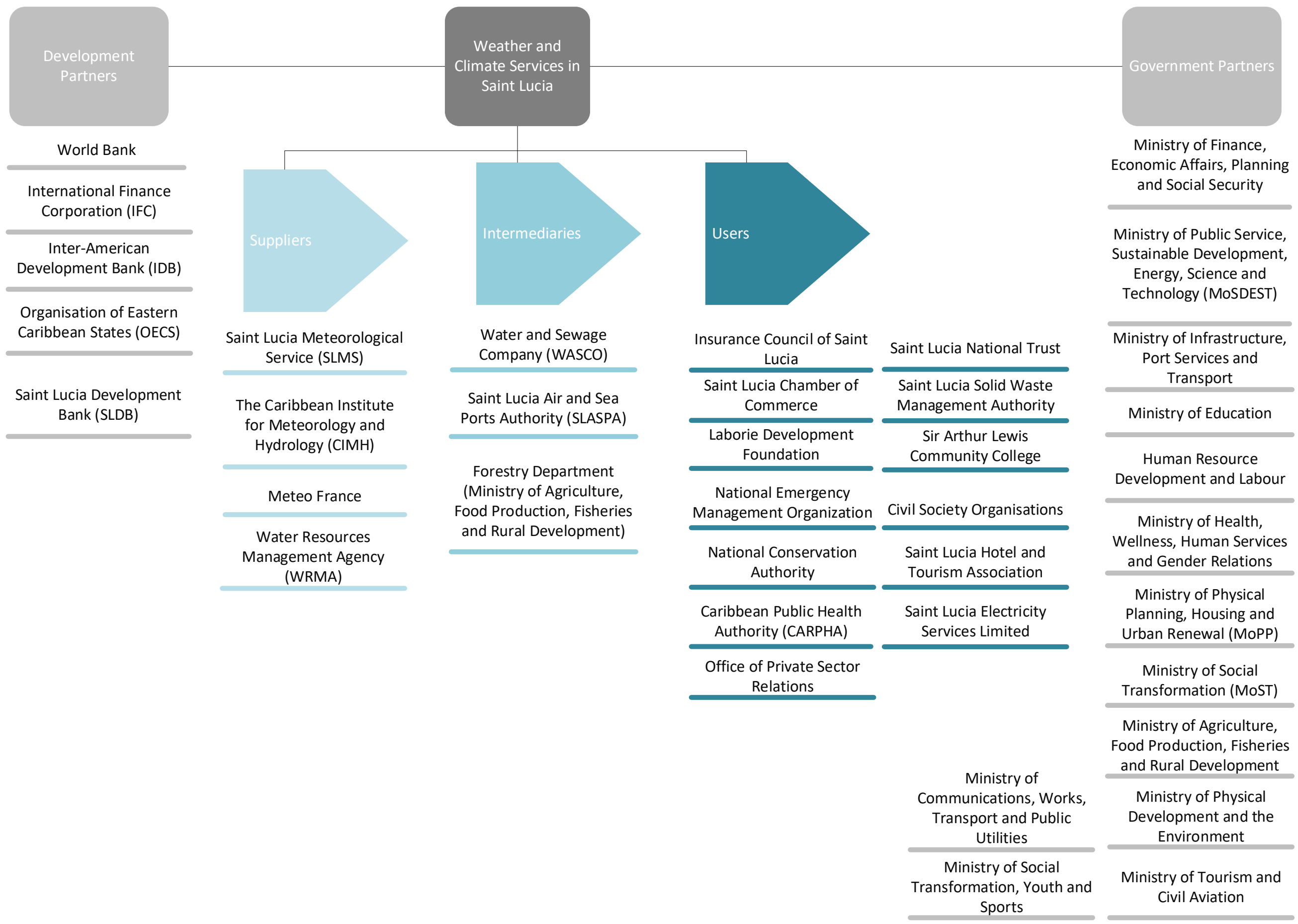
Grants and loans are available to small and mid-sized enterprises as well as households through the Saint Lucia Development Bank for climate resilience activities, for example, stabilising walls, as well as improving drainage and small works.

Commercialising HMCS

WRMA that is able to issue licences for water abstraction can raise funds this way; however, it needs better internal capacity to maximise this potential, including greater monitoring capability to ensure the proper adherence to abstraction licences. It is perceived that there is an interest, for example, from airport fuelling and shipping companies, along with tourism operators, among others, in paying for quality data if it is available for purchase. However, there is a concern that the private sector partners would ultimately gain an unfair profit, working as intermediaries by repackaging and selling data. This has been witnessed regionally in telecoms.

WRMA works very closely with forestry and other agencies across various ministries, in addition to the Caribbean agricultural research institute and some universities. The Water and Sewerage Company (WASCO) is semi-private; it has had limited success in trying to work with bottle water companies due to conflicting priorities.

Key stakeholder map



Appendix 11. Learning Brief on Hydromet and Climate Services Project: St. Vincent and the Grenadines

The learning review aims to take stock of the progress made to date on the lessons learned from strengthening HMCS under CIF's PPCR and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews.

This learning brief that focuses on SVG forms part of the final learning review.

This learning brief has been informed by interviews with representatives from WB, the SVG Meteorological Office, the Ministry of Finance & Economic Planning, and the Independent Hydromet Consultant. It should be noted that due to the eruption of La Soufrière volcano, several stakeholders were unavailable for interviews within the learning review programme timeframes. These include representatives from the National Emergency Management Organisation (NEMO) and the Central Water and Sewerage Authority (CWSA).

Project Overview

Brief country context

As of September 2015, the SVG Meteorological Office (SVGMO) categorised itself as a 'Category 2' climate services provider, offering a basic range of climate services and products along with climate predictions. SVGMO provides the monthly 'Agro-Meteorological Bulletin' on seasonal rainfall, temperature and drought outlooks, a drought and precipitation statement, along with wet and extremely wet spell outlooks.[74] It also operates the weather station located at the E.T. Joshua Airport and monitors rainfall at a minimum of seven locations on the island of Saint Vincent.

[74] CIMH, 2018, *Country Profile: St. Vincent and the Grenadines*, https://rcc.cimh.edu.bb/files/2018/06/Country-Profile-St.-Vincent-and-the-Grenadines.pdf.

An updated map of the stakeholders involved in the HMCS system can be found at the end of this learning brief.

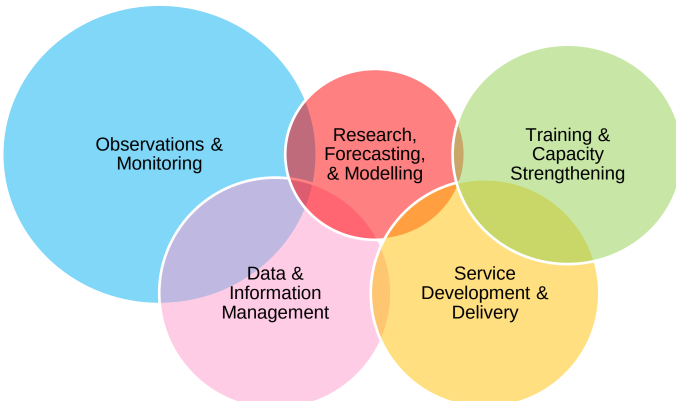
PPCR project overview

Name of project	Disaster Vulnerability Reduction Project (DVRP)
Implementing multilateral development bank (MDB)	International Bank for Reconstruction and Development (IBRD)
Approval date	June 2011
Closing date	January 2022
PPCR financing	USD15 million (including grant of USD12 million and non-grant of USD3 million)
Objectives	**To measurably reduce vulnerability to natural hazards and climate change impacts.** The SVG DVRP included a wide range of interventions to build infrastructure resilience and improve regional platforms for hazard and risk evaluation. HMCS activities that formed a relatively small part of the overall scope were predominantly driven by SVGMO. These activities were front-loaded in the overall programme and largely completed by 2018.[75]
Project components	1) Prevention and adaptation investments; 2) Regional platform for hazard and risk evaluation, along with applications for improved decision-making and building practices; 3) Emergency recovery and rehabilitation mechanism; along with 4) Project management and implementation support.

[75] World Bank, 2020, *Restructuring Paper on a Proposed Project Restructuring of DVRP SVG*.

Relevance for the HMCS Value Chain

The focus placed on each aspect of the HMCS value chain is indicated by the size of the circle in the diagram below.



Stage of value chain	Project activities
1. Observations and monitoring	• A new manual weather station was installed at the Argyle International Airport when it opened in 2017. • A hydromet network that had recently been extended under an EU-funded project has been providing a robust network with good coverage. The main focus of this DVRP project was the operation and maintenance of the existing network, obtaining new power supplies, fixing broken gauges, and so on.
2. Data and information management	• To improve data management and sharing capacity in the Eastern Caribbean, capacity building in the use of open-source software for geospatial information (GeoNode) was provided.
3. Research, forecasting, and modelling	• The majority of research forecasting is done by CIMH at the regional level. Though DVRP's scope was very limited in this area, it tried to collate/establish data in order to calculate return periods and improve local forecasts, by using historical rainfall data for bias correction.

Stage of value chain	Project activities
4. Service development and delivery	• Monthly climate bulletins are issued by SVGMO. DVRP conducted workshops to tailor them to the users' needs. Hurricane and shipping forecasts for the region are supplied by the National Oceanic and Atmospheric Administration (NOAA).
5. Training and capacity strengthening	• The project included significant training, as requested by the SVGMO staff, on forecasting, climatology, and instrument maintenance. A number of officers were trained by CIMH on topics, such as the new regional GeoNode platform and the regional probabilistic risk assessment platform, for extended periods.

Key Findings

Main project successes

What have the major achievements been?

The hydromet activities, which were very detailed and focused from the inception of the project, all met their objectives.

A significant training programme for SVGMO and the CWSA staff was provided.

The objective for incorporating user feedback systems into activities was met/exceeded.

Which factors were highlighted as pivotal to or supportive of these successes?

- **User/wider stakeholder engagement was a very strong enabler** in this project. SVGMO has a very good relationship with CIMH; they have a shared vision, along with excellent personal relationships and collaboration.
- Extremely **strong engagement, mandates, and data sharing between ministries**, which is viewed as one of the strongest in the region, with a clear mandate in the Physical Planning department to share data, was also an important factor. Although SVGMO is the custodian of the hydromet data, it has

put significant effort into an open data platform to facilitate the easier sharing of data and products between agencies. The continuity of staff at SVGMO has also been a strong enabler.

- The **WB team was very clear on what was needed for this project and worked collaboratively** with SVGMO to achieve it.
- It is felt that the **government agenda was aligned with the project objectives**; senior government officials were very supportive of the project.

Challenges

- **Procurement of equipment for Emergency Communication Network:** The design process was protracted, with many iterations of specifications exchanged with WB. It was then followed by a failed tender as the requirements were not met. Ultimately, it was extremely difficult to agree on value for money while addressing the needs of the system.
- **Technology was a barrier:** If communications and data management systems were more established, the project could have been executed more efficiently.
- While the WB team was praised for its work on this contract, there is a feeling among some stakeholders that **donors can be barriers to the hydromet strategic plan** being realised if they do not fully understand the technical needs. Preconceived ideas of donors can make it challenging to fulfil existing national objectives.

Lessons Learned

- **Focus on larger impact elements**, rather than lots of small, fragmented activities: The initial DVRP procurement plan had a lot of small activities (wider-reaching than just HMCS) for different ministries, but not all agencies were championing them. Consequently, the project decided to move towards larger infrastructure resilience works with clearer, larger outcomes and consolidated ownership within ministries/agencies. Although the project still included HMCS aspects, they were no longer the main focus.
- The effort required by the implementation team is often underestimated. **Greater capacity within the Ministry of Finance implementation team** could have helped drive the project with respective agencies. The procurement of the Emergency Communication Network would have been smoother if

it had had a dedicated team member. Doing this in SVG would require recruitment into the Ministry and likely an increase in office space, which is a constraint at present.

- The DVRP programme was structured so that data collection would happen at the project outset and inform the hydromet design and DVRP investments. This has not always been possible due to delays in procurement, technical capacity, and national emergencies. This needs to be recognised and not relied upon in future—**expectations around already available data and how it can be utilised to provide the required users services and products should be more realistic**.

Key Recommendations

HMCS priorities

Future HCMS priorities as raised by stakeholders are shown in the table below.

Stage of value chain	Priorities for future projects
1. Observations and monitoring	• Additional weather stations to build up the national network and improve the network of automatic gauges • SVGMO and CWSA to develop a roadmap for HMCS
2. Data and information management	• Need for better topographic and land use data to feed into modelling
3. Research, forecasting, and modelling	• With CIMH doing the majority of the hydromet modelling and long-range forecasting, for droughts in particular, this is not seen as a key priority area for SVG from a national perspective. The focus of SVGMO is more on observation and monitoring, data management, as well as training and capacity building.
4. Training and capacity strengthening	• General need for further training on climate service products and all aspects of the value chain

Achieving sustainable HMCS

Regional Collaboration

There are clear advantages to regional HMCS collaboration, especially among the Caribbean Small Island States. Within the Caribbean, there are a number of key organisations supporting regional collaboration in HMCS:

CIMH is a training and research organisation that aims to improve the meteorological and hydrological services and assist in promoting the awareness of the benefits of these services for the economic well-being of the countries. SVG has a good, established relationship with CIMH and feels well supported by them. SVGMO receives training and technological support from CIMH, including monthly forecasting models; its in-house capacity is well complemented and boosted by services provided by CIMH.

CCCCC is a regional entity whose work is focused on SIDS in the Caribbean and the improvement of the region's framework for activities that address climate change. SVG has a focal point for CCCCC, but no structured way of interacting with CCCCC's regional projects.

The mandate for CIMH and CCCCC in supporting SVG is not clear to all stakeholders; thus, formalising and/or raising awareness of this aspect would be advantageous. By integrating regional services and projects into the national HMCS strategy, collaboration could be further improved and SVGMO would be better able to maximise the benefits and opportunities presented by regional bodies.

It is understood that there are significant differences between the maturity of the relationship between regional organisations and the member states. While the relationships are good with SVG, they are more strained in other countries, and as a result, the CIF funding of regional projects may have varied impacts across the region.

Funding Arrangements

In general, the stakeholders who were engaged with felt that SVGMO is able to obtain sufficient funds for the services currently being delivered. Most equipment comes through projects and donor funding support. CIMH has an equipment and maintenance section that supports SVGMO with advice. Ministry funding is secured for the operation and maintenance of the network, with provisions made for spares and other items not included in the DVRP project scope.

Staffing levels within the SVGMO are currently sufficient. However, if the services provided change (for example, SVGMO is considering moving from a 12hr to 24hr operation), additional capacity will be required.

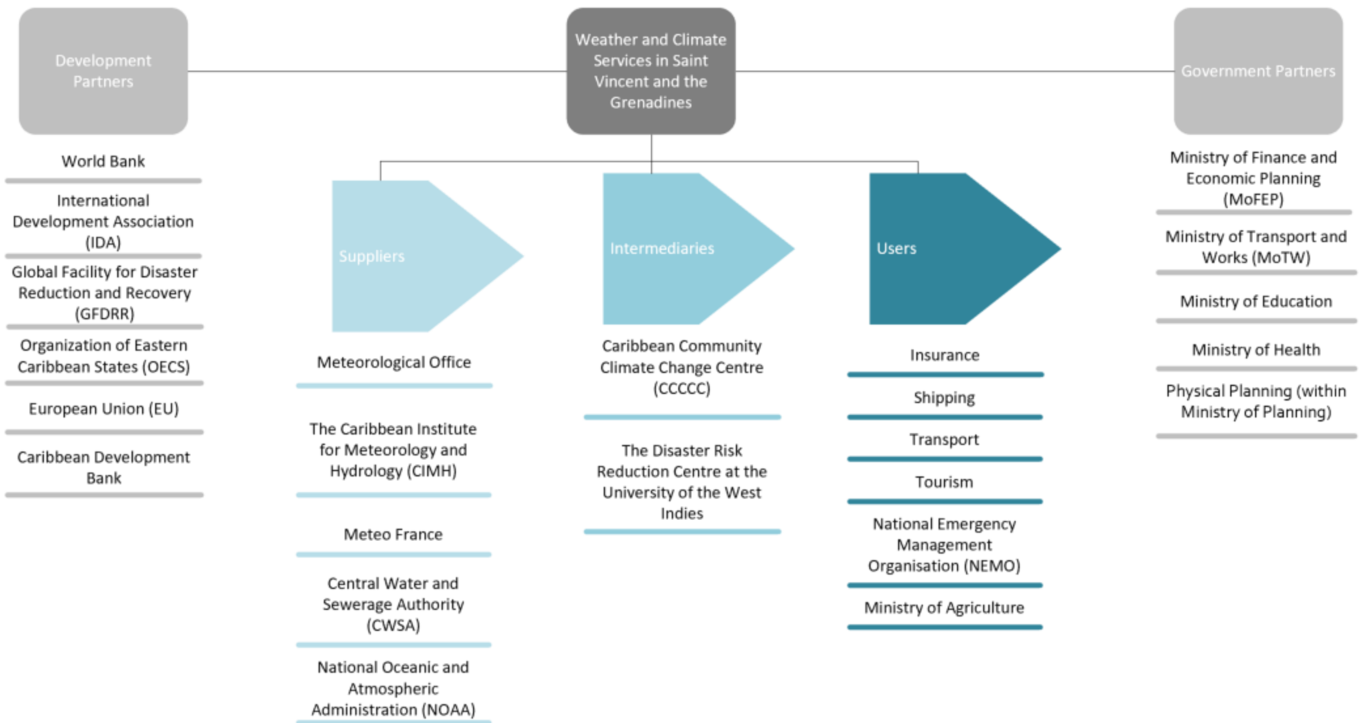
Suppliers and intermediaries jointly funding HMCS projects is not commonplace at present, but it has potential where the joint benefit is clear: for example, obtaining geospatial data that is of use to many agencies/users could be an incentive.

Commercialising HMCS

As SVGMO is not a statutory body, it is not currently permitted to accept funds for its products or services. There is a proposal to change this situation to allow SVGMO to generate revenue, because it is perceived that there is an interest, for example, from airport fuelling and shipping companies along with tourism operators, among others, in paying for quality data, if it is available for purchase. This would enable decisions regarding future activities to be made based on data-driven, localised hydromet information. However, there is concern that the private sector partners would ultimately gain an unfair profit in working as intermediaries and repackaging and selling data. This has been witnessed regionally in telecoms.

Additionally, some stakeholders view SVG HMCS as a public service, and as such, the data should be open and freely available. NEMO has led joint training sessions for the public and private sector in engaging SVGMO and tropical shipping interests. SVGMO gave a presentation on its products and services, with a continuity plan currently being established to build on this initiative and determine the potential for commercial weather and climate services.

Key Stakeholder Map



Appendix 12. Learning Brief on Hydromet and Climate Services Project: Tajikistan

The learning review aims to take stock of the progress made to date on the lessons learned from strengthening HMCS under' CIF's PPCR and contributes to the global learning on the effective financing of HMCS. To do this, stakeholders, involved in the 12 CIF-supported HMCS Projects within the PPCR HMCS portfolio, were deeply engaged through workshops and interviews.

This learning brief that focuses on Tajikistan forms part of the final learning review.

This learning brief has been informed by interviews with representatives from the Agency for Hydrometeorology of the Committee for Environmental Protection (Tajikhydromet) and the WB staff involved in the project.

Project Overview

Brief country context

Over the past decade, Tajikistan has made steady progress in reducing poverty and growing its economy. However, its high vulnerability to climate change and natural disasters continue to present an additional challenge to sustainable economic growth. Between 1992 and 2016, natural and climate-related disasters affected almost seven million people and led to GDP losses of roughly USD1.8 billion, equivalent to around one percent of its gross domestic product (GDP).[76] Improvements in weather and climate services can reduce weather and climate risks, as well as inform adaptation decision-making in the country's most important economic sectors. In the past, the State Agency for Hydrometeorology (Tajikhydromet) has been hampered by the common problems faced by post-Soviet institutions, including limited budgets, ageing infrastructure, and poor staff retention.

[76] World Bank, 2021, "Tajikistan Overview," Tajikistan Overview (worldbank.org).

Tajikistan is one of the pilot countries under CIF ’s PPCR. Through the PPCR support, the government of Tajikistan developed its SPCR, in partnership with WB, the Asian Development Bank (ADB), and the European Bank for Reconstruction and Development (EBRD). Under SPCR, six projects were identified as priority investments, including the **Improvement of Weather, Climate and Hydrological Service Delivery Project**. Led by WB, it formed part of the Central Asia Hydrometeorology Modernization Project (CAHMP). This project is one of the case studies in this learning review.

A map of key stakeholders involved in HMCS in Tajikistan has been included at the end of this learning brief.

PPCR project overview

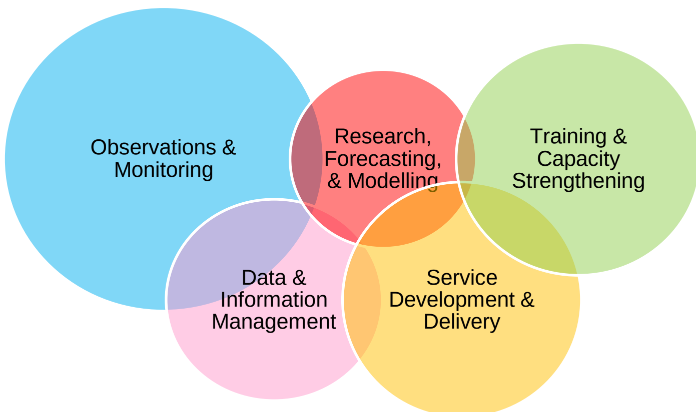
Name of project	Improvement of Weather, Climate and Hydrological Service Delivery Project
Implementing multilateral development bank (MDB)	International Bank for Reconstruction and Development (IBRD)
MDB approval date	May 2011
Closing date	March 2023
Total cost	USD7 million (grant)
Objectives	The objective of CAHMP Component C—'Strengthening of Hydromet Services in the Republic of Tajikistan’—was **to strengthen Tajikhydromet to ensure it has the infrastructure and capability to observe, forecast, and deliver weather, water, and climate services that meet the country's identified economic and societal needs**. CAHMP had a strong regional dimension that was focused on regional cooperation and the modernisation of hydromet services in both the Kyrgyz Republic and Tajikistan.

Project components	The project design was the first to use the three-component approach to do the following: 1) Modernise observations and monitoring; 2) Enhance institutional capacity; and 3) Improve the delivery of weather and climate services. As such, it aimed to shift the focus towards the development of **improved services**, while providing an essential upgrade to **observations and monitoring**. The project was the first stand-alone project on hydromet services in Tajikistan (previous projects had used a piecemeal approach). It was the first opportunity that the country had had to upgrade its **observations and monitoring network**. This aspect formed the largest part of the project, although it also addressed **data and information management**, along with the development **of improved services**, particularly in the water sector. Some work on **research and forecasting** was also included in this project, and further activities are ongoing as part of the ADB project: '47181-003 Tajikistan: Water Resources Management in the Pyanj River Basin Project'.[77]

[77] ADB, 2021, "Tajikistan: Water Resources Management in Pyanj River Basin Project," 47181-003: Water Resources Management in the Pyanj River Basin Project (Additional Finance) | Asian Development Bank (adb.org).

Relevance for the HMCS Value Chain

The focus placed on each aspect of the HMCS value chain is indicated by the size of the circle in the diagram below.



Stage of value chain	Project activities
1. Observations and monitoring	• Restoration and technical upgrade of the hydrological and meteorological observation networks • Improvements in snow measurement and observation networks, along with hydrographic surveys • Establishment of a national centre for metrological and technical support
2. Data and information management	• Development of a regional remote sensing monitoring system, including systems for receiving and processing high-resolution satellite images • Improvement of data processing systems and the transmission of data to the Global Telecommunications System (GTS) • Improvements in the management and dissemination of historical data and climate change information
3. Research, forecasting, and modelling	• Development of improved runoff forecasting system for river basins • Improvements in Numerical Weather Prediction (NWP), using the Consortium for Small-scale Modeling (COSMO) model
4. Service development and delivery	• Improved strategic planning at Tajikhydromet, including the consideration of business models for service delivery and Standard Operating Procedures (SOPs)

Stage of value chain	Project activities
	• Improved NHMS interaction with users of hydromet and climate services • Improved guidance on hazardous hydrometeorological events, including flash flooding, landslides, and snowmelt
5. Training and capacity strengthening	• Development of a distance learning platform for the Central Asian NMHS • Training of the Tajikhydromet staff and other stakeholders through technical assistance and regional workshops with other Central Asian NMHS

Key Findings

Main project successes

The project raised the awareness of the importance of weather and climate services in Tajikistan and delivered a major upgrade to the observation and monitoring network, laying the foundations for improvements in service delivery.

- It promoted greater regional cooperation between the five agencies in Central Asia. These agencies that possess a wide range of capabilities are all Russian-speaking, which provided the opportunity for knowledge sharing between countries. For example, professional colleagues in Kazakhstan were able to support the training in Tajikistan and the Hydrometeorological Centre of Russia was also able to provide some technical assistance.
- As well as upgrading the observations network, the project has increased the sustainability and performance of Tajikhydromet, as well as increased the capacity of stakeholders in the hydromet value chain through a range of activities, including the provision of technical assistance from advanced National Meteorological and Hydrological Services (NMHS), such as the Finnish Meteorological Institute (FMI).

Challenges

- In the past, a **traditional approach to hydrometeorology** was adopted, with the government's weather and climate information delivered to users, with limited interactions to understand the requirements of each sector. A new strategy and business plan have now been adopted, which promotes greater engagement with users and a broader understanding of the potential for hydromet services.

- **Staff retention** and the **capacity of ICT systems** were seen as significant barriers to progress on the project.
- In the past, NMHS was underfunded, and one response to this challenge was to charge for access to weather and climate data sets. While **funding remains a challenge**, the situation has improved and the focus has since shifted towards developing a more service-oriented institution.
- There were **some delays to installing observation stations** in very remote locations. However, Tajikhydromet is well accustomed to the challenging conditions; so this was considered as 'business as usual' and the network upgrade was successfully concluded.
- A **legacy network design** approach was adopted, that is, the project did not change the design of the observation network; instead, it replaced old Soviet stations in the same locations. Although there are clear benefits to maintaining historical observation sites for developing long-term climate records, this approach may have missed opportunities for improving the network design and the data it can provide, as well as optimising the cost efficiency of the network.[78]

Lessons Learned

- **Adopting a country programmatic approach**, in this case in the form of SPCR, helped multiple development partners work together and align climate resilience projects in the energy, agriculture, and water sectors.
- With its **regional /national project design**, the project consisted of three components: two national (Tajikistan and Kyrgyzstan) and one regional (covering Central Asia). This approach of ring-fencing funds as part of the project design was beneficial, because there was no reliance on national funds to improve the regional cooperation. Without ring-fencing, it might have been difficult for Tajikhydromet to participate in regional activities.

[78] In many countries with advanced NMHS, there has been a process of network rationalisation following periods of network expansion. This happens as individual sites are replaced by remotely sensed data, assimilated data (for example, from aviation), or modelled data, or they cease to be cost-effective for climate reporting or forecasting purposes.

- The PPCR project was a **foundation** project, as it was the first major hydromet project in the country. Thus, the lessons learned from this project have been very useful in informing related projects. One such example is an ongoing ADB project to improve weather services in transboundary river basins.[79,80]
- A **long-term strategy for hydromet service modernisation is needed** to enable the successful development of partner coordination and continued improvements in services. Long-term planning, including strategic plans and business planning, has now been adopted by Tajikhydromet's leadership team.
- **A demand-driven design** can be adopted for future projects now that this project has upgraded the observation network. Essentially, they can have a stronger focus on the users and the services they require. Project design can start with the users and work backwards from there to inform design decisions, such as (i) what information is needed by specific user groups and (ii) what digital innovations would be most beneficial to create more efficient forecasting processes and service delivery.

[79] ADB, 2021, "Tajikistan: Water Resources Management in Pyanj River Basin Project," https://www.adb.org/projects/47181-003/main#project-overview.
[80] Green Climate Fund, 2018, "International Development of the State Agency for Hydrometeorology of Tajikistan," FP075: Institutional Development of the State Agency for Hydrometeorology of Tajikistan | Green Climate Fund.

Key Recommendations

HMCS priorities

Stage of value chain	Priorities for future projects
1. Observations and monitoring	• Although there is still a national interest in specialist equipment, the focus must now shift towards data and information management, as well as service delivery.
2. Data and information management	• Following the modernisation of the observation network, there now needs to be further improvements in data and information management systems. These systems are required for storing archive data and improving information availability for forecasters, as well as the efficient delivery of new services.
3. Research, forecasting, and modelling	• Tajikhydromet has a central role and aims to fulfil a wide range of functions, including the development of its own numerical weather prediction (NWP) models. The increased utilisation of global and regional weather and climate centre products may allow Tajikhydromet to focus on improving the delivery of specific national services. In most cases, running limited area modelling (LAM) is not the most optimal use of resources to quickly improve forecast capabilities.[81]
4. Service development and delivery	• There have been good outputs from the project, but there is still a need to improve the accuracy of weather forecast products and the marketing of services to generate additional support from government departments (G2G) or additional income from the private sector (G2B).
5. Training and capacity strengthening	• Staff retention is difficult because Tajikistan does not have universities or research centres that can provide relevant training (for example, in the fields of meteorology, hydrology, atmospheric physics, and data science); so people have to train elsewhere. Those with digital skills often do not return,

[81] David P. Rogers, et al., 2019, "Weathering the Change: How to Improve Hydromet Services in Developing Countries?" https://openknowledge.worldbank.org/handle/10986/31507.

Stage of value chain	Priorities for future projects
	as government pay is relatively low and traditional civil service jobs may be less attractive than private sector jobs. Therefore, staff development and retention remain a top priority.

Achieving sustainable HMCS

The **long-term sustainability of hydromet services is still a key concern**, for example, ensuring operational funding to maintain a modern observation network and skilled staff to contribute to research and forecasting.

The Central Government is the main source of funding for Tajikhydromet. Therefore, a first step towards sustainability is securing adequate government funds for providing a PWS and funding for additional services to other government departments.

The second step is to understand local market conditions, the demand for commercial services, and how they could be delivered. There are some users who pay for data, but not for bespoke weather or climate services. Furthermore, there may be potential for commercial services in some sectors (for example, energy), and their feasibility is being explored under the ongoing ADB project. However, the potential is likely to be too low to replicate the commercial HMCS in countries with longstanding commercial HMCS (for example, New Zealand, Japan, or UK).

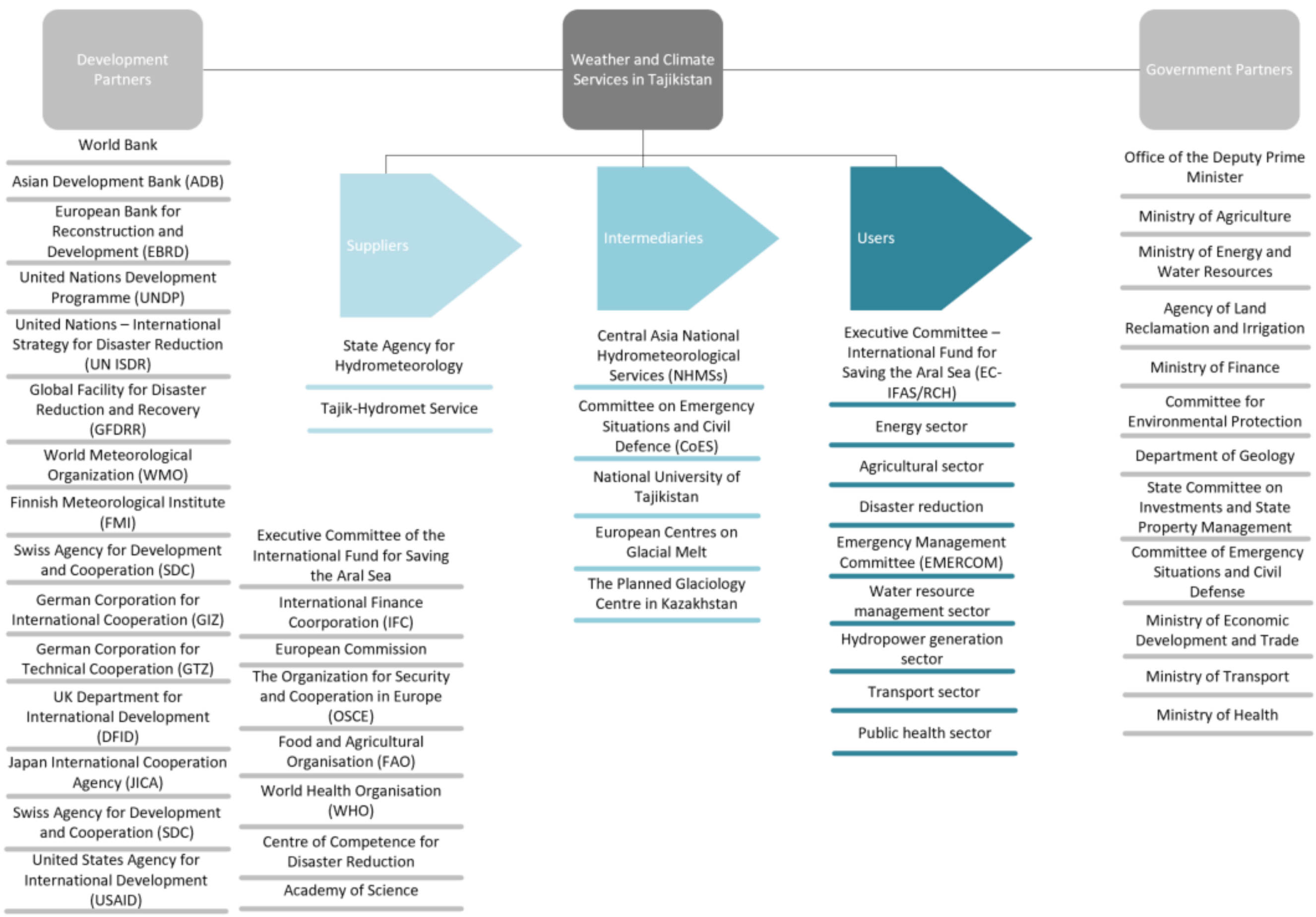
A third step is to consider other sources of funding or partnerships, with the possible pathways set out below:

- **Research grants**: Tajikhydromet is investigating potential research grants, such as with the Finnish Meteorological Association (FMA). FMA provides technical assistance, capacity building, equipment, and consultancy services, and Tajikhydromet has worked with FMA on air quality and glaciology.
- **Partnerships for observations and monitoring:** Some NGOs that have investigated setting up observation networks to support specific projects have considered cost- and data-sharing models.

Such arrangements need to consider the long-term sustainability of these stations, though they may offer opportunities for jointly improving HMCS in selected pilot areas.

- **Collaboration on aviation services:** There is potential for further income from HMCS in relation to aviation services. As the airport in Tajikistan has its own forecasting office, it is not reliant on Tajikhydromet, though there could still be an opportunity for collaboration. In the most developed NMHS, regulated and non-regulated aviation services provide a significant source of funding.

Key stakeholder map



Appendix 13. Project Successes

Observations and Monitoring

Many of the projects exceeded their objectives by increasing reliability and coverage through the installation of AWS and hydrological stations to develop new or existing hydromet observation networks. Where these projects were successful, effective procurement approaches were involved; for example, in Jamaica, professional management and procurement enabled the project to proceed quickly with some direct procurement of equipment, based on well-researched and well-developed specifications, to allow integration into the existing networks. In Niger, procurement was highlighted as a successful process in this project, with the role of AfDB noted as having been critical in helping the project to navigate international procurement processes in a relatively smooth manner, thereby minimising delays with equipment and installation.

Data Information and Management

Success was underpinned by having a clear governance structure from the outset of the project, which allowed for collaborations and the integration of activities, as well as data exchanges between institutions to strengthen the information management system. This was found to be the case in Bolivia, Mozambique, as well as SVG. For example, Mozambique developed protocols, such as an MoU and decrees for inter-agency data sharing. The MOU on data sharing between INAM and DNGRH was critical to the project's success.

Furthermore, the coordination and sharing of data were underpinned by the successful development of information management systems. In Grenada, the establishment of the real-time hydromet data portal was a great success, where the alignment and standardisation with the intermediary, CCCCC, helped with the development of databases. In Haiti, where previously there had been no integrated central system, a new NHP at UHM is now operational and receiving data; it is highlighted as a major achievement. The development of effective information management systems has improved the speed of information sharing, thus enabling the quicker production of products or services. This is demonstrated in Jamaica where WRA actively provides regular hydrological reports.

Research, Forecasting, and Modelling

Success was demonstrated across a range of prediction timescales. In Mozambique, NWP modelling, linked to the project, was used by INAM to develop the response actions to Cyclone Idai in 2019, thus reducing potential social and economic impacts. In Tajikistan, improvements have been made in the NWP modelling, using the COSMO model, while a runoff forecasting system was developed for river basins. However, it is thought that the greater utilisation of global and regional weather and climate centre products may allow NMHS to focus on improving the delivery of specific national services. In Bolivia, the development of a seasonal prediction system was supported by the NGO, CIIFEN, where statistical calibration techniques were applied to readily available global models. This approach provided technical support, even after the contract had expired, thus allowing staff members to work directly with the experts on a regular basis and receive additional help where needed. In Niger, a regional climate model was developed and regional climate projections are now available.

Service Development and Delivery

The projects that were most successful had strong institutional collaboration in place, which allowed NMHS to better inform stakeholders' decision-making and plan activities with enough lead time. In Nepal, for example, DHM had good collaboration between agricultural intermediaries and users in the development of agricultural advisories. In the Caribbean, beneficiaries exerted a strong influence throughout the project design and implementation stages, which helped to develop a tailored service. In Bolivia, the coordination between different stakeholders who shared limited water resources within the same river basin has been essential to ensure an integrated participatory approach to planning and management, including the HMCS service development. Working in integrated ways with trusted intermediaries, such as the Red Cross in Mozambique, has enabled the effective communication of messages to community leaders, through the explanation of probabilistic forecasting, therefore building confidence at a local level in the forecasts and early warning messages.

Successful projects have also managed to increase the reach of weather and climate information. In Niger, the project led to a significant increase in the number of farmers and communities being able to access agro-climatic information, reaching its target of 150,000 farmers. In Mozambique, the project has led to the increased safety of maritime navigation, which has enhanced opportunities in coastal areas. The projects have also raised the profile of the NMHS through the provision of weather and climate services. In Nepal, the social and economic benefits demonstrated to the country have contributed to the government's commitment to increase DHM's budgets on both capital expenditure and operational aspects in order to manage the expanded observation network.

Training and Capacity Building

Successful projects implemented training and capacity building across all aspects of the HMCS value chain, as well as within the national- and sub-national-/local-level institutions. In Mozambique, projects strengthened the capacity of INAM and DNGRH staff in equipment installation and monitoring, along with the management of data integration tools/platforms, modelling, forecasting, and the dissemination of targeted products. Training and capacity building were delivered to providers and end-users of weather and climate information; there was also effective use of technical assistance from advanced NMHS, such as FMI.

Appendix 14. Priority needs for the further development of HMCS, as identified by PPCR project countries

Observations and Monitoring

Most PPCR project designs included upgrading or rehabilitating existing monitoring stations, or extending the observation network. None included the rationalisation or the redesign of networks.

The demand for further observations equipment from NMHS is in response to perceived gaps in network density, types of monitoring, or limitations in the national services offered, due to insufficient data. There was also a strong demand for robust equipment (for example, to prevent the theft of solar panels) and established regional supply chains to support operational maintenance and the provision of training and spare parts.

Priority needs for this component of the WCIS value chain are presented below:

- **Specialist observation and monitoring equipment**, including upper air measurements, wind profiling, and marine observations to support aviation and maritime forecast services;
- **Increase of the density of observation networks** or rehabilitation of remaining manual weather stations and river monitoring stations with automatic monitoring equipment;
- **Addressing of additional monitoring requirements** that fall within the remit of some NMHS, including groundwater modelling, snow cover monitoring, and the Glacial Lake Outburst Flood monitoring;
- **Greater coordinated use of satellite remote sensing and other digital data** to support Impact-Based Forecasting (IBF), which will require the coordination between government ministries and agencies to combine hazard and vulnerability data (for example, exposure, sensitivity, damage-cost curves, and so on); and
- **Collaboration between the government NMHS and other potential suppliers of hydromet data** with the overall aim of improving services and sustainability of observations systems (this may include other government departments, NGOs or the private sector);

User demand within individual countries is strongly focused on service delivery. Where improved services can be delivered with the existing observation systems, other parts of the WCIS value chain were given a higher priority. For example, in Nepal, one interviewee highlighted that *'the number one priority is using PPCR to its full potential'* and a number of opportunities were identified to develop new services for the mountaineering and tourism, health, and energy sectors, using the investments made in the PPCR project.

There are also external demands for better observations and greater data access. For example, global and regional modelling centres are concerned with assimilating data to improve global NWP, which would benefit from more upper air observations as well as further ground observations in LDCs and SIDS. The proposed SOFF is requesting a 10-fold increase in observations and a results-based framework based on data availability[82].

Data management, data exchange, and IT

Data management, data exchange, and associated ICT requirements are essential for the maintenance of global weather observing and modelling systems, the development of RCCs, and the improvement of national WCIS. The PPCR projects included activities to create databases for historical climate and hydrological databases.

Priority needs for this component of the WCIS value chain include the following areas:

- **Systems integration** needs to be done in cases where NMHS have developed observation networks under different projects or from different development partners, and the data have not yet been integrated into a central meteorological or hydrological database for operational use, quality assurance, and archiving.
- **Global and regional data exchange should be improved** so that NMHS can receive products from global and regional modelling centres and provide access to their monitoring to relevant WMO centres. Although most PPCR observations and monitoring stations are being used in the country or

[82] WMO, 2020, *The Value of Surface-Based Meteorological Observation Data: Costs and Benefits of the Global Basic Observing Network*, The value of Surface-Based Meteorological Observation Data: Costs and benefits of the Global Basic Observing Network | E-Library (wmo.int).

regional context, they are not routinely being made available on global systems in accordance with WMO commitments.[83]

- **Mechanisms and pilots for data sharing across national borders should be improved**, for example, for transboundary river basin flow forecasting in Nepal and development of regional products in the Caribbean. In some parts of the Caribbean, radar products on one island covers neighbouring islands, but traditionally, sharing this information has been difficult.
- **Data policies and data exchange between government departments and the private sector[84] should be improved** to realise the maximum socioeconomic benefits for sectors and communities exposed to hydromet-related natural hazards and climate change. (N.B. Alternative business models and sustainability issues are discussed in Section 4.)
- **Overall strengthening of ICT capacity for NMHS and other related government agencies**, including the provision of appropriate robust telecommunications, hardware, software, and investments in the necessary skills to manage large volumes of operational data and provide WCIS services, is needed.
- **Standards and procedures for meta-data, data formats, and data exchange should be implemented** to allow for effective Quality Assurance and the assimilation of data from different sources. This would be particularly beneficial to support the mandate of RCCs and pilot projects on transboundary flood forecasting or similar regional forecasting initiatives.
- **Further provisions for data rescue are needed** in cases where manual recordings have not yet been fully digitised and archived, alongside low cost/affordable software tools and database systems for countries with limited operational budgets for investments in proprietary software products and their associated annual subscription fees.

[83] WMO Congress in Resolution 40 (Cg-XII) explicitly affirms WMO's commitment to the principle of free and unrestricted exchange of meteorological and related data and products. In addition to the sharing of operational and time-critical information in accordance with the policy of information providers, the WMO Information System (WIS) facilitates the free and unrestricted access to data and information products and services on matters relating to safety and security of society, economic welfare, and the protection of the environment.

[84] There is a high demand from the private sector for data access, particularly in the insurance sector, with its interests in offering re-insurance products to national governments and private sector clients.

Research, modelling, and forecasting

Research, modelling, and forecasting covers a wide range of activities, including the development of NWP models for short-term, medium-, and long-range forecasting; the development of climate change models; the production of national climate change projections; multihazard risk assessments; flood forecasting; and the downscaling of global and regional forecast data from Global Producing Centres (GPCs).

Some PPCR countries have good capabilities to run local NWP for forecasting purposes (for example, Tajikistan, Jamaica, and Mozambique), but the case for further investments in local NWP and the necessary high-performance computing (HPC) is weak. This is primarily due to (i) advances in very high-resolution global models, with performance exceeding many local models; (ii) the concentration of HPC in global and regional centres; along with (iii) the high operational costs of running larger HPCs.[85] Leading global centres are moving towards global 'digital twins' at ~ 1km resolution that promise a step change in the performance of global ensemble forecasting.[86] The European Centre for Medium-Range Weather Forecasts (ECMWF) and North American Ensemble Forecast System forecasts (1–14 days) are now used by many NMHS and private organisations without the added step of further local area modelling. Instead, the focus is on the statistical downscaling of these products to provide improved local medium-range forecasts.

Priority needs for this component of the WCIS value chain include:

- **Maintenance and improvement of existing NWP modelling systems**, where these aspects are an important integrated part of the national forecasting processes, as well as working with global and regional partners to improve the model's performance;
- **Provision of access to the best-available global and regional forecasts, as well as the development of the suitable downscaling** of these forecasts to national, township, and local scales, using local observations and statistical methods, potentially incorporating machine learning (ML) and artificial intelligence (AI);

[85] WMO, 2021, *Open Consultative Platform White Paper #1: Future of Weather and Climate Forecasting*, WMO Paper No. 1263, [doc_num.php (wmo.int).]

[86] Primarily led by ECMWF and partners in Europe; for background, see [https://events.ecmwf.int/event/167/contributions/1356/.]

- **Collaborative research partnerships with international and national partners** to improve modelling systems, support the continued professional development of suppliers and users of forecasts, and develop scientific consulting skills within NHMS seeking further funding sources;
- **Development of more impact-based forecasting pilots for floods, droughts, heatwaves, and other impacts**, including working closely with users to ensure that actionable forecasts reach vulnerable communities exposed to hazards;[87]
- **Update of national climate change projections, as well as the production of data and information products** that raise awareness of climate change and support mitigation and adaptation plans for the government and key economic sectors. Although the current round of the Coupled Model Intercomparison Project Phase 6 (CMIP6) modelling is highly accessible,[88,89] it also requires further downscaling and assessments for PPCR target countries to be able to use them to update national climate change projections.
- **Development of digital tools** to make greater use of available global data sets, remote sensing, and mobile phone technology to improve hazard, exposure, and vulnerability data sets for IBF. PPCR countries can participate in a global community, developing tools and services using cloud computing;[90]
- **Monitoring, review, and objective verification of forecast performance for high-impact events** so that this information can be used to refine and improve national forecasting services as well as regional and global services.

[87] *The Future of Forecasts: Impact-based Forecasting for Early Action*, 2020,. Impact-based-forecasting-guide-2020.pdf (forecast-based-financing.org).
[88] CMIP6, 2019, CMIP6 Homepage (llnl.gov).
[89] For example, the IPCC WGI Interactive Atlas provides easy access to data on large climate regions and river basins.
[90] For example, Microsoft is hosting a large volume of data in a cloud computing environment: Home | Planetary Computer (microsoft.com).

Product services and development

Although there was a greater expenditure on observations and monitoring on PPCR projects, improving services was part of all project designs and there were several examples of good progress in product development, particularly in the agriculture, DRM, and water sectors. In Nepal, for example**,** over 40,000 farmers and advisors have downloaded the Agro-met Advisory Bulletin (AAB) mobile phone app that provides a weather summary and forecast for the next week, along with agricultural advice.[91,23] In Mozambique, improved hydromet forecasts and early warning notices, reaching over 300,000 beneficiaries in farming and fishing communities, help support day-to-day decision-making.[92]

The improvement of services is the prime objective for WCIS suppliers. Apart from helping to maintain government support for NMHS, it is also a prerequisite to any commercial activities. The greatest socioeconomic benefits are achieved when services provide salient and timely information to avoid damage and loss caused by hydromet-related natural hazards or optimise tactical or strategic decision-making to improve outputs, such as irrigation scheduling to improve agricultural yields.

Some of the priority needs for this component of the WCIS value chain are discussed here:

- Development of improved **Service Delivery Platforms**, which encompass a range of technologies[93] to provide digital forecasts more efficiently and tailor information for specific user requirements. Improved forecaster workflows and automated processes can ensure that forecasters can focus on specialist tasks and deliver a high volume of products to a wide range of users including the media, the public, and specialist users.
- **Development of improved services using the existing global, regional, and national data sets**, which include increased reliability, timeliness, improved communications, better presentation, and tailored information. For some interviewees, this was a much higher priority that was needed before

[91] Figures based on the latest World Bank's *Implementation Status & Results Report*
[92] CIF, 2020, *Strengthening Weather and Climate Information Services: Highlights from PPCR-Supported Projects Climate Investment Fund Knowledge for Resilience Series*, September 2020, ppcr_resilience_series_weather_and_climate_information_services.pdf (climateinvestmentfunds.org).
[93] John L. Guiney, 2008, "Innovations and New Technology for Improved Weather Services," Innovations and New Technology for Improved Weather Services | World Meteorological Organization (wmo.int).

embarking on the further extension of hydromet networks. The demand and technical requirements for these services would determine where future expenditure should be focused.

- Improved **'User Interface Platforms'** that enable far deeper coproduction of new services with users. Most PPCR countries have some forms of user engagement with government partners and the wider public, such as the National Climate Outlook Forum (NCOF) platform. Regional Climate Outlook Forums (RCOFs) provide a platform for NMHS to engage with other organisations, share good practices, receive feedback, and develop stronger links with sectors affected by weather and climate.
- **Strengthened partnerships** with government ministries, departments, and agencies, including ensuring strong links between the 'national capability' for meteorology and hydrology, along with the development of a wider range of services supporting different sectors, including the health and energy sectors. With the drive to reduce greenhouse gas emissions and reach Net Zero, the energy sector is likely to become an increasingly important user of WCIS to model energy supply and demand as well as ensure that electricity networks are climate resilient.
  The development of **Multi-hazard Early Warning Systems (MHEWS)**, including the four core elements (1) knowledge, (2) forecasting, (3) warning dissemination and communication and (4) disaster preparedness as outlined in the Sendai Agreement and by WMO.[94]

[94] WMO, 2021, "Multi-Hazard Early Warning Systems: A Checklist," Multi-Hazard Early Warning Systems: A Checklist | World Meteorological Organization (wmo.int).

Capacity Building

Capacity building underpins the previous four components of the WCIS value chain. The availability of skilled national staff, and where required, technical assistance from international organisations, were key enablers for successful projects in PPCR countries. At the same time, the challenge of retaining staff, succession planning, upskilling, and the lack of resources for continued professional development and learning was seen as a barrier in many cases. For some PPCR projects, training was severely interrupted by COVID-19 and the lack of support locally during the pandemic.

Priority needs for this WCIS value chain component include:

- **Continued support from WMO and affiliated regional centres** to provide capacity building and promote regional collaboration, where this can provide effective peer-to-peer learning and improve specific regional services, such as regional drought outlooks.
- **Long-term support** (beyond individual projects) from meteorological and hydrological specialists, including suppliers, so that NMHS staff can learn to implement new observation methods or forecasting methods over several seasons, rather than just at the point of equipment handover.
- **Technical assistance** or consultancy services are required to improve services, but these are likely to include more national and regional support, as well as international support, in the most specialist areas of work. There was a demand for more operational support rather than one-off specialist projects, which highlights the need for local and regional supply chains and ways of funding this support through increased government funding or grant aid.
- **Staff development and retention** were a challenge cited by all PPCR countries; therefore, support is needed to develop effective Human Resources strategies to attract Science, Technology, Engineering, and Math (STEM) graduates and technicians and provide a rewarding and sufficiently well-paid career path. Strong relationships with universities and other research partners can provide a supply of staff and some opportunities for scientific career progression in the region, which may slow the ‘brain drain’ experienced in some regions, with staff moving to the US, Europe, or Australia.
- **Wider outreach activities** to increase the levels of awareness and understanding of weather, hydromet-related natural hazards, and climate change within specific sectors were highlighted as an important activity in several PPCR countries, in order to raise the profile of disaster risks and climate change, as well as promote preparedness and climate change adaptation in vulnerable communities.

Priority needs country examples.

Grenada – There is a need to institutionalise monitoring and data collection between the ministries and make a longer-term plan for HMCS management in general. Each party has a different focus, but there are common data and information needs, which need to be linked with the Land Use Division, the primary custodian of the majority of HMCS data, and NAWASA that owns the majority of the handheld sampling equipment.

Saint Vincent and the Grenadines – There is a need for better topographic and land-use data to feed into modelling.

Dominica – There is a need for the creation of a more detailed spatial database, including on-the-ground surveys, to complement the digital models and LIDAR modelling in order to enable the extension of the profiles of river cross-sections and support hydraulic modelling.

Tajikistan – Tajikhydromet, which has a central role, aims to fulfil a wide range of functions, including developing its own numerical weather prediction models. There is a need for the greater utilisation of global and regional weather and climate centre products, which may allow Tajikhydromet to focus on improving the delivery of specific national services. In most cases, running a limited area modelling (LAM) is not the most optimal use of resources to quickly improve forecast capabilities.

Niger – There is a need for improved hydrological data. In order to increase the understanding of key hydrological risks in the country, stakeholders noted the need for better monitoring, modelling for key catchments, and research to improve the understanding of catchments as a holistic system.

Bolivia – There is a need for improvement in all value chain services, which will lead to better service development and delivery. Service development and delivery cannot be addressed in isolation, but instead, as an outcome of better equipment, data management, modelling, and forecasting, as well as improved capacity.

Observations and Monitoring → Data and Information Management → Research, Forecasting and Modelling → Service Development and Delivery

Training and Capacity Building

Nepal – There is a need to address remaining gaps in the observation and monitoring network. These gaps could be filled with targeted capital expenditure, for example, for additional radar stations. A few of the remote AWS that have been installed have issues transmitting data. Some stations were not installed in high-altitude areas as intended; so these will need to be added in the future to provide a network

Mozambique – There is a need to improve staff retention: though INAM and DNGRH are continually investing in training, they are not benefitting from increased capacity, as the people leave once trained. Strategies to improve staff motivation, salaries, career progression, and job security are thus needed. Also, there is a need for the provision of good supervision and the equipment needed for the work, such as computers.

Jamaica – There is a need for improving regional collaboration. CIMH plays an important role as a WMO Regional Climate Centre and the project maintains good links with CIMH. However, there is still limited collaboration between the individual islands unless there is a regional workshop. Regional cooperation is likely to be supported by the Jamaican government and it would be beneficial for the region to share knowledge and learn from the islands' experiences.

Haiti – There is a need to build on the project's investments in observations and data management and develop processes for the development of user-oriented services. A first step would be a greater exploration of the services that can be offered to other government departments. However, there is also a clear view that services are needed to reduce vulnerability in the agriculture sector, in particular. The development of a clear user engagement platform would facilitate the development of user-oriented services.

Photo: Planning Institute of Jamaica (PIOJ)

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