TRANSFORMING WEATHER, WATER AND CLIMATE SERVICES: SYNTHESIS REPORT

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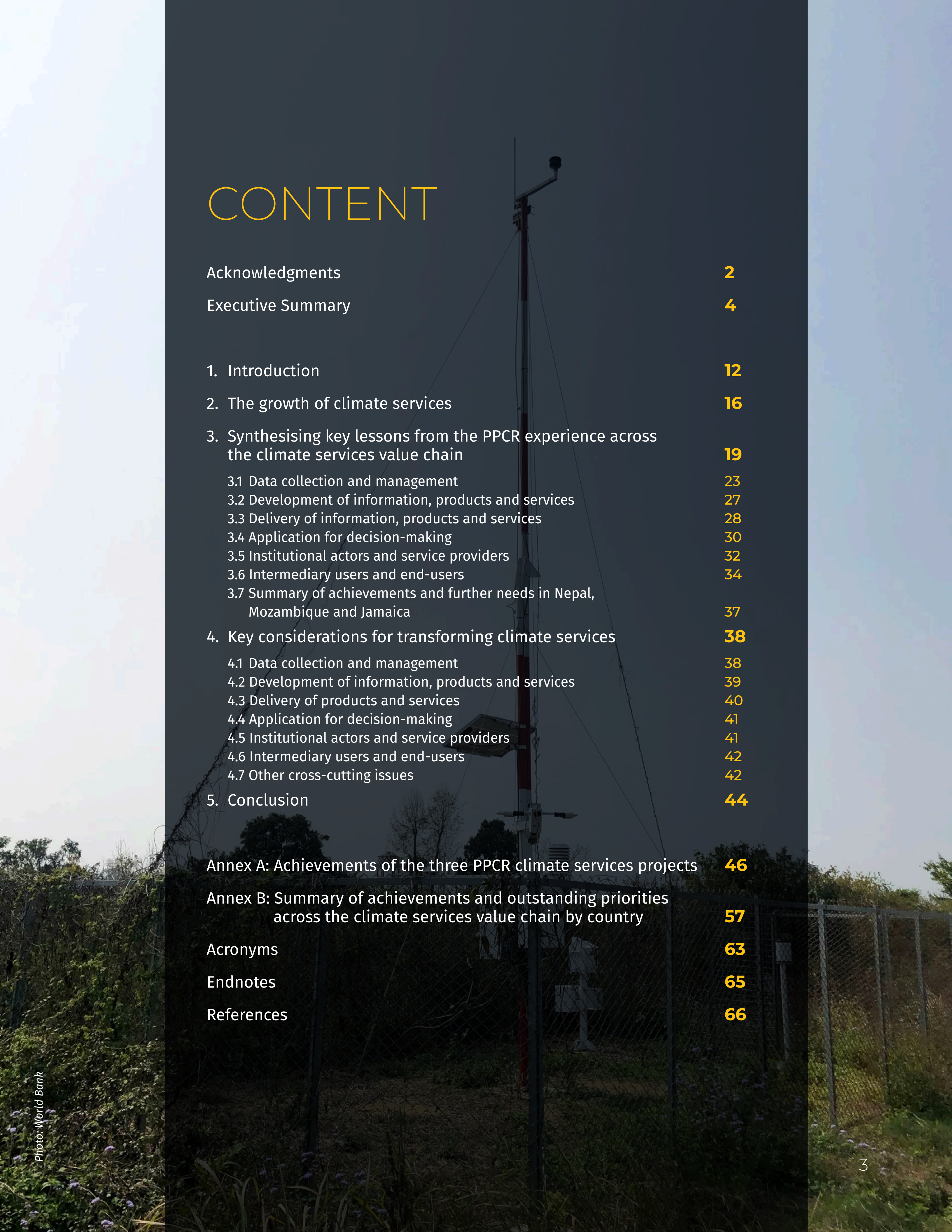

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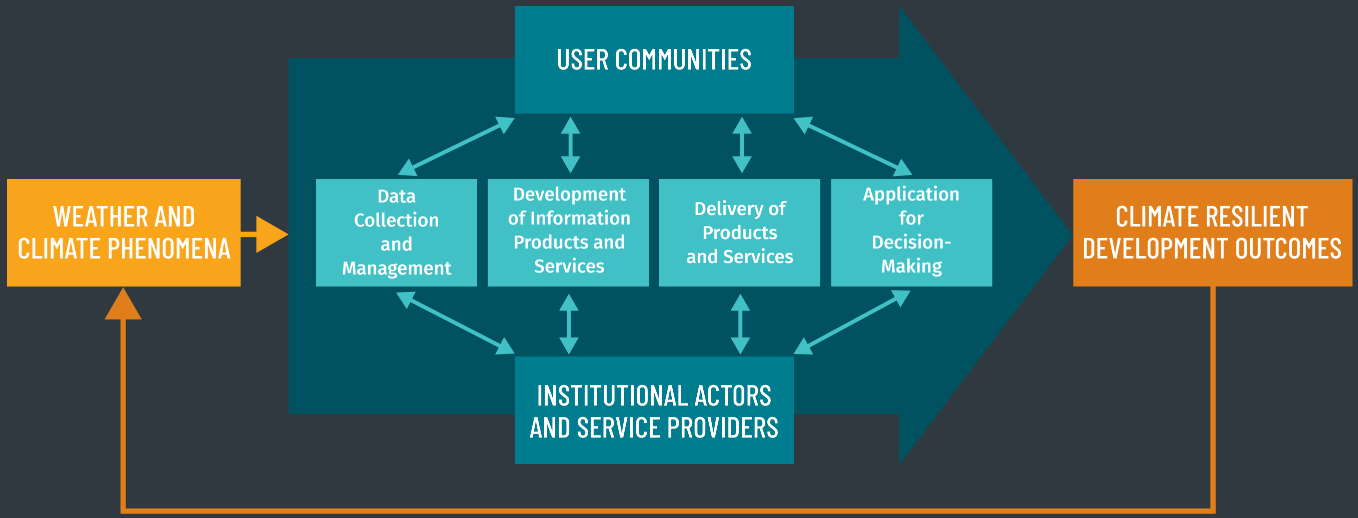
EXECUTIVE SUMMARY

Livelihoods and economies in lower- and middle-income countries are highly dependent on natural resources, the availability of which is linked to weather and climatic conditions. Weather and climate information is, therefore, essential for reducing the risk of weather events and climate hazards, as well as maximising economic opportunities. The concept of "climate services" is concerned with delivering useful and useable climate information to decision-makers, thus aiding them in their efforts to reduce climate risk. Economic analyses have shown that investments in climate services are cost-effective, considering the lives and assets lost from disasters.

The generation of climate services involves several stages, as represented in the climate services value chain (see figure below). Most fundamentally, climate services require data from observation and monitoring, which is often lacking or of poor quality in many developing countries. Using this data, information, products and services that meet users' needs first need to be developed and second, delivered through means accessible to users and in a timely manner for application to decision-making contexts in order to support resilience and adaptation. Thus, there is a significant emphasis on meeting the users' needs and demand for climate services, which is often contingent upon the involvement of a number of institutional actors and service providers.

Figure
THE CLIMATE SERVICES VALUE CHAIN



Source: World Bank, 2021

Recognising the need for climate information to reduce risks and support climate-resilient development, the Climate Investment Funds' (CIF) Pilot Program for Climate Resilience (PPCR) has been investing in climate services at the national level in several countries, including Nepal, Mozambique and Jamaica. **The Building Resilience to Climate-Related Hazards in Nepal** (2013-2020) project aimed to enhance government capacity to mitigate climate-related hazards, by improving the accuracy and timeliness of weather and flood forecasts as well as warnings for climate-vulnerable communities, along with supporting the development of agricultural management information system services to help farmers mitigate climate-related production risks. The **Climate Resilience: Transforming Hydro-Meteorological Services in Mozambique** (2013-2019) project aimed to strengthen hydrological and meteorological information services in order to deliver reliable and timely climate information to local communities, as well as support economic development, with a particular focus on agriculture, aquaculture and fisheries and transport. The **Improving Climate Data and Information Management in Jamaica** (2015-2022)[1] project that is still ongoing aims to improve the quality and use of climate-related data and information for effective planning and action at the local and national levels. This report synthesises experiences and lessons across these three projects along the climate services value chain.

Experiences from these three projects highlight opportunities and challenges that need to be overcome to transform climate services at scale to foster resilience. Within this context, key achievements of the projects can be distilled, according to the different components of the climate services value chain: data collection and management; the development of information, products and services; the delivery of products and services; application in decision-making; along with the cross-cutting issues involving institutional actors and service providers, intermediaries and end-user communities.

Data collection and management have been improved in various ways. Additional surface meteorological and hydrological stations have been installed, with others upgraded and modernised. Other monitoring equipment has been established as relevant to each country's context (for example, the Doppler weather radar in Nepal and Jamaica, as well as the soil-moisture probes and sea-level tide gauges in Jamaica). In addition, a data management system, covering both weather and water, has been installed (for example, the Agriculture Management Information System [AMIS] in Nepal) or replaced and upgraded (as in the case of Mozambique) to be compliant with the World Meteorological Organization (WMO) systems.

New information, products and services, covering a range of sectors, have been developed. They include agrometeorological advisories in Nepal; maritime navigation, aviation and cyclone early warning in Mozambique; along with high-resolution climate-change scenarios and vulnerability assessments for the agriculture and health sectors in Jamaica. Information, products and services have been delivered through a range of media, including newspapers, radio, television, websites, mobile apps, SMS and social media, as well as through a range of intermediaries, including extension officers and the staff of nongovernment organisations (NGOs). These new climate services have demonstrated their application in decision-making by improving maritime navigation, aviation flight planning, agricultural planning and disaster risk reduction (DRR). For example, in Mozambique, the benefit-cost ratios of improved forecasts are 1.26 for lives saved and 1.77 for economic-sector benefits, as per the *Implementation Completion and Results Report.*

The benefits of these improved climate services have been enabled by the actions of institutional actors and service providers, and collaborations between them. Improved collaboration has been enabled between the producers of information (for example, among the different agencies respectively responsible for meteorological and hydrological information, as

well as between meteorological and hydrological agencies and academic institutions), both within countries and regionally. Improved collaboration has also been enabled by data-sharing mechanisms, such as Memoranda of Understanding (MoUs); a stronger mechanism, that is, the institution of legislation, is under development in Nepal. Finally, the development and dissemination of information, products and services have been enabled through intermediary users and end-users, by forging and strengthening partnerships between government ministries and agencies (for example, those responsible for agriculture or DRR), along with the NGOs that are better-placed to communicate with end-user groups. Increased awareness, trust in its quality and use of climate information has been recorded through user surveys in Nepal.

The table below provides more details on the specific achievements from Nepal, Mozambique and Jamaica, along with the remaining priorities that still need to be supported. They are organised by the different components of the climate services value chain.

Table

SUMMARY OF ACHIEVEMENTS TO DATE AND OUTSTANDING PRIORITIES ACROSS THE CLIMATE SERVICES VALUE CHAIN IN THE THREE COUNTRIES[2]

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
NEPAL	Achievements to date	Upgraded meteorological (surface and atmosphere), surface hydrological observation; improved transmission of data to the World Meteorological Organization (WMO); as well as improved IT infrastructure that enabled the establishment of an Agriculture Management Information System (AMIS) and digitised historical datasets in the agriculture sector	Developed daily weather forecasts (24-hour and three-day), daily flood forecasts and early warning during the monsoon season; launched Agromet Advisory Bulletins (AABs) in the Nepali and Avadhi languages; launched the "Hamro Krishi" mobile application providing agriculture and agromet information; along with improved aviation forecasts	Disseminated forecasts and advisories through SMS, radio, TV, the Department of Hydrology and Meteorology's (DHM) social media accounts, the mobile app and newspapers; opened Kisan Call Centres (KCCs) for farmers; as well as distributed mobile phones loaded with the Hamro Krishi app and trained farmers to use it	Use of agricultural information by farmers	Enhanced collaboration between DHM, the Ministry of Agriculture and Livestock Development, along with the Nepal Agricultural Research Council (NARC)	Increased the awareness of climate information, the trust in its quality and its use, particularly among farmers
	Remaining priorities	Develop a national-level data-sharing policy and build in-house capacity for equipment and data management	Develop information targeting different sectors, including tourism (mountaineering), insurance, private airlines and climate-resilient development plans; as well as develop a seven-day forecast (longer lead time), location-specific forecasts and impact-based forecasts	Improve the comprehension of information among users	Applications related to the seven-day forecast (longer lead time), location-specific forecasts and impact-based forecasts	Finalise and approve the hydromet bill to enable cross-government (horizontal and vertical) collaboration; improve the collaboration between the government and the research community; as well as enhance regional collaboration, including data sharing with India and China	Introduce a formal process to collect feedback at the end-users' level; and improve advisories tailored to user needs

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
MOZAMBIQUE	Achievements to date	Improved the meteorological and hydrological observation network through the installation and modernisation of real-time, synoptic and automated stations; as well as operationalised and populated weather and hydrological data management systems that report to WMO	Developed specific climate information targeting marine navigation (sea wave models), aviation (to inform ISO 9001-2015-compliant flight plans), disaster risk reduction (DRR) (a numerical weather prediction [NWP] model to predict cyclones in order to trigger timely response actions)	Delivered flood early warnings, weather and water forecasts to farmers, along with maritime forecasts, to fishing communities and ports	Improved maritime and aviation safety and increased economic returns in farming and fishing	Improved data sharing on weather and water through a Memorandum of Understanding (MoU) and a manual on procedures; improved capacity through partnerships between the government and academia; improved collaboration around disaster risk (weather, water and DRR) through an MoU	Improved collaboration with intermediaries that are better-placed to communicate to diverse user groups
	Remaining priorities	Ensure all stations and water management meet WMO standards; develop a data policy to enable cost recovery parity between weather and water; as well as establish MoUs with local communities to encourage the stewardship of stations	Develop sector-specific climate information for transport, health and tourism, among other sectors that may benefit from climate information to reduce risk	Ensure the appropriate delivery of sector-specific climate information	Improve the use of long-term climate change projections for decision-making across sectors	Improve collaborations within the government; between the government and academia; as well as between the government and nongovernmental organisations (NGOs) involved in DRR	Introduce a formal evaluation process; train user groups on climate service utility; and make available information in languages other than Portuguese

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
JAMAICA	**Achievements to date**	Improved the meteorological (surface and atmosphere) and hydrological observation network and data transmission; as well as conducted the data rescue of past rainfall records	Developed downscaled climate change scenarios; undertook detailed health vulnerability assessment; developed early-warning messaging targeting low-income groups living in unplanned settlements in hazard-prone locations and persons with disabilities, among others.	Data collected by the Water Resources Authority (WRA) made available online	Too early to be seen, since the project is still under implementation	Improved the coordination of data collection and sharing between weather and water; improved cross-government coordination through the hydromet working group; as well as improved collaboration between the government and academia	Too early to be seen, since the project is still under implementation
	Remaining priorities	Expand the observation station coverage, including tidal gauges and sea-surface temperatures; continued data rescue for gap filling, including for soil moisture; install a WMO-compliant data management system; as well as continuously train new data collectors and impact-based forecasters	Develop climate information targeting health, energy, tourism and construction, along with impact-based forecasts	Increase open access to weather data; as well as improve the awareness and active communication of climate information	To be determined toward project completion	Expand cross-government collaboration; improve collaboration between the government and academia; as well as improve regional collaboration	Improve collaboration between producers and users; introduce a formal process to evaluate the ways information is accessed and used, as well as the extent to which it meets user needs

Synthesising the findings and experiences across the three PPCR projects has given rise to several key considerations for transforming climate services, considering the entire climate services value chain. It is important to note that no single investment can transform climate services, nor can climate services ever be effectively achieved by any one actor operating in isolation. PPCR was first launched at a time when climate services were less well developed than now. Addressing data gaps was thus a key priority and this has led to significant progress on the supply side. However, while data collection, management and processing do underpin the information component, attention also needs to be paid to connecting with users, understanding impact, building capacity and fostering collaboration, that is, across the entire climate services value chain and the entire "hydromet ecosystem" of actors necessary for their production, translation, communication and use. Furthermore, it is also critical to consider cross-cutting issues that affect the sustainability of an enabling environment in which service provision and dissemination can take place. In terms of the evolution of thinking and shift in attention to the demand side, PPCR has contributed to this, ensuring that user needs are central to the process from the very start (Atkins International and CIF 2021).

Recommendations for national governments for improving weather, water and climate services, organised by component along the climate services value chain, as well as cross-cutting issues, are set out below.

Data collection and management

- Ensure appropriate staffing and technologies are in place for functional data management (including the collection, quality control, storage and analysis of climate data)

- Ensure institutional arrangements are in place for climate-data sharing (within the country and cross-country)


Photo: World Bank

Development of information, products and services

- Ensure fit-for-purpose climate information, products and services (what the information says and how it is presented, as well as compatibility with the needs of the intended user audience)

Delivery of products and services

- Ensure the availability and accessibility of climate information, products and services (what is communicated, along with how, when and to whom it is communicated)

- Forge partnerships with agencies that possess comparative advantages in the interpretation and communication of climate information, products and services

Application for decision-making

- Build the capacity of producers to produce decision-relevant climate information, products and services
- Build the capacity of user groups (through two-way dialogues) to understand and use climate information, products and services
- Evaluate the perceptions and use of climate information, products and services periodically to know where course corrections and modifications are required

Other cross-cutting issues

- Establish and institutionalise an evaluation system that enables feedback and iteration, based on user feedback
- Ensure an appropriate plan for building human capacity at all stages of the climate services value chain, among producers, intermediaries and users
- Plan for financial sustainability in data collection and management, as well as the development and delivery of climate information, products and services

Institutional actors and service providers

- Ensure the transparency of roles and responsibilities in partnerships needed for the delivery of climate information, products and services
- Consider strategic partnerships to augment production and dissemination capacities

Intermediary users and end-users

- Forge partnerships with varied organisations that possess comparative advantages at different stages of the value chain
- Engage end-users as well as intermediary users from the very beginning
- Build the capacity of user groups (through two-way dialogues) to be better able to inform the design of climate information, products and services

1. INTRODUCTION

Lower-and middle-income countries are typically characterised by a high dependence on natural resources for the national economy and the livelihoods of their populations. The availability of many natural resources, such as for agriculture, forestry and fisheries, is closely linked to weather and climatic conditions. On a day-to-day basis, this means that weather and climate information, such as forecasts and early warning systems (EWSs), is essential for reducing risks and maximising economic opportunities. In the longer term, climate information is essential for strategic planning and enabling adaptation to the impacts of climate change (Alliance for Hydromet Development 2021).

The availability of such weather and climate information in many lower- and middle-income countries is often limited. Infrastructure is often inadequate and unevenly distributed, leaving gaps in information for certain locations. A gap analysis, conducted by the Systematic Observations Financing Facility (SOFF) in 2020, highlighted that, meeting the Global Basic Observation Network (GBON) target of about 2,300 surface and upper air stations in the Small Island Developing States (SIDS) and the Least Developed Countries (LDCs) will require the rehabilitation or installation of about 2,000 stations (SOFF 2020). Where infrastructure does exist, it is often manual in operation, meaning that the collection and transmission of data are subject to human error and delays due to poor communications technology. Given that the timely receipt of weather information is critical – in particular, early warning information for rapid onset events such as floods – these challenges impede effective climate risk management and adaptation.

Based on estimates generated by an economic analysis, upgrading hydromet information production and the early warning capacity of developing countries to the standards of a developed country would yield significant benefits. The total benefits would vary from USD4–36 billion per year (Hallegatte 2012). This figure is derived from avoided asset losses from disasters of USD300 million to USD2 billion per year; the economic value of saving 23,000 lives per year; and USD3–30 billion per year of additional benefits through improved planning and efficiency, based on an accurate knowledge of weather conditions. Since many of the most expensive components of EWSs already exist, such as earth observation satellites and global weather forecasts, there is significant cost efficiency in further investment. Benefit-cost ratios are estimated to range from four to 36, meaning that every dollar invested yields between USD4 and USD36 of benefits (Hallegatte 2012). A more recent analysis suggests that every dollar invested in GBON could realise at least USD26 in socioeconomic returns.

Recognising the importance of climate information for adaptation and to build resilience to the effects of climate change and the potential cost efficiency, the Climate Investment Funds' (CIF) Pilot Program for Climate Resilience (PPCR) has emphasised hydromet services in a number of its projects. As PPCR projects related to hydromet and climate services are coming to an end in some countries, there are opportunities to synthesise experiences across a variety of different case study contexts. This report was commissioned by CIF's Evaluation and Learning (E&L) Initiative to provide a synthesis of insights from three PPCR projects into how to effectively invest in hydromet services at scale to foster resilience.

This report is organised around the lessons learned across the climate services value chain. It presents the achievements and experiences from the implementation of three PPCR projects (see table 1):

Building Resilience to Climate-Related Hazards in Nepal (BRCH) (2013-2020) aimed to enhance the government's capacity to mitigate climate-related hazards by improving the accuracy and timeliness of weather and flood forecasts and warnings for climate-vulnerable communities, as well as support the development of agricultural management information system services to help farmers mitigate climate-related production risks.

Climate Resilience: Transforming Hydro-Meteorological Services in Mozambique (2013-2019) aimed to strengthen hydrological and meteorological information services' delivery of reliable and timely climate information to local communities and support economic development, with a particular focus on agriculture, aquaculture and fisheries and transport.

Improving Climate Data and Information Management in Jamaica (ICDIMP) (2015-2022) aims to improve the quality and use of climate-related data and information for effective planning and action at the local and national levels, with a particular focus on agriculture, water and health.

Table 1.
SUMMARY OF PPCR'S CLIMATE SERVICES INITIATIVES IN NEPAL, MOZAMBIQUE AND JAMAICA

COUNTRY	NEPAL	MOZAMBIQUE	JAMAICA
Aim	To enhance government capacity to mitigate climate-related hazards by improving the accuracy and timeliness of weather and flood forecasts and warnings for climate-vulnerable communities, as well as support the development of agricultural management information system services to help farmers mitigate climate-related production risks	To strengthen hydrological and meteorological information services' delivery of reliable and timely climate information to local communities and support economic development	To improve the quality and use of climate-related data and information for effective planning and action at the local and national levels.
Timeline	June 2013 - November 2020	September 2013 -December 2019	September 2015 - April 2022
Project Finance	USD31 million (PPCR grant of USD15 million and International Development Association [IDA] loan of USD16 million)	USD21 million (PPCR grant of USD15 million and the Nordic Development Fund [NDF] grant of USD6 million)	USD6.8 million (PPCR grant)
Implementing Multilateral Development Bank (MDB)	World Bank	World Bank	World Bank
Components	(i) Institutional strengthening and capacity building of the Department of Hydrology and Meteorology (DHM) (ii) Modernisation of hydrometeorological observation networks and forecasting system (iii) Enhancement of DHM's service delivery system (iv) Creation of an Agriculture Management Information System (AMIS), anchored at the Ministry of Agriculture and Livestock Development (MoALD)	(i) Strengthening Hydrological Information Management (ii) Strengthening Weather and Climate Information Management (iii) Delivery of improved weather and water information to support pilot interventions to enable more effective end-to-end delivery	(i) Upgrading hydrometeorological data collection, processing and forecasting systems (ii) Climate-resilient planning and hydro-meteorological information services (iii) Climate change education and awareness raising towards behavioural change
Target sector(s)	Agriculture and aviation	Agriculture, aquaculture and fisheries, along with transport	Agriculture, water and health

These three study countries have been selected from the PPCR portfolio due to the differences in their geographical settings, institutional frameworks and sectoral foci for the climate services generated. While Nepal has a mountainous environment, Mozambique and Jamaica both have significant coastal areas. In Nepal, meteorology and hydrology are combined under one Department of Hydrology and Meteorology (DHM), unlike both Jamaica and Mozambique that have divided the responsibilities for meteorology and hydrology among multiple authorities. While Jamaica has the Meteorological Service of Jamaica (MSJ) and Water Resources Authority (WRA), Mozambique has the National Institute for Meteorology (INAM), along with the National Directorate of Water Resources Management (DNGRH) and regional water authorities (ARAs). The meteorological and hydrological departments are also housed under various sectoral ministries. In Nepal, DHM is under the Ministry of Energy, Water Resources and Irrigation. With Jamaica and Mozambique, MSJ is under the Ministry of Housing, Urban Renewal, Environment and Climate Change and INAM is under the Ministry of Transport and Communications for meteorology, respectively. As for hydrology, DNGRH in Mozambique is under the Ministry of Public Works and Housing and Water Resources, while WRA in Jamaica is under the Ministry of Economic Growth and Job Creation. As outlined in table 2, although agriculture is the common sectoral focus for the climate services developed under PPCR among the three countries, the additional sectoral foci varies among the three countries. While aviation is important in Nepal, aquaculture and fisheries, along with transport, are important in Mozambique, with water and health being the foci in Jamaica.

As a result of these complementary geographical and institutional contexts in Nepal, Mozambique and Jamaica, it is possible to distil robust and in-depth insights on climate service delivery and use. of these three projects. More specifically, the report draws on the three experiences to synthesise key learnings related to the development of climate information, products and services; the delivery of products and services; their application for decision-making; institutional actors and service providers; intermediary users and end-users; along with cross-cutting issues. It draws on project documentation, including project reviews and completion reports for Nepal and Mozambique (the Jamaica project is still under implementation). The report also draws on primary data collected in each country through key informant interviews with government institutions, nongovernmental organisations (NGOs) and international organisations, as well as focus group discussions with local communities (in Nepal and Mozambique) used to produce country-level reports. The aim is to generate learning and strategic insights into the different operational pathways that can be taken by national hydrological and meteorological agencies to develop, deliver and strengthen hydrometeorological and climate services.

The report will be of interest to funders considering investing in hydromet and climate services projects in developing countries, to inform where best to place their resources along the climate services value chain and how such projects could be designed and implemented. It will also be of interest to the National Meteorological and Hydrological Services (NMHSs) interested in strategically reviewing their own approaches and learning from the experiences of other countries.

The report is structured as follows. Section 2 gives an overview of the development and evolution of climate services, as well as PPCR. Section 3 synthesises the key lessons from the three PPCR countries across the climate services value chain, comparing and contrasting the lessons learned and outstanding challenges as identified by project teams and partners. Distilling these experiences, together with the broader body of evidence on climate services, Section 4 summarises the key lessons for transforming hydromet services that are applicable to other contexts, bearing in mind the need for attention to be paid across the whole value chain. Section 5 then provides a conclusion that contextualises these findings in light of future investment needs.

2. THE GROWTH OF CLIMATE SERVICES

Box 1:
CLIMATE SERVICES VS HYDROMET SERVICES

The aims of climate services and hydromet services are similar, but there is no agreement on how best to refer to them. Internationally, "climate" services are promoted by the World Meteorological Organization (WMO) as "climate information to help individuals and organizations make climate smart decisions". "Hydromet" services explicitly include water, as well as weather and climate information, in the provision of real-time forecasts along with early warning and climate information, to end-users. Given the common aims, the terms are used interchangeably in this report to refer to weather, water and climate information for decision-making.

Recognising the critical role of weather and climate information in informing adaptation has led to a growth in the notion of "climate services". Climate services is concerned with delivering climate information that is useful to decision-makers and useable by them to reduce climate risk.

Several decades of evolution of World Climate Conferences, related research programmes and frameworks for the coordination of infrastructure have culminated in the establishment of the World Meteorological Organization's (WMO) Global Framework for Climate Services (GFCS) in 2009 (Hewitt et al. 2012). The vision of GFCS is "to enable better management of the risks of climate variability and change and adaptation to climate change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scale." A related initiative is the Climate Services Partnership that was established for collaboration and knowledge sharing among a wide range of stakeholders, as well as advance climate service capacities worldwide. It also runs the

International Conference on Climate Services every couple of years.

Providing climate services requires different approaches and the involvement of several actors, often with fluid boundaries separating them, depending on the service in question. This includes producers of climate information, as well as intermediary users and end-users of that climate information. Producers are typically the meteorological and hydrological service providers responsible for the collection, management and processing of data. Intermediary users transform and translate the information into sector-specific information to produce climate information products and services. Finally, end-users refer to the stakeholders in need of a finished useable climate advisory service or product that they can use for their decision-making process; they may include farmers and fishermen, as well as national decision-makers and planners.

The recent trend, marked by a shift to a focus on “services”, acknowledges that, in order to be useful for informing resilience and adaptation decisions, climate information needs to be targeted and tailored for application to different decision contexts. This requires increasing dialogue between the “producers” and “users” of information in order to identify these information needs. The early Regional Climate Outlook Fora (RCOFs) were the early precursors of climate services. RCOFs deliver consensus-based climate outlook products—typically seasonal forecasts—through the cooperation of national and regional meteorological and hydrological actors, along with the users of this information from different sectors, including water, agriculture and disaster risk reduction (DRR). All these stakeholders are typically invited to RCOFs (Daly and Dessai 2018). Climate services takes this one step further by actively encouraging user inputs into the design and format of information and products. The climate services value chain further differentiates “users” by creating the categories of “intermediary users” and “end-users”, as well as placing them in different positions along the chain. Intermediary users may include the likes of government departments working in partnership with the producers of weather and climate information, while end-users refer to groups using that information directly to inform their decisions.

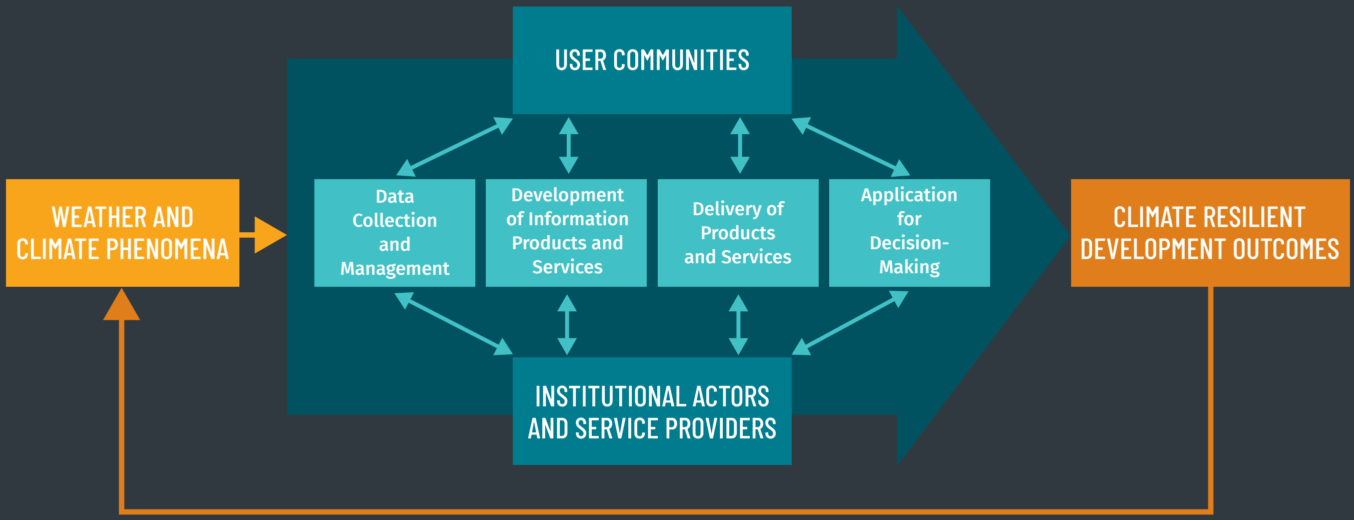
The climate services value chain highlights the different stages necessary for producing climate services (see figure 1). Most fundamentally, climate services require data from observation and monitoring. Based on its recognition of the inadequacies in the availability and quality of climate data in many parts of the world, GFCS highlights the need to first develop information, products and services and then ensure their availability by delivering them in a timely manner for application to decision-making contexts in order to support climate resilience and adaptation. Thus, with this approach, there is a significant emphasis on users and their demand for climate services, compared to the more traditional supply-based approach led by producers of information (Webber and Donner 2017).

While the observation, monitoring, storage and processing of this data have long been the remit of NMHSs, the downstream components of user engagement and the delivery of information, products and services require a transformation in their approach (Goddard 2016). There has been growing recognition that NMHSs need to build capacity in their engagement approaches and these downstream aspects of service delivery (Mahon et al. 2019). There are also increasing partnerships with the private sector in the production of climate services. With appropriate legislation in place, the private sector has a role to play in supporting the provision of climate services needed by both public and private actors (Rogers et al. 2021).

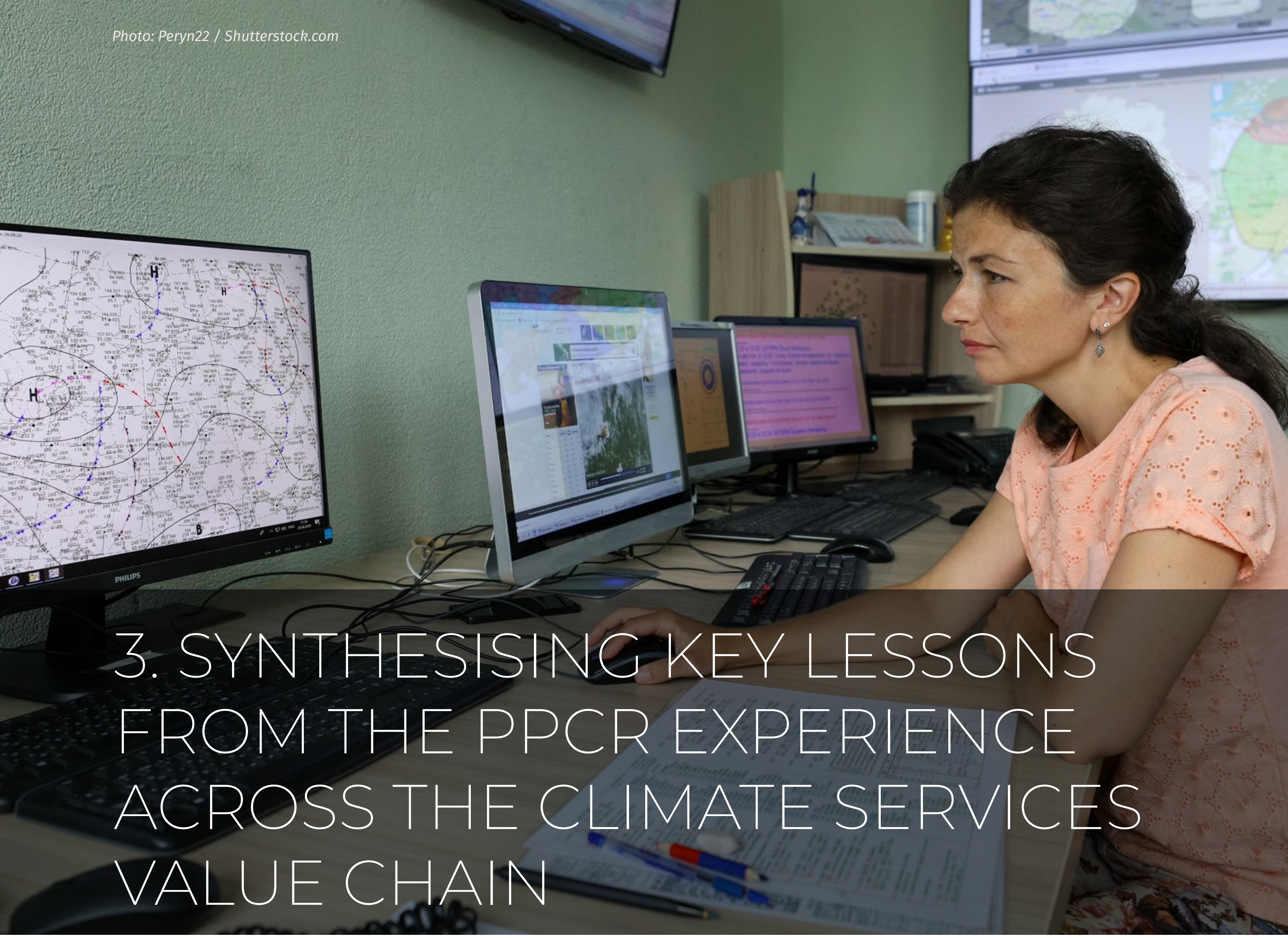
Other global initiatives to support climate service development include the Alliance for Hydromet Development. Launched in 2019, it brings together various actors committed to closing the hydromet capacity gap by 2030. It aims to do this by strengthening the capacity of NMHSs for the sustained operation of observational systems and data exchange that meet WMO standards for minimum monitoring coverage and reporting frequency. Moreover, it also leverages the financial resources and expertise of the private sector to provide sustainable solutions and modernise the hydromet infrastructure in developing countries.

Climate services are key to the premise of PPCR and the outcome it aims to achieve. The overall objective of PPCR is improved climate-resilient development, to be achieved through four pillars of activity: (1) policy and enabling environment; (2) physical investments; (3) capacity building; and (4) knowledge management. Country-level outcomes require that climate information is routinely applied in decision-making, with the associated output that climate data and information management are improved. As of 2021, the majority of the PPCR-supported climate services projects (including Nepal and Mozambique) have finished, while others (including Jamaica) are still under implementation.

Figure 1.
THE CLIMATE SERVICES VALUE CHAIN



Source: World Bank, 2021



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3. SYNTHESISING KEY LESSONS FROM THE PPCR EXPERIENCE ACROSS THE CLIMATE SERVICES VALUE CHAIN

Corresponding to the different starting contexts, the support to climate services development through PPCR in the three countries has taken different forms. Comparing and contrasting them, in relation to the different stages of the climate services value chain, thus enables the distillation of key lessons that can inform future investments for transforming climate services. Table 2 compares and contrasts the experiences of all three countries, in terms of their achievements to date and future priorities across the different stages of the climate services value chain. Additional elaboration of the specific achievements of each project is available in Annex A, while Annex B provides a tabular overview of the achievements and outstanding needs of each country, organised by the stages of the climate services value chain.

Table 2.

SUMMARY OF ACHIEVEMENTS TO DATE AND OUTSTANDING PRIORITIES ACROSS THE CLIMATE SERVICES VALUE CHAIN IN NEPAL, MOZAMBIQUE AND JAMAICA

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
NEPAL	Achievements to date	Upgraded meteorological (surface and atmosphere) and surface hydrological observation; improved the transmission of data to the World Meteorological Organization (WMO); as well as improved IT infrastructure, which enabled the establishment of an Agriculture Management Information System (AMIS) and the digitisation of historical datasets in the agriculture sector	Developed daily weather forecasts (24-hour and three-day), along with daily flood forecasts and early warning during the monsoon season; launched Agromet Advisory Bulletins (AABs) in the Nepali and Avadhi languages; launched the "Hamro Krishi" mobile application that provided agriculture and agromet information; along with improved aviation forecasts	Disseminated forecasts and advisories through SMS, radio, TV, the Department of Hydrology and Meteorology's (DHM) social media accounts, the mobile app and newspapers; opened the Kisan Call Centres (KCCs) for farmers; and distributed mobile phones loaded with the "Hamro Krishi" app and trained farmers	Use of agricultural information by farmers	Enhanced the collaboration between DHM, the Ministry of Agriculture and Livestock Development (MoALD), along with the Nepal Agricultural Research Council (NARC)	Increased the awareness of climate information, trust in its quality and its use, particularly among farmers
	Remaining priorities	Develop a national-level data-sharing policy and building in-house capacity for equipment and data management	Develop information targeting different sectors, including tourism (mountaineering), insurance, private airlines and climate-resilient development plans; as well as develop a seven-day forecast (longer lead time), location-specific forecasts and impact-based forecasts	Improve the comprehension of information among users	Applications related to the seven-day forecast (longer lead time), location-specific forecasts and impact-based forecasts	Finalise and approve the hydromet bill to enable cross-government (horizontal and vertical) collaboration; improve the collaboration between the government and the research community; as well as improve regional collaboration, including data sharing with India and China	Introduce a formal process to collect feedback at the end-users' level; and improve advisories tailored to user needs

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
MOZAMBIQUE	Achievements to date	Improved the meteorological and hydrological observation network through the installation and modernisation of real-time, synoptic and automated stations; as well as operationalised and populated the weather and hydrological data management systems that report to WMO	Developed specific climate information targeting marine navigation (sea wave models), aviation (to inform ISO 9001-2015-compliant flight plans) and disaster risk reduction (DRR) (numerical weather prediction [NWP] model to predict cyclones in order to trigger timely response actions)	Delivered flood early warnings, weather and water forecasts to farmers, along with maritime forecasts to fishing communities and ports	Improved maritime and aviation safety, as well as improved economic returns in farming and fishing	Improved data sharing on weather and water through a Memorandum of Understanding (MoU) and a manual on procedures; improved capacity through partnerships between the government and academia; as well as improved collaborations around disaster risks (weather, water and DRR) through an MoU	Improved collaborations with intermediaries that are better-placed to communicate to diverse user groups
	Remaining priorities	Ensure all stations and water management meet WMO standards; develop a data policy to enable cost recovery parity between weather and water; as well as establish MoUs with local communities to encourage the stewardship of stations	Develop climate information for the health and tourism sectors	Ensure the appropriate delivery of sector-specific climate information	Improve the use of long-term climate-change projections for decision-making across sectors	Improve collaborations within the government, between the government and academia, as well as between the government and nongovernmental organisations (NGOs) involved in DRR	Introduce a formal evaluation process; train user groups on climate service utility; and make available information in languages other than Portuguese

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
JAMAICA	Achievements to date	Improved the meteorological (surface and atmosphere) and hydrological observation network and data transmission; as well as conducted the data rescue of past rainfall records	Developed downscaled climate-change scenarios; undertook detailed health vulnerability assessment; developed early-warning messaging targeting low-income groups living in unplanned settlements in hazard-prone locations and persons with disabilities, among others.	Data collected by the Water Resources Authority (WRA) made available online	Too early to be seen, since the project is still under implementation	Improved the coordination of data collection and sharing between weather and water; improved cross- government coordination; as well as improved collaboration between the government and academia	Too early to be seen, since the project is still under implementation
	Remaining priorities	Expand observation station coverage, including tidal gauges and sea-surface temperatures; continued data rescue for gap filling, including for soil moisture; install a WMO-compliant data management system; as well as train new data collectors and impact-based forecasters	Develop climate information targeting health, energy, tourism and construction; and impact-based forecasts	Increase open access to weather data; as well as improve the awareness and active communication of climate information	To be determined towards project completion	Improve data sharing through a policy; improve cross-government collaboration; improve the collaboration between the government and academia; as well as improve regional collaboration	Improve the collaboration between producers and users; as well as introduce a formal evaluation process

3.1 DATA COLLECTION AND MANAGEMENT

Data is the foundation of a reliable scientific understanding of the climate system: its input into models is a prerequisite for producing weather and climate information. Observational hydromet records are used to inform the design of meteorological and climatological models, as well as to verify outputs from such models. Thus, forecasts and modelling outputs are directly dependent on the availability of observational data, which means that a robust observational network is necessary for weather and climate monitoring, as well as required for improving forecasting systems (WMO 2020). Being able to translate data into effective climate services requires that it is not only collected, but also managed and shared.

3.1.1 POSITIVE RESULTS ACHIEVED

3.1.1.1 Data collection

Helping countries to become GBON-compliant was a key achievement of PPCR across Nepal, Mozambique and Jamaica. The installation and upgrading of weather and hydrological stations was a key component in all three projects. In Nepal, 88 surface meteorological and 70 surface hydrological observation stations were upgraded to automated stations that allow for real-time data collection. New Doppler radars were installed in Nepal and Jamaica, thus enabling the improved detection of heavy rainfall, among other parameters (table 3).

Table 3.
SUMMARY OF OBSERVATIONAL EQUIPMENT INSTALLED/UPGRADED THROUGH PPCR IN NEPAL, MOZAMBIQUE AND JAMAICA

NATURE OF NEED	TYPE OF EQUIPMENT	NEPAL	MOZAMBIQUE	JAMAICA[3]
Universally required	Surface meteorological stations	88 Automated Weather Stations (AWSs) were installed and operationalised, of which 21 AWSs were installed in, or near, airports to benefit the aviation sector.	27 AWSs and one maritime AWS installed; 13 climatological (synoptic) stations modernised (with total 87 stations at project close); along with three Automated Weather Observing Systems (AWOSs) installed at the airports of Beira, Nampula and Lichinga	53 AWSs installed, including 14 agrometeorological and 39 weather stations
	Surface hydrological stations	70 hydrological stations installed and operationalised	58 river gauge stations rehabilitated and newly installed	40 rain gauges and water-level sensors modernised; along with 57 hydromet stations installed
	Doppler radar	Installed at Surkhet		Installed at Cooper's Hill
Country-specific needs	Lightning detectors	Lightning detection system—"Linet" (comprising nine stations) installed		
	Upper Air sounding station	One installed at Kirtipur, Kathmandu		
	Sea-level tide gauge			One installed at Montego Bay pier and two more procured
	Soil-moisture probes			32 procured and installed
	Meteorological equipment calibration lab	A laboratory to calibrate thermometers, hygrometers and air-pressure gauges established and operationalised at the Department of Hydrology and Meteorology (DHM)		

3.1.1.2 Addressing data gaps

While the installation of new observational equipment can improve data availability moving forward, it does not address past gaps in the records. In Jamaica, a fire in 1992 destroyed paper observational records, giving rise to gaps in monthly rainfall data. Data recovery under PPCR has contributed to filling those gaps.

Nepal's BRCH project, in contrast, did not seek to address data gaps from the past. Nevertheless, the project still provides a solid foundation for data storage and management, since the installation and operationalisation of automated stations will prevent any future gaps in the data.

3.1.1.3 Data management

For additional observational data to be effective, there needs to be an effective system in place for data management. Such systems should enable timely management and processing to ensure the prompt development of information products. Data management systems are particularly important, considering the range of hydromet data collected from observation networks in each country, in combination with various stations gathering different sets of data at different frequencies. In Mozambique, for example, INAM maintains a mix of a surface observation network—comprising manual synoptic stations that report at different frequencies, depending on staffing, Automated Weather Stations (AWSs) generating hourly synoptic messages and manual climate stations providing manual daily observations. This is complemented by a different network maintained by DNGRH for hydrological observations.

Furthermore, improvements have also been made to data management systems, ranging from physical infrastructure to software, in Nepal, Mozambique and Jamaica. In Nepal, a new DHM building was constructed, containing new IT infrastructure, labs for remote sensing, along with geographic information system (GIS) and data management systems, to support better climate information management. A new database management system (DMS), installed at the Government Integrated Data Centre (GIDC) in 2018, has been in operation since then. With the installation and operation of the DMS, DHM has benefited from managing meteorological and hydrological data through an integrated database and a web-based data entry platform for manually operated hydromet stations. Importantly, the new DMS has improved quality control through both automatic and human features.

In Mozambique, the improvements to data management, made for both arms of the NMHSs—INAM (meteorological) and DNGRH (hydrological)—have resulted in improved integration across multiple data streams. INAM's data management system was replaced and upgraded with Climsoft that enables reporting with WMO's Global Observational and Telecommunication System (GTS). Within DNGRH, a National Integrated Water Resources Management Information System (NIWRMIS) that is connected with a geographic information system (GIS) platform to other web interfaces was developed. This has enabled the integration, processing and management of multiple streams of water resources data to be more effective: it is able to host information from 717 water stations, 17 reservoirs, 1,389 rainfall stations, 7,686 boreholes, 3,598 National Directorate for Water Supply and Sanitation (DNAAS *[Direcção Nacional Abastecimento de Agua e Saneamento]*) sites, 428 water use licences, along with 6,598 recovered and digitised historical records. In addition, data was migrated to an open-source time-series hydrological data system used by the ARAs and DNGHR for data transmission and reporting.

In Jamaica, a hydrological monitoring centre and a situation room were established for the remote monitoring of hydrological resources by WRA.

3.1.1.4 Data sharing

Improvements in data management make it easier to share data. The improvements in data collection and management, implemented across Nepal, Mozambique and Jamaica, mean that each country is better able to transmit data to the WMO Information System (WIS)/ WMO Global Telecommunication System (GTS), thereby conforming with global standards.

Data sharing within countries is important for developing effective climate services; yet this is typically impeded by the fact that multiple institutions in these three countries have varying roles in the collection, management, processing and dissemination of climate information. In Jamaica, for example, data sharing between WRA and MSJ took considerable time, thus causing inefficiencies. A Memorandum of Understanding (MoU) between the two institutions was thus established to facilitate the sharing of hydromet data from rainfall, intensity and streamflow stations. Further, the MoU enhanced the coordination between the two institutions to locate hydromet stations and expand the spatial coverage of data collection. Likewise, in Mozambique, an MoU between INAM and DNGRH, along with the development of a manual for procedures, has facilitated data sharing. In Nepal, early discussions have taken place between DHM and MoALD regarding the sharing of past data, including from the AWSs, between the two institutions.

3.1.2 PRIORITIES FOR FURTHER DEVELOPMENT

Despite the positive achievements across the PPCR projects in data collection and management, there remain opportunities for improvement.

3.1.2.1 Data collection

Data collection improvements are typically expensive, requiring hardware and concurrent investments in staff capacity to manage increased data quantities. None of the three countries has attained the recommended density of observation networks as per GBON. The influence of the microclimate is particularly significant in the mountainous landscape of Nepal and the varied island topography in Jamaica: such areas need a higher density of stations to capture microclimate diversity to represent this in forecasts and early warnings. Depending on the particular geographical context, there is also scope for improving data collection in different parameters: examples include soil moisture (flood and drought monitoring); groundwater (the evaluation of the impacts of climate change through saltwater intrusion); sea level (the determination of trends in sea level as well as storm surges and other coastal hazards); and sea-surface temperature (climate projections and seasonal forecasting, as well as the evaluation of coral bleaching).

Although there is an increased number of stations, the type of station and the reporting frequency still vary. For the synoptic weather stations requiring manual recording, there are issues with geographical access and staffing across all three countries. Some gauge readers in Nepal have to read up to three stations per day; moreover, the lack of training and supervision, coupled with insufficient financial incentives, can undermine the quality of data collected, as well as the timeliness of recording and delivery. In Jamaica, due to remote connection issues, even the data from the AWSs has to be periodically downloaded manually, which renders it at risk of the same issues of timeliness as the synoptic weather stations. Another challenge observed in Jamaica is that the trained network of observers is ageing, with a large number retiring, and thus there is a need to train new observers.

While some progress has been made across the three countries in meeting international standards, there is room to further enhance the data collection process by ensuring that the stations hosted by the meteorological and hydrological services adopt the WMO Integrated Global Observing System (WIGOS) and the World Hydrological Cycle Observing System (WHYCOS) frameworks, as appropriate. These frameworks represent efforts to integrate WMO and WMO-co-sponsored observing systems into a single common design, management and regulatory framework to increase efficiency and effectiveness (Balogh and Kurino 2020).

3.1.2.2 Data management

Increasing observation station density is also accompanied by a concomitant rise in the volume of data generated, thus requiring sufficient technical capacity to handle, which, in turn, means additional staff capacity. However, in Nepal, the number of staff at DHM has remained static, even as the amount of data reported has increased significantly because of the additional AWSs. This has impeded the capacity of the staff to be able to utilise the new data management infrastructure to optimum capacity.

With upgraded data management systems (DMSs) in place in Nepal and Mozambique, there is significant potential to expand analytical capacity. This could take place in various ways. One could be the integration of remote sensing and GIS resources through international and freely available data repositories (for example, data from Sentinel Hub, Landsat and MODIS). Other ways could be managing additional technical human resources through organisation and management surveys, as well as human resources capacity mapping. In Jamaica, a priority is to implement a data management system that enables the archiving, management and processing of observational data. An open-source system and licence-free system, such as WMO's Meteorological, Climatological and Hydrological Database Management System (MCH), could be considered (WMO 2021).

3.1.2.3 Data sharing

PPCR was successful in addressing some of the data-sharing challenges through the establishment of MoUs. However, a stronger and more long-lasting mechanism to formalise data sharing comes from a data-sharing policy or ensuring the coherence of existing policies. Such a policy is relevant for national data sharing between different institutions, particularly those responsible for weather and water. Without such policies in place, revenue-raising incentives for NMHSs may act as a powerful barrier to sharing information with intermediary users. Appropriate data-sharing legislation can also pave the way for the private sector to play a supportive role in data collection, management and sharing (Rogers et al. 2021). However, policies for data sharing are also relevant at the regional and international levels, where the sharing of data is important as inputs to larger-scale modelling efforts for generating information that is useful at the national and subnational levels.

All three countries are members of the relevant RCOFs: the South Asian Seasonal Climate Outlook Forum (SASCOF) for Nepal; the Southern African Regional Climate Outlook Forum (SARCOF) for Mozambique; and the Caribbean Climate Outlook Forum (CariCOF) for Jamaica. In Nepal, for example, common climatic conditions with neighbouring India and China create a powerful argument for data sharing. The sharing of data/information on Glacial Lake Outburst Floods (GLOF) and possible Landslide Dam Outburst Floods (LDOF), due to a landslide blocking streams in Tibet, occurred a few times between Nepal and China in the past, but no formal mechanism of regular data sharing has been established. Such data sharing could be useful, not only for extreme events such as GLOF, but also for more efficient agrometeorological advisories.

Table 4 below summarizes the key priorities for further development in the three countries for data collection, management and sharing.

Table 4.
SUMMARY OF KEY PRIORITIES FOR DATA COLLECTION AND MANAGEMENT

Data collection	• Increase the density of observation stations to meet the Global Basic Observing Network (GBON) standards (Nepal, Mozambique and Jamaica) • Upgrade the stations to Automated Weather Stations (AWSs), where network connectivity allows (Nepal, Mozambique and Jamaica) • Increase data collection for different parameters, for example, soil moisture (Jamaica), groundwater (Jamaica), sea level (Mozambique and Jamaica) and sea-surface temperature (Mozambique and Jamaica) • Upgrade to ensure that all meteorological and hydrological services conform with the World Meteorological Organization's (WMO) standards (that is, the WMO Integrated Observing System [WIGOS] and the World Hydrological Cycle Observing System [WHYCOS]) (Nepal, Mozambique and Jamaica)
Data management	• Introduce a WMO-compliant open-source data management system (DMS) (Jamaica) • Build staff capacity for optimum data management and analysis (Nepal, Mozambique and Jamaica)
Data sharing	• Adopt a data-sharing policy or ensure the coherence of existing data policies (Nepal, Mozambique and Jamaica) • Pursue opportunities for regional data sharing (Nepal, Mozambique and Jamaica)

3.2 DEVELOPMENT OF INFORMATION, PRODUCTS AND SERVICES

Having a solid foundation, in terms of data collection and management, is essential to the development of climate services, which have the potential to build resilient livelihoods and protect development gains. In addition, ensuring that the development of information, products and services meet users' needs requires understanding of decision-making contexts (Jones et al. 2015). The three PPCR projects have developed a range of information, products and services targeting different sectors.

3.2.1 POSITIVE RESULTS ACHIEVED

In Nepal, information, products and services related to early warning, which are targeted at the agricultural sector, have been created. Forecasts covering 24-hour and three-day periods were developed, together with daily flood forecasting and early warning during monsoon season. An Agromet Advisory Bulletin (AAB) was also developed.

In Mozambique, information, products and services related to flood early warning and improved forecasts were developed. A numerical weather prediction (NWP) model, used by INAM, tracks cyclone development and trajectories to inform preparedness and response. The AWS at Inhambane port informs the sea wave models of five major coastal cities, along with Inhambane itself, for the improvement of maritime safety. Aviation-specific forecasts have been developed: ISO-9001-2015 (Quality Management System) real-time meteorological information is now used for flight plans for the Lichinga, Nampula and Beira airports.

In Jamaica, information, products and services have informed longer-term sectoral planning processes. Downscaled high resolution (10-4km blocks) climate scenarios have been produced in partnership with the University of the West Indies-Mona, for 2030, 2050 and 2080, together with the *State of the Jamaican Climate Report 2015* that assesses climate trends and sectoral impacts. Vulnerability assessments have also been produced for the agriculture, water and health sectors.

3.2.2 PRIORITIES FOR FURTHER DEVELOPMENT

While improvements have been made in the development of information, products and services, a number of outstanding needs and opportunities for sectoral expansion remains. Key priority sectors for information in Nepal include tourism (for example, avalanche early warnings); insurance (for informing weather-based index insurance products); aviation (for expanding the availability of aviation-specific forecasts to private airlines and helicopter operators); and infrastructure development (for example, addressing the vulnerability of hydropower generation to climate change). In Mozambique, transport, health and tourism have been identified as key sectors with future climate service needs. Jamaica has highlighted health and tourism, together with energy and construction as key priority sectors, for climate information.

Meeting user needs is a key component of effective climate services. Further opportunities for the development of information, products and services reflect the spatial and temporal priorities and the intended applications of user groups. In Nepal, farmers have expressed interest in a seven-day forecast, noting that the current three-day forecast does not provide them with enough time to make decisions, prepare for the weather conditions and make the necessary adjustments in their farming operations. There has also been interest in district-level forecasts, requiring a higher spatial resolution than currently provided to better represent spatial diversity. Finally, interest has also been expressed in impact-based forecasts in disaster risk management and the agricultural sector, which is focused on what the weather will do as opposed to merely what it will be. At the same time, developing user-driven information, products and services that can cater to the demand of their users also requires that there is sufficient technical capacity and resourcing for the staff, as well as the operations and maintenance costs of NMHSs.

Table 5 below summarizes key priorities for further development of information, products and services in the three countries.

Table 5.
SUMMARY OF KEY PRIORITIES FOR DEVELOPING INFORMATION, PRODUCTS AND SERVICES

Development of new products	• Climate services targeting the tourism sector (Nepal, Mozambique and Jamaica) • Climate services targeting the health sector (Mozambique and Jamaica) • Climate services targeting the insurance sector (for example, to enable weather-based index insurance products) (Nepal) • Climate services targeting the infrastructure sector (for example, to inform hydropower generation) (Nepal) • Impact-based forecasts (Mozambique and Jamaica)

3.3 DELIVERY OF INFORMATION, PRODUCTS AND SERVICES

Once information, products and services are developed, it is essential that they are effectively disseminated to the target audiences by considering their preferences for the medium of delivery. A range of different dissemination strategies have been employed across PPCR in the three countries, depending on the product or service.

3.3.1 POSITIVE RESULTS ACHIEVED

In Nepal, forecast information was disseminated through a range of media (both passive and active). This included DHM's website, radio, newspapers, television, SMS and social-media applications, such as Facebook and Twitter. The Agromet Advisory Bulletins (AABs) were made available in both the Nepali and Avadhi languages through the AMIS portal, mobile app, SMS, radio, television and newspapers. Two specific mechanisms were established to deliver agroclimatic and weather information to farmers: (1) the "Hamro Krishi" mobile app launched as a one-stop agriculture and agromet store for farmers and agricultural extension officers; and (2) 52 Kisan Call Centres (KCCs) opened at the District Agriculture Development Offices (DADOs) and the District Livestock Service Offices (DLSOs) in 26 pilot districts to timeously deliver agroclimatic and weather information under EWSs to farming communities.

In Mozambique, improvements have been made in providing information to the district directorates at the district scale. Coordination mechanisms exist between hydrological agencies—INAM and the National Institute of Disaster Risk Management and Reduction *(Instituto Nacional de Gestão e Redução do Risco de Desastres [INGD])* in the case of early warning, as well as between the district-level government, the local hydro and met agencies and the INGD office, along with the community radio and community leaders, in terms of disseminating information at the local level.

In Jamaica, early warning messaging is targeted at vulnerable communities, including low-income groups living in unplanned settlements in hazard-prone locations, as well as persons with disabilities, among others.

3.3.2 PRIORITIES FOR FURTHER DEVELOPMENT

Despite significant efforts to improve the dissemination of information, products and services, along with their adoption by a wide range of media across the countries, there remains opportunities for improvement.

3.3.2.1 Awareness of available information

First of all, there is a need to actively improve the awareness of the range of information, products and services that exist. For example, at a training session for volunteer climate observers in Jamaica, many volunteers were not aware of the climate information products produced by MSJ. Expanding the capacity to use information is also important. In Mozambique, representatives from community radio initiatives indicated that they would be interested in receiving training to better understand the forecasts issued by INAM. This, in turn, would enable them to act more effectively as intermediaries, thereby improving the communication and credibility of climate information.

3.3.2.2 Use of media channels

Although significant improvements were made in the range of media used to disseminate messages, these improvements can be expanded. There is recognition that the ways in which people expect to be provided with information are changing. For example, in the past, people could have been expected to visit a website to find a forecast, but now, there is more need for actively pushing information out through social media. At the same time, while electronic communication has expanded the range of media, there is a need to remember the digital divide across all three countries and thus, efforts need to be taken to proactively target those with limited or no access to electronic communication.

3.3.2.3 Timely delivery

The timely delivery of weather information is essential. In order to generate information in good time, staged processes can be used. This means less accurate longer-range forecasts are used over a long lead time to identify potential advisories. They are then supplemented with detailed shorter-range forecasts that can generate targeted early warnings.

Furthermore, timely generation needs to be accompanied by timely delivery so that people who need the information receive it with sufficient time to mitigate the risk. Additionally, it is also important to consider the timing of the information dissemination. Farmers and fishers tend to be busy working during the daytime, and may not be able to give due attention to early warning messages. So, sharing early-warning messages in the evening with sufficient lead time would help spread the message effectively.

3.3.2.4 Relevant and accessible information

Improvements are also needed to better understand climate information. Even if the information is well disseminated, it will not be used if it is not understood. In Nepal, weather information was not available in an easily understandable language for local governments in remote landslide-prone hilly districts, thus impeding them from being able to use it to reduce risk. In Mozambique, the technical language and the communication of the information in Portuguese (the official language of the country)—only spoken by about half of the population—means that various populations could not make use of the information. Since INAM is not able to provide information in local languages, intermediaries have been using proxy terms that can be understood differently by different populations.

Table 6 below summarizes key priorities for delivery of information, products and services in the three countries.

Table 6.
SUMMARY OF KEY PRIORITIES FOR DISSEMINATING INFORMATION, PRODUCTS AND SERVICES

Awareness of the range of information	• Build the capacity of intermediary users and end-users to understand what climate services are available and how they can be used (Nepal, Mozambique and Jamaica)
Use of media channels	• Use multiple channels to actively disseminate information (Nepal and Jamaica) • Ensure the inclusion of target audiences without access to electronic communication (Mozambique and Jamaica)
Timely delivery	• Ensure the timely delivery of climate information, appropriate to the intended use (Nepal, Mozambique and Jamaica)
Relevant and accessible information	• Communicate climate services in accessible languages, as well as avoid technical jargon (Nepal, Mozambique and Jamaica) • Disseminate climate services in local languages (Mozambique) • Partner with intermediaries to cover the last mile of climate-service delivery (Mozambique)

3.4 APPLICATION FOR DECISION-MAKING

Improved hydro and meteorological services are increasingly used and trusted by various government agencies, sectors and the general public for decision-making. It has helped to improve the resilience and adaptability to climate variability and climate-related extreme events across various sectors.

3.4.1 POSITIVE RESULTS ACHIEVED

The improvements in the hydro and meteorological services have exerted a positive impact on different stakeholders in the key sectors of the three countries. They include aviation, agriculture and DRR. These positive outcomes are reflected in enhanced planning and preparedness, as well as reduced socioeconomic costs, across all three countries.

3.4.1.1 Aviation

The aviation sector in both Nepal and Mozambique has been made safer by improved information. In Nepal, the Doppler weather radar-based forecasting has enabled efficient flight planning. In Mozambique, the use of certified ISO-9001-2015 (Quality Management System) real-time meteorological information for flight plans has ensured compliance with international safety standards.

3.4.1.2 Agriculture

The agriculture sector was the primary focus in Nepal, with significant efforts placed on improving the generation and communication of agrometeorological advisories to inform activities (see figure 2). Feedback from farmers illustrates how the availability of such agromet information is applied to determine when to plant and transplant paddy rice, as well as when to harvest. MoALD's 2019 endline user satisfaction survey found that 79 percent, 50 percent and 89 percent of the users are satisfied with its "Hamro Krishi" app, its AAB and its Krishi information SMS, respectively.

3.4.1.3 Disaster risk reduction

In Mozambique, the numerical weather prediction (NWP) model used by INAM was able to forecast and track the 2019 tropical cyclone Idai, as well as generate specific products for in-charge entities to enable preparedness and response. This effort proved critical for triggering timely response actions and minimising potential social and economic impacts (WMO 2019). The benefit-cost analysis (BCA) across all sectors covered by PPCR shows that the investment option is profitable, in terms of statistical lives saved and sectoral benefits of improved forecasts, according to an analysis conducted for the *Implementation Completion and Results Report* (see table 7).

In Nepal, the flood early warning messages and forecast information are embedded in the DHM web portal. It helps to disseminate information to various users, including the public and the disaster risk management authority, for preparedness and response.

Table 7.
SUMMARY OF BCA ESTIMATES ON HOUSEHOLDS, STATISTICAL LIVES SAVED AND SECTORAL BENEFITS OF IMPROVED FORECASTS (IN MOZAMBIQUE), 3% DISCOUNT RATE

	PRESENT VALUE: TOTAL COSTS (USD)	PRESENT VALUE: BENEFITS TO HOUSEHOLDS (USD)	PRESENT VALUE: BENEFITS OF STATISTICAL LIVES SAVED (USD)	PRESENT VALUE: SECTORAL BENEFITS OF IMPROVED FORECASTS (USD)
Total Present Value	46,420,662	6,818,288	58,348,009	82,377,403
Net Present Value (NPV)		-39,602,374	11,927,347	35,956,741
Benefit-Cost Ratio		0.15	1.26	1.77

Source: World Bank, 2021

Figure 2.
IMPACT CHAINS FOR CLIMATE INFORMATION FOR AGRICULTURE IN NEPAL

CLIMATE PHENOMENA >> IMPACTS	Too much or untimely rainfall, drought >> Loss of crop, low crop productivity
CLIMATE SERVICE USER >> END USER	Agro-met Advisory >> Local farmers and extension workers
CLIMATE SERVICE PROVIDER	Department of Meteorology and Hydrology (DHM) and Department of Agriculture and Livestock Development (MoALD)
DATA COLLECTION AND MANAGEMENT	DHM collects and manages data on rainfall and discharge, while MoALD does so for crop situation data from pilot districts
DEVELOPMENT OF INFORMATION PRODUCTS & SERVICES	Current crop situation → Advisory team (17-19 experts from DHM, MoALD, Nepal Agriculture Research Council (NARC), Nepal Agriculture Management Information System (AMIS)) ← Weather Data Agro-met Advisory Bulletin
DELIVERY OF PRODUCTS AND SERVICES	Website NARC/AMIS, SMS krish_information, Hamro Krishi mobile app, Print media and radio program
APPLICATION FOR DECISION MAKING	Response to too much untimely rainfall and drought changes/ adjustments in farming practices
CLIMATE RESILIENT OUTCOMES	Reduced loss of crops and crop productivity
INSTITUTIONAL OUTCOMES	NARC, MoALD, District Agriculture Development Office (DADO), District Livestock Development Office (DLDO), AMIS portal developer- Application Development Agency (ADA) consultant
FURTHER COLLABORATION NEEDED	- For the effective functionality of AMIS, the project team needs to work in close collaboration with DHM to develop data requirements, based on the users' needs, and discuss the possibility of providing the necessary equipment for the generation of essential data. - For the development of better information, products and services, along with their wider dissemination, DHM and MoALD need to collaborate with academic and non-government organizations working in the agriculture sector in Nepal (for example, Agriculture and Forestry University, Food and Agriculture Organization (FAO), World Food Programme (WFP), Practical Action)
ACHIEVEMENTS	Linkage between AMIS and WMO AMIS

Source: World Bank, 2021

3.4.2 PRIORITIES FOR FURTHER DEVELOPMENT

Further developing the application of climate information for decision-making relates to expanding the range of information available for the existing sectors and increasing the number of sectors for which the information, products and services are developed and disseminated.

In Nepal, there is a demand for the development of a seven-day forecast to accompany the shorter-range ones that have been developed and are already in use, as well as location-specific forecasts. There is also a call for developing impact-based forecasts that are focused on what the weather will do, not just what it will be, and thus have more direct applications for decision-making and risk-reduction purposes.

In Mozambique, priorities for the improved application of climate information involve enhancing the use of long-term climate projections and building on the existing success of applying shorter-term weather forecasts to the agriculture, aquaculture and fisheries, as well as transport sectors.

In Jamaica, since the PPCR project is still under implementation, future development priorities have yet to be identified.

Table 8 below summarizes key priorities for application for decision-making in the three countries.

Table 8.
SUMMARY OF KEY PRIORITIES FOR APPLICATION FOR DECISION-MAKING

Application for decision-making	• Improve the availability and use of longer-range, as well as impact-based, forecasts (Nepal) • Improve the availability and use of climate projections (Mozambique)

3.5 INSTITUTIONAL ACTORS AND SERVICE PROVIDERS

The development of effective climate services relies upon partnerships and collaborations between institutional actors and service providers. They also require collaborations among producers of information, as well as between the producers and users of information.

In the case of Mozambique and Jamaica, the partnerships and collaborations have been complicated by the challenge of there being more than one government institution involved in producing climate information. For example, in Mozambique, INAM and DNGRH both generate and issue information on meteorological and hydrological conditions, respectively, with DNGRH supported by the operational entities of ARAs. Jamaica has a similar setup: MSJ and WRA cover meteorology and hydrology, respectively, with the National Environment and Planning Agency (NEPA), the Office of Disaster Preparedness and Emergency Management (ODPEM) and the Rural Agricultural Development Authority (RADA) involved in the management of hydromet stations. Jamaica has also forged collaborations with a research institution producing climate information and the University of West Indies-Mona generating climate projections. Only Nepal has one government institution mandated to manage, monitor and forecast hydrology and meteorology—DHM under the Ministry of Energy Water Resources and Irrigation (MoEWRI).

3.5.1 POSITIVE RESULTS ACHIEVED

Improving the coordination between the actors of the hydromet ecosystem in these three countries has been a major achievement of PPCR. In Nepal, DHM has developed a hydromet bill, currently under review within the ministry and DHM, to strengthen its legal and regulatory framework. In Mozambique, the MoU between INAM and DNRGH has facilitated the formats and frequency of data sharing, along with the development of data and equipment standards and methodologies that have enabled better data sharing. This has enabled the sharing of forecasts as inputs to hydrological models for producing flood predictions. Additionally, Coordination between INGD, INAM, and DNGRH on DRM is done through the Technical Committee for Management of Disasters. In Jamaica, a similar MoU between MSJ and WRA has facilitated the sharing of hydromet data, coordination in locating hydromet stations and expansion in the spatial coverage of data collection.

In both Jamaica and Mozambique, institutional linkages have also been strengthened between the meteorological agencies and research institutions. In Jamaica, this has resulted in the University of the West Indies-Mona producing climate information, notably high-resolution downscaled scenarios for 2030, 2050 and 2080, along with the *State of Jamaica's Climate Report 2015*. In Mozambique, an MoU between the Department of Physics at the University of Eduardo Mondlane (UEM) and INAM has improved the modelling, processing and analysis of data. The Department of Physics also now trains most of the meteorologists at INAM, and there is the intention of introducing a masters-level university training course.

Regional and international linkages between producers have also been fostered under PPCR. Mozambique is a member of SARCOF, while Jamaica is a member of CariCOF. Jamaica has particularly strong regional and international linkages: as a SIDS, it has benefited from capacity building and climate information. MSJ staff participate in training run by the Caribbean Institute for Meteorology and Hydrology (CIMH) that also hosts CariCOF. Jamaica also has strong institutional linkages with the National Ocean and Atmospheric Administration's (NOAA) National Hurricane Center that provides information on hurricanes and participates in WMO's Hurricane Committee, as well as receives information from the Caribbean Community Climate Change Centre (CCCCC). Both Nepal and Mozambique are also reporting data to WMO.

3.5.2 PRIORITIES FOR FURTHER DEVELOPMENT

Despite the strengthened institutional partnerships and collaboration between producers, intermediaries and users, there is always room for improvement. This is especially important, since climate services require detailed understanding of user needs, thus enabling to capitalise on the strengths of different agencies in interpreting and communicating information. Improving institutional collaboration between government ministries typically requires dedicated efforts to overcome the inertia of how things have been done in the past, as well as address the various aspects of collaboration (for example, data sharing, service development and dissemination). This also needs to take place, both horizontally and vertically, with the government ministries.

While good links have been made at the national level between the meteorological and hydrological agencies, all three countries recognised the need for expanding partnerships with other sectors. In Nepal, improvements in communication between the central, provincial and local levels will ensure clarity of roles and responsibilities, as well as improve the coordination on disseminating agromet services and early warning at the grassroots level. A National Framework for Climate Services can establish the institutional mechanism to coordinate, facilitate and strengthen collaborations among national institutions to improve the production, tailoring, communication, delivery and use of climate services for national and local communities (Hewitt et al. 2020). There is also the opportunity to expand partnerships with the private sector that can play a role in augmenting the availability and dissemination of climate services. MoUs can strengthen collaborations by providing transparency on commitments, along with the roles and responsibilities, of participating parties.

Table 9 below summarizes key priorities for institutional actors and service providers in the three countries.

Table 9.
SUMMARY OF KEY PRIORITIES FOR INSTITUTIONAL ACTORS AND SERVICE PROVIDERS

National institutional linkages	• Ensure effective collaborations between climate service providers on data collection, management and use (for example, the agencies responsible for meteorology and hydrology) (Mozambique and Jamaica) • Ensure the effective collaboration between climate service providers and sectoral line ministries as intermediary users for data use as well as the creation of advisories and communication (Nepal and Mozambique) • Adopt a National Framework for Climate Services to formalise linkages

3.6 INTERMEDIARY USERS AND END-USERS

For climate services to be used effectively, collaborations and partnerships with intermediary users and end-users are also important. In addition to collaborations among producers of information, PPCR has promoted partnerships and collaborations between institutions that produce products, information and services and intermediaries interpreting and communicating it. Intermediaries can include other government ministries and nongovernment actors. Furthermore, the gathering and incorporation of end-users' input into the climate information, products and services is also vital in ensuring their relevance to end-users.


Photo: World Bank

3.6.1 POSITIVE RESULTS ACHIEVED

For climate services to be effectively used, collaboration and partnership with intermediary users and end-users are also important. In addition to collaboration between producers of information, PPCR has promoted partnerships and collaboration between institutions that produce products, information and services, and intermediaries who interpret and communicate it. Intermediaries include other government ministries and non-government actors.

3.6.1.1 Government intermediaries

In Nepal, the cooperation between DHM and other government departments has led to the development of advisories from the weather and climate information generated by DHM. MoALD and NARC prepared agrometeorological advisories through a newly formed Working Group of Agricultural Meteorology (WOGRAM) of which DHM is also a member. Although not finalised, DHM and MoALD have commenced discussions towards the end of the project, regarding the sharing of AWS data for further analysis.

In Mozambique, warnings issued by INAM and DNGRH are used by INGD. It coordinates the disaster preparedness and response with local committees for DRM that handle cyclones and droughts (for example, Vilankulos), floods (for example, Caia) and cyclones (for example, Nacala), along with four multiple uses and resources centres (CERUMs) at the district level that specialise in reducing the impacts of droughts. An MoU among DNGRH, INAM and INGD specifies the nature of the collaboration and enables INGD to articulate specific requests that foster DRR activities.

In Jamaica, the establishment of an interagency Hydromet Working Group under the project further supports coordination among MSJ, WRA and other implementing agencies, including NEPA, RADA, ODPEM and other line ministries.

3.6.1.2 NGO intermediaries

Nongovernmental intermediary users typically play a key role in brokering knowledge between producers and users, bridging the gaps that producers are unable to fill due to their relationships with end-users. In Nepal, the NGO, Practical Action, helps communicate users' feedback to DHM in areas of its activity. In Mozambique, disaster warning activities are augmented by partnerships with NGOs, such as the Red Cross and community structures. They are able to communicate concepts, such as the probabilities of certain events and impacts, by translating technical information into more accessible terms. Then they would deploy community leaders and local communities to communicate the forecast information among local populations.

3.6.1.3 End-users

Throughout the PPCR projects, the majority of direct communication was through intermediaries. However, engagement with users was used to obtain feedback on the nature of information provided and the extent to which it met their needs. In Mozambique, disaster early warning information (for floods and storms) was well appreciated. Farmers in Guijá and Zavora, as well as fishermen in Zavora, have shown a demand for information at subdaily timescales tailored for farming and fishing decisions, as well as for overall safety. Box 3.1 illustrates the extent to which gender inclusion was considered in climate services through the PPCR project in Nepal.

Box 3.1.
GENDER INCLUSION IN CLIMATE SERVICES IN NEPAL

Women in Nepal are among the most vulnerable groups to climate risks, because of their limited access to timely weather forecast information; limited available options for crop and livelihood diversification; the lack of independent sources of income and access to credit or financial institutions for better investments; along with limited decision-making power to apply adaptation measures. The *Building Resilience to Climate Hazards (BRCH)* project helped to reduce the gap of women's access to weather and agromet information by providing easily accessible data and information (for example, weather forecasts and the Agriculture Management Information System [AMIS]), as well as strengthening their capacity to make weather and climate-informed decisions for adaptation measures in the agriculture sector through capacity-building programs targeting female farmers. A total of 6,085 female farmers took part in the capacity-building programs. Moreover, the 2019 endline survey revealed that over 90 percent of the female respondents found the Agromet Advisory Bulletin (AAB) and the "Hamro Krishi" App to be "highly satisfactory" or "satisfactory".

3.6.2 PRIORITIES FOR FURTHER DEVELOPMENT

As outlined above, much of the focus in PPCR has been on the supply side of climate services, based on the recognition of the need for improved observational data to develop new information, products and services. Over the lifespan of the programme, thinking has shifted toward the imperative of placing more of the focus on the demand side, that is, identifying user needs and preferences to inform the design of such information and services. Essentially, despite the progress that has already been made in Nepal, Mozambique and Jamaica, it is acknowledged that there is significant potential for increasing user engagement, not only with end-users in particular, but also with NGO and government intermediaries.

The need to engage with users or intermediaries of climate services has created significant additional demands and necessitated the involvement of additional partners within the climate services value chain. Scaling up and out the positive experiences within PPCR is important, moving forward. In Nepal, for example, better collaborations and extension services will enable an even more tailored and targeted contextualisation of the agrometeorological bulletins that are already distributed through community radio. In Mozambique, while collaborations with the Red Cross as an intermediary have been effective, there are many other NGOs providing extension services in the country that could help expand the dissemination of information, products and services. These include the Adventist Development and Relief Agency (ADRA), the National Cooperative Business Association/Credit League of the United States of America (NCBA/CLUSA), Concern Worldwide, and Action Aid.

As well as engaging with users to identify their needs and obtain feedback on the suitability of services provided, another role for user engagement is to raise awareness of the role they can play in ensuring the reliability of data provision as inputs to the products and services. In Mozambique, a DNGRH representative explains that, in some areas, telemetric stations go

Photo: World Bank

offline, because people are stealing the batteries and solar panels on which the stations depend. To remedy this, DNGRH is exploring the potential to develop an MoU with local communities or otherwise foster collaborative arrangements whereby communities hosting weather stations feel some ownership and see some direct benefit in taking care of those stations.

Furthermore, the fostering of informed user communities should also be an important part of the projects in order to increase the legitimacy of climate services, so that users have a greater appreciation of the source of data. In Nepal, the project only provided thermometers, rain gauges and training at the local level. A survey, conducted in Nepal, as part of the PPCR project, found that less than half of the people were using DHM's weather and climate information: while some relied solely on DHM, others combined it with the use of traditional knowledge. Nearly half relied only on traditional knowledge to inform their decisions.[4] This was the case despite the recognition of the importance of climate and weather information in decision-making. Expanding training around participatory approaches for generating advisories, such as the Participatory Integrated Climate Services for Agriculture (PICSA) approach, has also been identified in Mozambique to stimulate user demand for climate services and increase their usage.

Table 10 below summarizes key priorities for intermediary users and end-users in the three countries.

Table 10.
SUMMARY OF KEY PRIORITIES FOR INTERMEDIARY USERS AND END-USERS

Forge partnerships with intermediaries	• Scale up and out partnerships with government intermediaries that can assist with the development of advisories (Nepal) • Scale up and out partnerships with NGO and private sector intermediaries that can assist with communication to end-users (Mozambique)
Forge partnerships with end-users	• Empower communities to own and provide the stewardship of weather stations to ensure reliable data provision (Mozambique) • Empower communities to contribute to data collection through citizen science, whereby people contribute to data monitoring (Nepal) • Increase the credibility of climate services with end-users through awareness raising and capacity building, including through participatory approaches (Nepal and Mozambique)

3.7 SUMMARY OF ACHIEVEMENTS AND FURTHER NEEDS IN NEPAL, MOZAMBIQUE AND JAMAICA

The PPCR projects—related to climate services in Nepal, Mozambique and Jamaica—have made significant progress in developing the climate services value chain across all three countries. To begin with, the foundational infrastructure for observation networks and data collection has been developed in all three countries. Hydrological and meteorological data management has been enhanced through the institution of Management Information Systems and improved compliance with international WMO quality standards. Together with targeted capacity building and the development of appropriate institutional relationships, this has enabled improvement in the development of information, products and services, including both real-time early warning and sector-specific weather and climate information. Dissemination has been aided by partnerships among government departments, as well as between government departments and NGOs. This has increased the awareness of climate services across a range of sectors, the trust in their quality and their use, thereby reducing climate risk.

Although substantial efforts have resulted in significant achievements, challenges and opportunities for further improvement remain. At the technical level, data collection can always be improved, both through increasing the density of the observation network, expanding the range of parameters observed and increasing data quality through the training of gauge readers and the appropriate type of observation stations. Furthermore, data management can also be strengthened through upgrades to infrastructure, including ensuring compliance with WMO standards and increased staff capacity.

Photo: World Bank

From the stakeholders' standpoint, policies and MoUs can better bolster data sharing and collaboration so as to further the development of effective partnerships between the different institutions collecting and processing data, at national, regional and international levels. Partnerships with NGO intermediaries can also expand the dissemination of climate services and strengthen human capacity. In addition, more effective user engagement to understand decision contexts and information needs can be used to improve the development of targeted climate services, while more effective feedback mechanisms will close the loop as well as enable evaluation and improvement.

Photo: World Bank

4. KEY CONSIDERATIONS FOR TRANSFORMING CLIMATE SERVICES

Section 3 distilled the key lessons and remaining opportunities for the development of climate services in Nepal, Mozambique and Jamaica. Based on those experiences and information from the broader body of evidence on climate services, this section summarises key lessons for transforming climate services that are replicable and scalable in other contexts. These lessons recognise the need for focus across the whole climate services value chain and the entire "hydromet ecosystem" of actors (institutional actors and service providers, government and non-governmental intermediaries, along with end-users). They also reflect the shifting emphasis within the climate services field towards the demand side, based on the growing recognition that user engagement and demands are central to the process. Key considerations can be grouped under the different categories of the climate services value chain, by factoring in data collection and management; the development of information, products and services; the delivery of products and services; application for decision-making; along with institutional actors and service providers, and intermediaries and end-users. In addition, recommendations are made pertaining to other cross-cutting issues necessary for considering the sustainability of climate services, namely the establishment of a system for monitoring, evaluating and learning, human capacity, along with financial sustainability.

4.1 DATA COLLECTION AND MANAGEMENT

Ensure that appropriate staffing and technologies are in place for functional data management (including the collection, quality control, storage and analysis of climate data)

For data to be used, it needs to be collected, quality controlled and stored, before it can be analysed. The considerations for investments in this part of the process are not only financial, in terms of supplying the infrastructure, but also relate to human capital, in terms of training the staff collecting observations (from synoptic stations) or cleaning the data (from the AWSs). Data management plans need to account for the interoperability between data flows and databases, particularly considering the climate and water-related data, as well as adherence to WMO quality control and interoperability standards to produce the maximum impact.

Ensure institutional arrangements are in place for climate-data sharing (within country and cross-country)

For effective climate services to be developed, there needs to be openness and sharing of data between the producers of the information in country, because the institutions in charge of meteorological and hydrological data are often different. This typically requires an MoU between institutions at a minimum, or a policy or a bill/act in the best-case scenario.

Sharing data is also important, regionally and internationally, as resource pooling and inputs to larger-scale modelling efforts can generate information that is useful at the national and subnational levels. Reporting to the WMO should take place, with adherence to WMO's standards for data collection and storage adopted as a mechanism of quality control. Data can be shared bilaterally, which is important for neighbouring countries whose weather is dependent on similar atmospheric/oceanic circulation features or that share river courses. It can also be shared regionally and internationally, through various existing fora, for example, RCOF and hazard-specific mechanisms, such as those monitoring hurricanes/tropical cyclones.

4.2 DEVELOPMENT OF INFORMATION, PRODUCTS AND SERVICES

Ensure fit-for-purpose climate information, products and services (what the information says, how it is presented, and the extent to which it matches the intended user audience)

What distinguishes climate services from traditional weather and climate products is the focus on tailoring information to suit users' needs. This is in contrast to the traditional approach employed, whereby the provision of information is supply side-driven, rather than demand side-driven. While there is a need for basic services for NMHSs to fulfil their mandates to protect lives and property, developing tailored services requires user engagement to understand the nature of their needs. There is also scope to bring in private-sector partners to support the development of such information, typically when supported by legislation that ensures effective information sharing.

Nonetheless, a recent analysis has shown that user needs are still often overlooked in climate services, whereby the focus is still on the supply of data, based only on assumptions made on the nature of needs and demands (Findlater et al. 2021). Understanding user needs requires an identification of who the users of weather and climate information are, what their decision context is and, in turn, what information they require, when and how often they need it, along with how they need to receive it. This type of user engagement typically requires meteorological and hydrological agencies to develop new sets of skills and partnerships to enable this to happen (McMahon et al. 2019).

Photo: Leo Morgan / Shutterstock.com

4.3 DELIVERY OF PRODUCTS AND SERVICES

Ensure the availability and accessibility of climate information, products and services (what is communicated, how it is communicated, to whom it is communicated and when it is communicated)

Generating better-quality information, products and services does not translate into more effective use, unless it is effectively delivered. Effective delivery requires an understanding of what, how and to whom the information, products and services are communicated. Taking into consideration the range of users and their different decision contexts may mean that the same forecast or climate projection information needs to be packaged differently according to the audience and disseminated through different means.

Forge partnerships with agencies that possess comparative advantages in the interpretation and communication of climate information, products and services

Delivering information, products and services, as well as tailoring their delivery to the needs of different audiences, is typically outside the skillset of meteorological and hydrological agencies themselves. Thus, forging partnerships with other agencies that are well-placed to do so can increase the effectiveness of delivery. NGOs, community-based institutions and civil society organisations typically play this role well, due to their close association with user groups, particularly at the grassroots level. Other options might include professional organisations or representative organisations for different sectors, including other government ministries (for example, those responsible for agriculture or DRR). Communications specialists, such as the media, also play a key role.

4.4 APPLICATION FOR DECISION-MAKING

Build the capacity of producers to produce decision-relevant climate information, products and services

Increasing the application of climate services for decision-making requires a two-pronged approach: first, build the capacity of producers to produce decision-relevant information and second, package their information to meet user needs. This can be enabled through institutional partnerships.

Build the capacity of user groups (through two-way dialogues) to understand and use climate information, products and services

The second part of this approach entails stimulating the demand for information among users, which requires raising awareness on what information can do, as well as building the credibility and legitimacy of the information and the organisations providing it. This is particularly important where there is limited history of accessing and using scientifically generated information to inform decision-making. User groups are then able to make appropriate requests for information and more likely use what they receive. The importance of this component was highlighted in Mozambique and Nepal, where the inability to understand the climate information impeded its use in risk management.

Institute evaluation systems to know where course corrections and modifications are required

To close the climate services value chain loop, an effective system of evaluating the perceptions and use of climate information is essential. The feedback can be transmitted to producers and intermediary institutions involved in the dissemination of climate information so that they can adjust their activities as necessary. To date, the evaluation of the impact of climate services, through their application and use, has been scant. This is because the evaluation of climate services is typically complex, since the benefits of the services and the impact chains are often multiple and interactive (Vaughan and Dessai 2014). It can also be effort-intensive to undertake in-depth data collection exercises.

Nonetheless, establishing a system for ongoing and rapid feedback can still be more cost-efficient and worthwhile, as it enables more nimble adaptation, if required, among producers in the nature of information communicated and the communication approach. Feedback can be sought from end-users directly, along with intermediary users typically working directly with end-users and thus possessing a clear perspective of their context, capacities and limitations.

4.5 INSTITUTIONAL ACTORS AND SERVICE PROVIDERS

Ensure the transparency of roles and responsibilities in partnerships required to deliver climate information, products and services

The importance of various institutions in the climate services value chain is clear, with roles for a variety of partners across the different activities. The notion of a "Global Weather Enterprise" (GWE) has been coined to describe the totality of activities by individuals and organisations to enable weather information to be created and provided to society (Rogers et al. 2019). The GWE is a supreme exemplar of the value of international cooperation, public-private management and scientific technological know-how.

To ensure effective coordination and collaboration, ensuring the transparency of roles and responsibilities is important. This is particularly the case given often-overlapping mandates that characterise the ownership of meteorological and hydrological information, along with the downstream partnerships needed for developing and disseminating information, products and services. Legal and institutional frameworks can help to define missions and mandates, ensure clarity in the definition of responsibilities, provide legal authority for certain responsibilities, gain recognition of NMHS' contribution to society and facilitate the allocation of adequate resources (WMO 2017).

Consider strategic partnerships to augment production and dissemination capacities

The development of climate services, which extends beyond the generation of information to the production of tailored services and advisories and communication, places additional demands on NMHSs. Based on this recognition, there is a need to consider the role of strategic partnerships to augment production and dissemination capacities. With an appropriate policy framework in place, ideally a coherent national framework, there is scope to leverage the support of the private sector in climate services production and delivery to support NMHSs and expand their remit. Similarly, strategic partnerships with intermediary users can augment dissemination, along with monitoring, evaluation and learning, among end-user groups, without placing additional human capital burdens on NMHSs.

4.6 INTERMEDIARY USERS AND END-USERS

Forge partnerships with various organisations that have comparative advantages at different stages of the value chain

As outlined in Section 3.6, partnerships with organisations that have comparative advantages at different stages of the value chain are essential for ensuring the effective design, delivery and application of information, products and services for decision-making.

Engage end-users and intermediary users from the very beginning

The PPCR projects all engaged with intermediary users (other government departments), as well as meteorological and hydrological agencies, from the start of the process. However, while intermediaries can provide a useful perspective, their involvement cannot fully replace the involvement of representatives of different end-user groups. This is particularly important for the identification of user information needs and communication preferences in order to design useful and useable climate services that are truly "demand-driven" and fit for purpose.

Build the capacity of user groups (through two-way dialogues) to better inform the design of climate information, products and services

Dialogues between producers and users are essential to inform the design of climate services, in terms of defining what information should be developed and how it should best be delivered. While it is possible to work with and through intermediary groups, in many cases direct contact with user groups is essential for understanding decision-making contexts. Building the capacity of users and user groups helps to improve the quality of such dialogues. For example, in Mozambique, dialogues with farmers and around DRR were identified as key to improving information.

4.7 OTHER CROSS-CUTTING ISSUES

4.7.1 A MONITORING, EVALUATING AND LEARNING SYSTEM

Establish and institutionalise an evaluation system that enables feedback and iteration, based on user feedback

Assessing whether or not the information, products and services meet user needs requires the establishment of an interactive monitoring and evaluation system that can feed this information back to the producers and enable them to make adjustments, if necessary. In the PPCR projects in Nepal, Mozambique and Jamaica, feedback was informally collected from various intermediary users. However, there is no structured process to systematically collect data on information needs and the extent to which the information, products and services are aligned with those needs. Moreover, due to the complex impact chains, the evaluation tends to focus more on the economic valuation of products (which is relatively simpler to approximate) than improvements in decision-making (Findlater et al. 2021). Taking a more holistic and comprehensive approach to evaluating impact also generates powerful economic evidence to motivate and support the continuation and expansion of climate services.

Building evaluation capacity among staff would be important to enable this outcome to happen, as would building on the institutional partnerships with those involved in disseminating the information. One mechanism might be building the capacity at the WMO Regional Climate Centres, with the intention that they then support individual countries with this evaluation capacity.

4.7.2 HUMAN CAPACITY

Ensure an appropriate plan for building human capacity at all stages of the climate services value chain, among producers, intermediaries and end-users

Since the climate services value chain involves a number of actors, from producers to intermediaries to end-users, appropriate capacity building needs to be in place to ensure that all actors are aware of their roles and able to perform them effectively.

On the producer side of the spectrum, plans need to be in place for the staffing, including upgrading skills and retaining staff at meteorological and hydrological agencies, so that they are well-placed to manage and process data and use it to generate forecasts and projections. In particular, the reduction of administrative burdens can free up producers to engage in research and innovation, possibly in partnership with universities and research organisations. Partnerships with universities can also, in turn, help to support capacity building through the provision of training for potential future staff.

Intermediary users and end-users also need to have plans for capacity building. For intermediary users to be able to effectively play their role, they need to have a good understanding of weather and climate, along with the forecasting and projection process, so that they can effectively participate in the design and delivery of climate information, products and services. They also need to be able to determine the information needs and communication preferences of users. Finally, end-users also need to understand the process of developing information, products and services so that there is increased credibility, which increases the likelihood of application for decision-making.

4.7.3 FINANCIAL SUSTAINABILITY

Plan for financial sustainability in data collection and management, as well as both the development and delivery of climate information, products and services

The provision of climate services typically requires meteorological and hydrological agencies to produce a wider range of information, products and services, reflecting the diversity of user groups and their varied needs for targeted information. This increases the costs of production that stem from building up the staff's technical capacity, the increased operations and maintenance costs of an expanded observational and monitoring network, along with baseline research and development for enabling improved capacity to analyse weather and climate conditions. Thus, for effective climate services to be sustained, a robust cost-recovery mechanism needs to be in place to ensure that the budget is sufficient for covering the costs of generating the needed information, products and services.

There are various options for ensuring the financial sustainability of climate services. Domestic budget resources can be made available, particularly if there is a Bill or Act in place that mandates it. Resources can also be made available, as specified through the policy framework. However, care needs to be taken to ensure consistency of the data policy between meteorological and hydrological agencies to avoid contradictions that can otherwise undermine the development of climate services, as in Mozambique where INAM charges for data while DNGRH structures its cost recovery around water resources themselves. Other business models, such as public-private engagement (PPE), could complement and enhance the functions of service providers by developing cost-sharing and revenue-generating activities (World Bank 2020).

5. CONCLUSION

PPCR has invested in climate services in a number of countries. This report has analysed the achievements and experiences of PPCR projects in three countries, namely Nepal, Mozambique and Jamaica. These countries were selected due to their different institutional frameworks, systems and contexts. As a result, it is possible to compare and contrast their experiences and draw out key lessons to inform future climate services investments.

In these PPCR countries, addressing data gaps was a key priority, and significant progress was made from the supply side. Notable achievements have been made, with regards to data collection and management in these three countries that had been previously restricted by poor data availability and analytical capabilities. New products and services have been developed—tailored to user needs and targeting different sectors. They have been communicated to users through diverse media, which have contributed to improving maritime navigation, aviation flight planning, agricultural planning and DRR. For other countries that still have significant gaps in their observation networks, as well as data collection and management capacity, investments in these areas are a prerequisite for generating climate information, services and products that can inform decision-making and foster resilience. This is in line with the targets set for surface and upper air stations under the GBON target supported by the Alliance for Hydromet Development, among others.

Effective climate services requires collaboration of the whole "hydromet ecosystem" of actors to enable the production, translation, communication and use of climate information across the climate services value chain. Only by adopting such a comprehensive approach, that involves connecting with users, understanding impact, building capacity and fostering collaboration, can climate information be understood and capacity built. Therefore, it is critical to consider cross-cutting issues that affect the sustainability of an enabling environment in which service provision and dissemination can take place. Institutional barriers to data sharing and the collaboration, required to generate useful climate information in these three countries, have been overcome by the signing of MoUs making clear the roles and responsibilities of different parties, along with the current drafting of policies and a bill. Improved collaborations with intermediary users and end-users have contributed to the development and communication of services that do reach the last mile and make a difference in promoting adaptation and resilience. Learning from these experiences can inform NMHSs in other countries that have a suitable base of data availability to be able to replicate the process of developing climate information, products and services.

Relatively speaking, despite their focus on the supply side of climate services, there remain improvements that can be made in these three PPCR countries, which require further investments. The density of observation stations still does not meet GBON standards, while the DMSs for weather and water are not universally compliant with WMO standards. The time taken during these projects to identify, establish or strengthen the relevant institutional linkages, and commence the process of developing supportive policy and legislative environments, highlights the substantial efforts required to transform the status quo. Even amidst the significant improvements that have been achieved in the design and delivery of climate information, products and services, their availability is not yet universal and their use not yet widespread.

Future investments in these three PPCR countries can leverage the advances made in data collection and analysis capacity in order to focus on assessing and meeting user needs. There is significant potential of private-sector partnerships to achieve this (Rogers et al. 2021). The needs identified in the country-level reports related to weather forecasts with different lead times and higher spatial resolution and impact-based forecasts (for Nepal), longer-term climate projections (for Mozambique) and the improved communication of products (for Jamaica). In the time since the PPCR was conceptualised, there has been an evolution of thinking and the shifting of attention to the demand side of the climate services value chain, ensuring that user needs are central to the process from the very start (Atkins International and CIF 2021). Further engagement with diverse potential intermediary users and end-users would likely lead to the identification of a wider range of information needs and communication preferences. Especially for countries that have significant data collection and management needs, there is scope to do this alongside immediate user engagement to inform the development of climate information, products and services so that they are immediately applicable to the decision-making needs in order to build resilience.

Further investments are required to identify the climate information needs and communication preferences of different user groups, so as to develop and disseminate decision-relevant climate services. Partnerships with intermediaries, including government authorities, NGOs and the private sector, offers a critical opportunity for this to happen, leveraging existing networks and capacities that complement the core skills of the NMHSs. Cultivating trusted relationships with intermediary users and end-users, as well as placing efforts in building the credibility of information with them, are both essential to improving the uptake of climate services and their effectiveness. Evaluation systems that track the progress of climate services production and use are essential to identify opportunities for course correction and additional bottlenecks impeding effectiveness. For other countries seeking to transform their climate services, all the aforementioned elements need to be considered.

ANNEX A: ACHIEVEMENTS OF THE THREE PPCR CLIMATE SERVICES PROJECTS

NEPAL: BUILDING RESILIENCE TO CLIMATE-RELATED HAZARDS

BASELINE SITUATION

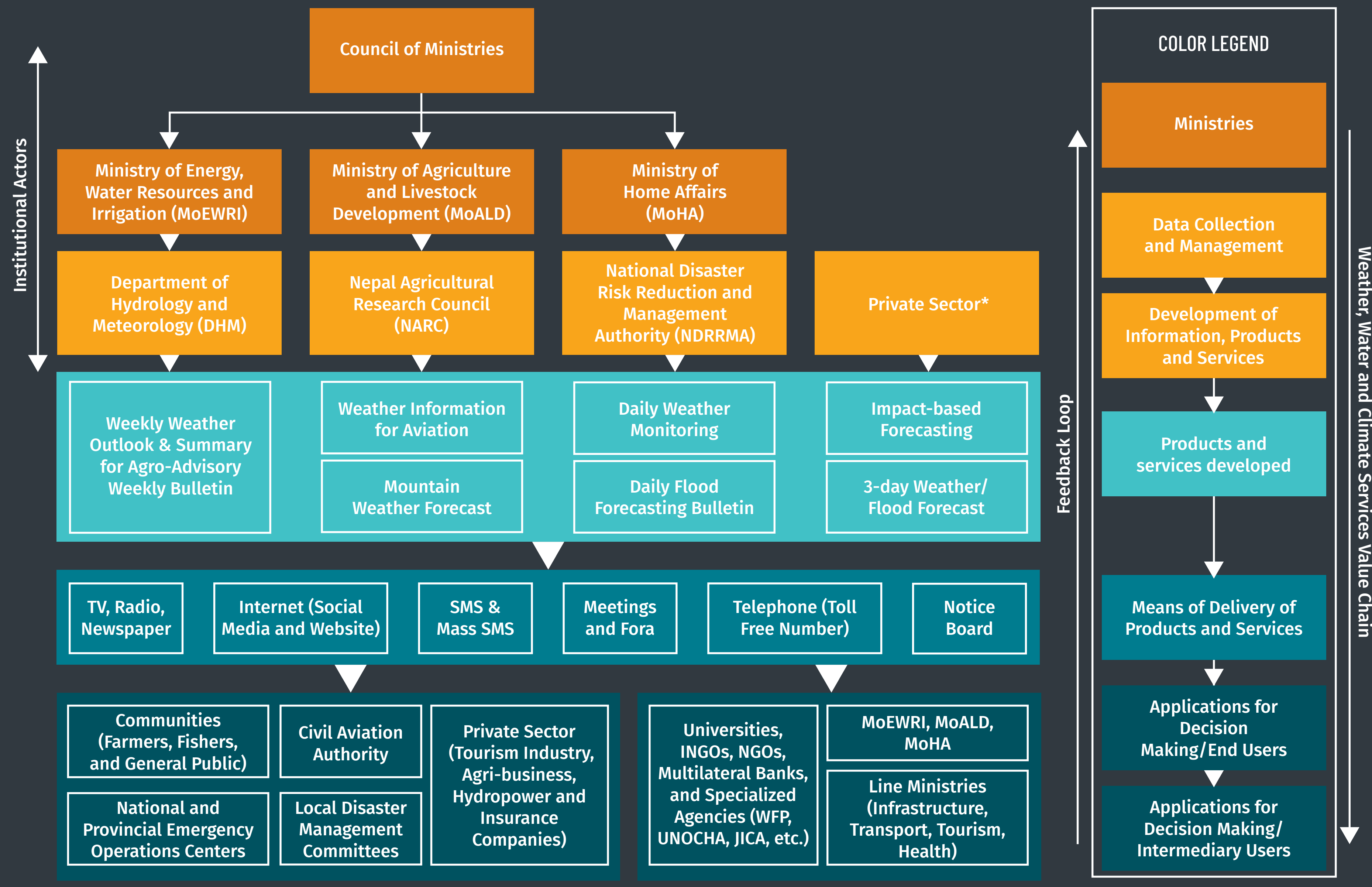
At the time of the project's approval in early 2013, the provision of climate services in Nepal was inadequate. Gaps in the monitoring network and reliance on manual data collection and transmission contributed to risk from a range of hydromet hazards—floods, glacial lake outburst floods (GLOFs), landslides, windstorms, heat and cold waves, forest fires and droughts—the nature of which is likely to change in the context of a changing climate. Hazard early warning and agriculture sector-specific advisories were not produced, which meant that farmers, comprising 80 percent of the population, were not able to rely on weather and climate information to maximise yields or reduce the risks of crop losses.

PROJECT OVERVIEW

The project, Building Resilience to Climate-Related Hazards, aimed to modernise the country's hydromet system through efficient data collection, transmission, storage, processing, use and dissemination to the public, government agencies and targeted user groups, thereby improving the accuracy and timeliness of weather and flood forecasts and warnings. This included creating an agricultural management information system that could provide weather information to inform crop management, pesticide management and weather risk-transfer mechanisms (index-linked weather insurance) for farmers and the agriculture sector.

The project was implemented by the Department of Hydrology and Meteorology (DHM) under the Ministry of Energy, Water Resources and Irrigation (MOEWRI), in collaboration with the Ministry of Agriculture and Livestock Development (MoALD).

Figure A.1.
INSTITUTIONAL ARRANGEMENTS FOR CLIMATE SERVICES IN NEPAL



*In IFC's Promoting Climate Resilient Agriculture Project, mPower, a private sector company, provided weather forecast and agrometreorological advisory to a group of farmers in Eastern Terai districts

Source: World Bank, 2021

KEY ACHIEVEMENTS

Established an institutional framework to support improved climate services

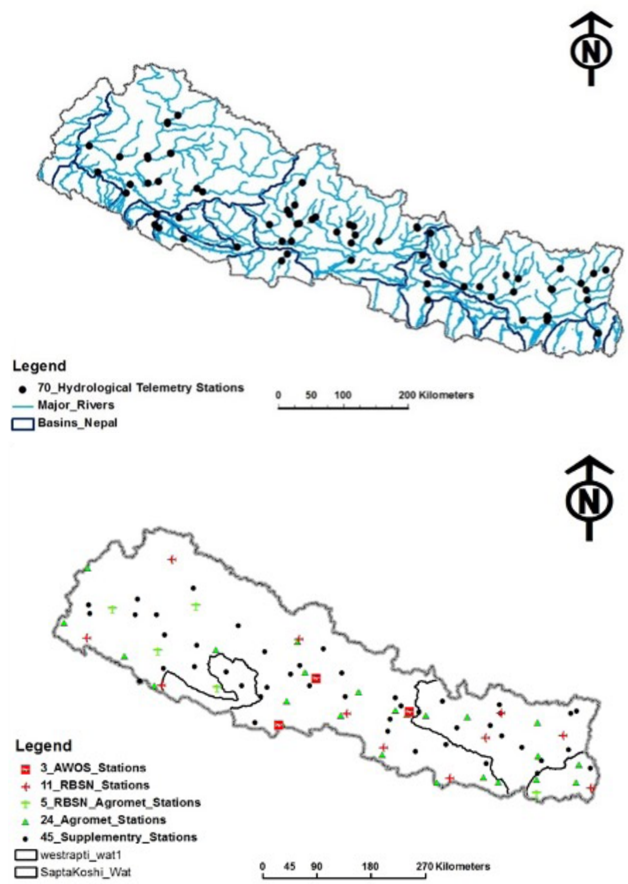
Key to encouraging the sustainability of a pilot programme is establishing an institutional framework that is necessary to support improved climate services. A Hydromet Bill that has been drafted is currently under review with MOEWRI. Furthermore, the resources of the Pilot Program for Climate Resilience (PPCR) have been used to refurbish MOEWRI's physical building to accommodate the necessary modern computing systems, along with training the staff in their operation and management. Crucially, the financial sustainability of the systems has been secured, with 100 percent of funds for essential operational needs now allocated from public funds through the normal national budgeting process to the parent ministry.

Modernised observation networks and forecasting

A significant achievement of the PPCR project in Nepal has been the modernisation and improvement of observation networks and forecasting, including the installation of various technologies for the first time. The expansion of the surface meteorological and hydrological observation networks has taken place, with the installation of 88 Automated Weather Stations (AWSs) and 70 Automated Hydrological Stations (see figure A.2.), thereby increasing the area of the country that is actively monitored. Nine lightning sensors have been installed to contribute to the lightning detection network. The first Doppler weather radar has also been installed: with a radial range of 200km, it enables the real-time and accurate weather monitoring of wind profiles and clouds, along with precipitation intensity and types. The country's first upper air radio sounding station has also been installed.

Parts of the new data collected, which are reported to the World Meteorological Organization (WMO) via the Global Observation and Telecommunication System (GTS)/WMO Information System (WIS), also provides DHM with data that help inform the High-Resolution Numerical Weather Prediction (NWP) model to improve forecasts. Forecasting now comes in a range of timescales from nowcasting up to multiple days, as well as weekly outlooks and seasonal forecasts. An end-to-end flood Early Warning System (EWS) model for the Koshi and West Rapti river basins provides forecasts of water runoff, which is vital for the issuance of flood early warnings to vulnerable communities across eight river basins through a mass SMS.

Figure A.2.
DISTRIBUTION OF HYDROLOGICAL TELEMETRY STATIONS (LEFT) AND WEATHER STATIONS (RIGHT) IN NEPAL



Source: Nepal Implementation Completion and Results Report, World Bank, 2021

Enhanced climate service delivery

Apart from improving the availability of climate information, there have been significant improvements in communicating this information as both weather forecasts and warnings. In addition to increases in the Composite Users Satisfaction Index (CUSI) from baseline to endline for early warnings, there is particular appreciation for the availability and reliability of forecasts, in relation to rainfall and temperature, along with agreement that the availability of the information has helped to protect lives and livelihoods.

Improved availability and use of agromet information through the Agriculture Management Information System

The Agriculture Management Information System (AMIS), linked to the WMO AMIS, first became operational in 2018. Comprising multiple levels of infrastructure, the hardware and software of the data and disaster recovery centre were installed under the National Information Technology Center of the Ministry of Communication and Information Technology. One central-level and 52 district-level Kisan Call Centres (KCCs) were installed—each comprising a computer set, a printer and a digital display board (LED monitor) with an uninterruptible solar backup system, including an internet connection for responding to farmer queries in local languages. Later, the previous District Agriculture Development Office (DADOs) and District Livestock Service Office (DLSOs) were replaced by 51 Agriculture Knowledge Centers (AKCs) and 47 Veterinary Hospital and Livestock Service Expert Centers (VHLSECs). Additionally, 1,263 sets of AMIS infrastructures (mobile phones, rain gauges and thermometers) were distributed to farmers' groups/cooperatives.

AMIS, serving as a one-stop shop for agrometeorological information, has been shown to be useful for farmers and extension workers. Products, made available through it, include a Package of Cultivation Practices (POCP) for 18 districts, a *Climate SMART Agriculture Manual,* a District Profile for 25 districts, Climate-Vulnerable Area Mapping focusing on the agriculture sector for 18 pilot districts and Integrated Crop Calendars of major crops cultivated in Nepal (such as cereals, cash crops and spices). AMIS also forms the basis of the weekly agromet advisory bulletins (AABs) issued by MoALD, in collaboration with the Nepal Agricultural Research Council (NARC), to a number of districts.

Apart from being accessible through a web portal, the AMIS portal is also linked to the "Hamro Krishi" app that had been downloaded 52,000 times by the end of the programme's lifespan. The app enables two-way communication: early warning and advisory information can be transmitted to farmers, while feedback can be returned to MoALD/NARC. An SMS alert system is also available to provide advisory and early warning information to farmers and extension workers, with around 40,000 people receiving 2–3 SMS alerts per week by the end of the programme.

The sustainability of these services will be enabled by a combination of the project's achievements. This includes the installation of the infrastructure and the training of the personnel, as well as several institutional setups, which will be formalised by the draft hydromet bill. The project established an interagency initiative: the Working Group of Agricultural Meteorology (WOGRAM), comprising officials from DHM, MoALD and NARC, meets regularly, shares information and enables the collaboration of the three agencies on the generation and issuance of weekly agricultural advisory bulletins. Similarly, the entire AMIS system was handed over by the project management unit (PMU) to the Agriculture Information and Training Center (AITC). It took on the operation, maintenance and upgrading of the system by using the government budget.

Economic impact analysis

An ex-post economic analysis of the project, conducted as part of the *Implementation Completion and Results Report,* outlined an Expected Net Present Value (NPV) of USD41.2m with a nine-percent discount rate and an Economic Internal Rate of Return of 32.98 percent. The ex-post benefit-cost ratios are 2.1–13.1, meaning that every dollar invested yields between

USD2.1 and USD13.1. This calculation does not take into consideration non-quantified benefits[5] and thus, likely underestimates economic viability; however, it is contingent on the continued effective operation of the systems established under the programme until 2027 (that is, Year 15).

CLIMATE RESILIENCE: TRANSFORMING HYDRO-METEOROLOGICAL SERVICES IN MOZAMBIQUE

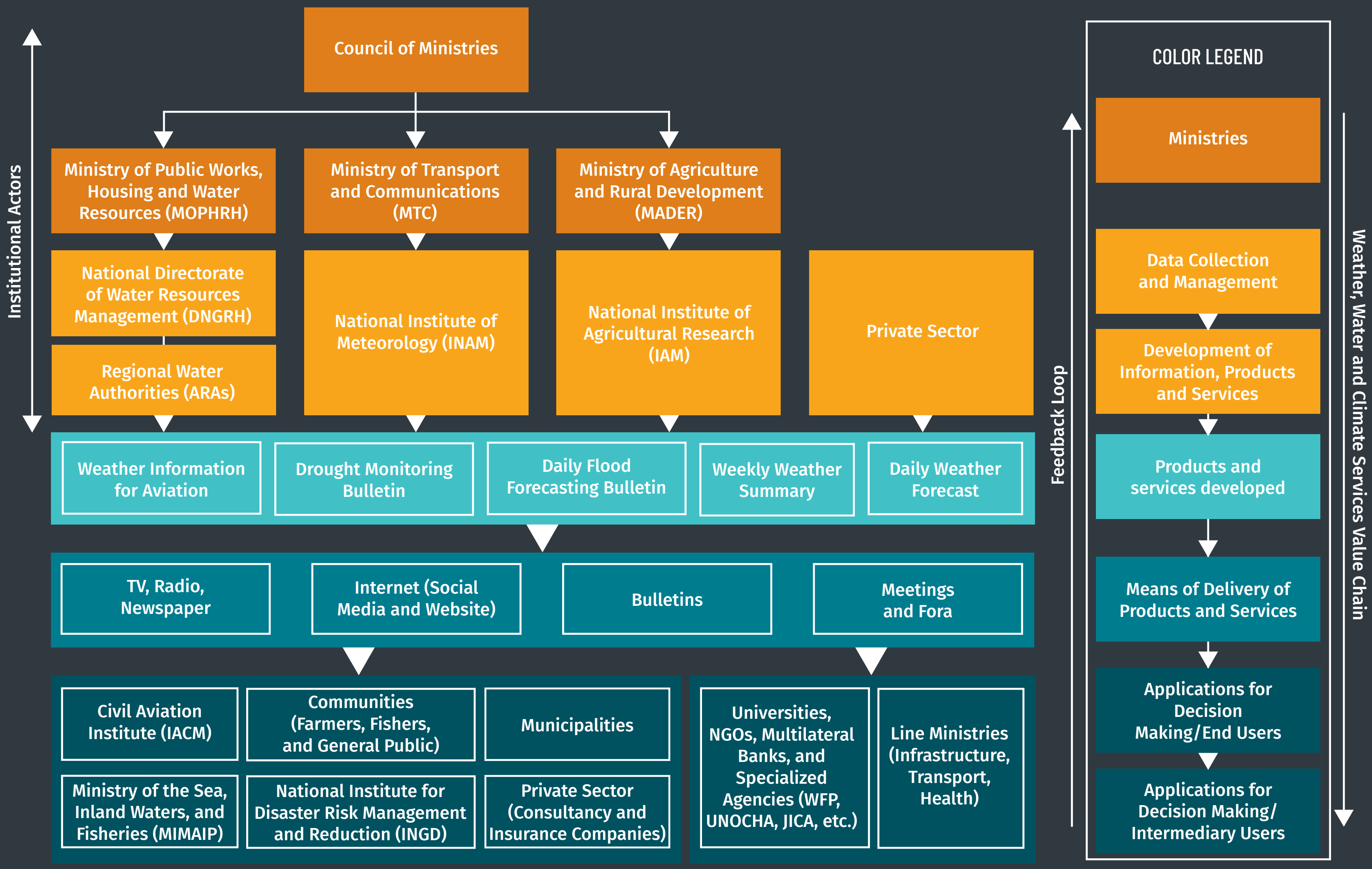
BASELINE SITUATION

At the time of the project's approval in 2013, the provision of effective climate services in Mozambique was impeded by fragmented institutional mandates and weak interagency collaborations between the various agencies responsible for hydrological and meteorological information (the National Institute for Meteorology [INAM, *Instituto Nacional de Meteorologia*] for meteorological information, along with the National Directorate of Water Resources Management [DNGRH, *Direcção Nacional de Gestão de Recursos Hídricos*] and the Regional Water Authorities [ARAs *Administrações Regionais de Águas*] for hydrological information). The poor quality of data collection, management and sharing impeded the information and provision, leading to the inadequate availability of forecasts and early warning information, as well as the poor targeting of user needs. Within the context of high exposure and vulnerability to droughts, floods and tropical cyclones, this gap was contributing to high economic and humanitarian costs of disasters that that will be exacerbated in the face of a changing climate.

PROJECT OVERVIEW

The Climate Resilience: Transforming Hydro-Meteorological Services in Mozambique project aimed to strengthen the country's hydrological and meteorological information services to deliver reliable and timely climate information to local communities, as well as support economic development. This was achieved through enhancing both hydrology and meteorology information management via data collection, data quality control, data storage; improving the capacity for generating information products; as well as supporting the delivery of better-quality weather and water information through a number of pilot activities. This pilot project included EWSs and flood forecasting in the Zambezi, Limpopo and Incomati River basins; hydrometeorological information for farmers at pilot locations in the Gaza and Inhambane provinces; weather service alerts at the coastal areas in Inhambane; and innovations for the interagency delivery of data. The project was implemented by DNGRH and INAM (see figure A.3).

Figure A.3.
INSTITUTIONAL ARRANGEMENTS FOR CLIMATE SERVICES IN MOZAMBIQUE



Source: World Bank, 2021

KEY ACHIEVEMENTS

Improved hydrological information led to increased accuracy and lead time of flood forecasts

Hydrological observations and monitoring were improved, such that, by the end of the project, nearly three-quarters of existing river gauge stations were reporting hourly and 80 Automated hydrological monitoring stations were reporting continuously. This data was managed and processed in the National Integrated Water Resources Management Information System (NIWRMIS): at the time the project closed, it hosted information from 717 water stations; 17 reservoirs; 1,389 rainfall stations; 7,686 boreholes; 3,598 National Directorates for Water Supply and Sanitation (DNAAS, *Direcção Nacional Abastecimento de Agua e Saneamento*) sites; 428 water use licences; along with 6,598 recovered and digitised (historical) records.

An open-access hydrological model, the Hydrologic Engineering Center's River Analysis System (HEC-RAS), was established and installed for Limpopo and Zambezi, and is running in the DNGRH and respective ARA offices. In conjunction with improved weather forecasts from INAM, this has enabled the generation of more accurate flood forecasts with an increased lead time of three days (as opposed to one day previously).

Improved meteorological data collection and management

The improvements in weather forecasts can be attributed to the upstream improvements of data collection and processing. By the end of the project, as a result of these improvements and new installations, 66 synoptic weather stations and 65 real-time weather monitoring stations were reporting with improved frequency—every three hours and monthly, while 27 AWSs, including one for maritime purposes, were transmitting data hourly. Three Automated Weather Observing Systems (AWOSs) that had also been installed were operating at the airports of Beira, Nampula and Lichinga.

Improved fibre-optic data connections between INAM's decentralised centres and headquarters facilitated the improved transmission of data collected, including automated climatological reporting from 28 conventional stations to WMO's GTS.

Improved weather forecast availability, accuracy and dissemination

INAM's data management was improved through the use of open-source Climsoft software. Data was used in a Numerical Weather Prediction (NWP) Model——the Weather Research and Forecasting Model (WARF)—to generate and deliver downscaled weather forecasts to 28 of the country's districts. As a comparison, forecasts were previously delivered at regional and national scale, with downscaling only available to six districts.

The capacity to disseminate forecast information and climate services has been enabled through the installation of a professional TV broadcasting studio at INAM and a revamped website. At the pilot districts of Malabane, Inhambane and Massinga, impact-based forecasts and warnings for farmers and fishermen are transmitted through the radio, phone apps and placards located at agreed sites.

Improved climate services among beneficiaries

Focus groups with beneficiaries in the pilots at the end of the project yielded a high degree of satisfaction with the products and a high proportion were using the information to inform their behaviour. For example, the fishermen gave feedback that they would use the forecasts to decide whether or not to carry out fishing activities, or when to enter and return from the sea, to avoid any exposure to potential risks.

Improved institutional coordination for sustainability

To overcome the obstacles to effective coordination, the project supported the establishment of a national Hydromet Working Group to support improved climate service production and delivery across the various actors (see figure A.3). The Hydromet Working Group led to the creation of two types of instruments for improving coordination—(1) the Inter-Ministerial Diploma on data sharing (including with the Ministry of Public Works, Housing and Water Resources [MOPHRH, Ministério das Obras Públicas, Habitação e Recursos Hídricos] and the Ministry of Transport and Communications [MTC, Ministério Dos Transportes E Comunicação]) and the signing of a Memorandum of Understanding (MoU) between INAM and DNRGH that addressed the formats and frequency of data sharing; along with (2) the development of manuals of hydromet data and equipment standards and methodologies. The adoption of these instruments has enabled the sharing of information between INAM and DNGRH/ARAs to deploy weather forecasts as input to hydrological models for producing flood predictions.

Economic impact analysis

The benefit and cost assessment, conducted at the project closing phase, reveals a total present value of USD46.42 million over a 50-year period, based on a three-percent discount rate, compared with the total costs of the project of USD13.9 million (around 92 percent of the original budget). An NPV of USD39.6 million was estimated for households, while the value of approximately USD12 million was derived for statistical lives saved as a result of the project. The NPV of the improved forecasts on economic sectors in Mozambique was estimated at approximately USD36 million. These values indicate that the project was largely viable.

Moreover, a discrete choice analysis was applied to derive benefits, based on the Willingness to Pay (WTP) from households' choices between the accuracy of existing forecasts and potential forecast-improvement programs. The total WTP estimate for the program, based on the actual improved forecasts, was 2.52 Mozambican Meticals (USD0.04) per year per household respondent, which when aggregated to the total population, and considering a 50-year programme lifetime with a three-percent discount rate, the present value estimate was USD7.5 million. For the Benefit Transfer Analysis (BTA) that focuses on the reduction of the natural hazards impact on statistical lives, adjustments to the weather and water-related fatalities are considered to capture the duration period of the project. The analysis of the variability of economic output, attributable to lives saved, was estimated to be USD2.42 million, while benefits estimated for the sectors amounted to USD4 million.

At the project closing phase, the financial overview showed sufficient government transfers to cover operations and maintenance, estimated to be USD353,000 per year. However, an overview of the different revenue sources (between 2013 and 2019) indicated that government subsidies, aggregated for all ARAs amount, on average to USD5.36 million per year, while the financing from external donors and other sources accounted for USD14.50 million and USD0.29 million on average per year, respectively.

JAMAICA: IMPROVING CLIMATE DATA AND INFORMATION MANAGEMENT PROJECT[6]

BASELINE SITUATION

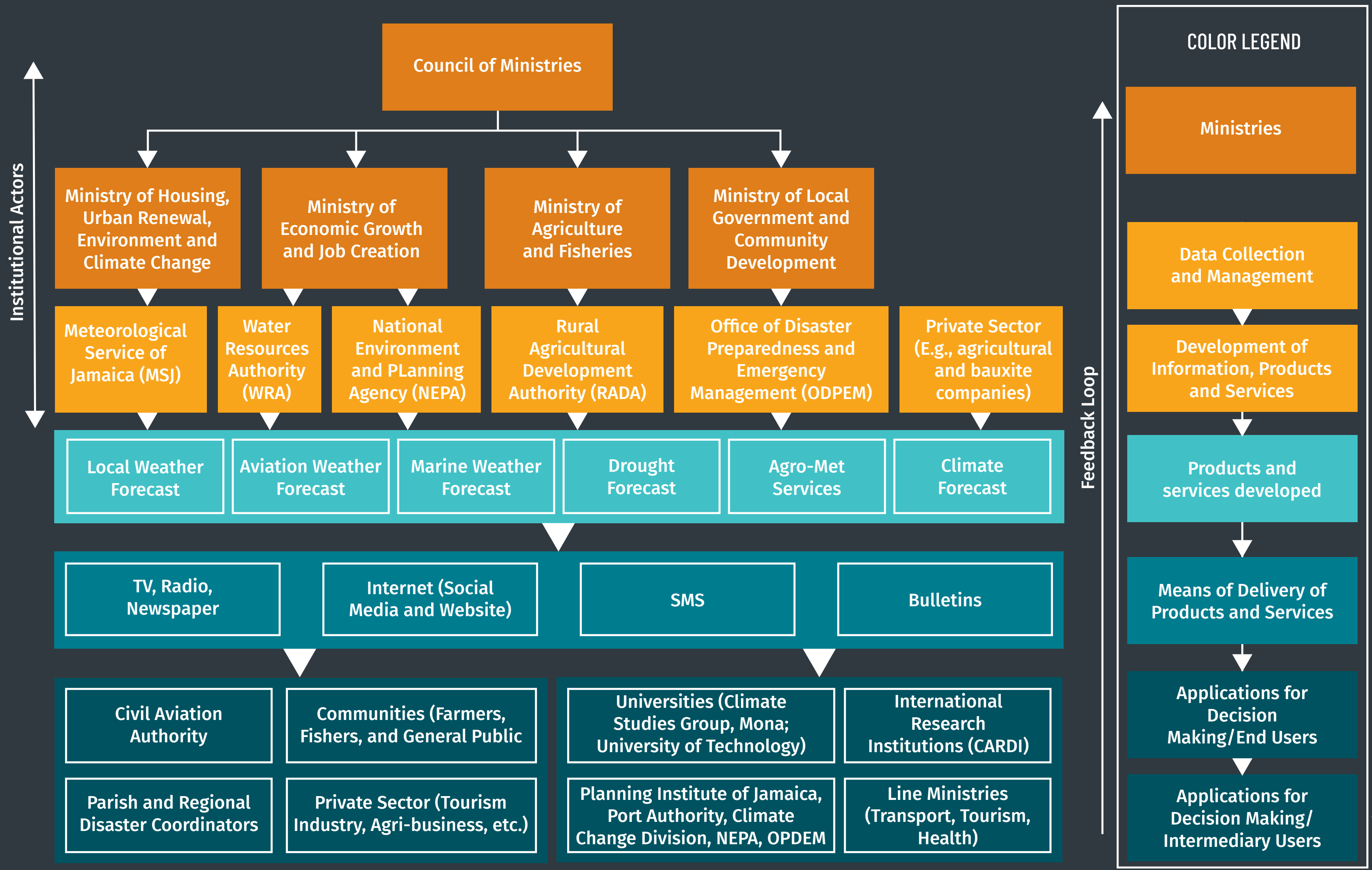
At the start of the PPCR intervention, Jamaica's hydromet system, along with the capacity of the Meteorological Service of Jamaica (MSJ) and the Water Resources Authority (WRA) to develop and deliver climate services, was under considerable strain. Limited financial resources impeded the routine maintenance and replacement of malfunctioning equipment in the hydromet monitoring network, which hindered further expansion. A high proportion of manual rainfall stations and climatological stations were not functioning, while the Doppler Weather Radar at Cooper's Hill was obsolete. Inadequate equipment and limited technical capacity also impeded the capability of data processing, as well as the production of information and services, to predict and prepare for weather events, therefore preventing the government from being able to integrate climate resilience into its planning. This situation was further exacerbated by limited interagency coordination between MSJ and WRA, respectively responsible for meteorological and hydrological monitoring, which also made the efficient management and distribution of stations a challenge.

PROJECT OVERVIEW

The Improving Climate Data and Information Management Project (ICDIMP) aims to improve the quality and use of climate-related data and information for effective planning and action at the local and national levels. It does so in three ways. First, hydromet data collection, processing and forecasting systems are improved: this includes optimising the monitoring networks for the sea level, hydrometeorology and agrometeorology; upgrading the weather Doppler radar; and strengthening human capacity on data collection, management and forecasting. Second, climate-resilient planning and climate services are enhanced by developing high-resolution climate scenarios, conducting vulnerability assessments at the national level and on priority sectors, including health, water and agriculture, as well as upgrading the multi-agency climate-risk data and information-sharing system. Finally, climate change education and awareness are improved through information campaigns as well as attitude and behavioural change initiatives.

The project is implemented by the Planning Institute of Jamaica (PIOJ)—a statutory body within the Ministry of Finance and the Public Services—in collaboration with a number of technical implementing agencies, including MSJ, WRA, the Rural Agricultural Development Authority (RADA), the Office of Disaster Preparedness and Emergency Management (ODPEM), along with the Ministry of Health, Climate Change Division and the National Spatial Management Division (NSMD).

Figure A.4.
INSTITUTIONAL ARRANGEMENTS FOR CLIMATE SERVICES IN JAMAICA



Source: World Bank, 2021

KEY ACHIEVEMENTS

Unlike the projects in Nepal and Mozambique, the PPCR project in Jamaica is still under implementation until April 2022, which means that the same range of data on involvement with users nor economic impacts (as in the case of the other two countries) is not yet available. As such, this section will only be presenting the achievements to date.

Modernisation of observation networks and data management

Significant achievements have been made in Jamaica, which include improvements to the hydromet network. Physical works and the instrumentation of 35 AWSs, including 14 agrometeorological and 21 weather stations, have taken place. Expanding the observational network is particularly important in Jamaica, due to its topography that creates microclimates. A real-time sea-level tide gauge has been installed and operationalised in the Montego Bay Pier. A Doppler weather radar has also been installed and operationalised. These are all under the control of MSJ.

Furthermore, WRA has also benefited from enhanced hydrological data resources. This includes the installation of physical works and instrumentation for 57 hydromet stations—comprising stream, river and intensity rain gauges; the modernisation of over 40 rain gauges and water-level sensors for real-time data transmission; along with the procurement and instrumentation of 12 soil-moisture probes essential for monitoring effectively and providing early warning of flood risk. The management of data has been improved by the establishment of a hydrological monitoring centre and a situation room for the remote monitoring of hydrological resources.

Data recovery

Observational records are fundamental for both weather forecasting and climate projections. A significant loss of past observational records occurred in Jamaica due to a fire in 1992 at MSJ, where past paper records were kept. As a result, the monthly rainfall data contains many gaps. PPCR has supported the data recovery and infilling of rainfall data from 1971 to 2010.

Provision of new climate information

New climate information products have been developed to inform climate-resilient planning across a range of sectors. In partnership with the University of the West Indies-Mona, the government produced a *State of the Jamaican Climate Report 2015.* It assesses climate trends and evaluates the sectoral impacts of climate change. The *State of the Jamaican Climate Report 2019* is being finalised. The same partnership has produced downscaled high resolution (10-4km blocks) climate change scenarios for 2030, 2050 and 2080. Vulnerability assessments have been undertaken to better understand the impacts of climate change on key sectors, such as health. The assessments will be incorporated into the preparation of manuals and guidelines for sector-specific climate-resilient planning and design.

Improved institutional coordination for sustainability

At the start of the project, there was inconsistent coordination between MSJ, in charge of meteorological information, and WRA, responsible for hydrological information. This had led to the inefficient use of resources, with observation and monitoring stations sited by each organization without consideration of the other. Their procedures were also incompatible with those of the other: for example, each organisation collected soil-moisture information at different depths, even though they had probes at the same locations. The project facilitated an MOU between the two organisations to facilitate the sharing of hydromet data, coordination in locating hydromet stations and the expansion in the spatial coverage of data collection. The establishment of an interagency Hydromet Working Group under the project has further supported the coordination among MSJ, WRA and other implementing agencies, including the National Environment and Planning Agency (NEPA), RADA, ODPEM and other line ministries (see figure A.4).

ANNEX B: SUMMARY OF ACHIEVEMENTS AND OUTSTANDING PRIORITIES ACROSS THE CLIMATE SERVICES VALUE CHAIN BY COUNTRY

Table B.1.

SUMMARY OF ACHIEVEMENTS AND OUTSTANDING PRIORITIES ACROSS THE CLIMATE SERVICES VALUE CHAIN IN NEPAL

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
NEPAL	Achievements to date	• Upgraded 88 surface meteorological as well as 70 surface and hydrological observation stations. • Installed Doppler weather radar in Surkhet, nine lightning detection networks and one Upper-Air Sounding station in Kathmandu. • Improved the transmission of data to the World Meteorological Organization's (WMO) Information System (WIS)/ WMO Global Telecommunication System (GTS). • Improved remote sensing and geographic information system (GIS) labs, along with improved IT infrastructure for database management. • Established an Agriculture Management Information System (AMIS). • Digitised more than 20,000 historical datasets in the agriculture sector, including the annual reports of different agricultural research stations, historical workshop proceedings, journals and factsheets collected from several research stations under the Nepal Agricultural Research Council (NARC).	• Installed infrastructure, such as computing equipment and Numerical Weather Prediction (NWP) models, to support the development of 24-hour and three-day weather forecasts, daily flood forecasting and early warning during monsoon season.Developed the Agromet Advisory Bulletin (AAB) in the Nepali and Avadhi languages. • Launched the "Hamro Krishi" Mobile Application that provides agriculture and agromet information. • Improved aviation forecasts.	• Disseminated forecasts and advisories through SMS, radio, TV, newspapers, the Department of Hydrology and Meteorology's (DHM) website, Facebook, Twitter and its Mobile app. • Opened 52 Kisan Call Centres (KCCs) at 52 District Agriculture Development Offices (DADOs) and District Livestock Service Offices (DLSOs) in 26 pilot districts • Distributed 1,263 sets of mobile phones with the "Hamro Krishi" app installed and the Kisan SIM card to selected farmers' groups/ cooperatives of pilot districts. • Trained approximately 16,208 farmers to enable the broader adoption of products and services.	• Doppler weather radar-based forecasting helped the Nepalgunj airport to make efficient flight-related decisions and plans. • In 2019, 79, 50 and 89% of users of the "Hamro Krishi" app, the AAB and the Krishi Information SMS were satisfied with their services, respectively. • The endline user satisfaction survey revealed significant improvements in services related to weather parameters (that is, rainfall and temperature): 75% of respondents reported satisfaction with the accuracy and utility of these services in protecting their lives and property.	• Enhanced collaboration between DHM, the Ministry of Agriculture and Livestock Development (MoALD) and NARC.	• Increased the awareness of climate information, trust in its quality and its use. • 27% of focus group participants (71 participants in six locations) mainly used DHM's climate and weather information (16% used DHM and traditional knowledge; 47% relied on traditional knowledge)—an improvement from previous findings, when weather forecasts had not been as accurate.

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
NEPAL	**Remaining priorities**	• Develop a comprehensive data-sharing policy at a national level to ensure hydromet data accessibility • Build in-house capacity for equipment and data management	• Develop information targeting tourism (mountaineering); insurance; the private-airlines sector; along with climate-resilient development, including national adaptation plans and other adaptation options • Develop a seven-day forecast (longer lead time), location-specific forecasts and impact-based forecasts	• Improve the comprehension of information among users	• Application of the seven-day forecast (longer lead time), location-specific forecasts and impact-based forecasts	• At the national level: • Develop linkages and collaborations with domestic and foreign universities and research and development organisations • Finalise and approve the hydromet bill to provide the legal basis of hydromet-related activities • Improve collaborations between departments and across governance levels • At the regional and international levels: • Strengthen collaborations between cross-border countries, including data sharing with India and China	• Introduce a formal process for collecting feedback at the end-user level • Improve advisories by tailoring them to user needs

Table B.2.

SUMMARY OF ACHIEVEMENTS AND OUTSTANDING PRIORITIES ACROSS THE CLIMATE SERVICES VALUE CHAIN IN MOZAMBIQUE

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
MOZAMBIQUE	Achievements to date	• Installed 27 Automated Weather Stations (AWSs) and one maritime AWS for Inhambane Port • Modernised additional climatological (synoptic) stations so that, by project close, 87 synoptic weather stations and 71 real-time weather monitoring stations were generating reports • Three Automated Weather Observing Systems (AWOSs) were installed and operational at the airports of Beira, Nampula and Lichinga • Replaced INAM's data management system (DMS) and upgraded it with Climsoft, thus enabling more effective integration of multiple data streams for forecasting and reporting with WMO's GTS. • Completed physical works and instrumentation for 58 river gauge stations • Developed and operationalised a National Integrated Water Resources Management Information System (NIWRMIS) that hosts information from multiple observational and historical data sources • Migrated hydrological data to the open-source time-series hydrological data system (HYDSTRA) now used for reporting	• Developed sea-wave models for five major coastal cities and Inhambane that have been incorporated into navigation systems • Developed aviation-specific climate information for flight plans that is compliant with ISO 9001-2015 international safety standards for airspace navigation • Implemented the use of an NWP model to predict cyclones to trigger timely response actions	• Delivery of flood early warnings along the Zambezi, Limpopo and Incomati River basins • Dissemination of weather and water forecasts to farmers in the Gaza and Inhambane Provinces • Enhanced access to weather information for ports, along with commercial maritime and artisanal fishery communities in the coastal areas of Inhambane	• Improved the safety of maritime navigation at Inhambane Port and five major coastal cities, thus supporting economic opportunities • Improved aviation safety • Benefit-cost ratios of 1.26 for lives saved and 1.77 for sectoral benefits, stemming from improved forecasts	• Improved data sharing between the National Institute for Meteorology (INAM) and the National Directorate of Water Resources Management (DNGRH), due to a Memorandum of Understanding (MoU) and a manual on procedures • Improved coordination between INAM and the University of Eduardo Mondlane (UEM) in order to build capacity • Improved collaboration around disaster risk reduction (DRR) through an MoU between DNGRH, INAM and the National Institute of Disaster Risk Management and Reduction (INGD) • Improved coordination within the government and with academia on the use of long-term climate change projections	• Improved collaboration with the intermediaries that are better-placed to communicate to diverse user groups

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
MOZAMBIQUE	**Remaining priorities**	• Improve the quality of DNGRH's data to meet the WMO standards • Ensure a data policy to streamline cost recovery options between INAM (that charges for its data) and DNGRH (that structures cost recovery around water resources) • Ensure all stations hosted by both INAM and DNGRH adopt the WIGOS standards • Build the capacity to improve data quality, including MoUs with local communities to encourage the stewardship of stations	• Develop climate information for the health and tourism sectors	• Ensure the appropriate delivery of sector-specific climate information	• Improve the use of long-term climate change projections for decision-making across sectors	• Improve collaborations between INAM and DNGRH; between INAM and a national university; between the government and nongovernmental organisations (NGOs) involved in DRR	• Institute a formal process to evaluate the ways information is accessed, used and the extent to which it meets needs • Train user groups on the meaning and utility of existing services within specific contexts • Make available information in languages other than Portuguese

Table B.3.

SUMMARY OF ACHIEVEMENTS AND OUTSTANDING PRIORITIES ACROSS THE CLIMATE SERVICES VALUE CHAIN IN JAMAICA

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
JAMAICA	Achievements to date	• Installed a Doppler weather radar • Set up physical works and instrumentation for 53 AWSs, including 14 agrometeorological and 39 weather stations • Recovered and filled in the gaps of a rainfall dataset for 1971–2010 • Installed a real-time sea-level tide gauge in the Montego Bay Pier and procured two more • Procured and installed 32 soil-moisture probes • Established a hydrological monitoring centre and a situation room • Set up physical works and instrumentation for 57 hydromet stations—comprising stream, river and rain gauges • Modernised over 40 rain gauges and water-level sensors for real-time data transmission	• Developed downscaled Climate Change Scenarios (10-4 km blocks) for 2030, 2050 and 2080 • Developed a State of the Jamaican Climate Report 2015 that assesses climate trends and sector impacts • Detailed health vulnerability assessment undertaken in order to inform the guidelines for sector-specific climate-resilient planning • Developed Early Warning Messaging targeting low-income groups living in unplanned settlements in hazard-prone locations and persons with disabilities, among others.	• Data collected by the Water Resources Authority (WRA) available online	• Too early to be seen	• Enhanced the coordination between WRA and the Meteorological Service of Jamaica (MSJ) through an MOU to facilitate the sharing of hydromet data, coordination in locating hydromet stations and expansion in the spatial coverage of data collection • Established the interagency Hydromet Working Group that has enabled the technical implementing agencies of the PPCR project to discuss issues related to the hydromet landscape in the country • Improved coordination with academia, for example, the Climate Studies Group of the University of the West Indies—Mona prepared the Jamaican State of the Climate Reports and the climate scenarios	• Information will be available upon the completion of the project.

COUNTRY		STAGES IN THE CLIMATE SERVICES VALUE CHAIN				CROSS-CUTTING	
		Data collection and management	Development of information, products and services	Delivery of products and services	Application for decision-making	Institutional actors and service providers	Intermediary users and end-users
JAMAICA	Remaining priorities	• Enhance the density of hydromet stations • Fill additional gap in soil-moisture data • Rescue data to fill remaining gaps in pre-2009 rainfall records and temperature data • Increase stations to measure groundwater • Increase tidal gauges to measure and monitor sea-level rises • Install equipment to monitor sea-surface temperature • Adopt the WMO Integrated Global Observing System (WIGOS) and the World Hydrological Cycle Observing System (WHYCOS) frameworks for better data management • Install a data management system, for example, WMO's open-source Meteorological, Climatological and Hydrological Database Management System (MCH). • Ensure a data policy for MSJ that enables it to establish a revenue stream (similar to that of WRA) • Train new data collectors and impact-based forecasters	• Develop climate information targeting health, energy, tourism and construction; impact-based forecasts	• Enhance access to the meteorological data from MSJ (currently only available upon request) • Improve the awareness and communication of available information • Shift from passive communication (for example, expecting people to visit a website) to active communication, for example, through social media	• To be determined toward project completion	• Promote formal collaboration and data-sharing mechanisms, for example, through a policy • Strengthen the coordination between MSJ and WRA with other line ministries and sectoral institutions, for example, the Ministries of Health and Tourism • Establish a platform for coordination between producers and users • Create synergies and strengthen the collaboration between service providers and academic institutions, which can further strengthen research and development and thus enhance the capacities of the actors involved. • Strengthen formal mechanisms for regional data sharing and use, for example, with the Caribbean Institute for Meteorology and Hydrology (CIMH), the National Ocean and Atmospheric Administration (NOAA), the National Hurricane Center and the Caribbean Community Climate Change Center (CCCCC)	• Improve collaborations between producers and users • Introduce a formal process to evaluate the ways information is accessed, used and the extent to which it meets needs

ACRONYMS

AAB	Agromet Advisory Bulletin
ADRA	Adventist Development and Relief Agency
AITC	Agriculture Information and Training Centre (Nepal)
AKC	Agriculture Knowledge Center (Nepal)
AMIS	Agriculture Management Information System
ARA	Regional Water Authorities *(Administrações Regionais de Águas)* (Mozambique)
AWOS	Automated Weather Observing System
AWS	Automated Weather Station
BCA	Benefit-Cost Analysis
BRCH	Building Resilience to Climate Hazards
BTA	Benefit Transfer Analysis
CariCOF	Caribbean Climate Outlook Forum
CCCCC	Caribbean Community Climate Change Center
CENOE	National Emergency Operative Centre (Mozambique)
CERUM	Multiple Uses and Resources Centre (Mozambique)
CIF	Climate Investment Funds
CIMH	Caribbean Institute for Meteorology and Hydrology
CLUSA	Credit League of the United States of America
CUSI	Composite User Satisfaction Index
DADO	District Agriculture Development Office (Nepal)
DHM	Department of Hydrology and Meteorology (Nepal)
DLSO	District Livestock Service Office (Nepal)
DMS	Data Management System
DNAAS	National Directorate for Water Supply and Sanitation *(Direcção Nacional Abastecimento de Agua e Saneamento)* (Mozambique)
DNGRH	National Directorate of Water Resources Management *(Direcção Nacional de Gestão de Recursos Hídricos)* (Mozambique)
DRR	Disaster Risk Reduction
EWS	Early Warning System
FAO	Food and Agriculture Organization
GBON	Global Basic Observing Network
GFCS	Global Framework for Climate Services
GIDC	Government Integrated Data Centre (Nepal)
GIS	Geographic Information System
GLOF	Glacial Lake Outburst Flood
GTS	Global Observation and Telecommunication System (WMO)
GWE	Global Weather Enterprise
HEC-RAS	Hydrologic Engineering Center's River Analysis System
ICDIMP	Improving Climate Data and Information Management Project
IDA	International Development Association
INAM	The National Institute for Meteorology *(Instituto Nacional de Meteorologia)* (Mozambique)
INGD	National Institute of Disaster Risk Management and Reduction *(Instituto Nacional de Gestão e Redução do Risco de Desastres)* (Mozambique)

KCC	Kisan Call Centre (Nepal)
LDC	Least Developed Country
LDOF	Landslide Dam Outburst Flood
MCH	Meteorological, Climatological and Hydrological Database Management System
MDB	Multilateral Development Bank
MoALD	Ministry of Agriculture and Livestock Development (Nepal)
MoEWRI	Ministry of Energy, Water Resources and Irrigation (Nepal)
MOPHRH	Ministry of Public Works, Housing and Water Resources *(Ministério das Obras Públicas, Habitação e Recursos Hídricos)* (Mozambique)
MoU	Memorandum of Understanding
MSJ	Meteorological Service of Jamaica
MTC	Ministry of Transport and Communications *(Ministério Dos Transportes E Comunicação)* (Mozambique)
NARC	Nepal Agricultural Research Council (Nepal)
NCBA	National Cooperative Business Association
NDF	Nordic Development Fund
NEPA	National Environment and Planning Agency (Jamaica)
NGO	Nongovernmental Organisation
NIWRMIS	National Integrated Water Resources Management Information System
NMHS	National Meteorological and Hydrological Services
NOAA	National Ocean and Atmospheric Administration
NPV	Net Present Value
NSMD	National Spatial Management Division (Jamaica)
NWP	Numerical Weather Prediction
ODPEM	Office of Disaster Preparedness and Emergency Management (Jamaica)
PICSA	Participatory Integrated Climate Services for Agriculture
PIOJ	Planning Institute of Jamaica
PMU	Project Management Unit
POCP	Package of Cultivation Practices
PPCR	Pilot Program for Climate Resilience
PPE	Public-private engagement
RADA	Rural Agricultural Development Authority (Jamaica)
RCOF	Regional Climate Outlook Forum
SARCOF	Southern African Regional Climate Outlook Forum
SASCOF	South Asian Seasonal Climate Outlook Forum
SIDS	Small Island Developing State
SOFF	Systematic Observations Financing Facility
UEM	University of Eduardo Mondlane (Mozambique)
VHLSEC	Veterinary Hospital and Livestock Service Expert Center (Nepal)
WARF	Weather Research and Forecasting Model
WHYCOS	World Hydrological Cycle Observing System
WIGOS	WMO Integrated Observing System
WMO	World Meteorological Organization
WOGRAM	Working Group of Agricultural Meteorology (Nepal)
WRA	Water Resources Authority (Jamaica)
WTP	Willingness to Pay

ENDNOTES

1 At the time of writing this report, the Jamaica project is still active; and thus, this report is based on the experiences and lessons from Jamaica until the end of December 2021.

2 The remaining priorities in Nepal, Mozambique and Jamaica pertain to the activities that expand beyond the scope of PPCR projects.

3 Note: As the project in Jamaica is still active at the time of writing, the information in the table relates only to experiences and lessons to December 2021.

4 Note that these figures may be low because currently, the weather information by DHM does not provide agro-advisories.

5 Non-quantified benefits include (i) avoided deaths, injuries and illness from weather-related disasters; (ii) improved general convenience of the public; and (iii) enhanced long-term environmental monitoring.

6 This project is still active at the time of writing; and thus, this report contains experiences and lessons to date.

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THE CLIMATE INVESTMENT FUNDS

c/o The World Bank Group
1818 H Street NW, Washington, D.C. 20433 USA

Telephone: +1 (202) 458-1801
Internet: www.climateinvestmentfunds.org

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