SAHF CLIMATE SERVICES PROJECT

ASSESSMENT REPORT ON THE STATUS OF CLIMATE SERVICES IN SOUTH ASIAN COUNTRIES

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EXECUTIVE SUMMARY

This assessment report examines the current status of climate services across South Asian countries participating in the South Asia Hydromet Forum (SAHF), namely Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan, and Sri Lanka. The assessment was undertaken as part of the SAHF Climate Services Working Group Implementation Plan Project, with support from the UK Government through the Foreign, Commonwealth & Development Office (FCDO)'s Weather and Climate Information Services (WISER) Asia-Pacific Programme.

South Asia remains one of the world's most climate-vulnerable regions, facing increasing risks from floods, droughts, tropical cyclones, heatwaves, and other climate extremes. In this context, climate services—including climate monitoring, forecasting, climate outlooks, and decision-support information—play a critical role in supporting disaster risk reduction, agriculture, water management, infrastructure planning, health, and climate adaptation.

The assessment reviewed the status of National Frameworks for Climate Services (NFCS), institutional arrangements, observing systems, climate information products across timescales, dissemination mechanisms, stakeholder engagement processes, co-production practices, and the use of climate information in decision-making. The assessment was informed through desk reviews, key informant interviews with SAHF Climate Services Working Group members, and analysis of National Climate Outlook Forum (NCOF) documentation.

Findings indicate that all countries have established foundational climate service functions, particularly in weather monitoring, climate observations, and seasonal forecasting. However, the maturity of climate services systems varies significantly across the region. Using an adapted five-category climate services framework tailored to the South Asian context, Afghanistan and Maldives were categorized under Basic Services; Bhutan, Nepal, Myanmar, and Sri Lanka under Emerging Services; Bangladesh and Pakistan under Essential Services; and India under Full Services due to its advanced institutional, technical, and sectoral climate service capabilities. No country currently meets the characteristics associated with Advanced Services.

Across the region, common challenges include uneven observation network coverage, incomplete digitization and integration of climate datasets, limited technical capacity for advanced modelling and downscaling, insufficient institutional coordination, and limited operationalization of impact-based and sector-specific climate services. While seasonal outlooks and hazard advisories are widely produced, many countries continue to face difficulties translating climate information into actionable decision-support tools tailored to user needs.

At the same time, the assessment highlights important regional strengths and opportunities. Countries across South Asia are increasingly engaging in seasonal climate outlook processes through SASCOF, strengthening agro-meteorological advisories, expanding dissemination systems, and improving integration of climate information into disaster preparedness and adaptation planning. Regional collaboration platforms such as SAHF, SASCOF, and CSUF have

become important mechanisms for technical exchange, peer learning, and coordination among NMHSs and user sectors.

The report further emphasizes the important and emerging role of the SAHF Climate Services Working Group as a regional coordination mechanism for advancing climate services development in South Asia. The Working Group provides a platform for NMHS collaboration, technical exchange, identification of regional priorities, and alignment of ongoing initiatives with the longer-term development of a Regional Framework for Climate Services (RFCS). Importantly, the current climate services project has provided critical foundational work toward this objective through the development of regional and national climate services assessment reports, identification of institutional and technical gaps, and documentation of existing capacities and good practices across the region.

The assessment identifies several priority next steps for the region. These include strengthening and operationalizing NFCS mechanisms; improving observational infrastructure and climate data systems; expanding technical capacity in climate modelling, downscaling, and impact-based forecasting; institutionalizing stakeholder engagement and co-production mechanisms; strengthening monitoring and evaluation systems; and enhancing communication approaches to improve the usability of climate information. Continued support for regional collaboration through SAHF, SASCOF, and CSUF will be essential for sustaining progress toward more integrated, user-oriented, and decision-relevant climate services systems across South Asia.

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1 INTRODUCTION

1.1 Background and Rationale

South Asia is among the most climate-vulnerable regions in the world, where climate variability and extreme weather events significantly affect economic development, food security, water resources, and public health. The region is characterized by complex climate dynamics driven by the South Asian monsoon system, Himalayan cryosphere processes, and ocean–atmosphere interactions such as the El Niño–Southern Oscillation (ENSO) and the Indian Ocean Dipole. These climatic drivers influence the frequency and intensity of hazards including floods, droughts, tropical cyclones, heatwaves, and glacial lake outburst floods, which have increasingly severe impacts on populations and infrastructure across the region (IPCC, 2021; WMO, 2024).

In recent decades, the growing recognition of climate-related risks has highlighted the importance of climate services—the provision of climate information tailored to support decision-making across climate-sensitive sectors such as agriculture, water resources, disaster risk management, health, and energy. Climate services translate climate data and predictions into actionable knowledge, enabling governments, communities, and economic sectors to manage risks associated with climate variability and long-term climate change (WMO, 2018).

To strengthen the development and delivery of such services, the Global Framework for Climate Services (GFCS) was established following the World Climate Conference-3 in 2009. The GFCS aims to enhance the generation, availability, and use of climate information through coordinated global collaboration and structured engagement between climate information providers and users. The framework is organized around five interconnected pillars: (1) observations and monitoring, (2) research, modelling and prediction, (3) climate services information systems, (4) user interface platforms, and (5) capacity development (Hewitt et al., 2012; WMO, 2018).

The GFCS recognizes that effective climate services require coordinated action across global, regional, and national levels. At the regional level, a Regional Framework for Climate Services (RFCS) strengthens collaboration to enhance co-production, tailoring, delivery, and use of science-based climate information and services among regional institutions, including Regional Climate Centres (RCCs), national meteorological services, and sectoral organizations. RFCS promotes coordinated action across the pillars of GFCS to support informed decision-making in climate-sensitive sectors and address shared climate risks (WMO, 2025).

At the national level, the National Framework for Climate Services (NFCS) serves as the primary institutional mechanism for coordinating the development, delivery, and use of climate services within a country. NFCS structures bring together National Meteorological and Hydrological Services (NMHSs), sectoral ministries, research institutions, development partners, and user communities to co-design and co-produce climate services that support sectoral decision-making (WMO, 2018).

The co-production of climate services—where climate information providers collaborate with sectoral users to tailor information to specific decision contexts—is widely recognized as a critical

element of effective climate service systems (Vaughan & Dessai, 2014). Without such engagement, climate information may remain underutilized or insufficiently aligned with sectoral needs.

In South Asia, regional cooperation on climate services has strengthened over the past decade through platforms such as the South Asia Seasonal Climate Outlook Forum (SASCOF) and the South Asia Hydromet Forum (SAHF). SASCOF provides a mechanism for regional experts to jointly develop seasonal climate outlooks and engage with sectoral users. On the other hand, SAHF complements SASCOF by serving as the broader regional coordination platform that brings together NMHSs, RCCs, development partners, and sectoral stakeholders to strengthen hydrometeorological services, climate services, and multi-hazard early warning systems. Together, SASCOF and SAHF provide a coordinated regional ecosystem that connects climate science, institutional collaboration, and service delivery that enables South Asian countries to better translate regional climate information into national and sector-specific decision-making.

Despite these advances, the development and uptake of climate services across South Asia remain uneven. Challenges persist in areas such as institutional coordination, observational network coverage, climate modelling capacity, data sharing, stakeholder engagement, and sustainable financing for climate services. Studies examining climate service implementation in South Asia have also highlighted the need for stronger institutional frameworks and improved integration of climate information into sectoral planning processes (Daron et al., 2022; Suckall & Soares, 2022).

Given these challenges, there is increasing demand for systematic assessments that evaluate the current status of climate services at the national level. Such assessments help identify strengths, capacity gaps, and opportunities for strengthening climate service systems, including the implementation of NFCS and the translation of climate information into actionable services.

This assessment therefore aims to synthesize regional progress in climate service development across South Asia by reviewing national institutional arrangements, technical capacities, and operational practices related to climate services delivery. By documenting existing practices and identifying opportunities for strengthening climate service systems, the assessment seeks to support the continued development of inclusive, sustainable, and decision-relevant climate services across the region.

1.2 Objectives and Scope

This assessment aims to synthesize regional progress in the development and implementation of the NFCS among South Asian countries by reviewing national strategies and National Climate Outlook Forum (NCOF) outcomes, ultimately identifying scalable opportunities for cross-sector engagement and sustainable climate service growth. It specifically aims to:

- Review national strategies and implementation status of NFCS,
- Document best practices and lessons learned across seasonal and climate timescales through the outputs and outcomes from NCOFs,
- Identify common challenges and opportunities for collaborative action that can inform the future work of the SAHF Climate Services Working Group.

1.3 Geographical Focus

This assessment focuses on South Asian countries participating in the South Asia Hydromet Forum, namely Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan, and Sri Lanka.

These countries share several common climatic drivers and regional climate systems, including the South Asian monsoon, Himalayan hydrological systems, and large-scale ocean-atmosphere interactions affecting seasonal variability. Regional climate processes frequently transcend national boundaries, highlighting the importance of collaborative climate monitoring, modelling, and service delivery across the region.

Disclaimer: The geographical designations used in this report follow internationally recognized datasets and institutional references. Consistent with standard United Nations and World Meteorological Organization practice, the depiction of geographic boundaries and territorial references does not imply any official opinion regarding the legal status or delimitation of international boundaries.

1.4 Methodology and Approach Used

This assessment adopts a qualitative and evidence-based analytical approach to synthesize the current status of climate services across South Asian countries. The analysis draws on multiple sources of information to examine institutional arrangements, technical capacities, and operational practices related to climate services development and delivery.

The assessment is based on three primary methods:

1. Desk Review of Literature and Institutional Documentation to examine relevant global, regional, and national documentation related to climate services development. The review provided background information on institutional mandates, governance structures, observational systems,

climate products, and climate service delivery mechanisms. It also helped identify existing regional initiatives and collaborative mechanisms supporting climate services in South Asia.

2. Key Informant Interviews (KIIs) were conducted with the SAHF Climate Services Working Group members to obtain operational insights into the development and delivery of climate services.

The interviews explored institutional, technical, and operational aspects of climate services, including NFCS implementation, observing network limitations, climate services production across timescales, dissemination and communication practices, user engagement and co-production mechanisms, and coordination with regional climate institutions.

These discussions provided valuable qualitative insights into both the enabling factors and constraints affecting climate service implementation in different national contexts.

3. Analysis of National Climate Outlook Forum (NCOF) Documentation

Where available, documentation from NCOFs was reviewed to understand how seasonal climate outlooks and related climate services are operationalized at the national level. This included the examination of NCOF reports, climate outlook bulletins, stakeholder consultation records, and related technical materials.

The analysis focused on the role of NCOFs as platforms for climate information production, stakeholder engagement, and the translation of regional climate outlooks into nationally relevant advisories. Particular attention was given to how NCOF processes contribute to the operationalization of NFCS objectives and the dissemination of climate services to sectoral users.

2 STATUS OF CLIMATE SERVICES IN SOUTH ASIAN COUNTRIES

To provide a structured understanding of climate service development across the South Asian countries, the assessment examined several key dimensions aligned with the GFCS pillars and NFCS implementation guidance:

- NFCS Implementation Status - The existence and operationalization of NFCS provide an important indicator of how effectively countries coordinate climate service activities. Assessing NFCS implementation helps determine whether institutional mechanisms exist to facilitate collaboration among climate service providers, sectoral agencies, and users.

- Institutional Structure and Mandates - Climate service delivery often involves multiple institutions, including NMHSs, sectoral ministries, research organizations, and development partners. Understanding institutional mandates and governance arrangements helps clarify roles and responsibilities and identify opportunities for strengthening coordination.

- Observing Networks and Climate Data Systems - Reliable observational data form the foundation of climate services. Assessing meteorological, hydrological, and climate observation networks—including station coverage, data management systems, and integration of satellite observations—helps identify gaps in climate monitoring infrastructure.

- Climate Services Production Across Timescales - Climate services operate across multiple temporal scales, including sub-seasonal to seasonal forecasts, seasonal outlooks, decadal climate predictions, and long-term climate change projections. Evaluating national capabilities across these timescales helps assess the capacity of countries to support both short-term risk management and long-term adaptation planning.

- Product and Service Dissemination Mechanisms - Effective climate services require accessible communication channels to ensure that information reaches decision-makers and communities. These may include climate bulletins, online dashboards, mobile platforms, media broadcasts, and sector-specific advisories.

- Stakeholder Engagement and User Interface Platforms - Engagement between climate service providers and users is central to the GFCS framework. Platforms such as climate outlook forums, stakeholder consultations, and sectoral working groups enable dialogue between climate scientists and decision-makers to ensure services meet user needs.

- Co-Production and Tailored Climate Services - Co-production processes transform climate information into sector-specific services through collaboration between climate experts and sectoral practitioners. These processes often involve joint development of advisories, decision-support tools, and climate risk management strategies.

- Informing Decision-Making, Adaptation and Mitigation - Climate services support evidence-based decision-making across sectors. Assessing how climate information is used in planning processes, adaptation strategies, and risk management systems helps evaluate the practical impact of climate services.

- Monitoring, Evaluation and Learning - Monitoring and evaluation mechanisms are essential for assessing the effectiveness and socio-economic benefits of climate services. They also support learning and continuous improvement by providing feedback on service performance and user uptake.

- Summary of key gap/priorities for development – Synthesis of findings across all assessment dimensions particularly key gaps and priority areas for strengthening climate services at the national level.

2.1 AFGHANISTAN

Afghanistan: Climate Services Snapshot

NFCS Status	At an early stage of development; no fully institutionalized NFCS or permanent national coordination mechanism
Main sectors served	Disaster risk management, agriculture, water resources, food security, humanitarian response, aviation
Climate services and products available	Daily and weekly weather forecasts, hazard warnings, seasonal rainfall and temperature outlooks, and basic climate monitoring
Strengths	Continued delivery of essential forecasting and warning services, supported by participation in SASCOF and externally supported early warning initiatives
Main constraints	Fragmented institutional arrangements, sparse observation coverage, limited technical personnel, and reliance on regional and global forecast products
Immediate Priority	Establish a formal NFCS coordination mechanism while strengthening observation networks, data management, forecasting, downscaling, and user-oriented communication

2.1.1 NFCS Implementation Status

Afghanistan is at an early stage of developing an NFCS. While the country participates in regional climate outlook processes and aligns conceptually with the GFCS, a fully institutionalized national framework has not yet been formally adopted. Climate services are currently delivered through a combination of national institutional functions and externally supported initiatives that aim to strengthen hydrometeorological monitoring and early warning systems (World Bank, 2018; UNDP, 2020).

Efforts to strengthen climate services in Afghanistan have been largely driven by the country's need to improve disaster risk management and climate resilience in the face of increasing climate variability. Afghanistan is highly vulnerable to climate hazards including droughts, floods, avalanches, and extreme temperatures, which significantly affect agriculture, water resources, and livelihoods (ADB, 2017). As a result, several international development initiatives have focused on rebuilding meteorological infrastructure, restoring observational networks, and strengthening early warning capacities (World Bank, 2018).

Despite these efforts, the operationalization of an NFCS remains constrained by institutional fragmentation, limited technical capacity, and resource constraints. Coordination between meteorological services, disaster management agencies, and sectoral ministries is often facilitated through development projects rather than through a formal national coordination mechanism. Strengthening institutional governance structures for climate services and clarifying roles among national agencies are therefore key priorities for advancing NFCS implementation in Afghanistan.

2.1.2 Institutional Structure and Mandates

AMD is responsible for providing weather forecasts, climate monitoring, and hazard warnings in Afghanistan. AMD operates under the Afghanistan Civil Aviation Authority and historically focused primarily on aviation meteorology. Over time, its role has expanded to include broader responsibilities related to disaster risk reduction and climate information services.

AMD collaborates with several national institutions involved in climate risk management. These include the Afghanistan National Disaster Management Authority (ANDMA), which coordinates disaster preparedness and response activities, as well as ministries responsible for agriculture, water management, and rural development. Through these collaborations, climate information generated by AMD are able to support national disaster preparedness efforts, agricultural and humanitarian response planning (UNDRR, 2019; FAO, 2019).

However, institutional arrangements for climate services remain relatively fragmented. Climate services functions are not centralized within a dedicated operational unit but are distributed across several departments within AMD. This structure can limit coordination and long-term strategic planning for climate services development. In addition, the department faces significant human resource constraints, including limited numbers of trained meteorologists and climate analysts.

Strengthening institutional capacity and establishing clearer mandates for climate services across relevant agencies will be important steps toward building a more coordinated national climate services system.

2.1.3 Observing Network and Data Availability

Afghanistan's meteorological observation network has experienced significant disruption over the past several decades due to conflict and infrastructure damage. Many meteorological stations that previously operated across the country ceased functioning, leading to substantial gaps in observational coverage and historical climate records (ADB, 2017).

Recent efforts, supported by international partners, have focused on restoring parts of this network through the installation of automatic weather stations and improved data transmission systems. These initiatives aim to improve real-time monitoring of key climate variables such as temperature, precipitation, and wind, which are essential for both weather forecasting and climate analysis (World Bank, 2018).

Despite these improvements, large portions of the country—particularly mountainous and remote regions—remain poorly monitored. Sparse observational coverage limits the accuracy of weather and climate analyses and constrains the development of localized climate services.

Data management systems within AMD are also still evolving. Observational data are collected and archived within departmental systems, but data sharing and interoperability with other national institutions remain limited.

2.1.4 Climate Services Production across Timescales

AMD currently produces a limited but expanding range of climate information products. These include daily weather forecasts, weekly outlooks, and seasonal climate outlooks based largely on regional and global climate model guidance.

At shorter timescales, AMD provides operational forecasts that support aviation safety and disaster preparedness. These forecasts form the foundation of Afghanistan's early warning systems for weather hazards such as heavy rainfall, snowfall, and extreme temperatures.

At the seasonal timescale, Afghanistan participates in SASCOF and uses regional forecasts to develop national outlooks for rainfall and temperature. These outlooks are disseminated to government agencies and humanitarian organizations to support preparedness planning.

However, operational capacity for sub-seasonal to seasonal (S2S) forecasting are limited as the Department relies heavily on global forecast products and regional outlooks due to limited in-country modelling and downscaling capacity (WCRP, 2022). Long-term climate projections and climate change analyses are typically conducted through externally supported research initiatives rather than routine operational activities.

2.1.5 Products and Services Dissemination and Communication Mechanisms

Climate information generated by AMD is disseminated through a range of communication channels, including official bulletins, coordination meetings with government agencies, and media broadcasts. Forecasts and warnings are shared with national disaster management authorities, sectoral ministries, and humanitarian organizations involved in emergency preparedness and response.

Media outlets and international organizations often play a key role in extending the reach of climate information to local communities. In many cases, climate information is incorporated into broader disaster early warning systems operated by national authorities or development partners.

On the other hand, infrastructure limitations and uneven access to communication networks in remote areas delay the dissemination of warnings. Communication products are also often technical in nature and may not always be presented in formats that are easily understood by non-specialist users.

2.1.6 Engagement with Stakeholders

Engagement between AMD and user sectors occurs primarily through coordination with national agencies responsible for disaster management, agriculture, and water resources. These engagements are typically facilitated through operational coordination meetings and project-based initiatives supported by international organizations.

While these mechanisms allow for information exchange between climate information providers and key institutional stakeholders, there is still a need for systematic processes for identifying user needs and collecting feedback. Structured stakeholder consultation platforms—such as national climate outlook forums or sectoral user forums—have not yet been fully institutionalized.

2.1.7 Co-Production and Tailored Services

Co-production of climate services remains at an early stage in Afghanistan. Most climate information products are developed within AMD and disseminated to sectoral agencies without extensive collaborative design processes (WMO, 2021).

Nevertheless, several pilot initiatives supported by international partners have demonstrated the value of co-production approaches. For example, climate information has been integrated into agricultural advisory services and drought monitoring initiatives aimed at improving food security planning (FAO, 2021).

Expanding these collaborative initiatives and institutionalizing co-production mechanisms would help ensure that climate services are better tailored to user needs and more effectively integrated into sectoral decision-making.

2.1.8 Informing Decision-Making, Adaptation, and Mitigation

Climate information plays a critical role in supporting disaster preparedness and humanitarian planning in Afghanistan. Seasonal forecasts and climate monitoring products are used by national agencies and international organizations to anticipate drought conditions, manage flood risks, and support food security assessments (WFP, 2022).

In the agricultural sector, climate information supports seasonal planning and helps inform decisions related to crop management and water use. Climate diagnostics are also used by humanitarian organizations to guide emergency response planning and resource allocation.

However, there is lack of integration of climate services into the broader national development and climate adaptation planning. Strengthening the role of climate information in policy and planning processes would help improve the country's ability to respond to climate risks and support long-term resilience.

2.1.9 Monitoring, Evaluation, and Learning (MEL)

Monitoring and evaluation systems for climate services are still developing. Feedback on climate information products is often obtained through stakeholder consultations, project evaluations, and coordination meetings with sectoral agencies.

However, systematic evaluation frameworks that assess the performance and impact of climate services have not yet been fully established. Developing structured monitoring and evaluation systems would help identify areas for improvement and support evidence-based investments in climate services infrastructure and capacity development.

2.1.10 Key Successes and Challenges

Afghanistan has made progress in rebuilding meteorological infrastructure and restoring forecasting services following decades of conflict. AMD continues to generate national weather forecasts and hazard warnings and has begun expanding its meteorological observation network.

Pilot initiatives for community-based early warning systems have also been implemented in several provinces, particularly for flood risk monitoring. These initiatives utilize low-cost technologies such as wireless water-level monitoring systems to transmit real-time flood warnings to vulnerable communities, demonstrating the potential for scalable, community-driven early warning approaches in hazard-prone areas (IFRC, 2020).

Afghanistan faces significant challenges in developing a comprehensive climate services system. Technical constraints include limited observation networks, gaps in historical climate data, and insufficient forecasting infrastructure. Institutional challenges also persist due to fragmented responsibilities among multiple agencies involved in monitoring hazards, issuing warnings, and coordinating disaster response.

Furthermore, the national early warning system remains underdeveloped, with limited integration between hazard monitoring, warning generation, and community-level response mechanisms. Forecast information is often disseminated at coarse spatial scales and may not provide sufficient detail for local decision-making.

Addressing these challenges will require sustained investment in hydrometeorological infrastructure, strengthening institutional coordination mechanisms, and expanding technical capacity for forecasting, data analysis, and climate information services.

Table 1. Summary of Key Gaps and Priorities for Development for Afghanistan

Key Gaps Observed	Priorities for Development
Fragmented institutional arrangements	Establish a formal NFCS and strengthen coordination mechanisms among AMD, ANDMA, and sectoral ministries to clarify roles and enable more coherent climate service delivery.
Gaps in observational and data systems	Where possible, continue expanding and modernizing the hydrological and meteorological observation networks, particularly in remote and mountainous regions, and strengthen data management, quality control, and sharing mechanisms.
Limited technical, modelling, and downscaling capacity	Enhance in-country capacity for forecasting, downscaling, and climate analysis, including S2S prediction and long-term climate projections, to reduce reliance on external products.
Difficulties in disseminating and communicating climate information and services	Strengthen communication infrastructure and develop more user-friendly, impact-based, and accessible climate information products for diverse user groups.
Project-based stakeholder engagement and co-production	Institutionalize structured user engagement platforms (e.g., national climate outlook forums) and expand co-production practices to better align services with sectoral needs.
Limited integration of climate information into broader policy, planning, and sectoral decision-making processes	Strengthen the integration of climate information into national development planning, adaptation strategies, and sectoral decision-making processes.

2.2 BANGLADESH

Bangladesh: Climate Services Snapshot

NFCS Status	Operational and evolving; several core NFCS functions are operational, while BANCCA provides an initial platform for coordinated climate service delivery
Main sectors served	Disaster risk management, agriculture, livestock, water resources, food security, health, and infrastructure planning
Climate services and products available	Daily and weekly forecasts, cyclone and severe-weather warnings, seasonal outlooks, climate monitoring, sector-oriented advisories, climate monitoring and climate change research
Strengths	Strong disaster early warning and dissemination systems, particularly for tropical cyclones, supported by extensive institutional and community networks
Main constraints	Incomplete institutionalization of NFCS and BANCCA, uneven data interoperability, and limited advanced S2S modelling and forecast-verification capacity
Immediate Priority	Operationalize NFCS and BANCCA governance arrangements and expand multi-timescale, localized, and sector-specific climate services

2.2.1 NFCS Implementation Status

Bangladesh has made significant progress toward establishing an NFCS to strengthen the provision and use of climate information across key sectors. The NFCS initiative builds on the country's strong experience in disaster risk management and early warning systems and seeks to enhance coordination among climate information providers, sectoral institutions, and end users.

The development of NFCS in Bangladesh has been supported by national agencies and international partners, particularly through technical assistance from the WMO and regional initiatives aimed at strengthening climate services in South Asia. Bangladesh already initiated an institutional pathway for coordinated climate service delivery through the Bangladesh National Centre for Climate Applications (BANCCA) under BMD-RIMES collaboration. BANCCA has been formed as a technical support and coordination mechanism linking BMD's multi-timescale climate information services with sectoral users for planning, preparedness, and risk-informed decisions. A steering committee led by the Ministry of Defence (the overseeing ministry of BMD) has been formed for BANCCA. Although the NFCS is still evolving, many of its core components—such as climate observation systems, climate data management, forecasting services, and user engagement platforms—are already functioning through existing institutional structures (Government of Bangladesh, 2023).

National policy frameworks provide additional support for NFCS implementation. The country's National Adaptation Plan (2023–2050) highlights climate information services as a key enabling mechanism for climate adaptation and risk-informed development planning. The plan emphasizes

improving climate observation networks, enhancing seasonal forecasting capacity, and strengthening institutional coordination for climate services.

Despite these advancements, further efforts are required to fully institutionalize the NFCS including operationalization of the formal governance structures, dedicated coordination mechanisms among sectoral ministries, and sustainable financing arrangements.

2.2.2 Institutional Structure and Mandates

The Bangladesh Meteorological Department (BMD) serves as the national authority responsible for meteorological and climate services in the country. Operating under the Ministry of Defence, BMD is mandated to monitor atmospheric conditions, provide weather forecasts and warnings, and generate climate information to support disaster risk reduction and socio-economic development (Bangladesh Meteorological Department, 2022; WMO, 2021).

Climate services functions within BMD include multi-timescale weather and climate monitoring, seasonal outlook generation, climate data management, and climate research activities. The department maintains close coordination with other national institutions involved in climate risk management and sectoral planning. Key partners include the Bangladesh Water Development Board (BWDB), the Department of Agricultural Extension (DAE), the Department of Disaster Management (DDM), and the Ministry of Environment, Forest and Climate Change.

Bangladesh has also established a strong institutional framework for disaster risk management, which provides an important platform for applying climate information in decision-making. National disaster management mechanisms integrate meteorological forecasts and warnings with community-based preparedness programs, contributing to the country's globally recognized cyclone early warning system (UNDRR, 2022; World Bank, 2018).

On the other hand, institutional arrangements for climate services coordination across sectors remain partly informal despite the formation of BANCCA in 2020. Many collaborative activities are implemented through externally supported projects rather than permanent institutional arrangements. Strengthening inter-agency coordination mechanisms and formalizing institutional roles within the NFCS framework will be important for improving climate services delivery.

2.2.3 Observing Network and Data

Bangladesh maintains a relatively extensive meteorological observation network compared with many countries in South Asia. BMD operates numerous surface meteorological stations, radar systems, and automatic weather stations across the country. These systems monitor key climate variables including rainfall, temperature, wind, humidity, and atmospheric pressure (BMD, 2020).

Recent modernization initiatives have expanded the use of automated observations and improved radar coverage. These upgrades support real-time monitoring of severe weather events such as tropical cyclones, thunderstorms, and heavy rainfall associated with the monsoon season.

Bangladesh also relies on regional and global climate datasets—including satellite observations and climate reanalysis products—to complement national observations. These datasets help support climate monitoring, seasonal outlook generation, and climate change research (WMO, 2020).

Nevertheless, challenges remain in maintaining long-term climate records and ensuring consistent data quality. Some observational stations have incomplete historical records, and the integration of observational data from different agencies is still limited. Improving interoperability between institutional data systems and strengthening quality control procedures are key priorities for enhancing climate services.

2.2.4 Climate Services Production across Timescales

BMD produces climate information across multiple timescales, ranging from short-range weather forecasts to seasonal outlooks and long-term climate analyses.

At the sub-seasonal to seasonal timescale, Bangladesh participates actively in SASCOF. Through this process, BMD contributes national observations and analyses to regional forecasts and produces national seasonal outlooks for rainfall and temperature.

At shorter timescales, BMD provides daily and weekly forecasts and warnings related to weather hazards. These forecasts are an essential component of Bangladesh's disaster early warning systems, particularly for cyclones, floods, and severe storms.

At longer timescales, BMD contributes to climate monitoring and climate change research through the analysis of long-term climate trends and climate projections. These analyses support national climate policy development and adaptation planning.

However, there remains operational capacity gaps for sub-seasonal forecasting and advanced climate modelling. Additional investments in modelling infrastructure, training, and forecast verification systems would help expand climate services across multiple timescales.

2.2.5 Product and Service Dissemination and Communication Mechanisms

Dissemination of climate information occurs through multiple channels including official bulletins, government coordination mechanisms, media broadcasts, and digital platforms. BMD regularly publishes weather bulletins, seasonal outlooks, and hazard warnings that are disseminated through television, radio, newspapers, and online platforms.

Bangladesh's cyclone early warning system represents one of the most effective dissemination systems globally. Forecast information generated by BMD is communicated through a network of government agencies, local authorities, and community volunteers, ensuring that warnings reach vulnerable populations in coastal areas (UNDRR, 2022).

However, communicating probabilistic climate information remains a challenge. Many climate products are presented in technical formats that may be difficult for non-specialist users to interpret. Expanding the use of visual communication tools, plain-language summaries, and sector-specific products would help improve the accessibility of climate services.

2.2.6 Engagement with Stakeholders

BMD engages with a range of user sectors including agriculture, water resources, disaster risk management, and health. Engagement mechanisms include conduct of climate application forums/monsoon forums, coordination meetings with government agencies, and project-based stakeholder consultations.

Climate application forums (previously monsoon forum) provide opportunities for scientists, policymakers, and sectoral agencies to discuss the upcoming seasonal forecasts and their implications for planning.These forums also facilitate feedback from users on the relevance and usability of climate information products. BMD also publishes seasonal outlook for both monsoon and winter-monsoon with the seasonal outlook and associated sectoral advisories In recent years, BMD has taken the initiative to organize this forum at regional level to connect with the local level stakeholders to share the regional seasonal forecast and incorporate their feedback in the seasonal outlook.

Engagement with end users—particularly local communities and private sector stakeholders—remains uneven. Strengthening structured user engagement mechanisms and institutionalizing feedback processes would help ensure that climate services are better aligned with user needs.

2.2.7 Co-Production and Tailored Services

Co-production of climate services in Bangladesh is gradually developing through collaborations between BMD and sectoral agencies. For example, climate information is increasingly integrated into agricultural advisory services that guide farmers on crop management decisions. Apart from farming decisions, multi-timescale weather and climate information are also being tailored for livestock sectors for warning to local-level adaptation planning guidance.

Several externally supported initiatives have also facilitated the development of tailored climate services for sectors such as water management and disaster risk reduction. These initiatives demonstrate the value of collaborative approaches in translating climate information into actionable guidance.

Nevertheless, co-production processes remain largely project-based rather than institutionalized within national climate service frameworks and do not fully cover the key GFCS priority sectors e.g. health and energy. Establishing permanent co-production platforms within the NFCS structure would support the long-term sustainability of tailored climate services.

2.2.8 Informing Decision-Making, Adaptation, and Mitigation

In Bangladesh, short and medium range forecast information contributes to disaster preparedness planning, agricultural management decisions, and water resource management. Seasonal forecasts and climate outlooks inform broader policy processes at limited scale, including climate adaptation planning under the National Adaptation Plan and other national climate strategies (FAO, 2019).

The country's experience with early warning systems demonstrates how climate services can support anticipatory action and reduce disaster risks. Continued integration of climate information into development planning and adaptation strategies will further strengthen climate resilience.

2.2.9 Monitoring, Evaluation, and Learning (MEL)

While feedback from sectoral stakeholders and project partners provides some insights into the usefulness of climate information products, systematic evaluation of climate service performance is not yet fully institutionalized.

Developing structured monitoring and evaluation frameworks would help assess the effectiveness of climate services, identify areas for improvement, and support evidence-based investments in climate information systems.

Learning from regional and international climate service initiatives, such as SASCOF, can also support continuous improvement of national climate service systems.

2.2.10 Key Successes and Challenges

Bangladesh has achieved significant progress in strengthening its climate services, particularly in the areas of disaster early warning, climate monitoring, and regional collaboration. The country's cyclone early warning system is widely recognized as a global best practice, demonstrating the life-saving potential of effective climate information services.

However, several challenges remain, including limited technical capacity for advanced climate modelling, gaps in observation networks and data integration. While the BANCCA initiative (initiated around 2019–2020) demonstrated early institutional intent to create a coordinated, multi-

sector mechanism through focal points and steering arrangements, momentum was interrupted by unprecedented circumstances, leaving key gaps in sustained governance, producer–user coordination, and routine service co-production. As a result, sectoral advisories and decision-support workflows are uneven across institutions, and formalized data-sharing and feedback mechanisms (linking BMD climate products with sector exposure/vulnerability information and user performance feedback) remain limited.

Addressing these challenges will require continued investment in hydrometeorological infrastructure, capacity development, and institutional mechanisms that support user-oriented climate services leveraging the existing institutional platforms such as BANCCA.

Table 2. Summary of Key Gaps and Priorities for Development for Bangladesh

Key Gaps Observed	Priorities for Development
Partially institutionalized NFCS and coordination mechanisms	Fully operationalize the NFCS by strengthening formal governance structures, clarifying inter-agency roles, and revitalizing coordination mechanisms such as BANCCA to ensure sustained producer–user engagement.
Gaps in data quality, interoperability, and long-term climate records	Strengthen data quality control, improve interoperability across institutional data systems, and enhance data-sharing mechanisms to support integrated climate services.
Limited technical capacity for advanced forecasting and modelling	Enhance capacity for sub-seasonal forecasting, advanced climate modelling, and forecast verification systems to support multi-timescale climate services.
Uneven development of sector-specific and localized climate services	Strengthen the development of sector-specific climate products and improve the translation of forecasts into actionable advisories across key sectors, including agriculture, water, health, and energy.
Challenges in communicating probabilistic climate information	Improve communication of probabilistic climate information through user-friendly formats, including visual tools and plain-language summaries, to enhance usability among non-specialist users.
Project-based stakeholder engagement and co-production	Institutionalize co-production mechanisms beyond project-based initiatives, expand engagement to underserved user groups (e.g., local communities and private sector), and strengthen feedback loops between users and providers.
Limited integration of climate information into broader policy and sectoral planning	Strengthen the integration of climate information into national development planning, adaptation strategies, and sectoral decision-making processes beyond disaster risk management.
Limited institutionalization of monitoring, evaluation, and learning systems	Establish systematic evaluation frameworks to assess the effectiveness, usability, and socio-economic impact of climate services and support continuous improvement.

2.3 BHUTAN

Bhutan: Climate Services Snapshot

NFCS Status	Not formally established; climate services are guided by the Hydromet Policy, NCHM Roadmap, and National Climate Outlook Forums
Main sectors served	Agriculture, water resources, disaster risk management, and health
Climate services and products available	Weather and hydrological forecasts, seasonal outlooks, climate monitoring, climate projections, and emerging agricultural decision-support services
Strengths	Clear institutional mandate and regular stakeholder engagement through NCOFs, Climate Field Schools, and agriculture-related initiatives
Main constraints	Sparse observations in high-altitude areas, limited long-term datasets, and constrained capacity for advanced modelling, downscaling, and impact-based services
Immediate Priority	Formalize an NFCS and strengthen climate datasets, advanced forecasting capacity, impact-based services, and structured co-production mechanisms

2.3.1 NFCS Implementation Status

Bhutan has made notable progress in strengthening national climate services, although a formal NFCS has not yet been fully established. Climate services are currently guided by the Hydromet Policy of the Kingdom of Bhutan, the National Climate Change Policy, and the institutional roadmap of the National Center for Hydrology and Meteorology (NCHM). These policy instruments clearly recognize the responsibilities of NCHM for providing meteorological, hydrological, and climate services to support national development planning, disaster risk management, and climate resilience (Royal Government of Bhutan, 2023).

The NCHM Roadmap identifies climate services as a priority area of work and aligns national activities with the principles of the GFCS. In practice, climate services are already supporting several key sectors, including agriculture, water resources management, and disaster risk reduction. However, the absence of a formal NFCS governance platform means that coordination across climate service providers and user sectors remains partly adhoc.

Bhutan has nonetheless established several mechanisms that reflect emerging NFCS practices. In particular, NCHM organizes NCOFs twice annually, providing seasonal climate outlooks and facilitating dialogue with sector stakeholders. These forums help translate regional climate outlooks into nationally relevant information and support climate-informed decision-making.

Despite these institutional advances, the development of climate services in Bhutan continues to face resource constraints including limited specialized climate personnel, restricted operational

funding, and gaps in technical infrastructure needed to support advanced climate analysis and forecasting. Strengthening institutional capacity and formalizing governance arrangements through an NFCS framework could significantly enhance the effectiveness and sustainability of climate services.

2.3.2 NMHS Institutional Structure and Mandate

NCHM is responsible for providing weather forecasts, climate information, hydrological monitoring, and early warning services across the country. Climate services within NCHM are delivered through multiple operational units responsible for meteorology, hydrology, climate analysis, and disaster risk monitoring. The institutional mandate for climate services is clearly articulated within Bhutan's Hydromet Policy framework, which assigns NCHM responsibility for generating and disseminating climate information for public safety, sectoral planning, and environmental management.

Institutional coordination between NCHM and key government agencies is generally functional but remains largely project-based. Collaboration with the agriculture sector is relatively well established, particularly through climate advisory initiatives and agricultural extension programs. Similarly, coordination with water resource management and disaster risk management agencies supports flood forecasting, early warning systems, and preparedness planning.

On the other side, stronger institutional mechanisms for routine coordination would improve the co-production of climate services and ensure that climate information is consistently integrated into sectoral planning processes. Establishing formal coordination platforms under a future NFCS could enhance collaboration between climate service providers and sector stakeholders.

2.3.3 Observing Network and Data

The reliability and usability of climate services in Bhutan are significantly influenced by the availability and quality of observational data. NCHM operates a national network of meteorological and hydrological observation stations, which provide essential data for weather forecasting, climate monitoring, and hydrological risk assessment.

Despite this infrastructure, several limitations affect observational coverage and data continuity. Bhutan's rugged mountainous terrain and remote high-altitude regions make it difficult to maintain dense observation networks. As a result, observing stations remain sparse in many high-altitude and remote areas, limiting the spatial resolution of climate monitoring and analysis.

Another challenge relates to the availability and consistency of long-term climate datasets. Many observational records contain relatively short or incomplete time series, which constrains the ability to analyze long-term climate variability and trends.

NCHM has established a centralized climate data management system, but this system requires upgrades and additional technical expertise to support advanced data processing and analysis. Limited capacity currently exists for working with global reanalysis datasets such as ERA5, IMDAA, and UIMD, which are increasingly important for high-resolution climate analysis and downscaling. Generating gridded, quality-controlled long-term datasets also require technical support, in particular, access to IMDAA datasets, along with training on its use and validation.

Strengthening Bhutan's climate data infrastructure—including improving observation networks, enhancing data management systems, and expanding capacity to use global datasets—would significantly improve the reliability and sectoral relevance of climate services.

2.3.4 Climate Services Production across Timescales

NCHM produces climate information across several temporal scales, ranging from short-term forecasts to seasonal outlooks and long-term climate projections.

Seasonal climate outlooks are produced using the Climate Predictability Tool (CPT) and are disseminated through the NCOFs. These outlooks provide guidance on expected rainfall and temperature conditions during upcoming seasons and are particularly relevant for agricultural planning and disaster preparedness.

Regional climate outlook products from SASCOF are routinely used as key inputs in the development of the country's national seasonal forecasts. NCHM integrates these regional outlooks with national observations and contextual knowledge to tailor climate information to Bhutan's specific climatic conditions.

However, reliance on the CPT platform limits the ability to fully utilize advanced forecasting tools and regional climate model outputs. The introduction of more advanced systems such as PyCPT and other modern seasonal forecasting tools could improve forecast skill and expand the range of climate services available to users.

Seasonal to sub-seasonal forecasting and long-term climate projections remain among the most difficult climate products to operationalize. Bhutan's complex topography, combined with sparse observation networks and limited high-resolution datasets, presents significant challenges for downscaling regional climate information to local decision-making scales.

Additionally, impact-based climate services are still emerging. Developing such services will require stronger integration of climate information with sector-specific datasets, particularly in sectors such as agriculture, hydropower, transport, and disaster risk management.

2.3.5 Product and Service Dissemination and Communication Mechanisms

Climate information dissemination in Bhutan is generally effective at the institutional level. NCHM distributes climate information through official bulletins, advisories, and direct communication with government agencies responsible for disaster risk management, agriculture, and water resources.

During extreme weather events, coordination between NCHM and disaster management authorities ensures that weather and climate advisories are communicated rapidly to relevant agencies. These mechanisms support preparedness planning and emergency response activities.

However, several challenges remain in communicating climate information effectively to broader audiences. In particular, communicating probabilistic forecasts and forecast uncertainty remains difficult, especially for seasonal outlooks that require interpretation by non-specialist users.

Language diversity also presents challenges for community-level communication. Bhutan's mountainous geography and dispersed rural communities mean that multiple local dialects are spoken across the country, complicating efforts to deliver consistent climate messaging. In some remote villages, limited familiarity with the national language may further affect the accessibility and interpretation of climate information.

To improve public understanding and trust in climate forecasts, NCHM has adopted innovative approaches such as collaborating with the School of Astrology, integrating traditional forecasting perspectives with scientific climate information. This initiative aims to build community trust and enhance the acceptance of climate forecasts while highlighting the importance of culturally appropriate communication strategies.

2.3.6 Stakeholder Engagement

NCHM maintains regular engagement with several key sector stakeholders, particularly in agriculture, disaster risk management, and water resource management.

In the agricultural sector, climate services support initiatives such as Climate Field Schools, which aim to improve farmers' understanding of climate variability and strengthen their capacity to adapt agricultural practices to changing climatic conditions. Climate information provided by NCHM contributes to the development of Agrometeorological Decision Support Systems (ADSS), which integrate climate and weather information into agricultural planning and operational decision-making.

Engagement with disaster management agencies also plays an important role in Bhutan's climate services ecosystem. Climate outlooks and weather forecasts support flood preparedness, landslide risk management, and early warning systems in vulnerable mountainous regions.

While these examples demonstrate active stakeholder engagement, systematic mechanisms for continuous user feedback and co-production of climate services remain limited. Expanding

participatory engagement processes would help ensure that climate services are aligned with sectoral decision-making needs.

2.3.7 Co-Production and Tailored Services

Climate-service co-production in Bhutan is gradually evolving through collaborative initiatives involving NCHM and sector stakeholders. Seasonal outlooks produced through the NCOF provide one platform for dialogue and interpretation between service providers and users.

Tailored-service development has also been supported through the customized Climate Services Toolkit, which was designed to provide climate information and data for Bhutan at national and sub-national scales and to support linkage with sector-specific decision-support systems, particularly in agriculture, water, and health (WMO, 2023).

However, many climate services are still primarily produced by NCHM and then disseminated outward, rather than being jointly designed through systematic, iterative co-production cycles. Technical assessments therefore point to the need for stronger capacity in tailored product development, user interfacing, and service evaluation.

2.3.8 Informing Decision-Making, Adaptation, and Mitigation

Climate information generated by NCHM is increasingly being used to support national decision-making processes. Seasonal climate outlooks help inform disaster preparedness planning and agricultural management decisions, particularly during the monsoon season.

Climate projection reports are also being used in national communications and sectoral climate impact studies, supporting Bhutan's commitments under international climate agreements and informing national adaptation planning processes.

As Bhutan continues to expand hydropower development and infrastructure investment in mountainous terrain, climate information will become increasingly important for risk-informed planning. Strengthening the integration of climate services into sectoral policy frameworks and development planning processes will therefore be critical for enhancing climate resilience (World Bank, n.d.).

2.3.9 Monitoring, Evaluation, and Learning (MEL)

Formal monitoring and evaluation systems for climate services are still developing in Bhutan. While climate services are actively used in several sectors, systematic evaluation of their effectiveness and socio-economic impact remains limited (FMI, 2024).

Establishing structured monitoring frameworks would help NCHM assess the performance of climate services, identify areas for improvement, and strengthen accountability. Monitoring and evaluation systems could also support evidence-based investment in observation networks, modelling infrastructure, and service delivery mechanisms.

2.3.10 Key Successes and Challenges

Bhutan's climate services system demonstrates several important strengths. These include a clear institutional mandate for climate services, active participation in regional climate outlook processes such as SASCOF, and strong engagement with the agricultural sector through climate advisory initiatives and Climate Field Schools.

At the same time, several challenges continue to constrain the development of climate services. These include sparse observation networks in mountainous areas, limited long-term climate datasets, restricted computational capacity for downscaling and modelling, and limited institutional mechanisms for co-producing climate services with sector stakeholders.

Addressing these challenges will require sustained investments in observation infrastructure, climate data systems, technical capacity development, and institutional coordination mechanisms. Strengthening seasonal forecasting systems, developing operational downscaling capabilities, and expanding impact-based climate services will be critical priorities for advancing Bhutan's climate services in the coming years.

Table 3. Summary of Key Gaps and Priorities for Development for Bhutan

Key Gaps Observed	Priorities for Development
Absence of a formal NFCS and partly ad hoc coordination mechanisms	Establish a formal NFCS framework and strengthen institutional coordination platforms to enable systematic collaboration between NCHM and sectoral agencies.
Sparse observation networks and limitations in long-term climate datasets	Expand observation networks in remote and high-altitude areas, improve data continuity, and strengthen the development of quality-controlled long-term climate datasets.
Limited capacity in data management and use of advanced climate datasets	Enhance data management systems and build technical capacity to utilize global datasets (e.g., reanalysis products) for high-resolution climate analysis and services.
Limited technical capacity for advanced forecasting, modelling, and downscaling	Strengthen in-country capacity for seasonal forecasting, downscaling, and climate modelling through training and adoption of advanced tools (e.g., PyCPT and regional models).

Challenges in communicating probabilistic forecasts and reaching diverse communities	Improve communication strategies by developing user-friendly, impact-based products and adopting culturally appropriate approaches for diverse linguistic and local contexts.
Limited institutionalization of stakeholder engagement and co-production	Establish structured user engagement and co-production platforms to ensure continuous feedback and alignment of climate services with sectoral needs.
Emerging but limited development of impact-based and sector-specific climate services	Strengthen integration of climate information with sectoral datasets to develop impact-based services for agriculture, hydropower, disaster risk management, and other key sectors.
Limited integration of climate information into sectoral policy and development planning	Enhance the use of climate information in national development planning, infrastructure investment, and adaptation strategies to support risk-informed decision-making.
Limited monitoring, evaluation, and learning (MEL) systems	Develop structured MEL frameworks to assess the effectiveness, usability, and socio-economic impact of climate services and guide continuous improvement.

2.4 INDIA

India: Climate Services Snapshot

NFCS Status	NFCS-India is under active development, supported by an advanced multi-institutional climate services system
Main sectors served	Agriculture, water resources, disaster risk management, health, energy, aviation, infrastructure, and urban planning
Climate services and products available	Short- and medium-range forecasts, extended-range and seasonal outlooks, monsoon prediction, climate monitoring, long-term projections, warning services, and sector-specific advisories
Strengths	Extensive observation and modelling infrastructure combined with highly operationalized agricultural climate services and multi-timescale forecasting
Main constraints	Co-production and tailored services with other sectors, while communication of probabilistic information and system-wide MEL require further development
Immediate Priority	Consolidate NFCS implementation, expand co-production across additional sectors, and establish more unified evaluation of climate service use and benefits

2.4.1 NFCS Implementation Status

India is one of the few countries in South Asia that has advanced NFCS implementation that strengthens coordination between climate information providers and sectoral users. The NFCS–India initiative, led by the India Meteorological Department (IMD) under the Ministry of Earth Sciences, is designed to align national climate service delivery with the principles of the GFCS (Government of India, 2023).

The framework was developed to improve the generation, dissemination, and application of climate information across priority sectors including agriculture, water resources, health, energy, disaster risk reduction, and urban planning. It builds on India's long-standing experience in operational forecasting and climate monitoring and provides a structured platform for connecting climate science with decision-making processes.

India's NFCS promotes collaboration between multiple national scientific institutions. Key contributors include IMD, Indian Institute of Tropical Meteorology (IITM), National Centre for Medium Range Weather Forecasting (NCMRWF), Indian National Centre for Ocean Information Services (INCOIS), and other research and operational agencies under the Ministry of Earth Sciences.

The framework has been developed to improve the generation, dissemination, and application of climate information across priority sectors including water, agriculture and food security, energy, health, and disaster risk reduction. In its October 2023 stakeholder workshop, it emphasized the

need for a formal national mechanism that enables agencies to collaborate and exchange climate information tailored to decision contexts.

India's NFCS initiative builds on the country's long-standing operational forecasting and climate monitoring capacities and is intended to provide a structured platform for linking climate science with policy and planning. IMD's Vision 2047 document states that NFCS-India is being developed to bring climate-service stakeholders, users, policymakers, industries, and the public under a more structured climate-services umbrella.

India's climate-services architecture also has a strong regional dimension. IMD and allied institutions support regional seasonal forecasting through SASCOF, while RCC-Pune serves a wider South Asian climate-services function under the WMO regional climate-centre system.

2.4.2 Institutional Structure and Mandates

IMD serves as the national authority responsible for weather and climate services in India. It provides operational weather forecasts, seasonal outlooks, climate monitoring, and early warning services.

India's climate services system benefits from a highly developed institutional ecosystem that integrates multiple research and operational agencies:

- The Indian Institute of Tropical Meteorology (IITM) plays a key role in climate modelling, seasonal prediction research, and climate change projections. IITM also develops coupled ocean–atmosphere climate models used for seasonal forecasting and long-term climate simulations.
- The National Centre for Medium Range Weather Forecasting (NCMRWF) provides numerical weather prediction products and supports forecast modelling and data assimilation systems.
- Other institutions contribute specialized expertise such as INCOIS that supports ocean monitoring and ocean–climate services, while several universities and research institutes contribute to climate research and modelling activities.

Within IMD, climate services are delivered through dedicated operational units responsible for climate monitoring, seasonal forecasting, agrometeorology, and climate change analysis. These units coordinate with national sector agencies and state-level institutions to ensure that climate information supports operational decision-making (Government of India, 2023).

2.4.3 Observing Network and Data

India maintains one of the region's most extensive hydrometeorological observing systems, including surface meteorological stations, automatic weather stations, rain-gauge networks,

upper-air systems, Doppler weather radars, and satellite-supported observation platforms. These systems underpin operational weather forecasting, climate monitoring, and long-term climatological analysis (Government of India, 2025).

India also maintains long-term historical climate datasets that support climatological assessments, seasonal forecast calibration, and climate-change analysis. IMD's climate-monitoring and climate-assessment functions are referenced in its annual reporting and broader climate-services documentation (India Meteorological Department, 2022).

The data ecosystem is strengthened by institutional complementarity across IMD, IITM, NCMRWF, and INCOIS. In particular, INCOIS serves as a national repository and service provider for ocean data and observations, while NCMRWF supports data assimilation and model-driven forecasting systems.

India also contributes to regional and global climate-monitoring and data-exchange functions through WMO-linked systems and regional climate services for South Asia. This gives the country a stronger-than-average institutional foundation for climate data management and operational use.

2.4.4 Climate Services Production across Timescales

India produces climate information across multiple timescales, from short-range and medium-range weather forecasts to extended-range outlooks, seasonal forecasts, and long-term climate analyses. IMD, IITM, and NCMRWF collectively support this continuum of products through operational forecasting and modelling systems.

Seasonal forecasting is one of the most developed elements of India's climate-services system. IITM's seasonal prediction programme explicitly focuses on improving prediction skill for the Indian monsoon, and IMD operationally issues the Indian summer monsoon forecast and related seasonal outlooks.

Sub-seasonal to extended-range forecasting has also advanced considerably. IITM documents the operational use of 2–4 week outlooks, monsoon onset guidance, active/break monsoon spell forecasts, and forecasts relevant to sectors such as agriculture, hydrology, energy, health, and disaster management.

India also produces sector-specific climate services. The Gramin Krishi Mausam Sewa (GKMS) / Agrometeorological Advisory Service is a major example, integrating weather and climate information with soil, crop, and farm-management information to support operational agricultural decisions (Ministry of Earth Sciences, 2020).

2.4.5 Product and Service Dissemination and Communication Mechanisms

Climate information dissemination in India is supported by multiple communication channels including official portals, mobile applications, SMS systems, media dissemination, and institutional advisory networks. IMD's agricultural meteorology division identifies dissemination, feedback, and awareness-building as explicit components of the agrometeorological service.

The GKMS programme is the most prominent dissemination mechanism for agricultural climate services. Its standard operating procedure states that IMD, in collaboration with ICAR and State Agricultural Universities, disseminates district- and block-level agrometeorological advisories through AMFUs and DAMUs and is extending service delivery down toward village level.

India's warning systems for high-impact weather are also comparatively mature. IMD issues operational warnings, while NDMA guidance and public materials reflect close coordination on heat-wave preparedness and other disaster-risk communications.

Despite this strong dissemination infrastructure, communication challenges remain, especially around probabilistic interpretation and user understanding of uncertainty. IMD's own NFCS-India rationale recognizes the need for more structured exchange of climate information tailored to decision contexts.

2.4.6 Engagement with Users and Stakeholders

India's NFCS approach places strong emphasis on engagement with user sectors. The October 2023 stakeholder consultation brought together representatives from ministries and agencies working in water, agriculture, health, energy, disaster management, and space applications, reflecting a broad cross-sector user base for climate services.

Agriculture remains the most institutionalized example of user engagement. IMD's agricultural meteorology services explicitly include dissemination, farmer-oriented advisories, feedback, and training, showing that user interaction is embedded in the service model rather than treated as an afterthought.

Climate services also support disaster-risk management through collaboration between IMD and NDMA, especially for heat waves and other extreme events. NDMA materials specifically reference IMD's warning systems and impact-based warning approaches.

2.4.7 Co-Production and Tailored Services

India has made considerable progress in tailored climate services, particularly where operational forecasting is combined with sectoral expertise. The agrometeorological advisory system is a clear example of co-production, as it combines meteorological information with crop, soil, and farm-management information through collaboration among IMD, ICAR, State Agricultural Universities, and field units (Ministry of Earth Sciences, 2020).

This model demonstrates how climate information can be translated into location-specific operational advice rather than being disseminated only as generic forecasts. It is one of the strongest practical examples of climate-service co-production in South Asia (Ministry of Earth Sciences, 2020).

At the same time, NFCS-India is still evolving as the broader platform for extending this co-production logic across additional sectors such as water, health, energy, and urban planning. Current official materials frame this as a strategic direction rather than a fully completed system.

2.4.8 Informing Decision-Making, Adaptation, and Mitigation

Climate services play an important role in national decision-making in India. Seasonal and extended-range forecasts inform agricultural operations and planning, while warning systems support disaster preparedness and emergency response for extreme events.

The agricultural advisory system is especially relevant to climate-resilient development because it directly supports farm-level decisions on planting, irrigation, and crop management using forecast-based information. Government reporting continues to identify GKMS as a core operational service (Ministry of Earth Sciences, 2020).

Longer-term climate information generated by IMD, IITM, and allied institutions also supports climate assessment and adaptation planning. NFCS-India is intended to further strengthen the connection between climate science, planning, policy, and practice.

2.4.9 Monitoring, Evaluation, and Learning (MEL)

India has begun to develop monitoring and evaluation mechanisms for assessing the performance of climate services. Sector programs such as agrometeorological advisory services include evaluation processes to assess the effectiveness of climate information in improving agricultural productivity and reducing climate risks.

2.4.10 Key Successes and Challenges

India’s climate-services system demonstrates several major strengths: a highly capable institutional ecosystem, advanced modelling and forecasting capacity, extensive observation infrastructure, strong agricultural climate services, and an active NFCS-India process aligned with GFCS principles.

Particular successes include the operational scale of GKMS, the strength of monsoon forecasting and extended-range prediction, and institutional linkages between IMD and sectoral agencies for disaster-risk management.

Key challenges remain. These include improving communication of probabilistic climate information, extending structured co-production into additional sectors such as health and urban resilience, and consolidating monitoring and evaluation across the climate-services system.

Table 4. Summary of Key Gaps and Priorities for Development for India

Key Gaps Observed	Priorities for Development
Challenges in communicating probabilistic forecasts and uncertainty	Improve communication of probabilistic and forecast uncertainty through user-oriented formats, decision-contextualized products, and enhanced risk communication strategies.
Uneven co-production across sectors beyond agriculture	Expand co-production approaches beyond agriculture to sectors such as health, energy, water, and urban planning through institutionalized partnerships and sector-specific service frameworks.
Need for enhanced integration of climate services into policy and planning processes	Strengthen the integration of climate information into national and sub-national development planning, adaptation strategies, and sectoral decision-making processes.
Fragmented MEL systems across services	Develop a unified and systematic MEL framework to assess the effectiveness, usability, and socio-economic impacts of climate services across sectors.
Need to further tailor climate services to diverse user groups and decision contexts	Enhance the development of user-specific, impact-based climate services that address the needs of different sectors, regions, and decision-making scales.

2.5 MALDIVES

Maldives: Climate Services Snapshot

NFCS Status	Under development; permanent governance and inter-agency coordination arrangements have not yet been operationalized
Main sectors served	Coastal infrastructure and national development planning
Climate services and products available	Weather forecasts, climate monitoring, seasonal and sub-seasonal outlooks, and long-term climate projections
Strengths	Demonstrated use of long-term climate projections in harbor development, land reclamation, and other strategic infrastructure decisions
Main constraints	Limited dedicated staffing and funding, observation-network maintenance challenges, weak climate data infrastructure, and limited localization of forecast products
Immediate Priority	Operationalize the NFCS, strengthen MMS institutional and data capacity, and develop localized impact-based services for priority island sectors

2.5.1 NFCS Implementation Status

Efforts are currently underway to establish an NFCS in the Maldives. The NFCS is expected to strengthen inter-agency coordination, clarify institutional roles across the climate services value chain, and formalize mechanisms for stakeholder engagement. Global experience indicates that NFCS platforms provide an important governance mechanism for aligning climate service providers with national policy priorities and sectoral decision-making needs.

The importance of strengthening climate services governance is particularly significant in the Maldivian context. As a Small Island Developing State (SIDS) composed of low-lying coral atolls, the Maldives faces acute climate risks, including sea-level rise, coastal flooding, coral reef degradation, saltwater intrusion, and heat stress. These risks intersect with key national development sectors such as infrastructure, fisheries, tourism, and water resources, highlighting the strategic importance of climate services in supporting national resilience planning.

2.5.2 Institutional Structure and Mandates

The Maldives Meteorological Service (MMS) serves as the national authority responsible for meteorological and climate services. While climate services are formally mandated, the Climate Section operates with limited dedicated staff and often relies on personnel whose primary roles are in weather forecasting and observation. In practice, this constrains sustained engagement with sector agencies and limits the systematic development of climate services beyond routine

monitoring and forecasting. Strengthening staffing, securing institutional funding, and establishing longer-term planning mechanisms remain priorities moving forward.

Institutional coordination with sector agencies exists but is not yet structured through permanent governance mechanisms. While focal points have been identified within relevant government agencies to facilitate consultation on climate-related issues, regular inter-agency coordination mechanisms remain limited. As a result, engagement with sector stakeholders is often conducted on an ad hoc basis rather than through formalized platforms.

The need for stronger institutional arrangements is particularly significant in the Maldives context, given the country's extreme vulnerability to sea-level rise, coastal flooding, coral reef degradation, and heat stress. The Climate Risk Country Profile underscores that climate risks are systemic and intersect with critical national development sectors, including infrastructure, fisheries, tourism, and water resources (World Bank & Asian Development Bank, 2021).

Global assessments of climate services highlight that many SIDS face similar institutional constraints, including limited human resources, fragmented coordination, and underdeveloped climate service governance structures (WMO, 2024).

2.5.3 Observing Networks and Data

The operational reliability of observing networks remains a significant constraint. MMS identified maintenance and operational continuity of meteorological stations as critical challenges, affecting data quality and reliability. In addition, the absence of a fully integrated and centralized climate database limits effective data management, archival, and service provision to end-user sectors. Strengthening data infrastructure would significantly improve both monitoring and forecasting capability.

Given Maldives' low-lying atoll geography and exposure to marine and coastal hazards, integrated climate-ocean data systems are essential for effective coastal planning and resilience strategies. The Climate Risk Country Profile highlights that sea-level rise and storm surge risks require robust long-term observational datasets (World Bank & Asian Development Bank, 2021).

At the global level, Maldives identifies observation network gaps and limited data management capacity as common constraints in SIDS and least developed countries, particularly affecting the quality and usability of climate services (WMO, 2024)

2.5.4 Climate Services Production across Timescales

MMS generates climate information across several timescales, including historical analyses, seasonal and sub-seasonal outlooks, and long-term climate change projections. Seasonal and

sub-seasonal forecasts, however, are not always straightforward to operationalize at the local level, particularly given resolution constraints and forecast uncertainty.

Regional guidance from SASCOF and RCCs provides important input, yet translating these products into sector-specific advisories requires further customization. In contrast, long-term climate projections appear to have clearer policy traction. MMS noted that such projections have informed infrastructure planning, including harbor construction and land reclamation initiatives which are encouraging examples of climate information influencing strategic investment decisions.

Long-term climate projections appear to be more consistently utilized. MMS confirmed that climate change projections have informed infrastructure decisions, including harbor construction and land reclamation planning, demonstrating integration of climate information at policy and infrastructure design levels.

However, systematic development of impact-based climate services remains limited. Regional experience shows that climate information alone is often insufficient; it must be translated into sector-specific impact and risk information through co-production approaches (Daron, et al., 2022).

Global assessments similarly note that while forecast production capacity has improved, many NMHSs still face gaps in producing co-designed and tailored climate services for decision-making contexts (WMO, 2024).

2.5.5 Product and Service Dissemination and Communication Mechanisms

Dissemination of climate information in Maldives is generally effective in terms of reach. MMS indicated that there are no major constraints in distributing climate information to government agencies and stakeholders through existing communication channels.

However, communicating forecast uncertainty remains a persistent challenge, particularly for seasonal and sub-seasonal information. Sectoral users often have limited understanding of probabilistic forecasts, which affects the uptake and confidence in using such information for planning and operational decisions.

Awareness-raising and capacity-building among sectoral users have been identified as critical needs, but MMS faces constraints related to funding and limited inter-agency coordination. These challenges hinder sustained engagement efforts aimed at improving climate literacy and fostering more effective use of climate information.

The literature on climate services in South Asia similarly highlights that effective dissemination alone is insufficient; investment is required in translation, communication, and sustained user engagement to ensure climate information supports real-world decision-making (Daron, et al., 2022).

2.5.6 Engagement with Users and Stakeholders

User engagement in Maldives remains largely consultative rather than fully co-productive. While climate information is shared with sector agencies and used in policy contexts, structured mechanisms for joint problem definition, product co-design, and iterative feedback are not yet embedded in climate services practice.

This reflects broader regional patterns identified in South Asia, where climate services often emphasize information provision over sustained co-production processes. Evidence suggests that climate services yield greater benefits when users are actively involved throughout the service lifecycle, particularly in interpreting uncertainty and aligning climate information with sectoral decision timelines (Suckall & Soares, 2022).

Implementation of the NFCS in Maldives could provide an institutional platform to formalize co-production mechanisms, align services with sectoral priorities, and embed monitoring and evaluation processes (WMO, 2024).

2.5.7 Co-Production and Tailored Services

Climate service co-production in the Maldives remains in an early stage of development. While climate information is used in some policy and planning processes, formal mechanisms for co-producing climate services with sector stakeholders have not yet been fully established.

The development of sector-specific impact-based advisories has been identified as a key priority for strengthening climate services in the Maldives. These advisories would translate climate forecasts into actionable information tailored to the operational needs of sectors such as fisheries, tourism, water management, and coastal infrastructure planning.

The implementation of an NFCS could provide an institutional platform for advancing co-production practices by establishing structured collaboration mechanisms between MMS and sector agencies.

2.5.8 Informing Decision-Making, Adaptation, and Mitigation

Despite institutional constraints, climate information has already played an important role in informing strategic planning decisions in the Maldives.

Climate projections generated by MMS have been used to support national infrastructure planning, particularly in the design of harbor facilities and land reclamation projects intended to enhance coastal resilience and support economic development.

These examples demonstrate the potential value of climate services in informing long-term development planning in highly climate-sensitive contexts. Expanding the application of climate services to other sectors—such as fisheries management, water resource planning, and tourism development—could further strengthen national climate resilience.

2.5.9 Monitoring, Evaluation, and Learning (MEL)

Monitoring and evaluation systems for climate services in the Maldives remain relatively limited. Although climate information is used in policy and planning contexts, structured processes for assessing the effectiveness of climate services or tracking their socio-economic impacts are not yet well established.

Developing systematic monitoring and evaluation frameworks would help identify areas where climate services are most effective and where further improvements are needed. Such frameworks could also support evidence-based decision-making and help guide investments in observation infrastructure, data systems, and institutional capacity.

2.5.10 Key Successes and Challenges

Despite capacity constraints, Maldives demonstrates several notable strengths:

- Clear governmental mandate for climate services
- Effective use of long-term climate change information in infrastructure and policy decisions
- Recognition of the importance of climate projections for national resilience
- Active engagement with regional climate mechanisms such as SASCOF

These strengths provide a solid foundation upon which more advanced climate services particularly impact-oriented and sector-specific products can be developed.

The Maldives climate services landscape is characterized by several interconnected challenges:

1. Institutional and Human Resource Constraints
    a. Understaffed Climate Section within MMS
    b. Limited dedicated funding for climate services development
    c. Absence of regular inter-agency coordination mechanisms
2. Technical and Data Challenges
    a. Operational and maintenance issues in observing networks
    b. Limited climate data management infrastructure
    c. Constraints in downscaling and localization of climate information
3. Service Delivery and Communication
    a. Difficulty communicating forecast uncertainty
    b. Limited sectoral awareness and climate literacy
    c. Lack of systematic feedback mechanisms

These challenges reinforce the importance of investing not only in climate data and models, but also in institutional capacity, user engagement, and governance frameworks. The planned implementation of an NFCS presents a critical opportunity to address these gaps and strengthen alignment between national climate services and regional initiatives.

Table 5. Summary of Key Gaps and Priorities for Development for Maldives

Key Gaps Observed	Priorities for Development
Absence of NFCS and formal coordination mechanisms	Establish and operationalize the NFCS to strengthen governance, clarify institutional roles, and enable structured coordination across climate service providers and sector agencies.
Limited institutional capacity and human resources for climate services	Strengthen staffing, secure sustainable funding, and enhance institutional capacity within MMS to support dedicated climate service development and long-term planning.
Gaps in observing network maintenance and climate data management systems	Improve maintenance and operational continuity of observation networks and establish a centralized, integrated climate data management system to enhance data reliability and accessibility.
Limited technical capacity for downscaling and localization of climate information	Enhance capacity to downscale and translate regional and global climate products into locally relevant, high-resolution information for decision-making.
Limited development of impact-based and sector-specific climate services	Strengthen the development of impact-based climate services and sector-specific advisories for key sectors such as fisheries, tourism, water resources, and coastal infrastructure.
Challenges in communicating probabilistic forecasts and limited climate literacy among users	Improve risk communication strategies and invest in user capacity-building to enhance understanding and use of probabilistic climate information.
Predominantly consultative rather than co-productive stakeholder engagement	Institutionalize co-production mechanisms through structured platforms to enable joint design, feedback, and iterative refinement of climate services.
Limited integration of climate services across all priority sectors	Expand the application of climate services beyond infrastructure planning to sectors such as fisheries, water management, and tourism for broader resilience outcomes.
Limited monitoring, evaluation, and learning (MEL) systems	Develop systematic MEL frameworks to assess climate service effectiveness, track impacts, and inform continuous improvement and investment decisions.

2.6 MYANMAR

Myanmar: Climate Services Snapshot

NFCS Status	Partially aligned with NFCS principles, but a formal and fully institutionalized national framework has not been established
Main sectors served	Disaster risk management, agriculture, water resources, and public health
Climate services and products available	Seasonal monsoon outlooks, weather and hazard forecasts, climate monitoring products, and multi-channel early warning information
Strengths	Institutionalized seasonal forecasting and stakeholder dialogue through national and regional monsoon forums, supported by broad dissemination channels
Main constraints	Uneven and partly manual observation networks, limited specialized staff, and insufficient capacity for localization, sector-data integration, and impact-based forecasting
Immediate Priority	Formalize NFCS governance, modernize observations, strengthen modelling and data-science capacity, and move from consultation toward structured co-production

2.6.1 NFCS Implementation Status

Myanmar has taken steps toward strengthening national climate services through the adoption of principles aligned with the NFCS. While a fully institutionalized NFCS structure has not yet been formally established, the Department of Meteorology and Hydrology (DMH) has incorporated NFCS concepts into the development and delivery of climate services, particularly in support of key sectors such as disaster risk management, agriculture, water resources, and public health.

These efforts are consistent with the priorities outlined in the Myanmar Climate Change Strategy (2018–2030), which emphasizes climate resilience, climate risk management, and the integration of climate information into national development planning. Within this policy framework, climate services are increasingly recognized as essential tools for supporting adaptation planning and risk-informed decision-making.

Regional mechanisms also play an important role in Myanmar's climate services system. The DMH participates in regional climate outlook processes, such as SASCOF, and uses regional seasonal forecasts as baseline inputs. However, these regional outlooks require further downscaling and interpretation to reflect Myanmar's diverse climatic zones, which include coastal regions, deltaic lowlands, central dry zones, and mountainous terrain. Strengthening national capacity for forecast downscaling and localization therefore remains a priority for improving the usability of regional climate information.

Overall, Myanmar's climate services system can be described as partially aligned with NFCS principles but still evolving toward a fully institutionalized national framework. Formalizing governance arrangements and strengthening institutional coordination across the climate services value chain would help consolidate ongoing efforts.

2.6.2 Institutional Structure and Mandates

DMH is responsible for the production and dissemination of meteorological, hydrological, and climate information. The DMH operates under the Ministry responsible for transport and communications and is mandated to provide weather forecasts, climate outlooks, early warning information, and related advisory services.

Climate services within DMH include climate monitoring, seasonal forecasting, and the provision of climate advisories to government agencies and sector stakeholders. Seasonal forecasts are issued twice each year, typically prior to the onset of the Southwest Monsoon season and following the monsoon season. These outlooks include information on monsoon onset and withdrawal dates, rainfall and temperature projections relative to the 1991–2020 climatological baseline, and additional seasonal indicators such as expected fog occurrence during winter months.

Institutional coordination with sector agencies is an important component of climate service delivery in Myanmar. DMH engages with multiple government ministries and agencies, including those responsible for agriculture, water management, energy, health, and disaster management. These engagements often occur through national monsoon forums and sectoral consultation meetings, which provide opportunities to interpret seasonal outlooks and discuss potential implications for sector planning.

Despite these coordination mechanisms, institutional capacity constraints remain a challenge. Key limitations include shortages of specialized technical staff, limited capacity in climate modelling and data science, and insufficient integration of sectoral datasets into climate service development processes. Addressing these capacity gaps will be important for strengthening climate services and expanding their application across national development sectors.

2.6.3 Observing Network and Data

Consultation with DMH highlighted uneven station distribution as a persistent constraint. Coverage gaps are particularly evident in mountainous, coastal, and remote areas, which affects the spatial reliability of localized climate information.

In addition, many observation stations continue to rely on manual systems. This limits real-time data transmission and reduces the efficiency of automated analysis workflows. Expanding

Automatic Weather Stations (AWS), strengthening digitization, and improving hydro-meteorological data integration were identified as immediate technical priorities.

Global assessments similarly identify observational gaps, limited automation, and insufficient data management systems as recurring barriers to high-quality climate service delivery in developing countries. Improving observational infrastructure and quality management systems directly enhances forecast skill and user confidence (WMO, 2024).

2.6.4 Climate Services Production across Timescales

DMH produces seasonal climate outlooks aligned with outputs from the SASCOF. These include forecasts of monsoon onset and withdrawal, rainfall distribution, and temperature anomalies using the 1991–2020 climatological baseline.

However, translating regional seasonal forecasts into localized, decision-relevant advisories remains technically demanding. DMH noted challenges in downscaling, integrating sector-specific datasets, and developing impact-based climate products tailored to agriculture, water management, and health sectors.

Regional experience from South Asia demonstrates that climate information alone is often insufficient to meet decision-makers' needs. Effective climate services require co-production approaches that integrate climate data with vulnerability, exposure, and impact information within a decision-centred framework (Daron, et al., 2022).

While Myanmar has made progress in seasonal forecasting, sub-seasonal services and localized impact-based advisories remain areas requiring further technical development, particularly in the context of increasing climate variability and extreme events.

2.6.5 Product and Service Dissemination and Communication Mechanisms

DMH has established a diversified communication architecture to ensure that climate and early warning information reaches both institutional stakeholders and the general public. Dissemination channels include national television broadcasts, radio announcements, SMS alerts, official bulletins, and digital platforms such as Facebook. This multi-platform approach increases redundancy in communication and improves reach during extreme weather events and seasonal transitions.

Operationally, dissemination is structured around forecast issuance cycles, particularly seasonal outlook releases and hazard advisories. Communication protocols emphasize timeliness, especially during flood and cyclone events when rapid information flow is critical. The integration of traditional media with digital platforms reflects adaptation to evolving information consumption patterns within Myanmar.

Despite these advances, communicating probabilistic information remains a technical and institutional challenge. Seasonal forecasts and outlooks inherently contain uncertainty ranges that are not always easily interpreted by sectoral users. Regional evidence shows that without sustained interpretation support, probabilistic products risk being simplified or misinterpreted at the decision-making stage (Suckall & Soares, 2022).

Myanmar's Disaster Risk Reduction framework underscores the importance of integrated early warning systems and inter-agency coordination mechanisms. Within this broader DRR architecture, climate services function as an upstream information source that supports preparedness planning and anticipatory action. Strengthening communication clarity and consistency is therefore directly linked to national resilience outcomes (UNDRR, 2020).

2.6.6 Engagement with Users and Stakeholders

User engagement in Myanmar is anchored primarily in institutional dialogue platforms such as National and Regional Monsoon Forums. These forums serve as formal consultation spaces where DMH presents seasonal outlooks and sector representatives provide reactions, clarification requests, and sector-specific concerns.

While these forums represent an important foundation for engagement, interaction largely occurs at the stage of forecast presentation rather than at earlier stages of product design. In practice, this means that feedback tends to refine communication rather than fundamentally shape forecast parameters, decision thresholds, or advisory formats.

Regional experience from South Asia indicates that more advanced climate service systems increasingly adopt co-production approaches in which sector agencies collaborate in defining information needs, risk triggers, and advisory thresholds before products are finalized. Such approaches enhance usability, ownership, and long-term institutional uptake (Daron, et al., 2022).

For Myanmar, transitioning from consultation-based engagement toward structured co-production would be particularly valuable in the development of impact-based advisories. Integrating exposure and vulnerability data from agriculture, water management, and disaster agencies into forecast interpretation processes would strengthen the relevance of climate services within operational planning cycles (UNDRR, 2020).

2.6.7 Co-Production and Tailored Services

The development of climate services in Myanmar increasingly recognizes the importance of collaboration between climate information providers and sector users.

Currently, most climate information products are produced by DMH and subsequently interpreted by sector agencies for application in planning and operational decision-making. While

coordination meetings provide opportunities for dialogue, systematic co-production processes—where users actively participate in designing climate services—are still developing.

Expanding co-production mechanisms would enable climate services to better align with sector decision calendars and operational needs. In particular, the development of impact-based advisories tailored to agriculture, water management, and public health sectors has been identified as a priority for strengthening the relevance of climate services.

Such advisory products would integrate climate forecasts with sector-specific vulnerability and exposure information, enabling more actionable guidance for decision-makers.

2.6.8 Informing Decision-Making, Adaptation, and Mitigation

Climate information plays a critical role in supporting disaster risk management and climate adaptation in Myanmar. Seasonal monsoon outlooks and hazard forecasts help inform preparedness planning and risk management strategies across multiple sectors.

For example, cyclone alerts and flood warnings are widely disseminated to support early warning systems and disaster preparedness. Seasonal forecasts also provide valuable information for agricultural planning, particularly in regions where monsoon variability strongly influences cropping cycles and water availability.

Despite these applications, the systematic integration of climate services into national development planning remains an ongoing process. Expanding the use of climate information in long-term adaptation planning and sectoral policy development represents an important opportunity for strengthening climate resilience.

2.6.9 Monitoring, Evaluation, and Learning (MEL)

Monitoring and evaluation systems for climate services remain relatively limited in Myanmar. While feedback from users is collected through surveys and consultations, formal mechanisms for evaluating the performance and socio-economic impact of climate services are not yet well established.

Developing structured monitoring and evaluation frameworks would help track improvements in climate service delivery, identify gaps in service provision, and strengthen accountability. Such systems could also support learning and knowledge exchange within the national climate services system.

2.6.10 Key Successes and Challenges

One of Myanmar's notable strengths lies in the institutionalization of seasonal forecasting processes aligned with the South Asian Climate Outlook Forum (SASCOF). DMH integrates regional guidance with national datasets to produce seasonal outlooks using the 1991–2020 climatological baseline, demonstrating technical consistency with regional standards.

The integration of climate services within national policy frameworks is another significant achievement. Climate information is embedded within the Myanmar Climate Change Strategy and Master Plan (2018–2030), which articulate clear sectoral priorities for adaptation, resilience, and low-carbon development. This policy alignment strengthens the relevance of climate services within broader national development planning.

Additionally, Myanmar's multi-channel dissemination strategy combining traditional media, digital platforms, and stakeholder forums enhances outreach and ensures climate information reaches diverse audiences. This diversified communication approach aligns with global recommendations for strengthening climate service accessibility in high-risk countries.

Several structural and operational constraints continue to shape the evolution of climate services in Myanmar. Observation coverage remains uneven, and manual systems limit automation and real-time analysis.

At the same time, translating probabilistic forecasts into sector-relevant advisories particularly for agriculture and water management requires additional technical refinement. Consultation responses also underscored staffing limitations and the need for sustained investment in automation and institutional strengthening.

Taken together, these experiences suggest that advancing climate services in Myanmar will depend not only on technical upgrades, but also on strengthening institutional coordination and moving gradually toward more structured co-production practices.

Table 6. Summary of Key Gaps and Priorities for Development for Myanmar

Key Gaps Observed	Priorities for Development
Partially institutionalized NFCS and evolving governance structures	Establish and formalize NFCS governance mechanisms to strengthen coordination across climate service providers, sector agencies, and stakeholders.
Limited institutional and technical capacity (staffing, modelling, data science)	Strengthen human resources and technical capacity in climate modelling, data science, and service development to support expanded climate services.
Uneven observation network coverage and limited automation	Expand observation networks in underserved regions, increase deployment of Automatic Weather Stations (AWS), and enhance digitization and real-time data systems.
Limited capacity for downscaling and localization of climate information	Enhance technical capacity to downscale regional forecasts and integrate national datasets to produce localized, decision-relevant climate information.
Limited development of impact-based and sector-specific climate services	Strengthen the development of impact-based advisories by integrating climate data with sectoral exposure and vulnerability information, particularly for agriculture, water, and health sectors.
Challenges in communicating probabilistic forecasts and uncertainty	Improve risk communication strategies and develop user-friendly formats to support interpretation and application of probabilistic climate information.
Predominantly consultation-based stakeholder engagement	Transition from consultation-based engagement toward structured co-production mechanisms that involve users in defining needs, thresholds, and advisory formats.
Limited integration of climate services into long-term planning and sectoral policies	Strengthen the integration of climate information into national development planning, adaptation strategies, and sectoral decision-making processes.
Limited monitoring, evaluation, and learning (MEL) systems	Develop structured MEL frameworks to evaluate climate service performance, track impacts, and support continuous learning and improvement.

2.7 NEPAL

Nepal: Climate Services Snapshot

NFCS Status	Not formally operationalized; the Hydrometeorology Policy 2081 and expanding climate application forums provide an institutional foundation
Main sectors served	Disaster risk management, agriculture, water resources, aviation, health, and climate adaptation
Climate services and products available	Daily and three-day forecasts, monthly climate summaries, seasonal outlooks, climate monitoring reports, and agro-meteorological bulletins
Strengths	Active regional participation and expansion of national, provincial, and district-level climate application and monsoon forums
Main constraints	Uneven high-altitude observation coverage, limited S2S and downscaling capacity, and project-based institutional partnerships and user engagement
Immediate Priority	Establish an NFCS, improve mountain observation and data systems, strengthen multi-timescale forecasting, and institutionalize co-production and MEL

2.7.1 NFCS Implementation Status

Nepal has made important progress toward strengthening climate services through policy development and institutional initiatives, although a fully operational NFCS has not yet been formally established. Many components of climate service delivery are already in place through the activities of the Department of Hydrology and Meteorology (DHM) and its collaboration with sectoral agencies, but these activities are not yet integrated under a comprehensive national framework.

The adoption of the Hydrometeorology Policy 2081 (2024) represents a significant step toward strengthening the institutional foundations for climate services in Nepal. The policy recognizes hydrometeorological information as a critical public service that supports disaster risk reduction, climate adaptation, water resource management, agriculture, and energy planning. It emphasizes the need to modernize observation networks, strengthen climate information systems, and enhance institutional coordination among national agencies. The policy aims to strengthen hydrometeorological services in Nepal by modernizing observation, forecasting, and impact-based early warning systems to reduce disaster risks. It emphasizes data integration, technology use, and timely information dissemination.

Nepal is also actively engaged in regional climate service initiatives. The country participates in SASCOF and collaborates with international organizations such as the World Meteorological Organization and regional climate centers to improve seasonal forecasting and climate monitoring capabilities. In addition, Nepal customises the seasonal outlooks based on these regional forecasts in SASCOF and shares them to its user institutions through National level Climate

Application Forums / Monsoon Forums. It also started provincial and district level forums in 2024/25.

Despite these advances, the operationalization of a comprehensive NFCS remains a work in progress. Coordination between climate information providers and sectoral users is often facilitated through project-based initiatives rather than institutionalized governance mechanisms. Establishing formal coordination structures and strengthening user interface platforms are key priorities for advancing climate services in Nepal.

2.7.2 Institutional Structure and Mandates

DHM is the national authority responsible for meteorological and hydrological services in Nepal. Operating under the Ministry of Energy, Water Resources, and Irrigation, DHM is mandated to monitor weather and climate conditions, provide forecasts and warnings, and support different sector agencies in national planning and disaster risk management.

Within DHM, climate services are primarily coordinated through the Climate Analysis Section, which produces climate monitoring reports, seasonal outlooks, and climate change analyses. Other operational divisions within the department contribute to climate services through weather forecasting, hydrological monitoring, and disaster early warning systems.

DHM collaborates with several national institutions that use climate information in planning and decision-making. These include the National Disaster Risk Reduction and Management Authority (NDRRMA), agricultural agencies (National Agriculture Research Council), hydropower authorities, and water resource management institutions. Through these partnerships, climate information generated by DHM supports early warning systems, agricultural bulletins , and water resource planning.

However, institutional coordination remains partly informal. Partnerships with sectoral agencies are often facilitated through project-based collaborations or ad hoc coordination mechanisms rather than permanent institutional arrangements. Strengthening formal collaboration platforms and clarifying institutional roles within a future NFCS framework would help improve the coordination and sustainability of climate services.

2.7.3 Observing Network and Data

Nepal operates a hydrometeorological observation network consisting of surface meteorological stations, hydrological monitoring stations, and automatic weather stations distributed across the country. These observation systems monitor key climate variables including precipitation, temperature, wind, and river flow, which are essential for both weather forecasting and climate analysis.

Despite this network, observational coverage remains uneven, particularly in high-altitude mountainous regions where climate variability is most pronounced. Many stations in these regions have relatively short observational records, often spanning only five to ten years. Limited accessibility, difficult terrain, and maintenance challenges contribute to gaps in observational coverage and data continuity.

Additional operational challenges also affect data quality and reliability. These include power supply interruptions, lightning damage to equipment, and communication limitations affecting data transmission from remote stations. The limited availability of trained personnel for station maintenance and calibration further constrains the reliability of observational data.

The Hydrometeorology Policy 2081 identifies the expansion and modernization of the observation network as a national priority. Strengthening station density, improving quality control procedures, and integrating remote sensing data are essential steps toward improving climate data availability and supporting more robust climate services.

2.7.4 Climate Services Production across Timescales

DHM produces climate information products across several timescales, including daily and three-day weather forecasts, monthly climate summaries, and seasonal outlooks. These products support decision-making in sectors such as disaster risk management, agriculture, aviation, health, and water resources.

Seasonal climate outlooks are developed in coordination with SASCOF and are disseminated through national climate outlook forums and other stakeholder engagement platforms. These outlooks provide probabilistic forecasts for rainfall and temperature during the monsoon season and are used to inform preparedness planning and agricultural decision-making. Similarly, winter forums were also initiated in province- and national-level through different projects in 2024/25.

DHM also produces climate monitoring reports and event analyses that document significant weather and climate events. These reports contribute to national climate assessments and support long-term climate monitoring.

However, several constraints limit the expansion of climate services production. Operational capacity for sub-seasonal forecasting and advanced climate modelling remains limited. The complex mountainous terrain of Nepal also makes it difficult to interpret large-scale climate drivers and teleconnections, reducing the reliability of seasonal forecasts in some regions.

Strengthening modelling capacity, improving downscaling techniques, and enhancing forecast verification systems are therefore important priorities for improving climate services production across timescales.

2.7.5 Product and Services Dissemination and Communication Mechanisms

Climate information generated by DHM is disseminated through multiple communication channels, including the department's website, social media platforms, television and radio broadcasts, and coordination mechanisms with government agencies.

Seasonal outlooks and climate reports often receive substantial media coverage, which helps extend the reach of climate information to a broader audience. The monsoon forum organized by DHM provides an important platform for disseminating seasonal forecasts and facilitating discussions among scientists, policymakers, and sectoral stakeholders.

Despite these dissemination mechanisms, several communication challenges remain. Feedback from users is often informal rather than structured, and climate information products are not always presented in formats that are easily interpreted by non-specialist users. Improving visualization tools, simplifying technical language, and strengthening feedback mechanisms would help enhance the usability of climate information.

2.7.6 Engagement with Stakeholders

DHM engages with a wide range of user sectors including agriculture, disaster risk management, hydropower, aviation, health, and water resource management. These engagements occur through coordination meetings, climate outlook forums, and collaborative initiatives with sectoral agencies.

The agricultural sector represents one of the most active areas of engagement. DHM produces weekly agro-meteorological bulletins that provide general guidance to farmers and agricultural extension services on crop management decisions based on expected weather conditions. These advisories are used to inform activities such as planting, irrigation scheduling, and harvesting.

Engagement with disaster management agencies is also significant. Seasonal monsoon outlooks and weather forecasts support preparedness planning and early warning activities coordinated by the National Disaster Risk Reduction and Management Authority and different other stakeholders.

However, engagement with end users—particularly local communities and private sector stakeholders—remains uneven and project-based. Establishing structured mechanisms for stakeholder consultation and feedback would help ensure that climate services are better aligned with user needs.

2.7.7 Co-Production and Tailored Services

Co-production of climate services in Nepal is gradually developing through collaborations between DHM and sectoral agencies. Agro-meteorological bulletins represent one example of tailored services developed in response to user needs in the agricultural sector.

These advisories combine meteorological forecasts with general crop management recommendations and are disseminated through emails to agricultural extension networks. Farmers and agricultural stakeholders get guidance through this information to adjust planting schedules, manage irrigation, and reduce climate-related risks to crop production.

However, broader institutional mechanisms for co-producing climate services with users remain limited. Many tailored climate services are developed through externally supported projects rather than permanent institutional arrangements.

Strengthening co-production processes and institutionalizing user interface platforms would help improve the relevance and sustainability of tailored climate services in Nepal.

2.7.8 Informing Decision-Making, Adaptation, and Mitigation

Climate services play an increasingly important role in supporting decision-making in Nepal. Seasonal monsoon outlooks help inform national disaster preparedness planning, particularly for flood and landslide risks during the monsoon season.

In the agricultural sector, climate information supports operational decisions related to crop management and seasonal planning. Agriculture Information and Training Center (AITC) is trying to utilize the DHM forecasts for specific advisories for crops and livestocks. Hydropower operators and water resource managers also use climate information to anticipate seasonal water availability.

Climate information generated by DHM also contributes to national climate change research and adaptation planning. Long-term climate monitoring and climate trend analyses provide valuable inputs for policy development and national adaptation strategies.

2.7.9 Monitoring, Evaluation, and Learning (MEL)

Formal monitoring and evaluation systems for climate services remain limited in Nepal. Feedback from stakeholders is often obtained through consultations, workshops, and project evaluations rather than through systematic evaluation frameworks.

Developing structured monitoring and evaluation systems would help assess the effectiveness of climate services and identify opportunities for improvement. Such systems could also support evidence-based investment in hydrometeorological infrastructure and capacity development.

2.7.10 Key Successes and Challenges

Nepal has made notable progress in strengthening climate services through policy development, expanded observation networks, and active participation in regional climate outlook forums as well as in national climate application forums, with initiation for provincial and district level forums.

However, major challenges remain, including limited observational coverage in mountainous regions, constrained modelling capacity, and the need for stronger institutional coordination under a formal NFCS.

Despite ongoing progress, several structural and technical gaps limit the effectiveness of climate services in Nepal.

1. Technical challenges
    a. Sparse observation networks in mountainous regions
    b. Limited high-altitude climate records
    c. Weak subseasonal and seasonal modelling capacity
    d. Limited integration of impact-based forecasting approaches.
2. Institutional challenges
    a. Project-based rather than institutionalized partnerships with sector agencies
    b. Limited staffing and analytical capacity within climate service units
    c. Absence of an operational National Framework for Climate Services.
3. Communication and user engagement gaps
    a. Informal feedback mechanisms from users
    b. Limited sector-specific customization of climate products
    c. Need for stronger user interface platforms for co-production of climate services.

Addressing these challenges will require sustained investment in observation systems, modelling capacity, institutional coordination, and user-oriented service development. Strengthening alignment with regional climate service mechanisms, such as SASCOF, may also support improvements in forecasting capacity and regional collaboration.

Table 7. Summary of Key Gaps and Priorities for Development for Nepal

Key Gaps Observed	Priorities for Development
Absence of NFCS and partly informal coordination mechanisms	Establish and operationalize an NFCS framework to strengthen governance, formalize coordination platforms, and clarify roles among climate service providers and sector agencies.
Limited institutional and technical capacity for climate services	Strengthen human resources, analytical capacity, and technical expertise within DHM to support expanded climate service delivery and long-term sustainability.
Uneven observation network coverage and limited high-altitude data	Expand and modernize observation networks, particularly in mountainous regions, and improve data continuity and quality control systems.
Limited capacity for sub-seasonal forecasting, modelling, and downscaling	Enhance technical capacity for climate modelling, sub-seasonal forecasting, and downscaling to improve the accuracy and usability of climate information.
Limited development of impact-based and sector-specific climate services	Strengthen the development of tailored and impact-based climate services by integrating climate information with sectoral data for agriculture, water, disaster risk management, and energy sectors.
Challenges in communication and usability of climate information	Improve communication formats through simplified language, visualization tools, and user-oriented products to enhance accessibility for non-specialist users.
Predominantly project-based stakeholder engagement and co-production	Institutionalize structured user engagement platforms and co-production mechanisms to enable continuous feedback and alignment with user needs.
Limited integration of climate services into sectoral planning and policy processes	Strengthen the integration of climate information into national development planning, adaptation strategies, and sectoral decision-making processes.
Limited monitoring, evaluation, and learning (MEL) systems	Develop systematic MEL frameworks to assess climate service performance, track impacts, and support continuous improvement.

2.8 PAKISTAN

Pakistan: Climate Services Snapshot

NFCS Status	Operational but not formally established – many NFCS components are operational through existing specialized institutions and services
Main sectors served	Agriculture, water resources, disaster risk management, drought management, irrigation, energy, aviation, and climate adaptation
Climate services and products available	Short-range forecasts, seasonal outlooks, drought monitoring, water-availability outlooks, agrometeorological advisories, climate projections, and impact-based warning products
Strengths	Strong specialized services in drought monitoring, agriculture, flood forecasting, regional climate outlook production, and multi-channel dissemination
Main constraints	Fragmented governance and observation systems, incomplete hydrometeorological data integration, and limited institutionalized user feedback and evaluation
Immediate Priority	Formalize NFCS governance, integrate and standardize hydrometeorological data systems, and strengthen modelling, verification, communication, and MEL

2.8.1 NFCS Implementation Status

Pakistan has made substantial progress in strengthening national climate services through institutional development, modernization of hydrometeorological infrastructure, and participation in regional climate outlook initiatives. While a formal NFCS has not yet been fully institutionalized through a dedicated national policy or governance structure, many of the key components of the framework are already operational within existing institutional arrangements (PMD, 2023).

Efforts to strengthen climate services in Pakistan have been supported by several national and international initiatives aimed at improving observation networks, forecasting capacity, and disaster early warning systems. In particular, hydrometeorological modernization programmes supported by development partners have contributed to the installation of new observation stations, radar systems, and forecasting infrastructure (World Bank, 2020). These initiatives aim to improve the accuracy and timeliness of weather and climate information and enhance its application in disaster risk reduction and climate resilience planning.

Pakistan is also an active participant in regional climate service initiatives. The Pakistan Meteorological Department (PMD) contributes to SASCOF and collaborates with regional climate centres in generating seasonal climate outlooks for South Asia. These engagements strengthen the technical capacity of the national forecasting system and facilitate the exchange of climate information across the region.

Despite these advances, further institutional strengthening is required to consolidate climate service functions under a comprehensive NFCS framework. Coordination between climate information providers and sectoral users remains partially decentralized, and formal mechanisms for integrating climate services into national planning processes could be further strengthened.

2.8.2 Institutional Structure and Mandates

PMD is the national authority responsible for meteorological and climate services in Pakistan. Operating under the Ministry of Aviation, PMD provides weather forecasts, climate monitoring products, and hazard warnings that support disaster management, agriculture, water resources management, aviation, and other sectors.

Within PMD, several specialized centres contribute to the development and delivery of climate services. The National Drought Monitoring Centre (NDMC) monitors drought conditions and produces drought assessments and outlooks that support agricultural planning and water resource management. The National Agrometeorological Centre (NAMC) provides agro-meteorological advisories and seasonal outlooks for the agricultural sector. In addition, the Climate Data Processing Centre (CDPC) manages climate datasets and supports climate monitoring and research activities.

PMD collaborates with a wide range of national institutions that rely on climate information in their operations and planning processes. Key partners include the National Disaster Management Authority (NDMA), provincial disaster management authorities, irrigation departments, agricultural agencies, and water resource management institutions.

Although these institutional arrangements support the delivery of climate services across sectors, coordination mechanisms are not always formalized through permanent governance structures. Strengthening inter-agency collaboration and establishing institutional platforms for climate services coordination would help enhance the effectiveness of climate information systems in Pakistan.

2.8.3 Observing Network and Data

PMD operates a nationwide observing network of more than one hundred meteorological observatories, supported by weather surveillance radars, automatic weather stations, seismic stations, and hydrological monitoring systems. This infrastructure enables continuous monitoring of key climate variables such as temperature, precipitation, wind, humidity, and pressure, with historical datasets extending back several decades.

Recent years have seen notable progress in expanding radar coverage and automated observations, including the installation of S-band radars in Islamabad and Karachi, an X-band radar in Mardan, and planned installations in Multan and Sukkur. Despite these advances,

coverage remains uneven, particularly in remote and climate-vulnerable regions. Fragmentation of observational systems, including the proliferation of non-calibrated stations operated by external entities without PMD coordination, continues to pose challenges to data integrity and national standardization.

PMD maintains centralized systems for archiving, quality control, validation, and long-term preservation of climate data. Daily and monthly climatic normals are routinely developed, and the Climate Atlas of Pakistan has been published to support climate trend analysis, sectoral planning, and climate change assessments. Data are made available to government agencies, researchers, and commercial users upon request, subject to established protocols.

2.8.4 Climate Services Production across Timescales

PMD produces climate information products across multiple timescales, ranging from short-range weather forecasts to seasonal outlooks and long-term climate analyses.

At the sub-seasonal to seasonal timescale, PMD contributes actively to SASCOF and produces national seasonal outlooks for rainfall and temperature. These outlooks are disseminated to government agencies, agricultural stakeholders, and disaster management authorities to support preparedness planning.

At shorter timescales, PMD provides daily and weekly forecasts and hazard warnings related to extreme weather events. These include warnings for heavy rainfall, floods, heatwaves, and tropical cyclones, which are disseminated to disaster management authorities and the public.

At longer timescales, PMD conducts climate monitoring and climate change analyses using historical climate datasets. These analyses support national climate change assessments and provide inputs for climate adaptation planning.

Climate projections for Pakistan, based on SSP4.5 and SSP8.5 scenarios, are generated using global and regional climate models and contribute to national climate change research aligned with IPCC AR6. PMD also fulfills a regional mandate by producing rolling three-month climate outlooks and seasonal composites for the Third Pole Regional Climate Center, covering precipitation and temperature forecasts uploaded to the TPRCC portal.

The SAHF assessment highlights PMD's growing role in multi-hazard Impact-Based Forecasting, particularly in flood forecasting, agrometeorology, and drought monitoring. The NDMC applies multi-scalar drought indices to translate climate diagnostics into impact-based advisories and early warning products, supporting anticipatory actions by agriculture, irrigation, disaster management authorities, and vulnerable communities. While forecast skill and product diversity have improved, gaps remain in integrated hydrological data management, model calibration, and systematic forecast verification.

2.8.5 Product and Service Dissemination and Communication Mechanisms

PMD disseminates climate information through multiple communication channels, including official reports, web portals, bulletins, media briefings, and digital platforms. Climate products—such as drought bulletins, seasonal outlooks, and agrometeorological advisories—are published regularly on PMD's website and distributed directly to sectoral stakeholders via email and institutional networks.

Media organizations play a key role in extending the reach of climate information. PMD maintains active communication channels with journalists through dedicated communication groups and regular media engagement, ensuring rapid dissemination of warnings and advisories to the public (NDMA, 2021).

Sector-specific communication tools have also been introduced. The Kisaan Mobile Application and agrometeorological bulletins issued by NAMC provide localized, actionable information to farmers, supporting decisions on sowing, irrigation, pest management, and harvesting. During the 2022 floods, PMD's timely forecasts and warnings were recognized by the World Meteorological Organization, demonstrating the effectiveness of its dissemination systems in high-impact events.

Persistent challenges remain. Uncertainty communication is still limited, with technical jargon often hindering user comprehension. PMD products disseminated through partner agencies are not always directly attributed, reducing institutional visibility. Feedback mechanisms to assess user comprehension and uptake are insufficient, limiting opportunities for iterative improvement. Strengthening plain-language communication, visualization tools, and institutional branding remains an important area for improvement.

2.8.6 Engagement with Users and Stakeholders

PMD engages with a wide range of user sectors including agriculture, water resources management, disaster risk reduction, and energy. These engagements occur through coordination meetings, climate outlook forums, and collaborative projects with sectoral agencies.

The agricultural sector is one of the primary users of climate information in Pakistan. Agro-meteorological advisories produced by the National Agrometeorological Centre provide guidance to farmers and agricultural extension services on crop management decisions based on expected weather conditions.

Engagement with disaster management agencies is also significant. Weather forecasts and seasonal outlooks are used by national and provincial disaster management authorities to support preparedness planning and risk reduction measures.

However, structured mechanisms for collecting user feedback and evaluating the usefulness of climate information products are still limited. Strengthening stakeholder engagement platforms

and institutionalizing user feedback processes would help improve the relevance of climate services.

2.8.7 Co-Production and Tailored Services

Several initiatives in Pakistan demonstrate the growing use of co-production approaches in climate services. Agro-meteorological advisory services are developed through collaboration between PMD, agricultural research institutions, and extension agencies to provide tailored information for farmers.

These advisories combine meteorological forecasts with crop management recommendations and are disseminated through agricultural extension networks and media platforms. Farmers use this information to adjust planting schedules, irrigation practices, and pest management strategies.

Despite these examples, broader institutional mechanisms for co-producing climate services with multiple sectors remain limited. Many tailored services are developed through project-based initiatives rather than permanent institutional arrangements. Expanding co-production platforms would help ensure that climate services better address sector-specific needs.

2.8.8 Informing Decision-Making, Adaptation, and Mitigation

Climate services play an important role in supporting decision-making in Pakistan. Seasonal outlooks and climate monitoring products inform agricultural planning, water resource management, and disaster preparedness activities.

Climate information is particularly important for managing water resources in the Indus River basin, where seasonal forecasts and snowmelt monitoring contribute to water allocation and irrigation planning. Climate information also supports early warning systems for floods and droughts.

In addition, climate monitoring and climate change analyses conducted by PMD contribute to national climate policy development and adaptation planning. These analyses provide important evidence for understanding climate trends and informing climate resilience strategies.

2.8.9 Monitoring, Evaluation, and Learning (MEL)

Monitoring and evaluation systems for climate services in Pakistan are still developing. Feedback from users is typically obtained through consultations, stakeholder workshops, and project evaluations rather than through systematic evaluation frameworks.

Establishing structured monitoring and evaluation systems would help assess the effectiveness of climate services and identify areas where improvements are needed. Such systems could also support evidence-based investments in observation infrastructure, modelling capacity, and service delivery mechanisms.

2.8.10 Key Successes and Challenges

Several successes highlight PMD's strengths. The institutionalization of drought monitoring through NDMC, routine production of seasonal water availability outlooks, and active regional engagement through SASCOF and TPRCC demonstrate its growing capacity. PMD's ISO certification in aviation meteorology reflects adherence to international quality management standards and positions it as a regional good practice.

The integration of climate forecasts with agricultural advisories via NAMC, adoption of IBF approaches, and expanding use of digital dissemination tools represent replicable practices with strong potential for scaling. Partnerships with international agencies such as CMA, JMA, JICA, KOICA, and ICIMOD further support capacity development and alignment with global best practices.

Despite significant progress, PMD faces persistent challenges related to fragmented legal frameworks, limited regulatory authority, uneven observational coverage, and insufficient integration of hydrological data across institutions. Budgetary allocations support core operations but remain inadequate for sustained infrastructure modernization and long-term human resource development.

Lessons learned underscore the importance of enacting a consolidated Meteorology Act, strengthening inter-agency coordination, institutionalizing user feedback mechanisms, and investing in capacity development aligned with WMO standards. Enhancing PMD's visibility as the authoritative scientific institution for weather and climate information is critical to improving trust, uptake, and impact of climate services in national planning and decision-making.

PMD has demonstrated strong foundational capacity in delivering hydrometeorological services and is increasingly recognized for its role in impact-based forecasting and regional collaboration. Yet, to fully realize its potential as a regional center of excellence, strategic investments in infrastructure, governance, communication, and capacity development are essential. With ongoing initiatives such as the Modernization of Hydromet Services Project and an experienced technical workforce, PMD is well-positioned to strengthen its role as a cornerstone of Pakistan's resilience against climate risks and extreme weather events.

Table 8. Summary of Key Gaps and Priorities for Development for Pakistan

Key Gaps Observed	Priorities for Development
Absence of NFCS and fragmented governance framework	Establish and formalize an NFCS framework, including enacting a consolidated Meteorology Act, to strengthen governance, clarify mandates, and enhance inter-agency coordination.
Partially decentralized coordination among climate service providers and sector agencies	Strengthen institutional coordination platforms to enable systematic collaboration and integration of climate services across sectors.
Fragmentation of observational systems and uneven coverage in remote areas	Improve standardization and regulation of observation networks, expand coverage in underserved regions, and strengthen calibration and quality control mechanisms.
Limited integration of hydrological and climate data systems	Enhance integration of hydrometeorological datasets across institutions to support more comprehensive forecasting, modelling, and impact-based services.
Gaps in modelling, forecast verification, and advanced analytical capacity	Strengthen technical capacity in modelling, calibration, and forecast verification to improve accuracy and reliability of climate services across timescales.
Challenges in communicating uncertainty and limited user comprehension of climate products	Improve risk communication through plain-language products, enhanced visualization tools, and clearer communication of probabilistic forecasts.
Limited institutionalized mechanisms for stakeholder feedback and co-production	Institutionalize user engagement platforms and feedback systems to support iterative improvement and co-production of climate services across sectors.
Limited integration of climate services into policy and sectoral planning processes	Strengthen the integration of climate information into national development planning, water resource management, agriculture, and disaster risk reduction strategies.
Limited monitoring, evaluation, and learning (MEL) systems	Develop systematic MEL frameworks to assess climate service performance, track socio-economic impacts, and guide evidence-based investments.

2.9 SRI LANKA

Sri Lanka: Climate Services Snapshot

NFCS Status	Not formally operationalized, although most core climate service functions and institutional coordination mechanisms are already functioning
Main sectors served	Agriculture, irrigation, water resources, disaster risk management, and energy
Climate services and products available	Daily forecasts, 15-day outlooks, weekly and monthly forecasts, three-month seasonal outlooks, climate monitoring, and integrated agro-meteorological advisories
Strengths	Long historical climate records and established inter-agency coordination through monsoon forums and integrated agricultural advisory processes
Main constraints	Incomplete digitization of historical data, uneven observation coverage and interoperability, and limited impact-based forecasting and community-level engagement
Immediate Priority	Operationalize an NFCS, digitize and integrate climate datasets, develop higher-resolution and impact-based services, and establish structured feedback and MEL systems

2.9.1 NFCS Implementation Status

Sri Lanka has not yet formally operationalized an NFCS, although many of the core functions typically associated with an NFCS are already being implemented in practice. The Department of Meteorology (DoM), as the national meteorological authority, routinely produces climate monitoring information, seasonal outlooks, and advisory services that support national decision-making processes. These activities are delivered through institutional coordination mechanisms and sector-specific advisory processes rather than through a formally established NFCS governance structure.

Consultations with the Department of Meteorology indicate that climate services activities—including monitoring, forecasting, and advisory dissemination—are carried out operationally but are not yet organized under a systematic NFCS framework. As a result, roles and coordination mechanisms across the climate services value chain remain partly informal, and opportunities exist to clarify institutional mandates, strengthen cross-sector coordination, and formalize user engagement processes.

Sri Lanka nevertheless demonstrates strong national policy commitment to climate action through several national strategies, including the Nationally Determined Contributions (NDCs), the National Adaptation Plan (NAP), and the National Climate Finance Strategy (2025–2030). These policies emphasize climate resilience, adaptation planning, and climate-informed development. While these frameworks recognize the importance of climate information, the systematic integration of climate services into sectoral planning processes is still evolving.

Overall, Sri Lanka's climate services system can be characterized as functionally operational but institutionally under-formalized, suggesting that formal NFCS implementation could significantly strengthen coordination and strategic planning.

2.9.2 Institutional Structure and Mandates

DoM operates as the national authority for meteorological and climate services within the country's broader environmental and disaster management framework. Climate services including monitoring, seasonal forecasting, and advisory dissemination are institutionally mandated functions. The Climate Change Study Center (CCSC), established through a cabinet memorandum, provides a formal anchor for climate-related work, although a dedicated legislative framework for climate services has yet to be enacted.

Sri Lanka has demonstrated strong national commitment to climate governance through policy instruments such as its Nationally Determined Contributions (NDCs), National Adaptation Plan (NAP), and most recently, the National Climate Finance Strategy (2025–2030), which positions adaptation, mitigation, and loss and damage as central pillars of climate action (MFPED, 2025). However, while these strategies establish high-level direction, the operational integration of climate services into sectoral planning remains partially institutionalized.

Operational coordination between the DOM and national stakeholders is comparatively strong. Regular engagement occurs with the Disaster Management Centre (DMC), agriculture agencies, irrigation authorities, water management institutions, and the power sector. Post-monsoon forums and sectoral coordination meetings enable forecast interpretation and integration into preparedness planning. This suggests that, even without full formalization of an NFCS structure, practical coordination mechanisms are in place.

Capacity constraints remain a key structural challenge. Staffing levels dedicated specifically to climate services are limited, and there are identified gaps in climate science, data science, and advanced analytical capabilities. Strengthening institutional capacity will therefore be essential to transition from operational delivery toward more advanced, integrated, and impact-oriented climate services.

2.9.3 Observing Network and Data

Sri Lanka possesses a long historical record of meteorological observations, with rainfall and temperature datasets extending back approximately 150 years. This represents a significant national asset for climatological analysis, seasonal forecast calibration, and long-term trend assessment.

However, a substantial proportion of historical records remains paper-based and has not yet been fully digitized. Limited digitization constrains accessibility, interoperability, and the application of

modern statistical and machine-learning approaches. A World Bank-supported modernization initiative is expected to improve data management systems and digitization efforts.

Spatial distribution of the observation network presents additional challenges. Sri Lanka's complex topography including central highlands, wet, intermediate, and dry zones results in highly variable precipitation and microclimatic conditions (Geldin, 2025). Uneven station coverage and integration gaps between meteorological, hydrological, and geological observation networks limit the ability to provide localized climate analysis.

Sri Lanka's Climate Impact Profile (Geldin, 2025) underscores increasing variability in precipitation and intensification of extreme rainfall events, particularly in wet zones. This reinforces the need for enhanced station density, improved real-time data integration, and cross-agency harmonization of observation networks to support more precise hazard monitoring.

Data-sharing protocols across agencies remain partially fragmented. Stronger integration between the DOM, Department of Irrigation (DOI), National Building Research Organization (NBRO), and other technical institutions would enable a more comprehensive multi-hazard climate service system.

2.9.4 Climate Services Production across Timescales

Sri Lanka's DOM produces climate information across multiple timescales. Operational outputs include:

- Daily weather forecasts
- 15-day outlooks
- Weekly and monthly forecasts, and
- Three-month seasonal outlooks

These products are produced by different operational divisions within the DOM and disseminated through institutional coordination platforms and sectoral advisory mechanisms.

Seasonal outlooks are particularly important in the context of Sri Lanka's dual monsoon system. These forecasts are shared during monsoon forums and sector meetings, supporting planning in agriculture, irrigation, and disaster management.

Climate information from the DOM is also integrated into sector-specific advisory products. For example, the national Agro-meteorological Advisory issued by the Department of Agriculture incorporates seasonal weather forecasts from the DOM along with irrigation and water availability information from multiple institutions. These advisories provide crop-specific guidance for farmers, including recommendations on pest management, irrigation scheduling, and crop protection measures.

The consultation indicated that Sri Lanka does not currently issue fully developed impact-based forecasts; instead, sector agencies interpret hazard-based climate outlooks independently. This

aligns with broader findings in South Asia, where climate information often requires additional translation and contextualization before supporting sectoral decisions (Daron, et al., 2022).

Stakeholder demand for higher-resolution, quantitative forecasts is increasing. For example, the energy sector has expressed interest in longer lead-time forecasts (e.g., six-month outlooks), which currently exceed DOM's operational production capacity. Similarly, users prefer rainfall amount estimates rather than probabilistic "above/below normal" classifications.

The Climate Innovation Needs Assessment report identifies early warning for food and water security, resilient power infrastructure, and climate-smart agriculture as priority areas for innovation (ADPC, 2021). This highlights opportunities to expand climate service production toward sector-specific, decision-support-oriented products.

2.9.5 Product and Service Dissemination and Communication Mechanisms

Climate information dissemination in Sri Lanka occurs primarily through structured forums and institutional coordination mechanisms. Monsoon forums and monthly stakeholder meetings provide platforms for sharing seasonal forecasts and discussing implications with sector agencies.

This structured approach supports coordination with the Disaster Management Centre, which uses seasonal outlooks to inform preparedness planning. Agriculture and irrigation authorities similarly incorporate outlooks into water allocation and crop planning decisions.

However, dissemination to end users particularly farmers and local communities remains indirect. Climate information is typically communicated through sector intermediaries rather than directly to last-mile users. There is recognition that improved digital platforms, including mobile-based applications, could enhance accessibility.

Communicating uncertainty remains a technical and institutional challenge. Seasonal forecasts are probabilistic in nature, and translating uncertainty into actionable guidance requires both technical refinement and communication training. Regional experience suggests that co-production and simplified communication formats significantly enhance uptake.

2.9.6 Engagement with Users and Stakeholders

Sri Lanka demonstrates relatively strong sectoral coordination mechanisms through its monsoon forums and inter-agency meetings. These platforms facilitate dialogue between forecast producers and institutional users, supporting iterative interpretation of seasonal outlooks.

Key stakeholders regularly engaged in these processes include the Disaster Management Centre, the Department of Agriculture, irrigation authorities, water management institutions, and the energy sector. In the agricultural sector, collaboration between meteorological, irrigation, and

agricultural agencies supports the production of integrated agro-meteorological advisories that translate climate information into sector-specific guidance.

Beyond public institutions, private sector actors also contribute to climate and disaster resilience efforts in Sri Lanka. Organizations such as the Ceylon Chamber of Commerce have implemented resilience-related initiatives with regional development partners, reflecting growing private sector engagement in climate risk management. However, these initiatives are not yet systematically linked with the Department of Meteorology or integrated into national climate service coordination mechanisms. Strengthening connections between private sector-led resilience initiatives and formal climate service systems could help improve information flow, avoid duplication, and expand the application of climate information in business continuity, infrastructure planning, and sectoral risk management.

While these coordination mechanisms support stakeholder engagement, user participation is primarily institutional rather than community-based. Engagement with end users remains mediated through sector agencies, and there are limited mechanisms for systematically collecting feedback from users on the usefulness and usability of climate services.

Regional evidence suggests that advancing climate services requires integrating climate information with socio-economic and sectoral impact analysis, moving toward “climate impact services” rather than hazard-only forecasts (Daron, et al., 2022). Sri Lanka presents an opportunity to adopt this more integrated approach. User engagement mechanisms are therefore functional but could be strengthened through formal NFCS implementation, systematic feedback collection, and participatory service design processes.

2.9.7 Co-Production and Tailored Services

Sri Lanka’s climate services system includes several elements of co-production, particularly through the preparation of agro-meteorological advisories and sectoral coordination meetings. These processes involve multiple agencies contributing data, expertise, and sectoral knowledge to produce advisory products.

For example, the national agro-meteorological advisory integrates weather forecasts from the DOM, irrigation water availability information from the Department of Irrigation and the Mahaweli Authority, and agricultural field data from research institutes and extension services. This collaborative approach reflects an emerging model of climate service co-production.

However, co-production remains primarily consultation-based rather than embedded in systematic design cycles. Formalized feedback loops, structured service evaluation mechanisms, and documented impact assessments are limited.

Strengthening structured co-production mechanisms—including participatory service design and user feedback loops—would help ensure that climate information products are more closely aligned with sectoral decision-making needs.

2.9.8 Informing Decision-Making, Adaptation, and Mitigation

Climate information plays an important role in supporting national decision-making processes in Sri Lanka. Seasonal forecasts and climate outlooks inform disaster preparedness planning, agricultural management decisions, and water resource allocation.

For example, seasonal rainfall outlooks are used by the Disaster Management Centre to guide preparedness planning following monsoon forum discussions. Similarly, irrigation authorities and agricultural agencies use seasonal outlooks to plan cropping patterns and water management strategies for major agricultural seasons.

Agro-meteorological advisories provide practical recommendations to farmers regarding crop management, pest control, and irrigation practices, illustrating how climate information can be translated into actionable guidance for agricultural decision-making.

Despite these examples, systematic integration of climate services into long-term development planning and climate adaptation strategies remains limited. Expanding the role of climate services in national adaptation planning and sectoral development strategies represents a key opportunity for strengthening climate resilience.

2.9.9 Monitoring, Evaluation, and Learning (MEL)

Formal monitoring and evaluation mechanisms for climate services remain limited in Sri Lanka. While sector agencies use climate information in operational decision-making, there are few structured processes for evaluating the effectiveness of climate services or assessing their socio-economic impacts.

Feedback from stakeholders is typically collected through informal discussions during coordination meetings rather than through systematic evaluation frameworks. Establishing structured monitoring and evaluation systems would help identify strengths and weaknesses in climate service delivery and support continuous improvement.

2.9.10 Key Successes and Challenges

Sri Lanka demonstrates several notable strengths:

- Long-term climate data records spanning approximately 150 years
- Structured monsoon forums supporting cross-sector dialogue
- Active coordination with disaster management and water authorities
- Alignment of climate governance with national adaptation and finance strategies
- Recognition of priority innovation areas for climate resilience

Sri Lanka's relatively high institutional capacity compared to some regional peers provides a solid foundation for advancing climate service maturity.

Several interconnected challenges shape the future trajectory of climate services in Sri Lanka. These include incomplete digitization of historical records, uneven station coverage, and limited interoperability between technical agencies.

There is also growing demand for higher-resolution and longer lead-time forecasts, particularly from sectors such as energy and water management. Meeting this demand will require both technical upgrades and institutional coordination improvements.

Overall, Sri Lanka's experience illustrates that strong foundational capacity does not automatically translate into fully integrated climate services. Formalizing NFCS implementation and strengthening structured feedback mechanisms could help bridge this gap.

Table 9. Summary of Key Gaps and Priorities for Development for Sri Lanka

Key Gaps Observed	Priorities for Development
Absence of a formal NFCS and partly informal coordination mechanisms	Establish and operationalize an NFCS framework to formalize governance structures, clarify institutional roles, and strengthen cross-sector coordination.
Limited institutional capacity and specialized technical expertise	Strengthen human resources and technical capacity in climate science, data analytics, and advanced forecasting to support more integrated and impact-oriented climate services.
Incomplete digitization and limited interoperability of climate data systems	Accelerate digitization of historical climate records and strengthen data integration and sharing across agencies to improve accessibility and analytical capacity.
Uneven observation network coverage and integration gaps across agencies	Enhance station density, particularly in areas with complex topography, and improve integration between meteorological, hydrological, and geological observation systems.
Limited development of impact-based and sector-specific climate services	Strengthen the development of impact-based climate services and sector-specific advisories by integrating climate information with sectoral data and decision-making needs.
Challenges in communicating probabilistic forecasts and uncertainty	Improve communication strategies through simplified formats, visualization tools, and user-oriented products to enhance understanding and uptake of climate information.
Predominantly institutional (rather than community-level) stakeholder engagement	Expand stakeholder engagement to include community-level users and establish structured feedback mechanisms to improve service relevance and usability.

Limited integration of climate services into long-term development and adaptation planning	Strengthen the integration of climate information into national development planning, adaptation strategies, and sectoral policies.
Limited monitoring, evaluation, and learning (MEL) systems	Develop systematic MEL frameworks to assess climate service effectiveness, track impacts, and support continuous improvement.

Table 10a. Comparative Status of Climate Service Systems across South Asia: Governance, Data, and Production

Country	NFCS Implementation Status	Institutional Structure and Mandates	Observing Networks and Climate Data Systems	Climate Services Production across Timescales
Afghanistan	At an early stage; no fully institutionalized NFCS	AMD leads climate services, but responsibilities are fragmented and technical staffing is limited	Network remains sparse and affected by historical disruption; major gaps persist in remote and mountainous areas; data sharing and interoperability are limited	Daily and weekly forecasts and seasonal outlooks are produced using regional and global guidance; limited S2S forecasting, downscaling, and operational long-term climate analysis
Bangladesh	Operational and evolving; core functions exist and BANCCA provides an initial coordination mechanism, but full operationalization remains incomplete	BMD leads climate services within a strong disaster-management system; cross-sector coordination remains partly informal or project-based	Relatively extensive station, radar, and AWS coverage; gaps remain in historical records, quality control, data integration, and interoperability	Daily, weekly, and seasonal services are operational; seasonal outlooks draw on SASCOF; gaps remain in S2S prediction, advanced modelling, and verification
Bhutan	No formal NFCS; Hydromet Policy, NCHM Roadmap, and twice-yearly NCOFs provide an emerging foundation	NCHM has a clear national mandate; collaboration with agriculture, water, and disaster agencies is functional but often project-based	Meteorological and hydrological networks are operational but sparse in remote and high-altitude areas; long-term records and advanced data-management capacity are limited	Seasonal outlooks are produced using CPT and SASCOF guidance; limited capacity for S2S forecasting, advanced downscaling, and impact-based services
India	Advanced NFCS initiative under development and implementation; broader institutionalization is continuing	Strong multi-institutional system led by IMD, with IITM, NCMRWF, INCOIS, and other specialized institutions	Extensive national observation infrastructure, long-term datasets, modelling systems, and institutional data capabilities	Advanced services across short-range, extended-range, seasonal, and long-term timescales; strong monsoon prediction and sector-specific applications
Maldives	NFCS establishment is underway	MMS has a formal mandate, but the Climate Section has limited dedicated staff, funding, and permanent inter-agency coordination	Observation network maintenance and continuity are major constraints; no fully integrated centralized climate database	Historical analyses, seasonal and sub-seasonal outlooks, and projections are produced; localization and downscaling remain limited, while long-term projections are used in infrastructure planning
Myanmar	Partially aligned with NFCS principles; formal governance structure is still evolving	DMH leads climate services and coordinates with sectors through	Station distribution is uneven, particularly in remote,	Seasonal monsoon outlooks are operational and linked to SASCOF; localized S2S and

		monsoon forums and meetings; staffing, modelling, and data-science capacity are limited	mountainous, and coastal areas; many stations remain manual	impact-based services remain limited
Nepal	No fully operational NFCS; Hydrometeorology Policy 2081 and expanding national, provincial, and district forums provide a foundation	DHM leads climate services; coordination with sector agencies is active but frequently project-based or informal	Hydrometeorological and AWS networks are operational but uneven in high-altitude areas; short records, maintenance issues, and data-continuity gaps persist	Daily, three-day, monthly, and seasonal products are produced; limited capacity remains for S2S forecasting, modelling, downscaling, and verification
Pakistan	No formal NFCS, but many core components are operational through existing institutions	PMD leads a comparatively developed system supported by NDMC, NAMC, and CDPC; inter-agency coordination is not consistently formalized	Broad national network with radar and automated systems; coverage remains uneven, while fragmented and non-standardized external networks affect data integrity	Multi-timescale services include seasonal outlooks, drought monitoring, agrometeorological advisories, water outlooks, climate projections, and TPRCC products; modelling and verification gaps remain
Sri Lanka	No formal NFCS; most core functions are operational through existing institutional and sectoral arrangements	DOM leads climate services, supported by the CCSC and regular coordination with disaster, agriculture, irrigation, water, and energy institutions	Approximately 150 years of records are available, but substantial data remain undigitized; station coverage and interoperability across agencies are uneven	Daily, 15-day, weekly, monthly, and three-month outlooks are operational; integrated sector advisories exist, but fully developed impact-based and longer lead-time services remain limited

Table 10b. Comparative Status of Climate Service Systems across South Asia: Delivery, Engagement, Use, and Learning

Country	Dissemination and Communication	Stakeholder Engagement	Co-Production and Tailored Services	Use in Decision-Making, Adaptation, and Mitigation	Monitoring, Evaluation, and Learning	Principal Development Priorities
Afghanistan	Bulletins, agency coordination, media, and partner-operated systems; remote-area access and technical language remain barriers	Primarily through government coordination and externally supported projects; no fully institutionalized user forum	At an early stage; limited pilots in agriculture, drought monitoring, and early warning	Used mainly for disaster preparedness, humanitarian planning, food security, and agriculture; limited integration into broader development planning	Feedback comes mainly from projects and consultations; no systematic framework	Formalize NFCS coordination; rebuild observation and data systems; strengthen forecasting and downscaling; improve communication and co-production
Bangladesh	Strong multi-channel dissemination and globally recognized cyclone-warning arrangements; probabilistic communication remains difficult	Climate application and monsoon forums support sector dialogue; local communities and private-sector engagement remain uneven	Developing in agriculture, livestock, water, and disaster management, but still largely project-based	Strong use in disaster preparedness and growing use in agriculture, water, and adaptation planning	Stakeholder and project feedback exists, but systematic evaluation is not institutionalized	Operationalize NFCS and BANCCA; improve data interoperability; expand S2S and sector services; institutionalize engagement and MEL
Bhutan	Effective institutional dissemination through bulletins and advisories; uncertainty, language diversity, and remote access create challenges	Active engagement in agriculture, disaster management, and water through NCOFs, Climate Field Schools, and related initiatives	Emerging through NCOFs and the Climate Services Toolkit; services remain largely provider-led	Seasonal information supports agriculture and disaster preparedness; projections support adaptation, hydropower, and infrastructure planning	Formal evaluation of usability and socio-economic benefits remains limited	Formalize NFCS; improve high-altitude observations and datasets; strengthen advanced forecasting; expand impact-based services and MEL

India	Extensive portals, mobile applications, SMS, media, warning systems, and agricultural advisory networks; uncertainty communication remains a challenge	Broad multi-sector engagement, with particularly strong institutionalization in agriculture and disaster risk management	Highly developed in agriculture through GKMS; broader co-production is expanding in water, health, energy, and urban planning	Extensively used in agriculture, disaster management, operational planning, climate assessment, and adaptation	Evaluation exists in some sector programmes, but system-wide MEL remains fragmented	Improve probabilistic communication; expand co-production beyond agriculture; strengthen policy integration and unified MEL
Maldives	Existing channels provide broad institutional reach; interpretation of seasonal uncertainty and limited climate literacy constrain uptake	Mainly consultative and ad hoc; structured mechanisms for joint design and iterative feedback are not yet embedded	At an early stage; priority sectors include fisheries, tourism, water, and coastal infrastructure	Long-term projections have informed harbor construction and land-reclamation planning; application in other sectors remains limited	No systematic framework for measuring effectiveness or socio-economic impacts	Operationalize NFCS; increase staffing and funding; improve observation and data management; develop localized and sector-specific services
Myanmar	Television, radio, SMS, bulletins, and social media provide broad reach; probabilistic information remains difficult to interpret	National and regional monsoon forums provide regular dialogue, primarily at the forecast-presentation stage	Developing; users are not yet systematically involved in defining thresholds, formats, or products	Supports cyclone and flood preparedness, agriculture, and seasonal planning; integration into long-term policy remains incomplete	User surveys and consultations occur, but structured performance and impact evaluation are limited	Formalize NFCS; automate observations; strengthen modelling and localization; move from consultation to co-production; establish MEL
Nepal	Website, social media, television, radio, and climate forums are used; technical language, visualization, and informal feedback limit usability	Broad sector participation through climate application and monsoon forums; local communities and private-sector users remain unevenly engaged	Developing through agro-meteorological bulletins and project-supported initiatives; permanent mechanisms remain limited	Supports monsoon preparedness, agriculture, hydropower, water management, and adaptation planning	Feedback is largely workshop- or project-based rather than systematic	Establish NFCS; expand mountain observations; strengthen S2S and downscaling; institutionalize co-production and MEL
Pakistan	Web portals, bulletins, media,	Strong engagement with agriculture,	Established in agrometeorological	Used for agriculture, Indus	Consultations and project	Formalize NFCS and governance; integrate

	email, and mobile applications support broad dissemination; jargon, attribution, and feedback gaps remain	water, disaster management, and energy, but systematic feedback mechanisms are limited	services and developing elsewhere; broader co-production remains project-based	Basin water management, drought and flood preparedness, climate policy, and adaptation	evaluations occur, but no unified systematic framework exists	hydrometeorological data; strengthen modelling and verification; improve communication, feedback, and MEL
Sri Lanka	Monsoon forums and institutional coordination support dissemination; end-user communication is indirect and digital last-mile mechanisms remain limited	Strong institutional engagement with disaster, agriculture, irrigation, water, and energy sectors; community feedback remains limited	Emerging multi-agency co-production in agro-meteorological advisories; processes remain consultation-based rather than iterative	Seasonal outlooks support disaster preparedness, cropping decisions, irrigation, and water allocation; long-term policy integration remains limited	Feedback occurs mainly through meetings; systematic service and impact evaluation is limited	Formalize NFCS; digitize historical data; integrate agency networks; develop impact-based services; expand community engagement and MEL

2.10 SYNTHESIS

To support a more regionally contextualized assessment of climate service maturity, this study adapts the WMO classification framework for NMHS capacities into a five-category climate services framework tailored to the South Asian context. While the WMO framework provides a useful basis for assessing operational meteorological, climatological, and hydrological capabilities, the adapted framework used in this assessment places greater emphasis on the progressive maturity of climate service systems, including institutional coordination, sector engagement, co-production processes, and the development of impact-based and decision-support-oriented services.

The adapted framework classifies climate service systems into five broad categories:

- **Category 1: Basic Services** – Foundational climate service systems characterized by core observation, monitoring, and basic forecasting functions.
- **Category 2: Emerging Services** – Developing climate service systems where operational activities exist but institutionalization, integration, and sectoral tailoring remain limited.
- **Category 3: Essential Services** – Operational climate service systems with more structured forecasting, advisory, and sector engagement mechanisms.
- **Category 4: Full Services** – Integrated and sector-driven climate service systems with stronger co-production, institutional coordination, and decision-support applications.
- **Category 5: Advanced Services** – Highly mature and innovation-driven systems characterized by advanced modelling, customized applications, research leadership, and extensive sector integration.

Using this adapted framework, the assessment indicates that most NMHSs in South Asia currently fall within the Category 2 (Emerging Services) to Category 3 (Essential Services) range, reflecting operational but still evolving climate service systems. Afghanistan and Maldives are broadly categorized under Category 1 (Basic Services) due to structural and capacity-related constraints affecting higher-level climate service development. Bhutan, Nepal, Myanmar, and Sri Lanka fall within Category 2 (Emerging Services), reflecting developing but not yet fully institutionalized climate service systems. Bangladesh and Pakistan demonstrate characteristics consistent with Category 3 (Essential Services), including more operationalized sectoral services and stronger institutional coordination mechanisms. India stands out regionally under Category 4 (Full Services), reflecting its advanced technical infrastructure, extensive modelling capabilities, and integrated sector-oriented climate service systems.

No country in the current assessment was categorized under Category 5 (Advanced Services), although some countries demonstrate emerging characteristics associated with this level in specific domains. This reflects the broader regional finding that while South Asia has made substantial progress in strengthening climate information production and dissemination, further

work is needed to advance toward fully integrated, impact-based, and decision-oriented climate service systems.

Table 11. Five-category classification on the status of Climate Services for South Asian countries

Category	Description	Country Classification
Category 1: Basic Services	Foundational systems	Afghanistan, Maldives
Category 2: Emerging Services	Developing, not institutionalized	Bhutan, Nepal, Myanmar, Sri Lanka
Category 3: Essential Services	Operational climate services	Bangladesh, Pakistan
Category 4: Full Services	Integrated, sector-driven services	India
Category 5: Advanced Services	Leading, innovation-driven	

- Category 1: Basic Services

  All NMHSs possess the foundational capabilities required for Basic service provision. These include maintaining meteorological observations, managing basic climate datasets, and producing standard weather forecasts and climate summaries.

  Countries such as Afghanistan and, to some extent, Maldives still face structural constraints that limit their ability to move beyond this foundational level in certain areas of service delivery. Sparse observation networks, limited human resources, and constrained computational capacity affect their ability to undertake more advanced climate data analysis or forecasting activities. In these contexts, NMHSs often rely heavily on regional products from mechanisms such as SASCOF or global modelling centres to support national climate outlooks.

  Despite these constraints, even NMHSs with relatively limited infrastructure demonstrate the ability to provide basic climate monitoring and climate information dissemination, fulfilling the minimum functional requirements expected of national meteorological services.

- Category 2: Emerging Services

  A majority of NMHSs in the region demonstrate capabilities consistent with Emerging Services. At this level, NMHSs extend beyond basic observations and data management to produce operational forecasting products such as seasonal outlooks, climate monitoring reports, and sector-relevant advisories.

Countries including Nepal, Bhutan, Myanmar, and Sri Lanka broadly fall within this category. These NMHSs regularly produce seasonal climate outlooks, often aligned with regional guidance from SASCOF and Regional Climate Centres. They also provide early warning information for climate-sensitive sectors such as agriculture and disaster risk management.

For example, several countries conduct NCOFs or similar consultation platforms to interpret seasonal forecasts and discuss their implications with sector stakeholders. Additionally, climate services are increasingly integrated into agricultural advisory systems and disaster preparedness mechanisms.

However, many NMHSs operating at this level still face challenges related to data integration, observation coverage, and advanced modelling capacity, which limit their ability to provide highly localized or sector-specific climate services.

- Category 3: Essential Services

A smaller group of NMHSs in South Asia demonstrate capacities under Essential services. At this level, NMHSs possess stronger technical infrastructure, including advanced observational systems, numerical modelling capability, and the ability to generate specialized weather and climate products.

Countries such as Bangladesh, Pakistan, and Sri Lanka show several characteristics associated with this category. These NMHSs operate relatively dense observation networks, produce specialized forecasting products, and provide tailored climate services for specific sectors.

Examples include agrometeorological advisory services, drought monitoring systems, flood forecasting systems, and specialized climate monitoring products. These services are often developed in collaboration with sector agencies and may involve the integration of climate information with sector-specific data.

At the Category 3 level, NMHSs also demonstrate more structured engagement with users through stakeholder forums, sector consultations, and collaborative service development initiatives.

- Category 4: Full Services

Within the region, India stands out as the only NMHS approaching Full Services capability across multiple domains. India's climate services system benefits from an extensive observational network, advanced climate modelling capabilities, and a well-developed institutional ecosystem involving multiple specialized research institutions.

India produces a wide range of specialized climate products, including long-range monsoon forecasts, sector-specific advisory systems, and climate projections used for national planning.

At this level, NMHSs demonstrate the capacity to develop customized climate services, decision-support tools, and sector-specific applications that support climate risk management across multiple sectors. They also maintain strong research and training capacities and actively contribute to regional climate services initiatives.

Regional Trends and Development Pathways

Across the region, a common pattern emerges: NMHSs generally demonstrate strong capabilities in observations, data management, and routine forecasting, but capacity decreases as services move further along the climate services value chain toward customized products and decision-support tools.

In particular, the transition from providing climate information to delivering impact-based climate services and sector-specific decision-support systems remains a major challenge across the region. This transition requires stronger integration of climate information with sectoral datasets, improved modelling and downscaling capabilities, and more structured co-production processes with user communities.

At the same time, the assessment highlights important opportunities for peer learning and regional knowledge transfer. Several countries demonstrate strengths in specific aspects of climate service development that could inform broader regional capacity strengthening efforts. India demonstrates advanced capability in multi-timescale forecasting, institutional coordination, and sector-specific service delivery. Bangladesh and Pakistan provide important examples of operational dissemination systems, impact-based approaches, and sector-oriented climate services. Bhutan, Nepal, and Sri Lanka illustrate emerging practices in stakeholder coordination, agro-meteorological advisory development, and climate service integration within national planning processes.

These diverse experiences suggest that strengthening climate services across South Asia does not require uniform development pathways, but rather structured mechanisms for sharing expertise, adapting good practices, and supporting countries according to their specific institutional and technical contexts.

Regional mechanisms such as SAHF, SASCOF, and CSUF provide important opportunities to facilitate technical collaboration, peer learning, and coordinated capacity development across countries. The establishment of the SAHF Climate Services Working Group composed of representatives from South Asian NMHSs represents an important step toward strengthening regional coordination and supporting the long-term development of an RFCS aligned with GFCS principles.

The framework presented in this assessment therefore provides not only a basis for understanding the current maturity of climate services in South Asia, but also a practical lens for identifying development pathways, regional priorities, and opportunities for sustained regional cooperation.

3 GOOD PRACTICES: NATIONAL CASE STUDIES

As experiences from other countries provide valuable insights for strengthening climate services, this section looks into several national initiatives and experiences on the development and implementation of NFCS, particularly from China, Ethiopia, and European counntries. While institutional contexts and capacities differ significantly across countries, several common elements of good practice and transferable lessons emerge.

3.1. China: Government-Led NFCS with Strong Sector Integration

China's experience represents a highly structured and government-driven NFCS model, anchored in the China Framework for Climate Services (CFCS) and led by the China Meteorological Administration (CMA). The system operates through a multi-level institutional structure, enabling coordinated production and delivery of climate services from national to local levels.

A defining feature of China's NFCS development is the role of international collaboration—particularly with the United Kingdom—in accelerating early progress. Through initiatives such as the Climate Science for Services Partnership (CSSP China), UK-supported collaboration helped bridge climate science and operational service delivery, strengthening the alignment of research outputs with sectoral needs and effectively jumpstarting NFCS development activities.

China's approach demonstrates a transition from science-driven to user-oriented climate services, with increasing emphasis on sector-specific applications in water, energy, agriculture, and urban resilience. Structured engagement mechanisms and prototype services enable the translation of probabilistic forecasts into decision-relevant tools.

Good Practices Identified:

- Clear institutional mandates and strong central coordination through CMA.
- Strategic use of international partnerships (e.g., UK collaboration) to accelerate NFCS development and innovation.
- Integration of climate services into sectoral decision-making processes (e.g., water, energy, urban planning).
- Structured co-development of services through sector-specific engagement mechanisms.
- Translation of forecasts into decision-relevant applications, including probabilistic and impact-oriented services.

Lessons Learned:

- International collaboration can play a critical role in accelerating early-stage NFCS development.
- Strong governance enables scale, but user uptake depends on trust and usability of information.

- Even advanced systems face challenges in communicating probabilistic forecasts effectively.
- Institutional strength must be complemented by continuous user engagement and contextualization.

3.2. Ethiopia: NFCS Development through Institutional Strengthening and Data System Transformation

Ethiopia illustrates a phased approach to NFCS development, where climate services evolved through gradual institutional strengthening rather than a single intervention. The Ethiopian Meteorological Institute (EMI) expanded from basic meteorological functions to multi-sector service delivery, culminating in the formal adoption of the NFCS in 2021 with strong government endorsement.

A key feature of this pathway is the systematic improvement of operational workflows, including forecasting across timescales, structured dissemination (e.g., NCOFs, media), and sector-specific service delivery in agriculture, water, health, and disaster risk management. These process enhancements enabled more consistent translation of climate information into decision-making.

Central to Ethiopia's progress is the Enhancing National Climate Services (ENACTS) approach, which transformed climate data systems by integrating station observations with satellite and reanalysis data to produce high-resolution, spatially complete datasets. Combined with tools such as Maproom, an interactive climate information portal, ENACTS improved data accessibility, standardization, and usability, supporting localized and sector-relevant applications.

The NFCS further institutionalized co-production mechanisms, including National Climate Outlook Forums and sectoral task forces, strengthening engagement between providers and users.

Good Practices Identified

- Phased NFCS development building on existing institutional systems.
- Strong government ownership and formal NFCS endorsement.
- Improved operational workflows for forecasting, dissemination, and service delivery.
- Use of ENACTS to transform climate data availability and usability.
- Institutionalized co-production through NCOFs and sectoral platforms.

Lessons Learned

- NFCS development is most effective when incremental and system-based.
- Data system improvements (e.g., ENACTS) are critical but require user capacity to ensure uptake.
- Resource and capacity constraints continue to affect sustainability.

3.3. Europe: Iterative and Coordination-Driven Development of NFCSs

Europe illustrates a collective, iterative approach to NFCS development, where countries progressively established national frameworks through stakeholder engagement, coordination mechanisms, and alignment with policy and research systems. Rather than a single model, NFCSs across countries such as the United Kingdom, Ireland, Switzerland, Norway, and Belgium evolved through context-specific pathways, shaped by institutional structures and national priorities.

A key feature of this process is the emphasis on structured and continuous stakeholder consultation, which informed the identification of priorities, clarified institutional roles, and strengthened ownership across sectors. This participatory approach supported the transition from fragmented activities to more coordinated and strategic climate services systems.

Another defining element is the strengthening of coordination mechanisms and institutional linkages. Countries adopted various models—such as network-based platforms and "virtual centres"—to connect NMHSs, research institutions, government agencies, and users. These mechanisms improved coherence, reduced duplication, and enabled more integrated service delivery.

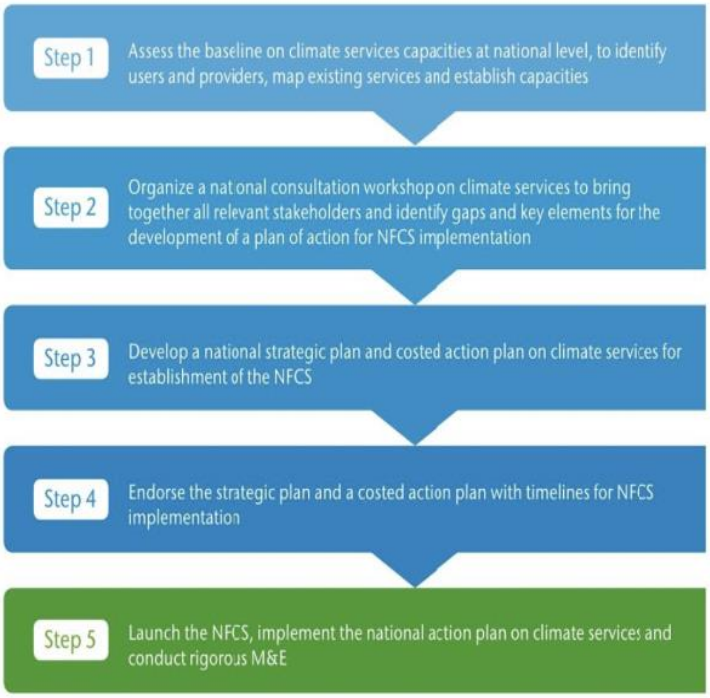

Figure 1. Steps in establishing an NFCS

Europe's experience also highlights the importance of improving climate data systems and interoperability. Efforts to harmonize datasets and develop standardized climate information products enhanced accessibility and usability for decision-making, particularly in adaptation planning.

NFCS development in Europe is inherently iterative, following cycles of assessment, consultation, planning, implementation, and evaluation (see Figure 1). This continuous process allows systems to evolve in response to emerging user needs, scientific advances, and policy demands.

Good Practices Identified

- United Kingdom: Extensive multi-sector stakeholder consultations to define NFCS priorities and ensure alignment across science, policy, and services.

- Ireland: Development of harmonized national climate datasets to address fragmentation and improve usability for adaptation planning.
- Switzerland: Establishment of the National Centre for Climate Services (NCCS) as a "virtual centre" linking institutions and users through a coordinated platform.
- Norway: Integration of climate services into national governance and sectoral planning systems, particularly for long-term adaptation.
- Belgium: Coordination of climate services across complex multi-level institutional arrangements, requiring alignment between federal and regional entities.

Lessons Learned

- NFCS development is most effective when adaptive and iterative, rather than linear.
- Coordination mechanisms are essential in multi-institutional environments, even without centralization.
- Data usability and standardization are critical to overcoming fragmentation.
- Sustained stakeholder engagement is necessary to ensure relevance and uptake.
- Complex institutional settings require clear roles and governance structures to function effectively.

3.4. Key Lessons

Drawing from the experiences of China, Ethiopia, and European countries, several strategic lessons emerge for strengthening NFCS in South Asian countries:

- **Adopt a phased and system-based approach to NFCS development** Experiences from Ethiopia and Europe demonstrate that NFCSs are most effective when developed incrementally, building on existing institutional systems, capacities, and processes rather than through one-time implementation.
- **Strengthen governance, institutional mandates, and coordination mechanisms** European countries' coordination platforms highlight the importance of clearly defined roles, strong institutional mandates, and mechanisms to align multiple actors across sectors and administrative levels.
- **Institutionalize stakeholder engagement and co-production processes** Across all cases, sustained and structured engagement—through forums, consultations, and sectoral platforms—is essential to ensure that climate services are demand-driven, relevant, and used in decision-making.
- **Invest in climate data systems that prioritize usability and accessibility** Ethiopia's ENACTS approach and Europe's data harmonization efforts underscore the need to move beyond data availability toward standardized, high-resolution, and user-oriented climate information systems.
- **Integrate climate services into sectoral planning and decision-making** China's sector-focused services and Ethiopia's applied advisories demonstrate that embedding climate information into operational processes (e.g., agriculture, water, energy, DRM) enhances uptake and impact.
- **Leverage international partnerships to accelerate NFCS development** China's collaboration with the United Kingdom illustrates how strategic partnerships

can help bridge climate science and service delivery, particularly in early stages of NFCS development.

- **Strengthen operational workflows and service delivery systems** Ethiopia's experience shows that improving forecasting, dissemination, and service delivery processes is critical for translating climate information into actionable services.
- **Invest in capacity development for both providers and users** Improved systems alone are insufficient; user capacity, awareness, and institutional readiness are necessary to ensure effective uptake and application of climate services.
- **Ensure flexibility and adaptability of NFCS frameworks** European experiences highlight that NFCSs must remain iterative and responsive to evolving user needs, scientific advancements, and policy priorities.
- **Address resource and sustainability constraints proactively** Ethiopia's experience underscores the importance of sustained financing, human resources, and institutional support to ensure long-term viability of NFCS implementation.

4. GAPS AND STRATEGIC OPPORTUNITIES

A. Summary of challenges

Despite considerable progress in strengthening climate services across South Asia, everal common challenges continue to limit the full operationalization and effective use of climate information at the national level. These include:

- **Limitations in observational infrastructure and climate data systems**
  - The spatial density, reliability, and continuity of meteorological observation networks remain uneven across the region.
  - Observation coverage is particularly limited in mountainous, remote, and conflict-affected areas.
  - These gaps reduce the accuracy of localized climate monitoring, analysis, and forecasting.
  - Incomplete digitization of historical climate records continues to limit data accessibility and use.
  - Limited interoperability between institutional data systems constrains climate research, data integration, and service development.

- **Limited technical capacity for climate analysis, modelling, and prediction**
  - Many NMHSs continue to rely heavily on global and regional forecasting products to generate national climate outlooks.
  - National capacities for climate modelling, statistical downscaling, and sub-seasonal to seasonal prediction remain limited in several countries.
  - Technical capacity for impact-based forecasting and localized climate analysis is also uneven.
  - These limitations affect the accuracy, localization, and decision relevance of climate services.

- **Weak or evolving institutional coordination mechanisms**
  - Climate service delivery requires collaboration among NMHSs, sectoral ministries, disaster management authorities, research institutions, and development partners.
  - In many countries, formal coordination mechanisms are still being developed or remain project-based.
  - The absence of fully operational NFCS or equivalent coordination platforms can result in fragmented responsibilities.
  - Limited coordination also constrains the systematic integration of climate information into sectoral planning and decision-making.

- **Challenges in communication and dissemination**
  - Many NMHSs regularly produce seasonal outlooks, climate monitoring products, and hazard information.
  - However, these products are not always translated into sector-specific advisories or decision-support tools.
  - Climate information may be presented in technical formats that are difficult for non-specialist users to understand or apply.
  - Communication of probabilistic information and forecast uncertainty remains a particular challenge.

- **Uneven stakeholder engagement and user feedback**
  - Regional platforms such as SASCOF provide important opportunities for dialogue between climate scientists and sector representatives.
  - However, structured engagement with users remains uneven across countries and sectors.
  - Processes for systematically capturing user needs, feedback, and experiences are not yet fully institutionalized.
  - User participation is often concentrated at the dissemination or consultation stage rather than throughout the design and development of climate services.

B. Opportunities for Climate Services at the National Level

The assessment also identifies significant opportunities for strengthening climate services across South Asia. Many countries already possess foundational capacities, including operational NMHSs, seasonal forecasting mechanisms, and participation in regional climate outlook forums. Key opportunities include:

- **Strengthening and operationalizing NFCS mechanisms**
  - Establishing or enhancing NFCS can improve coordination between climate information providers and sectoral institutions.
  - NFCS platforms can support the co-production of climate services and strengthen the integration of climate information into national development planning.
  - They can provide structured mechanisms for identifying user needs and prioritizing climate service investments.
  - NFCS implementation can also help align climate services with national adaptation strategies and sectoral priorities.
- **Expanding and modernizing observational networks and climate data systems**
  - Investments in automatic weather stations can improve the spatial and temporal coverage of climate observations.
  - Greater integration of satellite observations and other complementary datasets can address gaps in national monitoring networks.
  - Modern data management platforms can improve data quality, accessibility, interoperability, and long-term preservation.
  - Stronger climate data infrastructure can support research, modelling, forecasting, and the development of more sophisticated climate products.
- **Advancing climate modelling and forecasting capacity**
  - Improved sub-seasonal to seasonal prediction capacity can strengthen preparedness and planning across climate-sensitive sectors.
  - Enhanced access to regional and global prediction products can support national forecasting systems.
  - Closer collaboration with Regional Climate Centres can help NMHSs improve forecast interpretation, downscaling, verification, and localization.
  - Capacity development in modelling and advanced analytics can reduce reliance on externally produced climate information.
- **Developing sector-specific and decision-relevant climate services**
  - Greater opportunities exist to tailor climate services for agriculture, water resources, disaster risk management, health, energy, and other climate-sensitive sectors.
  - Climate forecasts can be translated into sector-relevant advisories, impact information, and decision-support tools.

  - Integrating climate information with sectoral exposure, vulnerability, and operational data can improve the practical value of services.
  - Stronger co-production can help ensure that services correspond to sectoral decision timelines and user needs.
- **Strengthening communication and user capacity**
  - Climate products can be made more accessible through simplified language, visualization tools, and user-oriented formats.
  - Improved communication of probabilistic forecasts and uncertainty can support more informed decision-making.
  - Capacity-building for sectoral users can strengthen their ability to interpret and apply climate information.
  - Multi-channel dissemination approaches can improve access among national, sub-national, and community-level users.
- **Expanding regional collaboration and knowledge sharing**
  - Regional mechanisms such as SASCOF and SAHF can continue to support technical exchange and capacity development among NMHSs.
  - Countries can benefit from sharing tools, expertise, methods, and good practices.
  - Regional platforms can support peer learning and help countries adapt successful approaches to their national contexts.
  - Continued regional cooperation can accelerate the development of more coordinated, user-oriented, and sustainable climate services across South Asia.

5. CONCLUSION

The assessment shows that South Asian countries have established important foundations for the production and delivery of climate services. All countries maintain core meteorological and climate functions, participate in regional climate outlook processes, and provide information that supports disaster risk management, agriculture, water resources, and other climate-sensitive sectors. However, the maturity of climate service systems remains uneven, reflecting differences in institutional arrangements, observation networks, technical capacities, stakeholder engagement mechanisms, and the extent to which climate information is integrated into decision-making.

Across the region, the principal challenge is the transition from producing and disseminating climate information toward delivering integrated, user-oriented, and decision-relevant climate services. While seasonal outlooks, climate monitoring products, and hazard information are widely available, their translation into localized, sector-specific advisories and decision-support tools remains limited in many countries. Formal coordination mechanisms, structured co-production processes, and systematic monitoring, evaluation, and learning systems are also still developing.

At the same time, the assessment identifies a strong basis for further progress. Existing NMHS capacities, national climate forums, regional mechanisms such as SASCOF and CSUF, and established collaboration among South Asian countries provide practical entry points for strengthening climate services. The development and operationalization of NFCS mechanisms, improvements in observation and data systems, enhanced technical capacity, and stronger engagement with user sectors can help countries build on these existing foundations.

Progress will require approaches that respond to the different institutional and technical contexts of individual countries while also addressing common regional priorities. Continued coordination through the SAHF Climate Services Working Group can support this process by facilitating knowledge exchange, technical collaboration, capacity development, and the sharing of good practices. Together, national and regional action can help advance more coordinated, sustainable, and user-oriented climate service systems across South Asia.

6. RECOMMENDATIONS AND NEXT STEPS

A. Recommendations for the Region and CS Working Group

The assessment indicates that significant progress has been made in strengthening the production and dissemination of climate information across South Asia. However, the transition from providing climate information to delivering fully operational climate services that support sectoral decision-making remains ongoing. Addressing this gap requires coordinated action at both national and regional levels.

Key recommendations include:

Strengthen and operationalize National Frameworks for Climate Services

- Countries should prioritize the strengthening and operationalization of NFCS.
- Formal coordination mechanisms should be established among NMHSs, sectoral ministries, and research institutions.
- These mechanisms can help institutionalize the co-production of climate services.
- They can also improve the integration of climate information into sectoral planning and policy processes.

Invest in observational infrastructure and climate data systems

- Continued investment in observational infrastructure and climate data management systems is essential.
- National observation networks should be strengthened.
- Climate data processing capabilities should be enhanced.
- These improvements can support the production of higher-resolution climate products.
- They can also improve the accuracy and reliability of climate information and strengthen climate risk management.

Strengthen technical capacity for advanced climate services

- Technical capacity for climate modelling, forecasting, and impact-based climate services should remain a regional priority.
- Training programmes can help strengthen the required expertise.
- Technical exchanges among countries and institutions should be supported.
- Collaborative initiatives with Regional Climate Centres can further contribute to the development of advanced climate services.

Improve communication and dissemination mechanisms

- Communication and dissemination systems should be strengthened to ensure that climate information is accessible and actionable for decision-makers.
- User-friendly climate products should be developed.
- Decision-support platforms should be strengthened or established.
- Multi-channel communication systems can help improve the usability of climate services.

Strengthen the role of the SAHF Climate Services Working Group

- The SAHF Climate Services Working Group can facilitate regional coordination, knowledge sharing, and capacity development.
- It can support technical collaboration among NMHSs.
- It can promote the exchange of best practices across countries.
- Through these functions, the Working Group can help accelerate the development of climate services across South Asia.

B. Next Steps and Way Forward

Building on the findings of the assessment, several next steps can be undertaken to further strengthen climate services across the region:

- **Continue supporting regional climate forums and technical collaboration platforms**
  - Continued support for regional climate forums and technical collaboration platforms will be essential.
  - SASCOF and CSUF provide important opportunities for strengthening dialogue between climate scientists and sector stakeholders.
- **Implement capacity development for NMHSs and user sectors**
  - Capacity development initiatives should target both NMHSs and user sectors.
  - Training programmes can be informed by the findings of the regional Training Needs Assessment.
  - Priority training areas include:
    - Climate modelling
    - Climate data management
    - Impact-based forecasting
    - Interpretation of climate information
    - Application of climate information in sectoral decision-making
- **Conduct national climate service assessments and develop roadmaps**
  - Countries may consider conducting national-level assessments of climate service systems.
  - These assessments can help identify priority investments.
  - They can also support the development of national climate service roadmaps aligned with NFCS.
- **Strengthen regional and international partnerships**
  - Regional cooperation should continue to be strengthened.
  - Partnerships with international organizations and development partners will remain important.
  - These partnerships can help mobilize technical and financial support for climate service development.
- **Support the long-term development and sustainability of climate services**
  - Collaborative initiatives can support the expansion of observational infrastructure.
  - They can help enhance forecasting capabilities.
  - They can also contribute to the long-term sustainability of climate service systems in South Asia.

7. APPENDICES

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ACRONYMS

ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Center
ADSS	Agrometeorological Decision Support System
AITC	Agriculture Information and Training Center
AMD	Afghanistan Meteorological Department
AMFU	Agrometeorological Field Unit
ANDMA	Afghanistan National Disaster Management Authority
AR6	Sixth Assessment Report
AWS	Automatic Weather Station
BANCCA	Bangladesh National Centre for Climate Applications
BMD	Bangladesh Meteorological Department
BWDB	Bangladesh Water Development Board
CARA	Climate Action for a Resilient Asia
CCSC	Climate Change Study Center
CDPC	Climate Data Processing Centre
CFCS	China Framework for Climate Services
CMA	China Meteorological Administration
CPT	Climate Predictability Tool
CS	Climate Services
CSSP China	Climate Science for Services Partnership China
CSUF	Climate Services User Forum
DAE	Department of Agricultural Extension
DAMU	District Agro-Met Unit
DDM	Department of Disaster Management
DHM	Department of Hydrology and Meteorology
DMC	Disaster Management Centre
DMH	Department of Meteorology and Hydrology
DOI	Department of Irrigation
DoM	Department of Meteorology
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EMI	Ethiopian Meteorological Institute
ENACTS	Enhancing National Climate Services
ENSO	El Niño–Southern Oscillation
ERA5	European Centre for Medium-Range Weather Forecasts Reanalysis, Version 5
FAO	Food and Agriculture Organization of the United Nations
FCDO	Foreign, Commonwealth & Development Office
FMI	Finnish Meteorological Institute

GFCS	Global Framework for Climate Services
GKMS	Gramin Krishi Mausam Sewa
IBF	Impact-Based Forecasting
ICAR	Indian Council of Agricultural Research
ICIMOD	International Centre for Integrated Mountain Development
IFRC	International Federation of Red Cross and Red Crescent Societies
IITM	Indian Institute of Tropical Meteorology
IMD	India Meteorological Department
IMDAA	Indian Monsoon Data Assimilation and Analysis
INCOIS	Indian National Centre for Ocean Information Services
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
JMA	Japan Meteorological Agency
KOICA	Korea International Cooperation Agency
MEL	Monitoring, Evaluation, and Learning
MFPED	Ministry of Finance, Planning and Economic Development
MMS	Maldives Meteorological Service
NAMC	National Agrometeorological Centre
NAP	National Adaptation Plan
NBRO	National Building Research Organization
NCCS	National Centre for Climate Services
NCHM	National Center for Hydrology and Meteorology
NCMRWF	National Centre for Medium Range Weather Forecasting
NCOF	National Climate Outlook Forum
NDC	Nationally Determined Contribution
NDMA	National Disaster Management Authority
NDMC	National Drought Monitoring Centre
NDRRMA	National Disaster Risk Reduction and Management Authority
NFCS	National Framework for Climate Services
NMHS	National Meteorological and Hydrological Service
PMD	Pakistan Meteorological Department
PyCPT	Python Interface to the Climate Predictability Tool
RCC	Regional Climate Centre
RFCS	Regional Framework for Climate Services
RIMES	Regional Integrated Multi-Hazard Early Warning System for Africa and Asia
S2S	Subseasonal to Seasonal
SAHF	South Asia Hydromet Forum
SASCOF	South Asian Seasonal Climate Outlook Forum
SIDS	Small Island Developing State

SMS	Short Message Service
SSP	Shared Socioeconomic Pathway
TPRCC	Third Pole Regional Climate Center
UK	United Kingdom
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
WCRP	World Climate Research Programme
WFP	World Food Programme
WISER	Weather and Climate Information Services
WMO	World Meteorological Organization