SAHF Capacity Enhancement Working Paper

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C O N T E N T S

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ACRONYMS

ARRCC   Asia Regional Resilience to a Changing Climate

CDMS   Climate Database Management System

CE   Capacity Enhancement

DRR   Disaster Risk Reduction

EC   Executive Council

IBF   Impact Based Forecasting

IMD   India Meteorological Department

INCOIS   Indian National Centre for Ocean Information System

IPCC   Intergovernmental Panel on Climate Change

ITCO   International Training Centre for Operational Oceanography

NMHS   National Meteorological and Hydrological Services

NWP   Numerical Weather Prediction

ON   Observational Networks

PMD   Pakistan Meteorological Department

RTC   Regional Training Centre

SAHF   South Asia Hydro-met Forum

TOT   Training of Trainers

WB   World Bank

WG   Working Group

WMO   World Meteorological Organization

Executive Summary

With climate change and severe weather events rapidly intensifying around the globe and in the South Asia region, it is imperative for countries to evolve collaborative strategies and develop action plans to minimize adverse impacts. Although most of the work happens at the national and sub-national level, regional cooperation is key for prospective advancement of building guidance strategies based on international best practices. To address increasing climate risks and reduce disasters, actionable hydro-meteorological services are crucial for the region. However, there are several challenges currently being faced by the National Meteorological and Hydrological Services (NMHSs) of South Asia that hinder the delivery of hydro-met services. Fragmented modernization efforts that remain financially and technically unsupported beyond project lifetimes are one of the main concerns.

The overarching objective was to reinforce national activities leading to a more sustainable program of building state-of-the-art meteorological and hydrological services across the region through a structured and staggered approach under the guidance of the Executive Council, the South Asia Hydro-met Forum (SAHF) brings together nine Asian countries: Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka. Among the most immediate and specific priorities – at a regional level – are the improvement of forecasts of extreme events, both in terms of intensity and lead time anticipation, using ensemble prediction systems, impact-based forecasting, and user-specific advisory services. To this end, adequate and competent human resources within national hydro-meteorological institutions are one of the key requisites for delivering effective demand-based services. However, at present the capability among NMHSs in the region varies enormously in terms of infrastructures, workforce and their skills. This gap will widen further as new technologies get operationalized unless focused efforts are implemented to jointly build such capacities in the region.

This Working Paper on Capacity Enhancement envisions capacity enhancement as a multi-dimensional attribute that cuts across the other three-thematic areas of SAHF, including Numerical Weather Prediction (NWP), Impact Based Forecasting (IBF), and Observational Networks (ON), for targeted improvement at individual and institutional levels to provide demand driven user sector services by NMHSs in respect of public safety and socio-economic benefits. The main objective of this working paper is to assess the existing capacities of NMHSs, map their capacity enhancement needs and prioritize them into immediate term efforts, to be addressed during the current phase of SAHF till March 2023 and other needs to be addressed beyond this phase of SAHF.

The stock take of existing capacities and needs of NMHSs was implemented through extensive consultation with the NMHSs. A Training Needs Assessment report and a Regional Strategy document were developed based on the analysis of the stock take data. The findings of these two documents are the main inputs to this working paper. Further, existing hydro-met

assessment reports of the SAHF member countries prepared by the WB and the hydro-met gap report of the Alliance for Hydro-met Development were reviewed to supplement the analysis to design and develop appropriate strategies targeting institutional and individual capacity enhancements.

It was found that numerous parallel initiatives are going on in the region. The training strategy endeavors to provide a common framework that brings together the various regional efforts and share common resources to accrue the maximum benefits. A training matrix was developed which forms the main training framework that considers the hydro-met services value chain in the verticals and training required in the horizontals. The capacity enhancement is targeted at three levels, that is, Basic (B), Mid (M) and Expert (E). The Basic (B) training are targeted to the recruits, operational hydrology and meteorology technical officers and technicians. The Mid (M) level training is targeted to mid-level professionals like meteorologists, hydrologists, engineers and forecasting technicians. The Expert (E) level training is targeted to senior management officers and specialists. **The matrix developed is open-ended as it allows any number of columns and rows to be added to suit the changing needs of NMHSs and their users. Thus, this is a scalable regional capacity enhancement framework that can accommodate ongoing, additional, and evolving future requirements at all levels of the hydro-meteorological institutional environment. Prioritized trainings were then identified from the training matrix.**

The priority training modules identified were - introduction to the basics of impact-based forecasting; impact-based forecasting in agriculture and disaster risk reduction; application of seasonal prediction, marine and coastal warning services; regional knowledge platform and aviation meteorology. To implement these prioritized training modules, resources and specific roles and responsibilities of partners were mapped. Accordingly, RIMES will coordinate the implementation of training - introduction to the basics of impact-based forecasting, impact-based forecasting in agriculture and disaster risk reduction and regional knowledge platform under SAHF from Dec 2022 to Mar 2023.

Parallel trainings at regional level that RIMES has been involved in are the trainings on seasonal prediction for operational services in South Asia, organized in April 05 through 21, 2022 in collaboration with UKMet Office supported by the Asia Regional Resilience to a Changing Climate (ARRCC) project. As a follow up to this, the advanced training on the use of seasonal forecasting tools was organized during May 23 through 27, 2022 in Pune, India, again within the ARRCC project. The marine and coastal warning services and aviation met trainings are proposed to be implemented in collaboration with International Training Centre for Operational Oceanography (ITCO) Ocean, Indian National Centre for Ocean Information System (INCOIS) and other institutional partners.

1. Introduction

In the last decade, about 600 million people have been affected by at least one climate-related disaster of which nearly one-third of the population affected are in South Asia (Germanwatch, 2021). The IPCC in its Sixth Assessment Report released in mid-2021 indicated that the South Asia weather hazard elements are worryingly intensifying - hotter weather with longer and highly variable monsoon seasons, cyclones, storm surge, floods, droughts, heat and cold waves and glacier melt events continuing to pose serious risks. Rapid economic growth, greater capital stocks, rising population and continued urbanization have increased the exposure in South Asia Region (SAR), i.e., more people and assets are exposed to hazard events. To address these increasing climate risks and reduce disasters, actionable hydro-meteorological services are crucial for the region. However, there are several challenges currently being faced by the National Meteorological and Hydrological services (NMHSs) of South Asia that hinder the delivery of hydro-met services. Fragmented modernization efforts that remain financially and technically unsupported beyond project lifetime are one of the main concerns besides the limited regional collaboration.

With the overarching objective to reinforce national activities leading to a more sustainable program of building state-of-the-art meteorological and hydrological services across the region through a structured and staggered approach under the guidance of the Executive Council, SAHF brings together nine countries: Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan, and Sri Lanka. SAHF endeavors to strengthen the key elements of the hydro-meteorological services by leveraging regional collaboration while enhancing national capacities to fully meeting user requirements. Among the most immediate and specific priorities – at a regional level – are the improvement of forecasts of extreme events, both in terms of intensity and lead time anticipation, using ensemble prediction systems, impact-based forecasting, and user-specific advisory services.

To this end, skilled and competent human resources and adequate technology and infrastructure within national hydro-meteorological institutions are the key requisites for delivering effective demand-based services. However, at present the capability among NMHSs in the region varies enormously in terms of infrastructures, workforce and their skills. This gap will widen further as new technologies get operationalized unless focused efforts are implemented to build such capacities. Hence, the needs of NMHSs are vast and varied. However, the need for capacity enhancement is a common need among all SAHF members.

Capacity enhancement is considered as a multi-dimensional attribute that cuts across the other three-thematic areas identified (Numerical Weather Prediction (NWP), Impact Based Forecasting (IBF), Observational Networks (ON)) under SAHF for targeted improvement at individual and institutional levels to provide demand driven user sector services by NMHSs in respect of public safety and socio-economic benefits. Therefore, this working paper is aimed to develop a long-term capacity enhancement framework for operational hydro-met service delivery that brings synergy in efforts of collaborating partner institutions and benefits a wider group of stakeholders across South Asia.

To begin with, the focus will be on enhancing core capacities of NMHSs within each component of the operational service delivery aligned to the generation of actionable information for sector relevant climate and disaster risk management applications. Subsequently, this working paper also cover the capacity enhancement needs of all sector stakeholders connected through a value-added weather and climate information that can be implemented through long term regional collaboration.

2.   Objectives

The envisaged Capacity Enhancement has the following objectives:

ASSESS NMHSs CAPACITY	To assess the existing capacities of NMHSs, map the capacity enhancement needs and prioritize them into immediate term efforts, to be addressed during the current phase of SAHF till December 2022 and other needs to be addressed beyond the current phase of SAHF.
MAP RESOURCES	To map regional and relevant global resources and strengths that will be leveraged in addressing the capacity requirements of NMHSs of the SAHF member countries
BUILD DYNAMIC STRATEGY	To build a dynamic regional strategy for enhancing the operational service delivery capacity of the NMHSs to build demand driven user sector services of the SAHF member countries

3.   Approach and Process

Two main approaches were adopted in the preparation of this working paper: 1) Stocktaking of NMHSs' existing capacities, gaps and needs through consultations and SAHF III; 2) Building appropriate strategies for enhancing existing capacities and needs. Each of the approaches adopted is described below.

As a first step, the Working Groups (WG) for four thematic areas (Numerical Weather Prediction (NWP), Impact Based Forecasting (IBF), Observational Networks (ON), Capacity Enhancement (CE)) of SAHF were established by the SAHF Executive Council in April 2021. The first WG meeting for the thematic area of Capacity Enhancement was conducted during 28-29 June 2021, where preliminary stocktaking of existing capacities and needs of NMHSs was undertaken (see Annex 1 for the meeting report). Following this, individual consultations with WG members of each NMHS of SAHF member countries were carried out to have an in-depth understanding of the status in four thematic areas concerning: existing capacities, available operational systems, gaps in current operational procedures, access to various datasets, challenges faced in sustaining operations, priorities for improvements and availability of human and technical resources (see Annex 2 for the consultation report). Additionally, an online survey was conducted from September to October 2021, which covered not only the WG members but also the staff from the NMHSs working at various levels (see Annex 3 for the survey results). The survey collected information on existing capacities, gaps and needs in the four SAHF thematic areas.

In November 2021, SAHF III brought together the NMHSs of SAHF member countries, regional partners and experts, international partners and experts, and users in the region to: (i) Showcase regional best practices and approaches in the hydro-met and climate services value chain; (ii) Deepen and strengthen the SAHF program, including weather, water, and climate services at the national and regional levels; (iii) Share knowledge about innovations and the socio-economic benefits of the value chain for hydro-met and climate services as countries invest in new technology over the next decade; and (iv) Discuss and agree on the design of future SAHF activities. The forum identified several needs to improve the capacities of SAHF NMHSs in operational services delivery and recognized capacity development as the backbone for improving services. Thus, SAHF III recommended to design and implement a capacity development calendar across all components of the information value chain. The needs identified and recommended during SAHF III were added to the findings from the stocktaking process. The summary of these needs is given in Annex 4.

The training needs assessment report (see Annex 5 for the training need assessment report) and the regional strategy document (see Annex 6 for the regional strategy document) were prepared based on the consultations and survey analysis. The training need assessment report details the training needs expressed by the NMHSs. The regional strategy document identifies needs that can be addressed through concerted regional efforts, while national efforts can be directed towards fulfilling country-specific gaps. The findings from these documents are the main inputs to this capacity enhancement working paper. Further, existing hydro-met assessment reports of the SAHF member countries prepared by the WB and the hydro-met gap report of the Alliance for Hydro-met Development were reviewed to supplement the analysis to design and develop appropriate strategies targeting institutional and individual capacity enhancements.

4. Assessment of Existing Capacities and Needs

From the analysis of training needs, it was found that the training needs of the NMHSs are vast and varied. The various training needs expressed by NMHSs were grouped under different themes of the hydro-meteorological services value chain for training prioritization. Table 1 outlines the assessment of existing capacities of NMHSs under each theme. The "status column" describes the existing status that were mentioned by respective countries during the consultations. The "SAHF Capacity Enhancement Focus column" describes the actions needed to address the existing gaps. This assessment leads to the development of a training strategy including the identification of modules for each theme.

Table 1: Assessment of existing capacities and training needs of SHAF NMHSs

Theme	Status	SAHF Capacity Enhancement Focus
Observational Networks	Capacities exist within all NMHSs to operate and maintain conventional observational networks (meteorological and hydrological) and ongoing efforts by development partners continue to enhance these. However, there is a need to strengthen capacities to design, implement and maintain an effective monitoring and detection networks for extreme hydro-meteorological events and specific sectorial applications to strengthen the service delivery value chain. Also, many countries need capacity enhancement particularly to enable accessing and utilization of satellite and RADAR products for severe weather detection and monitoring as capacities exist only in few of them.	To enhance competencies by incorporating user-specific service delivery perspective to design, build and operate national observational networks by leveraging regional and global resources such satellite and RADAR products. To enhance capacities to identify and fill critical observational gaps that contribute to better initial conditions, verification, calibration, and statistical post-processing in global, regional, and national operational NWP systems, particularly with a purpose of enhancing their capabilities to capture extreme weather/climate events.

Theme	Status	SAHF Capacity Enhancement Focus
Numerical Weather Prediction	Except for Afghanistan, the rest of the NMHSs of SAHF member countries are running WRF but not at a level of granularity to fully capture local scale extreme weather variability. However, there is a varying capacity to inject real time data for runs and fully use the model output. There is a need to enhance the capacity in NWP, particularly in understanding the basic physics of limited area modelling, interpretation, and use of model output for forecasting extreme weather events and assimilation of local data.	To build competencies to use NWP products to generate ensemble and probabilistic forecasts that can better cater to risk management and deliver sector-specific actionable forecasts at the national level by leveraging regional and global resources such as use of regional and global NWP including remote sensing products.
Data Management & Analysis	While most countries have the capacity in data management and analysis, countries like Afghanistan, Bhutan, Maldives, and Myanmar still do not have Climate Data Management Systems (CDMS) and capacity to manage the data as per the required standards. There is a need to enhance the capacity in data processing, quality control and management.	To build competencies for operational shift (24/7 roster duty) through: • Support for local data processing (quality control, homogeneity test & analysis) for, inter alia, generating all needed severe weather advisory products • Merging digital impact data and analytics to identify triggers for severe weather development • Generating metrics that influence decisions for action • Support for tailored hydro-met information to meet user needs • Identify and capture all characteristics of severe weather development through designing all needed tools for descriptive, predictive, and prescriptive analytics.
IT Competencies	Capacity varies among the NMHSs in terms of ICT. While NMHSs like IMD and PMD have significant capacities, there is still the need to strengthen the IT knowledge and skills to run models and programming skills to analyze model data. IT skills are limited in all NMHSs to design, implement and maintain decision support systems for sector specific operational service delivery.	To build competencies in ICT to use emerging technologies along with all needed skills for managing networking, web-services and computing systems and infrastructures in the development and delivery of user-specific weather and climate services by leveraging regional and global resources.
Impact Based Forecasting (IBF)	While India, Myanmar, Nepal, Bangladesh, and Pakistan have started IBF, there is little capacity in most NMHSs in the region, despite a great need for actionable warnings. As the process of evolving robust IBF systems is rooted in co-development, there is a need for	To build competencies of both NMHSs and user sector institutions in design and development of comprehensive IBF tools through interfacing specific impact and vulnerability data sets to minimize impacts of extreme weather and

Theme	Status	SAHF Capacity Enhancement Focus
	mainstreaming this approach. Most NMHSs have limited and a top-down approach to IBF that needs to be reoriented through systematic capacity enhancement to achieve effective value creation for hydro-meteorological services.	climate events. Also, leverage regional and global resources to build IBF capacity in the region.
Marine and Coastal Meteorology and Services	Besides India, in many of the SAHF coastal member countries, capacity in marine and coastal meteorology is limited to very limited. There is a need to build the capacity in marine forecasting and monitoring of sea-state and coastal extreme conditions.	To build competencies in delivering user-specific marine meteorological, ocean state and coastal hazard services to minimize impacts to islands and coastal zones including coastal zone protection with decision support systems considering human dimensions of vulnerability and exposure.
Mountain Weather and Climate Services	Limited capacity exists for Bhutan and Nepal in mountain weather and climate. There is a need to build capacity in mountain weather and climate to detect, monitor and forecast extreme hydro-meteorological hazards in the mountain regions. Monitoring glaciers, glacial lakes, glacial-mass balance dynamics and forecasting for avalanches and extreme mountain weather are key gaps in capacities of NMHSs with significant mountain area responsibilities.	To build competencies in delivering reliable extreme weather and climate services in the mountain regions involving hydrological-geological hazard services by leveraging regional and global resources.
Hydrological Services	Although capacities exist with all NMHSs to run basic hydrological models, there is a need to build capacity in flash flood forecasting, riverine floods, and urban flooding.	To build competencies to use state of the art hydrological models and data to provide reliable and timely basin scale flood forecasting and mountain valley scale flash floods to users to minimize flood-related impacts by leveraging regional and global resources.
Agrometeorological Services	Although capacities exist in catering basic agrometeorological services in many of the NMHSs, there is a need to strengthen the capacity in agrometeorology to provide reliable and timely services to the agriculture sector to minimize the impact of hydro-met induced disasters.	To build competencies in delivering state of the art agrometeorological services with appropriate crop specific decision support tools to the agriculture sector by leveraging regional and global resources.

5. Training Strategy

As many parallel initiatives are going on, even within the World Bank Group supported initiatives, one of the main challenges for SAHF Capacity Enhancement effort is to provide a framework that can enable contribution from various partners and make the best use of existing regional training infrastructure in IMD, PMD and ITCO Ocean and global partners like WMO, UKMO through ARRCC and COMET while staying on course to strengthen the value-chain through strategic gap-filling and orientation. In this Working Paper, we have taken this approach to provide a scalable regional capacity enhancement framework that can accommodate ongoing, additional, and evolving future requirements at all levels of the hydro-meteorological institutional environment. The capacity enhancement is targeted at three levels, that are: Basic (B), Mid (M) and Expert (E). The Basic(B) training are targeted to the recruits, operational hydrology and meteorology technical officers and technicians. The Mid (M) level training is targeted to mid-level professionals like meteorologists, hydrologists, engineers and forecasting technicians. The Expert (E) level training is targeted to senior management officers and specialists.

A training matrix to summarize all training requirements for NMHSs in South Asia is presented in Table 2. The training matrix forms the main training framework that considers the hydro-met services value chain in the verticals and training required in the horizontals. The matrix developed is open-ended as it allows any number of columns and rows to be added to suit the changing needs of NMHSs and their users. Thus, this is a scalable regional capacity enhancement framework that can accommodate ongoing, additional, and evolving future requirements at all levels of the hydro-meteorological institutional environment.

Table 2: Training matrix showing training requirements for NMHSs of SAHF member countries

[Designed to be an open-ended and live framework that will be filled-up based on evolving training needs of stakeholders of the Hydromet services delivery value-chain]

	Observational Networks (OBS)	Data Management & analysis (DM)	IT competencies (IT)	Numerical weather prediction (NWP)	Management, including procurement procedures etc. (QM)	Agromet (AG)	Road & Rail Transport/Aviation (AV)	Hydrological applications (HY)	Marine and coastal applications (MAR)	Mountain Weather & Climate (MT)	Impact based forecasting (IBF)
1.	Observation networks to support IBF (B-OBS-1)	Basic Climate Data Base Management (B-DM-1)	Operational systems for running limited area weather and climate	NWP products to support IBF(B-NWP-1)	Introduction to public procurement systems (B-QM-1)	Basic agrometeorology (B-AG-1)	Introduction to aviation meteorology and airport observation	Introduction to hydrologic science (B-HY-1)	Introduction to marine observation and forecastin	Introduction to mountain weather forecasting (B-MT-1)	Basics of IBF (B-IBF-1)

	Observational Networks (OBS)	Data Management & analysis (DM)	IT competencies (IT)	Numerical weather prediction (NWP)	Management, including procurement procedures etc. (QM)	Agromet (AG)	Road & Rail Transport/Aviation (AV)	Hydrological applications (HY)	Marine and coastal applications (MAR)	Mountain Weather & Climate (MT)	Impact based forecasting (IBF)
			models (B-IT-1)				systems (B-AV-1)		g (B-MAR-1)		
2.	Regional and global observational data to support better forecasts and services (B-OBS-2)	Advance Climate Data management and analysis (M-DM-2)	Introduction to Python for met applications (B-IT-2)	Basics of Dynamic Meteorology and NWP (B-NWP-2)	Basic elements of management in Climate Science (M-QM-2)	Weather and climate impacts on cereal crops (B-AG-2)	Introduction to aviation met forecasting (B-AV-2)	Hydrological forecasting (M-HY-2)	Cyclone and storm surge forecast for IBF (M-MAR-2)	Glacier studies and remote sensing (M-MT-2)	**Evaluating and assessing risk (M-IBF-2)**
3.	Upgradation and maintenance to sustain observational networks for monitoring extreme weather/climate events (B-OBS-3)	Statistics in Climate Science (M-MD-3)	DSSs for integrating and generating IBF (M-IT-3)	**Postprocessing and interpretation of NWP products to support extreme weather warnings and IBF (M-NWP-3)**	Procurement strategy development (M-QM-3)	Co-production for agromet advisories (M-AG-3)	Specialized aviation met forecasting (M-AV-3)	Urban flooding (M-HY-3)		Advances in monitoring and early warning of GLOFs (M-MT-3)	Derived indices for health sector impacts (M-IBF-3)
4.	Ocean observation systems (B-OBS-4)	Real time data processing and analysis (M-DM- 4)	Linux and GrADS programming for analysis and visualization (M-IT-4)	**Ensemble and probabilistic forecasts to support IBF (M-NWP-4)**	Exploring opportunities for Public-private partnerships to further	**Application of sub-seasonal and seasonal forecast for agriculture (M-AG-4)**	Developing weather advisories for Road Transport (M-AV-4)	Flood hazard mapping (M-HY-4)		Snow and glacier monitoring (M-MT-4)	Tailored products for the Energy sector including renewable

	Observational Networks (OBS)	Data Management & analysis (DM)	IT competencies (IT)	Numerical weather prediction (NWP)	Management, including procurement procedures etc. (QM)	Agromet (AG)	Road & Rail Transport/Aviation (AV)	Hydrological applications (HY)	Marine and coastal applications (MAR)	Mountain Weather & Climate (MT)	Impact based forecasting (IBF)
					modernization plans (E-QM-4)						energy resources (M-IBF-4)
5.	Basic Agromet Observation systems (B-OBS-5)	**Data Policy/Regional Knowledge Platform (E-DM-5)**	Integrating remote sensing data and RADAR data for generating IBF (M-IT-5)	Specialized indices to support extreme weather warnings and IBF services (M-NWP-5)	Change management (E-QM-5)	Agro DSSs available for effective decision making (E-AG-5)	Weather and climate change implications on surface transport (E-AV-5)				Socio-economic benefits of hydro-met services (E-IBF-5)
6.	WMO GBON protocols (M-OBS-6)			NWP products for Tropical Cyclone early warning and impacts (M-NWP-6)			Aeronautical requirements for meteorological services (E-AV-6)				
7.	Recent advances in observational systems to support nowcasting (M-OBS-7)			Extreme temperature forecast for forest fires (M-NWP-7)							
8.	Observational let works for air quality monitoring (M-OBS-8)			Specialized NWP products for fog forecasting (M-NWP-8)							

	Observational Networks (OBS)	Data Management & analysis (DM)	IT competencies (IT)	Numerical weather prediction (NWP)	Management, including procurement procedures etc. (QM)	Agromet (AG)	Road & Rail Transport/Aviation (AV)	Hydrological applications (HY)	Marine and coastal applications (MAR)	Mountain Weather & Climate (MT)	Impact based forecasting (IBF)
9.	Exploring strategies for regional cooperation (E-OBS-9)										
10.	Regional cooperation for better monitoring products for extreme weather (E-OBS-10)										

** Training module codes - B-Basic level, M-Mid-management level, E-Experts/senior management, next is the subject code as indicated in the title row and last hyphenated number is grid locator.

** **Blue Highlighted(bold)** training module identified to be conducted by RIMES within the current phase of SAHF

** **Green Highlighted(bold)** training module to be conducted in collaboration with ARRCC project in April 2022

** Purple Highlighted are training modules to be proposed under regional training institutes of IMD and PMD

It is vital for SAHF that in addition to its resources, a strategy is developed that effectively leverages the available and relevant regional and global resources. Leveraging the regional and global resources complements the SAHF in addressing critical gaps. For instance, the RIMES in collaboration with ARRCC Program has already planned to conduct the training on "Application of sub-seasonal and seasonal forecast for agriculture (M-AG-4)" in April 2022. To this end, a clear role of SAHF, regional and relevant global partners is drawn to facilitate the collaboration and leverage the available resources as outlined in Table 3.

Table 3: Resources allocation for prioritized training courses

Course Type	Probable Resources	Specific Roles
Pre- training		
Pre-courses (e.g., NWP, IBF, observation, weather forecasting, hydrology, etc.)	COMET, WMO Global Campus and RTCs	• RIMES/SAHF requests and facilitates the training • COMET/WMO/RTCs provide access and guidance to training materials
Basic education and training (Tier 1)		
For forecasting staff (NWP)	RTCs Pakistan and India	• RIMES/SAHF requests and facilitates the training • RTCs IMD/PMD plan and implement the training
For technical staff (Observations)	RTCs Pakistan and India	• RIMES/SAHF requests and facilitates the training • RTCs IMD/PMD plan and implement the training
For IT and Network systems	RTCs Pakistan and India	• RIMES/SAHF requests and facilitates the training • RTCs IMD/PMD plan and implement the training
Marine and Coastal warning service	ITCO-Ocean, INCOIS, India	• RIMES/SAHF requests and facilitates the training • INCOIS plans and implements the training
Mid-level (Tier 2)		
Refresher courses for extreme weather events	Experienced researchers and academicians	• RIMES in consultation with WG members /NMHSs will plan and assist in implementation

Aviation Met Service Professionals at Airports: Meteorological Telecommunication and METCAP + Software	Regional partners- RTC, IMD/UKMET Office	• RIMES/SAHF requests and facilitates the training • Regional partner involved will plan and implement the training
IBF in Agriculture	SAHF-RIMES	• RIMES under SAHF will plan and implement the training with 2022
IBF in DRR	SAHF-RIMES	• RIMES under SAHF will plan and implement the training with 2022

6. Priority Training to be Implemented within Current SAHF Phase

As indicated in earlier sections, the training needs of the NMHSs are vast and varied with a large population to be trained. Hence, it is evident that it is neither practical nor feasible to meet all the training needs of NMHSs within the current SAHF phase. A common training requirement for the NMHSs was prioritized to be implemented under SAHF, by regional training institutes and other ongoing projects in the SA region. While timeline and resources were confirmed for the training modules identified under SAHF and ARRCC program, training modules identified under regional training institutes are still proposals and require consultations with the RTCs. Training plans will have to be developed based on the outcome of the consultations with RTCs. Table 4 outlines the prioritized training to be conducted by RIMES within the current SAHF phase and through ongoing projects and partners.

Table 4: Trainings prioritized under SAHF and through ongoing regional cooperation

Title	Training Code	Timeline	Probable Resource	Status
Training to be implementation in collaboration with ARRC project				
Regional Training on Seasonal Prediction to Operational Services in South Asia	M-AG-4	April 2022	ARRCC	Completed
Training to be implemented by RIMES under SAHF				
Basics of IBF	B-IBF-1	July/Aug 2022	SAHF	Resources available and training proposed in January
IBF for DRR and Agriculture	M-NWP-3/M-NWP-4/ M-IBF-2	Sept/Oct 2022	SAHF	Resources available and training proposed in February
Data policies / Regional Knowledge Hub Orientation	E-DM-4	Oct/Nov 2022	SAHF	Training dates proposed (Dec 2022-Feb 2023)

7. Training Implementation Plan

A two-step process will be involved to roll out the training program. A preparatory phase and rollout of the training program. Table 5 outlines the sequence of activities leading towards the roll out of the training program.

Table 5: Sequence of activities for training implementation in the year 2022 and year 2023

Deliverables & Activities during Nov 2022 – March 2021	2022(Y2)		2023(Y3)		
	Nov	Dec	Jan	Feb	Mar
1. Implementation of IBF (Basic and Mid-level) Trainings					
1.1 Formalise contract for external consultants to develop training modules	▓				
1.2 Consultations with Bank experts to discuss training format and training modules	▓				
1.3 Liaise with NMHSs, seek nominations, and arrange training logistics		▓			
1.4 Implement virtual training- preparatory training for IBF			▓		
1.5 Implement training for Basic Level IBF			▓	▓	
1.6 Implement training for Mid-Level IBF (DRR & Agriculture focus)				▓	▓
1.7 Training evaluation and reporting					▓
2. SAHF Knowledge Hub (SKhub) Orientation Training					
2.1 SKhub Orientation (virtual)- for operational forecasters		▓	▓		
2.2 SKhub Orientation (virtual)- for senior and mid-level professionals of NMHS (virtual/ physical depending on time &resources)		▓	▓	▓	
2.3 Reporting on SKhub orientation				▓	

Annex I SAHF Training modules – a framework

This section provides a broad framework and a standardized structure for the training modules to be evolved under SAHF. Subject area experts with background and experience in training operational NMHS staff will be identified to work in close collaboration with the RIMES SAHF team to develop the training modules. RIMES shall make sure that all the WG Members are consulted, and their views and suggestions incorporated in the final draft.

Experts to be involved to develop the modules are expected to be experienced in such work, so the time taken for developing the training modules will be short, up to 45 days.

Example -

Title: [*Ensemble and probabilistic forecasts to support IBF (M-NWP-3)]*

Target groups: [*mid-level forecasters*] – also provide additional guidance on who could potentially be nominated.

Prerequisites: *[basic statistics, basic NWP*] – background that is essential to assimilate the training topics, try to keep it to the bare minimum, to ensure interest and uniformity among the participants.

Mode of training and duration: Typically, about **3-weeks** cumulative engagement – one-week online pre-training preparation through online classes (2 hours) and practice/familiarization exercises (6 hrs.). This is only an indicative framework, and actual modules will be customized to make them effective, interesting, experiential and tuned to operational demands.

In case of Mid and Expert level modules, efforts will be made to impart the trainings at a ToT level so that these more experienced officers could train their NMHSs staff in-turn. The availability of training materials and tools facilitated by the SAHF Knowledge Hub, this can easily be leveraged to sustain in-country capacities, both within NMHSs and key application sectors in interdisciplinary topics such as IBF.

[During the one-week pre-training, which will be online, efforts will be made to use resources available from COMET, UK Met Office online material, WMO and other global/regional resources and tools.]

5-days – in-person training course at a suitable venue to be decided.

Expected to be a mix of interactive talks and practical exercises, to be held at a venue within the region or RIMES office in Bangkok

One-week post-training follow-up exercise – 10 hrs. total duration – this may include sharing of the course with other officers in the NMHSs to build awareness and further interest.

Expected to consist of follow-up "practical case studies" to encourage in-country contextual application of the knowledge gained during the training process. In addition, there could be experience sharing session with other interested staff within NMHSs and concerned sector level user agencies, as appropriate. In all such follow-up training activities, support from SAHF team from the RIMES, WBG and other collaborating partners will be available or leveraged. Online tools available from ECMWF, Copernicus Centre and other such resources will be also used as required.

- *Evaluation & Certification: [under consideration] this is for awarding academically recognized certificates with appropriate evaluation procedures.*

- *Indicators for baseline and progress in capacity enhancement [to be refined by experts designing training modules – likely to include parameters like % staff competent in a particular subject area, numbers trained, enhanced numbers of products and improvements, user sectors covered through "value addition and service delivery," feedback survey from key sector stakeholders etc.]*

Annex II WG Meeting Report

Overview

The meeting of the Working Group (WG) IV- Capacity Enhancement (CB) was held online on 29 June 2021, from 3:00 to 4:30 PM Bangkok time (UTC+7). The agenda and list of participants are provided in Appendix-1 and Appendix-2. The meeting has the following objectives:

- To understand and carry out an initial assessment of country-wise existing capacities, gaps and priority requirements for capacity enhancement
- To appoint Co-Chairs of WG
- To acquaint WG members on the requirements of WG

Opening session

On behalf of RIMES and the World Bank, Mr. Tshencho Dorji, Project Officer, RIMES and chair of the session opened the session of the first meeting of Working Group IV-Capacity Enhancement at 3:00 pm Bangkok time (UTC+7) on Tuesday, 29 June 2021. He welcomed the members of the working group and other participants to the meeting. Dr. K. J. Ramesh, Senior Advisor, RIMES welcomed the participants on behalf of the Director, RIMES and he thanked the members of the working group for showing enthusiasm in this regional endeavors. He emphasized on the importance of building strategies to bring all NMHSs in the SA region in par with international standards. He highlighted the need to enhance operational service delivery capacity through skill building and assessment of training needs in the face of increasing extreme weather events in the region.

Introduction of participants

Mr. Tshencho Dorji moderated the introduction of participants. He highlighted the importance of continued communication and interaction within the WG members to know each other well and taking the work of the WG forward.

Appointment of Co-Chairs

To lead the WG and liaise with the project team of RIMES, the need for co-chairs of the WG was noted. The delegates from the NMHSs of the SAHF partner countries and members to this WG elected the following delegates as the co-chairs for the WG IV- Capacity Enhancement.

Mr. S.M. Quamrul Hassan, Meteorologist, Bangladesh Meteorological Department, Bangladesh (Co-Chair)

Dr. Somnath Dutta, Scientist E, CRS Pune, Meteorological Training Institute, India (Co-Chair)

Presentation by each WG member

The members of the working group presented their reflections on the TOR of the WG, and the existing capacities, gaps and priorities needs of their countries in capacity building. The summary of priority requirements of capacity enhancement in South Asia (SA) are highlighted below:

- Need for short term and long-term training in the SAHF thematic areas
- Trainings/workshops on aviation nowcasting, techniques and its operations, NWP, validation and verification-, short- and long-range forecasts, instrumentation and sensor calibration.
- Introductory trainings on IB.
- Short courses on concepts, and application of glacio-hydrological modelling and snow hydrology.
- Training and refresher programs to existing staff to get new competency standards as per the WMO requirement.

- Requirement of long-term capacity building in terms of graduate and master programme exclusively in meteorology and hydrology.
- Requirement of systematic capacity assessment in the NMHSs in SA region.

A summary of country-wise priority requirements is tabulated below. More information on country-wise requirements is provided in their respective presentations provided in Appendix-3.

Table 6: Summary of country-wise priority requirements for CE

Country	Priority requirement for CE
Afghanistan	Basic and advanced training in respect of weather and climate forecasting, observations, NWP (short/medium/extended/long range products), Aviation, Drought Monitoring, IT & GIS, Flash Flood Guidance System, Synoptic and Diagnostic assessments, Dust storm/Sandstorm warning, O & M issues of AWS and Manual OBNs for NMHS staffs
Bangladesh	Ensemble Model forecast products interpretation and model guidance with bias correction and verification tools IBF Applications focusing on Fog/Lightening/landslides forecasting DWR data interpretation & integration for nowcast services Training on O & M issues of AWS and Manual Observing Station with calibration Expansion of ocean state forecasting involving wave and storm surge models
Bhutan	Long term and short-term training in areas like aviation, nowcasting, short/medium/long range forecasting, snow hydrology, glacio-hydrological modeling and IBF Long term capacity building in terms of graduate and post graduate courses Training on O & M issues of AWS/Manual Observing Station, RS/RW, DWRs with calibration Building service support for QMS certification; Finance & HR; Procurement; Electronics & Instrumentation
India	Offered to build support for SAHF countries on Human capacity building and service delivery Coordination and systematic training needs analysis As WMO Regional Training Centre (RTC), IMD is already conducting, has designed and floated training modules in WMO's Global Campus. Willing to support development of customized modules in collaboration with RIMES and NMHSs for capacity requirements under SAHF to support operational forecasting and service delivery. Opportunity for tapping training facilities of Space Applications Centre, Ahmedabad for satellite data utilization and Indian Institute of Remote Sensing, Dehradun for Remote Sensing & GIS
Maldives	Improving in-service competency Training and refresher programme for existing NMHS staffs BIP-MT needed Training on O & M issues of AWS/Manual Observing Station, RS/RW, DWRs with calibration
Myanmar	Advanced computing facilities- server type high computing facilities Utilization of software to support the weather forecast and seasonal weather forecast Capacity building of human resource in weather forecasting, radar, satellite data utilization, GIS & Remote Sensing; systematic approach to IBF Monitoring, Detection and nowcast services through AWS, Satellite, DWR and Short range WRF model Wave forecasting, Ocean state Forecasting, storm surge model Forecast product utilization through bias correction and verification tools Thresholds for extreme weather prediction - SINCLIM; NEX NASA; Climate Change scenario analysis Data exchange system

	Training on O & M issues of AWS/Manual Observing Station, RS/RW, DWRs with calibration
Nepal	Developing SOP and threshold for monitoring extreme events Capacity assessment and capacity building in terms of technical, infrastructure and human resource Automation of Climate Information analysis and Sector specific climate services SOPs and thresholds for climate extremes Seasonal and sub-seasonal climate forecasting Drivers and scenarios of climate variability and climate change Nowcast and Short-range forecasting; Aviation services; services for tourism and transport sectors; Medium range forecast services for Agriculture Advisory services Forecast products utilization with bias correction & verification tools Approach for IBF and Hazard Mapping DWR data processing and analysis for utilization in NWP Training on O & M issues of AWS/Manual Observing Station, RS/RW, DWRs with calibration
Pakistan	Develop capacity building of operational NWP services (weather observing and weather forecasting) IBF capacity development and implementation of high-resolution weather forecast model required at national level and at 5-regional centers Flood routing models
Sri Lanka	Training of NMHS personnel on satellite meteorology, agro meteorology, short range and ensemble forecast products seasonal and sub-seasonal forecasting and marine meteorology and ocean state forecasting services; Forecast product utilization tools of bias correction and verification. IBF and modern forecasting services Availability of exclusive degree courses on meteorology available in the country Improving competency of existing DoM staffs in areas of radar installation, ICT, aviation, instrument repair and calibration

Possible supports from RTC, IMD and RTC, PDM

- RTC, IMD as a WMO Regional Training Centre (RTC), IMD is already conducting, has designed and floated training modules in WMO's Global Campus. RTC, IMD is willing to support development of customized modules in collaboration with RIMES and NMHSs for capacity requirements. IMD offered to provide support for SAHF countries on the following:
- Human capacity building and service delivery.
- Coordination and systematic training needs analysis.
- Opportunity for tapping training facilities of Space Applications Centre, Ahmedabad for satellite data utilization and Indian Institute of Remote Sensing, Dehradun for Remote Sensing & GIS.
- RTC, PMD offered to provide support for SAHF countries on the following:
- BIP-MT training needs of the region under SAHF.
- Design and conduct primary/middle level training and special courses for in-service personnel of NMHSs of the region.
- Competency assessment system development for the region.

Discussion and way forward

Dr. Ramesh, RIMES moderated the discussion session. Following recommendations ensued from discussions for taking the work forward.

- It is essential to generate sector and location specific weather/climate products with improved lead time.
- Basic needs like common requirements and refresher trainings to be identified.
- SAHF registry for training requirements of all NHMSs in SA region to be considered.
- Competency assessment system of all forecasting professionals in the region to understand the level of existing capacity is required.
- Requirements with relation to human resource and procurements to be addressed.
- Capacity building in terms of IT support in NMHSs and service level competency at forecasting level in SA region to be prioritized.

Appendix-1: Agenda

SAHF Working Group Meetings, Online session, 28-29 June 2021

DRAFT Agenda

Program	Time (minutes)
Remarks (Moderator)	5
Introduction	5
Appointment of Chair and Co-chair of the Working Group	10
Presentation by each WG member (5 minutes each) *Reflections on WG TOR* *Priority needs of each country based on respective Thematic Areas*	45
Discussion and way forward	25

Schedule

Monday, 28 June 2021	
1:00 pm-2:30 pm (Bangkok Time)	Working Group 1- Impact Based Forecasting
3:00pm-4:30 pm (Bangkok Time)	Working Group 2- Numerical Weather Prediction
Tuesday, 29 June 2021	
1:00 pm-2:30 pm (Bangkok Time)	Working Group 3- Observational Networks
3:00pm-4:30 pm (Bangkok Time)	Working Group 4- Capacity Building

Appendix-2: Participants List

WG-4	Mr. Khayberr	Afghanistan	khayber_rahmanie@yahoo.com
	Mr. S. M. Quamrul Hassan	Bangladesh	smquamrul77@yahoo.com
	Ms. Ugyen Tshomo	Bhutan	utshomo@nchm.gov.bt
	Dr. Somenath Dutta	India	dutta.drsomenath@gmail.com
	Ms Shaheema Ibrahim	Maldives	shaheema.ibrahim@met.gov.mv
	Ms. Han Swe	Myanmar	hanswedmh@gmail.com
	Mr. Shiva Nepal	Nepal	shivaamet@gmail.com
	Mr. Sarfaraz	Pakistan	sarfarazmet@hotmail.com
RIMES Team	Dr. G. Srinivasan		srini@rimes.int
	Dr. K.J. Ramesh		kjramesh2607@gmail.com
	Dr. Anshul Agarwal		anshul@rimes.int
	Dr. Itesh Dash		itesh@rimes.int
	Mr. Tshencho Dorji		tshencho@rimes.int
	Ms. Kousalya V Kumar		kousalya@rimes.int
Other Representatives	Mr. Nasim Muradi	Afghanistan	Nasim.muradi786@gmail.com

Annex III Country Consultations

Background

South Asia Hydromet Forum (SAHF) is constituted with the vision to strengthen the key elements of the hydro meteorological services at national and regional scale. The forums are dedicated towards evolving collaborative regional strategies to increase the use of ensemble predictions, impact-based forecasting systems and user oriented advisory services. Capacity enhancement shall align to these requirements by adopting a demand and context driven approach that leverages regional actions while meeting the differential needs of the various NMHSs.

It is a unique institutional mechanism involving shared vision, participatory process, openness to innovation, open data sharing and engagement with research institutes and communities for innovation. SAHF is envisioned to be a demonstrable institutional mechanism of the WMO's Hydromet value chain and a best practice to replicate in all other regions globally.

An overarching objective of the SAHF is to reinforce national activities leading to a more sustainable program of development of meteorological and hydrological services throughout the region. An important aspect of the forum is "learning from each other"; which involves developing solutions to the meteorological and hydrological challenges that are unique to the region. SAHF aims to leverage hydromet capacities within the region to strengthen each other through collaborative regional strategies. SAHF also aims to identify specific fit-for-purpose investments to build technical and intellectual capacity of NMHSs in South Asia to respond to the main users' needs using skills that exist in the region and globally.

Process and Preparation of Consultation

With the overarching objectives and purpose SAHF in place, meetings of the Working Groups (WG) in the four thematic areas were conducted during 28-29 June 2021 from all nine South Asian countries to familiarize WG members with SAHF process, seek initial understanding of each NMHSs' capacities and needs. This consultation with WG members of each NMHS of SAHF countries was carried out to get in-depth understanding of the status in four thematic areas with respect to: existing capacities, available operational systems, current operational procedures, access to various datasets, challenges faced in operations, priorities for improvements and human and availability of technical resources. Also, this consultation aimed to identify the strengths of individual NMHSs which could be

a resource for the region.

The consultation meetings were scheduled as shown in Table 7.

Table 7 Schedule for consultation meeting with WG members of SAHF countries

Date	Time (Bangkok Time: UTC+7hrs)	Country
10 August 2021	11:00 am- 1:00 pm	Bhutan
	3:00 pm -5:00 pm	Afghanistan
11 August 2021	11:00 am- 1:00 pm	Maldives
	3:00 pm -5:00 pm	Bangladesh
13 August 2021	3:00 pm -5:00 pm	Myanmar
16 August 2021	3:00 pm -5:00 pm	Pakistan
18 August 2021	11:00 am- 1:00 pm	India
19 August 2021	3:00 pm -5:00 pm	Nepal
20 August 2021	11:30 am -1:30 pm	Sri Lanka

The consultation meeting was coordinated and led by the RIMES and the World Bank team involved in SAHF implementation (Table 8). The consultation meeting was attended by the WG members of SAHF four thematic areas from the SAHF member countries.

Table 8 Composition of RIMES and World Bank for the consultation meetings

RIMES	Dr. G Srinivasan, Team leader Dr. K.J. Ramesh, Sr. Advisor Dr. Anshul Agarwal, Technical Expert Dr. Itesh Dash, Technical Expert Mr. Tshencho Dorji, Technical Expert Ms. Kousalya V Kumar, Program Coordinator
World Bank	Ms. Dechen Tshering, WB Expert

Summary of Consultation

The following sections provide a summary of discussions with individual SAHF countries.

Afghanistan

The consultation meeting with Afghanistan Meteorological Department (AMD) was held on 10 August 2021 between03:30 pm -05:00 pm (Bangkok time: UTC+7hrs). Following WG members of SAHF WG from Afghanistan Meteorological Department attended the meeting:

- Mr. Nasim Muradi
- Mrs. Tahmina Askari
- Mrs. Kubra Mahmoodi

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Table 9 Outlines the highlights of the discussion with Afghanistan

Impact Based Forecasting	**Existing Capacities** Flash Flood Warning provided through AMD website Warnings issued before 24 hours through media platforms like Facebook and WhatsApp 3-day weather forecast issued in AMD website
	Gaps and Needs GEFS forecasts not skillful over Afghanistan FFGS warnings not consistent, reported to have some uncovered areas where flood events were reported during 2021 monsoon season (JJA) No Media Center or broadcasting of weather information on television High altitude areas need to be focused on as they experience heavy snowfalls and avalanches
Numerical Weather Prediction	**Existing Capacities** 3 days forecast through AMD website in 3 languages Aviation Briefing Department Upper Air Station-1(Kabul Airport) METCAP+ connected to GFS model
	Gaps and Needs High resolution modelling MME and High-Resolution models required. GFS resolution is weak No operational WRF/LAM models being run at AMD
Observational Networks	**Existing Capacities** 25 synoptic stations (6 stations connected in GTS); 6 AWS stations Observations are shared between stakeholder on request Work on data sharing policy ongoing Weather stations in high elevation

	Gaps and Needs Generation of TAF reports and other aviation met forecasts Lack of stations in all provinces Other agencies and govt departments may have observational networks that need to be assessed, mapped and included in a future strategy for observational networks.	
Capacity Building	**Existing Capacities** Online Trainings	
	Gaps and Needs **Trainings in** Synoptic Division Basic synoptic training to carry out interpretations Communication Systems	

Others Matters

Online trainings are hardly possible because of limited resources a laptops/computers and poor internet connectivity. In addition, current civil the ongoing situation makes the situation worst for attending online trainings.

Prefer to receive face to face trainings at regional training center in India or other similar venues.

Bangladesh

The consultation meeting with Bangladesh Meteorological Department (BMD) was held on 11 August 2021 between 03:00 pm -05:00 pm (Bangkok time: UTC+7hrs). Following WG members of SAHF WG from BMD attended the meeting.

- Dr. Muhammad Abul Kalam Mallik
- Dr. Md. Abdul Mannan
- Mr. Md. Abdul Matin
- Mr. S. M. Quamrul Hassan

Table 10 Outlines the highlights of the discussion with Bangladesh

Impact Based Forecasting	**Existing Capacities** Thunderstorm, Cyclonic Storm, Storm Surge and Fog Forecasting Access to risk information as static data Heat Wave Forecast Pilot IBF project on Fog being conducted under ARRCC Work Package
	Gaps and Needs Event wise assessment of impact Lack of impact data Assessment of IBF Improve forecast accuracy Linking risk information with early warning and forecasting Access to risk information as meta data Increase lead time

	Listing of different indicators for vulnerability, exposure, examples of how the data intensive IBF process can be simplified using satellite-based analysis, gridded regional, global data. [This may help scaling up pilot initiatives]
Numerical Weather Prediction	**Existing Capacities** WRF model GFS Model JMA Model [Storm Surge]
	Gaps and Needs Advanced Storm Surge Model Test run for boundary forcing Probabilistic forecasts Institutional bias correction of models
Observational Networks	**Existing Capacities** 57 synoptic observations 5 RADAR system [conditions not good; 2 RADARS non-functional, 3 partially functioning, JAICA replacing 2 RADARS] AWS/AWLS [Lack of maintenance and communication concerns] Rain Gauge 8 lighting sensors Satellite data reception – HIMAWARI-CMA FY and KMA Under World Bank projects – 35 AWS, 65 Agromet stations and 125 automatic rain gauges being added
	Gaps and Needs Lack of manpower in synoptic stations Satellite observation system [to be received from JMA] Common lighting observation system BMD has been conducting induction trainings at both senior and Class 2 levels. For the last 2-3 years such trainings have not been conducted as no new recruitments are being done at BMD.
Capacity Building	**Existing Capacities** New Recruits: WMO affiliated 1 year training [Administrative problems in new recruitment] All staff has basic knowledge in Linux operating system Refresher courses [Not conducted for past 5 years] WB Supported Project-Trainings in Marine meteorology, climatology, disaster management and ICT In house trainings IMD training in association with UK Met Office

Other Matters

- Frequent trainings are necessary to keep update of evolving science in weather and climate.
- Integration of all RADARs in South Asia under one system is required

Bhutan

The consultation meeting with National Center for Hydrology and Meteorology (NCHM) was held on 10 August 2021 between 11:00 am -01:00 pm (Bangkok time: UTC+7hrs). Following WG members of SAHF WG from NCHM attended the meeting.

- Mr. Saroj Acharya
- Ms. Monju Subba
- Mr. Jangchup Choephyel Dorji
- Ms. Ugyen Tshomo

Table 11 Outlines the highlights of the discussion with Bhutan

Impact Based Forecasting	**Existing Capacities** IBF system not operational. Still in pilot phase (details required to be furnished) [IBF system- not sector specific. Covers air culture, roads, and transport services.] Dissemination of alerts through website, email, social media platforms Regular monitoring of glacier lakes (15) Water level monitoring in river basins Drought Monitoring Platform [Not Operational] ICIMOD Flash Flood Guidance system (SAFFG)
	Gaps and Needs Lack of knowledge about IBF Stakeholders' coordination Data on impacts and vulnerabilities Gaps in communication and utilization of warnings Web based applications for IBF There has been loss of lives due to extreme weather events
Numerical Weather Prediction	**Existing Capacities** WRF models
	Gaps and Needs Data Assimilation Medium Range Forecasting & Extended Range Forecasting System (ERFS) access to NCMRWF in addition to IMD Nowcasting-Aviation Forecasting Verification /Hydrological models being used for IB
Observational Networks	**Existing Capacities** Automatic weather station Water level stations **Normal Forecasting-** WRF Model Output+ Guidance from IMD + Thai Surface Charts Satex software for Satellite data – with analysis for RBG channels
	Gaps and Needs Network covering northern part of the region Training of new staffs in AWS/AWLS; as senior staff have left Calibration setup – (lab for pressure, temp and RH) Upper air observations and RADAR station

	Internships in instrumentation (3 months basic) GTS Data: To be able to represent at least 1 region and utilize 5-6 weather stations Dense observational network required
Capacity Building	**Existing Capacities** Virtual Training from WMO, IMD and RIMES on Seasonal Operational Services and Nowcasting
	Gaps and Needs **Trainings in** Nowcasting/Aviation Data Assimilation Short/Long Range Forecast Introductory training on IBF Hydrological IBF Introductory Training on Flood Forecasting Introductory Training in Glacio-Hydrological Modelling & glacier and mass-balance studies, snow mapping Upper Air Observations RADAR Installation Calibration and Instrumentation Network Design Satellite Image Processing Finance, Human Resource and Procurement ICT Short-term trainings; secondment training for six months and one-year (attachment) **Academic long term – degree courses:** Aeronautical Meteorology Electronics and Communication Glaciology Instrumentation

Other Matters

Past Trainings:

- 3 months training for new recruits including two months of theory sessions and 1 month of respective department technical training.

Existing Trainings:

- New recruits: 2 days orientation programme and 1 week of technical orientation
- Requirements and Preferences:
- Short Term Trainings and Knowledge Sharing Culture [With monitoring and evaluation]
- Secondment/ Internship [3 months or more]
- Institutionalization of mandatory training for freshers

NMHS Strength:

- Accurate Data Dissemination in GLOF as a result of past experience and importance given to the aspect.
- Glaciology

Training structure for consideration:

- Basic Modules – for induction level forecasters and instruments/communication
- Short-term (face-to-face) & Follow-up and pre-training online modules
- Specialized modules – face-to-face short-term – example Satellite data analysis
- Secondment and advanced training modules – 3 months/six-months/one-year
- Academic programs- masters and PhD in climate science

India

The consultation meeting with India Meteorological Department (IMD) was held on 18 August 2021 between 11:00 am -01:00 pm (Bangkok time: UTC+7hrs). Following WG members of SAHF WG from IMD attended the meeting.

- Dr Udhay Kumar Shende
- Dr. Somenath Dutta

Table 12 Outlines the highlights of the discussion with India

Observational Networks	**Existing Capacities** Calibration of AWS units, now being done at regional level after trainings 50 doppler RADARS data is being used to generate a high-resolution mosaic Can extend training support in various aspects
	Gaps and Needs Integration of observational networks from different agencies – not complete – at present some State Govt data is being received, private sector entities Upper air system – needs improvements
Capacity Building	**Existing Capacities** Several WMO compliant training courses are being organized and announced through WMO Global Campus platform for meteorological training.
	Gaps and Needs **Trainings in** India can extend support through RTC IMD, Pune Only limited numbers of participants/trainees from South Asia NMHSs

Maldives

The consultation meeting with Maldives Meteorological Department (MMS) was held on 11 August 2021 between 11:00 am -01:00 pm (Bangkok time: UTC+7hrs). Following WG members of SAHF WG from IMD attended the meeting.

- Mr. Ali Shareef
- Mr. Ahmed Rasheed
- Mr. Ibrahim Humaid
- Ms. Shaheema Ibrahim

Table 13 Outlines the highlights of the discussion with Maldives

Impact Based Forecasting	**Existing Capacities** Refined CAP system SWFP guidelines
	Gaps and Needs Coastal hazards
Numerical Weather Prediction	**Existing Capacities** WRF models Operational HPC- Wave Watch 3
	Gaps and Needs Capacity to support HPCs in long term High resolution run in WRF with data assimilation
Observational Networks	**Existing Capacities** INCOIS model Integration of all existing MMS system [AWS systems and NWP products] Mobile application improvement Rainfall data and ocean state data for fisheries Marine weather forecast for sea transportation Utilization of products from ECMWF, WMO and IMD
	Gaps and Needs Ocean observations Ocean current data Ocean current forecast for save and rescue Costal Hazards Datasets for visualization
Capacity Building	**Existing Capacities** Local trainings Basic and advanced courses in IMD Forecasters-Foreign Trainings Basic instruction package
	Gaps and Needs Introductory and middle level training in observational networks Introductory and middle level training in IBF and for forecasters Certification [required for eligibility for promotion] Refresher course in marine observations Improve manpower

Other Matter

Training Priorities:

- Virtual trainings are sufficient and necessary to maintain learning culture among the NMHS professionals.
- List of training in the last 3-5 years to be provide by MMS.

Country Priorities:

- Marine Observations
- Ongoing Projects
- WMO-Hydromet Diagnostic Project
- GCF Project

Myanmar

The consultation meeting with Department of Meteorology and Hydrology (DMH) was held on 13 August 2021 between 03:00 pm -05:00 pm (Bangkok time: UTC+7hrs). Following WG members of SAHF WG from DMH attended the meeting.

- Ms. Chaw Su Hlaing,
- Dr. Tin Mar Htay,
- Ms. Waitoe Aung,
- Ms. Han Swe,

Table 14 Outlines the highlights of the discussion with Myanmar

Impact Based Forecasting	**Existing Capacities** IBF in initial stage Water Level Forecast Flood Hazard Map-Hydrology Department Seismic Hazard Map- Hydrology Department Meteo LAN- EWA 2 threshold value
	Gaps and Needs Utilizing hazard data for issuing warning Hazard map for extreme rainfall, heat hazard and others
Numerical Weather Prediction	**Existing Capacities** WARF model Marine Forecasting- INCOIS Model, IITM Model Storm Surge- IITM Model, JMA Model Daily weather Forecast AgroMet Forecast Aviation Forecast Agricultural Forecasting Seasonal Forecast
	Gaps and Needs Nowcast Wave Model- Sea condition forecast and Marine Forecast 3 days forecast at district level Utilization of ECMWF and other global data for NWP models

Observational Networks	**Existing Capacities** WMO Projects-AWS Stations RADAR Stations 3 Doppler Weather Station 121 Synoptic Stations 40 Water Level Stations DIANA System- Himawari Data Two JICA Projects- Calibration
	Gaps and Needs Integration of Observational Networks- Common Integration platform
Capacity Building	**Existing Capacities** **Past Training:** Storm Surge Training **Planned Trainings:** COMET Training for forecasting, ON Marine Training UK Met- Aviation Training Climatology Training Meteo LAN system
	Gaps and Needs **Training on** Induction Training Threshold Value Calculation Issuance Of Warning Doppler Weather Training Aviation Forecasting Training Hydrological Forecasting Trainings **General** Barometer Calibration Phasing out plan for old systems Limited Human Resource Strengthening institutional capacities

Nepal

The consultation meeting with Department of Hydrology and Meteorology (DHM) was held on 13 August 2021 between 03:00 pm -05:00 pm (Bangkok time: UTC+7hrs). Following WG members of SAHF WG from DHM attended the meeting.

- Ms. Shanti Kandel,
- Mr. Rajudhar Pradhananga,
- Mr. Suman Kumar Regmi
- Mr. Shiva Nepal,

Table 15 Outlines the highlights of the discussion with Nepal

Impact Based Forecasting	**Existing Capacities** Piloting IBF in 16 municipalities of 4 districts in June 2021 under ARRCC UKMet support [Landslide as an impact of heavy rainfall along with other impacts of rainfall – more details requested from DHM WG Member on IBF] Flash Flood Guidance System (Utilizing high resolution products)
	Gaps and Needs IBF Research- Historical data & Analysis – thresholds Improving Reliability of NWP System- Hourly and Weekly Verified products of NWP system Rainfall, Wind and Temperature
Numerical Weather Prediction	**Existing Capacities** FMI- Older version of WRF WRF- 4.1.2: 4 times a day (Resolution 9 km) ECMWF products (ECMWF products better than GFS)
	Gaps and Needs Forecast Verification System Data Assimilation Optimization and customization of NWP Model Products for Aviation and Transportation Nowcasting Medium Range Forecast (Demand for Agriculture Sector) Ensemble Forecast Products Planning for Ensemble Prediction System [Meso Scale] Single Platform for all products to facilitate forecasters
Observational Networks	**Existing Capacities** 1 RADAR (2 under installation) 100 AWS (90 working)-PPCR Work on scanning strategy and data sharing Glacier Monitoring System – 6 AWS att high altitude other stations for Glacier mass-balance in collaboration with ICIMOD 2 upper air stations are being planned with Govt Nepal funds
	Gaps and Needs Glacier and Snow Monitoring Section
Capacity Building	**Existing Capacities** Refresher trainings for forecasters [1-2 years one] On the job training
	Gaps and Needs **Trainings on** Forecast Verification Modification and learning in IBF

	Manpower: Increase number of forecasters No induction trainings at present, only on job attachment – plans to restart this year.

Pakistan

The consultation meeting with Pakistan Meteorological Department (PMD) was held on 16 August 2021 between 03:00 pm -05:00 pm (Bangkok time: UTC+7hrs). Following WG members of SAHF WG from PMD attended the meeting.

- Mr. Sarfaraz
- Dr. Zaheer Ahmed Babar
- Mr. Nadeem Faisal
- Dr. Jehangir Ashraf Awan

Table 16 Outlines the highlights of the discussion with Pakistan

Impact Based Forecasting	**Existing Capacities** Ties with National disaster management authority, province disaster management authority and district DMA Weather Advisory-Information on identified impacts Flood Forecasting Division-Lahore Robust system for riverine flooding Flood Forecasting updated through website, fax, emails, and WhatsApp messages Weather Forecast Guidance System- Responsive and Robust [Ongoing]
	Gaps and Needs Impact Assessment Integration of forecast with severe weather events
Numerical Weather Prediction	**Existing Capacities** Two new Doppler Radars 90+ Weather Stations METCAP+ COSMO Model and ICON Model GFS Model downscaling JMA Model
	Gaps and Needs Numerical Modelling General processing of numerical models Assimilating various available data for forecasts Validation of NWP models
Observational Networks	**Existing Capacities** Access to ECMWF data Surface Observations GLOF project- 2nd phase

	Gaps and Needs Dense Network Better Ground Observations Better Radiosonde Observations Upper Air Observations
Capacity Building	**Existing Capacities** **Trainings in** Initial Meteorology Courses and other introductory courses Product Interpretation-JMA
	Gaps and Needs Trainings in IBF and NWP Trainings in data modelling, climate modelling, model validation and data assimilation Mechanism for refresher courses Improved computational capacities [ICT Infrastructure] Human resources lacking

Other Matter

NMHS Strength:

- Training Capacity, Regional Training Institute

Sri Lanka

The consultation meeting with Department of Meteorological (PMD) was held on 20 August 2021 between 11:30 am -01:30 pm (Bangkok time: UTC+7hrs). Following WG members of SAHF WG from DM attended the meeting.

- Dr. I.M.S.P. Jayawardane,
- Mr. Chana Rodrigo,
- Mr. Meril Mendis,
- Mr.A.G.M.M. Wimalasuriya,
- Mr.A.L.K. Wijemanna,
- Mr.T.P.N. Peries,

Table 17 Outlines the highlights of the discussion with Sri Lanka

Impact Based Forecasting	**Existing Capacities** Flash Flood Guidance Warning depended on thresholds
	Gaps and Needs Early warning for costal inundation Knowledge about impact from equatorial waves Automatic Rain Gauge System linked to FFG Single weather threshold for entire country. Specific thresholds for different areas.
	Existing Capacities

|	
Numerical Weather Prediction	Utilizing ECMWF Forecasts Data from INCOIS ECMWF ecCharts Standard Verification for 24 hours
	Gaps and Needs Customization requirements Verification for ocean products Verification of upper air temperatures and temperature data. Verification of ocean model data
Observational Networks	**Existing Capacities** Two new Doppler Radars[Yet to be installed] One radiosonde observation station Pilot balloons- 4 stations Lighting detection system- Chinese Government [Experimental State]
	Gaps and Needs Weather Buoys Real time data for thunderstorm and lighting forecast [Automatic Rain Gauges- Expansion of real time data network] Integration of Automatic Rain Gauges
Capacity Building	**Existing Capacities** **Trainings in** Basic Meteorology [New Recruits] On the job training [New Recruits]
	Gaps and Needs **Trainings in** Marine Meteorology [Introductory] NWP [In three levels]- Verification, Data Processing, and Data Model Processing. RADAR Meteorology Maintenance of Observational Network [On the job training] Equatorial and Tropical Meteorology Data Analysis and Programming Support for Marine Products

1. **Number of people responded from each country/NMHSs**
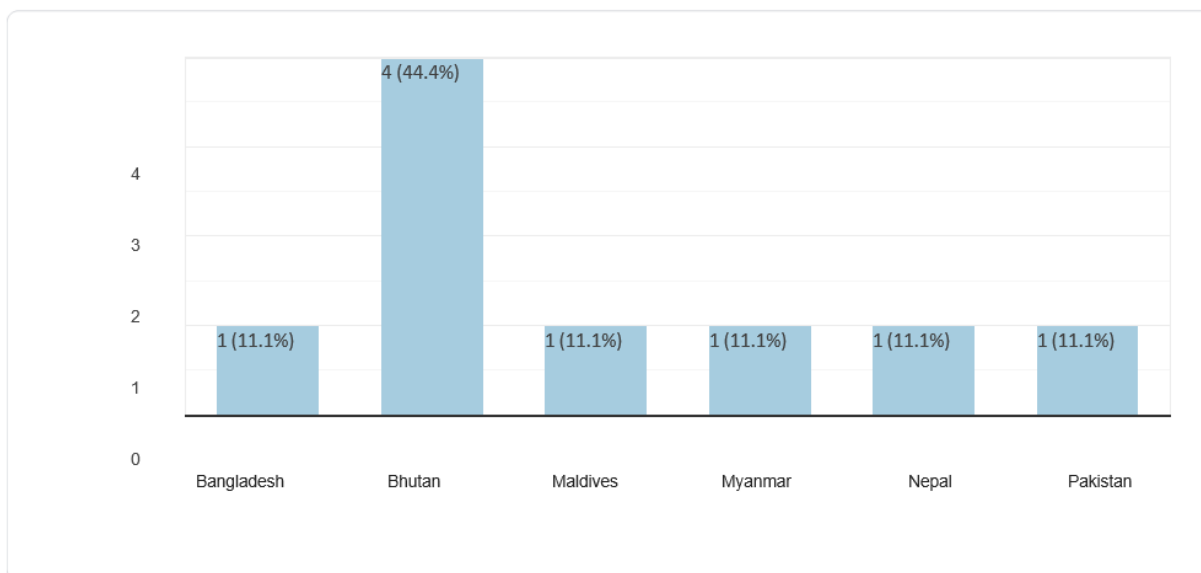

Institutional Capacity

2. **Does your agency have clear mandates and functions in relation to providing hydro meteorological services?** [9 responses]
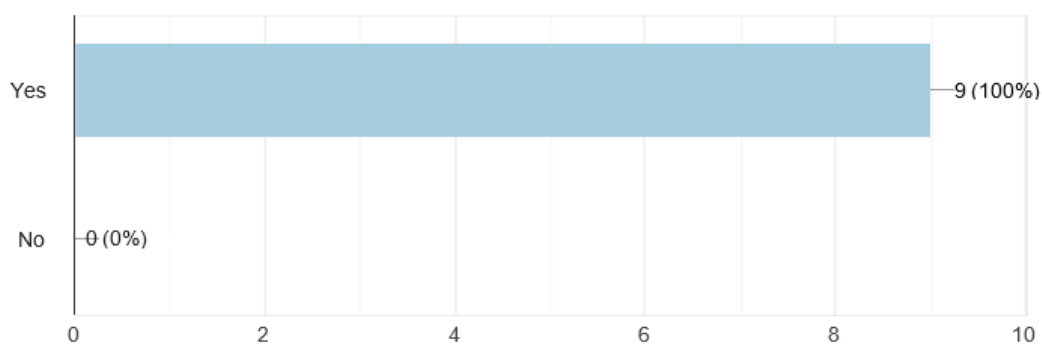
3. **Please list other legal frameworks such as acts and policies etc., that confers your agency with clear functions and mandates for providing hydro-meteorological services.** [8 responses]
   - Maldives Civil Service Regulation 2014, WMO Document no. 49, 731, 732, 904 and 1083, ICAO Document Annex 3, ICAO Document no. 8896 and 9377
   - No idea and I guess it is in draft phase
   - Daily updates of hydro- meteorological and keeping records.
   - 1, Weather and climate services., 2, Hydrology and water resources services., 3,Data analysis and services., 4, Flow forecasting services.
   - NCHM does not have any polices or acts as of now, but NCHM is working for Hydro-met policy
   - Hydro-met Bill was presented to line Ministry, and it is in process of approval from Ministry and then it needs to be approved by Parliament.
   - The Meteorological, Hydrological and Seismological Law is being drafted under World Bank Project.
   - Meteorological Act 2018

4. **Does your agency follow WMO quality management frameworks?** [10 responses]
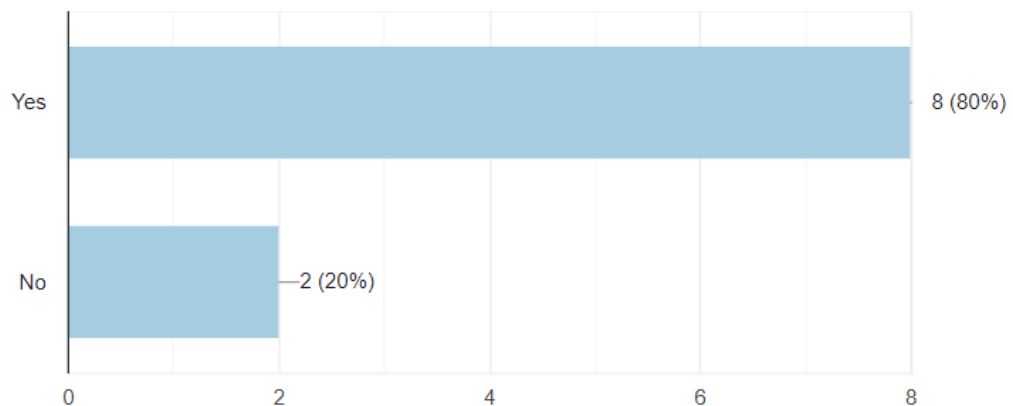
5. **If No, what are the challenges in implementing the WMO quality management system?** [4 responses]
   - Not upto the standard of WMO example station and equipment but trying to improve
   - Developing capacities for effective climate services.
   - Limited HR
     Lack Proper QC related Documentation and training.
     No Hydromet-Bill
   - QMS implemented in Aviation Met Services

6. How often does your agency interact with user sectors/stakeholders? [10 responses]
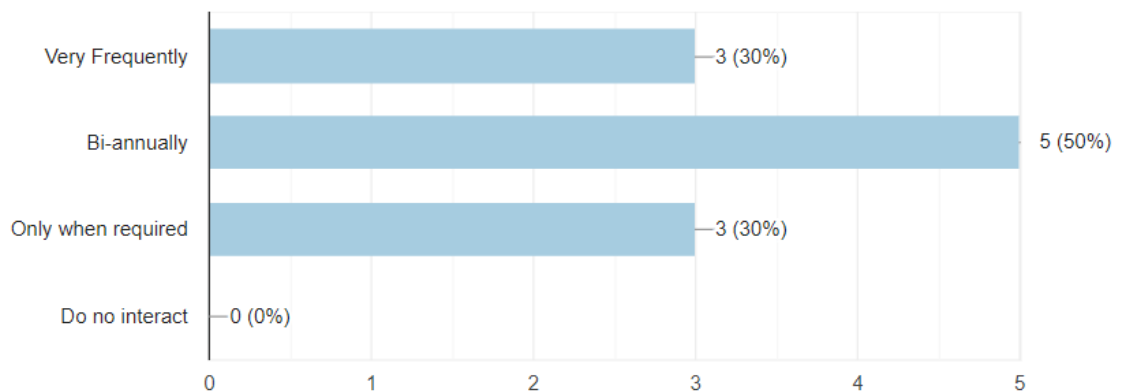
7. List the gaps/challenges causing weak institutional linkage with other user agencies
- Delays in responding., Few organizations have SOPs.,Financial challenges.
- Funding and others
- 1,Lack of opportunities, 2,Can share modern world news and information.
- Limited HR, Lack of institutional coordination, Lack of institutional commitment and priority:, (Recently formed Government institution National Disaster Risk Reduction and Management Authority -NDRMMA has linking with other agencies especially in DRM sectors in Nepal.)
- The absence of a clear demarcation of roles, responsibilities and coordination mechanism
- Irregular interaction, lack of collaboration
- Other agencies reluctance to give timely and proper feedback
- Institutional Strengths

8. Which areas you feel are well established in your organization? Have sufficient capacities to meet the user requirements [8 responses]
- Standard Operating Procedure, Quality Management System, Communication Network, Service Delivery, Weather forecast services and data
- 1, Decision making, Communication, Leadership, Problem solving,Team works
- Have well established weather forecast and flood warning services
- No well-established area in organization, however
- Flood Forecasting, NWP and Weather Forecasting :, Aviation Met-service, Climate Data analysis, Meteorological Instrument Calibration, and Database Management (DMS) are somehow well functioning
- We don't.t have sufficient capacities to meet your requirement
- Weather forecasting. But capacity building needed for further improvement
- meteorological Trainings, Aviation Met Services, Climate data base and data archiving, Public weather forecasting, Drought monitoring & Agromet forecasting

9. **Is there some SAHF thematic area in which trainings have been conducted recently? Provide brief about the training contents** [9 responses]

- None
- No ideas
- No training til date, Online Training -Pilot training for forecaster on IBF (UKMET,ARRCC project), Online- Sectoral stakeholder training on IBF (UKMET office, ARRCC Project), Online training- Capacity building for Maintenance of Meteorological Instruments and Early Warning System (KMA, KOICA), Online training -RADAR Data Analysis and Lightening Network O&M (FMI, FNP3)
- Hands-on training on Agrometeorology: and other Online few training under PPCR Project.
- Yes, Weather Prediction by Numerical Methods Modules 2 (WPNM-M2), Impact Based Forecasting for Flood
- Not training but webinar lecture series were conducted
- Observations recording, tabulation and data dissemination
- Nill

10. **List the decision support tools operational in your organization** [7 responses]

- SeisComp3, COROBOR System, Wave Forecast Demonstration
- No ideas
- 1,Defining the problems, Setting up criteria, Identify the best alternative, Developing plan, Monitoring
- We have a forecast editing tool called SmartMet which provides the forecaster a way to bias correct the model forecast.
- NWP-WRF, Hydro-Met Workstation, Satellite receiving stations- (FY2E and HIMAWARI Satellite), Flood Forecasting Models-Karnali, Babai and Narayani Basin (HEC-HMS Model), Flood Forecasting Models –Bagmati, Karnali Basin (MIKE-11, NAM), Probabilistic Forecast for short lead time in major river system(Based on real time observation):, GLOFAS forecast, ethys Forecasting Platform(Stream Flow Prediction Tool andHIWAT tool for Nepal (7 days forecast for small rivers), Regional Flood outlook –Ganges-Brahmaputra Basin, South Asia Flash Flood Guidance System (Nepal):, Central DMS system and HPC Hardware at NIDC:, GIS Lab, Water Quality Lab, TV studio etc, Meteorological Calibration Lab, :RADAR, AWSs and Radiosonde weather Camera and Lightening Data networks :Web Portal etc.
- Weather Research and Forecasting Model, DIANA Tool, Specialized Expert System for Agro-Meteorological Early Warning (SESAME) supported by RIMES, Agro-Climatic Advisory Services (ACAS) Web Portal is under implementation,CSI Web Tool
- Management review meetings, Determining forecast accuracy, getting disaster management agencies and users' feedback

11. **Are there sufficient staff trained in O&M of existing decision support tools? If no, what kind of training requirements exists.** [8 responses]

- No, there is no recruitment during last five years
- yes
- No, There are not sufficient staffs trained in O & M of existing decision support tools. Very few staffs are proficient in modeling.

- Yes, for operation, none in maintenance.
- No, operation and maintenance of existing tools
- No , Few Mid-level trained staffs in AWSs and Radar level sensors O&M, Specific O&M training on RADAR, Lightening, Radiosonde, Calibration lab, and also System Design, Programming, Communication and Management training are also required :, We need all kind of training if your good office support and we have limited RGOB funds specially in our center
- No
- Training requirements are as mentioned as below
    - 1, Refresher course
    - 2, Training facilities and equipment's
    - 3, Operating training
    - 4, Maintenance training
    - 5, Training to outside developing countries.

12. Tools which are operational in your organization, and you would like to demonstrate to other NMHSs in SA which could also benefit them. [8 responses]

- Digital Analysis System (DIANA)
- Management review meetings, Determining forecast accuracy, getting disaster management agencies and users' feedback
- Some of the tools are operational in our organization but we are not expert to demonstrate to other NMHSs in SA.
- We are looking forward to learning from others.
- None
- -Shearing of RADAR, Radiosonde, Lightening Data and AWSs Observed, Water level Sensor Data, Various Hydrological models used in Flood forecasting, Preparation of Agro Advisory Bulletin (ABB),Success stories in Glacial Lake lowering Project etc. might be beneficial to other SHMSs in SA:
- No ideas
- 1, Observation and monitoring of data., 2, Capacity development

13. List the expertise from your organization in SAHF thematic areas who can serve as resource person for SAHF regional capacity building programs. [8 responses]

- Installation and use of DIANA System, Seasonal forecast generation using PyCPT, WRF and LINUX basic training.
- Establishment of climate database, WMO BIP-MT & BIP-M training courses and NWP to some extent
- We have resources to provide Hydro-Met Services but not sufficient to perfect.
- None.
- Only limited resources available
- NO
- All are not trained and have limited knowledge. I hope our Chief may have some knowledge on it.
- Nill

Human Resources Capacity

14. **Does your agency have adequate manpower to carry out the agency's functions and mandates?** [10 responses]
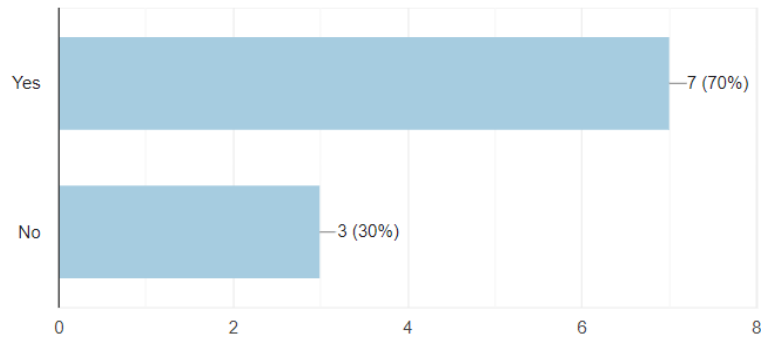
15. **If no, please state the gaps.**
   - Insufficient skilled manpower, New recruitment held up since last five years
   - Due to the fact that only the head office can provide Hydro-Met Services, most of the staff at the head office can attend the training. The staffs from the local office are less experienced than the staffs from Headquarters and they cannot capture all points even if they attend the training because they don't know daily route work for forecasting, they know observation only. Insufficient staffs and also skilled staffs in the Department
   - -Inadequate HR in all the sections, specially IT engineers and technicians for smooth operation of RADAR, Lightning, AWS,NWP and other operational facilities in DHM.

Capacity Building Programs

16. **Please specify the list of trainings organized in your organization in last 2 years**
   [9 responses]
   - Refresher Program Competency Assessment BIP-MT Training
   - Daily hands on training using Meteo-alarm type warning, Numerical Weather Prediction (NWP), Weather Prediction by Numerical Methods Module 2, Tropical Synoptic Meteorology, Ensemble Prediction/ Probabilistic Forecasting, Hydro-floods and PRISM Training Platform for Myanmar, Tropical Forecasting Technique, Online Training (Satellite & Radar application) by JICA, Sub-seasonal to Seasonal (S2S), Meteorological Satellite: Physical Principle, Retrieval and Application, Use of Space Technological for Weather and Climate Studies, Basic Principle of Satellite and Remote sensing, Coastal Zone Management in response to natural hazards and climate variability, Agro-climatic Advisory Services (ACAS) Training, DIANA Tool Training, Aviation Meteorological Training, Calibration and Maintenance training by JICA project, Flood Modeling using HEC-RAS training, Hydrological Modeling and Flow Routing training, Advanced Hydrological Data Analysis training, Advanced Hydrological Modeling Forecasting Training,
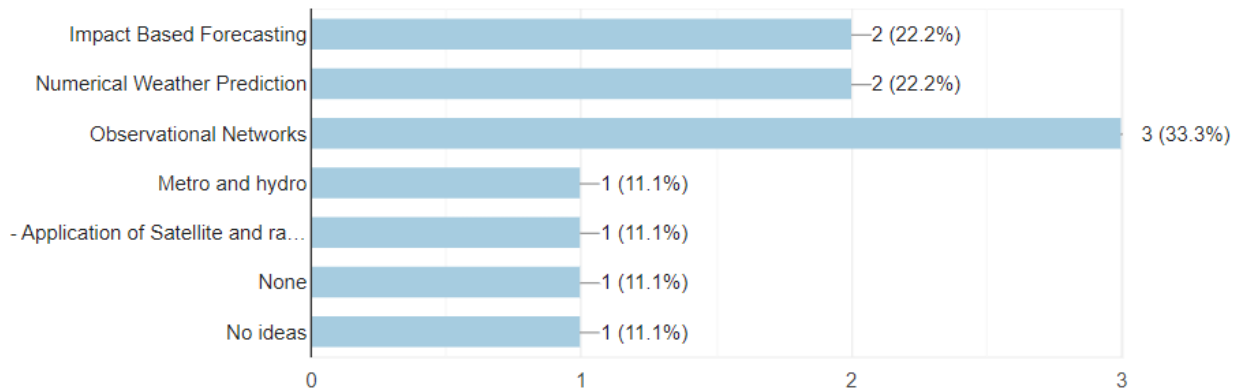
Urban Flood Risk Management a Changing Climate training, Mapping and GIS training, Disaster Monitoring and Response System (DRMS) training
- 1. Virtual training on Severe Weather and Impact Based Forecasting and Warning Services
    - 2. Virtual Training on Seasonal Prediction to Operational Services in south Asia
    - 3. Virtual training on International Distance Training on Nowcasting Techniques on Severe Convection Weather
    - 4. Virtual/e-Programme on Customized Seasonal Forecast Training
    - 5.Virtual/e-Programme on Geospatial Applications for Disaster Risk Management Phase 2
    - 6. Empowering Women in Geospatial Information Technology – Bhutan 2021 edition
    - 7. virtual training on glacier mass balance modelling using R
    - 8. Virtual/e-Programme Hydro-SAR Training: Extracting Flood Information from SAR
    - 9. Training on Water Supply Information from Snow and Ice; Extracting Information from Remote Sensing and Models
    - 10. Meteorological Satellites; Physical principle, retrieval and applications
- Refresher Program
    - Competency Assessment
    - BIP-MT Training
- No training due to Covid
    - Pilot Training for forecaster on IBF (UKMET,ARRCC project)
    - Sectoral stakeholder Training on IBF (UKMET office, ARRCC Project)
    - -Capacity building for maintenance of meteorological instruments and early warning system (KMA, KOICA)
    - -RADAR data analysis and Lightening Data base Management (FMI, FNP3)
    - and other few Trainings under PPCR Project.
- Data management and other software handling conducted by your office and by NCHM
- No training till date

17. Please specify the trainings planned with ongoing projects [7 responses]
- NWP, Satellite meteorology, AWS, WRF, CDMS
- BIP-MT, BIP-M, refresher course in aviation, QMS awareness, IBF, NWP,
    - Marine Meteorology
    - Training for Weather Forecasting
    - Aviation Forecasting
    - Training for Climatology
    - Impact Based Forecasting for Flood (HEC-RAS, HEC-HMS, RS and GIS)

- None from ongoing projects except we have few prior commitments for virtual regional and international workshops
- NWP, SatMet, Earthquake & Tsunami, BIP-M, BIP-MT, ICT & Engineering
- Operational and maintenance training on RADAR in US and also at the sites in Nepal By the suppliers.
    - Few trainings will be conducted in Aviation Met service from FNEP3 project.
    - Few trainings will be conducted in ARRCC Project
- No training plan due to COVID-19

18. Please specify the SAHF thematic areas in which trainings are currently being provided at your organization [9 responses]

Impact Based Forecasting	2 (22.2%)
Numerical Weather Prediction	2 (22.2%)
Observational Networks	3 (33.3%)
Metro and hydro	1 (11.1%)
- Application of Satellite and ra...	1 (11.1%)
None	1 (11.1%)
No ideas	1 (11.1%)

19. Are the current training modules sufficient to meet growing needs to enhance competency for service delivery? [8 responses]

● Yes
● No

87.5%
12.5%
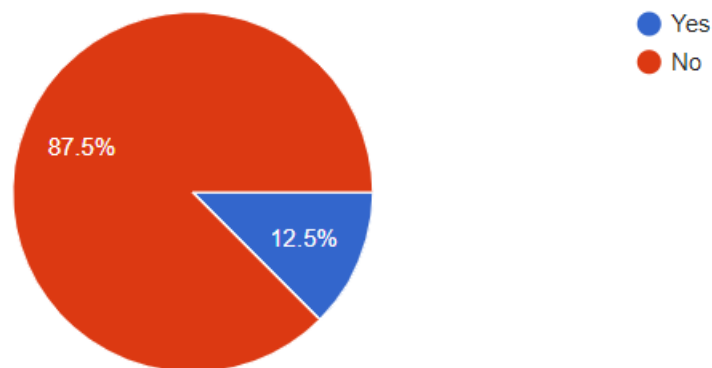
20. If no, suggest additional requirements and improvements. [7 responses]
- Impact Based Forecasting and Mountain weather forecasting
- 1, Refresher course
    - 2,Short term training in developing countries
- NWP modelling, Data Assimilation, Drought monitoring, Now forecasting.
- -Training to Forecaster on IBF preparation and Issuance
    - Training to Forecasters on information communication
    - -Training on How to utilize/use hindcast forecast
    - -Training on development of customized climate products (heat index, drought index, etc) required for various sectors (water resource, DRRM, agriculture, health, tourism, etc).
    - -Training on sub-seasonal to seasonal forecasting (including verification of forecast).
    - -Training on dynamical downscaling of climate projection.
    - -Training on generating/delivering drought monitoring and outlook (useful to all sectors mainly water resource, agriculture, hydropower, DRRM etc) system.

- o   -Training on translating climate information into action for assisting decision making of the end-user.
- o   -Training about data quality control.
- o   -Training on co-production of climate informations
- o   -Training on operational use of RADAR data, Radisounde and Lightening Data.
- o   Training on QMS .
- NWP modelling, Data Assimilation, Drought monitoring, Now forecasting.
  - o   -Training to Forecaster on IBF preparation and Issuance
  - o   -Training to Forecasters on information communication
  - o   -Training on How to utilize/use hindcast forecast
  - o   -Training on development of customized climate products (heat index, drought index, etc.) required for various sectors (water resource, DRRM, agriculture, health, tourism, etc.).
  - o   -Training on sub-seasonal to seasonal forecasting (including verification of forecast).
  - o   -Training on dynamical downscaling of climate projection.
  - o   -Training on generating/delivering drought monitoring and outlook (useful to all sectors mainly water resource, agriculture, hydropower, DRRM etc.) system.
  - o   -Training on translating climate information into action for assisting decision making of the end-user.
  - o   -Training about data quality control.
  - o   -Training on co-production of climate information
- We need more training modules:
  - o   - How to implement the IBF?
  - o   - Which method should approach?
  - o   - GIS & Remote Sensing
  - o   - How to produce and interpret Impact Based Forecasting using GIS software?
  - o   - Which data and information need to use for IBF?
  - o   - Forecasting & Monitoring of Drought
  - o   - Advanced and effective Flash Flood and River Flood Forecasting training
- No , We have to update our training module as it is already more than five years old
- IBF, NWP, Satellite Meteorology, Radar products understanding and application in IBF, urban/flash flooding & riverine floods forecasts and relevant early warning setups are the areas which require improvements

21. **What are the priority training needs in relation to capacity building in the context of your country requirements?** [8 responses]
- BIP-MT & Refreshing
  - o   Instrument maintenance and calibration
  - o   NWP modelling and IBF
  - o   Seasonal Forecasting
  - o   Climate modelling
  - o   Observation and maintenance
- Impact Based Forecasting
- 1,Group training
  - o   2,latest information training
- Now casting, and NWP modelling and data assimilation.
  - o   -Training to Forecaster on IBF preparation and Issuance

- o -Training to Forecasters on information communication
- o -Training on How to utilize/use hindcast forecast
- o -Training on development of customized climate products (heat index, drought index, etc) required for various sectors (water resource, DRRM, agriculture, health, tourism, etc).
- o -Training on sub-seasonal to seasonal forecasting (including verification of forecast).
- o -Training on dynamical downscaling of climate projection.
- o -Training on generating/delivering drought monitoring and outlook (useful to all sectors mainly water resource, agriculture, hydropower, DRRM etc) system.
- o -Training on translating climate information into action for assisting decision making of the end-user.
- o -Training about data quality control.
- o -Training on co-production of climate informations
- o -Training on operational use of RADAR data, Radisounde and Lightening Data.
- o Training on QMS .
- Implementation of Impact Based Forecasting
  - o NWP & Software Engineering
  - o Now-casting by using Radar & Satellite
  - o How to prepare drought monitoring system
  - o GIS & Remote Sensing training
  - o Calibration and Maintenance training
  - o Linux server administration (Basic to Advance)
  - o Programming training (Python, JAVA, C++)
  - o Training on Impact Based flood forecasting and risk based warning
  - o Advanced and effective Flash Flood and River Flood Forecasting training
- Basic training for newly recruited officers, Forecast verification, Data assimilation, NWP, NWP product interpretation, Climate projection. IBF
- IBF, NWP, Satellite Meteorology, Radar products understanding and application in IBF, urban/flash flooding & establishment of robust EWS

22. Would refresher programmes for senior NMHS staffs be useful? [10 responses]
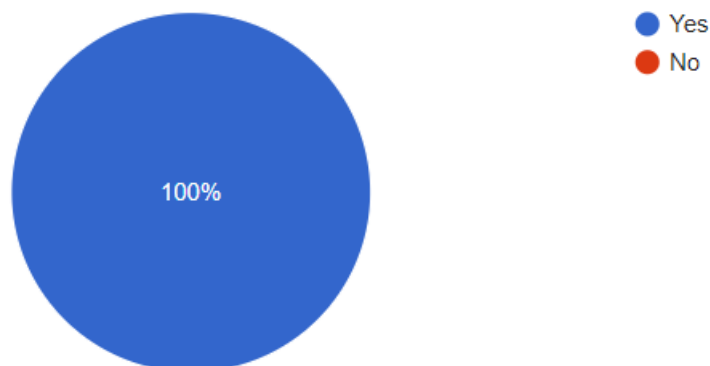
23. **If yes, provide a list of priority topics.** [8 responses]
- Management Development Programs
- Latest update information
- Basic meteorology and operational forecasting
  - Observational network O&M and troubleshooting.
- 1.Quality Management Service (QMS)
  - 2.Advance Level Management training.
  - 3.Advance Level Procurement training.
- Tropical Cyclone Forecasting by using Radar and Satellite Information
  - Advanced technology for Storm Surge Model
  - Knowledge Sharing Training (TOT)
  - Aviation Meteorological Training
- Refreshers training in different field
- Observations, Forecasting (general, aviation & marine)
- If they could only teach practical .

24. **Would it be beneficial to explore the possibilities for exclusive degree courses in hydrology and meteorology in your country?** [10 responses]
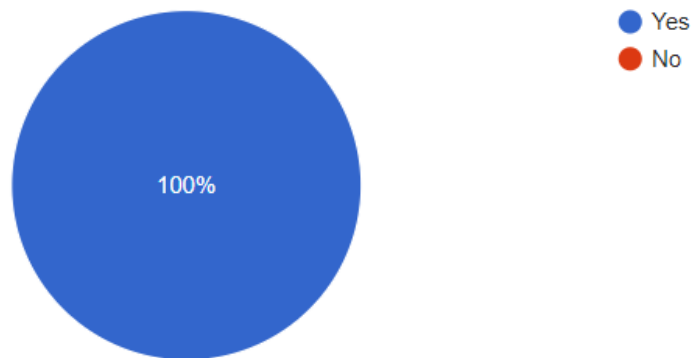
Long Term Capacity Development Strategy

25. **Please provide your views on current challenges and how to plan for future institutional and human resources capacity** [8 responses]
- No local institutions to provide meteorology related trainings
  - Lack of expertise in the area.
  - Through bilateral and regional cooperation these challenges can be mitigated.
- We need training for weather forecasters since we don't have any meteorological institute in Bhutan
- 1, Leadership development.
  - 2, Training and development
  - 3, Workplace changes
- Currently, NCHM staff lacks relevant entry qualifications and has only on job experiences. For now, NCHM is planning to work on competency based framework (CBF) in consultation with RCSC. Once CBF is finalised there will be identified sets of competencies and skills that

employees need to posses at various positions to deliver the task. Such skills and competencies development will be mandatory and will be facilitated at various interval. However, the Center will be looking forward to regional and international supports in terms financial resources and technical expertise in implementing CBF.

- Based on service enhancement in DHM, DHM is soon going to present the new Organization Structure for Human Resource to the line ministry.If approved,adequate HR will be recruited in near future:
- In our Department, current challenges are infrastructure, shortage skilled manpower and technology. To overcome those challenges, we need to cooperate between governmental and international organizations as well as research activities. We have the plans to do recruitment staffs, providing trainings, sharing experiences and knowledge gained from trainings, and conducting specialized study of a subject such as NWP, IBF, Radar & Satellite Meteorology, Software Engineering and ICT course.
- Lack of manpower
- Provision of precise and accurate forecasts especially impact based to save/mitigate the human & infrastructure damages. Application of GIS & RS in preparing hazard maps for cyclones, torrential rains, floods & droughts, landslides etc

26. List the short term capacity development needs under each SAHF thematic areas

Numerical Weather Prediction [7 responses]

- Pls refer to the WG presentation
- We have basic ideas only
- Trainings/workshops on aviation nowcasting, techniques and its operations Introduction to data assimilation and bias corrections Training on NWP, validation and verification Training/workshop on short- and long-range forecast.
- Forest Verification, Ensemble predictions and probabilistic forecast, NWP, forecast interpretation, Data Assimillation
    - Technology for data Assimilation, Bias Correction of Numerical Prediction Model, Skilled Manpower
- Data Assimilation, Product Interpretation, Verificalion, NWP System management
- Training of trainers, NWP (global & regional) models availability, computational facility enhancement

Impact Based Forecasting [7 responses]

- Pls refer to the WG presentation
- Very important and not yet started in Bhutan so we need training which will help in decision making by farmers
- Introductory trainings on IBF; Concepts and Operational Services Introductory training/workshop on flood forecasting for early warning services and integration of IBF to hydrological advisory and warning system Short courses on concepts, and application on glacio-hydrological modelling for water budget Training/workshops related to snow hydrology
- Training to Forecaster on IBF preparation and Issuance -Training to Forecasters on information communication -Training on How to utilize/use hindcast forecast

- How to implement the IBF? Which method should approach? GIS & Remote Sensing, How to produce and interpret Impact Based Forecasting using GIS software? Which data and information need to use for IBF?, Skilled Manpower
- Preparation of Impact matrix for different weather events
- Training of trainers, NWP (global & regional) models availability, computational facility enhancement

Observational Networks [7 responses]

- Pls refer to the WG presentation
- WMO standard as most of station is for agro meteorological purpose
- Trainings/workshops on environmental sensors, data logger and data collection platform/maintenance of hydro-met stations Short courses/trainings on operation and troubleshooting of Upper Air Observation and RADAR instruments. Introductory training/workshop to Lab calibration and certification
- Training about data quality control. -Training on operational use of RADAR data, Radisounde and Lightening Data. - Training on QMS .
- Calibration and Maintenance of Meteorological/ Hydrological Instrument, Linux server administration (Basic to Advance), Programming training (Python, JAVA, C++), Software Engineering & ICT Course
- Installation and maitenance along with monitoring
- Expansion of Observational Network (ON) ideally at every 30/50 Km for surface observations, sufficiently robust upper-atmospheric data recording and establishment of ON inside ocean for better sea monitoring and marine forecast

27. **Suggest strategies how regional training training institutes can assist buliding capacity of human resources in the region** [6 responses]
- Training of trainers
- By working closely and assisting funding for NCHM and also training NCHM staffs
- Through internship and attachment programs for at-least more than month to 6 months
- Regular sharing ideas, informations, training modules to NHMSs in SA:
- Assessing the capacity of different NMHSs, regional training training institutes can assist buliding capacity of human accordingly
- The established regional training institutes can offer to their expertise to build capacity of other NMHSs

28. **What are preferred choices of learning mode** [10 responses]
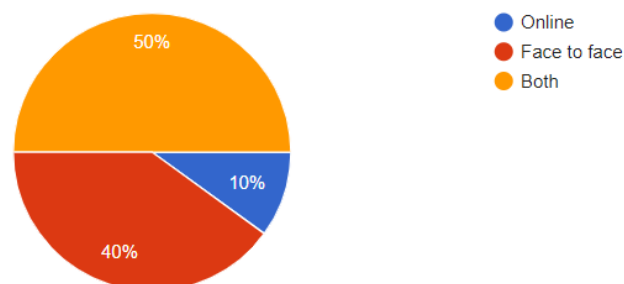
29. Please provide other specific suggestions for capacity development in the region
   [5 responses]

- Attachment programs and expert exchange programs
- Funding and manpower training in the filed of Hydro-meteorological
- 1,Refresher course, 2, Training on training center, 3, Training on developing countries
- Introductory courses/workshops for Finance, HR, Procurement and ICT personnel on management of NHMS staff, fundamental skills and knowledge required for providing support services to NHMS officials.
- Masters in Aeronautical Meteorology/aviation forecasting/Masters courses related to NWP, Programming and modelling/Masters in Electronic, Instrumentations and Communications/ Masters in glaciology/Masters in Water science/water resource management etc.)
- No

Annex V SAHF III Summary Needs

OUTCOMES

SAHF participants unanimously acknowledged SAHF as a vital & ongoing process in the South Asia region that would remain relevant in the future as well so as to strengthen and support the hydromet service delivery capacities of SAHF countries.

The forum agreed that:

1. **The changing landscape of real time observing system networks and forecast data acquisition** for monitoring, detection, and early warning of multi-hazards requires efforts to enhance actionable weather and climate services to protect lives & yield economic benefits.

2. **Collaborative efforts and resources are necessary** to tailor forecasts for key user sectors as per country's needs by generating a suite of useful indices to assist forecasters as well as for value addition towards sectoral applications. Enhancing observing systems- both terrestrial and upper air- in critical gap areas such as mountainous regions and oceans along with innovative mechanisms for their establishment and operation is a key need along with public-private sector engagement centred around NMHSs.

The Forum agreed on several tangible priorities to be undertaken in a time-bound manner as part of an Action Plan with measurable targets. The key outcomes of the Forum are listed below;

Driving the early-warning information value-chain with impact-based Forecasts:

1. Pool collaborative efforts and resources to post-process and tailor forecasts for different sectors and country requirements

2. Generate a range of useful indices that both assist forecasters as well as add value to users' situations within sectors

3. **IBFs offer opportunities for an integrative approach** towards better delivery of hydromet services. Such context oriented forecast information would lead to suitable decision support tools co-developed with sector/ line departments such as agriculture, water resources and fisheries, public health which would benefit them.

4. All SAHF countries would establish an institutional framework to connect NMHS and sector institutions for co-production of IBF services integrating geospatial and socio-economic data with real-time weather data and its exchange for improved IBF, development of Decision Support Systems (DSSs) for risk informed development.

Improving weather and climate forecasts:

5. To synergize efforts and to leverage global and regional strengths, **set up a South Asia Consortium for data and weather Predictions (SCOPE),** a regional collaborative mechanism blending both cutting-edge technological advances and conventional techniques potentially enabled by SAHF regional cloud computing, storage, and networking services infrastructure with investment by pooling of resources. All efforts in this endeavor would leverage significant commitment from institutions and partners collaborating with countries in the region. SCOPE would focus on post-processing data blending conventional MOS techniques, ensemble probabilistic forecasts, high-resolution regional domains for specific country clusters within the region and modern approaches like AI/ML to exploit all the forecast data and observational data to bring best science approaches for the generation of relevant forecast products and derived indices tailored to a range of users.

6. Focus on forecasting weather and climate extremes - tropical cyclones, severe thunderstorms & lightning, heavy rainfall events and heatwaves

7. Prioritize specific national requirements that are also common to sub-regions like marine & coastal services focusing on coastal hazards, shoreline management, mountain meteorology and similar requirements

8. Create knowledge repositories to support high-quality operational weather and climate forecasts

Observational Networks (OBN):

9. Improve observations in critical gap areas such as mountainous areas, upper-air networks and oceans along with innovative mechanisms to establish and maintain OBN.

10. **Establish a robust Regional Data Exchange mechanism** for rapid exchange of observational data and forecast products and significantly strengthen South Asia's overall extreme weather and climate services through a systematic increase in expansion of critical observing system networks.

11. Setup mechanism to lead to utilization of the additional data in forecasting systems, post-processing, and above-all value-addition for better hydromet services.

12. Enhance assimilation, leading to improved high-resolution forecasts and also better verification, evaluation, and downscaling.

13. **Capacity development is the backbone for improved services,** and SAHF III sought to design and implement a capacity development calendar across all components of the information value-chain.

Agreed Action Plan & Targets

The forum identified and agreed on several tangible priorities to be undertaken in a time-bound manner as a part of an action plan with measurable targets. The table below outlines the priorities and action plans that were agreed upon. Feasibility, resources required, and a phased approach will be initiated to implement the agreed action plans within the current phase of the SAHF project and beyond.

Table 18 Summary of agreed action plans and targets

Priority	Targets	Time Frame	Considerations for implementation
1. Enhance observations & integration into forecasting	1. NHMS-ECMWF and RIMES -Data Exchange Platform to be scaled up.	6- 9 months	Mechanism of feedback for improving medium range skill (3–5-day lead) of extreme weather prediction will be established using country level data for performance evaluation.
	1.2 Real-time data exchanged within the region: 15% improvement		RIMES data exchange platform is already operational. Countries will be pursued to meet the targets.
	1.3 Historical observation data: 20% improvement.		Historical data of extreme events for past 5-years will be used - to evaluate global severe weather forecasts - show value of additional data improving past country level severe weather predictions
2. Address user needs through tailor-made products leveraging collective strengths	2.1: Forecast Accuracy: 10% improvement -		By using real time data from countries for continuous assimilation at 3Km grid scale for SAHF countries NWP needs

	2.2: Establish SAHF Regional Cloud computing, storage, and networking services infrastructure with investment by pooling of resources Through scaling up existing DATAEX Platform to acquire, host and share new and additional global and regional digital ensemble prediction products		Under SAHF implementation knowledge platform will be operational within 1 year. This can be further enhanced based on a feasibility study to implement 2.2
3. IBF- An integrating approach for better service delivery	3.1: National institutional mechanisms involving User Sector institutions established on lines of BANCCA (Bangladesh), IRU (India) & SNCCA (Sri Lanka) for co-production of Services in all other 6 SAHF countries	1 Year	Initial steps to be taken to interface with relevant sectoral partners. Other follow up activities to be pursued beyond the current SAHF implementation
	3.2 IBF/DSS implemented for at least 3 sectors – Agri, DRM and Water	2 Years	Initial steps to be taken to interface with relevant sectoral partners. Other follow up activities to be pursued beyond the current SAHF implementation
4. Capacity development is the backbone	4.1 At least 30% of the NMHS operational staff trained	2-3 Years	All necessary efforts to be taken in working group activities and continue beyond current SAHF implementation
	4.2 At least 20% Staff of user sector institutions trained	2-3 Years	All necessary efforts to be taken in working group activities and continue beyond current SAHF implementation

Annex VI Training Need Assessment Report

A TRAINING NEED ASSESSMENT FOR SAHF REGIONAL STRATEGY FOR SERVICE DELIVERY CAPACITY ENHANCEMENT

Introduction

Appropriately staffed and relevant capacity and skills base is one of the key requisites in delivering effective services by the NMHSs to addressing disaster risk reduction and climate risk management.

There are several challenges currently being faced by the NMHSs of South Asia that hinders the delivery of services. South Asia Hydromet Forum (SAHF) is constituted with the vision to strengthen the key elements of the hydro meteorological services at national and regional scale so as to focus on fully meeting user and stakeholder requirements- addressing the current gaps and developing strategy for future improvements. Thus, the training in SAHF context is envisaged as one of most important vehicles for bringing about improved performance and change- be it improving existing capacities, developing new capacities, competencies, orientations or leadership styles; or supporting new structures, processes and systems contributing towards the enhancement of service delivery.

This training needs assessment (TNA) is a part of SAHF regional strategy for services delivery capacity enhancement. The key objectives of this TNA are:

1. To determine the capacities of NHMSs that are required to meet the current demands and needs arising from anticipated changes.
2. To ensure that the capacity enhancement interventions through SAHF are specifically focused on addressing most relevant issues and opportunities in four SAHF thematic areas (Impact Based Forecasting; Numerical Weather Prediction; Observational Networks; Capacity Development).
3. To provide a strategic framework and implementation plan.

Approach

The approach adopted in assessing the training needs is described as follows:

Consultation with NMHSs

With the overarching objectives and purpose SAHF in place, meetings of the Working Groups (WG) in the four thematic areas were conducted during 28-29 June 2021 from all nine South Asian countries to familiarize WG members with SAHF process, seek initial understanding of each NMHSs' capacities and needs. This consultation with WG members of each NMHS of SAHF countries was carried out to have in-depth understanding of the status in four thematic areas with respect to: existing capacities, available operational systems, gaps in current operational procedures, access to various datasets, challenges faced in sustaining operations, priorities for improvements and availability of human and technical resources. Also, this consultation aimed to identify the strengths of individual NMHSs which could be seen as core strength for the region. The consultation meetings were scheduled as shown in Table 1.

Table 19 Schedule for consultation meeting with WG members of SAHF countries

Date	Time (Bangkok Time: UTC+7hrs)	Country
10 August 2021	11:00 am- 1:00 pm	Bhutan
	3:00 pm -5:00 pm	Afghanistan
11 August 2021	11:00 am- 1:00 pm	Maldives
	3:00 pm -5:00 pm	Bangladesh
13 August 2021	3:00 pm -5:00 pm	Myanmar
16 August 2021	3:00 pm -5:00 pm	Pakistan
18 August 2021	11:00 am- 1:00 pm	India
19 August 2021	3:00 pm -5:00 pm	Nepal
20 August 2021	11:30 am -1:30 pm	Sri Lanka

The consultation meeting was coordinated by the RIMES and the World Bank team involved in SAHF implementation (Table 2). The consultation meeting was attended by the WG members of SAHF four thematic areas from the SAHF member countries.

Table 20 Composition of RIMES and World Bank for the consultation meetings

RIMES	● Dr. G Srinivasan ● Dr. K.J. Ramesh ● Dr. Anshul Agarwal ● Dr. Itesh Dash ● Mr. Tshencho Dorji ● Ms. Kousalya V Kumar
World Bank	● Ms. Dechen Tshering

Online Survey

In addition to the above, online survey was conducted from September to October 2021. The online survey covered not only the WG members but also the staffs from the NMHSs working at various levels. The survey collected information on existing capacities, gaps and needs in the four SAHF thematic areas (IBF, NWP, ON, CE).

World Banks Assessment Report of the SAHF Countries

World Bank assessment reports of the SAHF countries were also reviewed to assess critical training needs documented in those reports. The findings from the review complemented the country consultations and online survey in identifying and assessing training needs.

Training Needs

Currently the NMHSs of SAHF are being trained by WMO and through donor funded projects besides their planned training program. However, there are still gaps that need to be addressed to improve the service delivery. The improvement of service delivery at national scale will cascade towards improving service delivery at the SAHF regional scale. Therefore, the training needs in the table below have been concluded as necessary for enhancing service delivery to addressing disaster risk reduction and climate risk management through regional collaboration.

Table 21 SAHF Training Need Assessment

Sl No.	Name of Training	Skills to be developed	Target Group	Countries	Pre-requisites	Possible way forward
Training Need Assessment						
Numerical Weather Prediction (NWP) Training Needs						
1	Introduction to NWP (short range to extended range)	• Understanding basics of NWP • Ability to interpret and analyse NWP forecast	NMHSs	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Sri Lanka	• Good dynamic meteorology background • Good mathematics background	• Focus will be on application of NWP products to generate actionable information - suitable modules to be designed for entry level/mid-management
2	NWP model validation	• Ability to perform forecast validation and verification • Understanding ensemble and probabilistic forecast	NMHSs	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Sri Lanka	• Good dynamic meteorology background • Basic knowledge on modelling • knowledge of statistics	• Training modules for performance evaluation of NWP forecasts
3	Data Assimilation	• Ability to investigate and assess the meteorological data sets • Ability to process and analyse large quantity meteorological data sets • Ability to perform running and monitoring of the data assimilation system, quality assurance of the	NMHSs	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka	• Good background on NWP • Good background on Linear Algebra	• Modules for injecting local observations at 1 km resolution for severe weather prediction subject to availability of suitable manpower and computing resources (inputs are expected to

		reanalysis data outputs, archiving and verifying results				be 3km assimilated fields from IMD)
4	Medium Range Forecasting	• Ability to interpret and analyse the forecast information and data • Ability to perform basic forecast validation and verification • Ability to tailor the forecast to sector needs	NMHSs	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka	• Good background on weather models and climate drivers/physical science • Good mathematics background	(Covered under item 1 & 2)
5	Climate Change Projection	• Understanding climate downscaling, bias corrections • Documentation of climate change reports • Ability to perform climate change impact assessment	NHMSs and Sectors	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka	• Good climate modelling and statistics background • Good computer programming background • Good knowledge on climatology	• Need good experience in weather and climate and skills on data visualization and analysis tools • AR6 CORDEX from RDAS under CARE project will be used
6	Introduction to Glacio-Hydrological Modelling	• Understanding the basics of Glacio-hydrological modelling	NMHSs	Bhutan, Nepal, Pakistan	• Good hydrology/glaciology/water background • Good mathematical background	• Targeted to new recruits (fresh Glaciologist graduates) - Glacier monitoring and mass balance related aspects will be organized (potentially - Research Group in Univ of Geneva)

<table>
<tr><td colspan="7" style="background:#4472C4;color:#fff">Weather Forecasting and Impact Based Forecasting (IBF) Training Needs</td></tr>
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7	Introduction to Basic Weather Forecasting	• Understand the basic techniques of weather forecasting • Ability to interpret synoptic observations • Ability to prepare weather forecasting information	NMHSs	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Sri Lanka	• Meteorology/atmospheric science/engineering/physical science/geography background	• For tier-1 forecasters and new recruits; Training opportunities available with Pakistan and India - RTCs (IMD and PMD) will be leveraged

8	Impact based Forecasting	• Understanding the basics of impact-based forecasting • Ability to prepare impact matrix • Ability to process and analyse risk and vulnerability maps and data • Sectoral experts to work together with met experts	NMHSs, DRMSs	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka	• Good knowledge on weather forecasting and hazards • Good GIS and computer programming background • Good knowledge of the sector for which IBF to be developed	• As this is a priority requirement to be taken up in the current year 2022-23. Design IBF training modules using multi-hazard approach focusing on agriculture, water resources and health
9	Impact Assessment	• Ability to understand the process impact assessment • Ability to develop/generate impact data for impact-based forecasting and hazard mapping	NMHSs, DRMSs	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka	• Good knowledge on hazards • Good knowledge on the use of different datasets (weather, socio-economic, etc.) • Good geospatial background • GIS background	• Will be covered under item 8 above
10	Marine forecasting	• Understanding the requirements of marine observations • Ability to perform marine forecasting	NMHSs	Maldives, Sri Lanka	• Good marine meteorology background	• Requires good knowledge in basic marine meteorology - Training resources available from ITCO Ocean of INCOIS will be leveraged
Data and Observational Network Training Needs						
11	Data processing and analysis	• Ability to use different data analysis tools (python, R, GrADS) • Ability to work and process different data formats • Ability to prepare statistical weather and climate reports	NMHSs	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Sri Lanka	• Good statistical background • Basic knowledge on programming	• Targeted to data managers Training opportunities available with Pakistan and India - RTCs (IMD and PMD) will be leveraged
12	Designing and assessment of	• Ability to design optimal observational network	NMHSs	Afghanistan, Bangladesh, Bhutan, Maldives,	• Good knowledge on hydro-metrological instruments	• UKMet Office training resources to be leveraged

	observational network	• Ability to perform gap analysis for optimal observational network		Myanmar, Nepal, Pakistan, Sri Lanka	• Good knowledge on weather and climate	
13	Calibration and maintenance of meteorology and hydrological instruments	• Ability to understand, calibrate and maintain hydro-meteorological instruments	NMHSs	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka	• Good electronics and electrical background • Basic knowledge on weather observation, data formats • Basic knowledge on computer programming	• Requires prior working knowledge on operation and maintenance of hydro-met instruments • Training opportunities available with Pakistan and India - RTCs (IMD and PMD) will be leveraged
14	RADAR	• Understanding RADAR images and ability to use to use for IBF • Ability to operate and maintain RADAR	NMHSs	Bangladesh, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka	• Basic concepts in displaying geospatial data • Basic knowledge on geospatial data formats	• Requires basic knowledge about RADAR • Training opportunities to be leveraged through UKMet Office/JAICA/Univ of Colarado, Chandrashekar/IITM, Pune
Information and communication (ICT) Training Needs						
15	Linux	• Ability to use and script Linux commands • Ability to use LINUX for weather and climate modelling • Ability to use LINUX for data processing and analysis	NMHSs	Bhutan, Maldives, Myanmar, Nepal, Sri Lanka	• Good basic knowledge in computers and their OS • Basic knowledge in computer programming	• RIMES IT Team will design and render these modules
16	GIS	• Understanding GIS data types • Understanding the operation of geospatial tools • Ability to process geospatial data	NMHSs	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Sri Lanka	• Basic knowledge on computer programs	• Targeted to forecasters • RIMES IT Team will design and render these modules

17	Remote sensing	• Understanding and interpretation of satellite images • Ability to process and analyse images • Ability to generating risk maps and hazard maps	NMHSs	Afghanistan, Bangladesh, Bhutan, Pakistan, Maldives, Myanmar, Nepal, Sri Lanka	• Basic knowledge on geospatial data displaying • Basic knowledge on electromagnetic rays and spectrum	• Targeted to forecasters - to be arranged from ESA/EUMETSAT and IIRS, Dehradun, ISRO, India
Miscellaneous Training Needs						
18	Procurement	• Understand the basic of procurement • Ability to understand the existing norms and regulations of procuring good goods from international markets and understand document rules of the donors	NMHSs	Bhutan	• Working experience in procurement process	• Targeted to procurement, finance and project officers • WBank procurement team/UKMet
19	Budgeting planning and management	• Understand the techniques and skills require for efficient budget planning and management	NMHSs	Bhutan	• Working experience in budget planning and management	• Targeted to senior managers, finance and project officers • WBank procurement team/UKMet
20	Human resource Planning and Management	• Ability to understand the skills of effective human resource management	NMHSs	Bhutan	• Working experience in HR management	• Targeted to senior managers, HR and project officers • WBank procurement team/UKMet
Others-Long Terms Training Needs						
21	Secondment to regional institutes- e.g., RIMES, NCMRWF, RRC, Pune	• Ability to understand and acquire the working skills of the institutions • Develop specific skills – e.g NWP, Climate modelling, seasonal forecast, data analysis	NMHSs	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Sri Lanka		

| 22 | Higher Degrees in Meteorology, Hydrology, Oceanography, climate change | • Improve in depth understanding in specific fields and ability to perform and deliver hydro-met products and services | NMHSs | Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Sri Lanka | | |

**Basic concept building and understanding related refreshing lectures will be organized prior to the launch of the above-mentioned training modules.

Strategy to implement the training needs

The training needs of the NMHSs are vast and varied. A common training requirement for the NMHSs are assessed to develop a regional training strategy. However, the training requirement for the SAHF region and the population to be trained are large, hence it is evident that it is neither practical nor feasible to meet the all-training needs of NMHSs within the SAHF project phase.

Training courses has to be prioritized and well-paced, allowing sufficient time for the NMHSs to assimilate learning and for RIMES to organize the training within the phase of SAHF. The following strategies will be adopted:

i. Impact Based Forecasting is recognized as a region wide need. SHAF will focus its effort to build the capacity of NMHSs in IBF through design of trainings across the hydro-met services value chain. The training module will focus on IBF value chain including other training needs which will form the value chain. This priority training need will be further consulted with NMHSs through follow up consultations.

ii. The implementation will look at three main aspects: **Verticals-** based on subject areas which will include IT competencies, operation and maintenance, procurement and quality management**; Horizontals**- training of various groups of staff by targeting early career staff, mid-level officials and senior management in a tier system. At the broader level, specific sector like water, agriculture and disaster management will be included as they form an important part of IBF value chain; **Delivery modalities**-considering the present situation of the COVID-19 pandemic, the mode of training delivery will be a hybrid mode (online mostly and face to face wherever possible).

iii. To meet the vast training needs, alternatives such as providing self-paced learning and training online with the assistance from relevant partners (RTCs, WMO, COMET/UCAR and UKMOARRC) will be explored. Additionally, the knowledge hub will provide the NMHSs staff self-learning materials. The regional training centres particularly IMD and PMD may have to play a critical role in meeting the training needs which are not included in the priority list of SAHF.

iv. For future sustainability, Training of Trainers (TOT) program should be explored so that future training can be implemented in house within NMHSs.