



SAHF Observational Network Working Paper

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ACRONYMS

ADB	Asian Development Bank
AERI	Advanced Emitted Radiance Interferometry
CARE	Climate Adaptation and Resilience Project
CE	Capacity Enhancement
DHM	Department of Hydrology and Meteorology
ECMWF	European Centre for Medium-Range Weather Forecasts
ERFS	Extended Range Forecasting System
EWS	Early Warning System
FCDO	Foreign, Commonwealth & Development Office
GBON	Global Basic Observing Network
GFCS	Global Framework for Climate Services
GFDRR	Global Facility for Disaster Reduction and Recovery
GTS	Global Telecommunication System
HMA	High-Mountain Asia
IBF	Impact Based Forecasting
IBFWS	Impact-Based Forecasting and Warning Services
ICT	Information and Communication Technology
IMD	India Meteorological Department
INCOIS	Indian National Center for Ocean Information Services
IOOS	Integrated Ocean Observing System
LDC	Least Developed Countries
MHEWS	Multi-hazard Early Warning System
MoU	Memorandum of Understanding
NMHSs	National Meteorological and Hydrological Services
NWP	Numerical Weather Prediction
ON	Observational Networks
RDAS	Regional Data Analytics System
RIMES	Regional Integrated Multi-hazard Early Warning System
SAHF	South Asia Hydromet Forum
SOFF	Systematic Observations Financing Facility
WB	World Bank
WG	Working Groups
WMO	World Meteorological Organization

Executive Summary

Exchange of real time and reliable data is crucial for generation and delivery of quality hydro-met services. The demand for high quality and higher resolution datasets is increasing for Global Numerical Modeling that generates quality forecast products and data for sector level applications and characterize long term climate for mitigating an adapting to the long-term impacts of change in climate. To meet these demands, adequate observational network systems both convention and non-conventional are required. However, most countries in South Asia are not able to meet these requirements due to various socio-economic constraints. Fragmented modernization efforts that remain financially and technically unsupported beyond project lifetimes are further exacerbating the existing gaps.

SAHF, under the guidance of the Executive Council, brings together nine Asian countries: Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka. It has 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. SAHF endeavours to strengthen the key elements of hydro-meteorological services by leveraging regional collaboration and enhancing national capacities to fully meet user requirements. Thus, SAHF Working Group for Observational Network through series of consultations with the SAHF NMHS and online surveys reviewed and assessed the observational, monitoring and detection capacities of severe weather by NMHSs of the region.

It is found that the observational network and data capability of NMHSs vary enormously due to the differences in budget and capacities (both infrastructures and human resources) of the NMHSs. While all NMHSs fulfill basic requirement of surface observational network, there is still a gap in the critical observational networks for glaciers, aviation, urban floods, severe weather forecasting including tropical cyclones and, coastal and marine observations. Therefore, efforts are needed to address these gaps and meet the GBON requirements.

To meet the immediate needs, SAHF focus will focus on training and development of components of the SAHF Knowledge-hub and SAHF Data Ex. The SAHF Data Ex supports observing system networks through the rapid exchange of observational data and forecast products and significantly strengthens South Asia's overall extreme weather and climate services.

As for the long-term strategy, country-specific needs for observational system networks should be addressed through respective national efforts and by leveraging available regional and global resources. Such needs can be addressed as follows:

- Ensuring cost effective and fit for purpose investments observing system network by the countries and their development partners.
- Countries and development partners ensure that appropriate budget is allocated for operation and maintenance (O&M) of observational system networks.
- Countries and their development partners should ensure continued HR training plans are in place and is implemented.
- Provisioning and sharing of integrated remotely sensed observations from satellites provide vital information on the evolution of severe storms and remotely sensed soundings and water vapour imagery that contribute to the interpretation of the severe storm environment.
- Support severe weather monitoring by sharing transboundary RADAR observations.
- Support ocean and marine observing network.

1. Introduction

Real time observations and exchange of datasets are crucial for high quality hydro-met services. Gradual expansion of the observing system networks across the globe has been the driver of advancements in operational meteorological services under the umbrella of WMO. In the recent decade observing system network improvement has been driven by the increasing demands for higher-resolution data for numerical models, sector level applications, and the need to characterize long term climate at higher resolution. Such needs can be met by integrating standardized data generated by NMHSs and other supporting observations collected through non-conventional networks. If these efforts are synchronized and supported at a regional scale it can have more far-reaching benefits.

South Asia has not been able to catch up with the expansion and scaling up of observing system networks in line with the emerging service needs and demands due to various geopolitical and socio-economic constraints. Despite several challenges currently being faced by NMHSs of South Asia that hinder the delivery of hydromet services, attempts have been made for augmenting and sustaining established observing systems in line with the national circumstances and to close the GBON gaps and meet the GBON requirements. Fragmented modernization efforts that remain financially and technically unsupported beyond project lifetimes are further exacerbating the heterogeneity observing systems. The existing gap in baseline observing system networks has been a major handicap in improving data assimilation in global numerical weather prediction systems although this shortcoming is partially remedied by the increased use of multi-satellite radiances and retrievals.

The establishment of modern observing system networks and use of the resulting data are tied to several needs:

- Operational weather monitoring depends heavily on timely and geographically relevant observations that cater to wide range of user requirements.
- Numerical weather prediction that provides the basic guidance for weather forecasting beyond the first few hours are critically dependent on initial conditions, which drive the requirements for observations.
- Fundamental research to improve the understanding of basic atmospheric processes, inspires the development and expansion of new observing systems.

SAHF, under the guidance of the Executive Council, brings together nine Asian countries: Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka. It has 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. SAHF endeavours to strengthen the key elements of hydro-meteorological services by leveraging regional collaboration and enhancing national capacities to fully meet user requirements. Thus, the focus of the present regional efforts is to review the observational, monitoring and

detection capacities of severe weather by NMHSs of the region and through an appropriate regional perspective to address gaps in operational service delivery. Thus, adopting a regional approach to enhance observational networks will increase synergies and efficiency at a country level. To facilitate the regional implementation, a short-term and long-term approach to improve the observational networks and data access is proposed. In the short term, this will look at improving data access and exchange between NMHSs while in the long-term, it recommends improving the observational networks of NMHSs which could be strengthened through future projects, either through national or regional level projects (and related funding).

2. Objective

This working paper for Observational Network has the following objectives:

ANALYSE



Analyse the strengths, gaps and sustenance needs of the observing systems of each NMHS to identify ways to improve data acquisition and timely exchange between countries in order to ensure adequate data availability for monitoring, detection and early warning of severe weather particularly addressing transboundary extreme events, taking advantage of new technologies.

PRIORITIZE



Prioritize the regional needs and efforts that will complement and reinforce national activities leading toward more sustainable operation of hydrometeorological services throughout the region.

MAINTAIN & ASSESS



Maintain updated inventories of the existing weather, climate, water and ocean observing system networks (core and augmented networks by user agencies), assess the coverage and evaluate the incoming data of the SAHF member countries.

3. Approach and Process

As a first step, the Working Groups (WG) for four thematic areas, namely 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 Observational Networks was held on 29 June 2021, where a preliminary stocktaking of existing capacities and needs of NMHSs was implemented (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 was organized, bringing together 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 hydromet 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 hydromet 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. The needs that were identified and recommended during SAHF III were considered in the stocktaking process. The summary of needs ensued from SAHF III is given in Annex 4.

4. Overview of baseline observational network of SAHF NHMSs and challenges

The observational network and data capability of NMHSs vary enormously due to the differences in budget and capacities (both infrastructures and human resources) of the NMHSs. The baseline information of the observational system network in each country is provided in Annex I. The four main provisions of GBON were referred and followed for the assessment and identification of SAHF focus and recommendations¹. A country is considered to have an optimal observational network (surface land-based observations and upper-air land-based observations) for hydro-met services if it fulfils the following criteria.

Table 1: Criteria for evaluating country's observational network

Station Type	Minimal requirement	GBON requirements
Surface land-based observations	Operates a set of surface-based land observing stations/platforms that observes air temperature, atmospheric pressure, humidity, wind speed & direction, precipitation & snow depth with hourly frequency located horizontal at desirable spatial distance.	Operates a set of surface-based land observing stations/platforms that observes air temperature, atmospheric pressure, humidity, wind speed & direction, precipitation & snow depth located horizontally with spatial resolution of 500 km or higher for these variables, with an hourly frequency.
		Has additional surface land observations of air temperature, atmospheric pressure, humidity, wind speed & direction, precipitation & snow depth located horizontally with spatial resolution of 100 km or higher for all these variables, with an hourly frequency.
Upper-air land-based observations	Operates a set of upper air stations over land that observes temperature, humidity and horizontal wind profiles with vertical resolution of 100m or higher at least once a day	Operates a set of upper air stations over land that observes temperature, humidity and horizontal wind profiles with vertical resolution of 100m or higher, twice a day or better, upto a level of 30 hPa or higher located with GBON

¹ [The WMO Integrated Global Observing System: Introduction and Overview](#),

		horizontal resolution of 500 km or higher
		Operate a subset of the selected GBON upper air observing stations that observe temperature, humidity and horizontal wind profiles up to 10 hPa or higher, at least once per day, located such that, where geographical constraints allow, GBON has a horizontal resolution of 1000 kilometres or higher observations or these.

The first column outlines the assessment of the existing capacities of NMHSs under each theme. The "status" column describes the existing status that was mentioned by respective countries during the consultations. The "SAHF focus and recommendations" column describes the actions needed to address the existing gaps.

Table 2: Assessment of the existing capacities of NMHSs in SAHF domain, challenges and considerations

Theme	Existing capacities	Existing challenges/gaps	SAHF considerations
Surface meteorological observing system network	<ul style="list-style-type: none"> - Basic terrestrial observational network for synoptic measurement exists in all NMHSs. - Modernization has already taken place in Bhutan, Sri Lanka and Maldives. - Ongoing investments in the modernization of surface observation networks exist in Afghanistan, Myanmar, Nepal and Bangladesh. 	<ul style="list-style-type: none"> - Due to high variability in rainfall over the region adequate coverage by rain gauge network is a challenge - Surface snowfall and precipitation measurement remain a huge challenge in the mountain areas of the SAHF region (Bhutan, Nepal & Pakistan). - Except for India and Pakistan, rest of NMHSs still lacks required skills to operate and maintain AWSs. 	<ul style="list-style-type: none"> - Efforts must continue to modernize, expand and enhance the surface observational networks, particularly in the mountain areas of Bhutan, Nepal, Pakistan, Afghanistan and India. - Need to initiate transboundary sharing of real time AWS data between the NMHSs - Enhance skills and technology to blend gauge and satellite data to generate quantitative precipitation estimates (QPE)

		<ul style="list-style-type: none"> - Most of the NMHSs lack adequate fund and capacity to support operation and maintenance of AWS network - No information with NMHS on the non-synoptic stations operated by third parties/other agencies 	<ul style="list-style-type: none"> - Augment the network by combining non-synoptic stations managed by third parties to improve the capability for identifying and monitoring severe weather events.
Surface hydrological observing system network including cryosphere	In some countries, the surface hydrological observing system network is managed by NMHSs and in others, it is managed by other agencies.	While basic capacities exist for observing hydrological parameters in all countries, there is a gap in real-time monitoring and provision of early warning information on floods across most of the SAHF NMHSs.	<ul style="list-style-type: none"> - Efforts are needed to enhance the existing hydrological and cryosphere observing system networks. - Increase the use of remote sensing data for preparing reliable and accurate flood warnings, extreme value analysis for determining the thresholds/danger levels and cryosphere studies. - Efforts are needed to strengthen early warning systems for rainstorm floods in all SAHF countries and Glacial Lake Outburst Floods in Pakistan, Nepal, Bhutan and northern region of India.
Ground based upper-air measuring in-situ network	Except for a few (Bangladesh, India, Pakistan, Myanmar), most SAHF NMHSs have no GPS radiosonde and Pilot sonde networks.	<ul style="list-style-type: none"> - The ground based upper air measuring network in the region is too sparse - Even in the countries having radiosonde networks the number of stations are declining due to 	<ul style="list-style-type: none"> - Urgent and immediate efforts are needed to enhance and expand the sampling density of the GPS radiosonde and Pilot sonde networks that are currently poorly matched to capture the large amplitudes and small scales of lower tropospheric variability.

		<p>maintenance and procurement issues.</p>	<ul style="list-style-type: none"> - Ensure operation of GPS radiosonde networks for 00UTC & 12 UTC and GPS pilot sonde networks for 06 UTC & 18 UTC. - Enhance existing radiosonde network and set up in the countries where none at present.
<p>Doppler Weather Radar (DWR) networks</p>	<ul style="list-style-type: none"> - Except for Afghanistan, Bhutan and Sri Lanka at least one or more RADAR exist with the rest of SAHF NMHSs. - There are existing investment plans to establish and strengthen the RADAR network in Nepal and Sri Lanka. However, countries like Bhutan and Afghanistan have no investment plan to establish the RADAR network. 	<ul style="list-style-type: none"> - Bhutan and Afghanistan have no investment plan to establish the RADAR network. - NHMSs with RADAR network has limited skills to operate, maintain, analyse and use RADAR data - Maintenance of the RADARs and operational costs on a 24X7 basis is a challenge within many NMHSs. Due to these reasons, RADARs remain non-operational during critical times. 	<ul style="list-style-type: none"> - Establishment of operating national polarimetric DWR networks along with synchronization of DWR scanning strategy across the SAHF countries is the most essential target for the transboundary severe weather hydro-met events with a mosaic of DWR products generated through regional coordinated efforts. <p>Additional observing systems needs for improving severe weather process studies for the SAHF region include:</p> <ul style="list-style-type: none"> • Cloud Radars • Radar Wind Profilers • Doppler Wind Lidars • Ceilometric networks for Cloud base estimates at all functional airports • Microwave Radiometers • GPS Sensors for Integrated Precipitable Water Measurement Network

			<ul style="list-style-type: none"> • Advanced Emitted Radiance Interferometry (AERI) Network for trace gases Profiling • Sun Photometer/Sky Radiometer Networks for Aerosol Profiling • Athelometer Network for Black Carbon Measurements • Radio-Acoustic Sound Systems
Integrated Ocean Observing Systems	<ul style="list-style-type: none"> - Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, India provides real-time quality-controlled data from the global oceans to local scales of coastal ecosystems for the South Asia region. - Ocean surface forecasts are disseminated to island and coastal countries of SAHF through weekly SAHF forecasters' forum. 	<ul style="list-style-type: none"> - Currently, the density of ocean and marine observing system networks is low and very limited capacities exist at coastal NMHSs of the SAHF countries. 	<ul style="list-style-type: none"> - Regional efforts are needed to enhance and sustain the ocean and marine observing system networks with increase in quality and spatial resolution of the data.
Data sharing and exchange	<p>Most NMHSs share data through Global Telecommunication Systems (GTS).</p>	<ul style="list-style-type: none"> - Availability of GTS connectivity to countries and bandwidth limitations restrict the amount of station network data being shared from the countries. WMO is upgrading these systems and the issue is likely to be resolved soon. 	<ul style="list-style-type: none"> - Countries should make efforts to connect more stations to GTS. - Formulate and enhance mechanisms to improve data sharing in the region for operational utilization. - Use DataEx platform within the SAHF

		<ul style="list-style-type: none"> - Countries like Afghanistan, Bhutan, Maldives, and Nepal have very few stations connected to GTS. - There are limited real time mechanisms to exchange data in the region except the one initiated by RIMES - It is found that limited to very limited data from South Asia are being shared for operational NWP. 	<p>Knowledge Hub to facilitate data sharing in the region.</p>
Remote sensing observations and data	All countries have access to one or more remote sensing data and products.	Most of the NMHSs have limited skills and tools to fully use the remote sensing data and products. It is also constrained by the spatial and temporal resolutions of the data and inadequacies in ground truthing at a finer spatial scale.	<ul style="list-style-type: none"> - Enhance easier access to remote sensing data and tools to NMHSs - Build capacity of NMHSs to make use of existing remote sensing products to support the surface observing system network to detect and monitor extreme events.

5. Missing critical observational networks

South Asia extends from the Oceans to the Himalayas. The weather and climate of South Asia is quite complex, hence there is a requirement of various types of observing systems in the region. There is still a need for investment to strengthen the observational networks in the following areas:

- Glaciological Observations
- Aviation
- Urban floods
- Severe weather forecasting including tropical cyclones
- Marine Observations

The table below outlines requirements of critical observing networks that are still missing or requiring enhancement.

Table 3: Outline of critical observing networks requirements that are still missing or requires enhancement

S.No.	Needs	Countries
1	Snowpack accumulation/ablation monitoring and snow/glacier hydrology- Glacier mass balance need to be built with 15-day updating mechanism	Afghanistan, Bhutan, Nepal, Pakistan
2	Lightening EWS needs to be built	Bangladesh, Nepal, Bhutan, Myanmar, India
3	EWS for Coastal hazards, inundation and impacts including sub-Km scale wind and swell wave/tidal action along with tools for ocean data and ocean state forecasting products	Bangladesh, Maldives, Sri Lanka, Myanmar
4	Set up marine observation network	Bangladesh, Maldives, Sri Lanka, Myanmar
5	Development of DSSs for Flash Flood and Landslide impact assessment mapped with slope stability/vulnerability linked to upstream heavy rainfall warning in hilly areas	Afghanistan, Bhutan, Nepal, India, Myanmar
6	For severe weather phenomena like tropical cyclones, specialized observational capabilities like high wind speed recorders, tide gauge network to monitor storm surge etc.	Bangladesh, Pakistan, India, Myanmar, Sri Lanka

Enhancement of observational network and data exchange is driven by priorities and needs of respective NMHSs. There is an immense benefit both for the countries and in the region by enhancing the observational network and data exchange. The salient benefits include:

- Meet the GBON requirements by the countries in South Asia and the region as a whole and increases the SA's contribution to Global NWP improving the accuracy of global forecast products for the region.
- Enhanced data exchange between the countries in the region will allow faster flow of information than the impending hydro-meteorological hazards.
- Improved detection and monitoring of extreme hydro-meteorological events in the region.
- Improved initialization for regional NWP through enhanced observational networks and data sharing
- Leverage regional resources and capabilities in enhancing and building capacities of NMHSs in the operation and maintenance of observational networks.
- Improved confidence and skill in regional forecasts through better verification
- Ensures a sustained regional mechanism that will assist NMHSs in effective planning of the investments. For example, if a transboundary RADAR data from India is shared with Bangladesh for areas bordering India, an investment in RADAR is not needed in Bangladesh in that region.

Understanding the benefits of improved observational networks and data exchange, a short to long term strategies can be devised. To begin with, the focus will be on training and development of components of the SAHF Knowledge-hub and SAHF DataEx. The SAHF Data Ex supports observing system networks through the rapid exchange of observational data and forecast products and significantly strengthens South Asia's overall extreme weather and climate services. The World Bank CARE project components like the Regional Data Analytics System (RDAS) will also be used to source data and exchange data as inputs for the IBF process.

As for the long-term strategy, country-specific needs for observational system networks should be addressed through respective national efforts and by leveraging available regional and global resources. Such needs can be addressed as follows:

Cost effective and fit for purpose observing system network

The countries and their development partners need to ensure that future projects and investments particularly in the observational system network are not ambitious and are

focused to meet the intended purpose to derive the maximum benefit from the projects/investments and sustenance of the observing system network after the project. For example, countries in the SAHF region could invest in building observational system networks that address both country needs and regional requirements. While enhancing RADAR observational networks at national level, regional requirements can be also kept in view to enhance severe weather monitoring like cyclones and severe thunderstorms.

Allocate appropriate budget for operation and maintenance (O&M)

It is found that limited or lack of budget for O& M of observing system network after the projects as a common hurdle in almost all the SAHF countries to sustain the observing system network. Development partners and respective countries make provisions for funding O&M to sustain the observational infrastructures. On a regional level SAHF can evolve guidance and best practices to encourage standardized O&M procedures for the region. Also, leverage funding support at regional scale to ensure data sharing, interoperability within national and regional observational system networks and O&M support.

Ensure continued HR training

As budget is critical to sustain O&M of observing system network, it is equally important that a robust and continued training be conducted to the NMHSs staff. The countries should strive to provide inhouse refresher courses as well as leverage regional capacities to strengthen the capacities of their manpower in planning, development, update, operation, and maintenance of observing system networks.

Provisioning integrated remotely sensed observations from satellites

Satellites provide vital information on the evolution of severe storms and remotely sensed soundings and water vapour imagery that contribute to the interpretation of the severe storm environment. SAHF will facilitate the integration of remote sensing data from a variety of available platforms such as INSAT-3D, EUMETSAT, Himawari and similar resources to support observations of extreme events and long-term snow and glacial monitoring in South Asia. This can be facilitated through Data Ex.

Support severe weather monitoring by sharing transboundary RADAR observations

NMHSs in the region should make efforts to share transboundary observations in real-time to monitor and detect extreme events. Augmentation of simulated reflectivity by the models can support operational transboundary severe weather monitoring wherever RADAR networks are incomplete or non-functional. At a suitable stage this component can be integrated into Data Ex.

Support ocean and marine observing network

The Integrated Ocean Observing System (IOOS) provides real-time quality-controlled data from the global oceans to local scales of coastal ecosystems. IOOS is an end-to-end system that involves observations, data communications and management, and data analysis and modelling, through its three interacting subsystems, Observation and Data Telemetry, Data Management and Communications, and Data Analysis and Modeling. IOOS over the Indian Ocean covering the Arabian Sea and Bay of Bengal is established and managed by

the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, India. RIMES under the umbrella of SAHF could facilitate the augmentation of networks through deployment of ocean observation platforms funded by agencies such as INCOIS coastal states.

Support coordinated Observation systems for Glacier Monitoring

Glacier mass balance measurements are available only at a few benchmark glaciers across High-Mountain Asia (HMA). Such measurements are, however, logistically difficult. However, for a better representation of regional changes such observations need to be in adequate numbers to substantiate the remotely sensing estimates that are being used to monitor such a critical parameter impacting the hydrometeorology of the region.

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Annex I- Baseline information of the observational systems networks in the SAHF region

Table 4: Baseline information of the observational systems networks in the SAHF region

Observational Infrastructures	Afghanistan	Bangladesh	Bhutan	India	Maldives	Myanmar	Nepal	Pakistan	Sri Lanka
Surface Meteorological Networks									
Synoptic stations	25	57	-	??	??	121	16	97	23
Rain gauges	336 (312 by MEW & 24 AMD)	-	64 (with temperature recordings)		8	-	289 rainfalls; 112 climatological	??	135; 500 in collaboration with other agencies
Automatic Weather Stations	6	60 automatic weather stations; only 7 functional (3). 35 (to be added by WB project)	170 AWS (1).	700	20	158	100 (90 working); 6 AWS for glacial monitoring	95 (15 not functioning)	38
Automatic Rain gauges	??	125 stations to be added under the WB project	-	1400 (500 equipped with temperature and humidity sensors)	-	??	??	??	??
Lightning Detection systems	??	8	-	48	-	-	8	??	1 (experimental state)
Agromet stations	9 (operated by MAIL)	20, 65 (to be added by WB project)	20	??	-	17	21	??	??
Soil moisture	??	10	-	??	-	??	??	??	
Marine Observation systems	??	2 automated coastal ocean monitoring (WB, 2020)	-	563 including 10 coastal radars	-	3 (tide gauges)	-	??	??
Seismic stations	??	10	-	??	-	21	??	??	??

Air Quality Monitoring network	??	??	-	58	??	??	??	??	??
Radars (Doppler)	??	5 RADAR system [conditions not good; 2 RADARS non-functional, 3 partially functioning, JAICA replacing 2 RADARS]	-	50	1	3	1 (2 under installation)	7	2 to be installed
Upper Air Network									
Radiosonde Obs. Stn.	??	4	-	39	??	2	1	6	1
Pilot Balloon Obs. Stn.	??	10	-	62	??				4
Pilot GPS Sonde Network	-	??	1 (stopped, no hydrogen gas)	-	??	-	-	-	-
Satellite Data									
Satellite Data reception	Meteosat-8	Meteosat-8, HIMAWARI-CMA FY and KMA; Satellite receiver station/Digital Satellite Data Processing System	HIMAWARI satellite receiver station/Digital Satellite Data Processing System	INSAT-3D & INSAT-3DR	Satellite products from INSAT/KALPANA; METEOSAT 41.5 DEGREES (IODC)	DIANA System - Himawari Data	??	Chinese FY-2 Geostationary Satellite and some FY-3 Polar-orbiting are received through CMACast; EUMETSAT.	MA Feng Yun & the Japanese Himawari
Data sharing and exchange									
National data collection	Manual and automatic	Manual and automatic (1)	Manual and automatic (1)	Manual and automatic	??	Manual and automatic	Manual and automatic	Manual and automatic	Manual and automatic
WMO Global Telecommunication System	6 stns.	147 stns.	1 stn.	??	3 stns.	??	16 stns.	56 stns.	??
Climate Database Management System									

	??	Manual climate data storage system (??)	Standalone database; CLIMSOF T	??	No (stored in excel)	CLIMSOF T	CDMS (data stored in CDMS)	Locally built software (no standard CDMS)	CLIMSOF T
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Annex II- Working Group Meeting for Observational Networks Overview

The meeting of the Working Group (WG) III- Observational Networks (OBN) was held on 29 June 2021, from 1:00 to 2:30 PM Bangkok time (UTC+7) through virtual mode. 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 in OBN
- To appoint Co-Chairs of WG
- To acquaint WG members with 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 III-Observational Networks at 1:00 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. G. Srinivasan, Chief Scientist, 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 highlighted the need for the improvement and sustenance of the OBN in the SA region. He expressed his anticipation for further implementation of the activities of the WG ToR.

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 works of the WG forward.

Appointment of Co-Chairs

To lead the WG and liaise with the project team of the 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 tentatively elected the following delegates as the co-chairs for the WG III-Observational Networks. The final decision regarding the Co-Chairs is yet to be made.

Mr. Suman Kumar Regmi, Senior Divisional Meteorologist, Department of Hydrology and Meteorology, Nepal (Co-Chair)

Mr. Nadeem Faisal, Director, Climate Data Processing Center, Pakistan (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 observational networks. The summary of priority requirements of observational networks in South Asia (SA) are highlighted below:

- Real time observing system network augmentation to an optimal scale and build technical maintenance support strategy at national level
- Expansion of Doppler Weather RADAR network and its integration with satellite observing systems for Monitoring and Detection of extreme weather events for operating local nowcast services.
- Seamless crowd sourcing of extreme weather conditions and impacts from countries in the SA region along with tools for emergency response planning.
- Establishing effective lightning detection network for mapping hotspots of lightening intensity with associated thunderstorm data integration for targeted hazard communication protocols in support of lightening early warning services for public safety. Meeting training requirements to improve human resource in data processing and equipment related work in IT

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

Table 5: Country-wise requirements and priorities for Observational Network

Country	Priority requirement for OBN
Afghanistan	Increasing the number of trained professionals in meteorological department Capacity to support weather forecast Establishing sufficient real time data observing system networks
Bangladesh	Needs to establish a regional network for Lightning detection and early warning system Develop RADAR maintenance team and restoring faulty Doppler RADAR
Bhutan	Need to increase the number of weather observation stations in the northern parts of the country Establishment of DWR network Need for in-depth training of professionals on operation, calibration and troubleshooting of automatic weather/water level stations.
India	Need for addressing O & M issues and sustained acquisition of quality controlled data from observational system networks
Maldives	Establishment of lightning detection network Requirement of additional upper air observation and ocean observation systems Crowd sourcing of extreme weather information from several Islands
Nepal	Requirement of more weather stations in higher altitudes Capacity building in terms of human resource in OBN quality control Evolving quality control mechanism of OBN data

	Proposed for Wind Profiler Network Proposed for building system for Monitoring, detection and nowcast early warning services
Pakistan	Training of Met observers on additional parameters (agromet parameters) and refresher knowledge for met technicians Additional Radiosonde observations for supplementing upper air observations Access to additional satellite observation and installation of Doppler radar to increase coverage in the country Expansion of AWS network

Discussion and way forward

Dr. Srinivasan RIMES moderated the discussion session. The following recommendations ensued from discussions for taking the work in OBN forward.

- Data sharing and exchanges as per WMO standard is a critical aspect of OBN in the SA region
- Crowdsourcing of data within the SA region could be beneficial
- It is necessary to articulate OBN country needs and align them with the GBON and WMO standards.
- Regional needs for additional observations should be identified and supplemented to the GBON standards. The Systematic Observations Financing Facility (SOFF) is expected to provide long-term support for nations to achieve and maintain GBON compliance and data-sharing while leveraging its global value. SAHF could clearly articulate needs.
- Strategize implementation of RADAR network within scope of the SAHF project
- Common strategies for establishing manned and automatic observatory should be evolved
- Orientation courses for using lightning data to be considered.

Appendix-1: Agenda

Table 6: Agenda of Working Group meetings held on 28-29 June 2021

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) <i>Reflections on WG TOR</i> <i>Priority needs of each country based on respective Thematic Areas</i>	45
Discussion and way forward	25

Schedule

Table 7: Schedule of Working Group meetings held on 28-29 June 2021

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

Table 8: Participant list of the Working Group meetings held on 28-29 June 2021

WG-3	Mr. Said Rahman	Afghanistan	Saidrahmannaim@gmail.com
	Mr. Md. Abdul Matin	Bangladesh	amatin2004@yahoo.com
	Mr. Jangchup Choephyel Dorji	Bhutan	jcdorji@nchm.gov.bt
	Shri Uday Kumar Shende	India	uday.imd@gmail.com
	Mr. Ibrahim Humaid	Maldives	ibrahim.humaid@met.gov.mv
	Mr. Suman Kumar Regmi	Nepal	sumankregmi@gmail.com
	Mr. Nadeem Faisal	Pakistan	nadeemfaisal@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	Ms. Waitoe Aung	Myanmar	
	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 below.

Table 9: 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 10). The consultation meeting was attended by the WG members of SAHF four thematic areas from the SAHF member countries.

Table 10: 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 between 03:30 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

Table 11: Outlines of consultation meeting between WG from SAHF and Afghanistan

Impact Forecasting	Based	<p>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</p>
		<p>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</p>
Numerical Prediction	Weather	<p>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</p>
		<p>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</p>
Observational Networks		<p>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</p>
		<p>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.</p>
Capacity Building		<p>Existing Capacities</p>

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 12: Outlines of consultation meeting between WG from SAHF and 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 1
Impact Based Forecasting	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

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 13: Outlines of consultation meeting between WG from SAHF and Bhutan

Impact Forecasting	Based	<p>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)</p>
		<p>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</p>
Numerical Prediction	Weather	<p>Existing Capacities WRF models</p>
		<p>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</p>
Observational Networks		<p>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</p>
		<p>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</p>

Capacity Building	<p>Existing Capacities Virtual Training from WMO, IMD and RIMES on Seasonal Operational Services and Nowcasting</p>
	<p>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)</p> <p>Academic long term – degree courses: Aeronautical Meteorology Electronics and Communication Glaciology Instrumentation</p>

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 14: Outlines of consultation meeting between WG from SAHF and 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 15: Outlines of consultation meeting between WG from SAHF and 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 16: Outlines of consultation meeting between WG from SAHF and Myanmar

Impact Based Forecasting	<p>Existing Capacities</p> <ul style="list-style-type: none"> IBF in initial stage Water Level Forecast Flood Hazard Map-Hydrology Department Seismic Hazard Map- Hydrology Department Meteo LAN- EWA 2 threshold value
	<p>Gaps and Needs</p> <ul style="list-style-type: none"> Utilizing hazard data for issuing warning Hazard map for extreme rainfall, heat hazard and others
Numerical Weather Prediction	<p>Existing Capacities</p> <ul style="list-style-type: none"> 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
	<p>Gaps and Needs</p> <ul style="list-style-type: none"> 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 17: Outlines of consultation meeting between WG from SAHF and Nepal

Existing Capacities

Impact Based Forecasting	<p>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)</p>
	<p>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</p>
Numerical Weather Prediction	<p>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)</p>
	<p>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</p>
Observational Networks	<p>Existing Capacities 1 RADAR (2 under installation) 100 AWS (90 working)-PPCR Work on scanning strategy and data sharing Glacier Monitoring System – 6 AWS at high altitude other stations for Glacier mass-balance in collaboration with ICIMOD 2 upper air stations are being planned with Govt Nepal funds</p>
	<p>Gaps and Needs Glacier and Snow Monitoring Section</p>
Capacity Building	<p>Existing Capacities Refresher trainings for forecasters [1-2 years one] On the job training</p>
	<p>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.</p>

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 18: Outlines of consultation meeting between WG from SAHF and Pakistan

Impact Based Forecasting	<p>Existing Capacities</p> <p>Ties with National disaster management authority, province disaster management authority and district DMA</p> <p>Weather Advisory-Information on identified impacts</p> <p>Flood Forecasting Division-Lahore</p> <p>Robust system for riverine flooding</p> <p>Flood Forecasting updated through website, fax, emails, and WhatsApp messages</p> <p>Weather Forecast Guidance System- Responsive and Robust [Ongoing]</p>
	<p>Gaps and Needs</p> <p>Impact Assessment</p> <p>Integration of forecast with severe weather events</p>
Numerical Prediction	<p>Existing Capacities</p> <p>Two new Doppler Radars</p> <p>90+ Weather Stations</p> <p>METCAP+</p> <p>COSMO Model and ICON Model</p> <p>GFS Model downscaling</p> <p>JMA Model</p>
	<p>Gaps and Needs</p> <p>Numerical Modelling</p> <p>General processing of numerical models</p> <p>Assimilating various available data for forecasts</p> <p>Validation of NWP models</p>
Observational Networks	<p>Existing Capacities</p> <p>Access to ECMWF data</p> <p>Surface Observations</p> <p>GLOF project- 2nd phase</p>
	<p>Gaps and Needs</p> <p>Dense Network</p> <p>Better Ground Observations</p> <p>Better Radiosonde Observations</p> <p>Upper Air Observations</p>
Capacity Building	<p>Existing Capacities</p> <p>Trainings in</p> <p>Initial Meteorology Courses and other introductory courses</p> <p>Product Interpretation-JMA</p>

	<p>Gaps and Needs</p> <p>Trainings in IBF and NWP</p> <p>Trainings in data modelling, climate modelling, model validation and data assimilation</p> <p>Mechanism for refresher courses</p> <p>Improved computational capacities [ICT Infrastructure]</p> <p>Human resources lacking</p>
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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 19: Outlines of consultation meeting between WG from SAHF and Sri Lanka

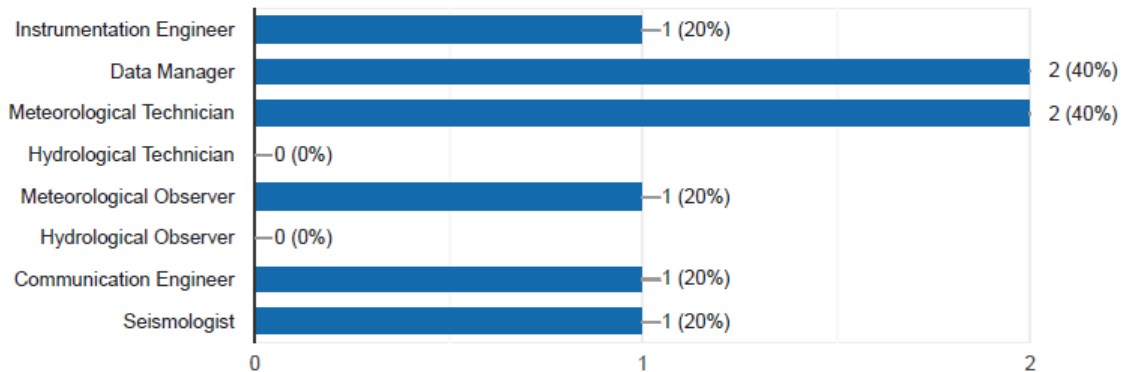
Impact Forecasting Based	<p>Existing Capacities</p> <p>Flash Flood Guidance</p> <p>Warning depended on thresholds</p>
	<p>Gaps and Needs</p> <p>Early warning for costal inundation</p> <p>Knowledge about impact from equatorial waves</p> <p>Automatic Rain Gauge System linked to FFG</p> <p>Single weather threshold for entire country. Specific thresholds for different areas.</p>
Numerical Prediction Weather	<p>Existing Capacities</p> <p>Utilizing ECMWF Forecasts</p> <p>Data from INCOIS</p> <p>ECMWF ecCharts</p> <p>Standard Verification for 24 hours</p>
	<p>Gaps and Needs</p> <p>Customization requirements</p> <p>Verification for ocean products</p> <p>Verification of upper air temperatures and temperature data.</p>

	Verification of ocean model data
Observational Networks	<p>Existing Capacities</p> <p>Two new Doppler Radars[Yet to be installed] One radiosonde observation station Pilot balloons- 4 stations Lighting detection system- Chinese Government [Experimental State]</p>
	<p>Gaps and Needs</p> <p>Weather Buoys Real time data for thunderstorm and lighting forecast [Automatic Rain Gauges- Expansion of real time data network] Integration of Automatic Rain Gauges</p>
Capacity Building	<p>Existing Capacities</p> <p>Trainings in</p> <p>Basic Meteorology [New Recruits] On the job training [New Recruits]</p>
	<p>Gaps and Needs / Trainings in</p> <p>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</p>

Annex IV – Country Survey

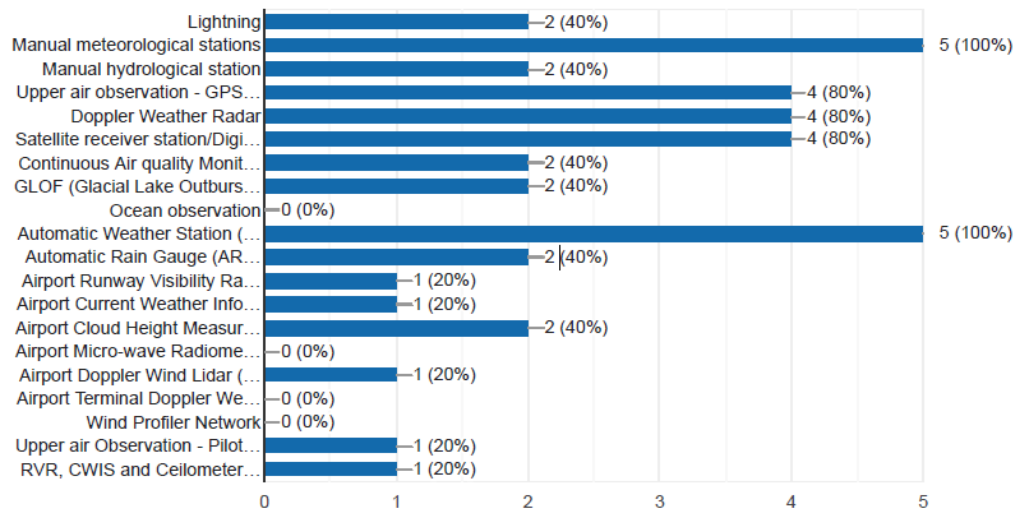
1. Nature of Work

5 responses



2. Please provide details of your agency's observational network

5 responses



3. Describe if these observation systems are adequate for the operational and extreme weather system's monitoring support to you?

- Yes, but we have no buoy observation in Bay of Bengal.
- Not enough
- The existing observation system is considerably inadequate
- We have observational network gap at northern part of the country. Moreover, we do not have calibration lab. There is a need for weather RADAR observation as well to get the real time spatial observation to further enhance our weather forecast accuracy.

- The observation systems at present are not adequate. Especially, there is more network gap in weather observation in high altitude regions above 3500 msl. Also we don't have wind profilers.

4. Please provide a list of other observational networks that your agency has access to.

- None
- No
- Provincial Irrigations Departments
- none

5. Describe the challenges in the operation and maintenance of observational networks? (e.g., different type of stations, data format and integration and inter-operability, human capacity etc.) 5 responses

- Human capacity and inter-operability of data.
- Minimum human capacity, data not integrated, instrument calibration difficulty and need more observational networks.
- Significant spatial gaps of observation in some areas, recording of additional parameters and refresher observational & instrumental knowledge of Met technician.
- We do not have experts to maintain stations. - We do not have capabilities in integrating new sensors with data logger and servers.- We have different servers for different brands of observational stations.- Accessibility to remote and high altitude areas is difficult and dangerous.
- Various stations, Hi-Tech system to handle and operate, Insufficient Human Resources, data format and its integration such as for RADAR.

6. Describe the challenges in the operation and maintenance of observational networks? (e.g., different type of stations, data format and integration and inter-operability, human capacity etc.) 5 responses

- Human capacity and inter-operability of data.
- Minimum human capacity, data not integrated, instrument calibration difficulty and need more observational networks.
- Significant spatial gaps of observation in some areas, recording of additional parameters and refresher observational & instrumental knowledge of Met technician.
- We do not have experts to maintain stations. –
- We do not have capabilities in integrating new sensors with data logger and servers. -
- We have different servers for different brands of observational stations.-
- Accessibility to remote and high-altitude areas is difficult and dangerous.
- Various stations, Hi-Tech system to handle and operate, Insufficient Human Resources, data format and its integration such as for RADAR.

7. What are the critical and residual gaps in operation and maintenance of the observation network? (e.g climate database, automation, quality control etc) 5 responses

- Quality control, automation and lack of skill manpower
- Manual quality control done monthly, no database at the moment and data stored in excel sheets.
- Installation of additional AWS and replacement of AWS with manual observation system. Implementation of climate database management system.
- Need to have robust and open data logger and server to be customized as per the user needs.- Trained personal for operation and maintenance of automatic stations.- Calibration and data quality check.
- Limited staffs in IT and communication, equipment related works, data processing and quality control, Still, we have not able to implement quality control in full fledge.

8. What are strategies adopted by your agency to address the gaps in operation and maintenance of observational networks? Need for support in building appropriate O & M strategy may also be indicated. 5 responses

- Only few trainings program
- Train enough technical staff, expand observational network, develop decision support systems and procure enough it equipment for staff use.
- Lack of sufficient financial resources is major issue, although the department, time to time, approaches the government for allocation of additional funds for operation & maintenance of the observation network.
- The agency provides refresher course to site staffs on basic operation and maintenance of the instruments and other accessories.- Have plans to setup calibration lab
- Shifting towards automation in measurement, Forward the proposal on O&M with line ministry and other agencies, Capacity building

9. Do AWS and ARG Networks have 2-way communication with the data reception server? If not so, any plans of upgrading to 2-way communication protocol? 5 responses

- Yes
- We are going to establish AWS and ARG Networks with 2- Way communication
- No, No upgradation plan yet due to paucity of funds

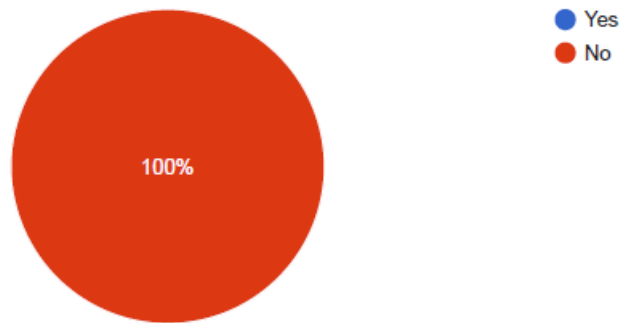
10. List any other agency systematically recording Meteorological observations and/or hydrological observations. 5 responses

- None
- In Bangladesh, another organization, Flood Forecasting and Warning Center records only hydrological observations

- Pakistan Water & Power Authority Provincial Irrigation Departments
- Department of Agriculture, Department of Forest, Department of Roads and Druk Green Power Corporation.

11. Are these data shared with NHMS and archived?

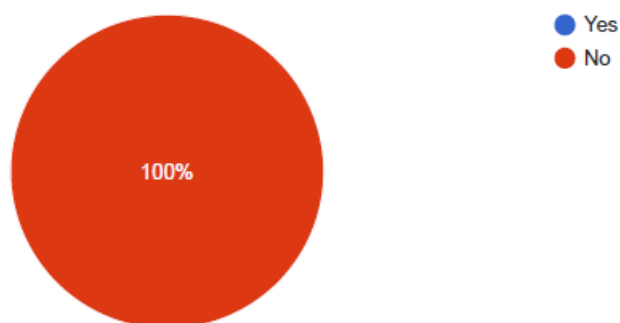
5 responses



Status of Human Resources

12. Is there enough technical human resource within the department for Maintenance and calibration of AWS?

5 responses



13. Describe the skill level of technical human resource available within the department for network maintenance (e.g. No skill, Basic entry level, mid level, etc.)

- Basic entry level and few mid-level
- Most are basic entry level and few mid and higher level.
- Good level
- Can carry out basic maintenance and troubleshooting of automatic stations.
- Mid-level

14. Describe the skill level of technical human resource available within the department for data analysis of different types?

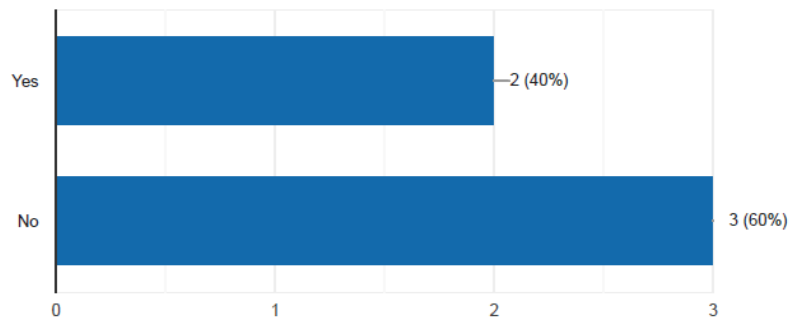
- Only few mid-level human resources are available
- Very basic level.
- Good level
- Does basic data quality check.
- Mid-level

15. List the Technical Human Resources requirement to efficiently manage the existing observation network? 5 responses

- Requirement of technical human resources are Basic entry level -10 persons, Mid-level- 5 persons and expert level- 2 persons
- Trained instrument technicians, At least BIP-MT qualified meteorological technicians, trained staff in climatology trained staff in data analysis.
- Frequent visit to observation sites Scheduled instruments calibration Uninterest and error free data communication system Refresher training of Met technicians/observers Repair/replacement of faulty/unserviceable sensors
- There is a need to have Master program on Instrumentation engineering. - There is a need to provide short term training and on job training on operation and maintenance of stations, calibrations and data quality control.
- ICT, Equipment and calibration, data processing and quality control

16. Is there a Standard climate Database management system (CDMS) currently in place?

5 responses



17. If no, please state how you are currently managing the data.

- Earlier we had Climate database management system along with manual Climate data storage system. Manual Climate data storage system is working well and we are going to establish new CDMS in very nearfuture.
- Data are stored in excel sheets after manual quality check is done monthly.
- in-house/locally built in software's

18. If yes, are all these stations and other datasets integrated in to the CDMS? Please describe how data is integrated. 4 responses

- It will be done with our new CDMS
- No integration at the moment.
- Yes, the other servers transfer the data collected via FTP to the CDMS but the current CDMS does not have the capacity to integrate all the stations.
- Yes. File format data are stored in Network-attached storage (NAS)

19. List the current challenges in using and managing the CDMS tool 5 responses

- Lack of expertise to use and manage the CDMS tool
- No CDMS established
- Could not implement CDMS due to shortage of financial resource
- Does not have the capacity to integrate all the observational stations. - Have issue with transferring the data from one server to CDMS.
- Timely update and improvement

20. Are there any standard mechanism for Data Quality control? Please describe.

5 responses

- Not yet
- None
- Through using in-house built-in programs
- Automatic control mechanism does the basic data quality control that can be customize by the users.
- Automatic QC-Human QC

21. Provide the number of stations currently linked to GTS5 responses

- 47 stations
- 03
- 56
- Tsampa AWS is only connected.
- 16

22. Provide a list of remote sensing data currently accessed and used by your agency? 4 responses

- No
- Doppler weather radar.
- Doppler radars data Satellite pictures
- Satellite data

23. Please specify the Automatic weather station/Automatic Water level Stations requirements in your country based on network design/ geography and demographics. 5 responses

- As per requirement we are going to establish another 35 AWS all over the country
- At least one AWS in each atoll, two or three in bigger atolls. Need support for AWS maintenance.
- Presently PMD has the access to 160 surface observation sites (96-PMD manned stations, 14-PAF stations &40-PMD AWS). PMD must now modify its observation strategy to survive in the future. PMD observation stations network should be expended in way to cater the existing spatial station gaps. In general, the network of automated surface stations should reach around 500. At present PMD has very little upper-air observation system (observations are operational due financial constraints) and radiosonde observation network must be established to at least 20-25 stations.
- We uses automatic weather stations and automatic Water level stations with online data communication using either GPRS network, HF communication or satellite communication as there are no human settlements near the river banks and because of extreme weather at higher altitude.
- Varies as per geographic condition.

24. Please specify the ocean observation requirements in your country based on the geography and demographics 5 responses

- In southern part of Bangladesh, a huge area is not covered under meteorological observation as in Bay of Bengal we have no buoy observation. We need to establish at least 5 buoy observatories.
- Require ocean observation from at least three locations namely north, center and south.
- Presently PMD has no ocean observations. The coastline of Pakistan extends 1,050 km and its territorial waters cover an area of 24,000 square-km with its population over 220 million. PMD needs to establish sufficient numbers (15-20) of stations for ocean observation.
- Does not ocean in our country.




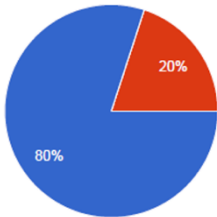

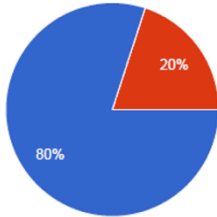
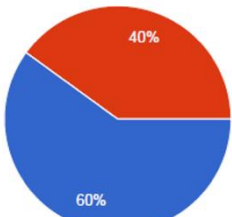
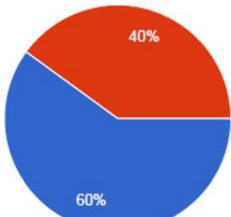
25. What are the communication requirements for data uninterrupted data transmission? Provide the details needs 5 responses

- Currently we are using GSM and broad band Internet service for uninterrupted data transmission. So need to improvise the services.
- Need redundancy network in case failure of basis ISP network during a disaster like satellite-based communication network.
- Replacement of existing GPRS with high speed & secured satellite-based communication system.
- HF and satellite communication is needed as whole country does not have GPRS network coverage or have poor GPRS network.
- Upgrading communication network (External factors), Satellite communication

26. Are there ongoing initiatives for installation and expansion of the network (WB, ADB, FAO, other Un agencies)? 5 responses

- Yes, through WB
- AWS installation. integration project and wave modelling project. (Italian aid)
- No
- Bhutan for Life project under UN LDC-GCF will install three new stations at high altitude in norther part of the country.
- ADB (Priority River Basins Flood Risk Management Project)

27. Observation Network System status and needs

<p>Systematic Data Archiving and Management 5 responses</p> 	<p>Observation data processing 5 responses</p> 
<p>Observation Network Maintenance 5 responses</p> 	<p>Observation (Optimum) Network Design 5 responses</p> 
<p>Field and Lab Calibration 5 responses</p> 	<p>Upper air observation mechanism 5 responses</p> 
<p>Ocean observation mechanism 5 responses</p> 	<p>Observations for glaciers and snow monitoring 5 responses</p> 

- Required
- Not required

28. Please provide suggestions how you can leverage capacities available in the region in development of an optimum observational network in the region. 4 responses

- Regional RADAR network and Lightning network can be established
- Provide financial aid, train our staff, provide in-house training, and exchange programs.
- Networking and on job training from regional experts would assist in realizing the development of an optimum observational network in the region.
- Regular training, facilities such as sufficient field vehicle, enough travel allowances for high altitude regions (at present, we have same TA throughout the country as per government rules and regulation)

29. What are the future plans to attain an optimum observation network and highlight ongoing initiatives? 5 responses

- Our ongoing initiatives are to establish 35 AWS, 65 ARG and 125 Ag-AWS all over the country. Replacing two conventional RADARs with Doppler RADARs. A receiving system of Geo-KOMPSAT-2 soon to be install
- Train enough staff for areas, expand network and capacity and procure information systems for staff use and conduct and maintain competency of staff.
- 40 numbers of AWS are being installed over the country with help of JICA.
- Use is currently using RADAR data from IMD for weather forecast or weather warning and hope that some of the critical synoptic stations could be shared real time to further assist the weather forecaster in making their decisions.
- Upgrading existing stations, review current station network, calibration of equipment in full fledge and also timely replace sensors if required

30. Describe strength of your department on observation network which other countries can leverage from (e.g. Observational network, data analysis, calibration, etc.,) 5 responses

- RADAR observational network, AWS network, ARG and AG-AWS
- Service delivery, SOP's.
- Data analysis
- We have good observational network and have experience in maintaining automatic weather station for over a decade now.
- Implementation of automatic QC, maintain observation network in complex geographic conditions

31. Please provide additional or other specific requirements for observational network and data. 4 responses

- Satellite derived microwave data
- Lightning network, three ocean observation systems, two more weather radars, cloud height measuring ceilometers and airport runway visual range. Provide enough IT instruments for staff use.
- None.
- None

Annex V – SAHF III Outcomes

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.

Establish a robust Regional Data Exchange mechanism

10. 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.

Capacity Enhancement

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.

Priority	Targets	Time Frame	Considerations for implementation
Enhance observations & integration into forecasting	1. NHMS-ECMWF and <u>RIMES -Data Exchange Platform</u> 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
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

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
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