Contents

ACRONYMS

ADSS	Agromet Decision Support System
AI	Artificial Intelligence
ARRCC	Asia Regional Resilience to a Changing Climate
BCWC	BIMSTEC Center for Weather and Climate
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
C3S	Copernicus Climate Change Service
CAPEX	Capital Expenditure
CARA	Climate Action for a Resilient Asia Program
COP	Community of Practice
DataEx	SAHF Data Exchange
DRM	Disaster Risk Management
DSS	Decision Support System
EC	SAHF Executive Council
ECMWF	European Center for Medium-Range Weather Forecasts
EU	European Union
EUMETNET	European Meteorological Network
EWS	Early Warning System
FCDO	UK Foreign Commonwealth and Development Office
FMI	Finnish Meteorological Institute
GBON	Global Basic Observing Network
GFDRR	Global Facility for Disaster Risk Reduction
GFCS	Global Framework for Climate Services
HMEI	Hydro Meteorological and Environmental Industry
ICIMOD	International Centre for Integrated Mountain Development
IBF	Impact Based Forecasting
IBFEWS	Impact Based Forecasting Early Warning System
IFRC	International Federation of Red Cross Red Crescent
IMD	India Meteorological Department
INCOIS	India National Centre for Ocean Information Services
IWMI	International Water Management Institute
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Prediction
NCMRWF	National Centre for Medium Range Weather Forecasts
NCHM	National Center for Hydrology and Meteorology
NDRRMA	National Disaster Risk Reduction and Management Authority
NFCS	National Frameworks for Climate Services
NMHS	National Meteorological and Hydrological Services
NWP	Numerical Weather Prediction
ON	Observation Network
RAP	Resilient Asia Program
RIMES	Regional Integrated Multi Hazard Early Warning Systems
RMC	Regional Met Centre
SA	South Asia
SAHF	South Asia Hydromet Forum
SAR	South Asia Region
SASCOF	South Asia Seasonal Climate Outlook Forum

SEB	Socio Economic Benefit Analyses
SIDS	Small Island Developing States
SKHub	SAHF Knowledge Hub
SOFF	Systematic Observations Financing Facility
UN	United Nations
UN-ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WB	World Bank
WG	SAHF Working Group
WISER	Weather and Climate Information Services Programme
WMO	World Meteorological Organization

Executive Summary

South Asia is the most densely populated region in the world and particularly vulnerable to climate change-related hazards such as floods, landslides, and tropical cyclones - threats which transcend borders and wreak havoc on communities, infrastructure, and economies. With over 750 million people across eight countries bearing the brunt of climate-related disasters, the imperative for collaborative action has never been more urgent. The South Asia Hydromet Forum (SAHF) serves as a critical platform for stakeholders from diverse sectors to converge, exchange insights, and chart a course towards enhanced resilience in the face of escalating climate risks.

Founded in 2018, SAHF has evolved into a vital nexus for regional cooperation in hydromet, early warning, and climate services for the countries of South Asia. SAHF has spearheaded initiatives ranging from data exchange platforms to capacity building programs. Through collaborative efforts, SAHF has facilitated regional collaboration around priority topics, knowledge and data sharing, enhanced forecasting product accessibility, and empowered stakeholders to navigate the complex landscape of climate resilience.

The fourth South Asia Hydromet Forum (SAHF IV), convened in Colombo, Sri Lanka, from February 6th to 9th, 2024, marked a pivotal moment in the region's collective efforts to address the multifaceted challenges posed by climate change. SAHF IV focused on unlocking regional synergies to improve hydrometeorological services and disaster management, framed by the concept of value creation and decision-making based on actionable hydromet information. The conference delved into five key themes, each addressing critical aspects of climate resilience:

Creating value – the role of hydrometeorological services: Participants emphasized the importance of providing actionable information to reduce weather, water, and climate risks, highlighting the value derived from user-driven services and interagency collaboration.

Forging a shared vision for building a regional observation network: Discussions centered on expanding and sustaining observation networks to achieve high-resolution spatial and temporal observations, emphasizing the need for collaboration and efficient utilization of existing resources.

Fostering regional collaboration to strengthen service delivery and impact on public welfare: Participants explored opportunities for joint enhancement of services, particularly for vulnerable populations across diverse geographic contexts (e.g., mountainous, coastal, and agricultural regions).

Empowering Communities to make informed decisions: Discussions focused on digital solutions and last-mile communication necessary to enable anticipatory action and progress towards climate resilience.

Towards Regional Prediction and Analytics: Participants examined requirements, resources, and coordination mechanisms needed to support the strengthening of regional forecasting and scenario planning, including the adoption of emerging technologies.

Framing the elements of a SAHF action plan: Attendees collaboratively identified actionable next steps for SAHF, with a focus on enhancing observation networks, fostering data sharing, enhancing early warning services, investing in capacity building, and giving consideration to climate services for longer term resilience and adaptation.

Stakeholders reaffirmed their commitment to strengthening the capabilities of National Meteorological and Hydrological Services (NMHSs) and expanding collaboration across sectors and borders. Embracing a vision of resilience that transcends geographical boundaries, participants pledged to foster multi-sectoral Communities of Practices (COPs) and bolster regional partnerships to drive collective action towards climate resilience. Several actionable recommendations emerged, including the need for financial support, skill development, and collaborative frameworks.

Critically, SAHF IV resulted in a SAHF IV Declaration, outlining commitments to strengthen information and services to support informed decision-making among user communities, with a focus on deepening collaboration, improving regional observation networks, and strengthening hydromet services for public services and climate resilience. The Declaration acknowledges strategic partnerships, highlights the need for resource mobilization and coordination, and underscores the importance of reinforcing early warning systems and institutional mechanisms for successful program implementation.

Going forward, efforts will center on establishing COPs for knowledge exchange, ensuring sustainability of national investments through collaboration with RIMES and other development partners, and engaging the private sector for hydromet service delivery, and leveraging synergies between the hydromet, air pollution, and heat agendas.

Introduction

South Asia is prone to a range of hydromet hazards, and Bangladesh, Nepal, and Pakistan are in the top 10 vulnerable countries to climate change[1]. Between 1990 and 2022, a total of 1,210 meteorological, hydrological, climatological disasters were reported in the region, cumulatively affecting over 1.8 billion people in the nine countries—Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan, and Sri Lanka—and leading to over 420 thousand deaths. The economic damages from the disasters are estimated to be close to US$ 250 billion[2]. The changing climate could sharply diminish living conditions for up to 800 million people in a region that already has some of the world's poorest and most vulnerable populations. Importantly, climate change related losses in GDP per capita are projected to be higher than the global average by up to seven percent [3]. Meteorological and hydrological information is required on all time scales, from the immediate impact of a weather event causing floods, landslides or coastal inundation, to adaptation planning with the purpose to mitigate the threat of climate change on society and to maximize productivity of climate sensitive sectors and ultimately create socioeconomic benefits.

South Asian (SA) countries are varied in their capacities and access to quality early warning and hydromet services. As different countries make efforts to modernize their systems and transition towards delivery of user-oriented hydrometeorological and early warning services, they face many technical, capacity, sustainability and other challenges which are common across the region. There is a clear understanding of the potential of regional collaboration in this context, not only to manage difficulties in operationalizing technologically complex systems and strengthen capacities while also enhancing service quality, but also to maximize South Asia's capability to become a region of excellence.

The South Asia Hydromet Forum (SAHF) serves as a platform connecting national meteorological and hydrological service providers (NMHSs) from the region to promote data and knowledge exchange, address technical challenges, and enhance collaboration. Simultaneously, SAHF enables NMHSs and user sectors to collaborate on improving the delivery and use of weather, water, and climate services to minimize the adverse impacts of natural hazards. As a catalyst for enhanced coordination and collaboration, SAHF organizes conferences, with the latest event, SAHF IV – Unlocking Regional Synergies, held in Colombo, Sri Lanka, from February 6 to 9, 2024.

History of SAHF

The history of SAHF builds upon collaborative efforts made by each country in the region, with support provided by the Global Facility for Disaster Reduction and Recovery (GFDRR) through the European Union financed EU-South Asia Capacity Building for Disaster Risk Management program and UK Foreign Commonwealth and Development Office (FCDO) through the Asia Regional Resilience to a Changing Climate (ARRCC). The inaugural South Asia Hydromet Forum, co-hosted by the World Bank (WB) and the World Meteorological Organization (WMO) in Geneva, Switzerland, in 2018, marked a pivotal moment. It paved the

[1] Germanwatch Global Climate Risk Index (2021): The 10 countries most affected from 2000 to 2019 (annual averages)
[2] According to the EM-DAT database as of June 30, 2022.
[3] World Bank. (2021). Climate Change Action Plan 2021-2025: South Asia Roadmap.

way for SAHF's establishment as the platform for regional exchange, collaboration, and fostering innovation on hydromet, early warning and climate services in the region.

In 2019, at the second South Asia Hydromet Forum, hosted in Kathmandu, Nepal, the SAHF Executive Council (SAHF EC), comprising heads of NMHSs from South Asian countries was established and began defining the strategic direction of SAHF. The Regional Integrated Multi-Hazard Early Warning System (RIMES) was designated to serve as the SAHF Secretariat and Program Unit. Technical working groups (WGs), with representation of all member countries, were formed to address critical hydromet priorities, including observation networks, numerical weather prediction, impact-based forecasting, capacity enhancement and, since December 2023, hydrological services.

SAHF III, held virtually in November 2021 during COVID-19 pandemic, focused on strengthening regional collaboration and stimulating innovation, formally launching a set of initiatives such as the SAHF Data Exchange and the Forecasters Forum as further detailed below.

Achievements

SAHF has made remarkable progress in enhancing collaboration and coordination for hydromet and early warning services across South Asia, while also fostering knowledge generation and sharing throughout the region. The key results supporting stakeholders in the region include:

- **Data exchange**

To facilitate data exchange and access to hydrometeorological information, SAHF has developed the **SAHF Data Exchange** (DataEx) platform (QR CODE below). This platform provides access to numerical weather prediction products and information from regional and global centers e.g. from the European Center for Medium-Range Weather Forecasts (ECMWF), National Centers for Environmental Prediction (NCEP), and the India Meteorological Department (IMD). It also enables regional and global centers (e.g. ECMWF) to access local observation data of the region, while offering the opportunity for data exchange between countries. Additionally, DataEx integrates socio-economic information, enhancing its utility for decision-makers.

- **Knowledge generation**

SAHF has conducted four **regional assessments of the hydromet supply chain**, outlining a strategic approach to address present and future needs from a regional perspective. These assessments cover four priority themes: observation networks, numerical weather prediction, impact-based forecasting, and capacity building (QR CODE).

- **Knowledge sharing**

SAHF has established the **SAHF Knowledge Hub** (SKHub), serving as a virtual library and repository for documents and proceedings of SAHF conferences. SKHub also hosts virtual training webinars, providing stakeholders with valuable insights and expertise in hydrometeorological matters (QR CODE).

Moreover, SAHF has established a **regional data analytics hub** aimed at transforming data into actionable information (QR CODE). This hub leverages state-of-the-art IT technology to develop Decision Support Systems (DSSs), empowering users and beneficiaries of weather information with tools for informed decision-making. These initiatives collectively underscore SAHF's commitment to become the regional technical hub for knowledge generation and sharing across South Asia.

- **Regional Collaboration**

SAHF organizes the weekly **Forecasters' Forum** (FForum) for operational weather forecasters to discuss complex weather situations including approaching extreme events, oceanic conditions, and share knowledge and experience to improve forecasting services. As of March 2024, 108 weekly fora were held.

SAHF has established four **Working Groups**, each dedicated to one of the priority topics: numerical weather prediction, impact-based forecasting, observational networks, and capacity enhancement. These working groups comprise at least one expert from each SAHF member country and play a pivotal role in advancing the dialogue on these priority topics. In 2022, the working groups were also instrumental in assessing the existing capacities, gaps, and establishing priorities in the four identified areas, laying the foundation for the four regional assessments of the hydromet supply chain.

- **Capacity building**

Additionally, SAHF organized **online and in-person regional training programs** for staff of national hydromet organizations and user agencies, covering topics such as Impact-Based Forecasting. As of March 2024, 125 staff of regional NMHSs attended three trainings on Impact-Based Forecasting led by international experts from the Met Office, UK.

Commitment and vision

During the 3rd SAHF EC meeting held on November 30, 2023, the Executive Council reaffirmed its dedication to enhancing the capabilities of all SAHF National Meteorological and Hydrological Services (NMHSs). The primary objective remains the mitigation of adverse impacts stemming from weather, water, and climate-related hazards. This will be achieved through continuous support of the four Working Groups, with the inclusion of one Working Group dedicated to hydrology. Moreover, the EC meeting pledged to expand the SAHF network to encompass user sectors, academia, and private companies. This strategic decision is crucial for advancing weather and climate services, particularly in domains like Impact-Based Forecasting and Early Warning Systems and to expand the support to new areas such as climate services and routine social and economic benefit analyses. Collaboration with diverse stakeholders beyond the traditional hydromet sector is essential. To realize this vision, SAHF is proposing the establishment of multi-sectoral Communities of Practices (COPs) around key areas of collaboration such as marine services, mountain meteorology, decision support systems, etc.

SOUTH ASIA HYDROMET FORUM IV

As a catalyst for regional engagement, the South Asia Hydromet Forum organizes conferences, and most recently culminating in the convening of the South Asia Hydromet Forum IV – "Unlocking Regional Synergies" in Colombo, Sri Lanka, from February 6th to 9th, 2024.

The objective of SAHF IV was to facilitate knowledge sharing, collaboration, and strategize how to address common challenges related to hydromet and early warning services in South Asia. In addition, the aim was to define a path towards deepening collaboration and increasing regional synergies and economies of scale for improved services, leading to greater socioeconomic benefits in the region. These synergies revolve around six key topics, each explored in dedicated sessions during the first three days of the conference:

1. **Creating value – the role of hydrometeorological services**: This session framed the conference along the value chain, highlighting the importance of providing actionable information to reduce multi-hazard risks and realize socioeconomic benefits.
2. **Forging a shared vision for building a regional observation network:** This session explored mechanisms to expand, sustain, and efficiently utilize existing observations in the region. It also discusses steps towards establishing rules for an operational regional observation network to achieve high-resolution spatial and temporal observations.
3. **Fostering regional collaboration to strengthen service delivery and impact on public welfare**: This session explored opportunities to jointly enhance services in South Asia, with a focus on the needs of people in mountain regions, coastal communities, and agricultural areas.

4. **Empowering Communities to make informed decisions**: This session facilitated discussions on digital solutions and last-mile communication necessary for enabling people and local communities to take anticipatory action. It also considered how the region can collectively progress towards climate resilience actions.
5. **Towards Regional Prediction and Analytics**: This session delved into requirements, resources, products, models, and coordination mechanisms needed to support the strengthening of regional forecasting, analytics, and scenario planning, including emerging technologies.
6. **Framing the elements of SAHF future**: Based on inputs provided by the attendees, this session aimed to identify key actionable next steps for SAHF.
7. Additionally, a concluding panel discussion involving the SAHF Executive Council and RIMES (SAHF's Secretariat) reflected on the **conference deliberations** and discussed the future direction of SAHF.

Day four of the SAHF Conference comprised four closed sessions, attended by staff from NMHSs in South Asia, along with key stakeholders and partner agencies representing forecast and early warning service users. Key topics for discussion included:

- **Dealing with forecast uncertainty** in an Impact Based Forecasting approach, and the role of Decision Support Systems
- **Climate Services** in SAHF
- Establishment of the SAHF **Hydrology Working Group**
- Cultivate **communities of practices** (COPs) for delivering operational hydromet services

Partnerships

The SAHF IV Forum was a collaborative effort between the World Bank (WB), the Met Office of the United Kingdom (UK), the Regional Integrated Multi-hazard and Early Warning System (RIMES) and the World Meteorological Organization (WMO) with financial support from the UK Foreign, Commonwealth and Development Office (FCDO). The Government of Sri Lanka hosted the event.

SESSION 1: Opening Ceremony

The opening ceremony of the conference began with **Karma Dupchu** (Co-Chair of the SAHF EC and Director of the National Center for Hydrology and Meteorology, Bhutan) welcoming the attendees to the 4th South Asia Hydromet Forum. While highlighting the interconnectedness of South Asian countries despite geographical boundaries, Mr Dupchu emphasized the importance of regional collaboration in addressing weather and climate challenges and the importance of SAHF, remarking "*I'm very confident that this event will significantly contribute to the future directions of SAHF, and we are committed to translate these ideas into operating programs*". He acknowledged the support received by the WB and the WMO in advancing the SAHF agenda, by ECMWF in providing increased access to forecast products, as well as by RIMES in enhancing hydromet, early warning and climate services delivery.

Following Dupchu's speech, there were remarks from **Dina Umali Deininger** (Regional Director for Sustainable Development of the South Asia Region, WB), who highlighted the significant impacts of climate change on South Asia and the importance of early warning systems in mitigating risks and strengthening resilience to the changing climate, asserting, "*Effective hydromet climate and early warning systems aren't just informative. They're foundational to disaster preparedness and response*". She discussed the World Bank's commitment to support climate resilience projects in the region and emphasized the need for collaboration and innovation in addressing climate challenges, including recognizing and enhancing the role of private sector.

Next, **Ranil Wickremesinghe**, President of Sri Lanka, spoke about the country's initiatives in climate change mitigation and adaptation, including plans for establishing a Climate Change University and advocating for the creation of a tropical belt as a carbon sink. He stressed the importance of regional cooperation in addressing climate change impacts, particularly in the face of shared vulnerabilities and challenges and demonstrated his commitment to regional collaboration, stating "*We support the strengthening and building up of our regional network*".

Andrew Patrick, the UK's High Commissioner, expressed gratitude for Sri Lanka's leadership in climate change initiatives, remarking, "*Sri Lanka has shown great leadership, not just because it is vulnerable, but because they are demonstrating the importance of sharing expertise and strengthening innovation*." He highlighted the UK's commitment to supporting climate resilience projects, including the South Asia Hydromet Forum. He emphasized the importance of early warning systems in reducing the impact of extreme weather events and reiterated the UK's dedication to climate action including through its Climate Action for a Resilient Asia (CARA) program.

Cecile Fruman, Director for Regional Integration in South Asia at the World Bank, commended the collaborative efforts of South Asian countries in building climate resilience and highlighted the importance of regional cooperation in addressing common climate challenges. She stated "*The impact of climate change is a shared concern as South Asian countries are affected by the same weather systems and are linked by common rivers and ecosystems. In the face of these common challenges, we need collaborative efforts. Cross-*

border cooperation has the potential to unlock efficient and effective use of financial, technical, and human resources to strengthen hydromet services and fortify climate resilience." She also discussed the World Bank's support for regional programs like the Resilient Asia Program (RAP) and thanked the Government of the United Kingdom for its financial support for RAP and SAHF. In addition, she emphasized the need for continued collaboration and knowledge sharing.

Celeste Saulo, Secretary General of the World Meteorological Organization, stressed the urgency of addressing climate change impacts, stating, "*Meteorological, hydrological and climatological events impose a heavy human toll and significant economic losses. Recognizing the immense benefits of meteorological information and services, national meteorological and hydrological services play a pivotal role in delivering timely inputs to early warning systems developed to mitigate these risks*". She discussed the WMO's Early Warnings for All initiative and encouraged collaboration among stakeholders to achieve lasting progress in climate resilience.

A consistent message emerged throughout the opening ceremony, emphasizing the critical role of regional collaboration, early warning systems, and innovative solutions in addressing the challenges posed by climate change in South Asia.

SESSION 2: Creating Value – The Role of Hydrometeorological Services

The goal of the session was to frame the conference around the role of hydrometeorological services in creating value for people and society, through the provision of actionable information aimed at reducing weather, water, and climate risks.

Melanie Kappes (Disaster Risk Management Specialist, WB) outlined the conceptual approach for hydrometeorological value creation, emphasizing that the true value emerges when users leverage the provided data and services to make informed decisions observing that "*Unless someone is actually making use of data and services […], hydrometeorological services only have a potential value but not a real value*". Highlighting data sharing as a critical aspect, Ms Kappes discussed how to unlock the full benefits of hydrometeorological services. She also stressed the importance of collaboration, co-production, and continuous innovation in navigating the challenges and opportunities in this evolving landscape.

Nusrat Noman (Joint Secretary, Planning Commission, Government of Bangladesh), underscored the critical role of hydromet services in Bangladesh's climate resilience journey, emphasizing the contribution to informed decision-making and disaster preparedness, resulting in significant savings for the country. She recommended the adoption of long-term programmatic approaches when designing hydrometeorological investments, rather than adopting project-based strategies unable to sustain impacts beyond the project life. She also stressed the importance of data sharing, interagency collaboration, and decision support systems as pivotal for future resilience.

Carlo Buontempo (Director of the Copernicus Climate Change Service, ECMWF) introduced the opportunities offered by Copernicus Climate Change Service (C3S) for building climate resilience in South Asia. In his remarks, Mr Buontempo emphasized C3S open data policy favoring research and commercial purposes, and the importance of observation data, both historical and present, in improving climate analysis and forecast accuracy. Mr Buontempo underscored, "*At the very basis of the value chain, there is observation data, essential if we want to improve the quality of the analysis to understand vulnerability and prepare for the future*". In relation to this, he stressed the need for continued efforts in observation data recovery and sharing, through platforms such as SAHF DataEx. Collaboration between organizations and open-data policies are emphasized as essential for effective climate adaptation and decision-making.

The last speaker for the session, **Abhas Jha** (Practice Manager, WB), discussed the socioeconomic value of hydromet services and the role of regional collaboration. He stressed the effectiveness of regional cooperation, and the economic benefits of long-term investments in hydromet services. He also highlighted the importance of sharing success stories, emphasizing the need to communicate achievements in this field to a broader audience, particularly policymakers, and the importance of embracing technological advancements to improve services provided. The presentations emphasized the importance of hydromet services in avoiding damages, increasing efficiency, and enhancing climate

resilience. Data sharing and cost-benefit studies are recommended to demonstrate the economic value of hydromet services.

Key takeaways

- **Hydromet Value is User-Driven**: the true value of hydromet services is realized when users make informed decisions based on the provided data and services. Without user engagement, and subsequent actions, the potential value remains untapped.
- **Interagency Collaboration and Data Sharing is Essential**: data sharing and co-development between producers and users are key to creating value within the hydromet services ecosystem. By sharing data, additional benefits can be generated, leading to more effective decision-making and risk management.
- **Open Data Policy**: open data policies, allowing unrestricted access to generated data for public, research and commercial purposes, are a driver of innovation and are key to addressing weather and climate change risks.
- **Long-Term Programmatic Approach**: climate investments often require shifting towards long-term programmatic approaches rather than project-based strategies to ensure sustained impact beyond the completion of individual projects.
- **Communicating Success**: Technical experts must share success stories outside their field to raise awareness among policymakers and the public.

Key Recommendations

- Develop user-centric approaches to hydromet services, involving stakeholders from multiple sectors in the design and implementation process, and include feedback mechanisms to continuously assess, and address, user needs.
- Facilitate collaboration between hydrometeorological agencies, government departments, research institutions, and private sector entities to promote data sharing and co-development of solutions.
- Encourage the adoption of open data policies to foster innovation and support research, as well as development of standardized protocols and platforms for data sharing, ensuring interoperability and accessibility of hydromet data across diverse stakeholders.
- Advocate for the adoption of long-term programmatic approaches in hydromet and climate investments, engaging with Finance Ministries to revise budgeting and planning policies, enabling direct earmarking of investments to National Meteorological and Hydrological Services (NMHSs) for sustained infrastructure development and service delivery.

- Strengthen the regional evidence base for hydromet investments, by conducting Socio Economic Benefits analyses (SEBs) that provide empirical evidence of the value of weather and climate services.
- Develop targeted communication strategies to translate technical findings into accessible formats to disseminate success stories and demonstrate the societal benefits of hydromet services to policymakers, media, and the general public.

SESSION 3: Forging A Shared Vision for Building a Regional Observation Network for More Efficient Weather, Water and Climate Services

The panel discussion focused on the significance of building sustainable national and regional hydromet observation networks in South Asia, emphasizing the importance of high-quality observational data, regional cooperation and collaboration. Each speaker provided insights into various aspects of these topics.

K. J. Ramesh (SAHF advisor, RIMES) highlighted the challenge of data gaps in the region and the efforts to overcome them through investments in the observation network infrastructure and improved data quality. He emphasized the need for consistency, addressing heterogeneity, and integrating non-NMHS networks such as those from the private sector or from other public entities (e.g., environmental protection agencies or agriculture ministries), into national networks for better data availability.

Estelle Grueter (Chair of Standing Committee on Earth Observing Systems and Monitoring Networks, WMO) discussed the importance of global observing networks and related initiatives, such as WMO Global Basic Observing Network (GBON), in filling observational gaps but also on the importance of ensuring observing network sustainability. She stressed the need for compliance with regulations, regional collaboration, and capacity development for effective network management.

Anju Gaur (Water Resource Management Specialist, World Bank), shared the case study of India's hydrology project, showcasing the government's vision for unified and standardized water data platforms. She emphasized the importance of financial support, technical assistance, and innovative procurement models for successful implementation and operation of hydrological networks.

Ashish Raval, (President & CEO of Synoptic Data PBC and HMEI Vice-Chair), discussed the role of the private sector in data sharing and innovation. He highlighted the benefits of collaborative efforts between public and private sectors in expanding data access, improving data quality, and leveraging emerging technologies like artificial intelligence and machine learning for better forecasting and decision-making.

Roar Skalin (Chair of the EUMETNET Assembly and Director General Met Norway) shared insights into the collaborative framework of European national meteorological services. He emphasized the benefits of collaboration in filling observation gaps, sharing costs and expertise, and addressing new challenges like the integration of artificial intelligence into the meteorological value chain. Mr. Skalin highlighted a crucial aspect of establishing regional collaborations and training programs to improve sustainability and capacity building. This approach not only enhances the sharing of knowledge and resources but also fosters partnerships among NMHSs of the region.

In his concluding remarks, the chair, **David Grimes** (Hydromet Advisor, WB) recognized the important contributions of the panel with a common theme that regional collaboration is a catalyst for success for all. He further explored the concept of "systems of systems" thinking and co-design, and its potential application in South Asia. This is particularly important for creating a cooperative regional observation network. While co-design offers many benefits such as efficiency, sharing of expertise and technical cooperation, it also presents challenges, particularly in overcoming national barriers. SAHF and RIMES are well positioned to address and help overcome these challenges and support the development of a regional observation network for South Asia. In concluding, the chair emphasized that establishing functional observation networks requires significant capital investments and partnerships for data sharing with recommendations including training in operation and maintenance and enhancing collaboration among national meteorological services.

Key Takeaways

- **Establishing a functional ON entails more than capital investments**; it also requires sufficient financial support and skilled human resources for Operation and Maintenance (O&M), and data management and applications.
- **Partnerships for data sharing** are crucial at multiple levels: regionally (across countries) to enhance data availability and nationally to broaden data integration. The common benefits of adopting a regional approach should be demonstrated to build trust.
- **Co-design and co-production ON** contribute to enhance collaboration among NMHSs, and across sectors, including active engagement to harness the capabilities of the private sector. Co-Design can promote interoperability, for example, through common data sharing platforms. RIMES is well positioned to promote the co-production and co-design of ON through SAHF. It is important for development partners to invest in the region, including in capacity building and knowledge enhancement.

Key Recommendations

- Leadership training as well as training on O&M, ON knowledge transfer, and staff retention strategies are crucial to ensure the sustainability of ON. Regional institutions such as RIMES and WMO Regional Training Centers should strengthen their training offerings.
- Flexible business models should be explored in supporting and maintaining ON. Such models range from pure capital expenditure (CAPEX) to data-as-a-service models. These model options should be considered in the context of regional and national circumstances. Furthermore, business model approaches should encourage engagement beyond provision and installation of stations, and include O&M, and data management aspects.
- SAHF can draw lessons from EUMETNET, which effectively developed strong institutional governance and collaboration processes among its members, fostering efficiency and effectiveness, trust and relationship building.

Box 1. Technical Side Session: Implement and leverage SOFF from a regional perspective.

The SOFF (Systematic Observations Financing Facility) is a specialized United Nations Fund co-created by the WMO, United Nations Development Programme (UNDP), and United Nations Environmental Programme (UNEP). Its primary objective is to bridge the gap in climate and weather observations globally, focusing on countries with significant deficiencies in observations, especially the least developed countries and small island developing states (SIDS). In this side session chaired by **Ben Churchill** (Director, Regional Office for Asia, and the South-West Pacific, WMO), the importance of SOFF was highlighted. SOFF provides long-term, sustainable financial and technical assistance to support the generation and sharing of basic weather and climate observations. These observations are crucial for various purposes such as forecasting, early warnings, and climate information services. Moreover, SOFF aims to invest in the development of countries and strengthen collaboration between the countries, peer advisors, and implementing entities. Panelists including representatives from peer advisor agencies such as **Mr. Pietarila** from Finland Meteorological Institute (FMI) and **Mr. Hygen** from MetNorway shared their insights from collaborating with SOFF beneficiaries in South Asia. They emphasized the necessity of strong collaboration among nations and peer-to-peer cooperation to achieve the goals of SOFF, particularly in enhancing weather observation and early warning systems. Additionally, **Mr. Ali Sharif**, Deputy Director General of Maldives Meteorological Services, and **Mr. Jagadishwor Karmacharya**, Director General of the Department of Hydrology and Meteorology of Nepal, highlighted that their countries were attracted to the SOFF initiative not just for the installation of weather stations but for the continuous operational support. They stressed the importance of sustainability, mentioning challenges faced during the implementation of previous hydromet projects. The session underscored the significance of SOFF in helping countries meet their obligations to contribute to the WMO's Global Basic Observing Network, addressing climate-related challenges and fostering collaboration among nations and agencies to enhance weather observation and early warning systems, noting importantly that SOFF is also a key enabler of the UN Early Warnings for All initiative.

SESSION 4: Fostering Regional Collaboration to Strengthen the Service Delivery and Impact on Public Welfare

The session focused on enhancing weather forecasting capabilities in South Asia, stressing tailored services and collaboration between institutions. Speakers emphasized the importance of integrating observation networks, translating climate data into actionable insights, and bridging the gap between scientists and policymakers to address regional climate challenges effectively.

Karma Dupchu, (Co-Chair SAHF and Director, NCHM, Bhutan) spoke about the diversity of climatic conditions in South Asia and the importance of tailored services. He stressed the need for an end-to-end approach in service delivery, from observation networks to data utilization, highlighting the importance of institutional arrangements and legal frameworks, particularly in integrating meteorological and hydrological services. Mr Dupchu shared experiences from Bhutan, highlighting the need for better collaboration between regional institutions while stressing the importance of understanding local cultures.

Nishadi Eriyagama (Deputy Country Manager Sri Lanka, International Water Management Institute (IWMI)), introduced the organization's pivotal role in water management and research for development in South Asia. She delved into IWMI's efforts to translate climate data into actionable insights, citing the South Asia drought monitoring system as a significant example. Ms Eriyagama also emphasized IWMI's initiatives in building a community of practice focused on managing water storage in South Asia, while also offering support for establishing similar communities in other crucial areas such as early warning systems and data management.

Faisal Mueen Qamar (Intervention Manager for Resilient River Basin, International Centre for Integrated Mountain Development (ICIMOD)) reiterated the alignment between ICIMOD's objectives and those of SAHF, emphasizing collaborative efforts. He discussed specific projects with NASA aimed at improving seasonal forecasts and assessing extreme weather events in the region. Mr Qamar provided an example of how global weather models are translated into useful products for agriculture practitioners. Additionally, he delved into efforts to simplify complex models and provide downscaled forecasts at the district and sub-district level.

Ajay Kumar (Scientist, India National Centre for Ocean Information Services INCOIS)) outlined INCOIS's crucial role in providing ocean services, including forecasting extreme weather events and tsunamis. He detailed the observation networks and ocean modeling techniques used to deliver these essential services to South Asian countries.

Temily Baker (Programme Management Officer, United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP)) introduced UN-ESCAP's role in facilitating regional cooperation and policy advocacy. She highlighted the importance of downscaling global models to local contexts and advocated for collaboration among regional

organizations like SAHF to influence policymakers and address development goals. Ms Baker also discussed ESCAP's work in building resilience through data integration and risk assessment, including the Risk and Resilience Portal's role in mapping hazards, critical infrastructure, and vulnerabilities. Moreover, she emphasized the importance of multidisciplinary approaches and community engagement in early warning forecasting, suggesting closer collaboration with other ministries and leveraging intergovernmental architecture for regional dialogue.

Tshering Wangchen (Principal Agriculture Officer, Ministry of Agriculture, Bhutan) discussed the Agromet Decision Support System (ADSS) supported by the World Bank. He highlighted the need for reliable weather forecasts from NMHSs for effective decision-making and elaborated on collaboration with NCHM (National Center for Hydrology and Meteorology) in issuing agro advisories and developing drought response plans. Additionally, he addressed challenges in sensitizing farming communities and agricultural extension officials about climate and weather services.

Key Takeaways

- **Communities of practice** (COPs) are a useful means to create so called end-to-end solutions for public welfare through SAHF. Regional organizations play a catalytic role in developing COPs.
- **Regional entities work well with national institutions** but cooperation between regional entities is weak, except for interaction with RIMES. Scope for much greater co-production of solutions building on the unique strengths of each regional entity.
- **Potential to use SAHF in cooperation with regional entities such as UN-ESCAP, to utilize regional platforms to support** policymakers addressing progress against UN sustainability goals.
- **A legal and regulatory framework is essential** to formalize roles and responsibilities for public service delivery.
- There is an opportunity to strengthen **collaboration between SAHF** and Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation **(BIMSTEC)** and between SAHF and Copernicus Climate Change Service (**C3S**).

Key Recommendations

- Establish cooperative arrangements between SAHF and other regional/international entities.
- Early warning systems for extreme weather events, such as tsunamis and droughts, should be strengthened. This includes improving observation networks and ocean modeling techniques to provide timely and accurate forecasts.

- Make recommendations to SOFF to include marine observations and expand to include entire SAHF region.
- Create and extend COP concept to include transdisciplinary entities (e.g., “science to society”).

SESSION 5: Empowering Communities to Make Informed Decisions

The session focused on digital solutions and last-mile communication, understanding user behavior and decision-making, integrating forecast data effectively. Discussion centered on addressing the challenges of uncertainty and risk communication, building trust with communities, and fostering collaboration between meteorological and humanitarian organizations to improve disaster response and protect livelihoods.

During the panel discussion, **David Rogers** (Senior Hydromet Advisor, World Bank), welcomed the panelists and provided context by emphasizing the persistent challenge of understanding why poor outcomes still occur despite significant improvements, and investments, in weather forecasting over the past 25 years and more, stressing the importance of addressing user behavior and decision-making. Rogers also emphasized the responsibility of those involved in disaster management to understand the needs and real-life problems faced by communities at risk and highlighted the importance of effective communication of information and support systems to aid disaster response.

Ruby Rose Policarpo (Institutional Development Specialist, RIMES) discussed the risks faced by end-users and underscored the need to educate stakeholders for informed decision-making. She emphasized integrating forecast data across various sectors and the importance of credibility in last-mile communication.

Abhas Jha, (Practice Manager, World Bank) emphasized the critical need for credibility in last-mile communication. He raised questions about building community credibility and understanding communities better to effectively communicate uncertainty. *"We've done a great job on reducing deaths from cyclones. We haven't done such a great job of protecting livelihoods. And this goes to the heart of the question. If, for example, you're a poor farmer and one or two cows is your only asset, you're going to stick around and try and protect that cow and even if it means risking your life."* He cited successful use of anticipatory transfers to mitigate losses from a disaster.

Terrence Fernando, (Professor, University of Salford) highlighted the importance of risk perception and suggested interventions such as community engagement and impact-based early warning systems. Mr Fernando discussed the creation of Living Labs in Sri Lanka, Pakistan, and Malaysia to address local disaster management challenges, engaging stakeholders in problem-solving iteratively. He emphasized integrating indigenous knowledge with scientific models for effective risk management and advocated collaborative systems approaches involving various partners, including urban developers and landscape planning agencies, to prioritize community involvement and resilience-building efforts.

Helen Caughey (Deputy Chief Meteorologist, Met Office, UK) stressed the importance of understanding communities' risk appetite and effectively communicating forecast uncertainty. She advocated for increased warning lead time to allow communities where needed to take no regrets actions, and emphasized stronger collaboration between meteorologists and stakeholders such as humanitarian organizations. She added the messenger can be a critical determinant of the success of early warnings and cited a successful example from Pakistan where the Met Department worked through agricultural extension workers because they are the ones that have established trust within the community.

Madhab Uprety (Sr. Technical Advisor, Red Cross Red Crescent) emphasized the role of risk modeling in anticipatory action and disaster risk management and discussed collaboration between hydrometeorological and humanitarian actors. He provided examples of successful initiatives and emphasized the need for evaluating forecast accuracy and impact realization.

Shanika Thrimanna (Additional District Secretary, Kalutara District, Sri Lanka) discussed the role of district secretariats in disaster management, particularly in protecting lives, infrastructure, and livelihoods. He described the process of issuing early warnings through various departments and grassroots level officers, emphasizing the importance of trust in local sources of information. Audience speakers brought valuable insights on two-way communication, local data challenges, and community engagement strategies.

Abhas Jha concluded the discussion by underscoring the need to catalog successful experiences in communicating uncertainty and building a community of practice around decision-making in disaster management, highlighting the importance of collaboration in addressing the challenges posed by climate change. Overall, the main points revolved around improving last-mile communication, understanding user behavior and decision-making, integrating forecast data effectively, and addressing the challenges of uncertainty and risk communication, aiming to enhance disaster preparedness and response efforts.

Key Takeaways

- **An effective early warning system (EWS) relies on accuracy, reliability, credibility, and richness of information**, ensuring precise communication between agencies and trustworthy messages for the community. Routine evaluation improves accuracy over time, considering data needs and technological constraints.
- **Effective risk communication involves thorough impact evaluation and stakeholder engagement** to understand various scenarios and local contexts and mobilization of resources accordingly for risk reduction activities, integrating systems and considering alternative costs.
- It is **crucial to comprehend the needs and real-life problems faced by communities** at risk to tailor effective communication and support systems.

- **Integrating forecast data across various sectors and bridging the gap between meteorological and humanitarian organizations is essential** to effectively utilize forecast data for disaster response and protection of livelihoods.

Key Recommendations

- Work to better understand community responses to early warning messages by profiling risk appetite and working with communities to better understand concepts such as forecast uncertainty.
- Establishing trusted communication channels at the local level, leveraging community leaders and grassroots organizations.
- Develop tailored messaging strategies to address the specific needs and risk perceptions of vulnerable communities, ensuring inclusion of marginalized community members such as women and the elderly. Implement training programs to empower local stakeholders in effectively disseminating warnings and information.
- Engage communities and foster collaboration between various stakeholders through initiatives such as living labs and collaborative systems to prioritize inclusive community involvement in resilience-building efforts and build community credibility, helping ensure longer term sustainability.
- Assess resource availability and align with victims' livelihood patterns and governance procedures for effective response planning to identified risks.
- Catalog successful experiences in communicating uncertainty and decision-making in disaster management to build a community of practice and facilitate knowledge sharing.

SESSION 6: Towards Regional Prediction and Analytics

The session aimed to identify strategies for enhancing regional forecasting capabilities, leveraging emerging technologies and collaborative mechanisms to address the needs of various user sectors including agriculture, water resources, health, and disaster risk management.

During the panel discussion, **Alice Soares** (Senior Hydromet Advisor, World Bank) initiated discussions by emphasizing the significance of models, analytics, and forecasts in the weather forecasting value chain, particularly amidst challenges faced by NMHSs due to budget and human resources' constraints. Alice noted the lack of focus on ocean observations in initiatives like GBON and SOFF and suggested expanding these efforts to include oceanic data. She facilitated discussion on the steps needed to improve access and use of global and regional models, highlighting the significance of partnerships and collaborative frameworks.

Kirstine Dale (Chief AI Officer, Met Office, UK), acknowledged the transformative potential of AI in weather forecasting due to their cost-effectiveness and agility, but emphasized that AI should complement rather than replace traditional numerical weather prediction with data-driven approaches for weather forecasting. *"It's critical that machine learning models run alongside traditional numerical weather prediction.... It's an evolution, not a revolution."* Deploying machine learning technology alongside traditional techniques will improve our ability for forecasting some extreme weather events with even greater accuracy. She highlighted the challenge of recruiting and retaining data science expertise, proposing partnerships between NMHSs and Universities or Research Institutes, like the Met Office's collaboration with the UK's Alan Turing Institute for developing FastNet as an example of how the partnership model can expedite access to necessary expertise, addressing organizational challenges. "*So, I think the key thing here is because this technology is moving so fast, collaborative frameworks, mechanisms to draw in the critical mass of expertise that you need to take advantage of the technology, is really important.*"

Alan Thorpe (Professor, Department of Meteorology, University of Redding) provided insights into mesoscale prediction and the value of machine learning and its potential to improve probabilistic predictions. He stressed the role of observations in improving forecast skills and model evaluation, advocating for increased observational data, ensemble forecasting, satellite-based technologies, and private sector data integration.

K.J. Ramesh (SAHF Advisor, RIMES) explored options for integrating non-NMHS data sets, particularly from the private sector, into forecasting systems, aiming to enhance forecast scale. He discussed the challenges of integrating high-frequency private sector data into observation and modeling systems and on anticipating and quantifying the impacts of extreme weather events, particularly cascading and compounding effects such as landslides triggered by heavy rainfall.

V.S. Prasad (Head, National Centre for Medium Range Weather Forecasts (NCMRWF)) discussed challenges in accessing non-NMHS data sets, especially satellite data in real time, and the use of high-frequency data in mesoscale analysis and simulation systems to improve rainfall predictions. Mr Prasad discussed India's NWP and use of AI techniques across various aspects of weather forecasting and highlighted the importance of assimilating data from radar networks, and satellite rainfall data, alongside with downscaling forecasts. He emphasized the importance of generating datasets and customizing AI models not only for India but also for South Asia as a whole.

Quamrul Hassan (Meteorologist, Bangladesh Meteorological Department and Chair, SAHF Numerical Weather Prediction WG) discussed challenges in interpreting model outputs and the need for skill development for users, particularly in visualization tools and data archival, as well as regional cooperation to enhance overall NWP and forecasting capabilities. He cited the successful development and utilization of the DIANA visualization software in improving forecasting capabilities in Bangladesh.

Hans Olav Hygen (Head, Climate Service, Met Norway) emphasized peer collaboration, capacity building, and sustainable regional solutions, advocating for training of trainers and supporting regional actors for long-term success. Other participants raised concerns about data accessibility and AI integration, suggesting coordinated efforts through platforms like SAHF and sharing successful case studies for mutual learning.

Helen Caughey, (Met Office, UK) shared insights from European experiences, advocating for consortium-type collaborations to optimize models for regional needs.

Overall, the speakers emphasized collaboration, communication, and capacity building as essential strategies for leveraging advancements in weather forecasting technologies in South Asia. Recommendations emphasize the importance of partnerships, data integration, and skill development to address the diverse needs of user sectors and enhance regional forecasting capabilities.

Key Takeaways

- **Collaboration among meteorological services, researchers, and stakeholders is critical for advancing weather forecasting capabilities in South Asia.** Communities of practice can serve as valuable platforms for strengthening collaboration and knowledge sharing.
- **Transformative potential of Emerging technologies** such as artificial intelligence (AI) and high-resolution observational data utilization to improve forecast accuracy and address weather-related challenges but must be integrated into traditional numerical weather prediction.
- There is a **recognized need for skill development among meteorological staff** to interpret model outputs accurately and effectively utilize advanced forecasting

techniques. Training programs, demo systems, and peer-to-peer collaboration are needed to ensure sustainability and local ownership of forecasting initiatives.

- **Strengthen Data Integration and Skill Development**: Focus on integrating non-NMHS data sets, including high-frequency private sector data, into forecasting systems to improve forecast scale and accuracy. Additionally, prioritize skill development for users, particularly in interpreting model outputs and utilizing visualization tools, to enhance the effectiveness of forecasting systems.

Key Recommendations

- Promote Collaborative Frameworks: Foster partnerships and collaborative mechanisms to improve access and utilization of global and regional models. These partnerships should involve stakeholders from diverse sectors, including meteorological services, the private sector, academia, and neighboring countries and emphasize the importance of sharing resources, expertise, and data to address shared challenges.
- Facilitate collaboration between AI developers and NMHSs to customize models and integrate them with traditional forecasting methods.
- Invest in capacity building initiatives, including the establishment of training programs, demo systems, and peer-to-peer collaboration, to ensure the sustainability and local ownership of forecasting initiatives. Prioritize skills development programs for meteorological staff to enhance their ability to interpret model outputs accurately and effectively utilize advanced forecasting techniques.
- Leverage COPs to strengthen regional cooperation through platforms like SAHF and RIMES, facilitating data sharing, collaboration, and the exchange of expertise among countries in South Asia for more accurate and timely weather forecasting.

BOX 2: Technical Side Session: The Role of the Private Sector to Foster Innovation and Empower Hydromet Services

The session discussed the role of private sector in providing sustainable systems, actionable insights, and early warnings to save lives and protect property. This technical side session discussed how to establish trust, develop sustainable projects, and leverage the latest technology through public private partnerships. The session, led by Ashish Raval (Vice-chair of HMEI and CEO of Synoptic Data PBC) shed light on the critical role of public-private partnerships in bolstering HydroMet services, emphasizing the mission of HMEI to align capabilities and foster collaboration in weather and environmental initiatives. Raval showcased successful models like the National Mesonet Program and Synoptic, highlighting their contribution to data aggregation and distribution. He stressed the importance of specialization and collaboration, advocating for efficient global problem-solving and leveraging comparative advantages of different sectors. *"Focus on your core competencies where you are great, and partner or outsource other tasks. NGOs and the right partnerships*

can help develop a global platform that benefits everybody." The discussion further delved into the initiative brought forward by Dialog, the leading telecommunication company of Sri Lanka, in climate resilience and disaster risk reduction, highlighting projects like Dune and Gome Thuru, which focus on early warning networks and agricultural information services in Sri Lanka. Representatives from Google and Kisters also shared insights into their collaborations with governments and organizations, emphasizing the significance of understanding local needs and capacity building in successful partnerships. Throughout the session, participants highlighted the transformative potential of public-private joint ventures in promoting innovation and sustainability, while addressing concerns about data longevity and safety by proposing open-source models for accessibility and replication. Overall, the discussion underscored the need for supportive policies and guidelines to enable effective partnerships and ensure the long-term impact of NMHSs' initiatives.

BOX 3: Technical Side Session: Early Warnings for All – A Partnerships Approach

This technical side session focused on the UN Early Warnings for All (EW4All) initiative and its enabling mechanisms. Participants shared experiences and identified opportunities and innovative approaches to fast-track early warning systems that help vulnerable communities adapt to climate change, save lives and livelihoods, and contribute to socio-economic development. **Ben Churchill** (Director, Regional Office for Asia, and the South-West Pacific, WMO) highlighted the importance of collaboration and data sharing in the context of early warning systems, particularly for least developed countries and small island developing states. He emphasized the need for co-designing systems across the early warning value cycle with input from all stakeholders, including national meteorological and hydrological services (NMHS), to ensure the effectiveness of the EW4All initiative. **Madhab Uprety** (Sr. Technical Advisor, International Federation of Red Cross and Red Crescent Societies (IFRC)) discussed the importance of scaling up existing efforts on early warning and early action, highlighting successful examples of community-driven approaches. IFRC is leading on pillar 4 – community preparedness and response of the EW4All. He outlined some of the early actions that IFRC has been taking under the initiative, particularly at the community and stakeholder level. **Ali Sharif**, (Deputy Director of Maldives Meteorological Service), shared the country's experience in developing a national roadmap for early warnings, which was approved as the first of its kind globally. He emphasized the value of government support and coordination in developing and implementing the roadmap, including leveraging funding from the Green Climate Fund. **Abhishek Modi** (Google, Crisis Response) team showcased various projects aimed at improving early warning systems, such as flood alerts, earthquake early warnings, and wildfire predictions. He emphasized the importance of data and AI in enhancing disaster response and highlighted Google's efforts to democratize access to public datasets through tools like Data Commons. Overall, the session underscored the significance of collaboration, technology, data-sharing and people-centred approaches in strengthening early warning systems to mitigate the impacts of climate-related hazards at the same time as contributing to sustainable development.

Session 7-9: Framing the elements of a SAHF action plan

Sessions 7 to 9 were interactive sessions where participants were organized into small thematic groups – NMHS, User Groups, Private Sector/International Organizations and Regional Centers. The aims of these discussions were to identify priorities that needed urgent attention and how different groups could contribute to their success. The results represent the building blocks for an action plan. The following summary provide a high-level overview of the key outcomes for each thematic group, delineated by priorities, directions for implementation, and primary challenges:

NMHS perspective

The group identified three main priorities and directions for enhancing hydromet services regionally.

- Augmentation of observation networks through a regional perspective is a recognized necessity for improving regional capabilities in forecasting as it is ensuring data quality and accuracy.
- Data Sharing was defined as crucial to enhance hydromet services and a priority for regional collaboration. Dedicated data sharing and visualization platforms, such as DataEx, and capacity building in the use of these tools are needed. Formal agreements and data sharing policies to ensure continuous accessibility among countries should be promoted.
- Collaboration on Decision Support Systems and Impact-Based Forecasting: Developing customized systems collaboratively to meet diverse regional needs will require capacity building on NWP, skills in communicating forecast uncertainty, co-development among different user sectors and piloting IBF applications.

Challenges Identified:

- Data Calibration and data security: Ensuring consistency and accuracy in data across systems and platforms and the importance of data security and addressing related challenges.
- Coordination and collaboration between countries: Policy differences among different countries may hinder effective collaboration. Similarly, there are challenges in engaging effectively with different user sectors.
- Resource Constraints: Dealing with limited funding and human resources for implementing and maintaining hydromet observation network, and the limited availability of skilled manpower.
- Sustainability: Ensuring the long-term sustainability of hydromet systems amid evolving technologies and challenges.

User Groups perspective

The group identified four main priorities for enhancing services regionally.

- Strengthening Impact-Based Forecasting for various geographical regions: This will require risk and vulnerability assessments, capacity building for officials and the

communities but also a shift in perspective towards community-driven products and the importance of open platforms to facilitate accessibility to last mile users.
- Establishment of a common platform for centralized data management: This should include real time data collection and quality control, but also socioeconomic information.
- Need-based capacity building for officials and communities: Commitment and collaboration among stakeholders for sustainability.
- Financial and technical assistance for mitigation and adaptation efforts, sustained government support and coordination among agencies: The group recommended engaging NGOs and supporting startups in hydromet hardware development for faster and accurate data acquisition.

Challenges identified:

- Inadequate financial and technical support, and insufficient political commitment and stability
- Concerns regarding data security, reliability, and management
- Lack of community engagement and inclusivity

Private sector and international development partners perspective

The group identified three main priorities for enhancing hydromet services regionally.

- Upscale the role of SAHF to become a regional interface between technical partners (NMHSs) and user sector including governments. SAHF should encourage investments in hydromet in a holistic and long-term perspective.
- Ensuring data security while promoting data sharing for hazard mapping and forecasting weather and climate risks which requires a strong data policy.
- Human resources skills: build a pipeline of academics and investments targeting recipient countries to support the next generation of forecasters, address challenges related to salaries, and prevent brain drain.

Regional centers perspective

The group identified three main priorities for enhancing hydromet services regionally.

- Bridging the gap between providers and users of meteorological services, aiming to bring the community of users closer to the service providers. It was proposed to establish a Community of Practice (CoP) fostering closer collaboration and understanding between these two parties. One area which deserves attention is the evaluation of disasters impacts, to identify challenges and areas of improvements from a regional perspective, leveraging national experience.
- Foster better interaction between NMHSs and regional centers, emphasizing the necessity for dedicated focal points to facilitate seamless exchange. This approach ensures that regional centers remain attuned to evolving needs and demands while NMHSs contribute effectively to this synergy.

Implementation Factors for consideration include:

- Improved communication, collaboration, and engagement between SAHF and regional centers to avoid duplication of efforts and leverage expertise from regional agencies to address common gaps and challenges. This will require assigning dedicated focal points in each regional agency to contribute to SAHF initiatives, and definition of milestones for each agency to track progress.

Session 10: Panel Discussion of the SAHF Executive Council and RIMES

Reflecting on the SAHF journey since its inception in 2018, **Melanie Kappes** (Disaster Risk Management Specialist, WB) acknowledged the strides made in institutionalizing the SAHF mechanisms for collaboration among member states. The conferences serve as pivotal milestones, encapsulating decisions, and ambitious plans. In the words of Melanie Kappes, "*the aim is to translate the SAHF Executive Council's vision into actionable initiatives. Let us not only envision but actively pursue the transformative potential of SAHF*."

In his address, **Karma Dupchu** (Co-Chair of the SAHF EC and Director National Center for Hydrology and Meteorology, Bhutan) reflected on the genesis of the SAHF, a collaborative initiative of the WMO and the WB. He recalled the initial uncertainties surrounding the venture but emphasized a shared vision for regional cooperation. Highlighting the diverse geography of South Asia, ranging from the Himalayas to the Indian Ocean, Mr Dupchu underscored the imperative for unified action in weather and climate management. He emphasized the need to enhance the capacity of national meteorological services, acknowledging the variations in infrastructure and observation networks across the region. Mr Dupchu articulated the forum's commitment to aligning efforts with user needs and prioritizing capacity-building initiatives, as gleaned from stakeholder insights gathered during the conference.

Jagadishwor Karmacharya (Director General Department of Hydrology and Meteorology, Nepal) brought the perspective of a Himalayan country, explaining that this opportunity to revive regional collaboration, drawing inspiration from the successful practices of European countries, holds great promise. The potential for synergy-building within existing mechanisms like WMO and the BIMSTEC Center for Weather and Climate (BCWC), alongside national platforms, is significant. Mr Dupchu added that "*Over the past two days, we have explored the vast possibilities of enhancing services to society, incorporating inputs from both the public and private sectors. The goal is to scale up services from regional to local levels, leveraging early warning systems and other initiatives. Even the creation of a single impactful product or output from these collaborative efforts would be immensely gratifying*."

Shareef Ali (Deputy Director General, Maldives Meteorological Services) commented on the valuable discussions on the hydromet value chain and the need for investments in climate services, observing that, "*Cost recovery presents a viable means to sustain the services provided by meteorological agencies. Currently, many services are offered free of charge, but the implementation of cost recovery mechanisms can ensure sustainability, especially when regular budgets are limited*".

Subbiah Arjunapermal (Director, RIMES) reflecting on the journey of SAHF from its inception in 2018 to the present, emphasized that there has been significant expansion and deepening of the program's scope, with increased involvement from various sectors and institutions, including academia and the private sector. One key takeaway from the discussions was the need to shift the focus from merely providing basic services to reorienting services towards

meeting the specific needs of users. This entails adding value to services and ensuring that resources are allocated for maintaining and operating systems.

Kyaw Moe Oo (Director General, Department of Meteorology and Hydrology, Myanmar), reminded that without adequate observation data, the ability to accurately predict weather and climate patterns is compromised. Therefore, we must prioritize real-time observation and invest in improving the accuracy of numerical weather applications.

Discussing the priorities for SAHF, **Shareef Ali** emphasized the importance of advancing the implementation of Impact-Based Forecasting and Decision Support Systems for the entire region. **Jagadishwor Karmacharya** stressed the need for capacity building within the region, emphasizing the need for customized on-site training for forecasters to address diverse country-specific situations effectively. He also suggested focusing on regional scale modeling activities and developing decision support systems for common hazards across multiple countries, such as coastal and mountainous regions. **Karma Dupchu** emphasized two critical priorities. Firstly, he highlighted the need for enhancing data sharing mechanisms in the region by strengthening SAHF DataEx portal. This system should facilitate the exchange of basic data and enable the sharing of products and services. As a second item he emphasized the significance of capacity building, tailored to the specific needs of each country. He particularly emphasized the importance of investing in institutional capacity building for impact-based forecasting, focusing on hazards, risks, observation, monitoring, and user engagement. These areas, he believes, require immediate attention within the next one to two years. **Quamrul Hassan** (Meteorologist, Bangladesh Meteorological Department) emphasized that the focus for SAHF should be on implementation, "*Implementation should be the next step, physical and visible implementation*," while stressing the importance of moving beyond meetings and workshops to tangible actions. In his suggestion, **Athula Karunanayake** (Director General, Department of Meteorology Sri Lanka) stressed the importance of accessing data quickly for effective forecasting, stating, "*If we can get that data quickly, that is very important for the forecasting.*" He also urged SAHF assessment of maintenance requirements for the observation network, to ensure accuracy and reliability of data. **Subbiah Arjunapermal** emphasized the critical importance of implementation in moving forward, stating, "*Implementation is the key now*." He highlighted the existing foundation documents, such as the 2021 strategy and action plan, endorsed resolutions, and declarations, as the basis for future action. He also underscored the need to translate these documents into actionable programs to be implemented over the next two years. He emphasized the role of governments in reporting back to their countries on the outcomes of these deliberations and the importance of delivering on promised actions.

In his concluding remarks, the co-chair for the session **Jerry Lengoasa** (Hydromet Advisor, WB) expressed gratitude to the participants for their contributions to the discussions over the past days, acknowledging their role in shaping the outcomes of SAHF Declaration and supporting SAHF's implementation efforts.

Session 11: Closing session

Karma Dupchu (Co-Chair of the SAHF EC and Director National Center for Hydrology and Meteorology, Bhutan) closed the three-day conference by expressing gratitude to the participants and acknowledging the diverse sessions covering topics such as the hydromet value chain, regional observation networks, and public-private partnerships. Mr Dupchu emphasized the importance of implementation, urging action to translate discussions into concrete projects. He highlighted the need for greater alignment between regional, national, and community-level initiatives and suggested building upon existing regional initiatives rather than creating new ones. Mr Dupchu underscored the priority of establishing a regional hydromet portal and data exchange platform. He thanked the World Bank, the UK Met Office, conference organizers, attendees, development partners and the Government of Sri Lanka for their contributions to this successful event.

In her closing remarks, **Chiyo Kanda** (Country Manager for Sri Lanka, WB), expressed her delight at the World Bank's support for the SAHF IV, emphasizing its importance in enhancing climate and disaster resilience across borders. She highlighted the need for collaborative efforts in sharing information and establishing systems that benefit people beyond national boundaries. The event witnessed participation from various stakeholders, including government officials, development partners, private sector representatives, and academia, reflecting the forum's significance. Ms Kanda underscored the Forum's aim to deepen collaboration and increase regional synergies for improved services and socioeconomic benefits. She stressed the importance of addressing transboundary challenges and leveraging the potential of the private sector and academia working in tandem with development partners. Ms Kanda thanked the supporting organizations and participants for their contributions and urged continued collaboration to advance the hydromet agenda.

Lisa Whanstall (Deputy High Commissioner, UK) expressed her gratitude for the opportunity to participate in the SAHF IV in Sri Lanka. She emphasized the urgency of addressing climate change and highlighted UK's commitment to climate action through dedicated initiatives as the CARA (Climate Action for a Resilient Asia) program and its support for SAHF, which aim to tackle the challenges of adaptation and alleviate the human impact of climate change. She stressed the importance of collaboration, knowledge sharing, and storytelling in conveying the societal benefits of hydromet services to various stakeholders. Deputy HC Whanstall concluded by commending the progress made so far and encouraged continued efforts to translate declarations into tangible actions and benefits for the region.

Athula Karunanayake (Director General Department of Meteorology, Sri Lanka) expressed gratitude for the opportunity to participate in the 4th SAHF, highlighting the engaging discussions and presentations that took place over four days. He provided an overview of the topics covered, including establishing a regional observation network, advancing regional prediction and analytics, empowering communities for informed and inclusive decision-making, and enhancing regional cooperation for service delivery. Mr Karunanayake emphasized the importance of collaboration, institutional arrangements, and technical infrastructure development to improve hydrological and early warning services. He underscored the significance of addressing hydrometeorological hazards, which account for

over 90 percent of disasters in the region, and pledged support for the implementation of the declaration formulated during the forum. Mr Karunanayake thanked all speakers, participants, and supporting organizations for their contributions to the event's success.

Melanie Kappes (Disaster Risk Management, WB) expressed her gratitude for the successful culmination of the four-day SAHF IV, highlighting the energy, connections, and knowledge exchange that took place. She thanked all participants, including the Government of Sri Lanka for hosting the event and His Excellency, the President of Sri Lanka, for his involvement. Kappes acknowledged the collaboration of co-organizers from the UK Met Office, RIMES, and WMO, and the support from the UK Foreign Commonwealth and Development Office.

SAHF Way Forward

SAHF IV offers actionable insights and recommendations to enhance hydrometeorological services and disaster management in South Asia. It emphasizes the need for financial support and skilled human resources to expand and sustain observation networks, support enhanced training opportunities, and consider flexible business models to help with program implementation. Partnerships for data sharing at regional and national levels were deemed essential, with recommendations to establish cooperative arrangements and Communities of Practice (COPs) to accelerate action.

Crucially, SAHF IV resulted in a Declaration formulated by participants, emphasizing the strengthening of information and services essential for aiding user communities in making informed decisions. Key aspects highlighted in the Declaration include deepening collaboration, creating a shared vision for enhancing regional observation networks, and strengthening hydromet services' contribution to public services and climate resilience.

The SAHF IV Declaration serves as a strategic document steering efforts towards a more resilient South Asia in the face of hydrometeorological challenges. It recognizes strategic partnerships, emphasizes resource mobilization, and coordinated planning among development partners, and further encourages collaboration with academia, the private sector, and user communities. The Declaration also emphasizes the importance of reinforcing people-oriented, impact-based, multi-hazard early warning systems, establishing institutional mechanisms between users and NMHSs, and strengthening capabilities of regional organizations and partners for successful program implementation.

Going forward, efforts will be made to create COPs to share knowledge and lessons learned and serve as safe spaces for questions and feedback. Efforts will be dedicated to exploring ways to strengthen the sustainability of national hydromet investments through collaborations with agencies such as the World Bank, Met Office of the United Kingdom, Met Norway, and RIMES to complement national level investments. The SAHF EC and development partners will work on the development of a sustainability model for one or two pilot NMHSs, that includes value-added/commercial services, and ways to foster private sector engagement to better hydromet services in SAR.

Box 4: Closed side session: critical technical and strategic aspects to make best use of NWP data by NMHSs

In this closed-door side session, restricted to operational forecasters from NMHSs and development partners supporting data-processing and forecasting systems, participants discussed critical technical aspects enabling the use of NWP data, including visualization tools and capacity-building requirements. Specifically, the participants discussed the potential benefits derived from the use of a common visualization platform among all countries in the region, particularly if this involved the use of license-free forecaster workstation software. Participants requested RIMES to assist in establishing a core team to

help NMHSs in the region to install and customize such forecaster workstation software packages that are already utilized in the region.

Regarding capacity building, participants recognized the contribution of FMI, MetNorway, and the Met Office, UK, in providing training and support to the NMHSs in the region. It was further agreed that additional capacity building in manipulation and management of data and data flow is critical, alongside the interpretation of model products. Thus, a comprehensive capacity development and training program on various NWP-related aspects, including data management, and post-processing, should be put in place under the umbrella of SAHF. It was also requested that the World Bank and RIMES support in coordinating with partners (FMI, MetNorway, and the Met Office, UK) the implementation of the suggested program.

SESSION 12: Dealing with forecast uncertainty in an Impact Based Forecasting approach, and the role of Decision Support Systems

Commented [EF1]: Comment for the designer: the following sessions, from 12 to 15 - should be colored in a different manner, since not all attendees participated to this additional day of the event.

Commented [MSK2R1]: I think we need a paragraph intro explaining that the fourth day happened after the official closing of the conference to go deeper - with just the NHMSs

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Day four of the SAHF Conference comprised four closed sessions (12 to 15), attended by staff from NMHSs in South Asia, along with key stakeholders and partner agencies representing forecast and early warning service users to deep dive on specific topics related to NMHSs and SAHF operations.

Session 12 aimed to explore how impact-based forecasting (IBF) can account for forecast uncertainty in the communication of risk to stakeholders, at lead times which enable effective decision making supporting early action, and the role of Decision Support Systems (DSS), understanding limitations and challenges of different approaches, both from a producer and user perspective.

The facilitators, **Helen Caughey** (Deputy Chief and International Meteorologist, Met Office, UK) and **Anshul Agarwal** (Team Leader, Hydrology, RIMES) led a moderated discussion of thoughts, considerations, challenges, and comments from participants. The session also aimed to follow up on key regional priorities identified by the SAHF IBF working group (WG), to assist in the design of the UK aid funded Weather and Climate Information Services (WISER) Asia-Pacific programme support to the enhancement of IBF and early warning services under SAHF, in collaboration with RIMES. **Ms Shanti Kandel** (Senior Divisional Meteorologist, Department of Hydrology and Meteorology, Nepal) presented on the SAHF IBF WG priorities, addressing the sustainability of IBF projects within NHMSs, the development of prototypes for different hazards and regions, quantitative IBF training for forecasters, structured design of pilots, user sector engagement in IBF, joint operability for IBF implementation and collaborative efforts for hazard specific data gathering.

Discussions debated the increased demand for data and information which supports effective decision making, particularly amidst potentially increasing forecast uncertainty under the context of a changing climate. This demand is leading many organizations towards building their own DSS tools. However, some NHMSs feel these, when used in isolation or to the exclusion of contribution from technical experts', risks portraying a false confidence in detail and accuracy. NHMSs agreed that working in better partnership with stakeholders was key to progress and long-term sustainability. They felt this should include training for stakeholders in forecast uncertainty especially where they are heavily reliant on DSS.

Forecasts are inherently uncertain, and raw NWP (Numerical Weather Prediction) models feeding many DSS tools are limited in temporal and spatial resolution. Where DSS tools are used in isolation, NHMSs and operational staff are unable to add value based on their experience and understanding of local, meso-scale, effects which cannot be effectively resolved in NWP. There were discussions around different risk appetite levels of different users, and it was noted that there is perhaps less risk in reliance on DSS tooling alone in some circumstances, but in others it would benefit from a more comprehensive approach. In unpicking what applications may benefit from one approach, a number of considerations were identified including resources required and available, risks and benefits, forecast

limitations, user application (and risk appetite), timeliness, nature of the hazard onset (i.e., slow or rapid), engagement level of the user.

This led to discussions on human intervened IBF which offers the opportunity to make a fuller assessment of potential risk, including considerations such as antecedent conditions, cumulative impact from successive events and the background of these against climatology and socio-economic factors. DSS can be incorporated into an IBF process, however, it was noted that currently this is limited in observed practices, with many DSS existing outside of NHMSs.

Some promising examples were identified including ongoing work between DHM, NDRRMA (National Disaster Risk Reduction and Management Authority) and various NGOs in Nepal on heat and cold waves. It was noted that this is often a subjective and challenging process, especially to those NHMSs for which this was a new concept. Understandably, NMHSs were concerned about resourcing challenges and information gaps, particularly overall assessments of the likelihood of impacts occurring. Limited engagement and buy-in from partner agencies, who can help fill information gaps, was also identified as a key challenge. There was debate around the development of hyper-local forecasts, with concerns raised about meeting user expectations and the potential for false confidence in higher accuracy perceived by the users.

It was agreed that co-production and co-delivery of IBFEWS is critical for success, helping producers and users better understand each other and ensuring information is shared and decisions take account of all available data and understanding. It was discussed that this co-production or co-delivery could also be approached at a regional level, particularly for key hazards such as lightning and heat. Suggestions for approaches to tackling this were discussed, especially in identifying and considering how the UK funded WISER Asia Pacific programme could support capacity development.in the longer term, by engaging RIMES, the IBF WG, and national focal persons from NHMSs. Key recommendations from this discussion are below.

Key Takeaways

- **DSS tooling should be used cautiously depending on the scenario to which it is being applied**. DSS tooling is there to help in the decision-making process but should not be used in isolation, or without consideration of other issues. There are inherent limitations of NWP which directly feed some of this output, and users need to better understand these limitations to be more effectively able to interpret and use outputs.
- **There is a role for DSS output to be used as part of the forecast process supporting IBFEWS**. Where DSS tooling exists outside of NHMSs it would be beneficial for them to have oversight to be able to incorporate some benefits it offers in wider assessment of potential impacts.
- **Producers and users need to work together** more closely to fully understand each other's position. Producers need to understand actions, lead times and risk appetite of users, and users need to understand forecast limitations and uncertainty.

Ultimately, forecasts and warnings need to be actionable, and this is best achieved through a coproduction framework and methodology.

- **Consideration needs to be given to the suitability of different forecast approaches for different applications/sectors/users**. Hyper-local forecasts may not be realistic, or it may not be the user who is best placed to localize the forecasts, especially where these are impact based.
- **Users may be the ones best placed to understand how a broader forecast may materialize at a local scale** based on their experience and potentially the subsequent application of a DSS to IBF forecast (e.g., highlight areas of enhanced vulnerability within an area by interrogating other appropriate data sources).

Key Recommendations

- RIMES and the Met Office to work together with the SAHF IBF working group on addressing the key priorities of the working group.
- The Met Office, in conjunction with RIMES and IBF working group members, should work to develop a toolkit to support the design, development and implementation of IBFEWS in the region, under SAHF.
- The toolkit should address the working group priorities, especially around sustainability, and include capacity development materials, case studies, best practice, resources, and troubleshooting guides. RIMES and nominated national focal persons would be trained and upskilled in the use and application of the toolkit, ensuring longer term sustainability.
- To enable the training and upskilling in the use and application of the toolkit the following proposal was agreed as a potential way forward:
    - Identification of a common regional hazard (to be agreed by SAHF IBF working group, with input from designated regional centers, RIMES, and the Met Office)
    - Development of a regional approach to the hazard
    - Development of a community of practice around the regional approach and hazard
    - Piloting of the agreed approach in different national contexts
    - Verification/review of national pilots
    - Refinement and optimization of approach and toolkit
    - Development of best practice and sharing of experiences across common geographies
    - Mainstreaming and widespread implementation for regional hazard
- Training and capacity development is required for users in the concept of forecast uncertainty to help improve their ability to take appropriate action based on forecasts and early warnings.

SESSION 13: Climate Services in SAHF

This session aimed to explore the current status, needs and priorities for climate services that could be addressed under SAHF. The requirement for this session was driven by the outcomes of the 3rd meeting of the SAHF Executive Council (EC) in Bangkok on 30th November 2023. The draft resolution document included a commitment from the EC for the SAHF to explore and develop strategies in new areas including, '*enhancement of Climate Services*.'

The session was conducted in an interactive manner, with questions posed by the facilitator, **Sarah Holmes** (International Climate Scientist, Met Office, UK) with facilitation assistance for the exploration/discussion session from **Anshul Agarwal** (Team Leader, Hydrology, RIMES), **Helen Caughey** (Deputy Chief and International Meteorologist, Met Office, UK) and **David Corbelli** (Senior International Development Manager, Met Office, UK). In understanding the region's needs and priorities, the overall aim of the session was to understand appetite for a climate services component in the SAHF while also assisting in the design of the Met Office funded Weather and Climate Services (WISER) Asia Pacific programme, which sits under the UK government funded Climate Action for a Resilient Asia (CARA) initiative. Previous Met Office activities in the region, namely the Asia Regional Resilience to a Changing Climate (ARRCC) programme, identified a need for regular and sustained dialogue and knowledge exchange amongst providers and users of climate change information in the region with a 'Regional South Asia Climate Forum' proposed. This session re-visited the requirement for such a forum, questioning whether the SAHF, with an additional climate services element may be able to fill this gap, and act as a mechanism for the enhancement of climate services in South Asia.

The session began with a brief overview of relevant information including a definition of 'climate services', WMO initiatives including both the Global and Regional Framework(s) for Climate Services (GFCS and NFCS), as well as an overview of climate services activities in the region, including the current progress towards a potential Regional South Asia Climate Forum. The majority of the session was given to a semi-structured discussion, with participants split into three groups. Consideration was given in the structuring of groups to ensure each was comprised of a range of stakeholders and NHMS representatives, ensuring both producer and user perspectives were reflected.

The groups were first asked to think about, and discuss, current climate services activities (termed as a 'stock take'), including sharing whether their countries were developing a NFCS, whether any national mandates existed, and what organizations were already working in the climate services space. Each group, with the aid of a lead facilitator, documented their information on post-it notes. In the second part of the discussion, participants were asked to think about future priorities, and what a potential climate services component in the SAHF may look like. This discussion was guided by questions including '*should there be a climate services strategy in SAHF?*', '*what are the most important needs and priorities?*', '*who should be involved?*', and 'is *there a need for capacity building?*'. In the final part of the session, each group fed back their key points to identify consistent themes and priorities and allow some inter-group knowledge sharing and exchange.

Overall, general feedback from participants indicated that for (longer term) climate services (and science), SAHF will need to broaden, bringing in more sectors where climate information is relevant and needed. Many participants fed back that a key barrier is that many in-country government departments can be 'siloed' in their approaches to disaster risk reduction and climate adaptation. Adding to this, another issue was that in some cases the responsibility for hydrometeorology sits with one agency, while in others the responsibility is divided, with hydrology and meteorology sitting in separate agencies. It was noted however that the SAHF could provide the mechanism through which to bring these different agencies, with different remits and perspectives together, to tackle common challenges, enhancing collaboration and understanding across siloes.

A large part of the discussion built on topics from some of the main conference sessions, namely on the need for a coordinated regional approach to a number of priorities (such as observations/ data). There was a suggestion of the requirement for a coordinated regional approach to climate services that assisted nationally focused efforts. For example, a Regional Framework for Climate Services would help SA nations to work towards their NFCSs, especially considering many of the climate impacts are shared regionally.

Some specific examples of where a regional approach and initiative of climate services could add value included: a coordinated approach to data or a regional data sharing facilitation; development of gridded climate datasets, developing a regional understanding of climate norms and extreme values, enhancing the understanding the changing nature of tropical cyclones (TCs), such as how TCs will change (intensity/frequency/location etc.,) in the Bay of Bengal (which do, and will continue to affect multiple SA countries). There was also discussion on regional capacity building requirements including, training on development of climate projections, understanding climate impacts to the region, capacity building for users (policymakers, to vulnerable communities).

While the session identified some clear areas and priorities for regional support on climate services, the discussions often reverted to weather-specific needs and priorities. Nonetheless, many participants noted that many approaches in weather-timescale information could be applied longer term.

Key Takeaways

- To enable inclusion of longer-term climate information and services, the remit and reach of SAHF would need to be broadened, including the 'users' of climate information/ services i.e., additional organizations and sectors would need to be involved.
- SAHF could act as a mechanism to tackle issues around 'siloing,' particularly by bringing producers and users together to enhance understanding and collaboration, and at technical levels by better connecting those working across different timescales i.e., weather, seasonal and longer-term climate information.
- As discussed throughout SAHF VI, a coordinated regional approach is required throughout, including the approach to climate services – many impacts of climate change happen regionally, such as changes to TCs.
- Lessons from shorter-term weather/ seasonal information can be applied at longer timescales.

- Few countries have started work on their NFCS (India, Bangladesh fed back that they have).
- While countries are interested in climate services, the appetite is for climate services at shorter timescales, but exploration of information on longer-timescales is still important.

Key Recommendations

- The is a clear requirement for a climate services component in SAHF. This should also consider broadening the range of stakeholder groups involved.
- An interim working group on climate services is required to further develop priorities and develop a proposal and plan for a climate services component under SAHF. To be presented to the SAHF EC for approval.
- An important element of this will be to understand how SAHF will work with other regional mechanisms such as SASCOF (South Asia Seasonal Climate Outlook Forum)* to avoid duplication of effort. This interim working group should be coordinated by RIMES, with assistance from the Met Office with representation from NMHSs or other related national government actors/ NGOs across the region.
- A timescale transition period for climate services may be required, with a focus on climate services at shorter timescales, later bringing in longer-timescale information.

*It should be noted that the Met Office are running a session on the NFCS in the upcoming SASCOF with reference to what was discussed in this session.

Session 14: Update from the SAHF Hydrology Working Group

During Session 14, **Anshul Agarwal** (Team Leader, Hydrology, RIMES), facilitated a discussion focusing on the establishment and objectives of the Hydrology Working Group (WG) within SAHF. The session centered on recognizing the broad implications of hydrology across various sectors in the region, including agriculture and disaster management. This recognition prompted the formation of the Hydrology WG, reflecting a concerted effort to consolidate expertise, foster collaboration, and develop tailored initiatives addressing hydrology-specific challenges in South Asia (SA).

A notable highlight of the session was the positive progress in nomination of members for the Hydrology WG, with significant nominations from the NMHSs and relevant stakeholders in the region. This inclusive approach establishes a promising foundation for the group's effectiveness in addressing the diverse challenges within the hydrology domain.

The session also delineated clear expectations for the WG, emphasizing its potential to effectively address pressing water-related challenges across SA. These expectations encompassed a range of responsibilities, from conducting thorough reviews of existing hydrological capacities to advocating for sustainable development programs aimed at enhancing resilience against water-related risks. Additionally, the session outlined a robust set of tasks for the WG, including collaborating with national and international partners, engaging relevant stakeholders, and providing strategic recommendations to the SAHF Executive Council (EC). These responsibilities underscored the pivotal role of the WG in guiding policy formulation, facilitating capacity-building efforts, and integrating hydrological insights into decision-making processes at both regional and national levels.

Overall, the session demonstrated a collective commitment to leveraging the expertise and resources within the Hydrology WG to advance the objectives of the SAHF and contribute meaningfully to achieving sustainable water security and resilience across SA.

Session 15: Cultivate communities of practices (COPs) for delivering operational hydromet services

The session objectives were to help define Community of Practice (CoP) for SAHF with an emphasis on identifying CoP(s') that could help accelerate progress in the priority actions that had already been identified and agreed during the conference.

The two facilitator, Jerry Lengoasa (Hydromet Advisor, WB) and Efrem Ferrari (DRM expert, WB) opened the session by introducing the topic of COPs, while examples of three communities of practice established in the region were shared by attendees: in India (by Geetha Balasubramanian - IMD RMC Chennai), in the Caribbean (David Grimes – WB) and in Sri Lanka (Ruby Policarpio - RIMES). A comprehensive dialogue followed in which several key characteristics of COPs were identified, including that the CoP should be transdisciplinary, be driven by passion for a subject, be voluntary, handle both quantitative and qualitative information.

The discourse expanded on potential thematic foci for CoPs, which could be spanning geographical features at local or regional scales, such as mountain meteorology and coastal services, as well as topic-specific domains like communicating uncertainty in Impact-based forecasts (IBF) and Decision Support Systems. Furthermore, the CoP's could be supportive of projects or programs, be for information sharing, or innovation and breaking new ground. Attendees also highlighted that COPs are distinct from Working Groups, which are an already established, formal and structured mechanism to advance the SAHF agenda.

Consensus was reached that initiating CoPs is a prudent endeavor, subject to refinement through experiential learning. This approach builds upon the collaborative ethos of SAHF while fostering dynamic knowledge networks conducive to advancing hydrometeorological resilience in the South Asian region. To expedite this tool for SAHF, several recommendations surfaced.

Key Recommendations

- RIMES will establish a task team to develop Concept Notes for each COP.
- The task team will propose a costed working mechanism leveraging the SAHF Knowledge Hub as an online platform to allow CoP's hybrid (virtual and in-person) interactions.
- Propose focus areas/topics to commence CoP's with informal and /or curated content (e.g., webinars to deep dive on specific conference topics).
- Propose administrative systems for registration and management of the CoP tool.

Annex I – SAHF IV Declaration

SAHF IV

UNLOCKING REGIONAL SYNERGIES

DECLARATION

Colombo, 8th February 2024

We, representatives of National Meteorological and Hydrological Services, Disaster Risk Management agencies, regional organizations, academia, development organizations, sectoral and other stakeholder groups, meeting in Colombo, Sri Lanka from 6 to 8, February 2024 at the Fourth South Asia Hydromet Forum[4], **consider** the need to:

- Deepen collaboration and increase regional synergies and economies of scale for better hydrometeorological and early warning services to enhance resilience and socioeconomic benefits in the region;
- Create a shared vision for enhancing a regional observation network to support weather, water, and climate services;
- Create mechanisms, based on science, to strengthen regional forecasting, data analytics, and scenario planning;
- Develop effective last-mile communication mechanisms to enable people, including stakeholders, to take informed decisions;
- Help the region collectively to undertake actions for climate resilience by strengthening the hydromet services' contribution to public services, in an effective and efficient manner;
- Enhance opportunities for sharing experiences and lessons learned towards mainstreaming weather, water and climate services that contribute to the achievement of Sustainable Development Goals.

APPRECIATING

- The achievements made by SAHF since its inception;

[4] The Forum was co-hosted by The World Bank, Met Office UK, the World Meteorological Organization, the Regional Integrated Multi Hazard Early Warning Systems (RIMES), with support from the Foreign, Commonwealth & Development Office.

- The strategic role of the SAHF Executive Council, and the Resolution of the 3rd SAHF Executive Council Meeting adopted on 30th November 2023;

- The assistance provided by RIMES in managing, coordinating and facilitating SAHF activities on behalf of the SAHF Executive Council;

- The support provided by the World Bank, the Global Facility for Disaster Reduction and Recovery (GFDRR), the World Meteorological Organization, Met Office United Kingdom (UK), Indian Meteorological Department (IMD), the UK Foreign, Commonwealth and Development Office and the European Union;

- The collaborations and contributions by regional governments, agencies, and stakeholders.

RECOGNIZING

- The strategic engagement between RIMES and WMO, which has materialized into a joint strategy and action plan;

- The significance of the strategic partnership between the European Centre for Medium-Range Weather Forecasts (ECMWF) and SAHF, enabling the delivery of high quality, high-resolution and timely forecasts;

- The potential benefits of continued collaborations, regional networks and institutions, and data sharing;

AFFIRM

Our shared commitment to advancing hydrometeorological and related services in South Asia by promoting and strengthening:

- Alignment with WMO Regional Association II (RA-II), through the inclusion of SAHF activities in their Operating Plan. SAHF, as a sub-regional mechanism, will effectively contribute to Plan's objectives by fostering a cohesive approach to addressing priority themes such as strengthening of observation network and data sharing, utilization of radar data and techniques, capacity building on integrated services - including polar and high mountain activities, marine and coastal services, and impact-based multi-hazard early warning;

- The relationship between SAHF and ECMWF, by enhancing the use of ECMWF products in the region. SAHF will contribute effectively to ECMWF's requirements for observation data, facilitating data exchange among SAHF members and ECMWF; model verification, through the Data Exchange Platform (DATAEX); and enhancing forecasters' capacities in

utilizing ECMWF products. This will be achieved through the deployment of regional capacity-building programs and the promotion of ECMWF products' use in sector applications;

- Enhanced collaboration between SAHF and technical partners, including the European Meteorological Network (EUMETNET) and the Systematic Observations Financing Facility (SOFF), to strengthen the hydromet value chain in South Asia. This includes promoting the exchange of best practices in observation, forecasting and capacity building and exploiting synergies to enhance weather, water and climate services. This will ensure all SAHF members have the capacity to visualize, use and integrate model data and other information into the forecast processes, maximizing the social and economic benefits of these services;

- Co-development of hydromet services among NMHSs and South Asia regional institutions, including RIMES, Indian National Centre for Ocean Information (INCOIS), International Centre for Integrated Mountain Development (ICIMOD), and National Centre for Medium Range Weather Forecasting (NCMRWF);

- Enhanced collaboration between SAHF and Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) Centre for Weather and Climate (BCWC) to develop and advance regional weather and climate modelling, promote related applications and enhance capacity building.

RECOGNIZING

- The need for adequate resources to fully implement the SAHF plan and program,

EMPHASIZE

- The need for stronger coordination among development partners to avoid duplication, explore synergies and ensure optimal allocation of financial resources, and pledge to strengthen resource mobilization efforts at national level. We also reaffirm the use of SAHF as the primary cooperation platform for developing regional projects and encourage both, private and public investments in the region.

ENCOURAGE

- Collaboration with academia and private sector, including start-ups in the region, to support capacity development, the testing and adoption of new technologies and applications such as machine learning, artificial intelligence and radar techniques, and to realize the benefit of advances in science and technology for South Asia region;

- Collaboration with academia to contribute to the supply of skilled hydromet personnel to meet the needs of South Asia region for the future;

- Collaboration among NMHSs and regional institutions to share and propagate new knowledge and techniques;

- Collaboration with communities and school based hydromet observation networks for increasing local awareness and coproduction of alerts for extreme events at local scales.

RECOGNIZING

- The urgency to enhance preparedness and response to weather-related hazards in South Asia, we

REAFFIRM

- Our commitment to implement a regional effort to reinforce people-oriented, impact-based, multi-hazard early warning systems and services, and request RIMES to lead this effort by defining communities of practice adopting a collective, "whole-of-society" approach;

- The importance of ensuring that all SAHF members have the same opportunity to minimize the adverse impacts of weather, water and climate related hazards;

- Continued collaboration among agencies and NMHSs to share new knowledge and techniques;

CALL

- For increased synergies between SAHF and the United Nations-led Early Warnings for All initiative to ensure that communities at risk receive timely, accurate, and actionable alerts, contributing to the overall resilience of the region;

- For enhanced access to information and capacity to mainstream hydromet applications;

COMMIT

- To enhance climate services in support of community resilience, by building on RIMES Climate Data Access and Analysis System (CDAAS), Regional Data Analytics System (RDAS) and Copernicus Climate Changes Service (C3S), among others;

- To engage with potential users so they can maximize the benefits from new developments.

RECOGNIZING

- That uncertainty is an impediment to effective decision-making stemming from impact-based forecasting services,

CALL

- To establish institutional mechanisms between users and NMHSs to facilitate the co-production of products and services that help user communities to make more informed decisions.

RECOGNIZING

- That the benefits derived from effective hydromet services greatly exceed the costs associated with their creation, we

ENCOURAGE

- Further assessments of the socio-economic value of hydromet services and the benefits of regional and global collaboration;

- Review of NMHS's business models to improve access to resources – both human and financial - for strengthening weather, water, and climate services in the region.

We believe the successful implementation of SAHF program will require the strengthening of capabilities of regional NMHSs, RIMES and other organizations, and the need for well-defined program and project objectives and strategy. This SAHF conference in Colombo, Sri Lanka, marks a significant milestone in fostering a common vision and cooperation among SAHF members, and solidifies an urgent call for all partners, governments, and institutions to join this worthy challenge of creating a safe and sustainable South Asia.

Annex II – SAHF IV Agenda

Day 1 – February 6	
8:30 – 9:45 **Security Check, Coffee and Registration**	
Session 1 **10:00 - 11:00**	**Opening Ceremony.** *This session offered opening remarks and reflections on the relevance of hydromet services for climate resilience as well as the complementarity of national and regional efforts. After the lighting of the lamp, opening remarks were provided by:* **Karma Dupchu,** Co-chair of SAHF and Director National Center for Hydrology and Meteorology, Bhutan **Dina Umali-Deininger**, Director of the South Asia Region, WB **Ranil Wickremesinghe**, President of Sri Lanka **Andrew Patrick,** High Commissioner, UK **Cecile Fruman**, Director for Regional Integration in South Asia, WB **Celeste Saulo**, Secretary-General, WMO
Group photo **11:00 – 11:15**	
Break **11:15 – 11:45**	
Session 2 **11:45 – 12:45**	**Creating value – the role of hydrometeorological services.** *This session framed the conference along the value chain and the need for actionable information provided to the right people at the right time to reduce multi-hazard risk and enable socio-economic benefits. Presenters included:* **Melanie Kappes**, Disaster Risk Management Specialist, WB - Creation of value along the hydromet value chain **Nusrat Noman**, Joint Secretary, Planning Commission Bangladesh - The role of hydromet services in public investment planning **Carlo Buontempo** (virtual), Director of the Copernicus Climate Change Service, ECMWF - The role of climate services for climate resilience **Abhas Jha**, Practice Manager, WB - The socio-economic value of hydromet services and the role of regional collaboration
Lunch **12:45 – 14:00**	
Session 3 **14:00 - 15:30** **Chair: David Grimes, Sr. Hydromet Advisor, WB**	**Forging a shared vision for building a regional observation network for more efficient weather, water and climate services:** *This session explored mechanisms that can be applied to expand, sustain and make most efficient use of the existing observations as a region, and steps towards establishing rules of an operational regional basic observation network, to achieve high-resolution spatial and temporal observation. A panel discussion was followed by a facilitated conversation including the audience. The panelists of the session were:* **K. J. Ramesh**, SAHF Advisor, RIMES **Roar Skålin** (virtual), Chair of the EUMETNET Assembly and Director General Met Norway **Estelle Grueter** (virtual), Chair of Standing Committee on Earth Observing Systems and Monitoring Networks, WMO **Anju Gaur**, Sr. Water Resource Management Specialist, WB **Ashish Raval**, President & CEO of Synoptic Data PBC and HMEI Vice-Chair

Break **15:30 – 15:45**	
Technical Side Session **15:45 - 17:15** **Chair: Ben Churchill, Director, Regional Office for Asia and the South-West Pacific, WMO**	**Technical side-session: Implement and leverage SOFF from a regional perspective**
19:30 Welcome dinner and cultural event **Speaker – Dinendra Ruwan Wijewardene, Sr. Advisor to the President on Climate Change**	

Day 2 – February 7	
Session 4 **09:30 – 11:00** **Chair: Mr. Karma Dupchu, Co-chair SAHF & Director NCHM Bhutan** **& Ali Shareef, Deputy Director, MMS Maldives**	**Fostering regional collaboration to strengthen the service delivery and impact on public welfare**: *This session explored opportunities to jointly enhance services in South Asia with emphasis on the needs of people in mountain regions, coastal communities, and agriculture. Expertise is scattered throughout the region with limited human resources to develop the required level of services in many countries. A panel discussion was followed by a facilitated conversation including the audience. The panelists of the session were:* **Nishadi Eriyagama**, Deputy Country Manger, Sri Lanka, International Water Management Institute (IWMI) **Faisal Mueen Qamar**, Intervention Manager for Resilient River Basin, International Center for Integrated Mountain Development (ICIMOD) **Ajay Kumar**, Scientist, India National Centre for Ocean Information Services (INCOIS) **Temily Baker**, Programme Management Officer, United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) **Tshering Wangchen**, Principal Agriculture Officer, Ministry of Agriculture, Bhutan
Break 11:00 - 11:30	
Session 5 **11:30 – 13:00** **Chairs: Abhas Jha, WB and David Rogers, WB**	**Empowering communities to make informed decisions:** *This session facilitated an exchange and discussion on digital solutions and last-mile communication needed to enable people to take anticipatory action, and how the region can jointly progress towards action for climate resilience. A panel discussion was followed by a facilitated conversation including the audience. The panelists of the session were:* **Ruby Rose Policarpio**, Institutional Development Specialist, RIMES **Terrence Fernando**, Professor, University of Salford **Helen Caughey**, Deputy Chief Meteorologist, Met Office, UK **Madhab Uprety,** Sr. Technical Advisor, Red Cross Red Crescent **S. Thrimanne**, Additional District Secretary, Kalutara District, Sri Lanka
Lunch **13:00 – 14.00**	
Session 6 **14:00 – 15:30** **Chairs: K.J. Ramesh, SAHF Advisor, RIMES & Alice Soares, WB**	**Towards Regional Prediction and Analytics:** *This session explored requirements, resources, products, models, and coordination mechanisms that can support the strengthening of regional forecasting and analytics including emerging new technologies. A panel discussion was followed by a facilitated conversation including the audience. The panelists of the session were:* **S. M. Quamrul Hassan**, Meteorologist, Bangladesh Meteorological Department and Chair of the SAHF Numerical Weather Prediction Working Group **V. S. Prasad,** Head, National Centre for Medium Range Weather Forecasts (NCMRWF) **Alan Thorpe,** (virtual), Professor of the Department of Meteorology, University of Redding **Kirstine Dale**, (virtual) Chief AI Officer, UK Met Office **Hans Olav Hygen**, Head of Climate Services, Met Norway
Break **15:30 – 16:00**	

Technical Side Session **16:00 - 17:00** **Chair: Ashish Raval, vice-chair of HMEI and CEO of Synoptic Data PBC**	**The role of the private sector to foster innovation and empower hydromet services for providing sustainable systems, actionable insights and early warnings to save lives and protect property.** *This session discussed how trust can be established, sustainable projects can be developed, and latest technology can be leveraged through public private partnerships.*
Technical Side Session **17:00 – 18:00** **Chair: Ben Churchill, Director, Regional Office for Asia and the South-West Pacific, WMO**	**Early Warnings for All – A Partnership Approach.** *This session facilitated a discussion on the UN Early Warnings for All initiative and its enabling mechanisms. The objective was to share experiences and identify opportunities and innovative approaches to fast-track early warning systems that help vulnerable communities adapt to climate change, save lives and livelihoods, and contribute to socio-economic development.*
Closed Side Event **18:00 – 19:00** **Facilitator: Subbiah Arjunapermal, Director, RIMES**	***Reception - Partners meeting on SAHF (invitation only):*** **Dev. Partners, RIMES & SAHF EC members**

Day 3 – February 8	
Session 7 **9:00 – 9:20** **Presenter: Ruby Rose, RIMES**	**Setting the scene:** *This session provided a summary of key points raised over the previous two days particularly in relation to the resolution, and a presentation of the draft Conference Declaration*
Session 8 **9:20 – 10:30** **Facilitator: David Grimes, Sr. Hydromet Advisor, WB**	**Aligning around key outcomes and priorities:** *In this session participants discussed in small groups to provide their aspirations and priorities for enhanced regional cooperation in South Asia Region, followed by a short plenary to facilitate quick reporting.*
Break 10:30 - 10:45	
Session 9 **10:45 – 13:00** **Facilitator: David Grimes, Sr. Hydromet Advisor, WB and K.J. Ramesh, SAHF Advisor, RIMES**	**Framing the elements of a SAHF action plan:** *Aligned with the preceding Session (8) outcomes and the implementation of enhanced regional cooperation among SAHF members, group discussions aimed at identifying key actionable "next steps".*
Lunch **13:00 – 14:00**	
Session 10 **14:00 – 15:00** **Chair: Melanie Kappes, DRM Specialist, WB & Jerry Lengoasa, Sr. Hydromet Advisor, WB**	**Panel Discussion of the SAHF Executive Council and RIMES:** *Reflections on the conference deliberations and the future direction of SAHF*
Break **15:00 – 15:15**	
Session 11 **15:15 - 16:00**	**Closing session:** **Presentation of the final draft Declaration** **Karma Dupchu**, Director of the National Centre of Hydrology and Meteorology (NCHM), Bhutan and SAHF Co-chair **Chiyo Kanda**, Country Manager for Sri Lanka, WB **Lisa Whanstall**, Deputy High Commissioner, UK **Athula Karunanayake**, Director General of the Department of Meteorology, GoSL **Vote of Thanks**
Conference Ends **"Market Place" of local vendors outside the Banquet Hall**	
Closed Side Session **16:30 - 17:30**	**Critical technical and strategic aspects to make best use of NWP data by NMHSs***: In this session participants discussed in small group to address critical technical aspects that allow use of NWP*

Chair: **Alice Soares**	*data, including the visualization tools and capacity building requirements. The group also discussed strategic approaches for the region to overcome the challenges NMHSs face in NWP.*

Day 4 – February (Only Hydromet Representatives, RIMES, UK Met, WB and WMO) – Planning of next steps for SAHF Break-out room, Galle Face Hotel	
Session 12 **9:30 – 11:00** **Facilitator: Helen Caughey, UK Met Office & Anshul Agarwal, Team Leader Hydrology, RIMES**	**Dealing with forecast uncertainty in an impact-based forecasting approach, and the role of DSS:** *This session aimed to explore how impact-based forecasting tries to account for forecast uncertainty in the communication of risk to stakeholders, at lead times which enable decision making and effective early action, discussing the role of DSS in support of an IBF framework, understanding limitations and challenges of different approaches, both from a producer and user perspective.*
Break **11:00 – 11:30**	
Session 13 **11:30 – 12:30** **Facilitator: Sarah Holmes, UK Met**	**Climate services: priorities, needs and opportunities under SAHF:** *This session aimed to understand the current status, future needs and priorities around climate services and discussion of how SAHF can support and facilitate these priorities.*
Lunch **12:30 – 13:30**	
Session 14 **13:30 – 14:00**	**Update from the Hydrology Working Group:**
Break **14:00 – 14:30**	
Session 15 **14:30 – 16:00** **Facilitators: Efrem Ferrari and Jerry Lengoasa**	**Cultivate communities of practices (COPs) for delivering operational hydromet services**