PROCEEDINGS

Regional workshop on climate services for the water and hydropower sectors in South Asia

24–26 September 2019
Kathmandu, Nepal

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Jointly prepared by

ICIMOD and the Met Office

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Mountain Environment Regional Information System (MENRIS)

Contents

Abbreviations and acronyms

AKDN	Aga Khan Development Network
ARRCC	Asia Regional Resilience to a Changing Climate
BMD	Bangladesh Meteorological Department
BWDB	Bangladesh Water Development Board
CARISSA	Climate Analysis for Risk Information and Services in South Asia
CEWRE	Centre of Excellence in Water Resources Engineering
CORDEX	Coordinated Regional Climate Downscaling Experiment
DFID	Department for International Development
ICIMOD	International Centre for Integrated Mountain Development
GCM	General Circulation Model
GLOF	Glacial Lake Outburst Flood
GHG	Greenhouse gas
HKH	Hindu Kush Himalaya
IPCC	Intergovernmental Panel on Climate Change
MTOE	Million Tons of Oil Equivalent
NDRI	Nepal Development Research Institute
NUST	National University of Science and Technology
RCPs	Representative Concentration Pathways
SAARC	South Asian Association for Regional Cooperation
TERI	The Energy and Resources Institute
WAPDA	Water and Power Development Authority

Executive summary

A three-day regional workshop brought together climate researchers, climate service providers, boundary organizations and users of future climate information. The workshop aimed to discuss and identify needs, requirements and knowledge gaps related to climate information for the water and hydropower sectors in South Asia.

The workshop was the second in a series of regional workshops jointly hosted by the Met Office and the International Centre for Integrated Mountain Development (ICIMOD) as part of the Asia Regional Resilience to a Changing Climate (ARRCC) programme. These workshops were organized as part of the Climate Analysis for Risk Information and Services in South Asia (CARISSA) work package of the ARRCC programme, which aims to improve the uptake and use of future climate projections in decision-making across the South Asia region. The first regional workshop, held at ICIMOD, Kathmandu, in January 2019, identified the development of climate services for the water and hydropower sectors as one of six priority activities of the CARISSA project.

The workshop was organized to begin the process of identifying the key climate vulnerabilities for the water and hydropower sectors and to identify potential areas where climate services could add value to relevant decision and policy processes. The workshop began by setting the scene for why climate services are needed for the water and hydropower sectors. Case studies of extreme events and their impacts were shared, such as flash flooding in Afghanistan and Bangladesh and Glacial Lake Outburst Floods (GLOFs) and their impacts on hydropower projects in Pakistan and Nepal. This was followed by a practical activity which highlighted the need to tailor climate information to user decision contexts through a process of climate information "distillation".

The second day of the workshop focused on identifying key climate-related issues for the water and hydropower sectors in the ARRCC focus countries through a series of presentations and discussion sessions. These included flash flooding and drought impacts on agriculture in Afghanistan, tropical cyclones and sea level rise in coastal Bangladesh, flooding and inundation in the southern plains of Nepal and extremes in catchments upstream of hydropower stations in Pakistan. Met Office scientists also shared an update on the progress of a pilot climate information product focusing on the hydropower sector in Nepal to demonstrate the process and benefit of climate information distillation. The key issues identified during the workshop could be the subject of future pilot studies.

The third and final day focused on providing examples and gathering requirements for communicating climate information, along with identification and discussion of other key gaps in the data and science in order to develop these services. Gaps identified included characterization of teleconnections linked to extreme events, and improved data sharing across the region.

In the afternoon, there was a focus session on the pilot study for hydropower in Nepal. This session brought together relevant stakeholders to identify further requirements for this service. Following overview presentations, the discussion focused on the complexities of the orography and the need for high-resolution data to meet the requirements

of hydropower developers. Outcomes of the discussion included the requirement for training on the use of climate model projections, improved communication on the benefits and limitations of climate model projections, and the need to better understand the current and future risk of extreme rainfall events.

The workshop succeeded in its objective of identifying key climate-related issues for these sectors across the region. Outcomes of discussions have helped to shape ongoing plans for this activity under the CARISSA project. Common themes that emerged throughout the workshop were:

- the importance of extreme events, such as extreme rainfall, flash flooding and drought;
- the lack of reliable observational data relevant to sectoral applications; and
- the difficulties of understanding the uncertainties and limitations of climate models and applying them for use in decision-making.

Through three days of presentations, interactive activities and discussion, the workshop also helped to improve regional collaboration and interaction between different actors in the development of climate services; from providers, intermediaries and users of climate information. This ongoing engagement and collaboration among institutions will support the future development of climate services to improve the uptake of climate information and build resilience to a changing climate.

SECTION 1

Background

Water is a crucial resource for South Asian communities, which are mostly agrarian economies and meeting their energy demands mainly from hydropower. The South Asian monsoon is one of the most anticipated, tracked, and closely studied weather phenomena in the region because of its effect on agriculture, river flows, water levels in reservoirs, environment and climate. Water availability in the region is also heavily influenced by tropical storms and Western Disturbance precipitation. Snow and glacial melt water, mostly from the Hindu Kush Himalaya (HKH), also provide water throughout the year. Under climate change, river flows and monsoon patterns may alter significantly.

The Asia Regional Resilience to a Changing Climate (ARRCC) programme[1], which commenced in September 2018, is a four-year programme aiming to strengthen the provision and uptake of weather and climate services across South Asia. Although regional in nature, ARRCC will focus on the most vulnerable countries in the region, primarily Afghanistan, Bangladesh, Nepal, and Pakistan.

As part of the Climate Analysis for Risk Information and Services in South Asia (CARISSA) Work Package of the ARRCC programme, a "Regional workshop on future climate projections and their applications in South Asia" was held in January 2019 at the International Centre for Integrated Mountain Development (ICIMOD) in Kathmandu[2]. At this workshop participants highlighted the importance of climate information for the water sector and identified climate services for water and hydropower as one of the topics for further research and discussion in a subsequent workshop. While priorities in these sectors are different across the four focus countries, this topic is very relevant across the region because of people's dependence on water and the issues that arise around the seasonal and inter-annual variability of water availability. Large parts of the ARRCC focus regions are drought and flood prone, and it is important to understand whether and how these areas will be affected by future climate change and consequent risks, to try to improve uptake of climate information in decision-making.

Developing climate services for the water and hydropower sectors is one of the six primary activities under CARISSA, identified at the initial regional workshop. One of the objectives for this activity by the end of the first year of ARRCC (September 2019) was to jointly host a regional workshop focusing specifically on climate services for the water and hydropower sectors. In addition, a pilot climate information product focused on the hydropower sector in Nepal is being developed to demonstrate the process of "distilling" climate information to inform decision-making.

SECTION 2

Objectives

The workshop was the second in a series of regional workshops being held as part of the CARISSA project. The workshop had a specific focus on the role of climate services in the water and hydropower sectors in South Asia. It brought together researchers, providers, boundary organizations and users of future climate information to discuss and identify needs, gaps and issues related to climate information available for the water and hydropower sectors in South Asia.

The workshop was organized as a dialogue and showcase event, including short seminar-style presentations, demonstration of the pilot climate information service developments, question and answer sessions, group discussions, and focused group activities.

The workshop had three main objectives:

1. To identify the needs and gaps in climate information available for the water and hydropower sector and determine how downscaled regional climate models can help decision making in the sector
2. To present initial work on a pilot climate information service for the water and hydropower sectors
3. To demonstrate the value and challenges of bringing multiple sources of information together (including multi-model, multi-method climate projections) for a sector

[1] The ARRCC programme is funded by the UK's Department for International Development (DFID), and is a partnership with the Met Office and the World Bank.
[2] Met Office and ICIMOD (2019). Regional workshop on future climate projections and their applications in South Asia. ARRCC Programme. Workshop Report 1029/6. Kathmandu: ICIMOD

SECTION 3

Proceedings of the workshop

3.1 Day 1 – Setting the scene: Why do we need climate services for the water sector in South Asia?

OPENING SESSION

The day began with a formal opening of the workshop by Mandira Singh Shrestha, Programme Coordinator for the Climate Services and Hi-Risk initiatives, ICIMOD. She warmly welcomed the participants, acknowledging the different countries and organizations that were represented, and provided an introduction to the workshop and agenda.

Opening remarks were provided by Eklabya Sharma, Deputy Director General, ICIMOD. Sharma set the context for the importance of developing climate services for the water and hydropower sectors in the South Asia region, in particular the HKH region. The HKH mountain region is home to 1.9 billion people and the six river basins located in the region are a source of food, water and energy for 3–4 billion people. Understanding how climate change could impact hydropower, irrigation, agriculture and other industries is a key question. In addition, changes in land use and land cover will also affect hydrological cycles, water discharge and hydropower. While glaciers and snow are important components, fresh flowing water is equally important, and there is a need to consider water storage and develop a holistic approach. Sharma mentioned the recent HKH Assessment Report, which reflects the lack and uncertainty of data in higher elevations. He spoke about ICIMOD's work in the region and the need for capacity building and climate services to be developed at the regional level.

The final contribution to the opening session was provided by Bernd Eggen (Met Office, UK). He gave an overview of the ARRCC programme objectives, the planned activities under the CARISSA Work Package (identified at the Regional Workshop hosted at ICIMOD in January 2019), and the objectives of this workshop focusing on climate services for the water and hydropower sectors.

EKLABYA SHARMA FROM ICIMOD (LEFT) AND BERND EGGEN FROM THE MET OFFICE (RIGHT) SPEAKING DURING THE OPENING SESSION.

PARTICIPANT INTRODUCTIONS (LEFT) AND A PHOTO OF THE EXPECTATIONS PARTICIPANTS WROTE DOWN (RIGHT).

The opening remarks and talks were followed by an 'ice breaker' activity, led by Bernd Eggen, which required participants to join a circle and introduce themselves by mentioning their name and institution and their expectations of the workshop.

PRESENTATIONS – EXTREME EVENTS AFFECTING THE WATER AND HYDROPOWER SECTORS IN SOUTH ASIA

The aim of this session was to set the scene regarding the need for climate services in the water and hydropower sectors. Four short presentations described extreme events that have affected the water and hydropower sectors in their respective countries. The session was chaired by Ghulam Rasul, Regional Programme Manager of Mountain Environment and Regional Information System (MENRIS), ICIMOD.

Amjad Masood, Global Change Impact Studies Centre (GCISC), Pakistan, spoke on "Extreme Events Affecting Water and Hydro Sectors in Pakistan". The presentation identified flash floods, debris flow, GLOFs and landslides as the key challenges in relation to water resources and hydropower in Pakistan. He noted that there has been an observed increase in these types of events. He gave examples of recent GLOF events in Chitral and Hunza as well as the associated impacts on hydropower stations, infrastructure and livelihoods. He finished by listing some recommendations to help prevent similar events in the future: improved network of hydro-met stations for continuous monitoring of glaciers and glacial lakes, community training, historical data analysis, RS/GIS analysis with high-resolution satellite images ground-truthing.

Shajib Hussein, Bangladesh Meteorology Department (BMD), Bangladesh gave a presentation on "Climate Changes in Bangladesh: Hazards, Impacts, Affected, Action". The presentation introduced BMD and the climate risks facing Bangladesh. He gave examples of recent extreme events; extreme rainfall in Chittagong in June 2017 which caused 133 deaths as a result of landslides, and flash floods in the Hoar region of Sunamganj Sylhet in April 2017 which caused heavy losses of Boro crops. He mentioned that Bangladesh is working on adapting to these water-related disasters through several initiatives. Different flood and drought resilient crops and flood management measures are being introduced. However, there is a need for transboundary cooperation in data sharing and managing sedimentation further upstream to minimize impacts in countries downstream.

AMJAD MASOOD (GCISC, TOP LEFT), SHAJIB HUSSEIN (BMD, TOP RIGHT), HAMEEDULLAH ARGHANDEWAL (AMD, BOTTOM LEFT) AND SAMUEL INGLIS (ICIMOD, BOTTOM RIGHT) PRESENTING ON EXTREME EVENTS AFFECTING THE WATER AND HYDROPOWER SECTORS IN SOUTH ASIA.

Hameedullah Arghandewal, Afghanistan Meteorological Department (AMD), Afghanistan, presented on "Impact of Climate Change of Flash Floods Severity in Afghanistan". He explained that flash floods are the most common meteorological hazard in Afghanistan, causing damage to property, lives, and economic loss, as well as soil erosion and spread of malaria and other water borne diseases. There has been an increase in incidences of flash flood events due to deforestation, heavy rainfall and urban developments, with the most severe events occurring in 2014 and 2019. He highlighted the need for improved early warning systems and incorporation of climate information in building resilient systems and infrastructure design as these types of events are projected to increase in future due to climate change.

Samuel Inglis, ICIMOD, Nepal, described case studies of extreme climate-driven cryospheric events in the HKH region in his presentation "Cryospheric Response to Weather and Climate – Considerations for Hydropower in the HKH Region". He gave detailed summaries of the causes and impacts of four GLOF events: the Kedarnath disaster of 2013; the Pareechu floods of 2005; the collapse of the Aru-1 & 2 glaciers in 2016; and the Chong Kumdan GLOF of 1921. He talked about the potential exposure of hydropower projects in the HKH region to GLOFs; 177 hydropower projects are along potential GLOF paths and half of operational hydropower stations are within 140 km of a glacial lake. He identified the need for hydrometeorological stations throughout the region and the need to understand the system for greater transboundary communication, coordination and collaboration with diverse and dynamic phenomena and environments.

PRACTICAL EXERCISE: INTERPRETING COMPLEX AND CONTRADICTING CLIMATE INFORMATION FOR DECISION-MAKING

In the afternoon there was a practical exercise led by Katy Richardson, Met Office, UK (pictured below, left panel). The aim of the session was to demonstrate the experience of interpreting complex and contradicting climate information from the perspective of decision-makers, highlighting the need for climate information to be "distilled" and tailored to user requirements.

To ensure that the participants have a common understanding, Kate Salmon, Met Office, UK, (pictured below, right panel) began the session with a brief overview of climate modelling and the type of information climate model projections can provide. The participants were then divided into four groups for the practical exercise, ensuring a mix of providers and users of climate projections in each group. Each group was allocated a case study of an extreme event which has occurred in each of the ARRCC focus countries (e.g., flooding in Pakistan in July 2010) and were provided with information about the extreme event and the impacts experienced.

The groups were asked to assume the role of decision-makers who have responsibility for building resilience to the types of events in their case study in the future. The groups were then given a series of figures showing climate model projections from different sets of models and with different ways of presenting the information. The figures were given to the groups in various rounds. In each round they discussed what the figures showed, how they could use the information to inform their case study decision, and what key issues might arise while using the information to guide their decision or while using multiple sources to inform their decision (in the latter rounds of the activity).

KATY RICHARDSON (LEFT) AND KATE SALMON (RIGHT) FROM THE MET OFFICE SETTING THE SCENE FOR THE PRACTICAL SESSION.

Group members held engaging discussions, and a representative from each group provided feedback to the rest of the participants sharing their experience at the end of the activity. Common themes that arose were:

- Interpreting figures can be difficult and assumptions about how to present the information may not be most useful for the decisions being made.
- The plots were not necessarily compatible with each other in the domain, greenhouse gas scenarios and time period they showed.
- There is a need to consider multiple sources of information to better understand uncertainty, but when more information is provided it is more difficult to make a decision.
- More detailed and additional sector-specific information is required, such as output from hydrological models, or further details about the vulnerability of different stakeholders.

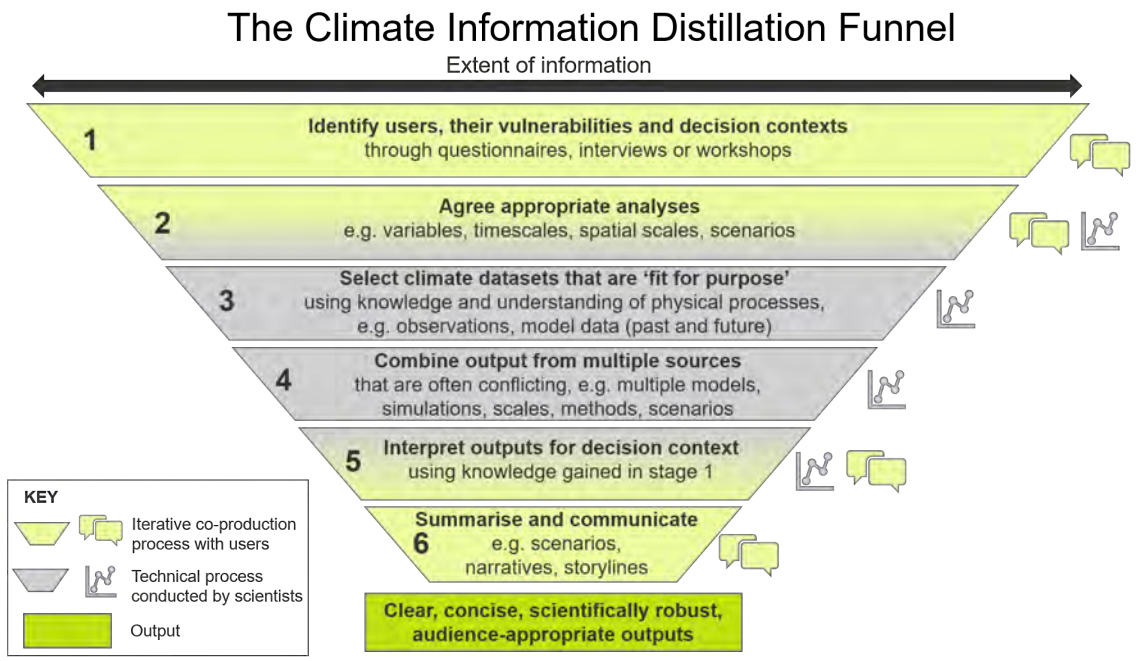
PRESENTATION: INTRODUCTION TO CLIMATE INFORMATION DISTILLATION

The practical exercise demonstrated the need for tailored climate information to inform decision-making. In the CARISSA project, work is being done to develop an approach to the 'distillation' of climate information for use in decision-making. In the final session of the day, Katy Richardson presented this approach.

Richardson introduced the concept of climate information distillation as a process of comparing, understanding and combining multiple sources of climate information to create clear, concise and scientifically robust audience-appropriate outputs. She presented the Climate Information Distillation Funnel; a schematic diagram that illustrates the climate information distillation process in six key stages (Figure 1).

The schematic is designed to demonstrate the flow of the process, showing the sequential reduction in information and available decision pathways as each stage is completed. The different stages of the process are colour-coded to acknowledge the stages that involve an iterative co-production process with the users (green, with conversation icons to indicate interaction with users), and those that are more technically focused (grey, with graph icons to indicate the technical nature), and fall within the expertise and responsibility of climate scientists. Richardson gave examples of what is involved at each stage of the process, and how the stages should be conducted. She also highlighted that there are inevitable feedbacks and iteration between each of the stages throughout the process.

FIGURE 1 **THE CLIMATE INFORMATION DISTILLATION FUNNEL – A TOOL FOR COMMUNICATING THE PROCESS OF DISTILLING CLIMATE INFORMATION, DEVELOPED AS PART OF ARRCC CARISSA.**



Source: Met Office, © Crown Copyright 2019'

Richardson noted that this approach is a work-in-progress, and that it is being tested in practice in the pilot study on climate services for the hydropower sector in Nepal (discussed on Day 2). She welcomed feedback from the participants and opened the floor for discussion.

In general, the participants thought this was a useful way to demonstrate the process of tailoring climate information for decision-making, although there was some confusion around how the process works in practice. Some of the key pieces of feedback included:

- Ensure that uncertainty is represented in the schematic diagram.
- Include modelling downstream of the climate projections, i.e. impacts modelling for specific sectors, and the associated collaborations required for this in the schematic diagram.
- The diagram could be reversed to a bottom-up approach where users identify a problem and allow scientists to get involved as part of the co-production process.
- It is important for scientists to work with users of climate information to better understand their needs and decision contexts, and this process is a good example of how this could be done through bringing scientists and users together to better tailor climate information to their needs.
- Communication is really important for engaging with users, and scientists need to expand their methods for communication in innovative ways.

REFLECTIONS ON DAY 1

Bernd Eggen delivered closing remarks at the end of Day 1. Participants said they expected to learn from each other about what different stakeholders are doing, and to learn more about climate models and climate services. Mandira Shrestha said that it had been an interesting day in terms of sharing knowledge, experiences and discussion.

DISCUSSIONS DURING THE ACTIVITY ON 'INTERPRETING COMPLEX AND CONFLICTING CLIMATE INFORMATION FOR DECISION-MAKING'.

3.2 Day 2 – Identifying key climate related issues for the water sector in South Asia

On the second day of the workshop, the focus shifted from extreme events and the challenges of interpreting complex climate information to identifying key climate related issues for the water sector across South Asia. The day started with a review of the first day, facilitated by Bernd Eggen, where participants reflected on the hydrological extremes that the region was experiencing and their impacts (Figure 2).

David Molden, Director General of ICIMOD, greeted the participants and highlighted the importance of water and hydropower, acknowledging that there were still many challenges and opportunities. He expressed optimism that all participants and organizations can work together and said he was delighted to see people from all the different countries of the region.

The rest of the morning was dedicated to presentations from invited participants representing different organizations across the region. The aim of these presentations was to provide a range of perspectives on key climate vulnerabilities of different aspects of the water sector and to improve understanding of the landscape of climate studies on these specific issues. The presentations were split into two sessions: first session included presenters from research organizations, and it was chaired by Saiful Islam (Institute of Water and Flood Management; IWFM and Bangladesh University of Engineering and Technology; BUET); second session included presenters from government organizations, and it was chaired by Shozab Abbas (Ministry of Foreign Affairs, Pakistan).

PRESENTATIONS ON WATER ISSUES, PART 1: RESEARCH ORGANIZATIONS

Divas Basnyat and Dibesh Shrestha, Nepal Development Research Institute (NDRI), Nepal, presented on "Climate Related Issues – Nepal's Water and Hydropower Sector". The presentation focused on the uncertainties in climate model projections, particularly for winter precipitation. They stated that climate change uncertainty was only one aspect of multiple uncertainties that the sector faces, such as regulation, policy, disruptive technologies and other project variables. They highlighted the need for a risk-based approach and the requirement to translate climate information into performance indicators relevant to the developer and regulator communities. They summarized several NDRI studies that follow this approach and have developed a stochastic weather generator to simulate synthetic climate data informed by GCM projections, which can be used in these studies.

Saurabh Bhardwaj, The Energy and Resources Institute (TERI), India, gave a presentation on "Flood Forecasting and Early Warning for Cities". He stated that there has been an observed increase in extreme rainfall and associated flooding events in recent years at the regional scale across India. There are

FIGURE 2 **WORD CLOUD SUMMARISING THE KEY DISCUSSION POINTS FROM DAY 1**

still large uncertainties in prediction, limitations in data collection and monitoring, and methodological challenges for comprehensive assessment. He highlighted the need for a flood early warning system to be developed at the catchment scale, and that this requires collaboration between scientists and policy planners. He ended his presentation by describing a case study of flood risk maps being developed by TERI for flooding impacts on the road network in Mumbai and Bangalore.

Tarikul Islam, Institute of Water Modelling (IWM), Bangladesh, spoke about the "Role of IWM for Mitigation and Adaptation of Climate Change Impact". He started by highlighting Bangladesh's exposure to many climate-related challenges, including its vulnerable location downstream of very large catchment areas with high sedimentation loads. He summarized the range of research being done at IWM, including flood modelling using a range of regional and basin-scale models which project increases in flooding events. They also produce vulnerability maps, irrigation maps for use in drought management projects, and inundation risk maps for coastal flooding, cyclones, tidal effects, sea level rise and also the risk of salt water intrusion. He ended his presentation by stating that regional cooperation is required for adaptation measures and knowledge and data sharing, particularly for Bangladesh where in-country data alone is not sufficient.

Noor Muhammad Khan, Centre of Excellence in Water Resources Engineering (CEWRE), Pakistan, discussed "Climate Related Water Issues in Pakistan". He noted that Pakistan has relatively low annual rainfall, which is unevenly distributed throughout the year, and 95% of the water is used for agriculture. There is not enough storage capacity and ground water reserves are overexploited. Extreme events, such as floods, droughts, and GLOFs have increased in recent decades. He stated that some of the ways forward include trying to slow down climate change, adaptation through research and development, efficient use of resources, sustainable development, and mutual cooperation among nations and stakeholders. Research is being conducted for adaptation measures through the University of Engineering and Technology, on topics such as flood modelling for improved warning, remote sensing of reservoir storage, and simulation and optimization of surface water distribution.

PRESENTATIONS ON WATER ISSUES BY MEMBERS OF RESEARCH ORGANIZATIONS, FOLLOWED BY A DISCUSSION.

PRESENTATIONS ON WATER ISSUES, PART 2: GOVERNMENT ORGANIZATIONS

Bhaskar Pradhan, South Asian Association for Regional Cooperation (SAARC) Energy Centre, Pakistan, gave a talk on "Climate Services for Hydropower in South Asia". He gave an overview of the status of renewable energy capacity across the world. He stated that energy consumption in SAARC member states is projected to increase in the future and there are efforts being made to shift the energy mix to renewable sources. Hydropower plays an important role in balancing the renewable energy mix in the grid system (with wind and solar projects) as it is more reliable and has faster reaction times. Hydropower projects with storage capacity also provide additional benefits such as irrigation and flood control. Finally, he introduced the work of SAARC Energy Centre, highlighting a number of reports and an upcoming data portal on energy.

Muhammad Azam Joya, Water and Power Development Authority (WAPDA), Pakistan, as part of "Climate Related Issues in Water Sector of Pakistan", showed a video about WAPDA commissioned hydropower development projects. He mentioned that a great challenge for hydropower in Pakistan is sedimentation; sediments cause reservoir storage loss and abrasion. He illustrated the multiple impacts of climate change on the water sector; rise in temperatures, melting of glaciers, floods, damages to water structures, and also droughts. He summarized the impacts of recent flood events on hydropower projects; the 2010 Pakistan floods washed away part of the Munda hydropower project and the 2019 GLOF caused the Golen Gol hydropower plant to fill up with debris and sediments. He mentioned that there are three units in WAPDA that carry out climate change studies. He concluded that mitigation measures could include the establishment of more efficient weather records, construction of new reservoirs to capture flood water, better coordination and data sharing, preparedness of communities, and sustainable catchments management.

AKM Saifuddin, Bangladesh Water Development Board (BWDB), Bangladesh, gave a detailed account of the "North-eastern Flash Flood 2017 of Bangladesh". The presentation focused on the issues associated with the timing of pre-monsoon flash flooding in the North-eastern Haor region; the main concern is the loss of paddy rice crop. Adaptation measures implemented include submersible embankments that protect the crop from flash floods and introduction of short duration cultivars; however, these yield less produce and so farmers

PRESENTATIONS AND DISCUSSION ON WATER ISSUES DURING THE SECOND SESSION.

continue to take the risk of longer duration higher yielding varieties. The flooding season is shifting from May to earlier months. He described a case study of flash flooding in 2017 when they received very heavy rains in March rather than May as expected. The flood was unprecedented in terms of rainfall, inundation, and damage to agriculture and fisheries. BWDB has established the Haor Flood Management and Livelihood Improvement Project, to address the problems in the Haor area. It is trying to focus on seasonal and regional forecasting for floods as well.

Sana Rasool, National University of Science and Technology, (NUST), Pakistan, presented on "Investigating Inundation Dynamics in the Indus Basin in Pakistan". She noted that the frequency of floods and droughts in South Asia has increased, with Pakistan being one of the countries most vulnerable to floods in the region. She described how the Indus basin is vulnerable due to its flat topography, urbanization, population growth, and poverty. Her study investigated how hydrological factors interact with sociological dynamics that exacerbate vulnerabilities to floods and droughts. She noted that one cannot link the number of floods directly to climate change. However, floods are becoming more damaging, and this is due to sociological factors too. Floods disproportionately affect the poorest segments of the population. She listed a number of current issues and limitations; the lack of high-resolution topographical details of the floodplain, the need to develop a better understanding of the monsoon and a detailed evaluation of sociological factors.

PRESENTATION: CLIMATE INFORMATION FOR THE WATER SECTOR IN SOUTH ASIA

In the afternoon, Kate Salmon, Met Office, UK, gave an overview of available climate model projections relevant to the water sector in South Asia and the type of information that can be provided from these. The presentation covered the current climate of South Asia, observed trends in temperature and precipitation, and a summary of the climate projections available for the South Asia region, including those from the CMIP5 models in the IPCC AR5 report, the CORDEX South Asia regional climate models, and regional climate model projections from the DECCMA project. The purpose of this presentation was to set the scene for discussions on potential climate services.

PRESENTATION: PILOT STUDY – CLIMATE INFORMATION FOR THE HYDROPOWER SECTOR IN NEPAL

Katy Richardson, Met Office, UK, presented an update on a pilot study on climate information for the hydropower sector in Nepal which is being undertaken as part of CARISSA Activity 4 – climate services for water and hydropower. The aim of this pilot study was to demonstrate and conduct a trial of the Climate Information Distillation Funnel (as demonstrated on Day 1 and in Figure 1). Hydropower in Nepal was chosen as the focus for this pilot study based on the clear vulnerabilities of the hydropower sector to climate change identified in the Regional Workshop hosted in January, the Nepal government's plan to vastly increase hydropower, and the good relationships established with key researchers in the region and their contacts with key players in the hydropower sector.

Much of the progress on the pilot study has been focused on the first stage of the distillation process; identifying key climate-related issues for the hydropower sector in Nepal and users of a potential climate service, and understanding their decision contexts. Richardson presented a summary of the information gathered to date through background research and consultation with key stakeholders. She concluded that the focus of the pilot would be on better understanding and quantification of the risk of extreme rainfall in the region both in the present day and under future climate projections, either for updating thresholds used in planning regulations, or for driving impact models relevant to the hydropower sector.

Some progress has been made on stages 2–4 of the Climate Information Distillation Funnel. For example, analysis will focus on both baseline and future projections of extreme rainfall in Nepal, with a specific focus on the Trishuli basin for any downstream impact assessments. Appropriate datasets have been selected for analysing both baseline and future climate projections and initial analysis has been conducted. The pilot project is currently in the complex stage of analysing, comparing and condensing output across multiple models and sources. More work is required to scope out the specific analysis that will be of most use to stakeholders in the hydropower sector, and to collaborate with the relevant organizations that can translate the climate model projections into a format relevant to the sector.

PRACTICAL EXERCISE: IDENTIFICATION OF KEY CLIMATE-RELATED ISSUES FOR THE WATER SECTOR IN SOUTH ASIA

Following on from the demonstration of the pilot study being conducted in Nepal, a practical exercise was held to gather information for other potential pilot studies that could be conducted within this programme in other parts of the region. The aim of the exercise was to identify key climate-related issues affecting the water sector in each of the ARRCC countries and the key stakeholders who would be users of a potential climate service. This activity served as an opportunity to gather information for stage 1 of the distillation process for other key issues affecting the water sector across the ARRCC focus countries.

Participants were divided into groups for each of the ARRCC countries and asked to fill in a table identifying key climate-related hazards that impact the water sector, what the impacts are, who is impacted and who is responsible for decision-making or relevant stakeholders related to these issues. The groups were then asked to prioritize the list they had made by highlighting which of the issues they identified was the most pressing. These most pressing issues are shown in Table 1 and further information gathered related to these issues is included in Annex IV.

TABLE 1 SUMMARY OF KEY ISSUES IDENTIFIED IN ARRCC FOCUS COUNTRIES DURING GROUP ACTIVITY

Country	Key climate-related issues for the water sector
Afghanistan	Flash floods and drought impacts on the agriculture sector
Bangladesh	Tropical cyclones and sea level rise and their impacts on livelihoods, agriculture, fisheries, and infrastructure
Nepal	Flooding and inundation in the southern plains and the impacts on the agriculture sector
Pakistan	Extreme events in catchments upstream of hydropower stations

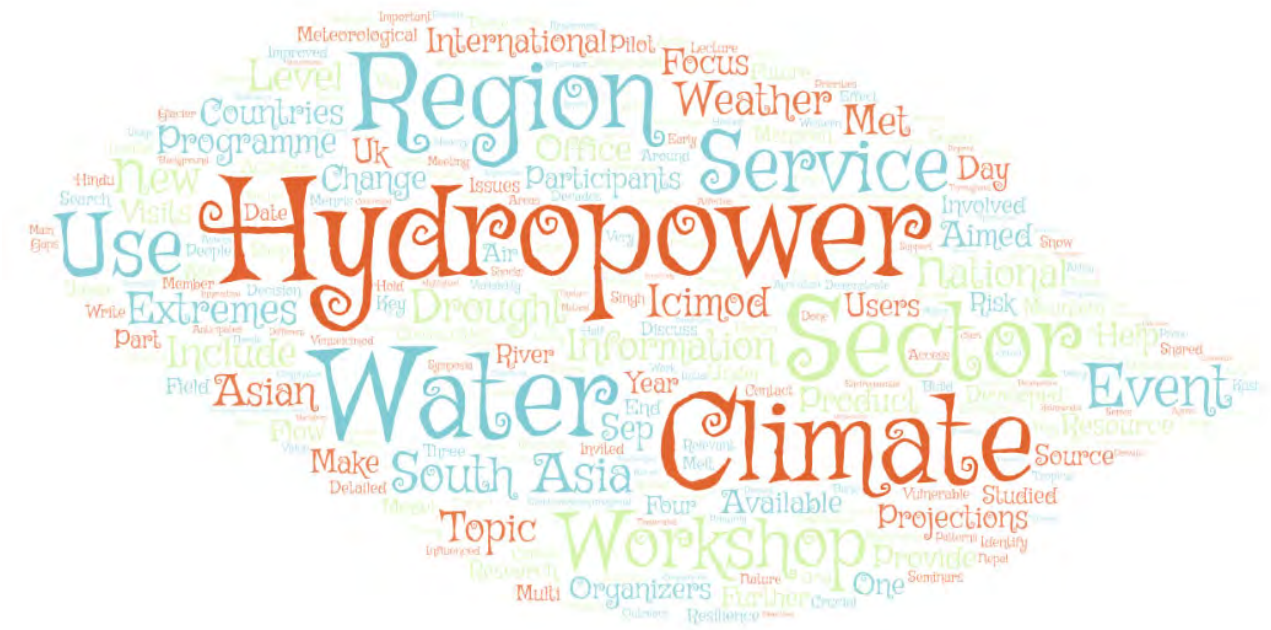
3.3 Day 3 – Climate information services for the water sector in South Asia

The aim of the last day was to focus on climate information services for the water sector in South Asia. Examples of other services were given, with a particular focus on the communication aspects (i.e., the final stages of climate information distillation process), and also to identify the current gaps.

REVIEW OF DAY 2

Bernd Eggen led a short session revisiting the key messages from Day 1, in particular the climate information distillation process. He presented a word cluster that represented the discussions (Figure 3).

FIGURE 3 WORD CLOUD SUMMARISING THE KEY DISCUSSION POINTS FROM DAY 2



PRESENTATIONS: EXAMPLES OF CLIMATE SERVICES

Cathryn Fox, Met Office, UK, gave a presentation on "Climate Risk Communication – Examples from Other Projects". Fox showcased some of the methods used in other climate services projects to develop engaging co-produced communication tools. Examples included co-produced Climate Risk Narratives developed as part of the FRACTAL project, infographics developed as part of the HyCRISTAL project, and the use of scenarios to communicate the potential impacts of climate change on food security in Sudan. There was discussion around the need to engage users in the development of these communication tools, and the need to engage with people from other disciplines such as social scientists, communication experts and designers. It was noted that this process can be very time consuming, but that the process of engaging users can lead to better uptake of the outputs.

Bernd Eggen, Met Office, UK, provided a demonstration of some of the climate services for water and hydropower that have been developed under the European Union funded Copernicus Climate Change Service (C3S). He showed the Service for Water Indicators in Climate Change Adaptation (SWICCA), which provides climate impact indicators relevant to climate change adaptation in water management across Europe in a user-friendly way for a variety of users. One of the examples included a European small hydropower atlas. He also presented the Copernicus Climate Data Store (CDS), which aims to provide a one-stop-shop for viewing and analysing past, present and future climate information. It enables policy-makers, businesses and scientists to browse and combine large datasets through a cloud-based system, and build their own applications, maps and graphs. It also includes a toolbox enabling users to build their own web-based applications, and to analyse, monitor and predict changes in climate drivers. The interests in GCMs ad reanalysis datasets (ERA5, CMIP5) and climate services are constantly growing. New datasets are likely to be added including CMIP6, CORDEX among others. Currently many of the services are focused in the European region, but CORDEX data for other regions could be included in the future.

GROUP DISCUSSION: WHERE ARE THE GAPS IN CLIMATE SERVICES FOR THE WATER SECTOR?

This session involved small group discussions on key gaps in climate services for the water sector that were identified throughout the workshop. Summaries of the discussions for the four key themes are provided below and a photo of the discussion groups is in the figure below.

COMMUNICATION

There is a communication gap between climate scientists who are generating climate information and decision makers who are using the information. Thus, communication between these two groups needs to be improved in order to increase the uptake of climate information in the region. The main discussion points from this session were:

- Climate information should be communicated in different ways for different users – information should be tailored to the user needs in order to make it relevant.
- Different climate information providers may use different data that might be conflicting and uncertain; this needs to be communicated effectively through authentic channels to ensure users trust.
- Users and providers should be brought together so that they can better understand each other – e.g., what data is possible to provide, and what would be useful in a decision-making context.

BREAKOUT GROUPS DISCUSS ON GAPS IN CLIMATE SERVICES FOR THE WATER SECTOR.

- There could be better communication strategies for making information relevant – e.g., information could be conveyed in a marketing format, to "sell" the benefits of acting in a climate-conscious way.
- Social scientists could be involved as they have a better understanding of the effects of the calamities on the lives of local people.

SCIENCE

A number of gaps were identified in the science discussion group:

- Characterising the seasonality of the monsoon, as well as its spatial extent (interaction with the westerly weather system and cyclonic action) is a central research question in order to predict future monsoonal changes.
- Parameterization of the teleconnections between different predictors in the climate system would help to understand the risk of extreme events.
- Better understanding on interannual and intraseasonal variability is necessary.
- Water storage is a major issue, particularly in Pakistan and Nepal. Characterising the fresh water held in glaciers would help, as well as improved hydrological modelling in Nepal to estimate the amount of groundwater released after the monsoon season.
- Microclimate variations have a large impact in countries like Nepal which can cause flash flooding. Higher resolution hydrological models could help to account for impact of extreme events which are exacerbated by microclimates.
- Better understanding of regional sea-level rise, in particular for Bangladesh is necessary.
- Better communication and collaboration between regional science centres would help data and research to be shared more efficiently.
- Capacity building to train people to analyse data is essential in order to further advance the science (guide the research and tools required).
- The gap between science and its applications needs to be bridged. This requires infrastructure within the government for applying the science. Amalgamating science into government policy would help to make it a priority.

DATA

Recommendations from the discussions on data gaps included:

- New reference data for the region as it was noted that there is a lack of trust in existing reanalysis datasets in certain areas of the South Asia region
- Improved resolution of global and regional climate models, and the potential use and application of the latest convection-permitting model simulations for the South Asia region
- Better observational networks, including requests to fill data gaps in existing stations, train people in obtaining data and extend station networks into more inaccessible (mountainous) regions, which are crucial for the catchments of many rivers; more coordination and cooperation is required to avoid replications, and data gathered from private companies could also feed into national and regional datasets
- Enhanced (hydro-meteorological) data sharing and addressing transboundary data sharing issues
- Improvements to and improved use of the RDS (Regional Database System, provided and maintained by ICIMOD), which is an important data repository for the region, and is another priority activity for the CARISSA project
- Improving underlying datasets, such as altimetry for river flow applications, and glacier mass balance
- Training on the use of datasets and tools for accessing them, such as the RDS, and Copernicus CDS

REGIONAL FORUM FOR CLIMATE SERVICES

The development of a regional forum for climate services in South Asia is one of key focus activities of the CARISSA project, identified at the first regional workshop. This discussion provided an opportunity to further gather needs and suggestions on how this regional forum may be useful for the water and hydropower sectors. The key points from this discussion were:

- A regional forum would be useful to improve regional collaboration and engagement between the different actors in the development of climate services, from data providers to users and decision-makers.

- Representatives from all stakeholders of the climate service process should be involved.
- The location of the forum should be accessible to all from across the region i.e., minimising visa issues. ICIMOD, being knowledge sharing hub for South Asia, could be the best choice.
- The forum could build on and learn from existing forums such as those held at ICIMOD or the South Asia Seasonal Climate Outlook Forum (SASCOF).
- The forum should be held annually and aim to provide an update on the science and provide opportunities for training and engagement across the sector.
- A publication of the proceedings of the forum would encourage commitment and engagement with the forum.

CLOSING SESSION OF REGIONAL WORKSHOP

In the final session of the regional workshop, Bernd Eggen presented a summary of the three days of the workshop and facilitated discussion around the key take-away messages of the workshop. These included an improved understanding of the challenges of using climate information to inform long-term decision-making and the need for climate information distillation. Participants showed enthusiasm for remaining involved in CARISSA activities such as conducting follow-up pilot studies for this sector, and also in forthcoming training activities. The participants also filled out a workshop evaluation survey and the results from the survey are available in Annex V.

3.4 Focus session: Climate services for the hydropower sector in Nepal

After the closing of the regional workshop, a focus session to bring together relevant stakeholders in the hydropower sector in Nepal was held on the afternoon of Day 3. The purpose of this session was to gather further information to inform the pilot study.

The session began with a brief round of introductions and some opening remarks from Bernd Eggen (Met Office) regarding the ARRCC project and the purpose of the session.

A few short presentations were given to set the scene for the current status and understanding of the needs for climate services in the hydropower sector in Nepal. Firstly, Mandira Singh Shrestha (ICIMOD) gave an overview of the outcomes and recommendations from a workshop on data needs for the hydropower sector held earlier in the year as part of the SnowAmp programme. Then Divas Basnyat (NDRI) and Katy Richardson (Met Office) summarized the presentations given earlier in the workshop for this new audience of hydropower stakeholders.

Following Katy's presentation on the pilot study for the hydropower sector in Nepal, the floor was opened for discussion around the gaps in climate services and where the pilot study may be able to add value. The main outcomes of the discussion are summarized below:

- GLOFs are a risk for hydropower projects and there have been several events in the past. Better understanding of GLOFs would be useful for planning new projects.

MANDIRA SINGH SHRESTHA (FROM ICIMOD) AND DIVAS BASNYAT (FROM NDRI) PRESENTING AT THE FOCUS SESSION.

PARTICIPANTS OF THE FOCUS SESSION ON CLIMATE SERVICES FOR THE HYDROPOWER SECTOR IN NEPAL.

- The developers of hydropower plants are risk-averse and want the data to be proven as reliable before they take any decisions using it. There have been previous incidents where extreme events occurred that were not predicted by the models, which makes developers lose trust in them.
- Sediment data is of great importance, but there isn't any reliable data or models available. Sediment load is not traditionally a climate output; it is difficult to say how this will change under climate change.
- Better access to data is required. The DHM has gauging stations on many rivers, but they are not at a high enough altitude.
- The current resolution of GCMs is not high enough. CORDEX models are better but need more validation. A model that is high resolution over the Himalayan region is needed.
- Uncertainty in climate model projections needs to be better communicated to users in the hydropower sector. Better understanding of the use and limitations of climate model projections within the sector is required and could be delivered through ARRCC training initiatives.

PRESENTATIONS AND DISCUSSION ON WATER ISSUES DURING THE SECOND SESSION.

SECTION 4

Conclusion and recommendations

This regional workshop brought together key stakeholders representing both users and providers of climate information in the water and hydropower sectors across the South Asia region. The presentations and discussion sessions throughout the three days provided valuable insights into the need for climate services for the water and hydropower sectors, the key climate-related issues facing these sectors in the ARRCC focal countries, and identification of the gaps in available climate information to develop climate services. Key themes that emerged were:

- The importance of extreme events, such as extreme rainfall, flash flooding and drought
- The lack of reliable observational data and
- The difficulties in understanding the uncertainties and limitations of climate models and applying them for use in decision-making

The workshop also provided an opportunity to demonstrate ongoing work within the CARISSA project to conceptualize the process of distilling climate information to inform decision-making. The six-stage process of the Climate Information Distillation Funnel was presented, and feedback gathered on the usefulness of this approach, which will inform further development of this concept. The workshop itself was a realisation of the first stage of this process in terms of gathering information about user needs for climate information across the water and hydropower sectors and prioritising the key issues across the region. The information gathered from the participants will help in identifying and informing potential climate service products later in the project.

Alongside the planning of this regional workshop, the Met Office, UK has started developing a pilot climate information product for hydropower in Nepal to test and demonstrate the climate information distillation process. An update on the progress of the pilot was presented at the regional workshop and the focus session on hydropower in Nepal held on the final day provided a further opportunity to engage with key stakeholders and gather requirements for a climate service.

The key learnings from both the regional workshop and the focus session on hydropower in Nepal will feed into ongoing plans for the CARISSA activity on climate services for the water and hydropower sectors across South Asia. Progress has been made on the initial stages of identifying key climate-related issues and potential users of climate information across these sectors. However, further work is required to refine the science questions and identify specific users of potential climate information.

Participants gave excellent input throughout the workshop, through both interesting presentations and engaging discussions. There was also great enthusiasm for working together across the region and potential for further engagement to improve the uptake and use of climate projections in the sector.

Annexes

Annex I: Agenda

DAY 1 – TUESDAY, 24 SEPTEMBER 2019 SETTING THE SCENE: WHY DO WE NEED CLIMATE SERVICES FOR THE WATER SECTOR IN SOUTH ASIA?	
09:00–09:30	Registration
09:30–10:00	**Opening session** Welcome remarks – Eklabya Sharma, ICIMOD Introduction of ARRCC, CARISSA and objectives of the workshop – Bernd Eggen, Met Office
10:00–10:30	Introductions – Bernd Eggen
10:30–11:00	Tea break and group photo
11:00–12:30	**Presentations: Extreme events affecting the water and hydropower sectors in South Asia** Chair: Ghulam Rasul, ICIMOD • Extreme events affecting water and hydro sectors in Pakistan - Amjad Masood, GCISC • Climate Changes in Bangladesh: Hazards, Impacts, Affected, Action - Shajib Hussein, BMD • Impact of Climate Change on Flash Floods Severity in Afghanistan - Hameedullah Arghandewal, AMD • Cryospheric response to weather and climate – considerations for Hydropower in the HKH region – Samuel Inglis, ICIMOD
12:30–13:30	Lunch
13:30–15:30	Practical exercise: Interpreting complex and contradicting climate information for decision making – Katy Richardson, Met Office
15:30–16:00	Tea break
16:00–16:30	Introduction to climate information distillation – Katy Richardson, Met Office
16:30–17:00	Reflections of Day 1 – Bernd Eggen, Met Office
18:00 onwards	Workshop dinner

DAY 2 – WEDNESDAY, 25 SEPTEMBER 2019 IDENTIFYING THE KEY CLIMATE-RELATED ISSUES FOR THE WATER SECTOR IN SOUTH ASIA	
09:00–09:15	Review of Day 1 - Bernd Eggen, Met Office
09:15–10:30	Presentations: Talks on water issues part 1: Research organizations Chair: Saiful Islam, IWFM and BUET • Climate related Issues – Nepal's water and hydropower sector - Divas Basnyat and Dibesh Shrestha, NDRI • Flood forecasting and early warning for cities - Saurabh Bhardwaj, TERI • Role of IWM for mitigation and adaptation of climate change impact - Tarikul Islam, IWM • Climate related water issues in Pakistan - Noor Muhammad Khan, CEWRE
10:30–11:00	Tea break
11:00–12:30	Presentations: Talks on water issues part 1: Government organizations Chair: Shozab Abbas, MoFA • Climate services for hydropower in South Asia - Bhaskar Pradhan, SAARC • Climate related issues in water sector of Pakistan - Muhammad Azam Joya, WAPDA • North-eastern flash flood 2017 of Bangladesh - AKM Saifuddin, BWDB • Investigating inundation dynamics in the Indus basin in Pakistan - Sana Rasool, NUST
12:30–13:30	Lunch
13:30–14:00	Climate information for the water sector in South Asia – Kate Salmon, Met Office
14:00–14:30	Pilot study–climate information for the hydropower sector in Nepal – Katy Richardson, Met office, UK
14:30–15:30	Practical exercise: Identification of the key climate-related issues for the water sector in South Asia and requirements gathering - Met Office
15:30–16:00	Tea break
16:00–16:30	Prioritisation of climate-related issues and feedback from groups
16:30–17:00	Reflections of Day 2 – Bernd Eggen, Met office, UK

DAY 3 – THURSDAY, 26 SEPTEMBER 2019 CLIMATE INFORMATION SERVICES FOR THE WATER SECTOR IN SOUTH ASIA	
09:00–09:15	Review of Day 2 - Bernd Eggen, Met Office
09:15–10:00	Presentations: Examples of climate services Chair: Arun Bhakta Shrestha, ICIMOD Cathryn Fox, Met Office Bernd Eggen, Met Office
10:00-10:45	Group discussion: Where are the gaps in climate services for the water sector? – Bernd Eggen, Met Office
10:45–11:00	Tea break
11:00–12:00	Reporting back from group discussions Conclusions and next steps
12:00–12:30	Closing session: End of workshop reflections and evaluation

THURSDAY, 26 SEPTEMBER 2019 FOCUS SESSION: CLIMATE SERVICES FOR THE HYDROPOWER SECTOR IN NEPAL	
14:00–14:15	Introductions of all participants
14:15–15:00	Presentations: Overview of current status of climate services for the hydropower sector in Nepal Mandira Singh Shrestha, ICIMOD Divas Basnet, NDRI Katy Richardson, Met Office
15:00–15:45	Discussion: What are the gaps in climate services for the hydropower sector in Nepal?
15:45–16:00	Tea break and group photo
16:00–16:30	Discussion: continued
16:30–17:00	Synthesis, conclusion, and next steps

Annex II: Participants of the main workshop

Name	Designation	Organization	Country
Hameedullah Arghandewal	General Manager	Civil Aviation Authority, Afghanistan Meteorological department	Afghanistan
Habib Rahman Khairka	GIS Analyst	National Statistics and Information Authority (NSIA)	Afghanistan
A K M Saifuddin	Executive Engineer (Civil)	Bangladesh Water Development Board (BWDB)	Bangladesh
Md Abu Baker Siddique Bhuayan	Executive Engineer	BWDB	Bangladesh
Md Tarikul Islam	Senior Specialist & Unit Head of Climate Change Cell	Institute of Water Modelling (IWM)	Bangladesh
Shah Md Shajib Hossain	Assistant Meteorologist	Bangladesh Meteorological Department (BMD)	Bangladesh
A.K.M Saiful Islam	Professor	Institute of Water and Flood Management (IWFM) and Bangladesh University of Engineering and Technology (BUET)	Bangladesh
Md. Abu Syed	Fellow and Director	Bangladesh Centre for Advanced Studies (BCAS)	Bangladesh
Sanjay Jayanarayanan	Scientist	Centre for Climate Change Research, Indian Institute of Tropical Meteorology, Pashan	India
Saurabh Bhardwaj	Fellow and Area Convener	Center for Climate Modelling, Earth Science and Climate Change Division, The Energy and Resources Institute (TERI)	India
Muhammad Azam Joya	Addl. Chief Engineer	Water and Power Development Authority (WAPDA)	Pakistan
Shozab Abbas	Director General	Audit Counsellor and Division, Ministry of Foreign Affairs (MoFA)	Pakistan
Amjad Masood	Scientific Officer	Global Change Impact Study Centre (GCISC)	Pakistan
Noor Muhammad Khan	Director	Centre of Excellence in Water Resources Engineering/ Lahore/ Peshawar	Pakistan
Bhaskar Pradhan	Program Leader (Energy Trade)	SAARC Energy Centre (SEC)	
Sana Rasool	Lecturer	School of Civil and Environmental Engineering, National University of Science and Technology	Pakistan
Divas Basnet	Coordinator Water & Climate Program	Nepal Development Research Institute (NDRI)	Nepal
Dibesh Shrestha	Senior Research Associate, Water& climate	Nepal Development Research Institute (NDRI)	Nepal
Pratik MS Pradhan	Vice President	Butwal Power Company (BPC)	Nepal
Ravi Kishor Dutta	Engineer	Nepal Electricity Authority (NEA)	Nepal
Katy Richardson	Senior Climate Information Scientist (International Development)	Met Office, UK	
Cathryn Fox	Climate Information Scientist (International Development)	Met Office, UK	
Bernd Eggen	Senior Climate Services Scientist (International Climate Services)	Met Office, UK	
Kate Salmon	Applied Scientist (Applied Science & Scientific Consultancy)	Met Office, UK	
Ghulam Rasul	Regional Programme Manager, MENRIS	ICIMOD	
Arun Bhakta Shrestha	Regional Programme Manager, Water and Cryosphere	ICIMOD	

Name	Designation	Organization	Country
Angeli Shrestha	Senior Programme Associate	ICIMOD	
Anna Sinisalo	Programme Coordinator – Cryosphere Initiative	ICIMOD	
Birendra Bajracharya	Programme Coordinator – SERVIR-HKH	ICIMOD	
Mandira Singh Shrestha	Programme Coordinator: Climate Services and Hi-RISK	ICIMOD	
Rajesh Shrestha	Program Assistant	ICIMOD	
Santosh Nepal	Water and Climate Specialist	ICIMOD	
Samuel Inglis	Cryosphere Outreach Analyst	ICIMOD	
Utsav Maden	Knowledge Management and Communication (KMC) Officer	ICIMOD	
Sanita Dhaubanjar	PhD Fellow, Indus	ICIMOD	
Sudip Pradhan	Programme Coordinator, Regional Database System Initiative	ICIMOD	
Karma Tshering	Senior Remote Sensing and Geoinformation Specialist	ICIMOD	
Vijay Khadgi	Flood Early Warning System and Energy Analyst	ICIMOD	
Binu Maharjan	Flood Modelling Associate	ICIMOD	
Nisha Wagle	Research Associate – Water Resources	ICIMOD	
Chimi Sheldon	KMC Officer	ICIMOD	

Annex III: Participants of the special session on hydropower

Name	Designation	Organization
Basu Dev Bhandari	Chief Engineer	Hydroelectricity Investment and Development
Vishnu Bahadur Singh	President	NHA
Pratik MS Pradhan	Vice President, Business Development and Projects	Butwal Power Company
Ravi Kishor Dutta	Engineer	Nepal Electricity Authority
Arbindra Shrestha	Assistant Manager	Sanima Middle Tamor Hydropower project
Ravi Mulmi	Hydropower Engineer	Urja Developers Pvt. Ltd.
Manohar Shrestha	CEO	Hydroconsult
Umesh Singh	Senior Research Engineer	Hydro Lab Pvt. Ltd.
Dhurba Lochan Adhikari	Member, Executive Committee	Society of Hydrologists and Meteorologist - Nepal (SOHAM)
Divas Basnet	Coordinator Water & Climate Program	Nepal Development Research Institute (NDRI)
Sandip Shah	Managing Director	Dolma Himalayan Energy
Dibesh Shrestha	Senior Research Associate	Nepal Development Research Institute (NDRI)
Madan Lall Shrestha	Academician	National Academy of Science and Technology
Mandira Shrestha	Programme Coordinator: Climate Services	ICIMOD
Arun Bhakta Shrestha	Programme Manager: River Basin and Cryosphere	ICIMOD
Saurav Pradhanangs	Climate data analyst	ICIMOD
Sanita Dhaubanjar	PhD Scholar	ICIMOD
Karma Tshering	Remote sensing and DRR specialist	ICIMOD
Rajesh Shrestha	Programme Associate	ICIMOD
Katy Richardson	Senior Climate Information Scientist (International Development)	Met office, UK
Cathryn Fox	Climate Information Scientist (International Development)	Met office, UK
Bernd Eggen	Senior Climate Services Scientist (International Climate Services)	Met office, UK
Kate Salmon	Climate Information Scientist (International Development)	Met office, UK

Annex IV: Outcomes of the session on climate-related issues identification

Below are the transcripts of the information gathered during the activity on identifying key climate-related issues for the water sector held in the afternoon of Day 2. There were four groups, one for each of the ARRCC focus countries, and different approaches to filling out the tables were used for different groups (the original format is retained here). The stars (*) indicate the entries that were identified as the most pressing and taken forward to the summary in Table 1.

AFGHANISTAN

Climate-related hazard	What is the impact?	Who is impacted?	Who are the decision makers?
*** Flash flooding** (sudden rainfall)	Agriculture - destroyed crops - cultivated land is inundated & submerged	Local communities Land owners farmers	Government – Ministry of Agriculture Disaster management (long term outlook) Ministry of Rural Rehabilitation and Development
Flash flooding (sudden rainfall)	Roads / public infrastructure - washed away - bridges washed away	People Ministry of Transport	Ministry of Transport Private companies (which design & build roads / infrastructure)
*** Drought** (lasting months to years)	Agriculture, irrigation -> low yield - crop production - livestock production - price volatility	People: - local communities; - pastoral communities - other parts of the population due to national shortages Farmers	Ministry of Agriculture Aid organizations Disaster management
Drought (lasting months to years)	Declining groundwater Declining surface water -> drinking water in capital (Kabul)	Economic losses -> Government Local communities (access to water)	Ministry of Water and Energy Ministry of Rural Rehabilitation and Development
Drought (Helmand River) (lasting months to years)	Hydropower – dams (potable water, irrigation, energy), e.g. Kamal Khan dam Local impacts: - low flow during summer exacerbated - delays to winter river flow - new projects planned Imported hydropower – impacts from drought elsewhere	Limited impact (no energy generated locally) Industry / Businesses Local people (economic losses)	Ministry of Water and Energy - planned projects - capacity to store water - political instability

BANGLADESH

Climate-related hazard	What are the impacts?	Who is impacted?	Who are the decision-makers?
Flash flood (extreme precip)	Damage to crop (boro) rice + fish	Farmers Fishermen (NE Hoar region)	BWDB Ministry of Water Resources Department of Agriculture Department of Fisheries BMD (forecasting, warnings (Agromet); DDM LGED (Local Government Engineering Department; small rubber dams)
Monsoon flooding - riverine / fluvial	Agriculture Livelihoods Communications Infrastructure Crops destroyed Economy affected Migration	Farmers Fishermen Civilians	Local administration (evacuation) [in future: perhaps insurance sector] World Bank, ADB Talking to insurance / crop insurance
*** Cyclone + Storm Surge** - sea level rise - increased temperature (SST) Pre- and post-monsoon	Salinity intrusion Inundation Destruction of infrastructure Loss of life / property Livelihoods / fisheries	Coastal area Livelihoods Farmers (boro & aman crops)	Insurance sector NGOs – CPP (Cyclone Preparation Project, Red Crescent Society + Government of Bangladesh) Government of Bangladesh Coastal Embankment Improvement Project BRRI (Bangladesh Rice Research Institute) BRAC (Building Resources Across Communities); Work with planning commissions BWDB implementation. Local Government Departments BUET – coastal model BMD, BCAS, IWM also involved
*** Sea level rise + salinity intrusion** (warming temperatures)	Salinity intrusion: - damages crops - health of population, especially women - potable water contamination - inundation - displacement	Coastal population Fishermen Farmers Women & children	Research organizations Planning commission (5yr plan) Delta Plan 2100 Bangladesh strategy & action plan
River bank erosion (monsoon flood); later monsoon (Aug-Sep)	Destruction of houses / villages / infrastructure Loss of land / life	Local population & lives Rural areas	DDM (Department Of Disaster Management)
Drought lack of precip (NW) -> hydrology lack of soil moisture -> agriculture	Aug/Sep extra irrigation required for rainfed rice Lack of drinking water Agriculture [Also during dry season]	Farmers (Public) Health	BADC BARI (Bangladesh Agricultural Research Institute) BRRI DAE (Department of Agricultural Extension) BMDA DPHE (Department of Public Health Engineering)

NEPAL

Climate-related hazard	What is the impact?	Who is impacted?	Who are the decision makers?
*** Flood inundation** (in Southern Plains, Terai)	Crop damage Ecosystems Road damage Sedimentation Displacement / migration Health – water borne diseases Loss of livelihoods Loss of livestock Deaths	Poor /vulnerable groups Communities / households Infrastructure: - roads - electricity Gender issues Youth (for livelihoods) Agriculture / food security	Local government - municipalities - provinces - land use planning Central government Ministry of Home Affairs Disaster Management NEOC (National Emergency Operation Center) "Disaster Risk Reduction Act 2017" Upcoming: NDMA (National Disaster Management Authority) Department of Irrigation - water induced disaster prevention - embankments Soil conservation and Watershed management
High mountain hazards: - Snowstorms - GLOF - Landslide - Extreme temperatures	Loss of lives / livestock Damage to trails / hotels / service providers Loss of GDP Out-migration Change of climbing season -> reduce permits	Tourism sector Mountain communities - homestays - tour operators - guides National Park Authority	National Park Authority - trails - preparedness - vulnerability maps Travel agencies / hotels / tour operators National Government – GDP projections Municipalities – maintain roads DHM – Support, build capacity to provide: - early warning - climate services - sustainability Department of Tourism Ministry of Culture / Tourism Communication Pathways Mountaineering Associations - communication of warnings

PAKISTAN

Climate-related hazard	What is the impact?	Who is impacted?	Who are the decision makers?
Monsoon rain **Extreme Rainfall** (cloud burst) **Heatwave** **GLOFs** **Floods** - riverine - coastal floods (cyclones) - urban **Landslides** **Avalanches** **Droughts** **Desertification** **Sea Level Rise** **Seawater Intrusion**	Disruption of livelihoods Sedimentation Damage to infrastructure - roads - communication - transmission lines - hydropower plants * - health facilities Agricultural production - soil depletion Water availability Loss of ecosystems - forests - coastal ecosystems - wetlands - mangroves Loss of biodiversity National economy (all items listed above ultimately feed into economy / GDP) Groundwater salinity	Hydropower / reservoirs - HP operators - local communities (farmers/traders) - industries (e.g. textile) Government - Ministry of Water - WAPDA - Ministry of Climate Change (MoCC) - Disaster Management Tourism Industry Fisheries (downstream)	Ministry of Defence (Met Department) Ministry of Climate Change - rain - ecosystems - resilience - emissions National Disaster Management Authority (NDMA) Ministry of Agriculture (federal) Provincial Ministries of Agriculture Departments of Irrigation Ministry of Water |Resources - WAPDA (Water & Power Development Authority) - IRSA Indus River System Authority // Indus Commission - FFC (Federal Flood Commission) Ministries of Health (provincial) Ministry of Energy Donors

Annex V – Workshop evaluation survey results

Workshop evaluation survey

Regional workshop on climate services for water and hydropower sector in South Asia
ICIMOD, Kathmandu, Nepal
24– 26 September 2019

Thank you very much for your participation in the workshop. To help improve future workshops and engagements, and further understand how the ARRCC programme can benefit you and your organization, we'd be grateful if you could answer the following 16 questions. All responses will be collated and remain anonymous.

Name:

Organization/Industry:

For the first four questions, please indicate how much you agree with the following statements.

1) Overall the workshop met my expectations.

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
		2	12	7

2) The workshop objectives were relevant to my work.

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
		1	11	9

3) Overall, the workshop had a good balance of talks, discussion and exercises.

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
			17	4

4) Prior to attending the workshop, I had heard of the ARRCC programme

Yes	No
12	9

5) I understand the objectives of the ARRCC programme

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
		4	14	3

6) On a scale of 1 to 10, what level of understanding of climate services do you currently have? [where 1 is very limited understanding and 10 is a very thorough understanding]

1/10	2/10	3/10	4/10	5/10	6/10	7/10	8/10	9/10	10/10
			2	3	5	7	3		1

Answer question 7 if you are a provider of climate services or an intermediary ("purveyor").

7) On a scale of 1 to 10 how would you rate your current level of engagement with users of climate services? [where 1 is no interaction and 10 is ongoing collaboration]

1/10	2/10	3/10	4/10	5/10	6/10	7/10	8/10	9/10	10/10
1			1	1	5	2	1		

Answer questions 8 and 9 if you are a user or end-user of climate services.

8) On a scale of 1 to 10 how would you rate your current level of engagement with providers of climate services?
[where 1 is no interaction and 10 is ongoing collaboration]

1/10	2/10	3/10	4/10	5/10	6/10	7/10	8/10	9/10	10/10
1			1	1	6	6	3		1

9) On a scale of 1 to 10 how confident are you that you can access climate information / climate services to meet your needs? [where 1 is not at all confident and 10 is extremely confident]

1/10	2/10	3/10	4/10	5/10	6/10	7/10	8/10	9/10	10/10
			1	2	2	6	8		

10) Prior to the workshop, had you used or referred to climate services in your work?

11 ☐ Yes, I have used/analysed raw climate model data
5 ☐ Yes, but only processed data in the form of graphics, reports, tables etc. prepared by other organizations
6 ☐ Yes, other forms of climate information / climate services
3 ☐ No, but I plan to do so in future
0 ☐ No, I haven't used or don't plan to use climate services

11) What other forms of weather, climate and hydrological information have you used in your work? [tick all that apply, or list out others if not included, feel free to be very specific]

11 ☐ Near-term weather forecasts (from hours to days)
12 ☐ Seasonal forecasts (e.g. forecasts for next month or season)
18 ☐ Historical climate data and observations
16 ☐ Hydrological data and observations
8 ☐ Geophysical data and observations
1 ☐ None

Other (please specify):
- Reanalysis, open source gridded data, projections.
- Reanalysis data, satellite data.
- River flow data.
- GCM / RCM hindcasts and projections.
- Biophysical, geographic, topographic, socio-economic, ecological.

12) What do you think are the most important barriers to using climate services in your work?
[tick all that apply]

6 ☐ Difficulty in interpreting and understanding climate model data and/or climate information
8 ☐ Accessing and processing climate data
10 ☐ Relevant climate impact indicators (CIIs) for sector(s) are not readily available
12 ☐ Spatial resolution of the current generation of climate projections are too coarse
10 ☐ Temporal resolution of the current generation of climate projections are too coarse
14 ☐ Challenges in integrating long-term future climate information into policy/planning
3 ☐ Data formats are not suitable for my work

Other (please specify):
- Availability of socio-economic data.

13) Given the above barriers (question 12) how could those barriers be overcome? What would help you to use climate services in your work?

14 ☐ Better distillation of existing climate data
12 ☐ Better communication with climate modellers
15 ☐ Better communication with climate service providers / purveyors
20 ☐ Training and capacity development activities (e.g. via a learning portal)
11 ☐ Publications, scientific papers, reports

Other (please specify):
- Better communication with impact modellers as well.

14) Please indicate if you wish to be informed about the following aspects of the CARISSA project under the ARRCC programme.

19 ☐ Use and application of climate services in the region
15 ☐ Workshops to explore information needs and develop solutions
19 ☐ Training and capacity development activities
15 ☐ Publications, scientific papers, reports
17 ☐ Development of climate information / climate service portals or information products

Other (please specify):
- Co-developments & collaborations.

15) Please indicate if you wish to be involved in the planning and delivery of the following.

16 ☐ Use and application of climate services in the region
16 ☐ Workshops to explore information needs and develop solutions
16 ☐ Training and capacity development activities
16 ☐ Publications, scientific papers, reports
13 ☐ Development of climate information / climate service portals or information products

Other (please specify)

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