Regional Workshop on Future Climate Projections and their Applications in South Asia

ARRCC
Asia Regional Resilience to a Changing Climate

ICIMOD

Met Office

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The Met Office is the UK's National Meteorological Service, providing 24x7 world-renowned scientific excellence in weather, climate and environmental forecasts and severe weather warnings for the protection of life and property. The Met Office has been at the forefront of global weather and climate science for over 160 years www.metoffice.gov.uk

About ICIMOD

The International Centre for Integrated Mountain Development (ICIMOD) is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush Himalaya (HKH) – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – based in Kathmandu, Nepal. Globalization and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream and downstream issues. ICIMOD supports regional transboundary programmes through partnerships with regional partner institutions, facilitates the exchange of experiences, and serves as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop economically and environmentally-sound mountain ecosystems to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now and in the future.

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Acronyms and Abbreviations

AgMIP	Agricultural Model Intercomparison and Improvement Project
APSS	Agricultural Production System Simulator
AR	Assessment Report
ARRCC	Asia Regional Resilience to a Changing Climate
BCAS	Bangladesh Centre for Advanced Studies
BMD	Bangladesh Meteorological Department
CARISSA	Climate Analysis for Risk Information and Services in South Asia
CCCR	Centre for Climate Change Research
CMIP	Climate Model Intercomparison Project
CORDEX	Coordinated Regional Climate Downscaling Experiment
CSIS	Climate Services Information System
CRA	Climate Risk Assessment
DHM	Department of Hydrology and Meteorology
DFID	Department for International Development
DSS	Decision Support System
DSSAT	Decision Support System for Agrotechnology Transfer
FAO	Food and Agriculture Organization
GBM	Ganges-Brahmaputra-Meghna
GCM	General Circulation Models
GFS	Global Forecast System
GFCS	Global Framework for Climate Service
GFDL-CM3	Geophysical Fluid Dynamics Laboratory Coupled Model
GHGs	Greenhouse Gases
HELIX	High-End cLimate Impacts and eXtremes
HI-AWARE	Himalayan Adaptation, Water and Resilience Research
HICAP	Himalayan Climate Change Adaptation Programme
HIMAP	Hindu Kush Himalayan Monitoring and Assessment Programme
HKH-HYCOS	Hindu Kush Himalaya Hydrological Cycle Observation System
ICIMOD	International Centre for Integrated Mountain Development
IITM	Indian Institute of Tropical Meteorology
IMD	Indian Meteorological Department
IPCC	Intergovernmental Panel on Climate Change
LAI	Leaf Area Index
LULC	Land Use Land Cover
MAIL	Ministry of Agriculture Irrigation and Livelihoods
MENRIS	Mountain Environment and Regional Information System
MEW	Ministry of Energy and Water
MRRD	Ministry of Rural Rehabilitation and Development
NAPA	National Adaptation Programme of Action
NAP	National Adaptation Plan
NDRI	Nepal Development Research Institute
NDVI	Normalized Difference Vegetation Index
NEPA	National Environmental Protection Afghanistan
NFCS	National Framework for Climate Services
PMD	Pakistan Meteorological Department
PRECIS	Providing Regional Climates for Impacts Studies
RADAR	Radio Detection and Ranging
RCC	Regional Climate Centres
RCM	Regional Climate Models
RCOF	Regional Climate Outlook Forums
RCP	Representative Concentration Pathways
RDS	Regional Database System
RMC	Regional Member Countries
SAARC	South Asian Association for Regional Cooperation
SAC	SAARC Agriculture Centre
SASCOF	South Asian Climate Outlook Forum
SDMC	SAARC Disaster Management Centre
SMS	Short Message Service
SRES	Special Report on Emissions Scenarios
TERI	The Energy and Resources Institute
TOA-MD	Tradeoff Analysis Model for Multi-dimensional Impact Assessment
UKCP	UK Climate Projections
UNEP	United Nations Environment Programme
UNSEEN	UNprecedented Simulated Extremes using Ensembles
WRF	Weather Research and Forecasting

Executive Summary

A three-day workshop brought together providers, intermediaries, and users of climate information to grapple with the challenges and opportunities associated with the provision and application of future climate projections in South Asia.

South Asia is a region highly sensitive to climate variability and change. There is a growing need for information to guide national adaptation plans and to inform decision-making to increase resilience to climate change. Questions therefore arise as to whether decision- and policy-makers in the region have access to high-quality future climate projections and derived climate services that are fit for purpose.

The regional workshop, organised by the Met Office and the International Centre for Integrated Mountain Development (ICIMOD), aimed to address some of these questions. The workshop was a primary activity of Climate Analysis for Risk Information and Services in South Asia (CARISSA), focused on understanding user needs for climate projections and developing climate change information services to meet these needs.

CARISSA is one of the four Work Packages that are part of the Met Office component of the Asia Regional Resilience to a Changing Climate (ARRCC) Programme. ARRCC is a new partnership between the Department for International Development (DFID), the Met Office, and the World Bank, that aims to deliver new technologies and innovative approaches to help vulnerable communities across South Asia make better use of weather forecasts and long-term projections to better prepare for climate-related hazards

The workshop took participants on a journey, starting with a review of the existing climate projections for the region, towards understanding the current and potential application of climate projections in key sectors such as hydropower, agriculture, water resources, biodiversity and health. Through a mixture of plenary discussions, presentations and interactive group exercises, the workshop enabled interactions between providers, intermediaries and users of climate services in the region.

To align the regional activities with global efforts to improve climate services, the workshop included a remote presentation by the World Meteorological Organisation (WMO) and Global Framework for Climate Services (GFCS), followed by a discussion. The workshop also discussed the application of climate projections produced through the Coordinated Regional Climate Downscaling Experiment (CORDEX).

The workshop provided valuable insight into the vast and varied requirements for provision of, access to, and improved application of future climate projections in South Asia. Discussions on the third day focused on recommendations for the CARISSA project, with five key themes emerging to frame the planning of activities in the project over the next four years. The themes were: 1) Regional coordination, cooperation and collaboration; 2) Data access and sharing; 3) Sector focused engagement, tools and information products; 4) Support for national and regional climate projections; and 5) Training and capacity building. A long list of recommendations was provided at the workshop with the next step being the prioritisation of activities.

The workshop succeeded in achieving buy-in to the project and enabling interaction between key organisations in the region. The learning has helped to inform plans for ongoing work under CARISSA and the wider ARRCC Programme. Along with improved regional coordination and cooperation amongst institutions, these activities will ultimately deliver benefits to a range of societal sectors.

1. ARRCC Programme

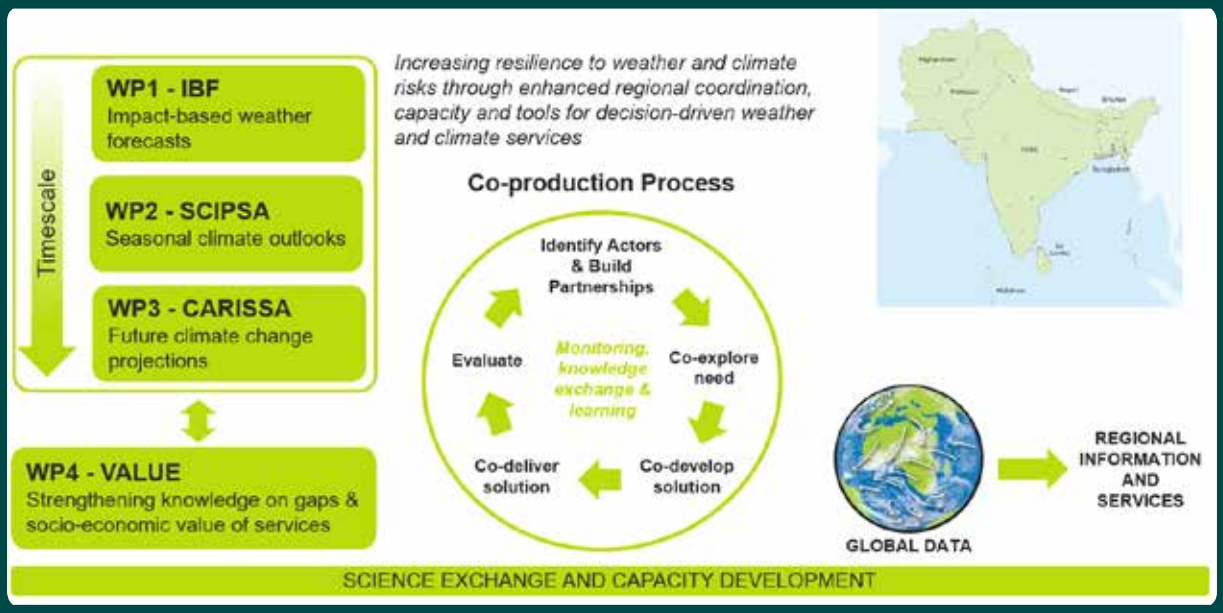
The Met Office is working in partnership with the World Bank and the UK's Department for International Development (DFID) on the UK aid-funded Asia Regional Resilience to a Changing Climate (ARRCC) programme. The four-year programme started in September 2018 and aims to strengthen weather forecasting systems and the provision of climate services across South Asia. The programme will deliver new technologies and innovative approaches to help vulnerable communities use weather warnings and forecasts to better prepare for climate-related hazards.

The ARRCC programme has a regional focus but will target specific activities in Afghanistan, Bangladesh, Nepal and Pakistan. Working together with organisations in these countries, as well as other key organisations across the region, ARRCC will deliver:

- new technologies and innovations to deliver climate information and advice to vulnerable groups;
- regional and sub-regional forecasting and early warning systems;
- improved access for 30 million people to climate information, services and early warning systems;
- Enhance the capabilities of regional organisations involved in the delivery or analysis of climate information, from seasonal forecasts to future climate projections.
- mobilisation of additional resources for building climate and environmental resilience.

The Met Office component of the ARRCC programme is organised into four key work packages (WPs), as summarised in the diagram below. These work packages span time-scales from near-term weather prediction (WP1), seasonal outlooks (WP2), to long-term climate projections (WP3). A fourth work package that seeks to assess and strengthen understanding of the socioeconomic benefits of weather and climate services underpins the three WPs. It promotes long-term investment and sustainability of key institutions in the region. Finally, ARRCC is aiming to develop weather and climate services in collaboration with partners and stakeholders through adopting best practice co-production approaches.

Figure 1: ARRCC Programme Work Packages



2. Workshop Scope and Aims

The aim of the workshop was to bring together researchers, providers, boundary organisations, and users of future climate information to discuss the challenges and opportunities associated with the use and uptake of future climate projections in South Asia.

The workshop had three main objectives

1. Review the existing regional future climate projections and discuss issues arising from their use in impact and adaptation studies
2. Improve understanding of user requirements for access to and use of future climate projections, and formulate next steps for adding value to existing data
3. Enhance regional networking and support better integration of regional actors

South Asia is a region highly sensitive to climate variability and change. The region is also very diverse both in terms of geography and associated environmental pressures, and with respect to its socioeconomic characteristics. It is subject to a wide range of hydro-meteorological and climate hazards including floods, drought and tropical cyclones, which have a significant impact on livelihoods and economic growth. The level of institutional capacity for developing effective weather and climates services varies across the region. Policy-makers in the region need access to good quality future climate projections to formulate national adaptation strategies that increase resilience to climate change. In many cases region-wide or national projections are being used, either from Global Climate Models (GCMs) employed in the Intergovernmental Panel on Climate Change (IPCC) or from statistical or dynamical regional climate downscaling studies. In addition to climate projections that provide future ranges of quantities such as temperature, rainfall, wind, and sea level rise, many users also require scenarios that consider the multi-sector impacts and their implications for adaptation planning.

Figure 2: Through a mix of plenary discussions, presentations, and interactive group exercises, participants listened to providers, intermediaries, and users of climate services in the region.

Figure 3: Panelists representing national and regional providers of climate change projections

This workshop aimed to provide an opportunity to discuss the range of projections available, approaches taken to generate and communicate the information, gaps in capabilities, and how best to co-produce climate services for use in long-term planning and policy. Discussions also aimed to identify gaps in the provision of climate projections and propose measures to improve data quality and coverage. Participants were able to discuss challenges in modelling the region's climate that affect the ability to provide reliable, relevant and robust climate projections – for example, capturing important monsoon processes, remote influences such as El Niño Southern Oscillation, as well as local coastal and mountain processes. Finally, the workshop provided an opportunity to discuss regional and national level cooperation between different provider and user groups from governmental, private and research organisations.

User Engagement for Climate Services

An essential step in the provision of climate projections involves asking who needs to use the projections and how they will do so. This will influence the combination of model domains, resolutions selected, along with the communication of results and methods. For this to work effectively, strong engagement with users is needed at every possible opportunity (from intermediaries to 'end-users'/decision-makers). Ideally the process of developing and providing climate projections should be fully collaborative; such a process is referred to as 'co-production'. Participants included a selection of users (both next-users, intermediaries and end-users) with some experience using climate projections.

Linking Regional Activities

It was important to build on existing developments in the region. The CORDEX (Coordinated Regional Downscaling Experiment) South Asia is particularly relevant as the stated vision is to "advance and coordinate the science and application of regional climate downscaling through global partnerships" (CORDEX, http://www.cordex.org/about/). Several goals are well aligned with the workshop objectives: (1) to evaluate and improve regional climate downscaling models and techniques, (2) to produce coordinated sets of regional downscaled projections worldwide, and (3) to foster communication and knowledge exchange with users of regional climate information. In addition to CORDEX, other projects, programmes and initiatives have generated future climate projections, which were discussed during the workshop. These include statistically downscaled projections for use in national projections (e.g., in Nepal), dynamically downscaled projections for specific projects (e.g., DECCMA, https://www.cariaa.net/consortium/deccma) and information from global climate models that feeds into the IPCC reports. The workshop was intended to be part of an ongoing series of activities in South Asia under the ARRCC programme.

3. Proceedings of the Workshop

3.1 Day 1: Provision of climate projections in South Asia

Opening session

The day began with a formal opening of the workshop by Mandira Singh Shrestha, programme coordinator for Climate Services and the Hi-Risk programme at ICIMOD. She said that the region is a multi-hazard environment and extremely vulnerable to the impacts of floods, droughts, landslides, and many other hazards, emphasising that such hazards have transboundary impacts which require regional cooperation for better preparedness and minimization of adverse impacts. Referring to ICIMOD's work with hydro-met agencies in strengthening the hydro-met capabilities in the region under the HKH-HYCOS initiative, she added that ICIMOD was now developing end user interfaces for last mile connectivity.

David Molden (Director General of ICIMOD) provided the welcome remarks, stating that although mountains are often considered natural dividers between countries and civilizations, they have special ways of bringing people together, especially on the issue of climate change. He noted that mountains and glaciers are particularly vulnerable to climate change, and changes in the mountains can impact water systems, ecosystems, and energy supplies, which is further compounded by movement of people towards urbanised centres. Molden stated that floods and droughts are expected to increase in both number and intensity, and that climate services will therefore have an important societal role to fulfill. He added that there are challenges in getting the data for models, and in providing useful information from datasets. He also stated that ICIMOD has been working towards addressing gaps in knowledge about the region, and is particularly interested in working on climate services. As a regional knowledge organization, ICIMOD provides a regional platform for cross-country and cross-discipline collaboration, and for addressing issues that are transboundary in nature.

Further welcome remarks were made by Simon Lucas (Climate Change Advisor and Team leader for the Inclusive Growth and Resilience Team at DFID Nepal). He stated that for a development agency like DFID, science is only important when it can be put to practical use. Lucas stated that if climate challenges were not well understood, it would be very hard for DFID to help the most vulnerable. In South Asia, the lives and livelihoods of over 750 million people could be affected. He stressed that information from climate services would be very helpful in designing future climate support and that the ARRCC programme is a critically important project for DFID. In conclusion, he said that climate science can help create a win-win situation for development agencies looking into climate and poverty resilience.

David Corbelli (Met Office ARRCC programme manager – pictured figure 2, left) described the main aims and objectives of the ARRCC programme, which was formally launched in September 2018. He said that the programme was focused on weather and climate services at the regional and national level, and will deliver new technologies and innovative approaches to help vulnerable communities use weather warnings and forecasts to better prepare for climate related shocks. He said that the programme would focus on four main areas – impact-based weather forecasting, seasonal climate outlooks, future climate change projections in South Asia, and the overall socioeconomic benefits of weather and climate services.

Following the opening remarks, Nicola Golding (pictured in figure 2, centre), Urban Climate Services Manager at the Met Office, explained the motivation behind the workshop and the main objectives for each day. She stated that the workshop was primarily being organized to further understand what projections were available, how they have been assessed and in what contexts they have been applied. She highlighted that the workshop would help increase understanding of user requirements, build relationships, and pave the roadmap for the WP3-CARISSA project over the four-year duration of the ARRCC programme.

Figure 4: Introductory remarks by Met Office representatives
David Corbelli (left), Nicola Golding (centre) and Joseph Daron (right)

Joseph Daron (pictured in figure 4, right), Science Manager in the International Climate Services team at the Met Office, and WP-lead for CARISSA, discussed the aims of the CARISSA project and how the workshop contributed as a key first year activity. He listed three main factors motivating the CARISSA project:

1. Limited uptake – use of available regional future climate projections is currently limited.
2. A gap remains between available data and the future climate risk information that is needed to inform decision-making.
3. Climate change projections for the region have been produced by multiple national projects, regional research programmes, and international initiatives. Consolidating this range of information (based on different models and methods) and communicating it to different stakeholders presents significant scientific and practical challenges.

Daron highlighted the evidence for limited uptake of climate projections, the importance of co-producing decision-relevant information, and provided an example from a previous Met Office project to demonstrate the challenges of resolving contradictions between different types of climate projections.

Arun Bhakta Shrestha (Programme Manager River Basins and Cryosphere Programme, ICIMOD) shared ICIMOD's experiences developing and using climate change scenarios to understand current and future water availability in the Hindu Kush Himalayan (HKH) region. He said that work on using climate scenarios had been carried out under two initiatives at ICIMOD – Himalayan Adaptation, Water and Resilience Research on Glacier and Snowpack Dependent River Basins for Improving Livelihoods (HI-AWARE) and Himalayan Climate Change Adaptation Programme (HICAP). The study under HICAP used a fully distributed model for the upstream parts of the Indus, Ganges, Brahmaputra, Salween and Mekong river basins, and was a first order assessment, which recommended conducting more accurate assessments. The study suggested that overall it dealt with average water availability but did not consider extreme events, glacial hazards, etc. On the other hand, HI-AWARE's study built on the understanding gained from HICAP, used a similar methodology but provided more simplified outputs. The initiative also commissioned some finer scale studies and sectorial studies on the impacts on hydropower.

The opening remarks and talks were followed by a group activity, an 'ice breaker' and a novel way for participants to introduce themselves. The 'crossing the circle' activity, led by Joseph Daron, required participants to stand in a circle. They were asked a series of questions (e.g., have you generated climate projections), and participants who answered yes moved to the opposite side of the circle, while participants who answered no remained where they were. The activity was followed by a group photo session and a short break.

Figure 5: 'Crossing the Circle' icebreaker

Presentations by national and regional providers of climate change projections and discussion

This session was chaired by Ghulam Rasul, Regional Programme Manager of Mountain Environment and Regional Information System (MENRIS).

Mohammad Shohidul Islam (Bangladesh Meteorological Department - BMD) provided an overview of weather and climate conditions in Bangladesh. He stated that Bangladesh was already experiencing higher temperatures, resulting in more variable precipitation, more extreme weather events – e.g., droughts, floods and flash floods, cyclones and storm surges – as well as sea level rise and salinity intrusion. He stated that climate change information produced by BMD has not been used for policy making or long-term planning, and identified lack of interconnection among different related organizations and limited funding as major challenges in provisioning of information from climate change projections.

A. P. Dimri (Jawaharlal Nehru University, India) presented on experiences using CORDEX to examine changes in climate over the Himalaya, a region known as the "water tower of Asia" or the third pole of the world for its unique bio-geophysical, climatic and hydrological features. He mentioned that the IPCC reports identify the Himalaya as one of the systems most vulnerable to climatic change, and that its hydrology, climate, demography and ecosystem may undergo irreversible changes. Dimri said that the new generation of high-resolution climate models suggest that such changes may vary widely across time and space due to the unique features of the Himalaya. He suggested that despite some weaknesses, most new models were better at accounting for changes and trends in precipitation and surface air temperature in the Himalaya than models from previous generations. Dimri said that higher elevations have higher warming rates compared to the plains, which may have further implications for the climate, hydrology, and people of the region; hence better coordinated mitigation and adaptation strategies are needed . Climate projections can be used for basin-scale assessments, but relevant projections are elusive for hydrologists and glaciologists, and bias correction needs to be carried out.

Saurabh Bhardwaj (The Energy and Resources Institute – TERI, India) discussed the need for regional modelling frameworks for India. His talk began with a general overview of the current state of climate knowledge, based on future GCM projections that are available from the Coupled Model Intercomparison Project phase 5 (CMIP5). He said that projections over India clearly indicate that extreme weather events will increase but that this information has not been used adequately. He mentioned that TERI has carried out various studies that shaped the action plans of India's state governments and many regional stakeholders. He mentioned TERI's study on the potential future impacts of climate change for the oil and gas sector of India, and case studies on coastal infrastructure resilience in India. At the end of the talk he presented a few preliminary results showing how the PRECIS 2.0 RCM performs better than its parent model HadGEM2-ES, especially in simulating regional extremes over parts of India, thus demonstrating the added value of downscaling.

Jehangir Ashraf Awan (Pakistan Meteorological Department – PMD, Pakistan) shared experiences related to dynamic downscaling for future scenarios (2010–2100) for the South Asian monsoon region. He mentioned that the projections were shared with the scientific community and public and private agencies in Pakistan working on climate-induced disaster management, and in planning and development. He added that the available data formats were suitable for use by climate scientists, but difficult for expects from other fields to access and interpret. . Awan said that PMD post-processed model outputs in Microsoft Excel made detailed climate projection information easily accessible to all stakeholders. The department also developed tailored climate projections for impact-based modelling studies – e.g., Agricultural Model Intercomparison and Improvement Project (AgMIP), Hydrological Impact Assessment for Indus basin, and Climate Change Impacts on Crop Yields under 1.5 and 2.0 degree scenarios.

Sanjay Jayanarayanan (Indian Institute of Tropical Meteorology – IITM, India) provided an overview of the South Asia CORDEX coordinated by the Centre for Climate Change Research (CCCR) at IITM. He presented the main findings from CORDEX South Asia for the HKH region. The results were included in a chapter of the Himalayan Monitoring and Assessment Programme (HIMAP) report coordinated by ICIMOD. Jayanarayanan said that CORDEX has identified both specific regional challenges and cross-cutting themes. He added that model outputs from the RCMs vary for projected warming over the Himalaya but mostly agree that the summer monsoons will intensify. It was discussed that in the CORDEX simulations, the spatial pattern of the monsoon is captured to some extent but the timing of the monsoon onset deviates from the India Meteorological Department (IMD) mean.

Group activity: Providing climate projections

The afternoon began with a group activity organised by Cathryn Fox from the Met Office (pictured figure 6, top left). The activity featured a role play-exercise in which participants tried to address sector-specific climate issues using the KNMI Climate Explorer (https://climexp.knmi.nl/start.cgi) – the platform allows the user to plot climate model output for different regions, seasons and variables. The aim of the exercise was to demonstrate some of the challenges of using climate model output to address sector-specific problems, as well as to highlight the availability of such data and the need to co-produce sector focused climate information. Participants, grouped according to

Figure 6: Group activity providing climate projections, featuring KMNI climate explorer

their country, were asked to provide briefings using information from CMIP5 projection data for a given scenario in a regional sector – agriculture, energy, tourism, and water. Each country group was asked to develop 1–2 slides outlining the main information that policy makers need to know for their given scenario. The exercise stimulated at lot of discussion about what the projection information was showing, demonstrating the value of bringing providers and users of information together. Some participants were surprised at the availability of such tools for accessing information, but the exercise highlighted that additional information is needed to answer sector-specific questions.

Perspectives from the WMO and GFCS

Filipe Lucio (World Meteorological Organization) introduced the Global Framework for Climate Service (GFCS), a global, multi-stakeholder framework for reducing communities' vulnerability to climate-related hazards through better provision of climate services as well as weather and climate information that can inform decision making across sectors. He said that the National Framework for Climate Services (NFCS) enabled the development and delivery of climate services at the country level to support adaptation in agriculture, water resource management, health, energy, disaster risk reduction and other climate-sensitive sectors. He presented the status of the implementation of NFCS, and stated that better adaptation outcomes can be achieved by combining national, regional and global resources to establish state-of-the-art climate services information systems that cater to a wide range of stakeholders in all sub-regions.

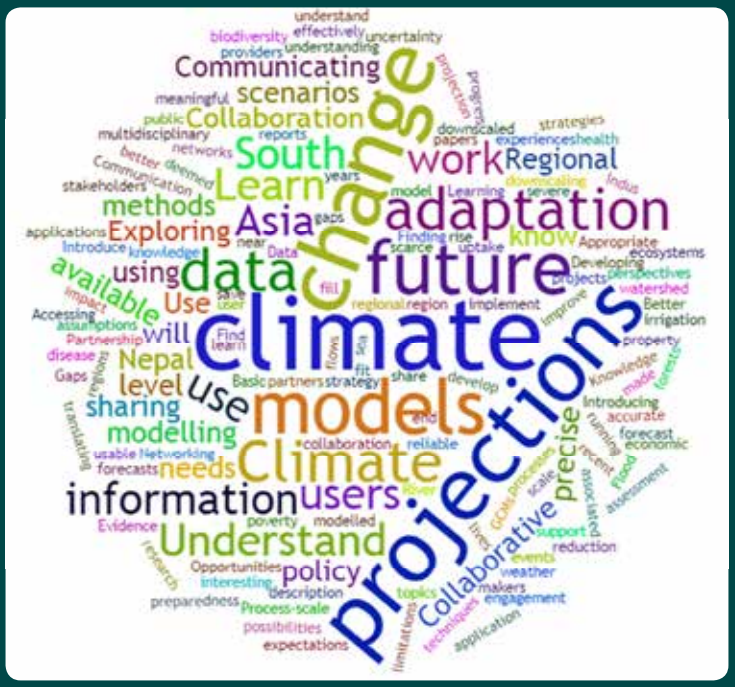
Figure 7: Remote presentation by the WMO on the Global Framework for Climate Services

Rupa Kumar Kolli, World Meteorological Organization, then described how the GFCS was operationalised through the Climate Services Information System (CSIS) to generate and disseminate climate information at the regional level. He explained the role of Regional Climate Centres (RCCs), and the Regional Climate Outlook Forums (RCOF) that contributed towards producing consensus-based, user-relevant climate outlook products in real time in order to reduce climate-related risks and support sustainable development for the coming season in sectors of critical socioeconomic significance. He cited South Asian Climate Outlook Forum (SASCOF) as an example of an RCOF. He added that the approach could be demonstrated in a few target regions and scaled up in other regions. In conclusion he said that national climate forums could be organized for the implementation of national CSISs. In the discussion, it was highlighted that RCCs are responsible for providing good quality climate services through NMHSs at the national and regional level for different prediction time scales. Ghulam Rasul, ICIMOD, asked if the Centre could be considered a common platform for a new Third Pole RCC (TPRCC) as all the beneficiary countries are members of ICIMOD. The response was that for ICIMOD to be considered as a candidate TPRCC host, there would need to be a proposal from the WMO representative of Nepal, the candidate host nation.

Reflection

Finally, Nicola Golding from the Met Office ended the day with a reflection session on key points gathered during the day – see figure 8. Participants were asked to pair up with someone they hadn't spoken to and discuss their key learning and highlights of the day.

Figure 8: Day 1 word cloud



3.2 Day 2: The use of climate projections in South Asia

On the second day of the workshop the focus shifted from projection provision to projection access and application. The day started with a review of the first day, facilitated by Nicola Golding, where participants highlighted the importance of policy implications, the challenges of dealing with an increasing volume of data and the need for cross-boundary data sharing.

Presentations by users of climate projections from different countries

The next session, chaired by Mandira Singh Shrestha, featured presentations from climate projection users from different countries and sectors.

In the first presentation, Saiful Islam (Institute of Water and Flood Management, Bangladesh University of Engineering and Technology, Bangladesh) discussed the use of climate projections for assessing flood, drought, cyclone and storm surge hazards under different climate scenarios, including the different impacts of 0.5m, 1.0m, and 1.5m rises in mean sea level. He explained that Bangladesh has been identified as one of the countries most vulnerable to climate change, primarily because of its low adaptive capacity, dense population, flat topography and exposure to various natural disasters. He shared research findings from the HELIX (High-End cLimate Impacts and eXtremes) study, a collaborative project led by Exeter University, which looked at highend climate scenarios, with global warming of 2°C, 4°C and 6°C upon different bio-physical systems – agriculture, water resources, ecology, infrastructure, health, socioeconomic, etc. Islam stated that the research findings suggested a dramatic shift in Bangladesh's vulnerability profile affecting agro-ecological systems, freshwater availability and climate extremes such as floods and droughts. He concluded that understanding potential implications of climate change would be very helpful in developing appropriate adaptation guidelines to meet agricultural and water management challenges in the country.

The second presentation by Ashfaq Chatta (University of Faisalabad, Pakistan) described the use of climate projections, with crop modelling technology to support decision making in the agriculture sector. He described how one study used selected outputs from five CMIP5 GCMs for the mid-century (2040–2069) under RCP4.5 and RCP8.5 to drive two crop growth models – Decision Support System for Agrotechnology Transfer (DSSAT) and the Agricultural Production System Simulator (APSIM) – as well as the Trade-off Analysis Model for Multi-dimensional Impact Assessment (TOA-MD) for economic analysis. His study indicated an overall rise in mean temperatures for mid-century (2040–2069), and a resulting yield reduction across both cropping systems. If current production technologies were continued in a changed climate, economic assessment indicated an economic loss of 83% at the household level rice-wheat systems, and identified 78% of households as vulnerable to climate change in cotton-wheat systems. His study also indicated that poverty among farm households will reduce significantly if adaptation measures are taken.

In the next presentation, Archana Shrestha (Department of Hydrology and Meteorology (DHM), Nepal) discussed the use of climate projections in the national context of Nepal. She highlighted a number of climate projection studies conducted over the past 15 years to inform national policies and adaptation planning, albeit with limited numbers of GCMs and RCMs. The most recent National Adaptation Plan (2016–2018) for Nepal carried out the first statistical downscaling of climate projections, and carried out climate projections at the district level using a multi-mode ensemble. Shrestha said that many capacity building programmes have been conducted at the DHM to strengthen the department's capacity for managing climate change data, data digitization and downscaling of climate change projection. She mentioned the climate projection study is no longer being continued. Shrestha identified a lack of strategic framework for using climate projection information in national documents, and projected data not being used in vulnerability assessment and adaptation plans as major gaps in the uptake of climate information. She concluded that science communication has to be improved, as policy makers would need to use the projection information in various thematic sectors – agriculture, water resources, etc. The discussion centred on the use of projections in practice. She mentioned that in agriculture adaptation plans, there is information on what a 1°C–2°C rise will cause, but it is unclear how this information can be used for specific adaptation measures. and projection information is not used.

Issues and challenges of using climate projections in Nepal were discussed in the following presentation by Divas Basnet of Nepal Development Research Institute (NDRI) – pictured figure 9, left). He described the development of climate risk assessments for the hydropower sector. Future changes to extreme rainfall events were highlighted as the main climate risk but non-climate factors primarily contributed to overall risk. He said that the future climate projections – precipitation and temperature – from current GCMs varied widely and were highly uncertain. He added that the wide physiographic and climatic variations, and local orographic and micro-climate effects experienced by catchments in Nepal made it difficult to generate accurate projections. He said that conventional climate risk assessment (CRA) studies typically follow a top-down approach, are time-consuming, and are often

Figure 9: Presentations by users and providers of climate information

limited to a few GCMs and emission scenarios. Basnet cited the lack of reliable, long-term climate observations in Nepal as an added disadvantage during downscaling and bias-correction of climate projections. He shared an alternative CRA approach that follows a bottom-up risk-based methodology recommended by the World Bank, using decision-scaling. The approach tries to identify responses of water resource systems to climate change and assesses the likelihood of risks by using climate information from a multi-GCM ensemble of climate projections. In the discussion, he cautioned against the use of daily data from climate models. He said that stochastic weather generators were used in the study to generate daily data using historical data.

The hydrological impacts of future climate change were also explored in the presentation by Veena Prasad (Divecha Centre for Climate Change). She shared her experiences estimating future changes in glacier mass and area in the Satluj basin under RCP 8.5 scenario using CNRM-CM5 and GFDL-CM3 GCMs. Prasad used the change factor method to correct the model data to estimate future temperature and precipitation appropriate for local climate in her study. She shared her findings from CNRM-CM5 projections that suggested an increase in summer temperature of 1.48°C, and an 8% decrease in winter snowfall compared to 2010 by 2050, and an increase of 3.5°C in summer temperature and 24% increase in winter precipitation by 2090 in the Satluj basin. Prasad stated that projections from GFDL-CM3 suggest a rise of 3.7°C and 7.94°C in the summer temperature by 2050 and 2090 respectively, compared to the present-day values (2005–2015), and a reduction in winter snowfall by 14% and 5% for 2050 and 2090 respectively. Both model outputs suggested an overall loss in glaciers in the basin. The research found that the glacier contribution to the Bhakra reservoir will increase by 2050, and then reduce by the end of the century. Prasad concluded her presentation stressing the need for better adaptation strategies to improve the resilience of high mountain communities and water management practices in the Bhakra command area.

The next session, chaired by Farid Ahmad, Head of Strategic Planning and Monitoring and Evaluation, ICIMOD, featured presentations from climate projection users from regional organisations.

In this session, Ashis Kumar Samantha from the SAARC Agriculture Centre (SAC) (pictured figure 10, right) presented on some of the initiatives taken up by the SAC on climate resilient agricultural activities (crop, livestock, horticulture, fisheries) in South Asia for small and marginal farmers: the most vulnerable communities to climate change. He said that the member States of the SAC were already experiencing the impacts of climate change – increased incidences of droughts and floods and the emergence of alien invasive pests (e.g. fall armyworm), transboundary zoonotic diseases, inundation of coastal zones, shortages of livestock feed and fodder etc. He pointed out that the fourteenth SAARC Summit in 2007 adopted the New Delhi Declaration for Climate Resilient Development in South Asia, and that member countries agreed to work on seven thematic areas of climate change during a SAARC ministerial meeting in 2008. Similarly, in 2010, SAARC heads of state adopted the 'Thimphu Statement on Climate Change' as a milestone for making South Asia disaster risk resilient under the climate change scenario. The SAARC Disaster Management Centre (SDMC) has initiated the process of implementing the Thimphu Statement on Climate Change. He mentioned a number of ongoing climate resilient activities being carried out by the centre and said that a multi-country climate smart development project is going to start very soon. Further, he highlighted the competence of the SAC in carrying out multi-country capacity building workshops/expert consultation meetings on climate projection and their applications in South Asia for the stakeholders of the region. He said the centre was looking forward to listing such an activity in the coming years under the ARRCC.

Before breaking for lunch, Santosh Nepal (ICIMOD) (picture Figure 10 left) presented on the process of developing climate change scenarios under NAP process to develop adaptation measures. RCP 4.5 and RCP 8.5 scenarios were used to project climate change impacts in the study. The climate models were selected based on changes in mean air temperature and annual precipitation and were further refined based on projected changes in four indices for climate extremes. The final selection accounted for model skills in simulating annual cycle of air temperature and precipitation. The study used historic database from 1981–2010 and various datasets for bias correction. The GCM with ~ 250 km resolution were downscaled to 10 km by a quantile mapping approach to preserve the extreme dynamics of the data. Results from the study indicate change in precipitation by 12% in the long-term period, an overall increase in temperature throughout the country, with a 2oC in some places in the mid-century. While all GCMs indicate an increase in temperature, 5 out of 8 GCMs show an increase in precipitation in the medium term (2016–2045) and 7 out of 8 showed an increase in the long term (2036–2065). Similarly, models

Figure 10: Presentation by regional providers

predicted an increase in extreme precipitation but a decrease in the number of rainy days; an increase in the number of warm days and a decrease in the number cold nights. Nepal said that the scenarios can be helpful in designing adaptation plans but the plans should be flexible enough to take the uncertainties into account.

Group activity – the Knowledge Café

The afternoon session allowed participants to assess the use of current climate projections in greater detail, by discussing the key features of a useful climate information system. This began with a group activity led by Arun Bhakta Shrestha, called the knowledge café, where participants were asked what ideal climate projections would look like. To help guide these discussions the activity was organised around four key sector groupings; 1) agriculture and biodiversity, 2) water and energy, 3) disaster risk reduction, and 4) tourism and health.

The following questions were formulated for the group activity:

1. How easy is it to access climate projection data relevant to the sector?
2. Do the available climate projections meet user requirements?
3. Are there currently interactions between providers and users in this sector? And is support available to help users understand and apply information from climate projections?
4. What are the needs and priorities for improving the application of climate projections in your sector?

Table 1: below outlines the key points captured from the sector-based tables.

The following paragraphs summarise key points for the different topics addressed in the questions:

Table 1: Knowledge Café group activity: Summary of key points.

Question	1	2	3	4
Agriculture and Biodiversity	• Data needed for biodiversity is less well understood; • Top down; • Farmers perhaps need advice on what to do, not just be given projection data; • Need of good observations for validation; • Data sharing across boundaries is challenging.	• Temporal resolution; • Local level projections are needed at a finer spatial scale; • Need of sector-specific projections; • Need of interpretation and translation	• No systematic or sustained interaction; • Unilateral effort; • Capacity building	• Understanding growing regimes of crops; • User engagement with the biodiversity sector; • Stronger collaboration on agriculture
Water and Energy	• Bandwidth issues for accessing data on the web; • Data format; • Need of specialists to define the role of the sector; • Data costs; • Access to data at local spatial scale	Mismatch in scales; • Lack of vertical grid information; • Realism of the climate model (effects of anthropogenic impacts are not included)	• Some interaction among hydrologists and climate scientists • Mismatch in supply vs demand: issue is often driven by scientists • Need of user driven interaction	• Tailored post processed data; • Collaboration among the stakeholders with feedback loop; • Capacity building: translating and understanding information; • Strengthening the sector specialist; transboundary/ cross-country issues
Disaster Risk Reduction	• Data is accessible but utility is not clear; • Formats not usable; • Need to predefine country specific disaster before the projection.	• Understanding temporal and spatial resolutions	• Not at all levels and scales; • Stakeholder hierarchy, who should communicate with whom; • Impact based; • Stakeholders need to know how to use the climate data.	• More user interaction; • Repositories of sector specific data on reducing risk; • Disaster atlas at sub-national or district level; • Continuous communication mechanism; • Improved impact models.
Tourism and Health	• Not easy and user friendly; • Coarse resolution; • Cost is high for high resolution data; • Users don't know how to use.	• Localized high resolution data is needed but not available; • No interest of users.	• No interaction and some interaction in countries (Nepal and India)	• More impact studies needed; • High resolution: Spatial and temporal; • Capacity building for the users; • More research is needed in tourism (CC impact on tourism); • Diseases projection; • Updating the academic curriculum: Climate projection; • Regional cooperation among countries of Asia or SAARC for cost management.

Data access and relevance

Availability, accessibility and relevance of data varied across countries. In some countries climate projection data can be obtained from central organisations like the national met services. The Pakistan and Bangladesh meteorology departments were highlighted as good examples. Data accessibility is dependent on users' expertise and technical proficiency. Participants raised questions about how the responsibility for data accessibility is distributed between users and providers. The general perception was that data access could be made easier and more user friendly. The available data does not provide enough relevant details for some sector applications.

Figure 11: Knowledge Café group activity

User data requirements

For some participants the data is available but not in a format they can readily use. In agriculture, for example, the data has to be processed further before it can be used with crop modelling software. Relevant variables are not always available. In the water sector, for example, users require precipitation projections that distinguish between snowfall and rainfall. For some sectors, users may not have clear data requirements. For the biodiversity sector, relevant climate variables and thresholds are not widely understood.

Figure 12: Knowledge Café group activity

User-provider interactions

For many of the sectors, interaction was characterised as mostly one-way communication from providers to users. Interaction was more common between research and intermediary organisations. In the agriculture sector, farmers occasionally contact the national met services for data but there is no mechanism for regular engagement. There was general recognition that more work could be done to facilitate interactions with some sectors.

Priorities for improving the application of climate projections

Participants' responses partly reflected the range of their backgrounds and expertise. Participants with a research background prioritised improving the science and refining impact models, while others aimed at improving science communication and developing sector focused products; encouraging more collaboration between providers, intermediary and users; establishing a process of continuous interaction that will act as a feedback mechanism; improving cooperation among countries to deal with transboundary climate impacts; and developing capacity through training and workshops with policy makers.

Science communication

The final session of the day was themed around science communication and featured presentations describing components of best practice science communication. The session was chaired by Laurie Vasily, Head of Knowledge Management and Communication at ICIMOD, who also delivered the first presentation.

Laurie Vasily's presentation provided guidance on how to become a confident science communicator. She emphasised that connecting with widely spread public values or points of 'local interest' and engaging audience would likely make the science heard. She identified 'uncertainty' in climate projections as a feature of climate science that should not be ignored or side-lined, but suggested that it could become a major stumbling block in conversations with a non-scientist audience. She highlighted the six key points outlined in the Climate Outreach handbook on communication for IPCC authors:

1. Be a confident communicator.
2. Talk about the real world not abstract.
3. Connect with what matters for your audience.
4. Tell a human story.
5. Lead with what you know.
6. Use the most effective visual communication.

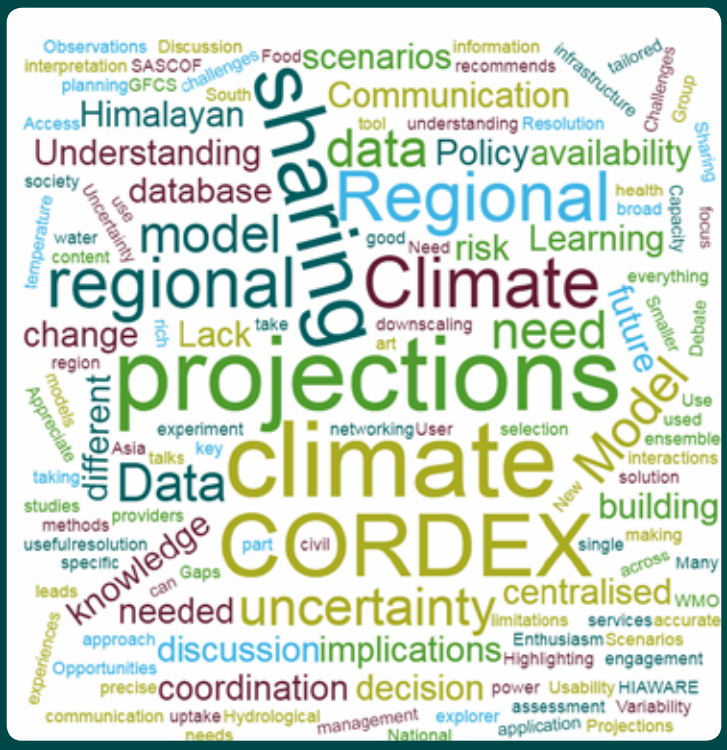
Vasily advocated using videos and cartographic platforms like Google Earth to convey information, and stressed the importance of using data visualization techniques to allow viewers to see long-term trends and variations in temperature.

In the next presentation Joe Daron from the Met Office described the challenge of distilling information from different types of projections into a coherent narrative, with examples from Met Office projects in other regions. He explained how 'Climate Risk Narratives' have been developed in a southern African project, FRACTAL, as a communication tool to promote two-way dialogue between climate science providers and climate information users. These 'conversation starters' aimed to illustrate climate information, subsequent climate impacts, and societal consequences and responses in concise, accessible formats using unambiguous, scientifically coherent and defensible 'stories' of future climate. He also talked about the information briefs on future tropical cyclone risks in the Philippines that were targeted at lay people.

Reflection

In the closing session Nicola Golding asked for reflections and highlights from the day. The word cloud below outlines the key words used in the sessions from the day.

Figure 13: Day 2 word cloud



3.3 Day 3: Key challenges and opportunities for South Asia

The final day focused on ways to address challenges discussed during the previous days and identify development opportunities.

In the opening session Nicola Golding asked the participants what the markers of a successful ARRCC programme would be and what they want to see achieved. Participants suggested better coordination at the regional level, with enhanced involvement from different user sectors and policy makers. The audience also emphasised the importance of maintaining benefits beyond the lifetime of the programme, establishing frameworks that will sustain and build on ARRCC achievements.

The following session aimed to give an overview of the range of projections available for the region and provide examples of where they have been used. In the first presentation, Cathryn Fox briefly discussed the CARISSA team's efforts to establish a baseline assessment of available climate projections. This highlighted the various ways in which climate projections are produced, the challenge of making sense of the information produced and ways of combining different methods to inform decision makers. The concept of distillation was defined as a '*process of comparing, understanding and combining multiple sources of information to create coherent, robust and audience-appropriate outputs*'.

Earlier in the workshop participants had discussed the changing nature and impact of extreme events, especially changes to the intensity of the South Asian monsoon. The presentation by Charan Singh (IMD) described recent cases of extreme rainfall events over the west Himalayan region and how they compared with the climatological records. His presentation focused on two extreme weather events in the western Himalaya region – Jammu Kashmir and Uttarakhand. Singh said that it is essential to consider climate information, weather forecasts along with RADAR and satellite inputs, seasonal scales, short range and nowcasts while planning for different agricultural activities.

The presentation by Assistant Professor Obaidullah Salehie (Kabul University) also featured some discussion of the historical record but focused more on long-term trends and impacts. His presentation covered climate change

impacts in the Kabul river basin in Afghanistan. He said that Afghanistan is one of the most vulnerable countries from the perspective of climate change. Afghanistan has very limited capacity to address impacts of climate change. Afghanistan experienced 1.8oC rise in temperature from 1951–2010, and a decrease in precipitation by 2% per decade between 1965 and 2015. A study by the United Nations Environment Programme (UNEP) and the National Environmental Protection Afghanistan (NEPA) suggests Afghanistan will face a strong increase in mean annual temperature, coupled with an overall decrease in water availability by 2100. Salehie identified droughts, desertification, floods, and glacial melt as major climatic hazards in Afghanistan. A joint study by ICIMOD and Afghanistan's Ministry of Water and Energy (MEW) found that Afghanistan lost 13.4% of its total glacier area from 1990–2015. Salehie shared that the law and policies for addressing climate issues are implemented through different agencies –NEPA, Ministry of Agriculture Irrigation and Livelihoods (MAIL), Ministry of Rural Rehabilitation and Development (MRRD), MEW, and Ministry of Transportation; many projects within these organisations help in coping with climate change impacts.

The previous day highlighted differences in the degree of interaction between providers and different sectors. For agriculture, there were examples of user-driven interaction and collaboration. In the next presentation, Abu Syed from the Bangladesh Centre for Advanced Studies (BCAS) discussed how climate influences diseases like potato blight and the role of farmers in developing seasonal forecasts for potato blight risk. He explained how BCAS used climate models, Land Use Land Cover (LULC), macro level climate/atmospheric information and integrated it into the crop model to analyse the time of the fungal attack, and passed on the information to the potato farmers in Bangladesh by text message.

On the first day Felipe Lucio had described the user-interface platform as the cornerstone of the climate services framework, and participants had expressed the need for accessible and user-friendly data portals. The presentation by Sudip Pradhan, a programme coordinator at ICIMOD, featured the Regional Database System (RDS), a data portal developed by ICIMOD. He gave an overview of the RDS climate services portal, with samples demonstrating the range of visualisation and analysis tools.

How different users interact with data and data providers was the subject of the next presentation, by Ben Harrison (Met Office – pictured figure 14). Ben Harrison discussed the recent update to the UK's national projection UKCP18, focusing on the UKCP18 user-engagement approach. This described how users of the previous round of national climate projections (UKCP09) influenced different phases of UKCP18. This included demonstration projects, where the Met Office provided selected organisations from different sectors to showcase the new science capabilities.

Figure 14: Ben Harrison, Met Office, UKCP18 explaining the user engagement approach

Future direction of CARISSA

In the final presentation of the morning, Joseph Daron discussed the future direction of the ARRCC programme and the CARISSA work package. He said that the focus of the first year will be on consolidating existing knowledge, engaging providers, users and co-producers of climate information, developing approaches around distilling information, and generating context-specific information to improve understanding of future climate risks.

Daron identified the following potential activities in CARISSA:

Advancing future climate projection information

- Support for the development and communication of regional/national climate projections
- Developing approaches and tools to exploit new and forthcoming climate projection datasets (e.g., UKCP 18 global data, CMIP6, CORDEX-CORE)
- Sea level rise projections for the Indian Ocean

Quantifying, communicating and integrating climate risk information into policy and planning

- Sector-specific engagements – e.g., planned follow-on workshop (Sept 2019)
- Development of 'climate risk narratives' for specific sectors/locations
- Quantifying key climate risks through applying the UNSEEN (UN precedented Simulated Extremes using Ensembles) method, for present day climate risk
- Climate Change attribution – examining both science and perceptions, and applications for policy
- Collaboration to produce a regular 'State of South Asia climate' report
- Regional climate and food security assessment

Capacity Building

- Developing practical guidance on 'distillation' of climate resilience issues and research requirements including generating relevant information from multi-model, multi-method climate projections
- Advice, training and development of guidance materials to support communication of climate projections
- Support for facilitating user engagement processes
- He also listed the following ideas that emerged from the regional workshop:
- Establishing a regular regional forum for knowledge exchange and cooperation on climate change projections
- Data portal for regional climate projection information and/or climate impacts information
- Enhancing observation-based products for application in the region
- Work to examine impacts of climate change on migration within focal countries and across the region
- General training on climate variability and change – science and applications

Group discussion on challenges for the provision and use of climate projections

The afternoon session asked participants to think about some of the issues raised and propose potential ways to address the most important of these challenges. Participants were asked to think about the following key themes:

1. Regional coordination, cooperation and collaboration
2. Data access and sharing
3. Sector focused engagement, tools and information products
4. Support for national and regional climate projections
5. Training and capacity building

The participants identified the following action points categorized under five key thematic topics:

1. Regional coordination, cooperation and collaboration
   - Need for a regional platform forum
   - Review existing platform forums
   - Universities as knowledge partners
   - Process for developing a regional forum like SASCOF. Could make South Asia Knowledge Forum like GFCS.
   - Major tasks of the forum thus formed will be to serve as a participatory guide, harmonization guide, systematic review of data, sharing capacity across countries and to provide training

2. Access to data and sharing
   - RDS-like data platform where there will be all GCM available for South Asia
   - Expert from each country
   - Make available non climatic data as well and include observation data rather than projection data
   - Training videos and tutorials should be made available online.
   - Should have different access points for different levels of expertise
   - RDS should be strengthened and more links should be made available.

3. Sector focused engagement, tools and information products
   - Water: sustainability of hydro power sector, future fresh water availability
   - Agriculture: Development of different crop varieties to make resilient agriculture plans in the region; rainfall data outside monsoon period is also important
   - Climate change projection for sectors like biodiversity, health and tourism must be provided.
   - Quality assured climate information will be more helpful than a wide range of data that is less reliable.

4. Support for national, regional climate projections
   - Have projection through monsoon period
   - Training and capacity building activities
   - Inventory of available projection
   - Development of handbooks and manuals
   - Financial support for providing projections, from financial agencies and transboundary collaborations.

5. Training and capacity building
   - Should focus on filling the gaps between sector expert and climate expert regarding use of climate projection data
   - Co-production of training by data users and providers
   - Separate training for people from technical and non-technical backgrounds.

Following these discussions, there was discussion on the outputs and outcomes of the workshop. This discussion included ideas on how the CARISSA project and ARRCC programme can continue to engage with participants, including ideas on sharing materials and creating a quarterly newsletter to send to a group mailing list.

Figure 15: Expectations from the workshop captured using meta cards.

Figure 16: CARISSA work package: Next steps

Closing session: Wrapping up

David Corbelli thanked everyone for a really productive workshop and the valuable comments and suggestions. He mentioned that the suggestions would be very useful in setting the priorities and activities for the ARRCC programme. He said that the next steps for the programme would focus on the five key thematic areas identified at the workshop.

David Molden said that the three-day programme was a good learning experience for everyone and had a good balance of climate projection science, usage and aspects of user engagement. He added that the new collaboration with the Met Office has brought together many institutions so that they can move towards understanding climate information and putting it to use for South Asia. Molden said that programmes like ARRCC helped in making meaningful contributions and fostering regional collaboration.

Ghulam Rasul said that the interactions between users and producers of climate information at the workshop would help lay the foundation for future collaboration and cooperation through the programme. He called upon partners to collaborate for making South Asia climate resilient.

Joe Daron expressed pleasure in seeing the programme take shape, and added that the workshop marked the start of the process, and future engagements would follow suit.

Mandira Singh Shrestha said that organizing the workshop had been a rewarding experience as it brought together diverse participants from the region. She added that she looked forward to four more years of working together and developing the partnership with the Met Office to enhance disaster resilience and to improve the lives and livelihoods of people in South Asia.

4. Conclusion and Recommendations

The workshop provided valuable insights regarding the opportunities and challenges in improving the application of future climate projections in South Asia. It succeeded in achieving buy-in for the project and enabling interaction between key organisations in the region. The learning has informed plans for ongoing work under CARISSA and the wider ARRCC programme. Along with improved regional coordination and cooperation amongst institutions, these activities will ultimately deliver benefits to a range of societal sectors.

Key themes that emerged in the workshop have helped in the planning of project activities for the next four years. Following a long list of recommendations created at the workshop, the CARISSA team has begun prioritisation of activities, which will continue to evolve through discussions with key partners and stakeholders.

Six proposed activities are now being considered, based on the outcomes of the workshop, the alignment with other ARRCC activities, and capabilities in the Met Office team and key partner organisations such as ICIMOD. The activities are:

Training and capacity development

- Training and Capacity Development

Regional forums and data platforms

- Development of a regional forum on climate change
- Enhancing regional climate projection data platforms

Sector and risk-specific activities

- Climate change information services for the water and hydropower sector
- Information for managing coastal climate risks
- Climate change and food security assessments

For each of these activities, detailed plans are being developed. The plans outline the main aims, a summary of key tasks, and expected outputs. It is envisaged that participants of the workshop will be further engaged in many of these activities to co-develop services and tools that can benefit the region. The Met Office will be further working with ICIMOD and other key regional and national partners to ensure the successful development and delivery of activities, helping to achieve the overall aims of the ARRCC programme.

Figure 17: Ghulam Rasul, David Molden, David Corbelli, Joe Daron, and Mandira Singh Shrestha in a facilitated discussion at the workshop closing

Annex I: Agenda

Tuesday, 29 January 2019 Day 1: The provision of climate projections in and for South Asia	
09:00–09:15	**Registration** – *Govinda Shrestha, ICIMOD*
09:15–09:40	**Opening session:** **Facilitator:** *Mandira Singh Shrestha, ICIMOD* • Welcome remarks – *David Molden, ICIMOD* • Opening remarks – *Simon Lucas, DFID* • Opening remarks – *David Corbelli, Met Office* • Background and objectives of the workshop – *Nicola Golding, Met Office*
9:40–10:00	Using climate scenarios for understanding current and future water availability of the Hindu Kush Himalaya – *Arun Bhakta Shrestha, ICIMOD*
10:00–10:30	Participant introductions – *Joe Daron, Met Office*
10:30–11:00	*Tea break and group photo*
11:00–12:15	**Presentations by national and regional providers of climate change projections and discussion** **Chair:** *Ghulam Rasul, ICIMOD* **Rapporteurs:** *Utsav Maden and Binu Maharjan, ICIMOD* • Observations, projections and impacts of climate change in Bangladesh – *Mohammad Shohidul Islam, Bangladesh Meteorological Department, Bangladesh* • Himalayan climate: past and future – *A.P. Dimri, Jawaharlal Nehru University, India* • Overview of climate projections in Nepal – *Archana Shrestha, Department of Hydrology and Meteorology, Nepal* • Story of climate projections in Pakistan – *Jehangir Ashraf Awan, Pakistan Meteorological Department, Pakistan*
12:15–12:45	**Overview of Coordinated Regional Climate Downscaling Experiment (CORDEX) for South Asia** – *Sanjay Jayanarayanan, IITM, India*
12:45–13:45	*Lunch*
13:45–15:00	Group Activity: providing climate projections – *Cathryn Fox, Met Office*
15:00–15:30	Feedback from groups
15:30–16:00	*Tea Break*
16:00–16:30	**Regional approach to Climate Services Information System: South Asian context** – *Rupa Kumar Kolli and Filipe Lucio, World Meteorological Organization*
16:30–17:00	End of day 1 reflection – *Nicola Golding, Met Office*
18:30 onwards	*Workshop dinner*

Wednesday, 30 January 2019

Day 2: The use of climate projections in South Asia

09:00–09:15	Review of day 1 – *Nicola Golding, Met Office*
09:15–10:30	**Presentations by users of climate projections from countries** **Chair:** *Mandira Singh Shrestha, ICIMOD* **Rapporteurs:** *Binu Maharjan and Utsav Maden, ICIMOD* • High-end climate change scenarios for floods, droughts, cyclone and storms surges hazards in Bangladesh – *Saiful Islam, Institute of Water and Flood Management, Bangladesh University of Engineering and Technology, Bangladesh* • Climate change impact assessment by Integrating Climate, Crop and Economics Modelling Approaches: A Case Study in Cropping Systems of Punjab, Pakistan – *Ashfaq Ahmad Chattha, University of Faisalabad, Pakistan* • The need of regional climate modelling for India – *Saurabh Bhardwaj, The Energy and Resources Institute (TERI), India* • Climate risk assessment of the hydropower sector in Nepal: issues and challenges of using climate projections – *Divas Basnet, Nepal Development Research Institute (NDRI), Nepal* • Effect of high emission climate change scenario on glaciers in the Satluj basin – *Veena Prasad, Divecha Centre for Climate Change, India*
10:30–11:00	*Tea break*
11:00–12:00	**Presentations by users of climate projection from regional organizations** **Chair:** *Farid Ahmad, ICIMOD* **Rapporteurs:** *Utsav Maden and Binu Maharjan, ICIMOD* • An overview of SAC activities on climate resilient agriculture in South Asia – *Ashis Kumar Samanta, SAARC Agriculture Research Centre, Bangladesh* • Climate scenarios for the national adaptation plans (NAPS) study in Nepal – *Santosh Nepal, ICIMOD*
12:00–12:30	Discussion on the use of climate projections in South Asia
12:30–13:30	*Lunch*
13:30–14:30	**Group activity**: *Knowledge Café* What would useful projections look like (including data, access, support, interactions)? – *Arun Bhakta Shrestha, ICIMOD*
14:30–15:00	Group presentations
15:00–15:30	*Tea break*
15:30–16:30	**Science communication** **Chair:** *Laurie Vasily, ICIMOD* **Rapporteur:** *Nisha Wagle, ICIMOD* • Communicating science: nuts and bolts – *Laurie Vasily, ICIMOD* • Communication of climate projections for policy makers and planning: examples in other regions – *Ben Harrison, Met Office*
16:30–17:00	End of day 2 reflection – *Nicola Golding, Met Office*

Thursday, 31 January 2018

Day 3: Key challenges and opportunities for South Asia

9:00–9:15	Review of day 2 – *Nicola Golding, Met Office*
9:15–11:00	**Key challenges in providing and using climate projections in South Asia** **Chair:** *Mir Matin, ICIMOD* **Rapporteurs:** *Nisha Wagle and Binu Maharjan, ICIMOD* • Available climate projections for South Asia – *Cathryn Fox, Met Office* • Extreme weather events particularly heavy rainfall over the Indian region – *Sr. Charan Singh, IMD, India* • Climate change impacts in Afghanistan – *Obaidullah Salehie, Kabul University, Afghanistan* • End User's expectation from national meteorology institution as climate services – *Abu Syed, Bangladesh Centre for Advanced Studies (BCAS), Bangladesh* • Integration of climate services and the Regional Database System – *Sudip Pradhan, ICIMOD*
11:00–11:30	*Tea break*
11:30–12:30	**Future directions for Asia Regional Resilience to a Changing Climate (ARRCC) programme** **Chair:** *David Corbelli, Met Office* **Rapporteur:** *Nisha Wagle and Binu Maharjan, ICIMOD* • The provider-user approach in UK Climate Projections 2018 (UKCP18) – *Ben Harrison, Met Office* • Setting the future direction for ARRCC-CARISSA – *Joe Daron, Met Office*
12:30–13:30	*Lunch*
13:30–14:45	Group discussions on challenges for the provision and use of climate projections in South Asia – *Joe Daron, Met Office*
14:45–15:00	Evaluation Survey
15:00–15:30	*Tea break*
15:30–16:00	Compilation of recommendations, next steps for ongoing engagement – *Joe Daron, Met Office*
16:00–17:00	**Closing Session: Wrapping up** – *Met Office/ICIMOD*

Annex II: Participants

Afghanistan

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Tasfia Tasnim
International Centre for Climate Change and Development (ICCCAD), Independent University Bangladesh (IUB), Dhaka

Md. Abu Syed
Bangladesh Centre for Advanced Studies (BCAS) and Director Nansen-Bangladesh International Centre for Coastal, Ocean and Climate Studies (NABIC), Dhaka

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Mir Matin

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Santosh Nepal

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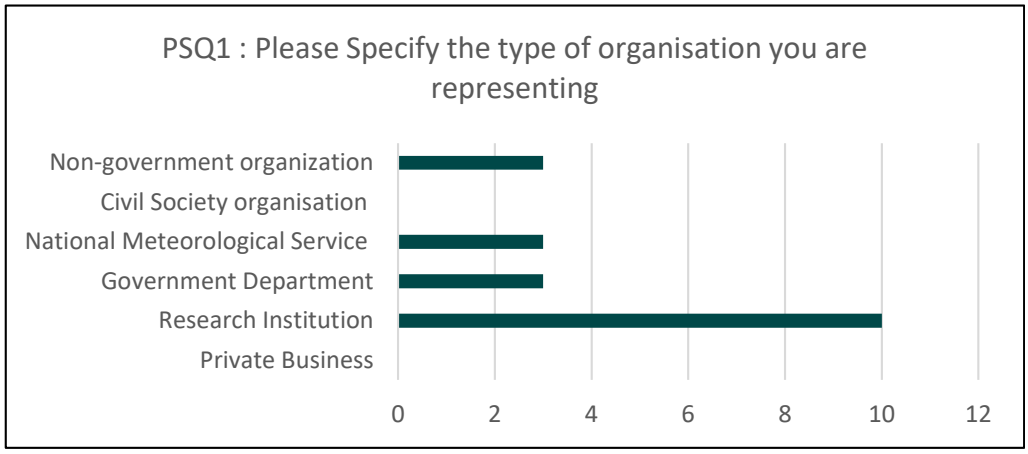
Annex III: Pre-workshop Survey Results

The responses indicated that most participants represented research or academic institutions, with the remaining participants coming from an equal mix of government department, NHMS and NGOs. The absence of private sector organisations suggested further engagement could be required to understand the requirements of these users.

Figure A3.1 – Results for Pre-Workshop Survey Question 1 (PSQ1)



The second question asked about the sectors the organizations work with or the sectors they represent. The responses reflect the fact that climate impacts have been studied more extensively for some sectors, while for others the science may be relatively new.

Figure A3.2 – Results for Pre-Workshop Survey Question 2 (PSQ2)

We asked participants whether they represented organizations that provided climate projections, processed climate projections, used projections to inform decision makers at other organizations, and/or used projections to make planning decisions. The following definitions were used.

Provider: Involved in the production and/or provision of climate projections.

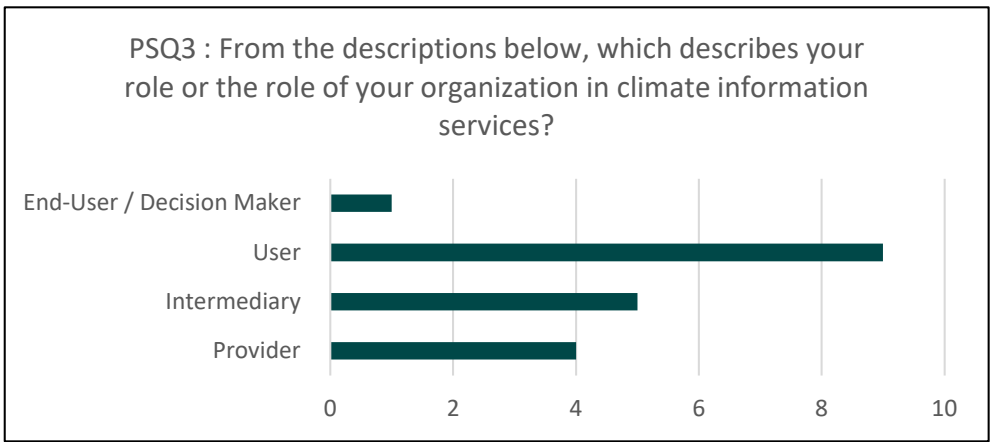
Intermediary: Involved in the translation or communication of future climate projections, including post-processing of data and impacts modelling

User: Involved in making use of climate projection data to inform policy formulation, business strategy and raising awareness.

End-user/Decision maker: Involved in using future climate projections as input into a decision-making process, either from raw model data or bespoke services from supporting organisations.

The user category received the most responses and the end-user received the least responses, with an approximately equal number of responses for the provider and intermediary categories.

Figure A3.3 – Results for Pre-Workshop Survey Question 3 (PSQ3)



The next section asked participants to rate their understanding of climate modelling, their level of engagement with user or providers of climate projections and their ability to find relevant climate projection data. These questions were repeated in the workshop evaluation survey (Annex 6), described the following section of this report and the section contains a comparison of the results from the two surveys.

Annex IV – Workshop Evaluation Survey Results

The first three questions related to the workshop format, the relevance of the content and whether the workshop met the participants expectations.

Figure A4.1 – Results for Workshop Evaluation Survey Question 1 (ESQ1)

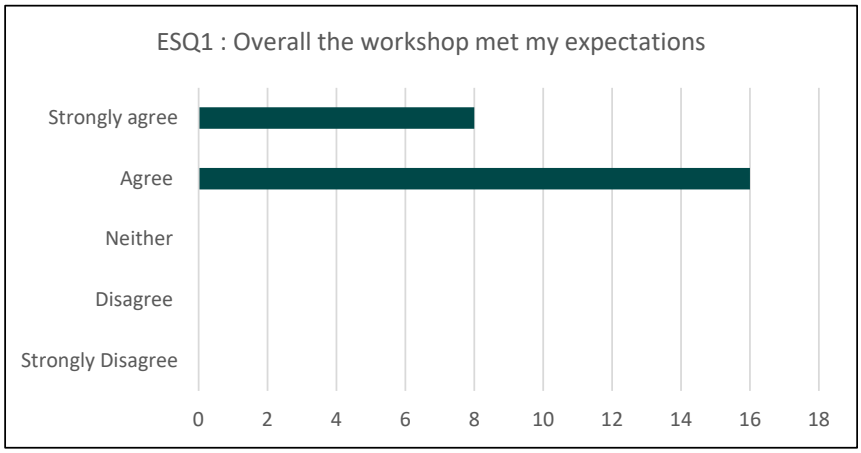


Figure A4.2 – Results for Workshop Evaluation Survey Question 2 (ESQ2)

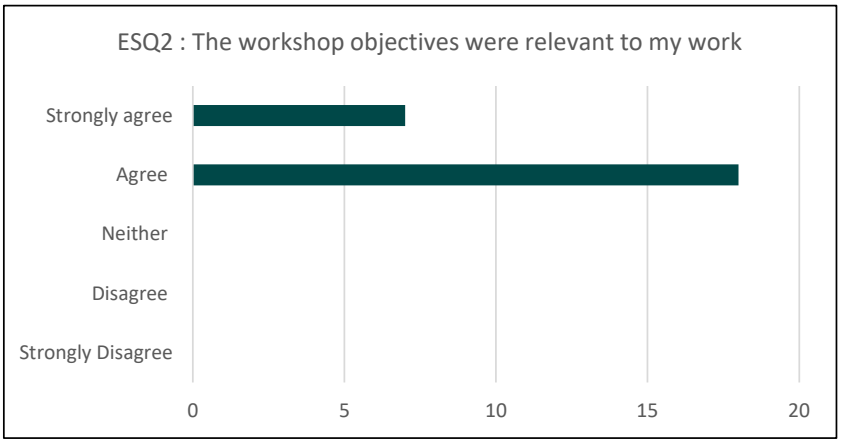


Figure A4.3 – Results for Workshop Evaluation Survey Question 3 (ESQ3)

The next two questions asked participants if they understood the objectives of the ARRCC programme and whether they had heard of ARRCC before attending the workshop.

Figure A4.4 – Results for Workshop Evaluation Survey Question 4 (ESQ4)

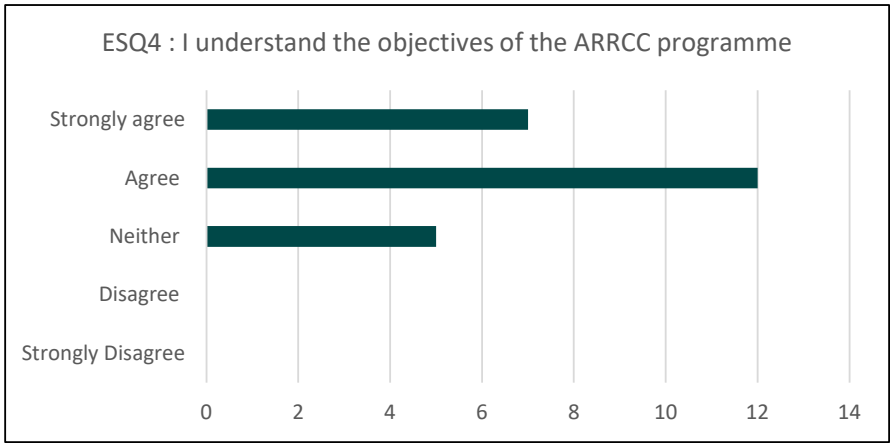
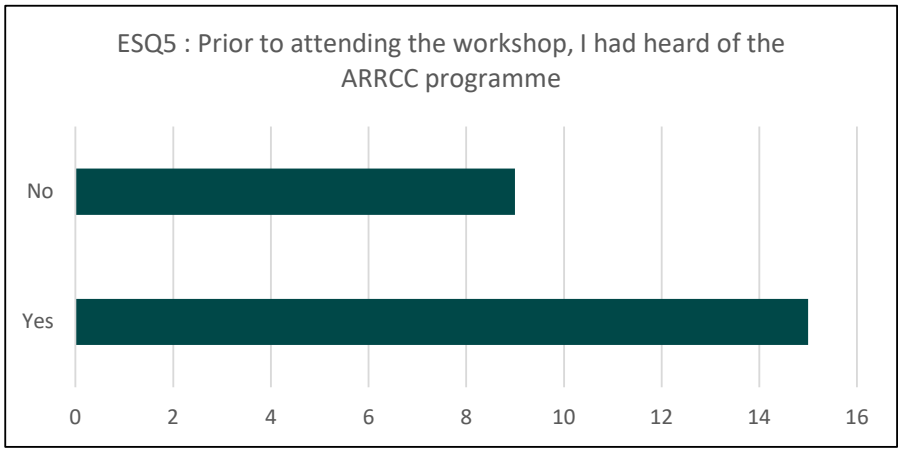
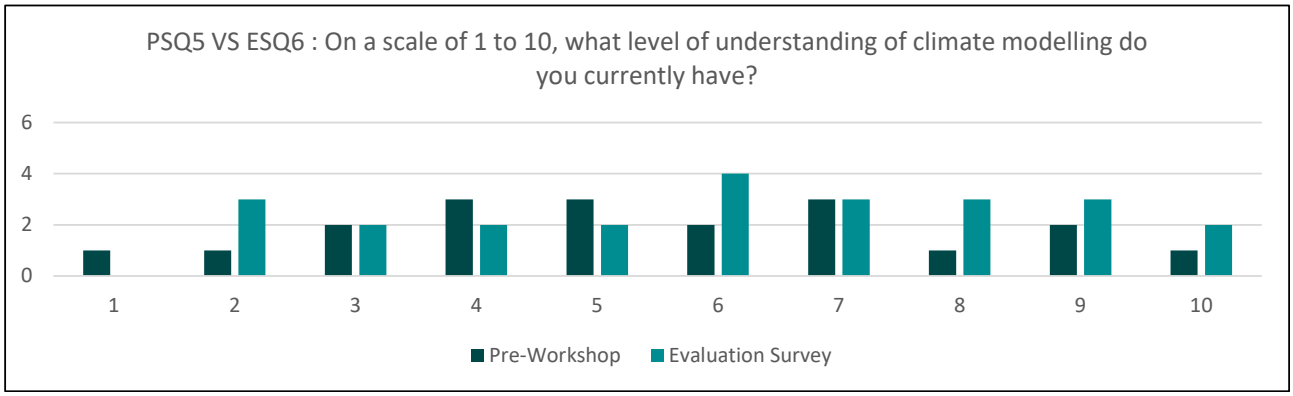


Figure A4.5 – Results for Workshop Evaluation Survey Question 5 (ESQ5)



The next section repeated the questions B2–B5 from the pre-workshop survey. The results from both surveys are shown in the figures below. (Note some of the participants were unable to attend the whole workshop and so the response rate for the evaluation survey was lower than for the pre-workshop survey)

Figure A4.6 – Results for Pre-Workshop Survey Question 5 (PSQ5) and Workshop Evaluation Survey Question 6 (ESQ6)



Compared to the pre-workshop survey, fewer participants rated their engagement with users/providers in both the lowest and highest categories. This could be because the workshop facilitated more user-provider engagement and provided examples of what high-levels of engagement might look like.

Figure A4.7 – Results for Pre-Workshop Survey Question 6 (PSQ5) and Workshop Evaluation Survey Question 7 (ESQ7)

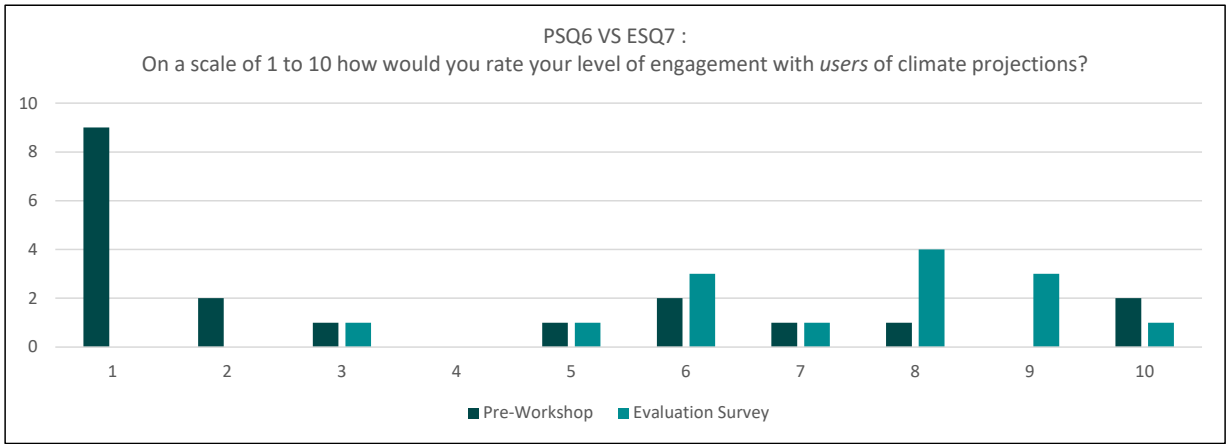
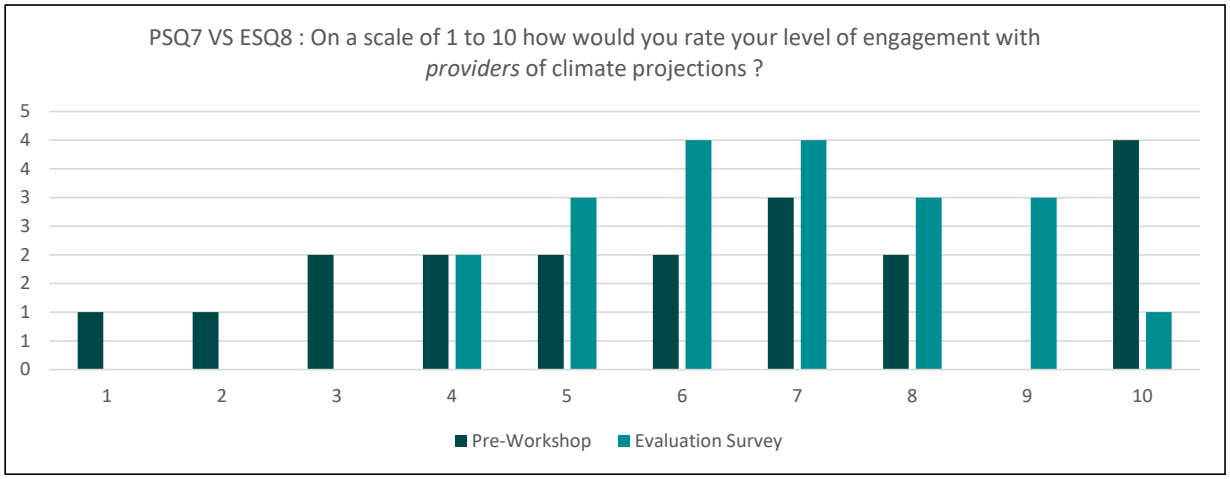
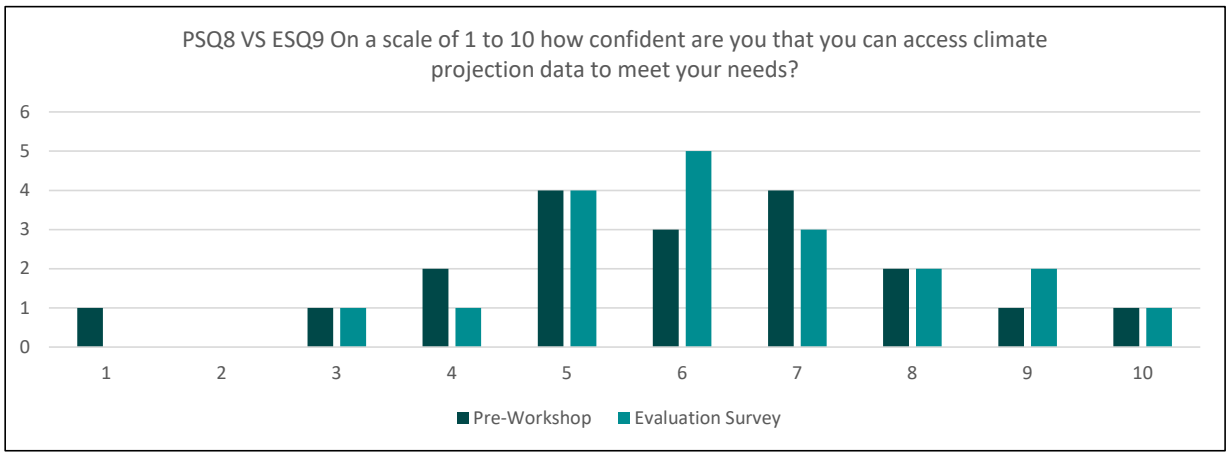


Figure A4.8 – Results for Pre-Workshop Survey Question 7 (PSQ7) and Workshop Evaluation Survey Question 8 (ESQ8)



For the question concerning the participant's ability to access relevant climate projections data, there was a slight increase in confidence.

Figure A4.9 – Results for Pre-Workshop Survey Question 8 (PSQ8) and Workshop Evaluation Survey Question 9 (ESQ9)



The next three questions asked participants if they used climate projections before, what other sources of climate information they use and what they thought the most important barriers for climate projection use in their work.

Figure A4.10 – Results for Workshop Evaluation Survey Question 11 (ESQ11)

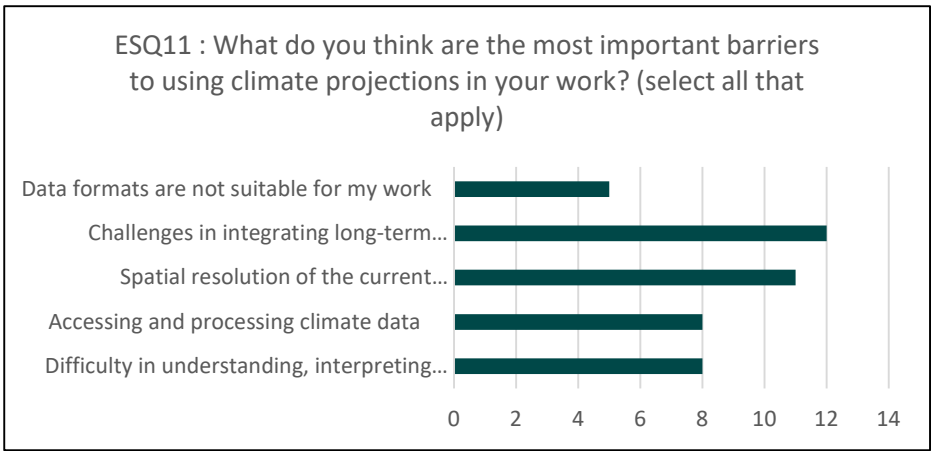


Figure A4.11 – Results for Workshop Evaluation Survey Question 12 (ESQ12)

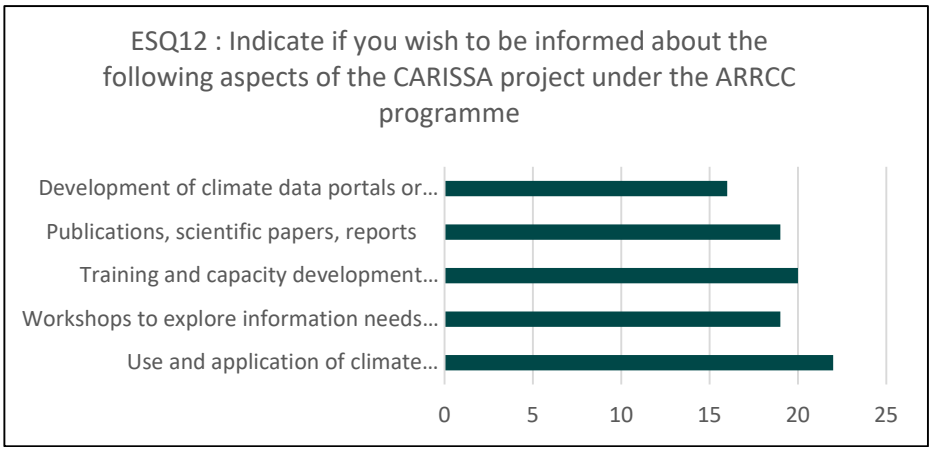
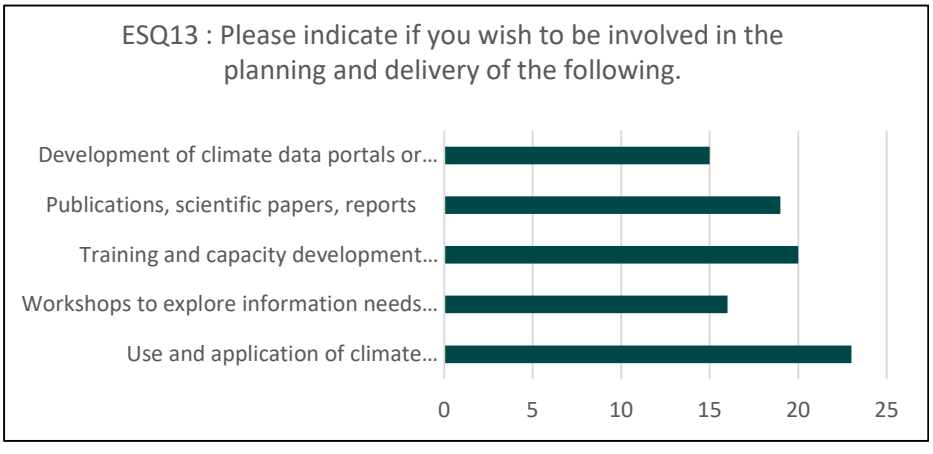


Figure A4.12 – Results for Workshop Evaluation Survey Question 13 (ESQ13)



Annex V – Pre-Workshop Survey

Section A: You and your organization

1) Please specify the type of organization you are representing.
   - Private business
   - Research institution/university
   - Governmental department/public administration
   - National meteorological service
   - Civil society organization
   - Non-governmental organization
   - Other (please specify):

……
……

2) Does your organization work in or supply information for any of the following sectors? (Please select all that apply.)
   - Agriculture and forestry
   - Water management
   - Disaster risk reduction
   - Infrastructure
   - Energy
   - Health
   - Other (please specify):

……
……

3) From the descriptions below, which best describes the role of your organization in climate information services?
   - Provider: Involved in the production and/or provision of future climate projections
   - Intermediary: Involved in the translation or communication of future climate projections, including post-processing of data and impacts modelling
   - User: Involved in making use of climate projection data to inform policy formulation, plan business strategy, and raise awareness
   - End User/decision maker: Involved in using future climate projections as input into a decision-making process, either from raw model data or bespoke services from supporting organizations
   - Other (please specify):

……
……

Section B: Workshop expectations and previous engagement

4) Which of the following are you hoping gain from the workshop? (Please select all that apply.)
   - A chance to share my institute's work with others in the region
   - Guidance from regional/international organizations
   - Understanding of recent or ongoing initiatives in the region
   - Information on how to produce regional climate projections
   - Information on how to access and use climate projections
   - Information on modelling of climate impacts and the development of sector-specific climate services
   - Opportunities for collaboration or networking
   - Understanding of the aims and objectives of the Asia Regional Resilience to a Changing Climate (ARRCC) programme
   - Information on how to get involved in the ARRCC programme
   - Other (please specify):

……
……

5) On a scale of 1 to 10, what level of understanding of climate modelling do you currently have?

……
……

6) If you are a provider of climate projections or an intermediary, on a scale of 1 to 10, how would you rate your current level of engagement with users of climate projections, where 1 is no interaction and 10 is ongoing collaboration?

……
……

7) If you are a user or end-user of climate projections, on a scale of 1 to 10, how would you rate your current level of engagement with providers of climate projections, where 1 is no interaction and 10 is ongoing collaboration?

……
……

8) If you are a user or end-user of climate projections, on a scale of 1 to 10, how confident are you that you can access climate projection data that meet your needs?

……
……

Annex VI – Workshop Evaluation Survey

Workshop Evaluation Survey
Future Climate Projections and their Applications in South Asia
29– 31 January 2019, ICIMOD, Kathmandu, Nepal

Thanks 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 organisation, we'd be grateful if you could answer the following questions. All responses will be collated and anonymised.

Name:

Organisation:

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 or disagree ☐ agree ☐ Strongly agree

Comments: .....
.....

2) The workshop objectives were relevant to my work.

☐ Strongly disagree ☐ Disagree ☐ Neither agree or disagree ☐ agree ☐ Strongly agree

Comments: .....
.....

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

☐ Strongly disagree ☐ Disagree ☐ Neither agree or disagree ☐ agree ☐ Strongly agree

Comments: .....
.....

4) I understand the objectives of the ARRCC programme

☐ Strongly disagree ☐ Disagree ☐ Neither agree or disagree ☐ agree ☐ Strongly agree

Comments: .....
.....

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

☐ Yes ☐ No

Comments: .....
.....

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

Answer question 7 if you are a provider of climate projections or an intermediary.

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

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

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

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

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

☐ Yes, I have used/analysed raw climate model data

☐ Yes, but only processed data in the form of graphics, reports, tables etc prepared by other organisations

☐ No, but I plan to do so in future

☐ No, I haven't used or plan to use climate projections

Comments: ……
……

11) What other forms of weather and climate information have you used in your work? [tick all that apply]

☐ Near-term weather forecasts (from hours to days)

☐ Seasonal forecasts (e.g. forecasts for next month or season)

☐ Historical climate data and observations

☐ None

Other (please specify) ……
……

Comments: ……
……

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

☐ Difficulty in understanding, interpreting and understanding climate model data

☐ Accessing and processing climate data

☐ Spatial resolution of the current generation of climate projections are too coarse

☐ Challenges in integrating long-term future climate information into policy/planning

☐ Data formats are not suitable for my work

Other (please specify) ……
……

Comments: ……
……

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

- ☐ Use and application of climate projections in the region
- ☐ Workshops to explore information needs and develop solutions
- ☐ Training and capacity development activities
- ☐ Publications, scientific papers, reports
- ☐ Development of climate data portals or information products

Other (please specify) ……
……

Comments: ……
……

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

- ☐ Use and application of climate projections in the region
- ☐ Workshops to explore information needs and develop solutions
- ☐ Training and capacity development activities
- ☐ Publications, scientific papers, reports
- ☐ Development of climate data portals or information products

Other (please specify) ……
……

Comments: ……
……

15) Do you have any other recommendations for the ARRCC programme and/or the CARISSA project?

Many thanks for your time!

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