WORKSHOP REPORT

Spatial and temporal analysis of climate change indices using the Climate Data Indices Tool and CORDEX datasets over South Asia

21–24 June 2022 | Dhulikhel and Kathmandu, Nepal

Executive summary

In collaboration with the Met Office, World Climate Research Programme (WCRP)/Coordinated Regional Climate Downscaling Experiment (CORDEX), Swedish Meteorological and Hydrological Institute (SMHI), and the Indian Institute of Tropical Meteorology (IITM) – Pune, ICIMOD organised a four-day regional training on spatial and temporal analysis of climate change indices.

The training focussed on using the Climate Data Indices Tool to calculate select indices for different sectors – agriculture, health, and water resources – by using selected representative models for a defined area of interest. Resource persons from ICIMOD and the University of Jena guided participants in calculating and analysing climate indices using the Climate Data Indices Tool, R software and CORDEX regional climate model simulations. Resource persons from IITM–Pune and SMHI made presentations on CORDEX South Asia-based climate indices used in the IPCC AR6 report and bias correction methods, respectively.

The training brought together sixteen participants, among them, five women, from national meteorological and hydrological services, namely, Bangladesh Meteorological Department, Department of Hydrology and Meteorology, Nepal, and Pakistan Meteorological Department as well as research institutions from the same three countries. Supported by the Asia Regional Resilience to a Changing Climate (ARRCC) programme funded by UK Aid, the regional training is the fifth training in a series of training organised by ICIMOD, the Met Office (UK), and partners in 2020–2022. These trainings are part of ARRCC's institutional capacity-building approach to strengthen the knowledge and capabilities of staff working at key national and regional institutions delivering climate services so as to equip them to provide the up-to-date information needed for informed climate change responses in South Asia.

The participants were asked to rate the training's contents and outcomes in a post-training assessment

survey. They scored the training's overall substance as well as their own overall level of learning, knowledge of the subjects covered after the training, and likelihood of using the information in their jobs (see Annex 2). They said it had been beneficial and that they were happy to gain working experience with the CDI Tool and climate indices.

After the training, the participants reported a marked increase in their knowledge about the topics discussed at the workshop. About 20 per cent of the participants reported having gained an excellent understanding of the concept of climate indices, and 40 per cent reported a very good understanding of the same, which is a significant improvement from their initial rating of 'poor' (6.3 per cent) or 'fair' (12.5 per cent) for the same concept before the training.

ICIMOD's institutional capacity-building efforts focus on building institutional capacity through building capacity in its people, and our country-focused training and regional training help us achieve this. Additionally, regional training also brings together people from across the region and provides critical feedback on how the different models and tools work in country-specific areas.

SECTION 1

About the training

In collaboration with the Met Office, the UK's national meteorological agency, World Climate Research Programme (WCRP)/Coordinated Regional Climate Downscaling Experiment (CORDEX), Swedish Meteorological and Hydrological Institute (SMHI), and Indian Institute of Tropical Meteorology (IITM) – Pune, ICIMOD organised a four-day regional training on spatial and temporal analysis of climate change indices using the Climate Data Analytical Tool and CORDEX datasets over South Asia.

Supported by the Asia Regional Resilience to a Changing Climate (ARRCC) programme funded by UK Aid, this training focussed on using the Climate Data Indices Tool to calculate select indices for different sectors – agriculture, health, and water resources – from a list of more than 50 climate indices of selected representative models for a defined area of interest. The tool also allows spatial and temporal analysis of the calculated climate indices.

Objectives

The training was organised to build knowledge and improve skills among professionals from Bangladesh, Nepal, and Pakistan to calculate and analyse climate indices using ICIMOD's Climate Data Indices Tool and CORDEX regional climate model simulations

Expected outcomes

The training helped participants calculate the climate indices for their sector of interest and analyse them to understand climate change impacts better and to assess the spatial and temporal variability of present and future climate indices over a defined area of interest.

In addition to using the tool to calculate the climate indices, the participants were able to

- select representative models for their defined area of interest;
- extract CORDEX datasets for their area of interest and analyse them separately;
- carry out spatial and temporal visualisation of climate indices over their defined area of interest;
- interpret the uncertainty of the results of the selected models

Participation

Sixteen participants, among them five women, from the different national meteorological and hydrological services (NMHS) of Bangladesh, Nepal, and Pakistan, attended the training. Most of them had participated in earlier training on CORDEX data access and use. The training was held in person in Dhulikhel and at the ICIMOD headquarters in Kathmandu, Nepal.

List of resource persons

ICIMOD: Saurav Pradhananga and **Mandira Singh Shrestha**

University of Jena: **Sven Kralisch**

Met Office: **Joseph Daron** (remote participation)

CORDEX: **Iréne Lake** and **Erik Kjellström** (remote participation)

Centre for Climate Change Research (CCCR), IITM – Pune: **J. Sanjay** (remote participation)

Background

The impact of climate change on the climate variable mean can only be visualised over a long period. However, the impact of climate change on climate extremes, i.e., events outside the typical range of weather conditions, both in terms of frequency and intensity, can be seen immediately. In 2021–2022, ICIMOD organised three country-focussed trainings for professionals from different NMHS in ARRCC-focal countries – Afghanistan, Bangladesh, Nepal, and Pakistan – on using CORDEX regional climate models to carry out spatial and temporal analyses of climate change over South Asia under the Climate Services Initiative.

The aforementioned trainings were organised as follow-onsto the "Regional climate change projections: Climate change analysis using CORDEX regional climate models over South Asia". These trainings are part of ARRCC's institutional capacity-building approach to strengthen the knowledge and capabilities of staff working at key national and regional institutions delivering climate services to enable them to formulate informed climate change responses in South Asia.

The training in June 2022 introduced the Climate Data Indices Tool and focussed on the calculation and spatial and temporal analysis of climate indices of a few representative models for a defined area of interest.

ARRCC's institutional capacity-building approach

The knowledge and capabilities of staff working at key national and regional institutions delivering climate services need to be strengthened to enable them to provide the information needed for informed climate change responses in South Asia. The ARRCC programme has, therefore, adopted an institutional capacity-building approach on regional climate projections to help meet this need. The approach targets NMHS and other organisations in the ARRCC focal countries working to provide climate services to government/non-government organisations, communities, and industrial sectors vulnerable to climate change impacts.

A series of training activities were organised between 2020 and 2022 to build the capacities of individuals at targeted institutions to analyse climate projections and produce information products for use in different sectoral applications. The training was jointly developed and delivered by ICIMOD and the Met Office, UK, with support from other relevant organisations, which included the World Climate Research Programme, Swedish Meteorological and Hydrological Institute, and the Indian Institute of Tropical Meteorology (IITM) – Pune, where appropriate.

Dates	Title	Audience
7–11 March 2022	Spatial and temporal climate change analysis using CORDEX regional climate models over Bangladesh	Bangladesh Meteorological Department and Institute of Water Modelling
13–15 December 2021	Spatial and temporal climate change analysis using CORDEX regional climate models over South Asia for Bangladesh	Bangladesh University of Engineering and Technology and other academic institutions
7–11 June 2021	Spatial and temporal climate change analysis using CORDEX regional climate models over South Asia	Nepal's Department of Hydrology and Meteorology and other institutions

SECTION 2

Day 1

21 June 2022

Mandira Singh Shrestha, ICIMOD, welcomed the participants to the workshop in Dhulikhel, Nepal. She facilitated a round of introductions.

Sven Kralisch, University of Jena and **Saurav Pradhananga**, ICIMOD, led participants through the installation of software – Climate Data Indices Tool (CDITool), R, R Studio and Rtools – used at the training. They addressed the problems faced by participants in installing the required software and downloading the data needed for the hands-on sessions.

The participants were also provided daily precipitation and temperature data for 1971–2100 for all the 17 RCMs and ERA5-Land data for 1971–2005. Participants were grouped into country groups and provided datasets for the Koshi River Basin for the demonstration as well as for their respective countries for the hands-on exercise.

Utsav Maden, ICIMOD, led participants on a pre-training self-assessment and undertook a poll on four key questions. These responses have been included as an annexe in the Report.

PMD's Burhan Ahmad and **Shahzada Adnan** presented the generation of climate change scenario-based indices and the impacts of climate change on agriculture in Pakistan. The team retrieved CORDEX datasets – maximum and minimum temperatures – from IITM-Pune's server and used the quantile mapping method to downscale and bias correct the data sets for Pakistan. Ahmad presented the baseline and projected probability density functions of SMHI RCA4 CORDEX data sets downscaled over Pakistan. The model results predict higher occurrences of hot extreme weather events attributed to significant shifts in temperature extremes and a higher probability of more than 250 mm/day precipitation extremes for 2011–2040.

In his presentation, **Shahzada Adnan**, PMD, offered a comparison of agro-climatic zones by using observed and bias-corrected model baseline data over Pakistan from 1971–2000. The team classified the country into four agro-climatic zones based on the amount of rainfall received. They analysed future climate scenarios for the 21st century for the two scenarios RCP4.5 and RCP8.5. They deduced the future projections of seasonal crop water requirements in the rabi (Oct-Apr) and kharif (May-Sep) seasons for the 21st century under two scenarios. Both scenarios indicate an increased demand for crop water, which would likely lead to groundwater depletion in the region, with farmers resorting to groundwater extraction for irrigation. Based on the projection data, the team recommended short-, medium- and long-term strategies for the different regions in Pakistan. The results of their study have already been published in two journals.

Post-presentation, the team addressed the following questions from the participants:

a. Use of three-decade periods in the research

Data for at least 30 years is required to observe a shift in climate. Shorter time scales exhibit greater variability as per current literature, and peer-reviewed literature recommends 30-year time scales for research. Quantile delta mapping is more credible when you use it on higher time scales.

b. Method used to assess crop water demand

Temperature data – maximum and minimum, relative humidity, and crop coefficient values – were used to calculate the crop water demand.

c. Selection of the model

Six RCMs were assessed before selecting a particular model for use. SMHI RC4 was selected because it had the least systemic biases and was able to replicate monsoon and winter precipitation well when compared with the other models.

d. Query on the proposed climate-smart agriculture

Climate-smart agriculture aims at high productivity while using fewer resources. Many methods can be adopted ranging from the replacement of sprinkler systems with drip irrigation systems, development and planting of drought- and pest-resistant seeds, and development and adoption of crop varieties that

have shorter stems but higher yields. Increasing agro-biodiversity in plantations and considering climate scenarios and climate shifts during decision-making on crop selection are examples of climate-smart agriculture.

Md Bazlur Rashid, BMD, provided a summary of the training organised at BMD's campus in March 2022 on "Spatial and temporal climate change analysis using CORDEX regional climate models over South Asia for Bangladesh". He provided a detailed breakdown of how the training was organised before sharing the results from the group exercise on future climate projections for three different divisions – Rangpur, Khulna, and Sylhet – in Bangladesh. Rashid outlined how the team, with guidance from resource persons, went about preparing the data sets for the spatial and temporal analysis of CORDEX data sets, model selection, analysis of model results, calculating delta change, and minimum and maximum errors for the two RCP scenarios. He shared the results for annual changes in precipitation and temperature from the downscaling exercise for the Rangpur division for the two scenarios – RCP4.5 and RCP8.5.

Nirmala Regmi, DHM, provided a summary of the training on spatial and temporal climate change analysis, using CORDEX regional climate models over South Asia, organised in June 2021 for DHM and other relevant organisations in Nepal. She outlined the major lessons from the training which included preparation of climate model projection data sets for analysis, selection of representative models for an area of interest, analysis of the spatial and temporal variability of present and future climate change for the defined area of interest, and the interpretation of uncertainty analysis. Regmi shared the results from the Chatara Basin in Nepal for the two scenarios – RCP4.5 and RCP8.5. She summarised the following points on behalf of the team.

The R software codes provided were useful for data analysis and visualisation because they helped the team to:

- Prepare CORDEX datasets in areas of interest and compare them with reference datasets
- To visualise spatial and temporal variation in climate change projections
- Interpret uncertainty in model results
- Analyse climate projections and produce information products to meet institutional needs.

Regmi said further that the team faced internet and power outages as well as competing demands from daily office work during the 2021 training, which was organised online given the COVID-19 pandemic. She welcomed the opportunity for in-person training in Dhulikhel as the team could focus on the training with fewer distractions.

Joseph Daron, Met Office, UK, joined the training remotely from the United Kingdom. He briefed the participants about the ARRCC programme and the Climate Analysis for Risk Information & Services in South Asia (CARISSA) work package. He said that, overall, the ARRCC programme works with international partners across South Asia to improve weather and climate services and that it engages with different user communities. He highlighted that this training is Part Three or the final part of the training series under this phase of the ARRCC programme and that it is extending work and discussions from the earlier training events while focusing on climate indices in particular. He said that climate indices provide people with insights on how climate change can impact communities and that they provide decision makers and policymakers with the information necessary to understand the hazards and the threats associated with climate change better.

He pointed out that this workshop aims at both creating as well as understanding climate information and communicating this information to different user communities who need to use this information. The service element here, according to him, was engaging the different user communities as a siloed approach, i.e., working in isolation, does not work. He emphasised that communities need the tools as well as the understanding, which would assist them in comprehending climate variability now and into the future. He stated that the ARRCC programme will come to an end in 2022 and that the Met Office is embarking on a new work programme that will cover South and Southeast Asia and the Pacific. But he saw the existence of an active community utilising CORDEX in Southeast Asia as presenting a cross-learning opportunity for the region. This, he said, would make it possible to address the gaps and remaining priorities identified under the ARRCC programme at future events and future engagements

Mandira Singh Shrestha, ICIMOD, gave a presentation on climate services in the Hindu Kush Himalaya (HKH) region. Shrestha stated that climate services empower decision-makers at different levels with science-based information and forecasts, which help them to not just anticipate and manage climate-related shocks but also to avail themselves

of the opportunities that may arise from possessing such information. She discussed the key issues and challenges faced in providing climate services in the Hindu Kush Himalaya (HKH) region. She also shared the overall objectives of the training with the participants.

Shrestha also informed the participants that ICIMOD's Climate Services Initiative (CSI) aims to increase the end-user comprehension of climate information services and enhance the capabilities of mandated institutions to use these services effectively for decision-making and long-term resilience development. She added that CSI works to achieve its objectives by forming alliances, improving the user experience, co-creating services with partners and other organisations, and bolstering pertinent capacities.

Moreover, she discussed the strategy to develop institutional capacity used by ARRCC and provided an overview of the many regional and country-specific training sessions held to develop the institutional capacities of NMHS in ARRC- focal countries.

Furthermore, she shared with the participants the objectives and the expected outcomes of the training.

J Sanjay, IITM–Pune, joined the training remotely and made a presentation on the CORDEX South Asia datasets-based climate data indices used in the Intergovernmental Panel on Climate Change (IPCC) Working Group I (WGI) contribution to the Sixth Assessment Report (AR6). He said that the CCCR based at the IITM-Pune has been leading the CORDEX South Asia activity in close collaboration with ICIMOD.

The IPCC WGI contribution to AR6 has identified some of the physical climate conditions that are key to understanding the impacts and risks to society and ecosystems, i.e., the so-called climatic impact-drivers (CIDs) and assessed the changing regional characteristics of these CID indices in a warming climate. He pointed out that the IPCC WGI Interactive Atlas is a novel tool available online for flexible spatial and temporal analyses of selected observed and projected global (CMIP5 and CMIP6) and downscaled regional (CORDEX) climate change information used in AR6, including a few CID indices. He demonstrated both the opportunities and challenges of using IPCC's Interactive Atlas tool to elicit better insights into changing extreme precipitation patterns over South Asia. He hoped that the integration of climate information would better inform decision makers about the future of rainfall-triggered natural hazards in the South Asian region.

Responding to questions from the participants, he also elaborated on the following.

Choice of climate indices

Climate indices are important metrics that assist in the analysis of regional and global datasets, e.g., extremes in meteorological events and assessment of impacts on sectors such as agriculture, health, energy, water resources, and hydrology. The World Meteorological Organization (WMO) has adopted the Expert Team on Sector-specific Climate Indices (ET-SCI core and non-core). The IPCC's interactive atlas and newer global and regional simulations are now available, which enable users to employ these different tools to understand climate variability better. The atlas also has its own limitations as it is drawn from a multi-model ensemble mean, which means that there may not be congruence on the changes.

Saurav Pradhananga, ICIMOD, made his presentation on the selection of representative models for a defined area of interest using annual and seasonal bias. Pradhananga provided an overview of installing the required software packages, and datasets to run the analysis. He then proceeded to show the steps required to select the representative models for the Koshi basin using the R codes in the morning session. The participants repeated the same process for their own study area during the hands-on afternoon session. Using the codes, the participants were able to select four models for their area of interest. These models were then used to calculate the climatic indices using the CDI Tool.

Day 2

22 June 2022

Joining remotely, **Erik Kjellström**, SMHI, gave his presentation on climate indices and bias adjustment. He shared with the participants experiences from SMHI's work in Europe and South Asia.

As climate model outputs are frequently used to address climate change impacts, a thorough analysis of climate change signals is crucial to assess climate impacts. Such an analysis requires an understanding of climate models, and if a climate model contains and describes relevant processes and can reproduce the past climate. Model evaluation often reveals systemic biases in model output that sometimes makes it difficult to assess climate change impacts. However, several methods to adjust, or correct, model output exist.

Kjellström shared a bias-correction method– empirical quantile-mapping – and highlighted the benefits and shortcomings of the method. He said that the model output and bias-adjusted or raw data, can be used to derive indices or climate change indicators that are subsequently used for determining climate change impacts. Kjellström showcased examples of different kinds of indices ranging from indices describing simple statistics and threshold exceedances to more complex indices working as models of their own. He also discussed bias adjustment methods and climate indices. He responded to a few questions put forward by participants. Given below are the questions and his responses.

Q: What are the other ways that could be used for model selection?

Modelers need to be aware of the systemic biases in the different models. Even if a model does not perform well in today's climate, it cannot be excluded as it may perform well in future scenarios.

Q: What share of biases is inherited from GCMs during dynamical downscaling to RCMs?

Our experiences indicate that it depends on seasons as well as the models. This has to do with several processes. There is no simple way of calculating the percentage of the biases that translate from GCMs to RCMs during downscaling.

Q: What would be an optimal bias correction method for use considering the absence of reference data in our region?

Extremes or changes in seasonal shifts require different methods. Anyone working with the production of climate services faces a lot of uncertainty. The effort is labour-intensive and requires a lot of grunt work. Bias adjustments might be seen as a black box. Bias adjustment methods often lead to another chain of uncertainty in the downscaling efforts.

Q: Are there any specific climate indices that could be considered?

Extremes – annual maximums and minimums in temperature and precipitation – could be considered for specific climate indices. These variables are easy to communicate to the end users. However, people might not be interested in the warmest or wettest day in the year alone. Therefore, a combination of different indices could also be useful. Countries have their own locally relevant issues which differ across nations. These need to be considered while selecting relevant climate indices.

Sven Kralisch, University of Jena, introduced the Climate Data Indices (CDI[1]) Tool, and the workspaces used for data extraction for selected models. He walked the participants through the use of the analysis/workspace in the CDI Tool. The CDI Tool provides a flexible and user-oriented data analysis workflow to process large climate projection datasets, calculate climate indices, and visualise outputs in the form of maps and charts. The tool is built on top of the JAMS[2] modelling platform, a software system for creating environmental models from individual data analysis and process simulation components. The CDI Tool reads NetCDF data and shapefiles (.shp) to define an area of interest

[1] Earlier referred to as the Climate Data Analytical Tool.
[2] http://jams.uni-jena.de

and processes them to extract the values to create vector data sets that can be easily read into a GIS environment like ArcGIS and QGIS.

The software can be freely downloaded from the following URL https://www.icimod.org/cditool/

They were also told that additional details on the CDI Tool are included in the CDI Tool documentation made available online[3] and that the documentation provides detailed guidance on installing and running the CDI Tool and working with analysis/workspaces.

Sven Kralisch and **Saurav Pradhananga** guided participants in the extraction of country-specific datasets using the CDI Tool for selected models using examples from the prepared datasets provided for each country – Bangladesh, Nepal, and Pakistan. They helped participants with trouble-shooting and resolving issues in feeding the NetCDF files and required shapefiles. The data extraction process requires users to input a NetCDF dataset that covers the full time period to be analysed and to supply a polygon shapefile containing the region of interest. The tool allows the processing of four datasets including precipitation, mean temperature, minimum temperature, and maximum temperature data, and requires users to supply a corresponding netCDF file.

Day 3

23 June 2022

Sven Kralisch and **Saurav Pradhananga** walked the participants through the use of the CDI Tool to calculate the climate indices for the selected models". Kralisch guided the participants through the entire process, and responded to the queries received. The procedures for calculation, analysis and visualisation are given in detail in the documentation developed for the CDI Tool. The core and non-core ET-SCI climate indices considered in the CDI Tool are included as an annex in the documentation developed for the tool.

They spent the latter part of the day helping participants understand and analyse the climate indices calculated by the programme.

[3] https://www.icimod.org/cditool/

Day 4

11 March 2022

The final day of the training was organised at the ICIMOD headquarters in Kathmandu, Nepal. Resource persons and participants spent the greater part of the day finalising the results obtained from the three-day exercise in country groups for the group presentations scheduled during the closing session. Resource persons provided a brief overview of the uncertainty analysis required for interpreting the results obtained.

The three groups representing the different countries presented the results from their exercise using the CDI Tool and ERA5-Land representation of precipitation using the supplied R code. **Md Shadman Sakib** and **Priata Rani Saha** presented on behalf of Bangladesh; **Bikash Nepal** and **Shankar Sharma** presented the findings from the group exercise on behalf of Nepal; and **Burhan Ahmad** presented on behalf of Pakistan.

The resource persons guided the country teams in interpreting the results and explained the possible margins of error and how these errors could be minimised and rectified during calculation, analysis and interpretation of results.

Feedback session

The participants were asked to rate the training's content and outcomes in a post-training assessment survey. They scored the training's overall substance, their overall level of learning, their knowledge of the subjects covered after the training, and their likelihood of using the information in their jobs (see Annex 2). They said the training had been beneficial and that they were glad to gain working experience on the CDI Tool and to work with climate indices.

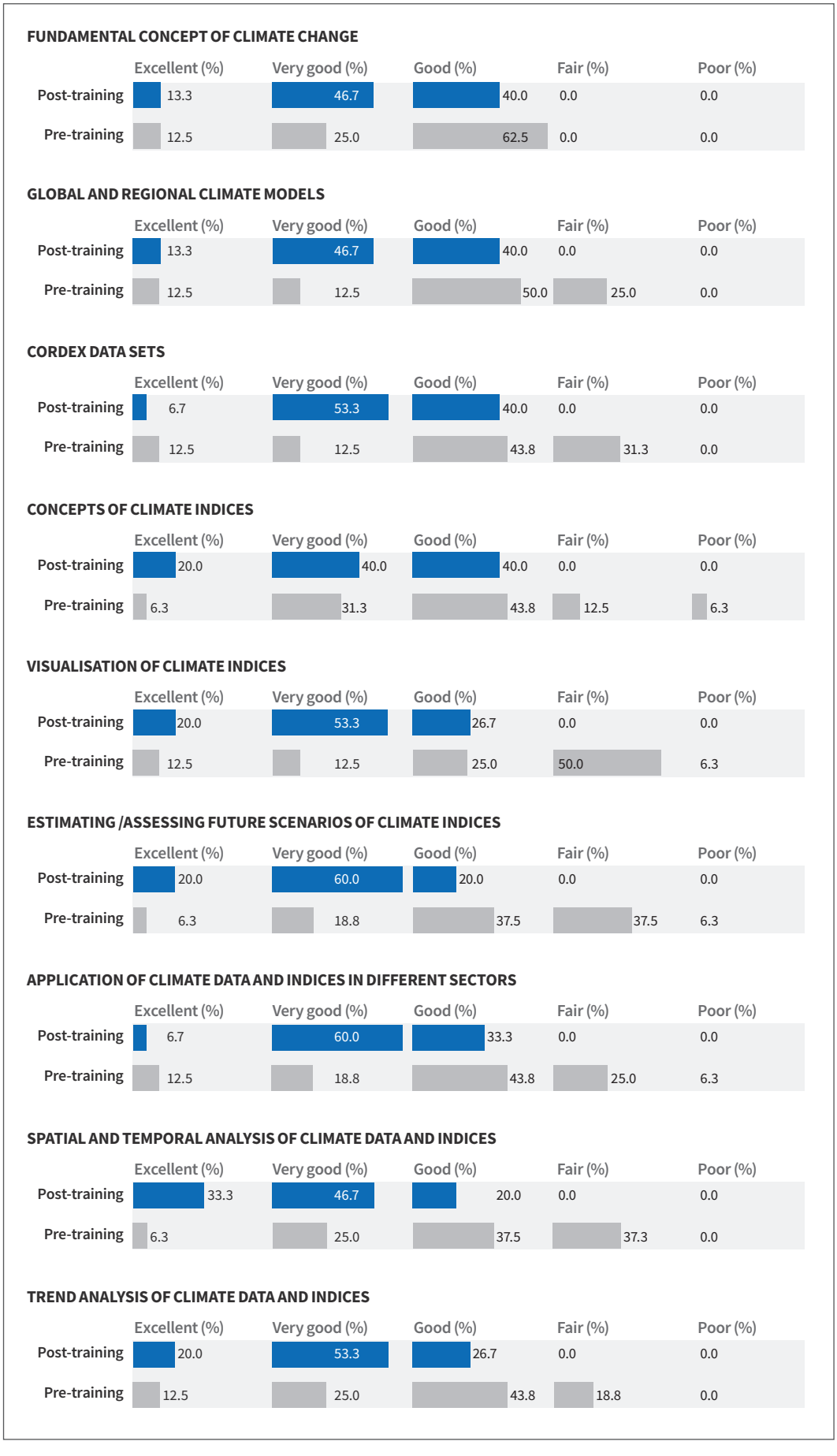
The participants reported a marked increase in their knowledge of the topics discussed at the workshop (Figure 1). About 20 per cent of the participants reported having gained an excellent understanding of the concept of climate indices while 40 per cent reported a very good understanding of the same, which is a significant improvement from 'poor' (6.3 per cent) or 'fair' (12.5 per cent), respectively, for the same before the training. They also reported either an "excellent" or "very good" understanding of visualisation and estimating/assessing of future climate scenarios of the climate indices introduced at the workshop.

Approximately 33 per cent of the participants reported an excellent understanding and 46.7 percent reported a very good understanding, respectively, of spatial and temporal analysis of climate data and indices introduced at the training. Similarly, 20 per cent of participants said that they had an excellent understanding and 53.3 percent stated that they had a very good understanding, respectively, of trend analysis of climate data and indices after the training (See annexes 2 and 3).

Closing session

Birendra Bajracharya, ICIMOD, thanked all the participants and resource persons for the hard work put in during the four days of the workshop. He pointed out that global models do not necessarily represent local regional processes well and that, therefore, local in situ observations are needed to reflect how the mountains are changing. He said that with the early onset of monsoons, there is an increase in floods in Bangladesh, Nepal and Northeast India. He reminded participants that climate variability is increasing with heatwaves increasing in the region and droughts becoming more severe, which underscores the need for more advanced models and, more importantly, skilled people to interpret such models to generate the evidence needed to guide early action on climate change. Climate services are integral to the decision-making process. He highlighted that the workshop brings together national hydrological and meteorological services from the region, which creates opportunities for networking and cross-learning opportunities. ICIMOD's institutional capacity building efforts focus on building institutional capacity by capacitating its people. Country-focussed training and regional training are aimed at building institutional capacities. Additionally, regional training also brings together people from across the region generating critical feedback on how the different models and tools work in country-specific contexts.

FIGURE 1 PARTICIPANTS' RESPONSES TO KNOWLEDGE OF WORKSHOP TOPICS (PRE-AND POST-TRAINING) ????



Mandira Singh Shrestha, ICIMOD, spoke of the way forward after the training and promised to organise future relevant training and opened the floor for feedback on the training.

Md Bazlur Rashid, BMD, stated that the training was exceptionally good and was an add-on to the training organised in Bangladesh. He commended the team for developing the CDI Tool and said that the tool has a lot of additional features that would help NMHSs in the region. He added that developing an understanding of which models perform better for Bangladesh would be helpful for BMD to conduct future climate assessments and supply the information required for climate action.

Shahzada Adnan, PMD, thanked the team for organising the training. He added that the datasets and the R software codes shared at the training make the processing of model projection data much easier and faster. Where downloading, preparing and processing datasets for climate analysis earlier took weeks, it can now be done in a few hours. The CDI Tool provides a simple user interface to handle complex processing that used to take hours of work for a climate data analyst. Similarly, the R code provided, he said, would enable the running processes for climate model selection.

Nawaraj Pokharel, CDHM, TU, thanked the organisers for the opportunity to participate in the training and creating a homely environment for participants. He added that the R code as well as the tools and data provided would assist him to complete his Masters' thesis.

Sven Kralisch, University of Jena, thanked ICIMOD and the participants for making the workshop and the development of the tool possible. He added that the training was one of the nicest to deliver as the participants were very eager to learn

Saurav Pradhananga, ICIMOD, thanked all the participants for their patience and requested that the participants reach out to the team for any queries related to the training. He highlighted the need for future regional collaboration.

PDF copies of the power points and other additional materials used at the workshop are available at: https://www.icimod.org/event/spatial-and-temporal-analysis-of-climate-change-indices-using-the-climate-data-analytical-tool-and-cordex-datasets-over-south-asia/

Photos from the event are available on our Flickr album https://www.flickr.com/photos/icimodgallery/albums/72177720300121550

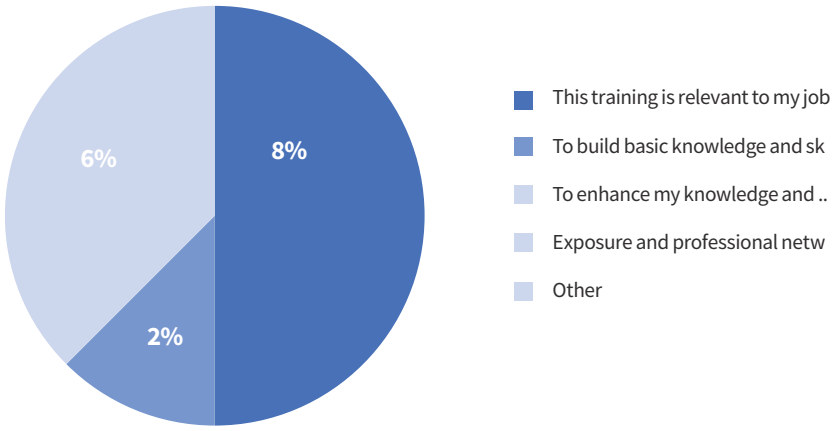
The Climate Data Indices Tool and documentation can be downloaded for free from https://www.icimod.org/cditool/ and http://jams.uni-jena.de/cditool/

SECTION 3

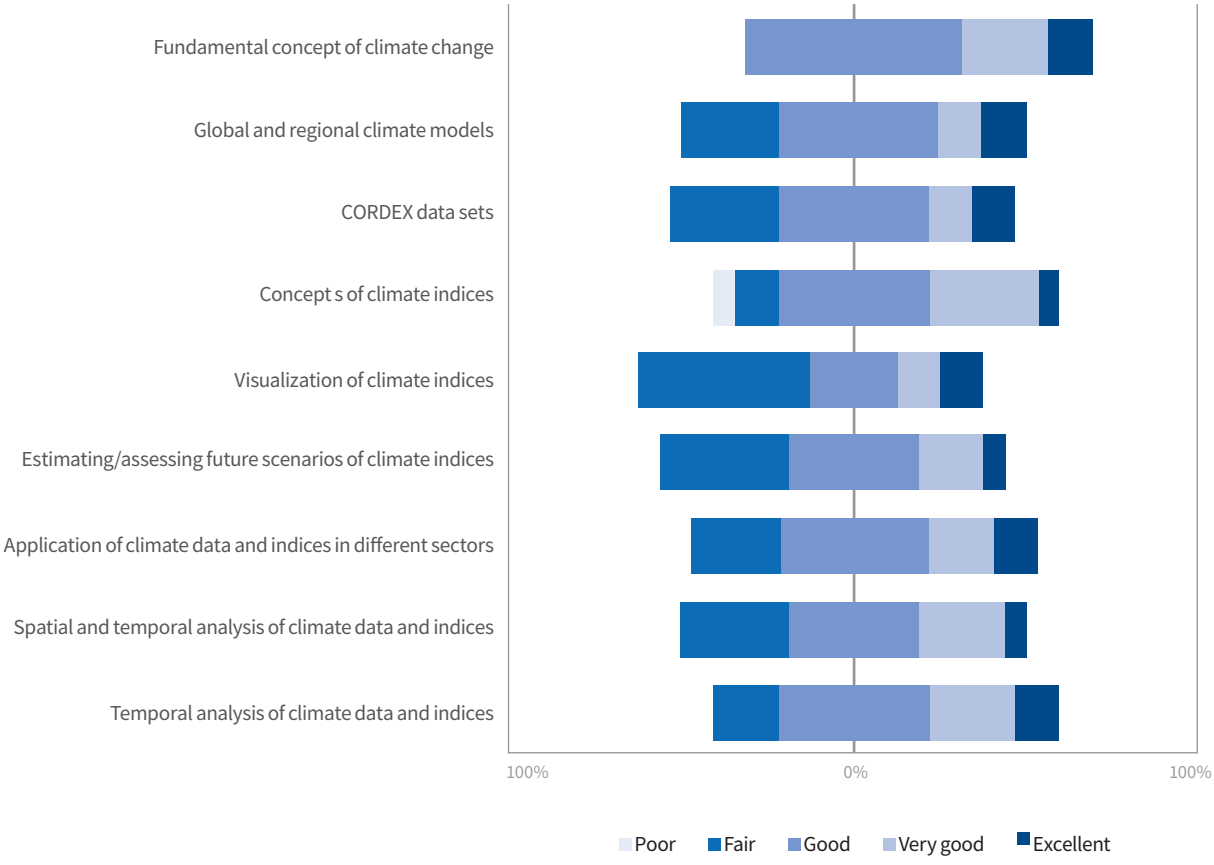
Annexes

Annex I: Results of the pre-training assessment

Why did you choose to participate in this event?

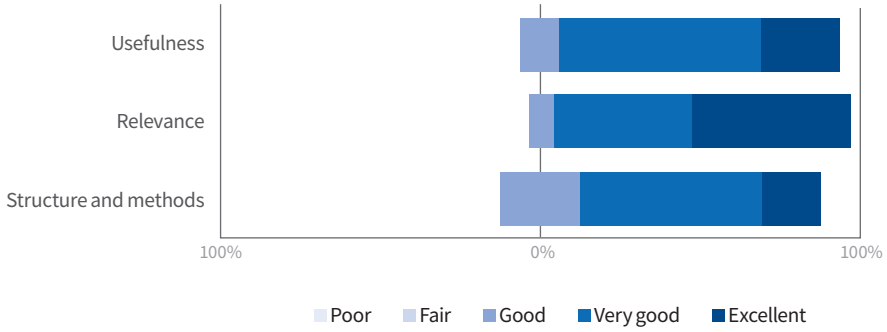


How would you rate your knowledge of the following topics?

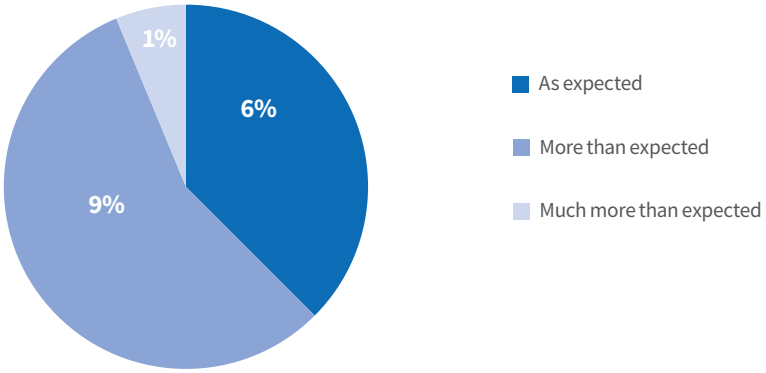


Annex 2: Results of the post-training assessment

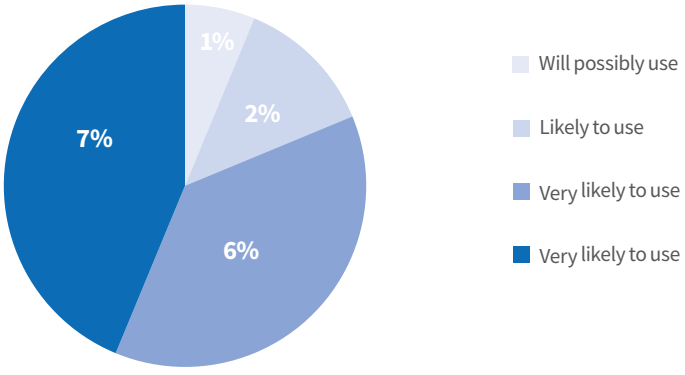
How would you rate the overall content of the training in the following areas?



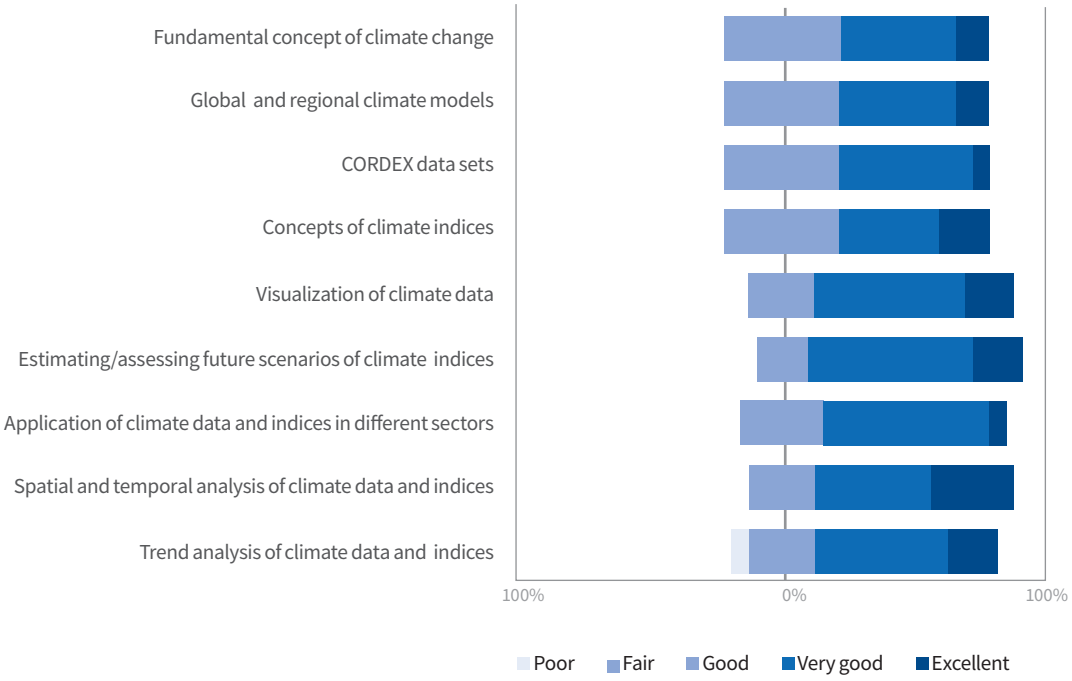
How much have you learned about the overall topic of the training?



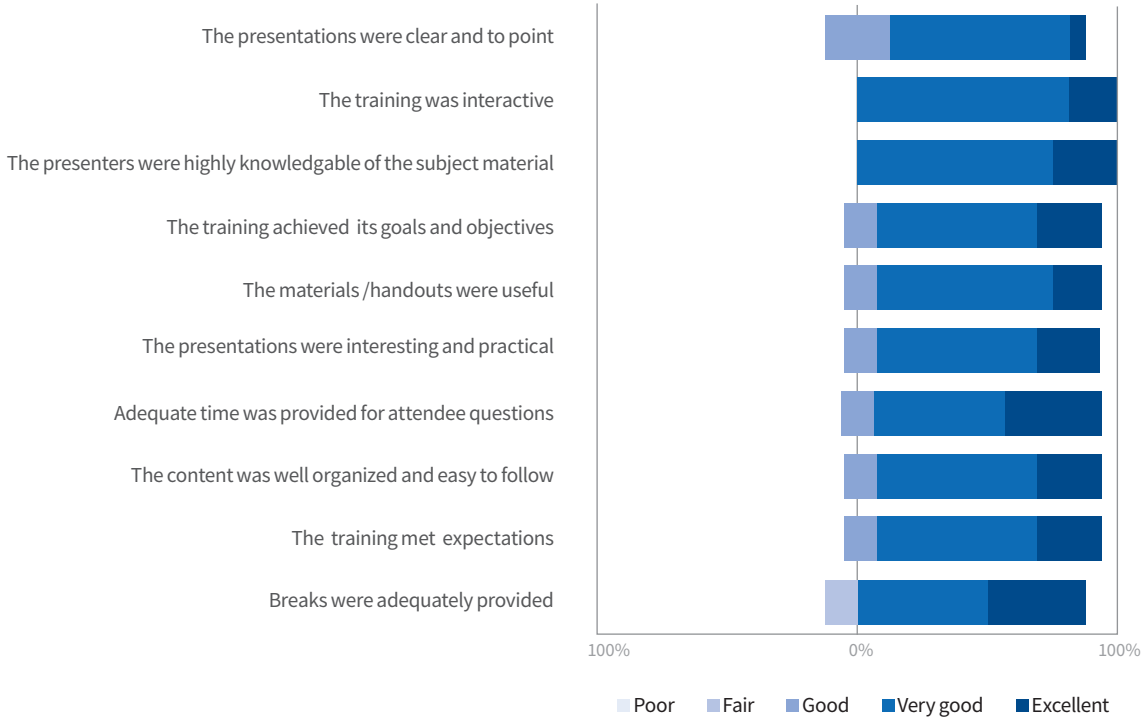
How likely are you to use the information or knowledge you gained in the training in your normal area of work?



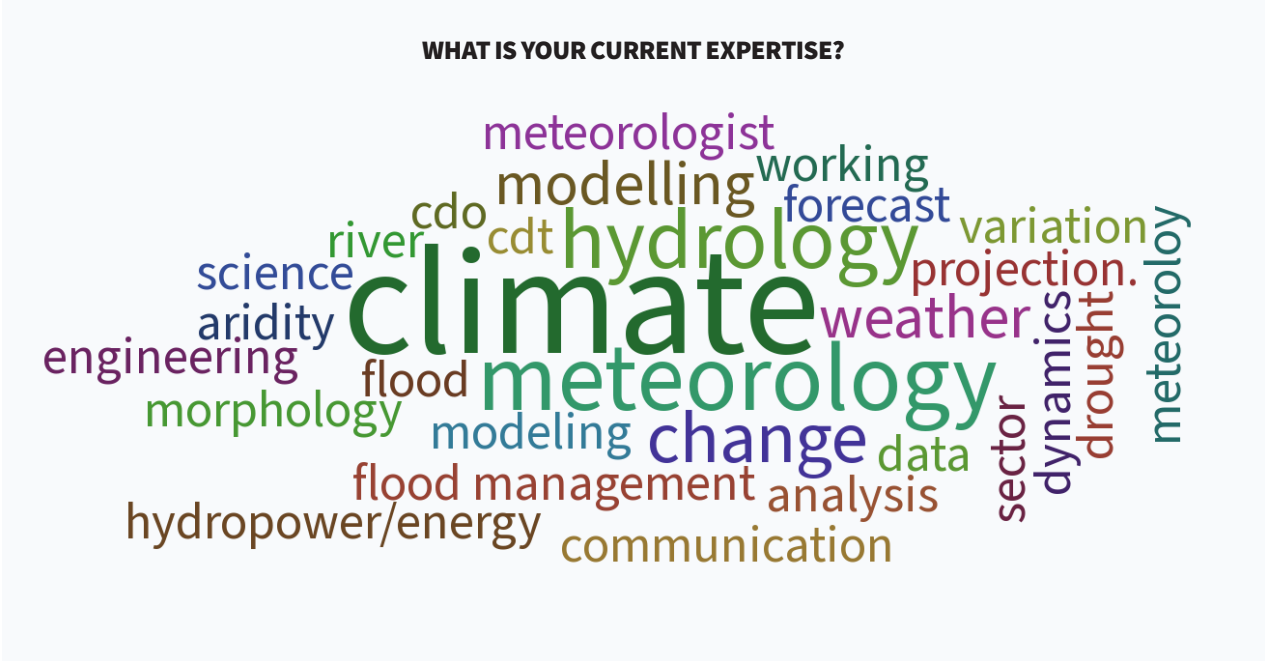
How would you rate your knowledge of the following topics after the training?

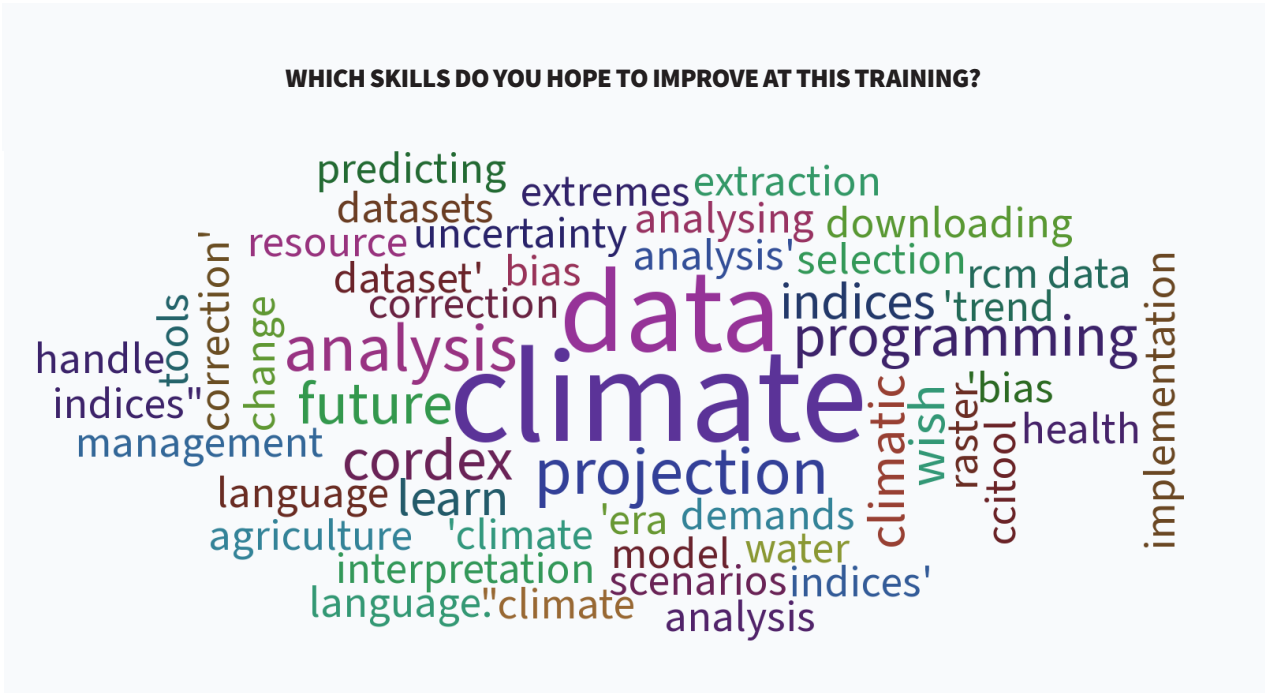


How would you rate the quality of the training in the following areas?

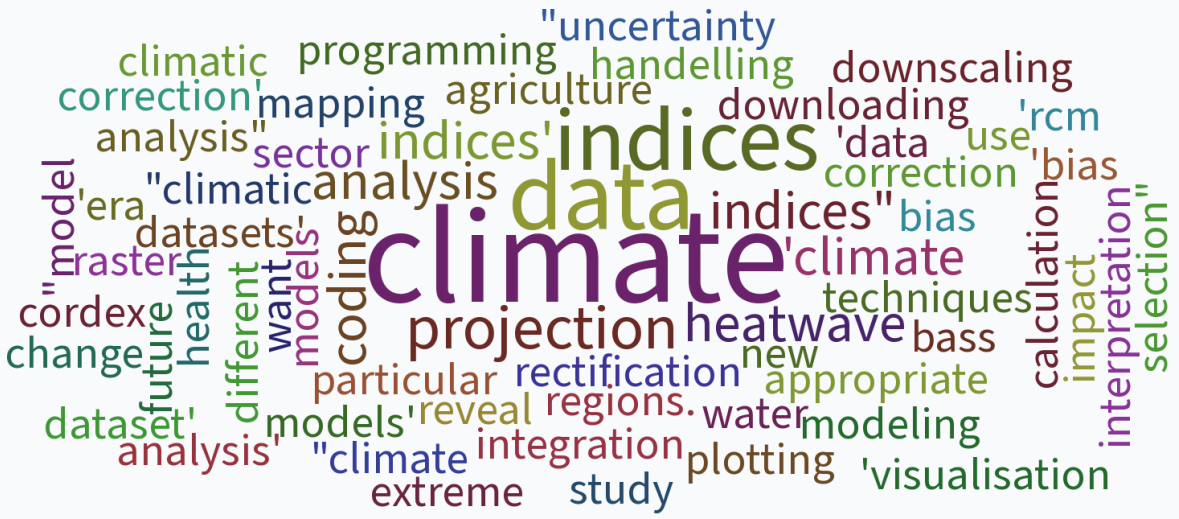


Annex 3: Results from the online polls held during the training

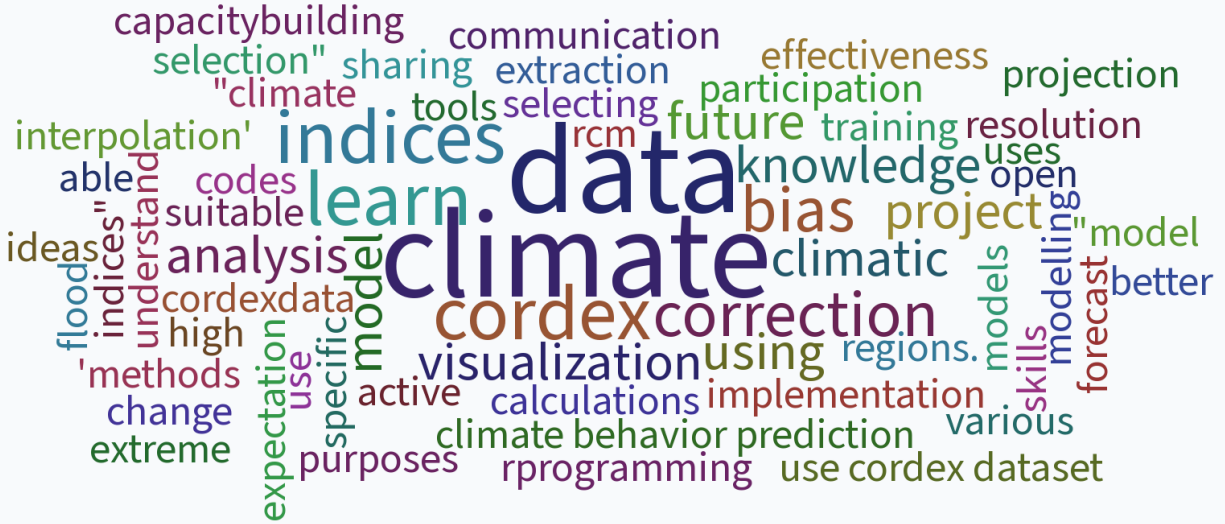




WHAT TOPICS WOULD YOU LIKE TO FOCUS ON DURING THE TRAINING?



WHAT ARE YOUR EXPECTATIONS FROM THIS TRAINING?



List of participants

S. No.	Name	Country	Designation	Institution
1	Kh Hafijur Rahman	Bangladesh	Meteorologist	Bangladesh Meteorological Department
2	Md Bazlur Rashid	Bangladesh	Meteorologist	Bangladesh Meteorological Department
3	Miz Nayma Baten	Bangladesh	Meteorologist	Bangladesh Meteorological Department
4	Miz Razia Sultana	Bangladesh	Assistant Communications Officer	Bangladesh Meteorological Department
5	Md Shadman Sakib	Bangladesh	Lecturer	Bangladesh University of Science and Technology
6	Priata Rani Saha	Bangladesh	Junior Climate Engineer	Institute of Water Modelling
7	Navaraj Pokhrel	Nepal	Postgraduate/PhD student	Central Department of Hydrology and Meteorology
8	Shankar Sharma	Nepal	Research Associate	Central Department of Hydrology and Meteorology
9	Bikash Nepal	Nepal	Meteorologist	Department of Hydrology and Meteorology
10	Nirmala Regmi	Nepal	Meteorologist	Department of Hydrology and Meteorology
11	Sanjeena Shakya	Nepal	Meteorologist	Department of Hydrology and Meteorology
12	Sudarshan Humagain	Nepal	Meteorologist	Department of Hydrology and Meteorology
13	Raj Singh	Nepal	Senior Electrical Engineer	Institute of Engineering
14	Burhan Ahmad	Pakistan	Meteorologist	Pakistan Meteorological Department
15	Shahzada Adnan	Pakistan	Meteorologist	Pakistan Meteorological Department
16	Usman Ali	Pakistan	Programmer	Pakistan Meteorological Department

List of resources persons

S. No.	Name	Designation	Institution
1	Mandira Singh Shrestha	Programme Coordinator – Climate Services	ICIMOD
2	Rajesh Shrestha	Programme Associate – MENRIS	ICIMOD
3	Saurav Pradhananga	Water and Climate Analyst	ICIMOD
4	Utsav Maden	Knowledge Management and Communication Officer	ICIMOD
5	Sven Kralisch	Consultant	University of Jena
6	Joseph Daron	Science Manager, Climate Services Development, International Applied Science & Services	Met Office
7	Erik Kjellström	Professor in Climatology	Swedish Meteorological and Hydrological Institute
8	J Sanjay	Scientist F	Indian Institute of Tropical Meteorology –Pune

Agenda

Day 1 – 21 June 2022: Opening presentations and software installation

Time	Programme
09:00–12:30	Morning session Software installation and troubleshooting Pre-training assessment
12:30–13:30	Lunch break
13:30–14:30	Afternoon session Opening session Opening remarks – **Joseph Daron**, Met Office, UK (online) Climate services in the HKH region and objectives of the training – **Mandira Singh Shrestha**, ICIMOD Introductions and expectations from participants
14:30–15:00	Group photo and break
15:00–17:00	(20 min presentations followed by 5 min Q & A) CORDEX South Asia datasets-based climate data indices used in the IPCC WGI AR6 Atlas – **J Sanjay**, CCCR, IITM – Pune (online) Break (20 min) Selection of representative models for a defined area of interest using annual and seasonal bias – **Saurav Pradhananga**, ICIMOD

Day 2 – 22 June 2022: Representative model selection and CORDEX data extraction

Time	Programme	Resource persons
09:00–11:45	Morning session Introduction to the Climate Data Indices Tool Data extraction for selected models	**Sven Kralisch**, University of Jena
11:45-12:30	Climate model evaluation, bias correction, climate change indicators and co-production of information for various usage (online)	**Erik Kjellström**, SMHI
12:30–13:30	Lunch break	
13:30–17:00	Afternoon session Data extraction for selected models (continued)	**Sven Kralisch**, University of Jena

Day 3 – 23 June 2022: Calculation, analysis, and visualisation of climate indices

Time	Programme	Resource persons
09:00–12:30	Morning session Climate indices calculation for selected models	**Sven Kralisch**, University of Jena **Saurav Pradhananga**, ICIMOD
12:30–13:30	Lunch break	
13:30–17:00	Afternoon session Climate indices analysis	**Sven Kralisch**, University of Jena **Saurav Pradhananga**, ICIMOD

Day 4 – 24 June 2022: Uncertainty analysis

Time	Programme	Resource persons
09:30–12:30	Morning session Spatial and temporal visualisation of climate indices	**Sven Kralisch**, University of Jena **Saurav Pradhananga**, ICIMOD
12:30–13:30	Lunch break	
13:30–15:00	Afternoon session Uncertainty analysis using ensemble bands Q & A followed by discussion	**Sven Kralisch**, University of Jena **Saurav Pradhananga**, ICIMOD
15:00–15:30	Tea break	
15:30–16:30	Closing session Group presentations Remarks by Met Office, UK Remarks by ICIMOD Way forward	Participants **Joseph Daron**, Met Office **Birendra Bajracharya**, ICIMOD **Mandira Singh Shrestha**, ICIMOD

Proceedings prepared by

ICIMOD: Utsav Maden, Saurav Pradhananga, Mandira Singh Shrestha

Met Office: Joseph Daron

SMHI/CORDEX: Erik Kjellström

Centre for Climate Change Research, IITM–Pune: J Sanjay

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