PROCEEDINGS OF THE TRAINING ON

Spatial and temporal analysis of climate change using CORDEX regional climate models for Bangladesh

7–11 March 2022 | Dhaka, Bangladesh

Executive summary

Regional climate models are gaining increasing salience in climate change science. They can inform detailed impact assessments and planning, in vulnerable regions in South Asia in particular. They are better able to capture local meteorological phenomena as they simulate climates at higher spatial scales and improve the reliability of climate projections at regional scales. In this context, ICIMOD, the UK's Met Office, the World Climate Research Programme (WCRP), the Coordinated Regional Climate Downscaling Experiment (CORDEX) office, the Swedish Meteorological and Hydrological Institute (SMHI), the Bangladesh Meteorological Department (BMD), and the Centre for Climate Change Research (CCCR) at the Indian Institute of Tropical Meteorology (IITM), Pune organized a five-day training event for relevant professionals in Bangladesh on the spatial and temporal analysis of climate change using CORDEX regional climate models for Bangladesh. The training event was supported by the Asia Regional Resilience to a Changing Climate (ARRCC) programme, funded by UK Aid.

Thirteen professionals from the Bangladesh Meteorological Department (BMD) and the Institute of Water Modelling (IWM), Dhaka participated in the training programme. Resource persons from ICIMOD facilitated the technical sessions and hands-on exercises, and resource persons from SMHI, CORDEX, CCCR, and the Institute of Water and Flood Management (IWFM) of the Bangladesh University of Engineering and Technology (BUET) provided technical presentations on the background and theoretical aspects of climate science, and CORDEX data sets and their application.

This training deepened the participants' understanding of the varied topics discussed at the workshop. These included global and regional climate models, CORDEX data sets, data extraction, R programming language, and assessing future climate scenarios. During the pre-training surveys, around 38 per cent of the participants said they had a poor knowledge of CORDEX data sets, and 31 per cent merely a fair knowledge. However, in the post-training self-assessment, 15 per cent

of the participants reported having gained an excellent understanding, and 62 per cent a very good understanding of these data sets. The participants also reported having gained an excellent or very good understanding of CORDEX access and data extraction and the R programming language introduced at the workshop.

The training helped participants select suitable climate models and then use the selected models to understand the future climate scenarios in Bangladesh and in three of its divisions – Rangpur, Khulna, and Sylhet – using CORDEX regional climate models. Through this training, the participants were able to use the R programming language to visualize spatial and temporal variations in climate change projections for a defined area of interest.

This training event was part of continuing efforts by ICIMOD and partner institutions to build institutional capacities regarding climate change analysis in the region.

The programme was part of ARRCC's institutional capacity-building approach, which aims to develop and deliver training services to enhance the institutional capacities of national climate service institutions in the ARRCC focal countries of Afghanistan, Bangladesh, Nepal, and Pakistan; the overall goal is to strengthen these countries' capacity to analyse, assess, use, and communicate future climate projections. This approach targets national meteorological and hydrological services (NMHSs) and other organizations that are working towards providing climate services to government/non-government organizations, communities, and industrial sectors; the underlying motive of the approach is to serve those who are vulnerable to climate change impacts.

During the pre-training surveys, around 25 per cent of the participants had stated that they had poor to average knowledge on climate projections and the topics covered at the workshop. Following the training, this percentage reduced to 2, with 38 per cent of the participants stating that they now had very good knowledge about these topics, and 15 per cent stating that they had gained excellent insights from the overall training programme.

Moreover, the resource persons and participants discussed and charted a road map to support further institutional capacity building on climate projections and services. An engagement plan was also developed, which clearly identifies the roles and responsibilities of the relevant institutions. Moving forward, ICIMOD, the Met Office, and their partners are set to organize a series of similar training activities in 2021 and 2022; these are intended to further build the capacities of individuals at the targeted institutions, develop their skills and knowledge to analyse climate projections, and to produce information products for use in different sectoral applications.

SECTION 1

Background

In October 2020, ICIMOD, along with the Met Office (the UK's national meteorological agency), the World Climate Research Programme (WCRP), the Coordinated Regional Climate Downscaling Experiment (CORDEX) office, the Swedish Meteorological and Hydrological Institute (SMHI), and the Indian Institute of Tropical Meteorology (IITM), Pune organized a six-day training event on Regional climate change projections: Climate change analysis using CORDEX regional climate models over South Asia for professionals from national meteorological and hydrological services (NMHSs) in Afghanistan, Bangladesh, Nepal, and Pakistan.

It was conducted under ICIMOD's Climate Services Initiative for these focal countries of the Asia Regional Resilience to a Changing Climate (ARRCC).

As a follow-up activity, ICIMOD organized two country-specific training events on using CORDEX regional climate models to carry out spatial and temporal analysis of climate change over South Asia. The first, for Nepal's Department of Hydrology and Meteorology was held in June 2021, and for Bangladesh University for Engineering and Technology (BUET) and other academic institutions in the country in December 2021.

Subsequently, a training event was held in March 2022 that focused on using CORDEX regional climate models for spatial and temporal analysis of climate change over Bangladesh for the Bangladesh Meteorological Department (BMD) and the Institute of Water Modelling (IWM), Dhaka. It delved into how the R programming language can be used to analyse and visualize climate change projections spatially at different time scales. Here we present the proceedings of this event. Taken together, these training activities aim to build the capacities of individuals at targeted institutions in analysing climate projections and producing information products for use in different sectors in their respective countries.

Institutional capacity-building approach

These training activities are part of the ARRCC's institutional capacity-building approach, which is aimed at strengthening the knowledge and capabilities of staff working at key national and regional institutions that deliver climate services. The approach targets NMHSs and other organizations in ARRCC focal countries (Afghanistan, Bangladesh, Nepal, and Pakistan) that provide climate services and related information to government departments, non-governmental organizations (NGOs), communities, and varied sectors vulnerable to the impacts of climate change, to enable informed climate change responses in South Asia.

About the training

The training in March 2022 was a five-day event for relevant professionals in Bangladesh on spatial and temporal climate change analysis using CORDEX regional climate models over Bangladesh. It was conducted by ICIMOD, in collaboration with the Met Office, WCRP/the CORDEX office, SMHI, BMD, and IITM, Pune. It was supported by the ARRCC programme, funded by UK Aid. The training programme introduced participants to climate change science, and helped them identify strategies for selecting representative climate models from 17 CORDEX models, calculating the seasonal and annual biases in the models, and understanding future climate change estimations for Bangladesh and three of its (smaller) divisions – Rangpur, Khulna, and Sylhet.

Objectives and outcomes

The training aimed to build the knowledge and skills of meteorological professionals in Bangladesh in analysing climate change projections using CORDEX regional climate model simulations.

It sought to help participants understand climate model projections better by using 17 regional climate model simulations, selecting representative models that best replicate historical climate cycles, and assessing spatial and temporal variability of present and future climate change over a defined area of interest.

In addition to the above, its more specific objectives were to enable participants to:

- Interpret CORDEX data sets and compare them with reference (APHRODITE) data sets
- Visualize spatial and temporal variation in climate change projections; and
- Understand the uncertainty in the model results.

Participation

Thirteen professionals – ten from the (BMD) and three from IWM – joined the training event. Five of the thirteen participants were women.

The training was organized at the BMD campus in Dhaka. Links to the agenda and the list of participants can be found on page 10.

SECTION 2

Day 1

7 March 2022

Opening session: Presentations and installation of software

Md. Azizur Rahman, BMD, and Joseph Daron, Met Office, welcomed the participants.

Daron emphasized the Met Office's focus on institutional capacity-building under the Climate Analysis for Risk Information & Services in South Asia (CARISSA) project of the ARRCC programme. He expressed the hope that such training events would enable the provision of climate-related services to the Bangladeshi government. Md. Rahman wished all the participants a successful training.

Mandira Singh Shrestha, ICIMOD stated that climate services empower decision-makers at different levels with science-based information and forecasts, which enable them to not just anticipate and manage climate-related shocks but also avail of opportunities that may arise. She discussed the key issues and challenges in providing climate services in the Hindu Kush Himalaya (HKH) region. She also shared the overall objectives of the training with the participants.

In introducing ICIMOD's Climate Services Initiative (CSI), Shrestha said that it works to improve the capacities of mandated institutions and the understanding of end-users in making the best use of climate information services for decision-making and building long-term resilience. CSI, she said, seeks to meet its goals by building partnerships, enhancing the user interface, developing services with partners and other institutions, and by strengthening relevant capacities.

Using global data sets, Shrestha stated, can be quite challenging, primarily because of the limitations in scaling coarser-resolution global data sets spatially and temporally to understand local processes of change. She said that in a changing climate, it has become more urgent to analyse and process such data sets to tailor climate products for the use of policy makers and relevant stakeholders. Shrestha concluded by stating that the training event would help BMD in generating useful climate data and information for relevant stakeholders.

Technical presentations

Fundamental concepts of climate change science and prediction

Mandira Singh Shrestha, ICIMOD made a presentation on climate change and its impacts in the HKH. She began by stating that the HKH is also known as the 'Third Pole' and is the pulse of the planet, feeding more than 1.9 billion people. She said that multi-hazards and disasters are increasing in the region, both in intensity and frequency, climate change and variability are having more severe impacts, and that a proper understanding of upstream–downstream linkages has become more important. Climate change and extreme events, she added, are adversely impacting different sectors, the cryosphere, water resource availability, food security, livelihoods, and different ecosystems. Changing precipitation and patterns in riverine flows are inducing more floods and droughts. This increasing trend in disasters is threatening sustainable development. Cascading events from multi-hazards have often created transboundary impacts, she said. Shrestha then shared some of ICIMOD's approaches and tools to reduce risks and vulnerability in the region. In conclusion, she said that the impacts of climate change could be lessened through effective regional cooperation, partnerships, and local action.

Joseph Daron, Met Office provided an overview of climate modelling and downscaling approaches. Daron began by explaining how climate models work, introduced downscaling approaches, and outlined approaches for evaluating regional climate models (RCMs). Climate models, he said, are mathematical models that numerically represent the climate system based on our understanding of the key equations and the physical, chemical, and biological properties of the climate system. Daron said that the latest general circulation model (GCM) simulations are increasing in spatial scale with more integrated components. These global models split the atmosphere and the oceans into grids and cubes, which are restricted in size given their computational requirements. He said that the IPCC's

Fifth Assessment Report (AR5) focused on radiative forcing (planetary energy imbalance caused by greenhouse gases), whereas the latest simulations in the Sixth Assessment Report (AR6) focus on shared socioeconomic pathways (SSPs), with different carbon dioxide (CO_2) concentrations in each.

Daron stressed the significance of uncertainty in climate models and the importance of communicating the range of changes in precipitation and temperature across models. While discussing RCMs, he explained the significance of choosing the optimum domain size and duration of simulation. We do not need a perfect climate model, he said, just one that serves the purpose. It is better to not have too large or too small a region for the simulation, and longer periods are always better.

He emphasized the importance of the RCM evaluation process in that it enables familiarization with the climate model and its projected output. It also provides, Daron said, a baseline for assessing the credibility of future projections from RCMs. He presented the following process for model evaluation:

- Identify the target and purpose of the evaluation
- Obtain multiple sources of observed data to evaluate a model's performance
- Assess the errors and biases in the GCMs that provide the lateral boundary conditions (LBCs) for the RCM; and
- Evaluate the RCM keeping in view the multiple sources of uncertainty.

J Sanjay, IITM–Pune made a presentation on CORDEX South Asia. He stated that CORDEX South Asia has been providing high-resolution climate projections for the South Asian region. Currently, he said, IITM–Pune has high resolution (50-kilometres [km]) dynamically downscaled Coupled Model Intercomparison Project 5 (CMIP5) climate projections. They are based on representative concentration pathway (RCP) scenarios for 1950–2100 using multiple RCMs. All the CORDEX simulations, he stated, are stored and curated in the Earth System Grid Federation (ESGF) (a collaborate enterprise that maintains software infrastructure for the analysis of model output) after standardization. More recently, said Sanjay, CORDEX South Asia modelling partners have generated CORDEX CORE (CORDEX Coordinated Output for Regional Evaluations) simulations with a 25-km spatial resolution, which were used in the IPCC's latest, Sixth Assessment Report.

Sanjay then shared some of the recent developments made by the CORDEX Science Advisory Team. These included the CORDEX experimental design for the dynamical downscaling of CMIP6 global climate model projections, a white paper on the future scientific challenges for CORDEX, and the CORDEX Flagship Pilot Studies (FPSs).

Sanjay briefly discussed the opportunities for regional capacity-building and spoke about the possibilities of, and challenges towards a better assessment of regional climate change provided by the availability of the CORDEX South Asia high-resolution data sets. He summarized the contributions from the CORDEX South Asia ensemble of high-resolution downscaled projections for regional climate change assessments over the HKH mountains, the Indian region, and in AR6. Sanjay showcased the opportunities from engaging in an ongoing CORDEX FPS using convection-permitting high resolution (~5 km) climate simulations aimed at an improved understanding of the regional characteristics of the water cycle over the Third Pole and adjoining regions. He concluded by encouraging the participants to email him if they had any queries related to CORDEX South Asia.

Md Saiful Islam, BUET made a presentation on the application of climate projections in Bangladesh. Regional climate models, he said, take coarse resolution information from GCMs and provide finer-scale climate information at higher spatial and temporal resolutions. An RCM, he stated, typically has a resolution of about 50 km in the horizontal while GCMs are usually 300–500 km representations of the climate system.

Islam then presented the mean monthly and seasonal temperature and rainfall changes over Bangladesh. He also showcased some of the case studies on extreme events in the country. Referring to plots derived from some of his studies, he said Bangladesh would face more intense and frequent extreme events such as heatwaves, flash floods, and landslides. The coastal areas of Bangladesh, he added, are highly prone to varied natural disasters such as cyclones, storm surges, river erosion, floods, salinity intrusion, and erratic weather conditions. This, he warned, will have a direct impact on human beings and agricultural productivity in Bangladesh.

Iréne Lake, IPOC, SMHI made a presentation on CORDEX. She said that CORDEX's objectives include global collaboration, knowledge transfer, capacity development, and informed decision-

making. CORDEX and the World Climate Research Programme (WCRP), she said, were working on connecting climate science and society. The Regional Information for Society (RifS) of the WCRP too works on the dissemination in society of regional climate information. This information is helpful for agriculture and food security, disaster risk reduction, water security, health, and energy. CORDEX envisions the advances made in, and coordinates the science and application of regional climate downscaling through global partnerships, she said. The CORDEX office is developing a white paper to understand regional climatic phenomena; assess climate change impacts and identify their drivers; evaluate, improve, and combine downscaling techniques and capacity-building by enhancing local expertise and enabling knowledge exchange.

Lake emphasized that climate change adaptation is one of the most important tasks and can be carried out only through transdisciplinary cooperation, partnerships, and networking. She spoke about how the CORDEX office is working with other organizations to address local and regional challenges that have large socio-economic impacts. Finally, she presented some impacts of climate change and emphasized the importance of the collective design and production of actionable climate information.

Use of Climate Data Operators software for data handling

The day's proceedings moved to the installation of software. The latest version of the R programming language and R studio software and different library packages such as raster, rgdal, regos, ggplot2, dplyr, ncdf4, and rstudioapi were installed on the participants' computers. Saurav Pradhananga and Kabi Raj Khatiwada, ICIMOD addressed the problems faced by them in installing the required software and downloading the data needed for the hands-on sessions.

The participants were also provided with daily precipitation and temperature data (for 1971–2100) for all the 17 models and APHRODITE (Asian Precipitation – Highly-Resolved Observational Data Integration Towards Evaluation) data for 1971–2005.

Khatiwada provided a walk-through on how the data sets were prepared. To support their preparation, the participants installed Climate Data Operators (CDO) software on their computers. After which, a series of codes were provided to generate subsets of the global data sets, manage the coordinate system, clip the global data sets for a region of interest, and perform mathematical operations in the data sets. The participants practised using the codes with a few years of data from the global data sets. They said this enhanced their confidence in preparing data sets for any area of interest and made them understand how data sets were prepared for this particular training.

Day 2

8 March 2022

CORDEX data extraction and management for the analysis

The second day of training included theoretical sessions as well as hands-on practice sessions on data extraction and the preparation of data sets. The resource persons from ICIMOD provided a walk-through of the processes in the morning session and demonstrated how the data sets had been prepared for the whole of Bangladesh. For the hands-on practice session later in the afternoon, the participants were divided into three groups and assigned to work on three divisions – Rangpur, Khulna, and Sylhet.

Extracting CORDEX data sets (precipitation and temperature)

The training used data from all 17 CORDEX model simulations for the two scenarios, RCP4.5 and RCP8.5. RCPs, used in IPCC's Fifth Assessment Report, reflect socioeconomic trajectories and represent greenhouse gas (GHG) concentrations that result in a certain radiative forcing, or planetary energy imbalance, by 2100, measured in watts per metre squared (W/m^2). For example, RCP4.5 refers to an energy imbalance of 4.5 W/m^2 in 2100.

Since the participants had received the data set for the whole of Bangladesh, they were able to extract and prepare data sets for their particular division by changing a few lines in the R programming language code provided.

Annual climate patterns of all 17 CORDEX model simulations

The resource persons conducting this session demonstrated how annual plots for temperature and precipitation could be generated from all 17 model simulations using the R language code supplied. They then briefly explained the results. They used APHRODITE V1101 (for 1976–2005), which has a spatial resolution of 0.25°, as the reference data for precipitation. APHRODITE data was chosen as the reference data set because it is widely used and freely available. The monthly plots successfully represented the monsoon system and were comparable with the climate data. APHRODITE V1204 was used as the reference data set for temperature. The participants computed and plotted annual and monthly averages of APHRODITE data to confirm agreement with Bangladesh's climate.

The participants also tested the data with their data sets (ENACTS–BMD) as the reference data sets for climate projection. ENACTS–BMD is the first high-resolution gridded surface meteorological data set developed by BMD, especially for the study of surface climate processes in Bangladesh. It is available from January 1981 to the present.

Understanding the present climatology using APHRODITE data (1976–2005)

The participants computed monthly values for temperature and precipitation to check whether APHRODITE data represented Bangladesh's climate. They also compared the results with the respective divisions in Bangladesh. The exercise supported the comparison and selection of representative models from the 17 CORDEX model simulations both for Bangladesh and the three divisions chosen, Rangpur, Khulna, and Sylhet. All the participants were able to generate graphs and spatial plots for Bangladesh and the three divisions.

Day 3

9 March 2022

Selection of representative models from the 17 CORDEX simulation runs

Comparing the CORDEX data sets with APHRODITE reference data sets

Monthly and annual data for both parameters, precipitation and temperature, was extracted for RCP4.5 and RCP8.5. The participants then compared the extracted information from both the CORDEX simulation data sets with the APHRODITE data sets, with the latter as the reference data. It was found that some CORDEX model simulations successfully represent the monsoon system while some do not. The monthly data was categorized into four seasons: pre-monsoon (March–May), monsoon (June–September), post-monsoon (October–November), and winter (December–February).

Selection of representative model simulations for RCP4.5 and RCP8.5

The purpose of comparing the 17 model simulations with the APHRODITE data sets was to select representative model simulations with the lowest bias. Bias in this context refers to the percentage difference between the model simulations and the APHRODITE data. Non-behavioural models that did not reflect the dominant weather systems in the region were eliminated. The participants selected eight models each for RCP4.5 and RCP8.5 from the 17 CORDEX model simulations using seasonal bias calculations for both variables, precipitation and temperature. They then filtered these eight further to select the four most representative models by using annual bias calculations.

Ensemble means and ensemble range of the four selected models

The participants then calculated the ensemble mean, or average, and the ensemble range using the four selected models. The ensemble mean is useful for climate change impact assessment studies as it shows the average direction of change in the future across the model simulations. However, it can also be misleading as it provides just one scenario. In contrast, the ensemble range provides many possible scenarios for the study area for the future.

Once the exercise for Bangladesh was carried out, the participants changed the R code supplied to calculate the seasonal and annual biases for the three divisions and narrowed the selection to four models in the three divisions.

Day 4

10 March 2022

Visualization of future scenarios based on selected model simulations

Calculation of future scenarios of precipitation and temperature

On the fourth day of the training event, the participants calculated and plotted the ensemble mean and the standard deviation (SD) for the four selected CORDEX models. This is done so that the range of data can be given instead of absolute values. The participants then obtained the annual ensemble mean and plotted the range along with the historical reference data set to obtain the future climate scenario for the division chosen. They plotted APHRODITE data along with climatic change data in the trend analysis graphs.

This exercise was done for the whole country, and the participants themselves changed a few lines of code so that they could run it for the three divisions. They observed that the model data was an underestimate in most cases in the reference period. In such cases, it is recommended that the bias in data be corrected to develop a better understanding. (However, although bias correction was discussed, it was not carried out in this training event.) The participants were also able to understand the differences in precipitation and temperature in Bangladesh as a whole and the three chosen divisions in Bangladesh.

Calculation of annual and seasonal changes

Delta changes in precipitation and temperature between the reference period (1976–2005) and the future period (2070–2099) were calculated for both RCPs. The participants computed the changes in precipitation in percentage terms and the changes in temperature as absolute values for both RCPs, and plotted future scenarios for both the parameters under the two RCPs.

The R code for Bangladesh as a whole was customized for the divisions in Bangladesh. The participants were able to calculate the annual changes for the country as a whole and their respective divisions. There was then an interactive discussion between the participants and the resource persons on the results from the selected models, and possible causes for the differences between the divisions and the whole country . It helped the participants understand that any one climate model may not be representative of different areas. Due to the differences in spatial scales, there were differences among the selected models and their results.

Day 5

11 March 2022

Uncertainty analysis, group presentations, and the closing session

Uncertainty analysis

The need for understanding uncertainty analysis while using climate data was highlighted in the morning session on the fifth day. During the discussion, it was pointed out that it is important to understand the range of, and determine the uncertainty in future climate projections, and that they occur due to uncertainties present in the selected RCMs and GCMs themselves. Through this discussion, the participants were able to understand that uncertainty analysis helps to convey more precise information to policy makers for informed decision-making while considering all possible aspects.

Participants calculated the delta changes for all 17 models and selected four models for uncertainty analysis. They compared the results using scatter plots for both RCPs. The calculations were done both for Bangladesh and the respective divisions.

As expected, the scatter plots showed that the uncertainty in the selected models was lower than the uncertainty in all the 17 models taken together. In most of the areas chosen, the scatter plots demonstrated higher uncertainties in RCP8.5 compared to RCP4.5. Between the two variables, temperature showed a smaller range of uncertainty than precipitation. The participants felt that the hands-on exercise on the divisions in Bangladesh helped them gain confidence in using the R language code and data provided for future work and in carrying out similar exercises for other parts of the world.

Group presentations

The participants had been divided into three groups on the first day; each group worked on a separate division of Bangladesh in the afternoon session of day 5. On this last day of training, the teams made comprehensive presentations on the overall results for Bangladesh and the respective divisions. The participants shared their experience in working with the CORDEX data sets, generating plots, and implementing output results. They expressed a desire to receive further training on bias correction, and the use of CMIP6. They stated that such training events are useful for their work and the efficient use of data for the implementation of appropriate policies.

The members of Group 1, Md. Bazlur Rashid, Reazul Zannah, Priata Saha, and Rimon Chandra Basak, made a presentation analysing spatial and temporal climate change in the Rangpur division and for Bangladesh. They compared the outputs from their division and for the whole of Bangladesh. The members of Group 2, Md. Abul Kalam Mallik, Md. Tarikul Newaz Kabir, Md. Arif Hossain, Afruza Sultana, and Md. Abdul Mannan, made a presentation on Khulna division. Similarly, the members of Group 3, S. M. Quamrul Hassan, Nayema Baten, Razia Sultana, and Shaheenul Islam, presented their results for the Sylhet division. Following the group presentations, there were discussions on uncertainty in the models, the different factors considered in the selection of models, and future scenario analysis.

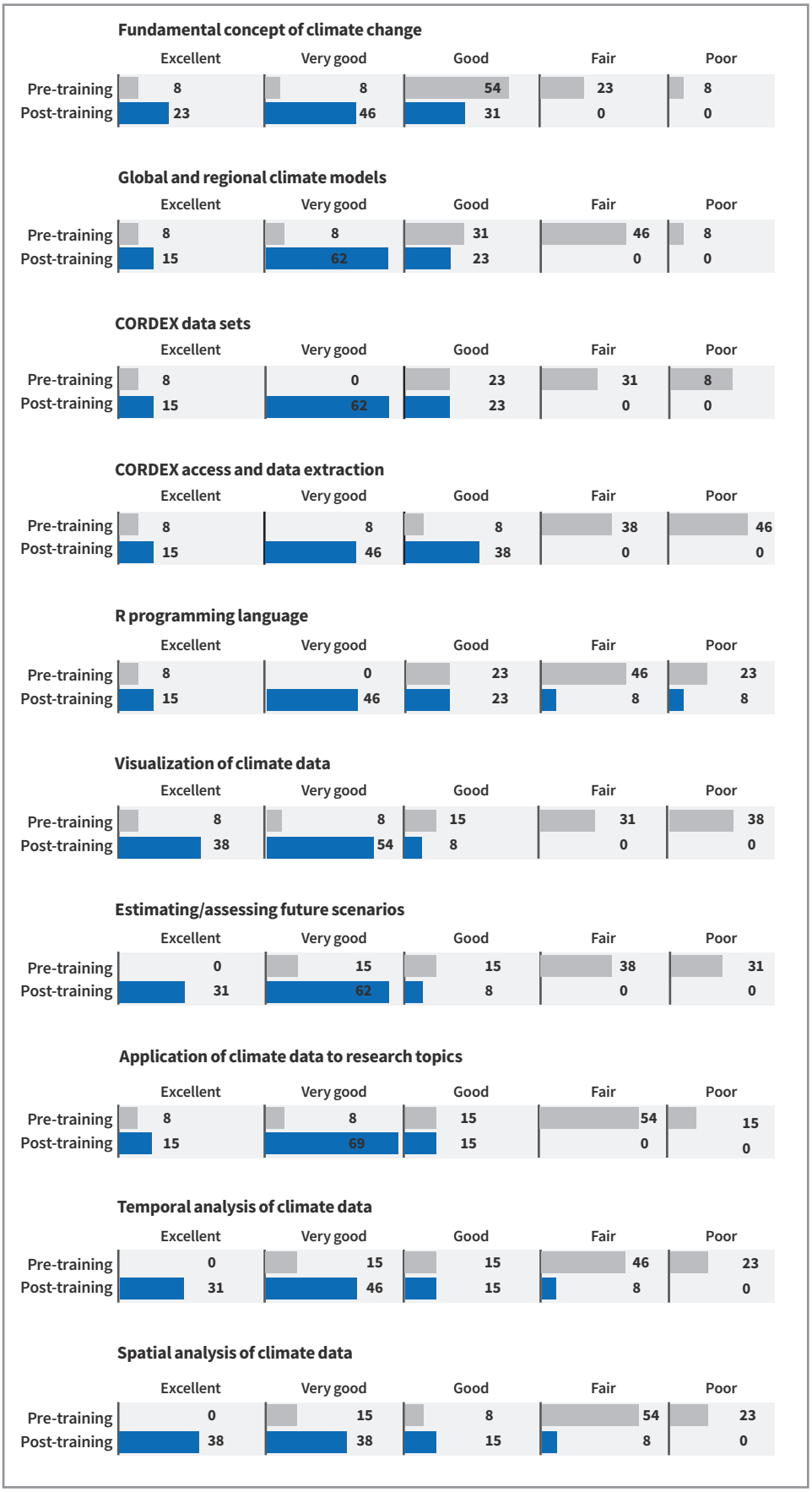
Feedback session

In a post-training assessment survey. the participants were asked to assess the content of, and benefits they got from the training. They were asked to rate its overall content, their knowledge of key topics before the training, how much they had learnt overall, their knowledge of topics after the training, and how likely they were to apply this knowledge in their work. They were also asked to rate the quality of the training received (see Annex 2).

They said it had been fruitful and that they were glad to gain working experience of CORDEX data sets. They expressed the need for advanced training in the future (see Annex 3).

The participants reported a marked increase in their knowledge about the topics discussed at the workshop (Figure 1). About 15 per cent of the participants reported having gained an excellent understanding of CORDEX data sets and 62 per cent a very good understanding of the same, a significant

FIGURE 1 PARTICIPANTS' RESPONSES ON THEIR KNOWLEDGE OF THE WORKSHOP'S TOPICS BEFORE AND AFTER THE TRAINING (%)



improvement from 'poor' (38 per cent) or 'fair' (31 per cent) before the training. They also reported either an "excellent" or "very good" understanding of CORDEX access, data extraction, and the R programming language introduced at the workshop.

'Approximately 38 per cent of the participants reported an excellent understanding of spatial analysis of climate data and 31 per cent of them said they had an excellent understanding of temporal analysis of climate data after the training. None did before the training session (see annex 2 and 3).

Closing session

The participants thanked the CORDEX team, ICIMOD, and the Met Office for inviting many experts to work together on a topic of such importance. ICIMOD's Saurav Pradhananga and Kabi Raj Khatiwada thanked the participants and the whole team for a successful training session. They said it was a learning opportunity not just for the participants but also for the resource persons.

Md Azizur Rahman, BMD shared his experience in working in the meteorological department and stated that these types of training programmes are useful for forecasting and institutional capacity-building. He added that the knowledge and skills gained at the training would be useful in disseminating climate information to a wider audience. He concluded by emphasizing the need for continued collaborative activities with ICIMOD.

Joseph Daron, Met Office said he was glad that the participants were able to use the CORDEX data sets for the spatial and temporal analysis of the climate om Bangladesh and the three divisions. He stated that the CORDEX team was working to increase collaboration among varied stakeholders in different regions. He thanked those attending for participating in the training diligently, understanding the concepts behind the data, and using the data for the analysis and visualization of their area of interest.

Mandira Singh Shrestha, ICIMOD thanked all the participants for completing the training and understanding the different aspects of the CORDEX data sets. She also thanked the resource persons from CCCR, SMHI, and ICIMOD for conducting the training and WCRP/CORDEX for funding the training event.

Bazrul Rashid, the focal person for the training at BMD, expressed his happiness about the successful completion of the training. He encouraged the participants to use the knowledge gained from the training in their work. He thanked the Met Office and ICIMOD and expressed the hope that there would be a follow-up.

PDF copies of the power points and other additional materials used are available at:

https://www.icimod.org/event/training-on-spatial-and-temporal-climate-change-analysis-using-cordex-regional-climate-models-over-bangladesh/

File links:

Agenda

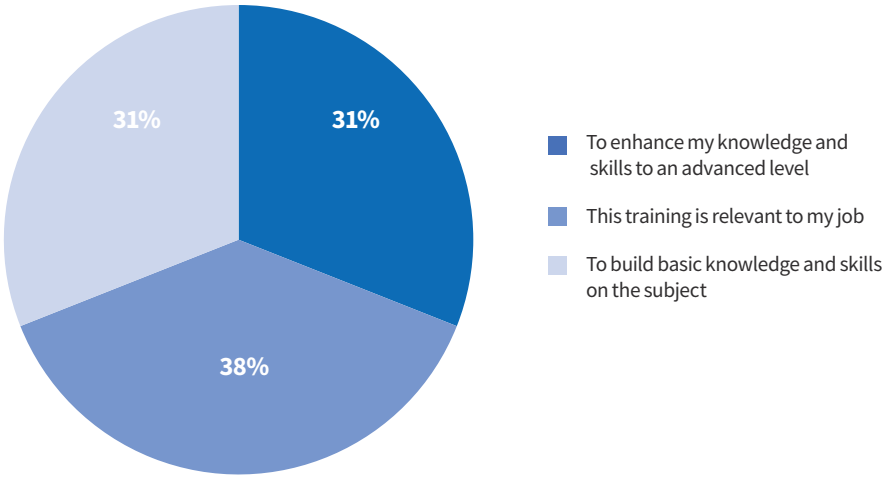
List of participants

SECTION 3

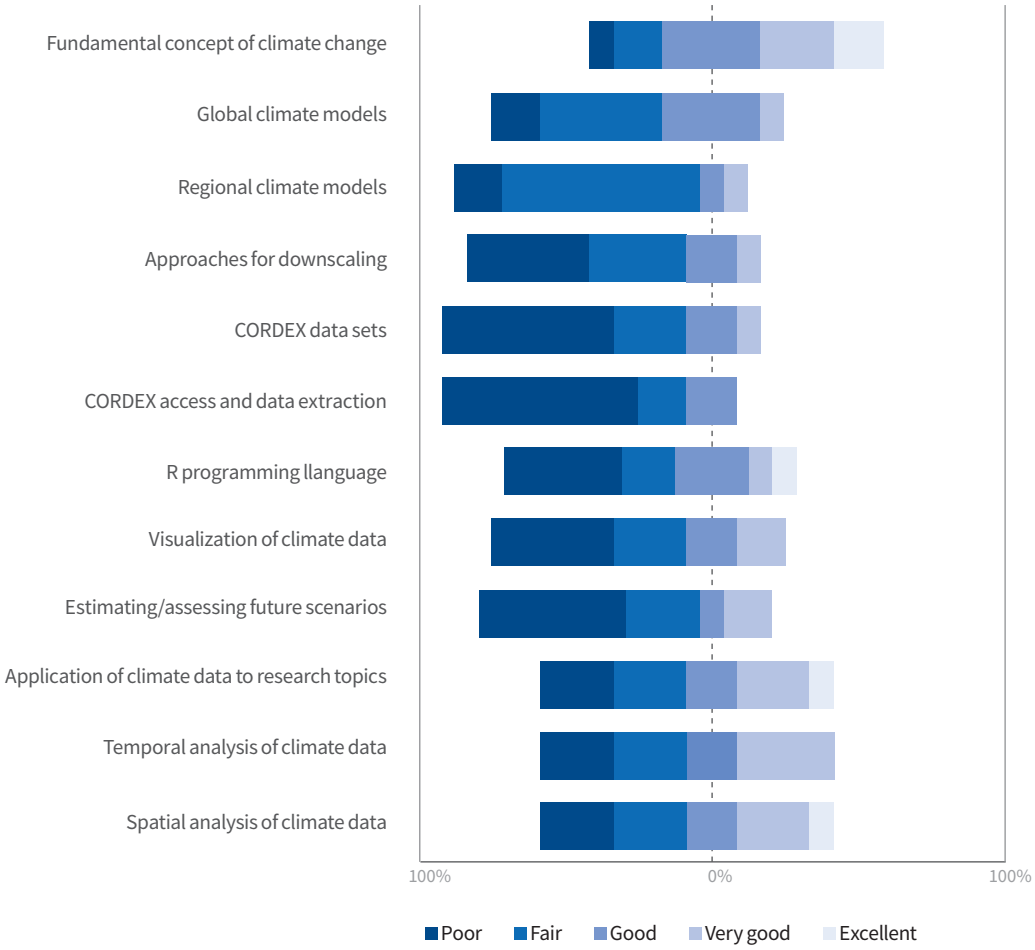
Annexes

Annex I: Results of the pre-training assessment

Why did you choose to participate in this event?

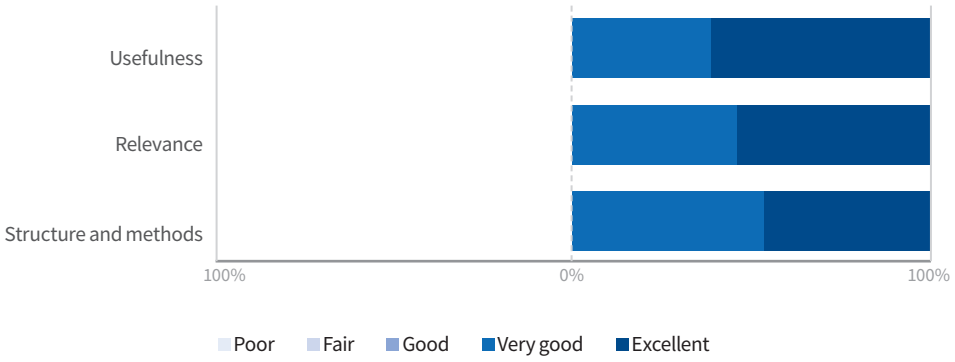


How would you rate your knowledge of the following topics?

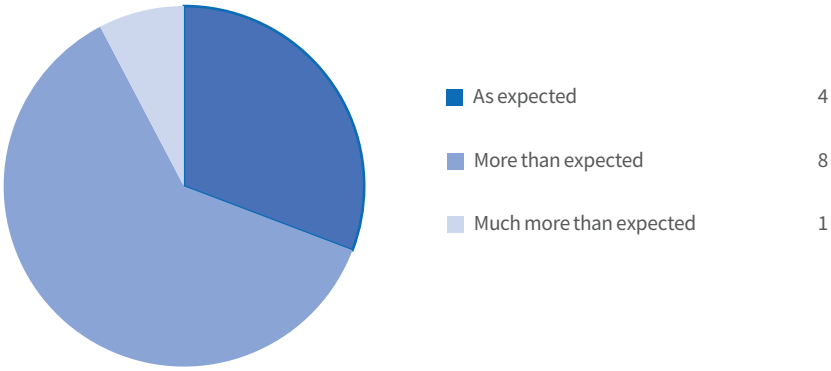


Annex 2: Results of the post-training assessment

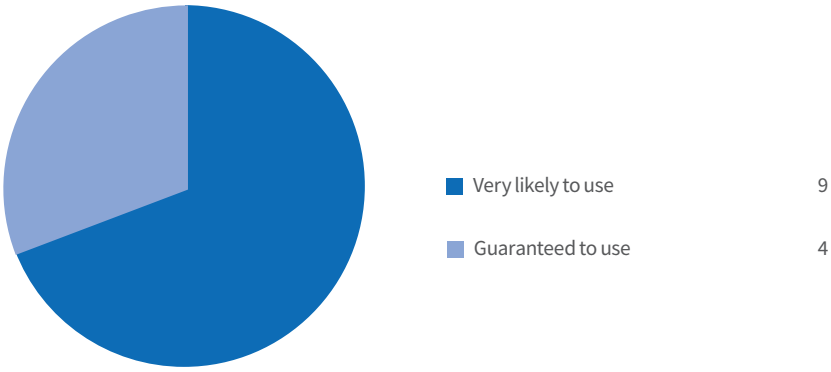
How would you rate the overall content of the training in the following areas?



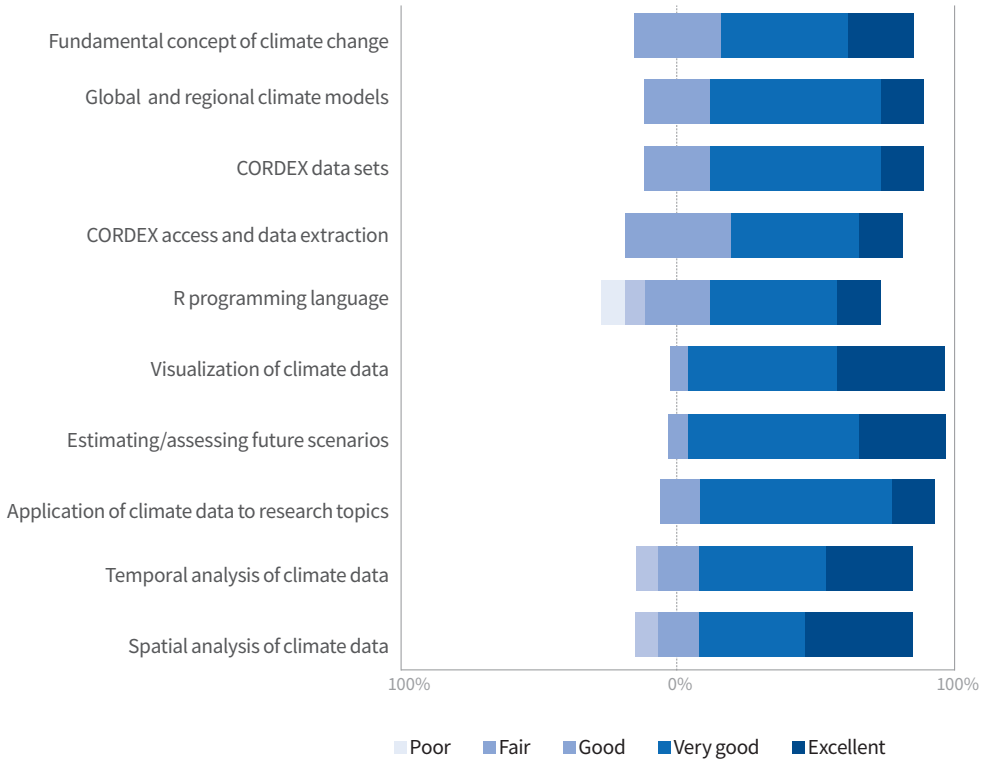
How much have you learned about the overall topic of the training?



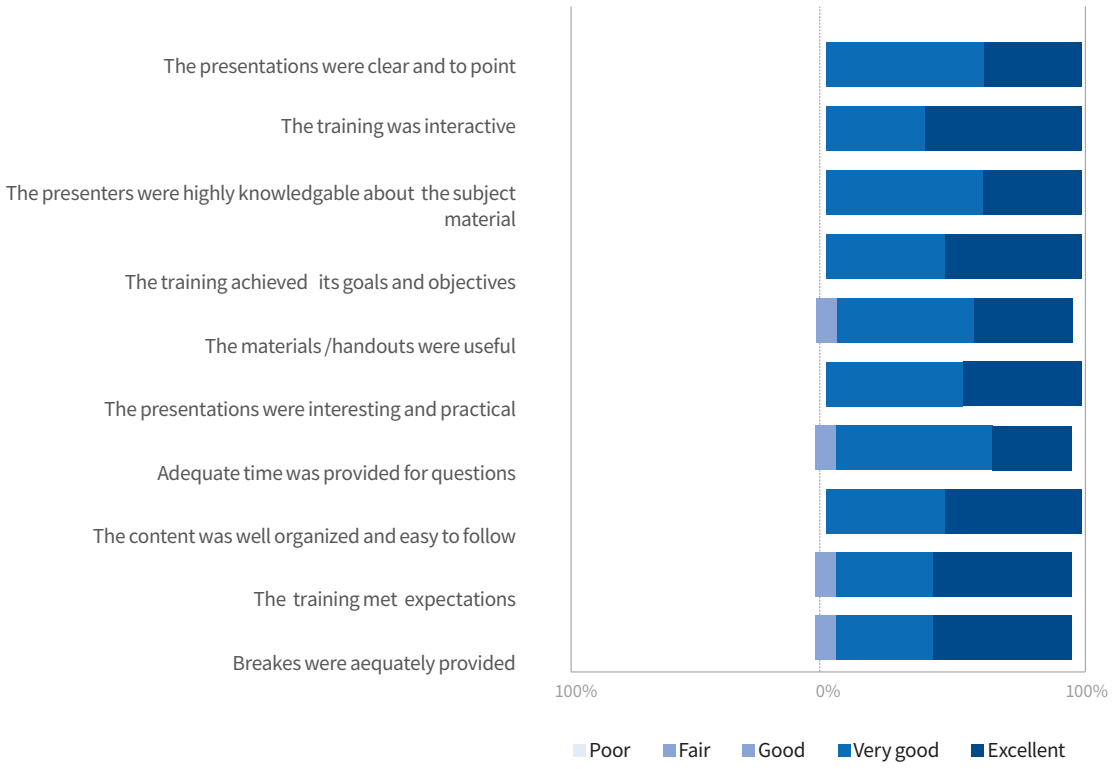
How likely are you to use the information or knowledge you gained in the training in your normal area of work?



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?

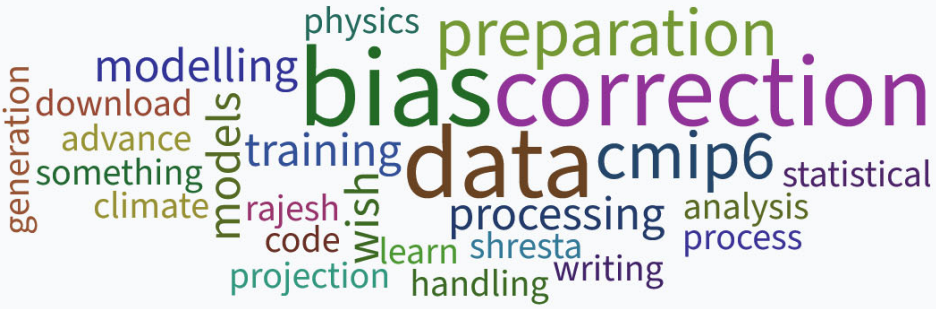


Annex 3: Results from the online polls held during the training

HOW DO YOU PLAN TO APPLY THIS KNOWLEDGE IN YOUR WORK?

Total Results: 25

WHAT ADDITIONAL TOPICS WOULD YOU LIKE COVERED IN FOLLOW-UP TRAINING?



Total Results: 25

Proceedings prepared by:

ICIMOD: Saurav Pradhananga, Kabi Raj Khatiwada, Utsav Maden, Mandira Singh Shrestha

Met Office: Joseph Daron

SMHI/CORDEX: Iréne Lake

Centre for Climate Change Research, IITM: J Sanjay

Institute for Water and Flood Management, BUET: Saiful Islam

ICIMOD gratefully acknowledges the support of its core donors: the Governments of Afghanistan, Australia, Austria, Bangladesh, Bhutan, China, India, Myanmar, Nepal, Norway, Pakistan, Sweden, and Switzerland.

International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Nepal
T +977 1 5275222 | **E** info@icimod.org | **www.icimod.org**