

Towards robust
projections of climate
extremes and adaptation
plans over South Asia.



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Project Leader and Contact Details: Dr. Shaukat Ali – Global Change Impact Studies Centre, Federal Ministry of Climate Change, Pakistan; pirshauki@gmail.com

Collaborators and Contact Details:

Collaborators	Organization/Country	Contact details
1. Prof. Madan Lall Shrestha	Small Earth, Nepal	madanls@hotmail.com; info@smallearth.org.np
2. Prof. Dan Li	Institute of Atmospheric Physics, China	danli@tea.ac.cn
3. Dr. Md. Mizanur Rahman	Save Earth Climate Services Bangladesh	mrahman648@gmail.com
4. Dr. Koji Dairaku	National Research Institute for Earth Science and Disaster, Japan	dairaku@bosai.go.jp
5. Dr. Jaepil Cho	Integrated Watershed Management Institute (IWMI), Korea	jpcho89@gmail.com
6. Dr. Moetasim Ashfaq	Oak Ridge National Lab, United States	mashfaq@ornl.gov
7. Dr. Sher Muhammad	ICIMOD, Nepal	msher.tpmb@itpcas.ac.cn
8. Dr. Lijun FAN	Institute of Atmospheric Physics, China	fanlj@tea.ac.cn
9. Dr. Fuqiang Cao	Institute of Atmospheric Physics, Chinese Academy of Sciences, China	yangfq@tea.ac.cn
10. Mr. Muhammad Arif Goheer	Global Change Impact Studies Centre, Pakistan	arifgoheer@gmail.com
11. Ms Nuzba Shaheen	Global Change Impact Studies Centre, Pakistan	nuzba.gcisc@gmail.com
12. Dr. Firdos KHAN	National University of Sciences and Technology, Pakistan	fkousafzai@gmail.com
13. Ms. Nadia Rehman	Global Change Impact Studies Centre, Pakistan	80.nadia@gmail.com

14. Mr. Mohammad Adnan	Global Change Impact Studies Centre, Pakistan	scarpion982@gmail.com
15. Dr. Asif Khan	Water Resources Engineering, UET Peshawar, Pakistan	engrasif_civil@yahoo.com
16. Dr. Shiva Ebrahimi	Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China	shiva@itpcas.ac.cn

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1. Summary

The study of future climate extremes at small scales with robustness depends on high-resolution reference and model data. The statistical and dynamical downscaling communities aim to improve reference and model data to produce reliable data at the local level, reduce uncertainty, and establish policy maker confidence in future climate extremes. However, there are still gaps in finer resolution, scaling issues between reference and model data, and insufficient observation data in South Asia. The need for high-resolution regional/local future climate extremes information is urgent for impact adaptation and vulnerability studies. To address this need, the project “Towards robust projections of climate extremes and adaptation plans over South Asia” was undertaken to produce 5km reference data over Pakistan, Nepal, and Bangladesh, and fine resolution climate model data for the future projection of extreme events over the region. These higher resolution data allowed for the projection of climate extremes in the region. Scientific research conducted under the project has led to the publication of eight research papers in well-reputed IF journals, with two cited in the recent AR6 report.

In addition to data preparation, the project has organized significant capacity building activities. Workshops were held in China, Pakistan, and Nepal to train young researchers and students in climate change modelling, climate change and media, and climate change and health. These workshops were attended by experts from around the world, with technical experts from Brazil and a collaborator from Bangladesh present physically. Gender equality was ensured in the workshops, and over 200 students were trained. The workshops received much appreciation and were highlighted in local media channels.

To meet the objective of communicating the project's outcomes to policymakers, the outcomes were communicated through multiple media channels. Five news articles were published in English newspapers, two radio and five TV interviews were conducted, and the outcomes were presented in ten national and two international conferences. The project has also collaborated with a number of national and international organizations in the project activities. All of these activities have highlighted the role of APN in promoting research and collaboration in the region.

Overall, this project has made significant contributions to the understanding of future climate extremes in South Asia, provided high-resolution data for impact adaptation and vulnerability studies, and organized capacity building activities to train young researchers and students. The communication of the project's outcomes to policymakers through multiple media channels and collaboration with national and international organizations further highlights its importance in promoting research and collaboration in the region.

2. Objectives

The objectives of this project were to:

1. Prepare local scales (5 km) reference data using statistical (long-term trend preserving bias correction methods) and dynamical downscaling approaches.

2. Produce local information of climate extremes and identify the vulnerable regions over South Asia.
3. Recommend adaptation measures at local, national and regional levels.
4. Capacity building of researchers, students and policy makers in the field of climate extremes in the developing countries involved in the project.
5. Develop a portal for reporting/recording information on current and future climate extremes.

3. Outputs, Outcomes and Impacts (add from Fatima input)

Outputs	Outcomes	Impacts
Workshops (Capacity) + Project meetings		
First Meeting cum Training Workshop in China, 2019	Inception meeting of project titled as "Observation and statistical models' requirement for preparation of high-resolution reference data" was held among the collaborators to set the short-term project goals and 15 students were trained regarding "Observation and statistical models' requirement for preparation of high-resolution reference data"	21 Students and early career researchers among the trainees had an opportunity to build their capacity in statistical models for preparation of high-resolution reference data. Developed project execution plan for next three years.
2 nd Meeting cum Training workshop in Pakistan, 2021	The 2 nd workshop titled at "Monsoon Variability and Extremes in a Changing Climate" provided a capacity building platform for the students and early career climate researchers from Pakistan in latest data preparation and analysis tools bringing them together with major project collaborators.	The workshop received overwhelming response (received 600 applications) from students and researchers and was highlighted on local media channels as well. Over 35 people were trained in the workshop in climate modelling. This workshop also led to a cultural exchange opportunity for technical trainers from Brazil and Bangladesh. Up to 50% of attendees were females, ensuring our goal of women empowerment and

		gender balance.
3 rd Training workshop in Pakistan, 2022	This Media Training Workshop on “Climate Extremes with Emphasis on Health Impacts” brought together people from three field of climate change, media and public health and was successful to emphasize upon the health impacts of climate change and role of media in effective communication of the said.	70+ trainees benefitted from exchange of experience between climate change experts, media persons and public health experts. Up to 60% of attendees were females, ensuring our goal of women empowerment and gender balance. The workshop played an important role to reduce the technical understanding gap between climate change experts, media persons and public health experts.
Final 4 th Training workshop in Nepal, 2022.	Training workshop on “Climate Data Analyses and Downscaling” was held in Nepal to train early career researchers and students from Nepal in climate data analyses techniques and downscaling methods.	30 students participated in the workshop where more than 50% of the students were females. The project final progress was shared with collaborators. This workshop also provided a chance for cultural exchange between Nepali students and trainers from Pakistan, Brazil and Bangladesh.
Data preparation		
Preparation of high-resolution reference data at 5km over study area of the project.	Prepared Reference data of maximum, minimum temperature and precipitation for Pakistan, Bangladesh, and Nepal.	This high-resolution data downscaled at local level is crucial for future studies of impacts of climate extremes since it is downscaled at as small as 5km This data can be imperative in studies related to agricultural adaptation towards increasing climate extremes in the region.

		<p>The data can further be an aid in validation of climate models and downscaling further. This data and studies derived out of it can be excellent foundations for science informed and science-based policymaking especially in the arenas of adaptation and mitigation plans on national and local levels.</p> <p>The paper of 5km preparation data is in review in Geoscience Data Journal.</p>
<p>CMIP6 Model Validation over Pakistan, Nepal, and Bangladesh.</p>	<p>The purpose of this study was to select models with better performance in reproducing the historical climate (1981-2014) for Pakistan, Nepal, and Bangladesh.</p>	<p>The research study has found out models with better performance in Pakistan, Nepal, Bangladesh, individually and collectively keeping two variables i.e., Precipitation and Air Temperature in consideration.</p> <p>The study also focused upon which models perform better per the seasonal variations.</p> <p>The findings of this study shall help in choosing the best CMIP6 models for future climate change and associated research in the region. The paper has been prepared and ready for submission.</p>
<p>Climate Extremes Data Analyses</p>	<p>The purpose of this study was to do extreme events analyses for baseline and future periods (21st century) with 5km data for Pakistan, Nepal, and Bangladesh.</p>	<p>Completed extreme event analyses over Pakistan, Nepal, and Bangladesh.</p>

Research papers		
8 Research papers have been published	8 research papers were published during project based on the data produced and analysed in the project. These research papers span a range of topics like spatial monsoon shifts, climate extremes, climate change and health etc.	The research papers have produced crucial information that shall aid in the science informed and science-based policy making in the country. 2 of the research papers were cited in the latest
Class for females		
Free online course on climate change for female students titled as Introduction to “Atmospheric Science: a look into the Southern and Northern Hemispheres”	In 2022 We launched a joint online course with Universidade Federal de Itajubá (UNIFEI), Brazil for female students in Pakistan by Prof. Michelle Simões Reboita free of cost with title “Introduction to Atmospheric Science: a look into the Southern and Northern Hemispheres”. The course this year has been conducted again for the second time, this spring semester and enrolled students from Nepal and Bangladesh, to promote regional and international collaboration and cultural exchange.	During the first semester of this course, 30 Pakistani students were taught the basics of climate science as a base for the climate modelling course. Now for the second semester 30 students from Nepal, Bangladesh, and Pakistan combined are being taught. During the second course 30 Pakistani students that previously took the above-mentioned course were taught the technicalities of basic climate modelling and data analysis.
Free online course for females titled as “Climate Modelling and Data Analysis”	This course is complementary to the aforementioned course and was piloted in 2022 as well. So far one semester has been conducted for this course.	This course is building capacity of female students and early career female researchers in the three countries, promoting women empowerment and gender balance. Further this course is a source of international educational and cultural collaboration between Brazil, Pakistan, Nepal and

		Bangladesh.
Science to policy communication		
Radio Programs	Two complete 01-hour each program was dedicated for awareness on climate change where the role of APN was also highlighted	The programs received positive feedback from the audience and was a source of climate awareness and education.
News Articles	Five news articles had been published. The articles explained the vulnerability of the country in terms of future hotspot cities, possible future changes in monsoon over the region of Pakistan, climate change and health, and discussed the policy implications of the research.	Thus, the articles provided climate awareness to public on mass level aiding in setting the public agenda for climate advocacy. Further, the role of APN-GCR in funding this project and various other regional climate research opportunities was also highlighted.
TV interviews	Four TV interviews had been conducted in different local language including English with the aim of promoting research conducted under APN Project (CRRP2018-04My-Ali).	The 2 interview were conducted in English and Urdu which is helpful to share our message across Pakistan and also international community. The other two interviews were conducted in the local languages, it delivered climate change awareness to the grassroots level.
Lectures in Universities		
10 Lectures delivered at various universities conference and workshops in Pakistan.	Students were made aware of latest climate change research findings in Pakistan in the areas of climate modelling, climate extremes, climate change and health, climate change and agriculture etc. and the role of APN in aiding the research.	This has provided a new paradigm to students who want to pursue research as careers and need platforms to fund their projects.
Student thesis		
Thesis supervision and	Four students were supervised	Ms. Rida Sehar Kiani and Ms.

<p>guidance in preparation for 4 students during the course of project duration.</p>	<p>for their university degree thesis preparation during this project. Titles of their theses were below:</p> <p>Ms. Rida Sehar Kiani <i><u>Hydrological Projections over Upper Indus Basin of Pakistan under Paris Agreement (1.5C and 2C increase.)</u></i></p> <p>Ms. Alia Saeed <i><u>Modelling the impact of climate change on dengue outbreaks and future spatiotemporal shift in Pakistan</u></i></p> <p>Ms. Fatima Saeed <i><u>A Content Analysis of Environmental Journalism in South Asian Print Media: 2016—2021</u></i></p> <p>Ms. Maryam Fazal <i><u>Assessing Trends in Observed and Simulated Climate Extremes and Future Projections using CMIP6 Models over different regions of Pakistan</u></i></p>	<p>Alia Saeed have contributed to the project research during their theses and also contributed in research papers which are enlisted below in <i>section 5. Publications</i>. Ms. Fatima Saeed and Ms. Maryam Fazal are currently working on producing a research paper out of her thesis.</p>
<p>Internship for students</p>		
<p>Internship opportunities for students under the subject project.</p>	<p>Four students enlisted below were given the internship opportunity under the said project.</p> <p>Ms. Rida Sehar Kiani Ms. Alia Saeed Mr. Azfar Hussain Ms. Fatima Saeed</p>	<p>The students got a chance to further their knowledge of climate science. The internship also built their capacity in fields of climate modelling and data analysis. Furthermore, the internship equipped them with essential management skills. The exposure these students got from this internship has opened new ventures for all of them.</p>

		<p>To state briefly,</p> <p>Ms. Rida Sehar Kiani was able to get her own APN project later on. Currently, she is pursuing her Doctorate in Australia.</p> <p>Ms. Alia Saeed has completed her Masters with her top grades in thesis.</p> <p>Mr. Azfar Hussain is pursuing his Post-Doctorate in China.</p> <p>Ms. Fatima Saeed is currently employed in Schlumberger Oilfield Services Company's Sustainability department and is closing working with the sustainability team to take to company towards Net-Zero.</p>
<p>2 papers were cited in IPCC AR6 recent report.</p>		
<p>2 research papers were cited in the 6th Assessment Report of the Intergovernmental Panel for Climate Change</p>	<p>Publication Title: Assessment of climate extremes in future projections downscaled by multiple statistical downscaling methods over Pakistan Publication URL: https://www.apn-gcr.org/?p=7244 Cited in: IPCC AR6 WGI Chapter 11</p> <p>Publication Title: Identifying hotspots cities vulnerable to climate change in Pakistan under CMIP5 climate projections</p>	<p>This gave the APN project and authors of these research papers, a renewed international and national level exposure and credibility.</p> <p>The citation in AR6 is testament that climate vulnerability in Pakistan and surrounding region is in dire need of emergency attention that is based on both short and long-term strategies.</p>

	<p>Publication URL: https://www.apn-gcr.org/?p=7245 Cited in: IPCC AR6 WGII Chapter 10</p>	
2 international presentations		
<p>Presentation at Workshop on Status of Climate Science and Technology in Asia CALL FOR SCIENTISTS IN ASIA TO CONTRIBUTE TO IPCC – AR6: APPLICATION FOR SPONSORSHIP 15-16 November 2018: Kuala Lumpur, Malaysia.</p>	<p>ANCST had collaborated with the Asia-Pacific Network for Global Change Research (APN) and International Council for Science Regional Office for Asia and the Pacific (ICSU-ROAP) to enhance support for the IPCC AR6 cycle.</p> <p>The emphasis was on sub-regional reviews or case-studies. I submitted my paper titled “Climate risk and vulnerability assessment over Hindu Kush sub-regions (Bajaur, Mohmand and Khyber agencies) of Pakistan”</p>	<p>The workshop enabled me for networking with key authors and scientists from Asia who were involved in the IPCC AR6 cycle.</p> <p>This workshop was also an opportunity to discuss my progress on subject project with Dr. Linda Anne STEVENSON, Head, Division of Communication and Scientific Affairs, Asia-Pacific Network for Global Change Research (APN).</p> <p>Exchange of experience during the workshop brought to my knowledge that there are excellent opportunities for Pakistani scientists and researchers to contribute as Corresponding Lead Author, Chapter Scientist and Expert Reviewer in AR6 by apply through open competition on merit.</p> <p>We also published the paper on this presentation that is listed in publications.</p>
<p>Presentation at International Mountain Conference, Innsbruck Austria, September 11-15, 2022.</p>	<p>The conference emphasized on the studies of mountainous regions thus the abstract I had submitted to IMC titled as:</p>	<p>I had numerous discussions with key presenters, and we agreed upon further exchange of experiences and regional</p>

	<p>“Development of high-resolution climate gridded data for mountainous regions of Pakistan and Nepal.”</p>	<p>collaboration.</p> <p>Subject project was appreciated as an important regional collaboration of research, development and networking.</p> <p>Discussion with IMC organizers to support people from remote regions of the world in order to make it possible for them to participate.</p>
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4. Key facts/figures (numbers)

1. Preparation of reference data at 5km resolution over study area of the project.
2. Eight (8) research publications in reputed IF journals.
3. Two (2) research publication are cited in AR6 by Intergovernmental Panel for Climate Change
4. We delivered ten (10) lectures in conferences and workshops in Pakistan.
5. Two (2) international presentations in the International Conferences in Malaysia and Austria.
6. Two (2) interviews on government Radio channel.
7. Five (4) interviews on TV channels.
8. Five (5) total news articles.

5. Publications

1. Saeed, A., Shaukat Ali., Khan, F., Muhammad, S., Reboita, M. S., Khan, A. W., ... & Pongpanich, S. (2022). Modelling the impact of climate change on dengue outbreaks and future spatiotemporal shift in Pakistan. *Environmental Geochemistry and Health*, 1-17.
2. Shaukat Ali., Reboita, M. S., & Kiani, R. S. (2021). 21st century precipitation and monsoonal shift over Pakistan and Upper Indus Basin (UIB) using high-resolution projections. *Science of The Total Environment*, 797, 149139.
3. Shaukat Ali, Eum, H. I., Jaepil, C., Li, D., Khan, F., Dairaku, K., ... & Fahad, S. (2019). Assessment of climate extremes in future projections downscaled by multiple statistical downscaling methods over Pakistan. *Atmospheric Research*.
4. Rehman, N., Adnan, M., and Ali, S. (2020). Future Extremes and Variability of Rainfall over Monsoon Region of Pakistan. *Pakistan Journal of Meteorology* 14 (28), 31-78.

5. Shaukat Ali., Saeed, A., Kiani, R. S., Muhammad, S., Khan, F., Babar, R., ... & Fahad, S. (2021). Future climatic changes, extreme events, related uncertainties, and policy recommendations in the Hindu Kush sub-regions of Pakistan. *Theoretical and Applied Climatology*, 143(1), 193-209
6. Shaukat Ali., Kiani, R. S., Reboita, M. S., Dan, L., Eum, H. I., Cho, J., ... & Shreshta, M. L. (2021). Identifying hotspots cities vulnerable to climate change in Pakistan under CMIP5 climate projections. *International Journal of Climatology*, 41(1), 559-581.
7. Kiani, R. S., Ali, S., Ashfaq, M., Khan, F., Muhammad, S., Reboita, M. S., & Farooqi, A. (2021). Hydrological projections over the Upper Indus Basin at 1.5 °C and 2.0 °C temperature increase. *Science of The Total Environment*, 788, 147759.
8. Khan, F., Shaukat Ali., Mayer, C., Ullah, H., & Muhammad, S. (2022). Climate change and spatio-temporal trend analysis of climate extremes in the homogeneous climatic zones of Pakistan during 1962-2019. *PloS one*, 17(7), e0271626.

6. Media reports, videos and other digital content (links of tv and articles)

- Two one hour-long each dedicated interview for climate change awareness and education on national level radio i.e., Program Rabita.
- Five news articles in leading national newspaper that discuss climate extremes, monsoon shifts, climate vulnerability and emphasize the urgency of science informed policymaking.
 - ❖ Climate Collaboration
<https://www.thenews.com.pk/print/581541-climate-collaboration>
 - ❖ Climate and Dengue
<https://www.thenews.com.pk/print/531071-climate-and-dengue>
 - ❖ Talking about the weather
<https://www.thenews.com.pk/print/465034-talking-about-the-weather>
 - ❖ Spatial shift in monsoon
<https://www.thenews.com.pk/print/898709-spatial-shift-in-monsoon>
 - ❖ Climate hotspots and policy
<https://www.thenews.com.pk/print/863195-climate-hotspots-and-policy>
- Five (4) TV interviews in a local language i.e., Pashto and 3 TV interviews in English and Urdu.
 - ❖ PERSPECTIVE 31-07-2022: Climate Change
<https://www.youtube.com/watch?v=2vY-qvpSZhU>
 - ❖ Khyber News Interview
<https://www.youtube.com/watch?v=8iuCQKVYKrw>
 - ❖ Hum TV Interview

<https://www.youtube.com/watch?v=ZCcyZaBTrDk>

❖ PTV News Heatwave TV Interview

<https://www.youtube.com/watch?v=EgGnXL8KgW4>

- Coverage of APN's 2nd Meeting cum Training Workshop by Samaa TV – a national level news channel (Appendix VIII)
- Coverage of a research paper (<https://rmets.onlinelibrary.wiley.com/.../10.1002/joc.6638>) published under this APN project by Samaa TV – a national level news channel (<https://www.facebook.com/1147911976/videos/1672778086390020/>)

7. Pull quotes

Dr. Shaukat Ali – PI CRRP2018-04My-Ali, Senior Scientific Officer, GCISC

This project has been incredibly successful in achieving its objectives and making significant contributions to climate change research and data. The collaboration among Pakistan, Nepal, and Bangladesh, as well as other countries like Brazil, China, USA, Japan, and Korea, is commendable in addressing a common challenge. The project's commitment to high-quality research and data-driven decision-making is evident in the preparation of 5 km data for present and future climate projections. The publication of 8 research papers and citation of 2 papers in IPCC 6th Assessment Report highlights the project's significant contributions to the scientific community and knowledge dissemination. The project's focus on student capacity building through training workshops and university courses is noteworthy, as it aims to build the next generation of climate change researchers and practitioners. The efforts in science-to-policy communication through media and engagement with policymakers demonstrate the project's dedication to translating research findings into actionable policy recommendations. Moreover, the project's impact on my career and international research networking is truly remarkable.

Congratulations to GCISC and APN for another exceptional joint project!

Mr. Arif Goheer – Head Agriculture & Coordination GCISC/ Member SPG from Pakistan

Pakistan in the recent past has faced a couple of extreme events and their frequency and magnitude is projected to increase in near future not only in Pakistan but in South Asia as well. In this context, the project holds significant value since fine resolution (5x5 km) scenarios were generated during the study. Several national and international institutes from Pakistan, Nepal, Bangladesh, China, Japan, Brazil, and USA have contributed to the project, produced eight papers and almost in similar number are in the pipeline. Besides this, the project has capacitated more than 200 professions/university students in the preparation of high-resolution reference climate data;

climate data analysis and downscaling; monsoon variability and climate extremes in changing climate; and Climate Extremes with emphasis on health impacts in four training workshops held in China, Nepal and Pakistan. The project provided a good interface between climate researchers, health specialists, media professionals, and policy makers. The project has effectively tried to fill the research-policy gap and I do hope that its findings and recommendations will create a meaningful impact in the participating countries. Another collaborative project between GCISC and APN completed – further strengthening the cordial relations between the two organizations.

Prof. Dr. Michelle Simões Reboita, Universidade Federal de Itajubá, UNIFEI

I was very happy to participate in the execution of the project, especially in contributing to the training of students. In the first training offered, I noticed the students' difficulty in both basic concepts of atmospheric sciences and computing. Therefore, I dedicated myself throughout the project to preparing training sessions that would be useful for students and early-career professionals. In terms of scientific development, the project allowed the team to increase their knowledge on the climate and projected climate changes for Pakistan, Nepal, and Bangladesh, which are countries that are highly vulnerable due to the economic conditions of their populations. During the project, I learned a lot about the meteorology of the Northern Hemisphere, which expanded my field of expertise.

Ms. Rida Sehar Kiani – Research Assistant CRRP2019-04MY-ALI

The subject project has been a huge learning opportunity for me to further my knowledge in climate science and build my capacity in climate modelling, climate data downscaling and data analyses. The project also gave me quite a lot of exposure to enhance my project, people and time management skills. Working under this project has gained me the authorship in up to 10 research papers due to my contributions in them. My learning experience from the project PI – Dr. Shaukat Ali has also been exceptional. He is an open-minded mentor who does not shy away from giving his students the room for growth and evolution. It is due to his guidance and my learning experience in the subject project that I was later able to get my own project from the APN-GCR, titled as “Towards capacity building of media and awareness of public and students to develop strong science-policy communication on climate change in Pakistan (ECSC2019-03-Kiani)”. I am grateful for the opportunities and exposure I have earned through this project and APN under the guidance of Dr. Shaukat Ali.

8. Acknowledgments

First and foremost, I express my sincere gratitude to APN for their invaluable financial support which has been instrumental in the success of this important project on the development of robust projections for climate extreme studies. APN's support has not only played a vital role in creating a knowledge base in the neglected area of climate change research in this region, but has also helped in building the capacity of numerous researchers who will continue to contribute credible research in the region in the years to come. I am truly thankful to the entire APN team, especially Ms. Nafesa Ismail and Dr. Linda Anne Stevenson, for their exceptional management skills, prompt responses, and valuable guidance, which have turned this project from a mere concept into reality. I am deeply indebted to all my collaborators, namely Prof. Madam Lal Shrestha from Small Earth Nepal, Dr. Mizan ur Rehman from Bangladesh, and Prof. Dan Li from China, for their research inputs, sincere efforts, and wholehearted dedication in carrying out the project activities as per the plan, and providing various reports and necessary inputs whenever required. Special thanks are also due to our technical expert, Prof. Michelle Simões Reboita, and all the resource persons for their efforts in imparting training during the four capacity building workshops organized under the project. Their contribution has been invaluable, and this project would not have been successful without their support. I would also like to express my gratitude to all my local counterparts from GCISC and other organizations for their unwavering support throughout the project. The administrative support of GCISC and climatology section in providing logistics for various activities, including the organization of workshops, is deeply appreciated. Last but not least, I extend my special gratitude to Mr. Muhammad Arif Goheer, Head of Agriculture and Coordination and Member SPG representing Pakistan, for his constant support, keen interest, and constructive insights during the course of the project. Their guidance has been invaluable in achieving the project's objectives.

9. Appendices

Provide a list of all appendices and attach them as separate files to the report.

Appendix – I	Summary of 1 st Meeting cum Training Workshop, China
Appendix – II	Summary of 2 nd Meeting cum Training Workshop, Pakistan
Appendix – III	Summary of Media Training Workshop on Climate Extremes with Emphasis on Health Impacts, Pakistan
Appendix – IV	Radio Interviews
Appendix – V	Television Interviews
Appendix – VI	Newspaper Articles
Appendix – VII	Lectures at Conferences and Workshops in Pakistan
Appendix – VIII	Media Coverage of finding of CRRP2018-04MY-Ali project through the platform of ECSC2019-03- Kiani project.
Appendix – IX	Summary of Final Meeting cum Training Workshop, Nepal
Appendix – X	International Mountain Conference, Innsbruck, Austria
Appendix – XI	International Presentation in Malaysia.