

Global Change Impact Studies Centre (GCISC)
(A Body Corporate established under the GCISC Act 2013)

Performance Report 2018-19

Global Change Impact Studies Centre (GCISC) was first established as a development project in April 2002, with the mandate to undertake research on climate change and its impacts and potential remedies. Subsequently, GCISC's status was formalized through the passage of the GCISC Act 2013 by the Parliament (notified vide Gazette of Pakistan on 26 March 2013 as Act No. XVII of 2013). The Act defines GCISC as a body corporate governed by an independent Board of Governors (BoG), which is chaired by the Federal Minister in-charge of the concerned Ministry dealing with the subject of climate change.

1. Mission Statement

To undertake scientific investigations of the phenomenon of climate change at regional and sub-regional levels and study its impact on various sectors of socio-economic development in order to prepare the country to meet threats to its water resources, agriculture, ecology, energy, health, bio-diversity etc.

2. Main Functions

Under the GCISC Act, the Centre is tasked with three functions, namely research, capacity building, and outreach and awareness:

- a. **Research:** the research program is driven by national policy goals, namely protecting people against the impacts of climate change, promoting economic growth and sustainable development in a climate-constrained future, and honoring Pakistan's international commitments. To these ends, research is organized in three groups:
 - ***Climatology and Environment:*** using climate system models to predict future climate behavior in Pakistan, including monsoons, temperature, precipitation, and climate extremes.
 - ***Water Resources and Glaciology:*** using Glacio-hydrological and water models to assess future behavior of snow and glaciers, aggregate and

seasonal impacts on flows in the Indus River System, and changes in the hydrological extremes across the country.

- ***Agriculture, Forestry & Land Use:*** using crop simulation models to predict the impact of projected changes in temperature, precipitation, and water availability on agriculture Forestry, Land Use
- b. **Capacity building:** imparting technical and communication skills to GCISC staff as well as students and climate scientists at other national research organizations and universities.
- c. **Dissemination of research findings:** to the scientific community, planners, policymakers, and to the public at large, in order to raising awareness of climate change among policymakers as well as the citizenry.

3. Ongoing Research Activities

I. Climatology & Environment Section

The key research activities of Climatology & Environment Section revolve around following themes:

- Assessment of past climatic changes;
- Development of future climate projections for Pakistan by employing state-of-the-art high resolution Climate Models;
- Scientific Investigation and Prediction of Climatic Extremes by using modeling as well as statistical techniques;
- Simulation modeling to study monsoon dynamics and its associated impacts;
- Intra seasonal to inter decadal climate predictions;
- Development & Updating of GHG Inventory of Pakistan for Energy & Industrial Processes Sectors;
- Research dissemination (International and national science journals and books, policy briefs, press releases);
- Capacity building and awareness raising.

II. Water Resources & Glaciology Section

- Climate change analysis for the high elevation Karakoram region;

- Analysis of early 21st century changes in Kabul Basin Hydro-glaciology;
- Spatio-temporal assessment of climate change impacts on the UIB-cryosphere and variability of flows based on high resolution climate model data;
- Analysis of climate impact on the frequency and intensity of hydrological extreme events;
- Plausible Adaptation strategies to ensure country's water security under the umbrella of Climate change and Water policies.

III. Agriculture, Forestry and Land Use Section

- Assess impacts of projected climate change on productivity of key agricultural crops in different climatic zones using crop models;
- Assess impacts on related areas, including productivity of forestry, grasslands, rangelands and fragile ecosystems (i.e., mountains, wetlands, coasts, and arid areas); livestock; and land degradation and deforestation, insect-pest infestation dynamics;
- Food security in the face of future climate change and especially reduced availability of irrigation water;
- Adaptation measures, including smart agriculture;
- Studies on water, food, energy nexus;
- Updating GHG emissions from agriculture and related sectors.

4. Achievements and Progress of GCISC:

During the year, GCISC made significant contribution to the international scientific literature in the field of climate change and its associated impacts, and made tangible contribution in a no. of research projects. It also organized a no. of workshops/seminars for information dissemination and awareness. The following is a summary of the accomplishments in 2018-19:

- Publication of key research findings in scientific journals = 16
- Contribution towards technical reports = 08
- Contributions in research projects = 06
- Provision of training to university students from across Pakistan in the field of climate change through summer internship program = 18

- Organization of scientific activities/workshops/seminars for information dissemination and awareness = 35
- GCISC experts delivered lectures as resource persons and imparted trainings to the researchers of various organizations = 25
- Played key role in the preparation of Pakistan's Second National Communication to UNFCCC.
- One GCISC scientist has been elected as Rapporteur in UNFCCC's Consultative Group of Experts(CGGE).
- Two GCISC scientists are contributing as Lead Authors for IPCC 2019 Refinement to IPCC 2006 Greenhouse Gas Inventories Guidelines
- A group of GCISC scientists made significant scientific contribution for R-SMOG (2018) Study conducted by Food and Agriculture Organization of the United Nations (FAO).
- Two scientists from GCISC are contributing as Lead Author for IPCC 6th Assessment Report.

A. Salient Research Studies/ Reports

(a) Assessment of temperature and precipitation based climate extremes in future projections over Pakistan

The study provides an insight of observed (1996-2005) and future extreme events over Pakistan by using statistical downscaling/bias-correction methods. The results show that the temperature over whole country is increasing at a higher rate as compared to global mean. The projected changes in daily minimum temperature (warm and cold nights) are more prominent than that for daily maximum temperature (warm and cold days) with respect to duration and frequency. Therefore, the rate of change in the minimum temperatures contribute more strongly to the overall increase of temperatures. Moreover, the highest increase in temperature is observed over north as compared to southern Pakistan. This increased warming will result in more rainfall events and can also intensify the hydrological cycles in most of the parts of Pakistan that may lead to flooding and drought at the regional scale. However, the lower agreement is observed in case of precipitation extremes among CMIP5 models than temperature extremes. The results over Pakistan are in agreement with global studies which indicate that anthropogenic activities would cause fewer cold extremes and more warm extremes in 21st century. Some key findings are presented in Fig. 1.

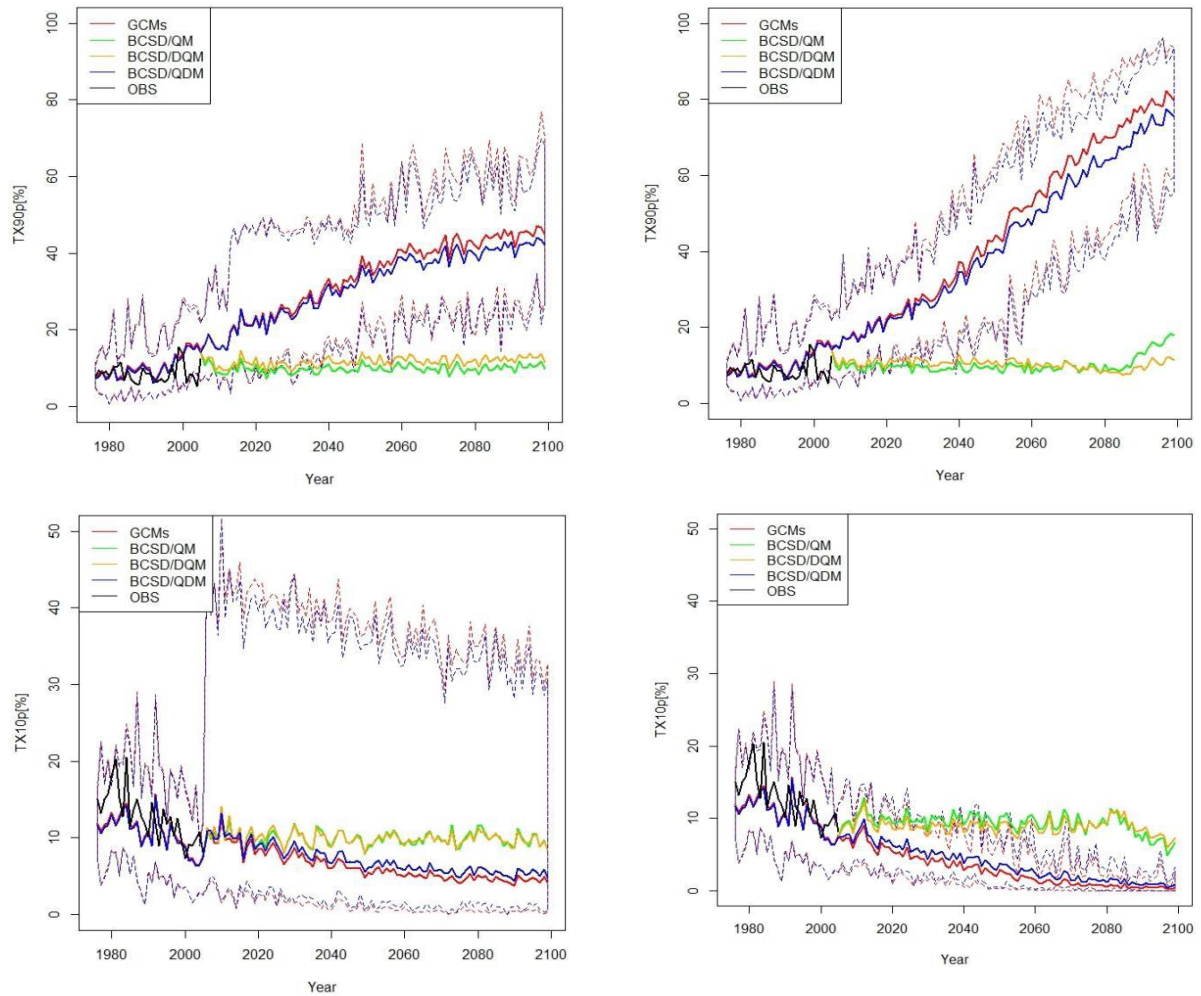


Fig.1: Trends of temperature extremes (TX90p, TX10p) from 1976 to 2099, downscaled for RCP4.5 (left panel) and RCP8.5 (right panel) over Pakistan.

(b) Spatio-temporal variability of summer monsoon over Pakistan

The study indicates inter-decadal spatial and temporal variability in the precipitation related to the monsoon onset in Pakistan. This study provides a detailed insight to the monsoon onset over Pakistan from 1971 to 2010. Analysis of 40 years of data revealed variations in the time of summer monsoon onset over Pakistan. The temporal analysis shows that monsoon onset has an earlier shift in Pakistan region. Although there are certain factors which effect the monsoon system such as ENSO that has caused a delay in the monsoon onset during the decade of 1981–1990. Therefore, the study concludes that mean monsoon onset over 40 years has a shift to an earlier time in the whole region. The key findings of the study are shown in Fig 2.

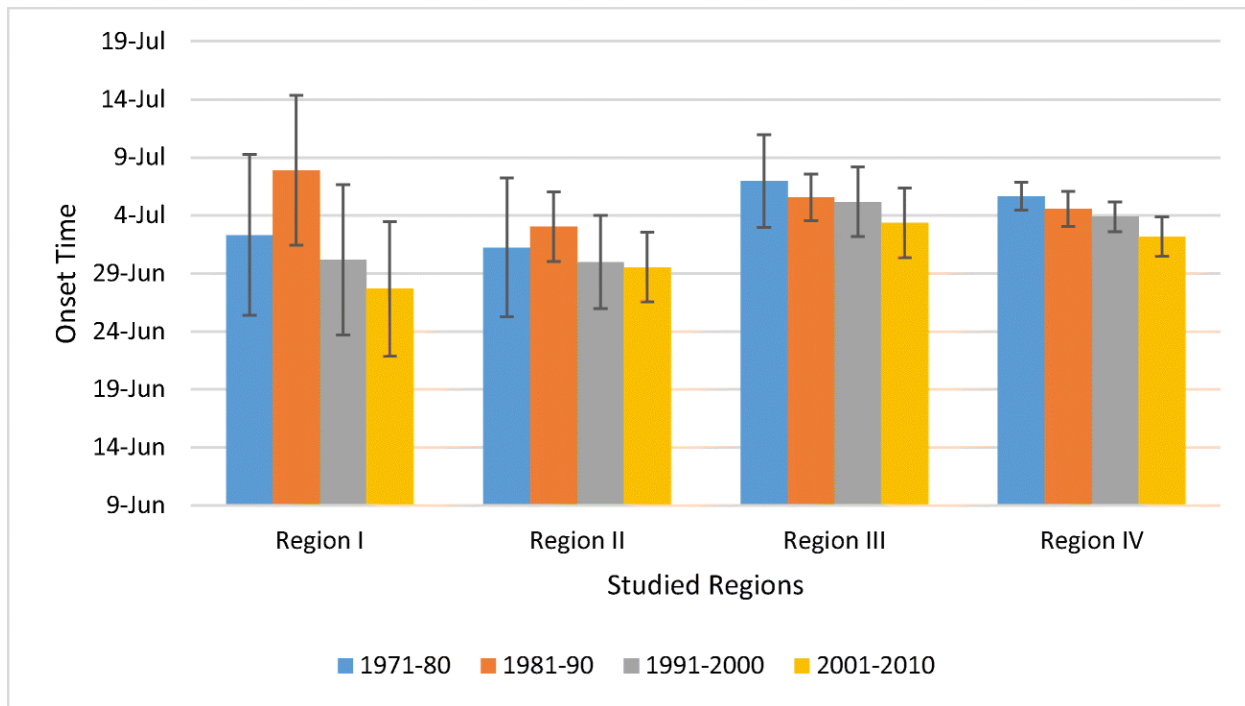


Fig.2: Standard deviation of monsoon onset in four regions of Pakistan over the four decades from 1971 to 2010)

(c) Assessment of Linkages of seasonal predictability to global climate patterns

This study is an attempt to highlight the global and regional climatic impact of increased magnitude of ENSO Modoki in winter and summer seasons. The study also tries to see how effectively ICTP-AGCM can reproduce ENSO Modoki-induced teleconnection patterns, especially in the South Asian and tropical MENA domain as these regions appears to be very sensitive to ENSO induced changes. In this study, ENSO Modoki sensitivity experiments have been conducted using ICTP-AGCM (SPEEDY). One of the main interests of this study is to see how sensitive is the global and regional climate to ENSO Modoki strength. The results show that the global and regional climatic impacts of ENSO are very sensitive to the intensity of ENSO phases in the tropical Pacific region. Increased magnitude of ENSO Modoki significantly affects Hadley and Walker circulations both in winter and summer season, that in turn induce considerable impact upon rainfall distribution in the tropical areas. El Nino/La Nina induced Hadley and Walker circulations result in decreased/increased rainfall activity, especially in the tropical rain belt areas of MENA and South Asia. The results further reveal that precipitation changes induced by ENSO Modoki are largely consistent with the precipitation response induced by conventional ENSO; however, the ENSO Modoki induced precipitation anomalies seem relatively weaker than produced by conventional ENSO.

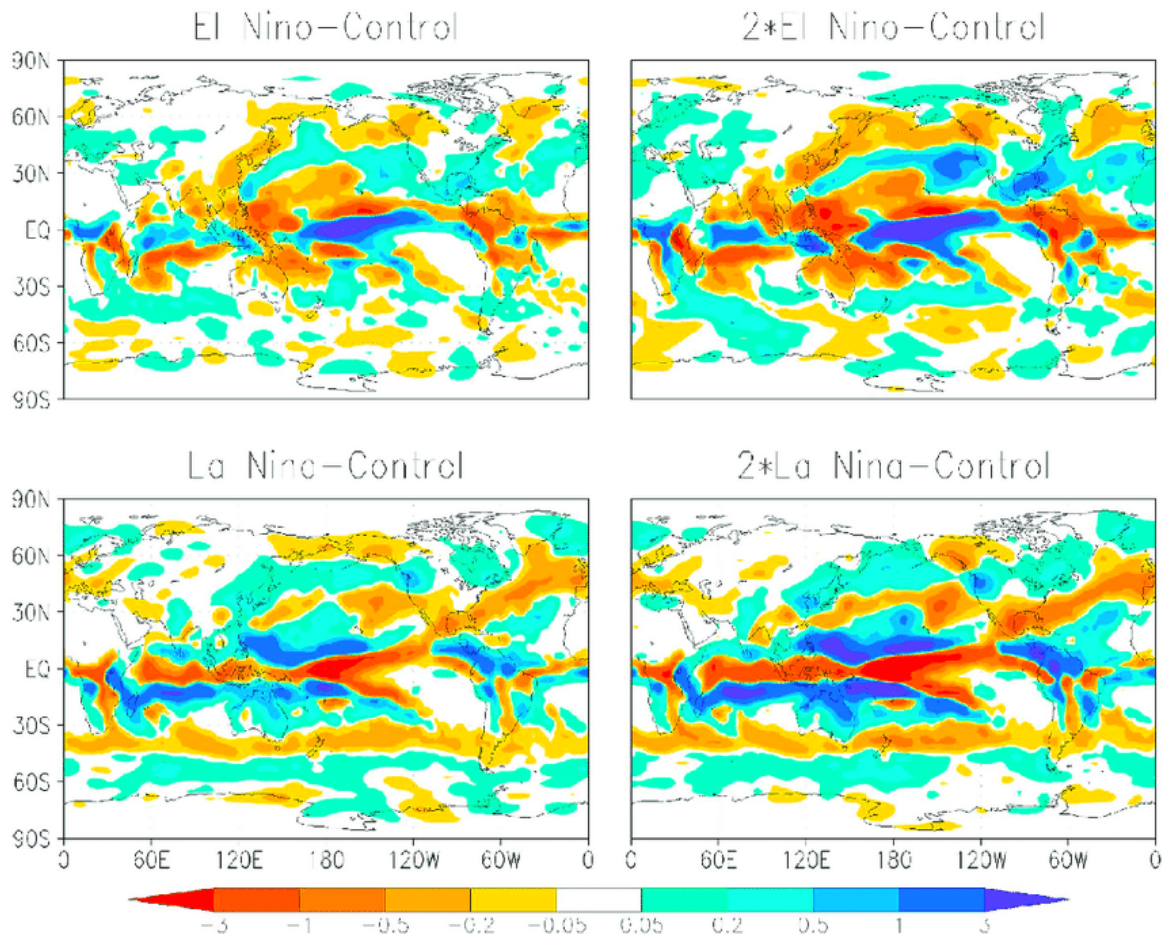


Fig.3: Composited mean precipitation (mm/d) anomaly (experiment -control) following El Niño and La Niña Modoki forcing in winter (DJF) season

(d) Investigation of the impacts of anthropogenic radiative forcing

A study has also been performed on the investigation of the impacts of anthropogenic radiative forcing, produced by the rise in the atmospheric concentrations of CO₂, on the diurnal temperature range. By using a sophisticated radiative-convective model of the diurnal cycle, the effects of increased CO₂ on the diurnal distribution of surface temperature, radiation fluxes, and water contents are evaluated. This study concludes that CO₂ plays a major role in the climatic variability of the mid-latitude semi-dry regions.

(e) Sensitivity of the monsoon regions to explosive volcanism and volcanic-induced ENSO forcing

In this study performed by Climatology Section, sensitivity of the monsoon regions to explosive volcanism and volcanic-induced ENSO forcing is studied to better understand the driving mechanism and climate variability in south Asian and African region. Using observations and a high resolution atmospheric model, effectively at 50- and 25-km grid spacing, this study shows that ENSO and tropical eruptions together weaken the upward branch of Northern Hemisphere (NH) Hadley cell, that is, Intertropical Convergence Zone.

This results in a significant decrease of monsoonal precipitation, suggesting severe drought conditions over the NH tropical rain belt regions. The volcanic-induced direct radiative cooling and associated land-sea thermal contrast result in significant warming and drying due to the reduction of clouds over the monsoon regions in boreal summer. The post eruption ENSO circulation also results in warming and drying over NH tropical rain belt regions. This study confirms that the monsoon climate regime responds vigorously to post eruption direct radiative and indirect circulation impacts caused by volcanic-induced ENSO forcing. Hence, quantification of magnitude and spatial pattern of these postvolcanic direct and indirect climatic responses is important for better understanding of climate variability and changes in Asian and African monsoon regions.

(f) Spatio-Temporal Analysis of Early Twenty-First Century Areal Changes in the Kabul River Basin Cryosphere,

A GCISC-led modelling study reveals that under future climate change scenarios, seasonal snow in the basin is likely to melt faster and earlier (Figure 4), thereby causing more frequent and higher magnitude extreme flow events in the form of localized flash floods in the mountainous part and larger floods in the flatter terrain (mostly in KP province of Pakistan e.g. Noshera and adjacent areas) of the basin. It poses a huge threat to a major proportion of the population living in the KRB on both sides of the border.

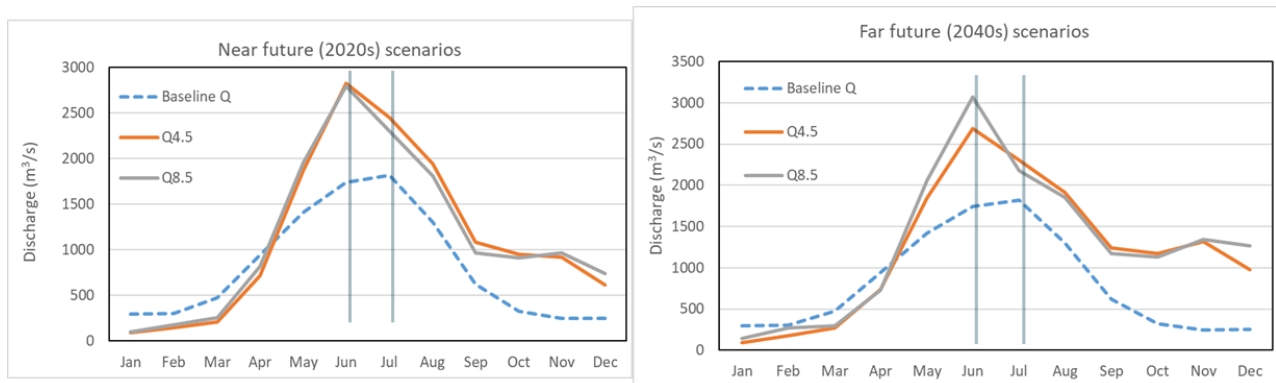


Figure 4

The study proposes following policy recommendations:

- *A joint campaign by the Meteorological agencies of the two riparian countries for installation of climate and river flow gauging sites in the basin, especially on the Afghanistan side which has virtually no long term data available required for a reliable climate analysis. It will help improve hydrological monitoring and climate change impact assessment research studies in the KRB. In this regard, Pakistan has better capacity and can offer full technical support to Afghanistan*
- *Joint watershed management practices including tree plantation to reduce soil erosion and flood risk, and flood plain management (restoring and creating wetlands) to make beneficial use of flood flows*

- *A formal mechanism of cooperation/coordination among the national weather and flood forecasting agencies in both the countries through enhanced knowledge and data sharing and mutual capacity building*
- *Developing jointly run flood early warning systems for saving as much as possible lives and property in both the countries.*

(g) Impact of climate change on the mean summer runoff of the Chitral River

In a modelling study, the impact of climate change on the mean summer runoff of the Chitral River was determined by applying the RCP climate change scenarios using SRM snow hydrology model. Basin's simulated discharge of year 2000 was taken as a base year for projecting the future runoff.

An increase of ~13–37% was estimated in the mean summer runoff of Chitral River basin under mid and late-21st century low to high emission RCP scenarios (Figure 5). The increase in runoff is a result of increasing precipitation and warming trend which leads to melting of snow and glaciers in Chitral

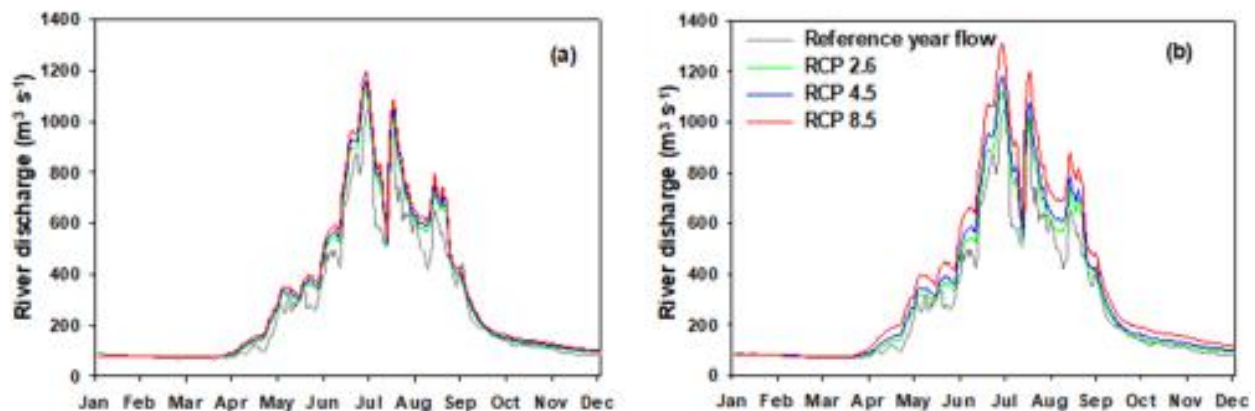


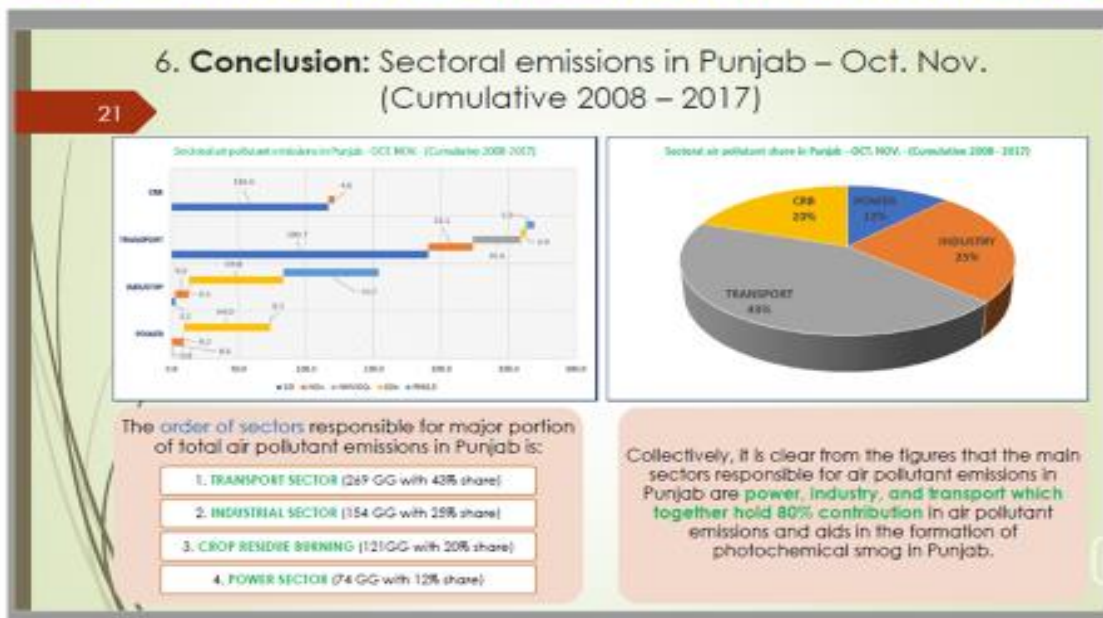
Figure 5: Simulation of the Chitral River discharge under RCP 2.6, 4.5 and 8.5 climate change scenarios for the (a) mid-21st century, and the (b) late-21st century

(h) Remote sensing for spatio-temporal mapping of smog in Punjab and identification of the underlying causes using GIS techniques (R-SMOG)

GCISC contributed to study which was launched by FAO Pakistan to investigate the underlying causes of Smog in Punjab and its relation to crop residue burning. The report The study clearly demonstrated that seasonal climatology plays a vital role in transport of different kinds of air pollutants affecting day to day human activities. HYSPLIT model based findings indicated that buildup of anthropogenic aerosols mainly has been taking place in winter (December, January, February, March) and post-monsoon (October, November) for which region wise point source locations were identified. It was found that 65 % of the

sources were detected within Pakistan. Secondly, sectoral contribution of pollutants (NO_x, SO_x, PM_{2.5}, CO, and NMVOCs) based on the data of last 10 years (2008-17) was determined using IPCC methodologies. The outcomes demonstrate the transport sector as biggest contributor (43%) in total air pollutants emission in Punjab while the rice residue burning adds just 20%. Besides, Industry and Power sectors holds 25% and 12% respectively. Overall, the energy sector occupies 80% of the total air pollutants emissions in Punjab. The emissions of NO_x, being main pollutant responsible for smog formation, are highest from transport sector (58%). Industry, and Power collectively holds 34% share in NO_x emissions while rice residue burning is just at 9%. The key recommendations of the above said study for the reduction of air pollutant emissions are based mainly on the analysis performed

Sectoral Share of Air Pollutants Emissions in Punjab



at GCISC. The key findings are shown in Figure 6.

Fig. 6: Sectoral share of air pollutants emissions in Punjab for Oct. and Nov. (Cumulative 2008 – 2017).

(i) Multi-criteria decision analysis for flood risk on the Chenab River

Pakistan has suffered cumulative economic losses of US\$38.165 billion due to 23 major flood events since its independence. This study was conducted to categorize possible flood risks using the Multi-Criteria Decision Analysis (MCDA) approach along the valley of the Chenab River reach from Maralla to Qadirabad for the flood of September 2014. The study aims to (i) determination of potential flood hazard zones, (ii) development of flood and risk assessment maps, and (iii) preparation of a flood hazard index (FHI) map. The finding of the study (Figure 8) showed that 11.47% of the total area are at high risk having a flood risk

index value of 95-150. Similarly, 29.53, 36.63 and 22.37% of the area are at high, medium and low risk having flood risk index value of 80-95, 65-80 and 34-65 respectively. The results showed that the MCDA approach in combination with GIS techniques are useful for accurate flood risk analysis and mapping.

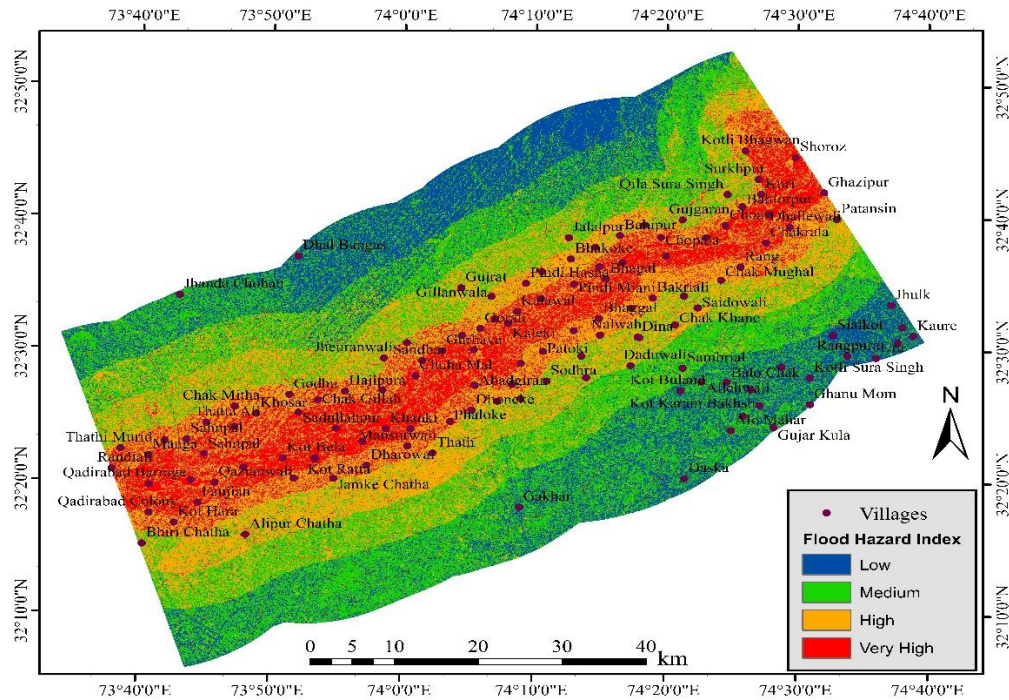


Figure 7. Flood Hazard Index map

(j) Drought Risk Assessment: A Case Study in Punjab, Pakistan

Drought is a natural hazard spreading gradually and caused serious harm to nature. Pakistan is one the counties which is affected badly by drought. In near Past, Pakistan faced one of the worst span drought from 1998 to 2003 which harshly affected socially and economically. The present study was conducted on dry land areas of Punjab-Pakistan. The main aim of the study is to analyze change in vegetation cover due to change in SPI and NDVI for barren, sparse and dense vegetation areas. The overall results if the study are summarized in table below.

Table 1: Summarized results

Indices	Feb	Mar – Apr	May-Jul	Aug-Oct	Nov-Dec
NDVI	mild drought conditions in the center of study area	Conditions harden in center	drought started to mature at east and west boundaries of region	drought happening to grow in extreme North	Drought happening to evacuate from region and dry condition started to scatter

VCI		Drought situations strengthen in middle of study area	Appeared at south, east and west boundaries	Intensive	
Standardized Precipitation Index (SPI)	Mianwali, moderate dry conditions, Jhang, severe dry condition, Bhakar, Khushab, Liah and Muzafarghr, saved from dry conditions				

(k) 2019 Refinement to IPCC 2006 Greenhouse Gas Inventories Guidelines

Based on the decision of Task Force Bureau, Taskforce on National Greenhouse Gas Inventories (TFI) conducted a technical assessment of IPCC 2006 GHG-I guidelines.

The technical assessment revealed that there has been abundant new scientific and empirical knowledge published since 2006 which the IPCC should consider, particularly with respect to data for emission factor development for some categories and gases. Consequently, the necessity and usefulness of *refining* the current methodological guidance (e.g. updating default emission factors) was recognized by TFB and refinement process was started by selecting the Coordinating Lead Authors, Lead Authors, Contributing Authors and Reviewers.

Two GCISC scientists (namely Muhammad Arif Goheer, Head-Agriculture, Forestry & Land Use and Muhammad Ijaz, SSO) contributed to the Volumes on Agriculture, Forestry & Land Use and Waste Sectors respectively. The emission coefficients have been revised and the new methodologies on estimation of emissions have been reported.

(l) Assessing Crop Water Requirements under Changing Climate

Water is central to crop production. While climate changes are negatively affecting crop production through reduction crop yields, altering the cropping cycle and increasing the crop water demand. In order to quantify the impact of climate change on net irrigation requirements of various field crops a set of studies has been initiated in the Agriculture Section. Under this program the crop water requirements for five major crops will be estimated in different cropping zones of the country and future water demands will be assessed. One of the study 'Climate Change Implications for Wheat Crop in D.I.Khan' was published in 2017. Work on the study of wheat water requirements on Bahawalpur and Faisalabad.

The study reports that a significant increase in CWR of Wheat has been observed over both selected sites. It is also noted that semi-arid climatology is more affected by climate change as compared to arid. The CWRs of wheat will increase by 3.01% and 6.86% in Faisalabad and by 2.46% and 5.64% in Bahawalpur for RCPs 4.5 and 8.5, respectively. Semi-arid climatic conditions will suffer more in terms of increased NIR as compared to arid climatic conditions. The net irrigation requirements will increase by 5.49 % and 10% in Faisalabad district and

by 2.41% and 5.86% in Bahawalpur for RCPs 4.5 and 8.5. Effective rainfall patterns showed a decline of 9.79% and 10.07% in Faisalabad, over all the selected future time series for both RCPs 4.5 and 8.5 respectively while in Bahawalpur overall effective rainfall increased by 3.16% and 2.81% against RCPs 4.5 and decrease against RCPs 8.5. There has been an inverse relationship between Net irrigation requirements and effective rainfall over selected sites for all the future time series and selected RCPs 4.5 and 8.5. The paper is currently in the process of review.

(m) Second National Communication (SNC)

The project 'Pakistan: enabling Activities for the Preparation of Pakistan's Second National Communication (SNC) under United Nations Framework Convention to Climate Change' funded by UNEP was awarded to Ministry of Climate change. An MOU was signed between GCISC and MOCC and GCISC contributed to the following outcomes of the report:

- Representative description of National Circumstances
- National Inventory Report
- Vulnerability and adaptation assessment for key sectors of National economy
- Integrating Climate change considerations into social, economic and environmental policies
- Research and Systematic Observation
- Report on constraints and gaps and related financial, technical and capacity needs in the implementation of Convention

The report provides a detailed stock of information on the aforementioned aspects from 2004 onwards, national vulnerabilities, action and strategies to combat the climate change challenge. The report was submitted to UNFCCC by Ministry of Climate Change in August 2020 and can be assessed at the UNFCCC website.

(n) Preparation of National GHG-Inventory Report (NIR)

As part of the work on Second National Communication, GCISC prepared the National Inventory Report (NIR). As per inventory report, the total estimated GHG emissions for the year 2015 are 408.1 million tons of CO₂ equivalents with 45.5% share of Energy sector, 42.7% share of Agriculture, 5.4% share of Industrial Processes, 3.8% share of Waste and 2.5% share of Land-Use Change and Forestry (LUCF) sector.

(o) Collaborative Climate Change Related Research Studies

GCISC is pursuing collaborative climate change related studies with various Universities and Research institutions on the aspects of (a) future scenarios in Pakistan for different degrees of global warming (i.e., 1.5 degrees, 2 degrees, 3 degrees, etc.); (b) Action on Pakistan's INDC's consistent with national goals and objectives; (c) disaster management under the impact of climate change; (d) climate finance; and (e) from climate policy to implementation. In the context above, forty studies (40) with nineteen (19) institutes have been carried out. Details are available in the Section 17 (a) of the Annex-I.

B. Capacity Building:

Capacity building is an important component of GCISC's activities. Climate change still is an evolving science. The new concepts, tools and methodologies for impact assessment emerge quite frequently. Capacitate the Centre's researchers as well as other institutions with upcoming technologies and skills is imperative for quality research and action.

During 2018-19, the Centre's scientists participated in a number of national/ international training workshops and acquired new skills ranging from climate science, climate modeling, seasonal forecasting, early warning systems, drought monitoring and assessments, hydrological, crop simulation and water management modeling, water surface runoff analysis, water-food-energy nexus, to earth observation systems, space technology and RS/GIS tools. In some the workshops GCISC's scientists also contributed as resources persons. The details of participation are available in Section 11 of Annex-I. The acquired skills are being used for the ongoing and planned research activities at the Centre.

Given the complex and evolving nature of the climate change subject, the international mentorship of the Centre's scientists is very much essential. To fill this gap, the Centre has declared some world renowned scientists, majority of them are Pakistani expatriates, as Senior Fellows. GCISC's researchers are engaged with in various research studies. A list of these fellows along with their expertise is available at Section 17(b) off the Annex-I.

Eighteen (18) students from National University of Science and Technology (NUST), Islamabad, Bahria University, Islamabad, PMAS-Arid Agriculture University Rawalpindi. University of Agriculture, Faisalabad and University of Engineering & Technology (UET) Peshawar attended GCISC as Interns for a period of 2-3 months. The Centre's researchers provided them orientation lectures on climate science, modeling and other analytical skills and supervised them for various studies assigned to them by their university teachers. The details of the students is available in Section 14 of Annex-I.

The Centre has also started a series of lectures called as 'Friday Seminar' in which GCISC's own as well as researchers from other institutions deliver lectures on the latest ongoing research and present studies on the aspects of climate sciences, sectoral impacts and response strategies. During 2018-19, twenty-nine (29) seminars were organized at GCISC. The details of the Seminars are available in Section 15 of the Annex-I

C. Mass Awareness / Media Appearance:

The Centre's scientists published six news articles in the leading national newspapers on the various aspects of climate science and its associated impacts on water, agriculture, forestry as well as on climate change negotiation and probable outcomes in COP-24. An exclusive

programme to highlight the climate change and allied impacts was broadcasted on PTV world in which GCISC Scientists highlighted the implications of Climate Change for the country and how the researchers are providing support for informed policy and decision making. In a Live Radio Programme “Raabta”, GCISC’s scientist discussed the issues of climate vulnerabilities to agriculture sector and how the ordinary farmers can adapt to minimize the risks and increase resilience.

The details of the newspaper articles and electronic media programs are available in Section 13 of Annex-I.

D. Inputs for parliamentary Business

GCISC, being the research arm of the Ministry of Climate Change is frequently engaged for providing technical inputs on climate change, impacts and response strategies for parliamentary business. In this regard GCISC provide answers to National Assembly and Senate questions and also contributes to the proceedings of the standing committees on the concerns of climate change. During 2018-19, GCISC provided responses to nine (9) NA/Senate starred questions and provided inputs (presentations/ briefs) for NA Standing Committee on Climate Change on the aspects of Climate Change, Agriculture and food security.

5. Dissemination of R&D findings: Research papers in International / National Journals & Book:

- i. **Hashmi, M. Z., Masood, A., Mushtaq, H.**, Syed Ahsan Ali Bukhari, Burhan Ahmad, Adnan Ahmad Tahir, “Exploring climate change impacts during 1st half of the 21st century on flow regime of the transboundary Kabul River in the Hindukush region” **accepted for publication in the Journal of Water and Climate Change.**
- ii. **Masood, A.**, Jarbou Bahrawi & Amro Elfeki, “Modeling annual rainfall time series in Saudi Arabia using first-order autoregressive AR(1) model”, **Arabian Journal of Geosciences (2019) 12:191** <https://doi.org/10.1007/s12517-019-4330-3>.
- iii. **Ali, S.**, 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.
- iv. **Ali, S.**, Bushra Khalid, **Kiani, R. S.**, Romaisa Babar, Sana Nasir, **Rehman, N., Adnan, M., Goheer, M. A.**, (2019), “Spatio-Temporal Variability of Summer Monsoon Onset over Pakistan”, Asia-Pacific J Atmos Sci (2019). <https://doi.org/10.1007/s13143-019-00130-z>.
- v. **Dogar, M. M.** (2019). The Sensitivity of DTR to the Increased CO₂ over Mid-latitude Semi-dry Regions, JOJ Horticulture and Aboriculture, 2(2), 001-007.
- vi. **Dogar, M. M.**, Kucharski, F., Sato, T., **Mehmood, S., Ali, S.**, Gong, Z., & Arraut, J. (2019). Towards understanding the global and regional climatic impacts of Modoki magnitude. Global and planetary change, 172, 223-241.
- vii. **Dogar, M. M.**, & Sato, T. (2019). Regional Climate Response of Middle Eastern, African and South Asian Monsoon Regions to Explosive Volcanism and ENSO Forcing. Journal of Geophysical Research: Atmospheres.
- viii. **Hassan, S. S., Ajmal, M., Khan, A. A., Goheer, M. A.**, Muhammad Shahzad Khattak, **Ali, S., Ijaz, M. and Adnan, M.**, (2019), “Multi-Criteria Decision Analysis for Flood Risk on the Chenab River”, Weather Journal, <https://doi.org/10.1002/wea.3490>.
- ix. A.Shakoor, Z.M.Khan, U.Umar Farid, M.Sultan, **Khan, A.A.**, I.Ahmad and M.Azmat. 2019. Groundwater Vulnerability Mapping in Faisalabad District Using GIS Based Drastic Model. Matec Web of Conferences 246, 01001 ISWSO.
- x. Amin, M., **A.A. Khan**, A. Perveen, Z. Rauf, **Hassan, S.S., Goheer, M.A., and Ijaz, M.** 2019. Drought risk assessment: a case study in Punjab, Pakistan. Sarhad Journal of Agriculture. Sarhad Journal of Agriculture.

- xi. T Qadir, K. Akhtar, **Ahmad, A.**, A. Shakoor, M. Saqib, S. Hussain and M. Rafiq. 2019. Wheat Production Under Changing Climate: Consequences of Environmental Vulnerabilities on Different Abiotic and Biotic Stresses. *J. Glob. Innov. Agric. Soc. Sci.*, 2019, 7(1):7-17. ISSN (Online): 2311-3839; ISSN (Print): 2312-5225 <http://www.jgiass.com>.
- xii. H. Umar Farid, M. Zubair, Z. M. Khan, A. Shakoor, B. Mustafa, **Khan, A.A.**, M. Mubeen, M.N. Anjum, I. Ahmad. 2019. Identification of Influencing Factors for Optimal Adoptability of High Efficiency Irrigation System (HEIS) in Punjab, Pakistan, *Sarhad Journal of Agriculture*. *Sarhad Journal of Agriculture*. June 2019, Volume 32, Issue 2, Page 539-549.
- xiii. S. Hussain*, **Khan, A.A.**, A. Shakoor, **Goheer, M. A.**, T. Qadir, M. Mujtaba and Z. Hussain. 2019. Effect of Cold and Heat Stress on Different Stages of Wheat: A Review. *J. Glob. Innov. Agric. Soc. Sci.*, 2018, 6(4): 123-128.
- xiv. **Masood, A., M. Z. Hashmi, Mushtaq, H.**, Spatio-Temporal Analysis of Early Twenty-First Century Areal Changes in the Kabul River Basin Cryosphere, **Earth Systems and Environment (2018)** 2:563–571 <https://doi.org/10.1007/s41748-018-0066-6>.
- xv. Abid, M.; Abid, Z., **Zafar, Q., Mahmood, S.** (2018), Detrimental Effects of Climate Change on Women, *Earth Systems and Environment*, Springer Journal. Volume 2, Issue 3, pp 537–551.
- xvi. G. Habib and **A. Ahmad**. 2018. Assessment and Mitigation of Methane Emissions from Livestock Sector in Pakistan. *Earth Systems and Environment*: <https://doi.org/10.1007/s41748-018-0076-4>, *Earth Syst Environ* 2, 601–608.

6. Technical Research Reports:

- i. Muhammad Arif Goheer & Muhammad Ijaz contributed to volume ix and v of Refinement to IPCC 2006 Greenhouse Gas Inventories Guidelines published by IPCC in 2019;
- ii. GCISC research contribution to various chapters of Second National Communication. The effort was coordinated by Muhammad Arif Goheer on behalf of GCISC;
- iii. Remote Sensing for Spatio-Temporal Mapping of Smog in Punjab and Identification of the Underlying Causes Using GIS Techniques (R- SMOG) published by FAO;
- iv. Muhammad Zia-ur-Rahman Hashmi, Amjad Masood and Shahbaz Mehmood. GCISC Report: Shushghai-Zhendoli (S-Z) Hydropower Project - GLOF and Climate Change Risk and Vulnerability Assessment Study;
- v. National Inventory Report (NIR) for the year 2014-15 of the Greenhouse Gas Inventory 2014-15 has been finalized;
- vi. Project Technical Report CBA2017-04MY-Akbar “Improving Skills for Promoting Sustainable Watershed Management Practices in South Asia”. Report has been submitted to APN which is available online on APN website;

- vii. External reviewer of the Chapter titled; “Disaster Risk Reduction and Increasing Resilience” of the Second Order Draft of ICIMOD-HIMAP;
- viii. A short report prepared in the context of Pakistan’ Indigenous Mitigation Efforts to Reduce Carbon Emissions.

7. Scientific Contribution Presentations in International Conferences and Workshops:

- i. Shaukat Ali, Junior Associate – 2019 in Abdus Salam International Centre for Theoretical Physics (AS-ICTP), 27 May-04 August 2019, Italy;
- ii. Qudsia Zafar, Paper-writing Workshop on Analysis of CORDEX-CORE Climate Projections (smr 3282), 06-10 May 2019, Italy;
- iii. Muhammad Ijaz, Workshop of the Asian Regional Group of the Partnership on Transparency in the Paris Agreement, 24-26 April 2019, Indonesia;
- iv. Muhammad Arif Goheer, 1st Meeting of the Consultative Group of Experts (CGE), UNFCCC, 20-22 February 2019, Germany;
- v. Muhammad Zia-ur-Rahman Hashmi, UIB-N Meeting for Enhancing Science Based Regional Cooperation, 17-18 January 2019, Nepal;
- vi. Muhammad Adnan, IPCC Second Lead Author Meeting for 6th Assessment Report, 07-11 January 2019, Canada;
- vii. Muhammad Amjad, IPCC Second Lead Author Meeting for 6th Assessment Report, 07-11 January 2019, Canada;
- viii. Shaukat Ali, delivered a presentation on “Climate Risk and Vulnerability Assessment (CRVA) in Bajaur, Khyber, and Mohmand Agencies”, at IPCC Sixth Assessment Report (AR6) meeting at Kuala Lumpur, Malaysia on 15-16 November 2018;
- ix. Muhammad Arif Goheer participated in the 4th Lead Author Meeting (LAM4) of the 2019 Refinement to IPCC 2006 GHG inventory Guidelines organized by IPCC – 22-26 October 2018, Rome, Italy;
- x. Muhammad Ijaz, Fourth Lead Author Meeting (LAM4) for the Elaboration of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories; 22-26 October 2018, Italy;
- xi. Muhammad Ijaz, The Joint Scientific Advisory Panel (SAP) and Review Editors Meeting of the Sixth Global Environment Outlook (GEO-6); 07-09 October 2018, Egypt;
- xii. Muhammad Arif Goheer, GHG Inventory Workshop Organized by UNFCCC, 20-24 August 2018, China;
- xiii. Shahbaz Mehmood, 23rd Intergovernmental Meeting and Science Planning Group Meeting 11-12 July 2018, Thailand.

8. Scientific Contribution Presentations in National Conferences and Workshops:

- i. Shahbaz Mehmood, delivered talk as resource person titled "Climate Change in Pakistan's Context" at Conference on Climate Change: An Existential Challenge for Pakistan, organized by The Pakistan Institute of International Affairs – Karachi, 3-4 May 2019;
- ii. Muhammad Zia-ur-Rahman Hashmi, delivered talk as resource person at Conference on Climate Change: An Existential Challenge for Pakistan, organized by The Pakistan Institute of International Affairs – Karachi, 3-4 May 2019;
- iii. Muhammad Arif Goheer participated in a workshop on Role of Media in Environment and Climate Change Reporting organized by Pak-EPA on 25 April 2019, Islamabad;
- iv. Muhammad Arif Goheer moderated a session on AFOLU in NDCP Roadmap workshop organized jointly Ministry of Climate Change and NDC on 24, April 2019, Islamabad;
- v. Amjad Masood-Guest Speaker in the Seminar on "Climate Change and Water Resources of Pakistan" at Department of Earth Sciences University of Sargodha-2 Apr 2019;
- vi. Muhammad Arif Goheer-Delivered a session in one day National Seminar on "Food Security: Future Challenges" at NCRD-21 Mar 2019;
- vii. Muhammad Arif Goheer delivered a presentation as a Keynote speaker on 'Climate Change Challenges to Agriculture & Food Security: Prospects of Climate Smart Agriculture' organized by University of Wah and Commonwealth on 11 March 2019 in Wah;
- viii. Muhammad Zia-ur-Rahman Hashmi at LEAD-Pakistan delivered a presentation as Speaker for National Consultation on "Capturing Opportunities and Managing Challenges: Cooperating in the Kabul River Basin for Afghanistan-Pakistan Water Relations at Serena Hotel-26 Feb 2019;
- ix. Muhammad Arif Goheer delivered a presentation on 'Climate Smart Agriculture: A Pathway to Food Security' in the training workshop on Food Security-Issues, Concerns & Strategies organized by AHK-NCRD on 30 January 2019, Islamabad;
- x. Muhammad Arif Goheer-Delivered a Presentation on Proposal to combat water shortage through artificial rain technology at Federal Flood Commission by M/s Magnetic Technologies LLC-28 Jan 2019;
- xi. Aftab Ahmad Khan represented GCISC in a workshop on 'Stakeholder Workshop on Climate Change Scenarios for KPK' Organized by CABI International, on 24 January 2019, Rawalpindi;
- xii. Muhammad Arif Goheer participated in NDMA workshop organized by NDMA on 18 January 2019, Islamabad;

- xiii. Muhammad Arif Goheer delivered a presentation in the R-SMOG report launch organized jointly by Punjab Agriculture Department and FAO on 17 January 2019, Lahore;
- xiv. Muhammad Arif Goheer delivered a presentation in GCISC seminar on Towards Enhanced Climate Action Transparency Framework: Challenges & Opportunities for Pakistan on Being Elected as a Member of CGE in UNFCCC on 11 January 2019;
- xv. Muhammad Arif Goheer, Muhammad Zia-ur-Rahman Hashmi & Shahbaz Mehmood-Presentation in Meeting at GCISC on food-energy-water security early warning system project-17 Dec 2018;
- xvi. Section Heads and GCISC Research Staff participated in Annual Conference organized by SDPI from 04-07 December 2018, Islamabad;
- xvii. Muhammad Arif Goheer delivered a presentation on Climate Change challenges to Agriculture and Food Security in a training course on 'Climate Change Implications and Adaptations' Organized by AHK - NCRD, on 29 November 2018, Islamabad;
- xviii. Shahbaz Mehmood, delivered a talk on "Science of Climate Change; an Overview & Climate of Pakistan and Future Climate Changes", at Training Course on Climate Change: Implications & Adaptations, 26 – 30 November 2018, NCRD, Islamabad;
- xix. Muhammad Arif Goheer moderated a session on Agriculture, Forestry and Land Use Sector in the NDC Roadmap workshop organized jointly by Ministry of Climate Change and NDC Partnership on 26 November 2018, Islamabad;
- xx. Aftab Ahmad Khan delivered a presentation on Spatio-Temporal analysis of Precipitation responses to Wheat crop in rain fed and irrigated units of District Lakki Marwat Using Google Earth Engine in National Conference on Agriculture problems and Food security in changing climate 15-17 November 2018, AUP Peshawar;
- xxi. Aftab Ahmad Khan-Present paper in National Conference organized by University of Peshawar - 14-17 Nov 2018;
- xxii. Amjad Masood-Participation as Guest Speaker and delivered a presentation in the 3rd International Conference on Emerging Trends in Engineering, Management & Sciences (ICETEMS) at KIU Gilgit-10-11 Nov 2018;
- xxiii. Muhammad Arif Goheer participated in the workshop on Mapping and valuing Ecosystem Services and Prioritizing Investment in Catchment Management Organized by World Bank on 31 October 2018, Islamabad;
- xxiv. Shahbaz Mehmood, delivered on "IPCC Special Report on the Impacts of Global Warming of 1.5°C – Key Messages" at Weekly GCISC Research Seminar, 12 October 2018, GCISC-Islamabad;
- xxv. Muhammad Arif Goheer delivered a presentation on the chapters written by GCISC in the National Steering Committee of Second National

Communication chaired by Secretary Ministry of Climate Change on 9 October 2018, Islamabad;

- xxvi. Muhammad Arif Goheer, Shahbaz Mehmood and Aftab Ahmad Khan, delivered presentations titled “Past & Projected Climate Changes over Pakistan” in the context of Agriculture, Food Security & Climate Change at National Expert Meeting on Climate Change and Food Security, October 5 – 6, 2018;
- xxvii. Muhammad Arif Goheer participated and delivered a presentation title “Climate Change Research in Pakistan” in the meeting organized by Planning Commission of Pakistan to finalize Climate Change research plan on 3 October 2018, Islamabad;
- xxviii. Muhammad Arif Goheer delivered a lecture on “Agriculture & Climate Change” in Training at NIGAB, PARC Organized by PARC under HI-AWARE project on 13 September 2018, Islamabad;
- xxix. Mubashar Dogar (2018)- GCISC weekly seminar presentation titled “Study of the Global and Regional Climate Impacts of ENSO Magnitude using ICTP AGCM”, 09 September 2018;
- xxx. Muhammad Arif Goheer delivered a presentation on Potential Greenhouse Gas Emissions from Agriculture Sector in a Training Workshop on Mitigation Analysis organized by NEECA, Ministry of Energy on 30 August 2018, Islamabad;
- xxxi. Muhammad Arif Goheer delivered a presentation on Youth and Climate Change Research in a Roundtable on Youth and Climate Change organized by Sustainable Development Policy Institute on 28 August 2018, Islamabad;
- xxxii. Muhammad Arif Goheer, Muhammad Zia-ur-Rahman Hashmi & Shahbaz Mehmood, delivered presentation titled “Overview of the Climate Profile and Climate Induced Disasters in Pakistan”, at GLOF-II Inception Workshop, 05 July 2018, MoCC-Islamabad.

9. Organization of Scientific Activities at International / National Level:

- i. GCISC organized a meeting to discuss and develop a project proposal on Early Warning system for Food, Energy and Water Security under climate Change on 17 December 2018, Islamabad;
- ii. Muhammad Arif Goheer, Shahbaz Mehmood, Qudsia Zafar & Kaleem Anwar Mir participated in Results sharing workshop on R-Smog study jointly organized by GCISC and FAO on 29 October 2018, Islamabad;
- iii. Muhammad Arif Goheer represented GCISC in the 6th meeting of National Climate Change Policy Implementation Committee on 17 October 2018, Islamabad;
- iv. GCISC Organized a two-day workshop on climate change and food security in NARC from 5-6 October 2018;

- v. Stakeholder meeting on Remote Sensing jointly organized by FAO and GCISC on 27 September 2018, Islamabad;
- vi. GCISC organized a field visit to Gilgit to study on the Impact of Debris Cover Thickness and Temperature Variations on Glacier Melting in the Upper Indus Basin" from 17-30 Sep 2018;

10. Effort on capacity building of GCISC young scientists through academic and specialized trainings and participation conferences, workshops etc at International level:

- i. Shaukat Ali, Junior Associate – 2019 in Abdus Salam International Centre for Theoretical Physics (AS-ICTP), 27 May-04 August 2019, Italy;
- ii. Qudsia Zafar, Paper-writing Workshop on Analysis of CORDEX-CORE Climate Projections (smr 3282), 06-10 May 2019, Italy;
- iii. Muhammad Ijaz, Workshop of the Asian Regional Group of the Partnership on Transparency in the Paris Agreement, 24-26 April 2019, Indonesia;
- iv. Muhammad Arif Goheer, 1st Meeting of the Consultative Group of Experts (CGE), UNFCCC, 20-22 February 2019, Germany;
- v. Muhammad Zia-ur-Rahman Hashmi, UIB-N Meeting for Enhancing Science Based Regional Cooperation, 17-18 January 2019, Nepal;
- vi. Muhammad Adnan, IPCC Second Lead Author Meeting for 6th Assessment Report, 07-11 January 2019, Canada;
- vii. Muhammad Amjad, IPCC Second Lead Author Meeting for 6th Assessment Report, 07-11 January 2019, Canada;
- viii. Shaukat Ali, delivered a presentation on “Climate Risk and Vulnerability Assessment (CRVA) in Bajaur, Khyber, and Mohmand Agencies”, at IPCC Sixth Assessment Report (AR6) meeting at Kuala Lumpur, Malaysia on 15-16 November 2018;
- ix. Muhammad Arif Goheer participated in the 4th Lead Author Meeting (LAM4) of the 2019 Refinement to IPCC 2006 GHG inventory Guidelines organized by IPCC – 22-26 October 2018, Rome, Italy;
- x. Muhammad Ijaz, Fourth Lead Author Meeting (LAM4) for the Elaboration of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories; 22-26 October 2018, Italy;
- xi. Muhammad Ijaz, The Joint Scientific Advisory Panel (SAP) and Review Editors Meeting of the Sixth Global Environment Outlook (GEO-6); 07-09 October 2018, Egypt;
- xii. Muhammad Arif Goheer, GHG Inventory Workshop Organized by UNFCCC, 20-24 August 2018, China;
- xiii. Shahbaz Mehmood, 23rd Intergovernmental Meeting and Science Planning Group Meeting 11-12 July 2018, Thailand.

11. Effort on capacity building of GCISC young scientists through academic and specialized trainings and participation conferences, workshops etc at National level:

- i. Muhammad Zia-ur-Rahman Hashmi- participation in Third Upper Indus Basin Network Pakistan Chapter (UIBN-PC) Meeting, and Dialogue on National Awareness and Advocacy on Water Energy and Food Nexus, organized by ICIMOD at Karakorum International University, Gilgit-27-28 Jun 2019;
- ii. Amjad Masood-Participation in “Pakistan’s Climate Challenge; a talk on the evolving global framework on climate change” at Research Society of International Law (RSIL), Islamabad-27 Jun 2019;
- iii. Muhammad Arif Goheer & Muhammad Amjad participation in SNC briefing to Advisor at Ministry of Climate Change-27 Jun 2019;
- iv. Aftab Ahmad Khan participation in Seminar on Water Resources Modelling at Chairman Flood Commission Office, M/o Water Resources-27 Jun 2019;
- v. Muhammad Arif Goheer participation in Meeting on Climate Change Risk on Agriculture with Kanji Advisory Firm MD- Inshan Ali Kanji Islamabad-26 Jun 2019;
- vi. Muhammad Arif Goheer participation in Meeting on SNC at Advisor / Minister MoCC office-20 Jun 2019;
- vii. Shahbaz Mehmood participation in PMD 7th Monsoon Forum at Avari Hotel Lahore-17 Jun 2019;
- viii. Muhammad Zia-ur-Rahman Hashmi-Field visit to Study Sites in Quetta and its Surrounding, as part of the GCISC-BUITEMS Collaborative Project on “Climate Change Impacts and Adaptation in Balochistan”-17-20 Jun 2019;
- ix. Muhammad Arif Goheer participation in Meeting of the National Assembly Standing Committee on Climate Change at Parliament House-30 May 2019;
- x. Muhammad Zia-ur-Rahman Hashmi-Participation in seminar by Hungarian Team on Flood Management-27 May 2019;
- xi. Muhammad Zia-ur-Rahman Hashmi participation in 5th Meeting of the Standing Committee On Water Resources at Committee Room No. 7 (Parliament House)-20 May 2019;
- xii. Muhammad Arif Goheer participation in Meeting of the National Assembly Standing Committee on Climate Change at Committee Room of MoCC-20 May 2019;
- xiii. Muhammad Zia-ur-Rahman Hashmi participation in 1st Meeting of Prime Minister’s Committee on Climate Change at the Prime Minister’s office-17 May 2019;
- xiv. Muhammad Arif Goheer attended preparatory Meeting of the National Assembly Standing Committee on Climate Change-16 May 2019;

- xv. Muhammad Zia-ur-Rahman Hashmi & Shahbaz Mehmood participated as a Guest Speaker in a 2-day Conference being organized by the Pakistan Institute of International Affairs (PIIA) at Karachi-3-4 May 2019;
- xvi. Shahbaz Mehmood-Participated in NUST SCEE Open House-30 Apr 2019;
- xvii. Muhammad Arif Goheer participated in a Meeting on Review the Progress on the Decisions of National Climate Change Policy Implementation Committee (NCCPIC)-29 Apr 2019;
- xviii. Muhammad Arif Goheer, Muhammad Zia-ur-Rahman Hashmi, Shahbaz Mehmood, M Amjad, M Adnan & M Ijaz- Participation in Ministry of Climate Change / NDU, "Multi-Stakeholder Climate Forum" under Nationally Determined Contributions (NDC) Partnership's Technical Assistance to Government of Pakistan at Serena Hotel Islamabad-24 Apr 2019;
- xix. Shaukat Ali & Mubashar Dogar- Participation in National Institute of Health, Lecture on Environmental Health at NIH-24 Apr 2019;
- xx. Muhammad Arif Goheer- Participation in Pak-EPA / MoCC-Participation in Panel discussion Among Air Quality Experts – Earth Day at EPA Office-23 Apr 2019;
- xxi. Shaukat Ali & Muhammad Adnan- Participation in Agha Khan University and LEAD Pakistan, Dissemination Seminar on "Preparing Communities and Hospitals for Heat Waves – Lessons Learnt from Karachi at Ramada Hotel Islamabad-19 Apr 2019;
- xxii. Muhammad Zia-ur-Rahman Hashmi- Participated in Meeting of Standing Committee on Climate Change at MoCC-19 Apr 2019;
- xxiii. Muhammad Arif Goheer- Participation in UNFCCC Consultative Meeting on Climate Change Issues at Ministry of Foreign Affairs-17 Apr 2019;
- xxiv. Aftab Ahmad Khan-Participation in Field Assessment and Workshop under Balochistan Water Engagement in Balochistan- 11-16 Apr 2019;
- xxv. Muhammad Arif Goheer-Participation in 5th meeting of NDMA and UN Strategic Coordination Forum – DM (SCF – DM)-11 Apr 2019;
- xxvi. Muhammad Amjad-Attended a seminar on Managing Shared Basins Impact of Climate Change on Water Quality: A case study of the Kabul River Basin-11 Apr 2019;
- xxvii. Muhammad Arif Goheer-Attended a briefing on smart water and flood management techniques scheduled by Federal Flood Commission office - 5 April 2019;
- xxviii. Muhammad Arif Goheer participated in World Bank Consultative Session on Regional Study on Ambient Air Pollution on March 28, 2019, Islamabad;
- xxix. Muhammad Arif Goheer, Muhammad Zia-ur-Rahman Hashmi & Shahbaz Mehmood-IUCN – Attended a Joint Event of International Day of Forests & the World Water Day at Serena Hotel-22 Mar 2019;
- xxx. Muhammad Arif Goheer-Attended a meeting on Clean & Green Pakistan Movement at MoCC-21 Mar 2019;

- xxxvi. Amjad Masood & Aftab Ahmad Khan-Participation in UNESCO sponsored International Water Technology Workshop (IWTW): Water-related Disaster Risk Reduction (DRR) at NUST-21-22 Feb 2019;
- xxxvii. Muhammad Arif Goheer participated in NDM SCF meeting organized jointly NDMA and UNOCHA on 7 February 2019 at UNOCHA office, Islamabad;
- xxxviii. Aftab Ahmad Khan-Stakeholder workshop on climate change scenarios for KPK-24 Jan 2019;
- xxxix. Muhammad Arif Goheer-NDMA Meeting on Prevailing Drought Like Situation Across Pakistan-18 Jan 2019;
- xl. Shahbaz Mehmood, Qudsia Zafar & Kaleem Anwar Mir-Participation in the R-SMOG project report launch event at Lahore-17 Jan 2019;
- xli. Muhammad Arif Goheer participated in the Science-Diplomacy meeting organized by Pakistan Foreign Office on January 16, 2019, Islamabad;
- xlii. GCISC research staff participated in One day international conference on Climate Change at Bahria University-27 Dec 2018;
- xliiii. Muhammad Ijaz, Nuzba Shaheen & Aftab Ahmad Khan and Sher Shah Hassan-Training Workshop on Earth Observation Applications in Agriculture by PARC & ICIMOD at NARC-26-28 Dec 2018;
- xliiiii. Muhammad Arif Goheer, Muhammad Zia-ur-Rahman Hashmi & Shahbaz Mehmood-Meeting at GCISC on food-energy-water security early warning system project-17 Dec 2018;
- xl. Muhammad Arif Goheer-4th meeting of NDMA and UN Strategic Coordination Forum – DM (SCF – DM) at Serena Business Complex-11 Dec 2018;
- xli. Muhammad Arif Goheer, Shahbaz Mehmood, M Amjad, Syed Raheel Haider & Saqib Mushtaq-SDPI's Eleventh South Asia Economic Summit at Margala Hotel-4-7 Dec 2018;
- xlii. Muhammad Ijaz-Participation in National Consultation on Pakistan at Global Warming of 1.5-2 C: Capturing opportunities and Managing challenges by LEAD-30 Nov 2018;
- xliiii. Shahbaz Mehmood, Muhammad Adnan, Muhammad Amjad & Muhammad Ijaz-National Consultation on Pakistan at Global Warming of 1.5- 2°C: Capturing Opportunities and Managing Challenges at Islamabad Club-30 Nov 2018;
- xliv. Muhammad Arif Goheer- Participated in AHK National Centre for Rural Development (AHKNCRD) Training Course on "Climate Change: Implications & Adaptations", from 26-30 November 2018, Lecture on Climate Change and Agriculture-29 Nov 2018;
- xlv. Muhammad Zia-ur-Rahman Hashmi-Upper Indus Basin (UIB) Network, Pakistan Chapter Meeting at PGRI Building, NARC, Park Road, Islamabad-29 Nov 2018;

- xlvi. Shahbaz Mehmood-AHK National Centre for Rural Development (AHKNCRD) Training Course on “Climate Change: Implications & Adaptations”, from 26-30 November 2018, Lecture/Talk on Climate Change: Science and implications for Pakistan'-27 Nov 2018;
- xlvii. Muhammad Arif Goheer, Shahbaz Mehmood, Muhammad Ijaz & Kaleem Anwar Mir-Ministry of Climate Change / NDC Partnership Workshop on Pakistan’s Nationally Determined Contributions: Way forward for implementation of climate action at Hill View Hotel Islamabad-26 Nov 2018
- xlviii. Shahbaz Mehmood-Participated in 5th Stakeholder Meeting at NUST-14 Nov 2018;
- xliv. Amjad Masood-Participation as Guest Speaker in the 3rd International Conference on Emerging Trends in Engineering, Management & Sciences (ICETEMS) at KIU Gilgit-10-11 Nov 2018;
 - I. Muhammad Arif Goheer, Shahbaz Mehmood, Qudsia Zafar & Kaleem Anwar Mir-Research Sharing Workshop for the TCP Project (R-SMOG)-29 Oct 2018;
 - ii. Shahbaz Mehmood, Kaleem Anwar Mir & Qudsia Zafar-Result sharing workshop "Remote sensing for spatio-temporal mapping of Smog in Punjab and identification of the underlying causes using GIS Techniques (R-SMOG) by FAO-29 Oct 2018;
 - iii. Muhammad Zia-ur-Rahman Hashmi attended 6th Meeting of the National Climate Change Policy Implementation Committee (NCCPIC) under the Chairmanship of Advisor to the Prime Minister on Climate Change at MoCC-17 Oct 2018;
 - liii. Muhammad Arif Goheer-Meeting of National Project Steering Committee of the ‘Proposed Design and Evaluation of Carbon Pricing Instruments for Pakistan-11 Oct 2018;
 - liv. Muhammad Zia-ur-Rahman Hashmi-Meeting of Working Group on Science & Technology for Preparation of the 12th Five Year Plan (2018-23)- 09 Oct 2018;
 - lv. Muhammad Arif Goheer, Aftab Ahmed Khan-UNESCO – Participated and delivered presentation on “Climate Change and Food Security Issues in Pakistan” in Two Day National Expert Meeting on Climate Change and Food Security at NARC- 05-06 Oct 2018;
 - lvi. Muhammad Arif Goheer- Meeting at Planning Commission, State of Scientific Research on Climate Science and 12th Five Year Plan- 03 Oct 2018;
 - lvii. Muhammad Arif Goheer, Shahbaz Mehmood, Qudsia Zafar & Kaleem Anwar Mir participated in a meeting on R-SMOG at FAO Office in NARC-27 Sep 2018;
 - lviii. Muhammad Arif Goheer- Attended a meeting at MoCC on NDC Support to Pakistan-27 Sep 2018;

- lix. Shaukat Ali-Field visit to Gilgit under project "Studies on the Impact of Debris Cover Thickness and Temperature Variations on Glacier Melting in the Upper Indus Basin" - 17-30 Sep 2018;
- lx. Muhammad Arif Goheer-Participated and delivered a Lecture on Agriculture & climate Change, Training at PARC-13 Sep 2018;
- lxi. Qudsia Zafar-Participated in training course on Drought Management at Pakistan Academy of Rural Development (PARD), Peshawar-6-10 Aug 2018;
- lxii. Muhammad Arif Goheer-Attended Inter-Ministerial Meeting on Tackling the SMOG Issue at Ministry of Foreign Affairs-7 Aug 2018;
- lxiii. Shahbaz Mehmood-Attended a Two Day National Expert Meeting on Climate Change and Food Security- July 2018;
- lxiv. Amjad Masood-Open house at Institute of Space Technology (IST)-11 Jul 2018;
- lxv. Muhammad Arif Goheer, Muhammad Zia-ur-Rahman Hashmi & Shahbaz Mehmood-Participated in Inception workshop on GLOF-II Project by MoCC & UNDP-3-5 Jul 2018;
- lxvi. Muhammad Adnan- Participated in Workshop on "Socio-economic impact assessment of CPEC Interventions" by Centre of Excellence CPEC at PIDE-3 Jul 2018.

12. Contributions to Research Projects:

- i). R-SMOG (2018). TCP (Technical Cooperation Programme) Project between Food and Agriculture Organization of the United Nations (FAO) and Global Change Impact Studies Centre (GCISC), Ministry of Climate Change on "Remote sensing for Spatio-temporal mapping of smog in Punjab and identification of the underlying causes using GIS techniques (R-SMOG)";
- ii). GLOF and Climate Change Risk and Vulnerability Assessment Study for FWO Hydropower Projects in Chitral;
- iii). Pak-SNC (2018). "Pakistan's Second National Communication (Pak-SNC) on climate change project" under United Nations Framework Convention on Climate Change (UNFCCC) by Ministry of Climate Change (MoCC), Government of Pakistan;
- iv). FAO: Development of Food Security and Nutrition Information System (FSNIS)/Food Security Monitoring System (FSMS) for Pakistan;
- v). FAO: Transformation of the Indus Basin with the Introduction of Climate Resilient Agriculture and Sustainable Water Management;
- vi). APN: Climate smart agriculture through sustainable water use management: Exploring new approaches and devising strategies for climate change adaptation In South Asia.

13. Mass Awareness / Media Appearance:

- i. GCISC scientists published Six **(06)** news articles in various leading national newspaper;
 - a. The importance of COP24, Published on December 25, 2018 in The News
 - b. The climate clock, Published on October 27, 2018 in The News
 - c. The climate conundrum, Published on July 25, 2018 in The News
 - d. How healthy are glaciers in Pakistan? Published on 16 December 2019 in The Express Tribune
 - e. Opportunities and challenges of Pakistan's massive afforestation drive Published on 5 February 2019 on www.thethirdpole.net
 - f. Water and peace, Published on 17 October 2018 in The News
- ii. An exclusive program to highlight the climate change and associated impact was broadcasted on PTV world in which GCISC Scientists highlighted the implications of Climate Change.
- iii. Muhammad Arif Goheer-Participation in Live Radio Pakistan Programme on Environment & Agriculture Base-26 Sep 2018;

14. Capacity Building:

- Provided trainings to following BS/MS level students from various universities under GCISC Internship Program.
 - Ms. Saima Lateef d/o Malik Abdul Lateef student of Bachelor of Environmental Sciences, Bahria University Islamabad.
 - Ms. Aleena Nazir d/o Muhammad Nazir student of Bachelor of Environmental Sciences, Bahria University Islamabad.
 - Mr Mubeen Shafqat S/o Shafqat Rasul student of Bachelor of Geo-Informatics, PMAS-Arid Agriculture University Rawalpindi.
 - Mr Haseeb Muneer Asam S/o Muneer Ahmed Asam student of Bachelor of Geo-Informatics, PMAS-Arid Agriculture University Rawalpindi.
 - Ms. Hamna Khurshid d/o Muhammad Khurshid student of Bachelor of Engineering in Geo-Informatics, Institute of Geographical Information Systems (IGIS) NUST, Islamabad.
 - Ms. Sidra Nadim d/o Muhammad Nadim Ahmad student of Bachelor of Engineering in Geo-Informatics, Institute of Geographical Information Systems (IGIS) NUST, Islamabad.
 - Ms. Nazia Parveen d/o Safdar Khan student of Bachelor of Geo-informatics & Remote Sensing, PMAS Arid Agriculture University Rawalpindi.

- Ms. Kaenat Gul d/o Umer Gul student of Bachelor of Geo-informatics & Remote Sensing, PMAS Arid Agriculture University Rawalpindi.
- Ms. Mahnoor Waqar d/o Khawaja Waqar Ahmed student of Bachelor of Geo-informatics & Remote Sensing, PMAS Arid Agriculture University Rawalpindi.
- Mr Muhammad Usama Zaheer S/o Zaheer Ahmad student of Bachelor of Geo-Informatics, PMAS-Arid Agriculture University Rawalpindi.
- Mr Muhammad Haris Rehman S/o Muhammad Qurban student of Bachelor of Geo-Informatics, PMAS-Arid Agriculture University Rawalpindi.
- Mr Mubashir Ali S/o Muhammad Akhtar Hussain student of Bachelor of Geo-Informatics, PMAS-Arid Agriculture University Rawalpindi.
- Mr Muhammad Hamza Dar S/o Sajid Mahmood Dar student of Bachelor of Geo-Informatics, PMAS-Arid Agriculture University Rawalpindi.
- Ms Tooba Amjad d/o Amjad Ali Qureshi student of Bachelor of Geo-Informatics, PMAS-Arid Agriculture University Rawalpindi.
- Ms Safa Arif d/o Arif Baig student of Bachelor of Geo-Informatics, PMAS-Arid Agriculture University Rawalpindi.
- Ms Zainab Asad d/o Asad Ullah student of Bachelor of Agricultural Engineering, University of Engineering & Technology (UET) Peshawar.
- Mr Asif Rehman d/o Ghani Ur Rehman student of Bachelor of Agricultural Engineering, University of Engineering & Technology (UET) Peshawar.
- Mr Muhammad Haris d/o Mukhtiar Ali student of Bachelor of Agricultural Engineering, University of Engineering & Technology (UET) Peshawar.

15. Organization of Seminars:

GCISC organized a number of Seminars for sharing of information/ enhancement of scientific knowledge of its researchers.

- i. GCISC's contribution in the 'Balochistan Water Engagement - Leaving No One Behind', Aftab Ahmad Khan, Scientific Officer, GCISC- 26 April 2019;
- ii. Climate Adaptation Governance and Role of Sub National Governments, Dr Muhammad Mumtaz, Sao Paulo School of Management (EAESP), Brazil- 19 April 2019;
- iii. In Hydropower relevant to the National Grid in the age of declining VRE Cost, M Waqar Ahmed Khan, CEO of Star Hydro Power Limited- 12 April 2019;
- iv. Future Projections of Head Waves in Pakistan Using Ensemble NEX-GDDP Data Set, Jahangir Ali, Researcher- 29 March 2019;

- v. Effective Proposal Writing for Securing Research Funding, Dr Attiq Ur Rahman, Project Management Consultant- 22 March 2019;
- vi. Research in the Age of Adaptation, Dr Adil Najam, Inaugural Dean of the Frederick S. Pardee School of Global Studies at Boston University- 15 March 2019;
- vii. Report on progress of the CGE Meeting at UNFCCC Office Germany, Muhammad Arif Goheer, Head Agriculture & Coordination, GCISC- 08 March 2019;
- viii. Approaches for 1.5 Degrees: Which path to Halting Climate Change, Muhammad Amjad, Senior Scientific Officer, GCISC- 08 February 2019;
- ix. The upcoming UN Environment's Global Environment Outlook 6 (GEO6) Report, History, Assessment & Review Process, Muhammad Ijaz, Senior Scientific Officer, GCISC- 25 January 2019;
- x. Towards Enhanced Climate Action Transparency Framework: Challenges & Opportunities for Pakistan on Being Elected as a Member of CGE in UNFCCC, Muhammad Arif Goheer, Head Agriculture & Coordination, GCISC- 11 January 2019;
- xi. Glacial Lake Outburst Floods: Threatening the Livelihood of Mountain Communities in Northern Pakistan, Imran Khan, Research Associate, Social Development, Islamabad- 04 January 2019;
- xii. Spatio-temporal Assessment of Precipitation Responses to Vegetation Indices and crop yield in an irrigated and Rain Fed Unit Using Google Earth Engine, Aftab Ahmad Khan, Scientific Officer, GCISC- 07 December 2018
- xiii. How the Monsoon Rainfall over Pakistan is Different from the Main South-Asian/ Indian Summer Monsoon, Dr Faisal Saeed, Climate Expert, Pakistan Meteorological Department, Islamabad- 30 November 2018;
- xiv. Importance of Science Education and Research According to the Teaching of Prophet Muhammad (PBUH), Hafiz Masood Alvi, Dars E Nizami Graduate- 16 November 2018;
- xv. Remote Sensing of Air Pollution that people can see: A Bulging Challenge in Big Cities under Climate Change, Dr Imran Shahzad, Associate Head, Department of Meteorology, Comsats University, Islamabad- 09 November 2018;
- xvi. Human Faces of Climate Change, Laila Kiran, Filmmaker-Researcher, Climate Impacts- 26 October 2019;
- xvii. Fate of Future Food Security of Pakistan Under Warming Extremes, Nuzba Shaheen, Senior Scientific Officer, GCISC- 19 October 2019;
- xviii. IPCC Special Report on the Impact of Global Warming of 1.5 C - An Overview, Shahbaz Mehmood, Head Climatology, GCISC- 12 October 2019;
- xix. Impact of Debris Cover on Glacier Melting in Karakoram, Shaukat Ali, Senior Scientific Officer, GCISC- 05 October 2019;

- xx. Educational Reforms Needed to Address Modern Era Challenges Including Climate Change, Umair Qureshi, CEO, Leader in Edu & Academic Development (Pvt) Ltd.- 28 September 2018;
- xxi. Emission Picture of Pakistan's Agriculture: Historical Trends and Baseline Projections Under Food Security Scenarios, Muhammad Ijaz, Senior Scientific Officer, GCISC- 14 September 2018;
- xxii. Study of the Global and Regional Impacts of EL-NINNO Oscillation Magnitude Using ICTP AGCM, Mubashar Dogar, Scientific Officer, GCISC- 07 September 2018;
- xxiii. IPCC-AR6 WG-I-Recent Lead Author Meeting: Overview and Progress, Muhammad Adnan, Statistical Climatology Researcher at GCISC- 31 August 2018;
- xxiv. GCISC's participation in the Inception Workshop of the NSFC-ICIMOD Project "Glacier changes and associated hydrologic impact under warming climate in Hunza Valley along the Sino-Pakistan Economic Corridor (CPEC)", Muhammad Zia-ur-Rahman Hashmi, Head Water Resources & Glaciology, GCISC- 17 August 2018;
- xxv. IPCC First Lead Author Meeting - AR6 WGI - Challenges in Assessment, Mr. Muhammad Amjad, Senior Scientific Officer, GCISC- 10 August 2018;
- xxvi. Country level quantification of GHGs emissions: Training Programme in Korea: Proceedings, Lessons learnt for Pakistan and Invaluable Moments, Engr. Kaleem Anwar Mir, Scientific Officer, GCISC- 03 August 2018;
- xxvii. Atmospheric composition, data assimilation and climate change, Dr. Faheem Khokhar, IESE-NUST- 27 July 2018;
- xxviii. Comparison between statistical and dynamical downscaling of rainfall under Representative Concentration Pathways scenarios over the Gwadar-Ormara basin, Pakistan, Engr. Raazia Attique, M.Sc Geo-Information Sc. and Earth Obs. with specialization in Water Resources and Environmental Management- 13 July 2018;
- xxix. Water Resources and Food Production in the Basins of the Hindu-Kush Himalaya (HKH): Quantification of Critical Moments and Adaptation Turning Points" (A component of the HI-AWARE Project), Qurat ul Ain Ahmad, Senior Scientific Officer-GCISC, Ph.D candidate at the Wageningen University, Netherlands- 06 July 2018.

16. Other Important Assignments:

General Administrative/ Technical Functioning:

- Provision of Scientific assistance to Ministry of Climate Change and other Government Departments regarding Climate Change assessment impacts etc. on as and when desired basis;
- Vetting/ approval process of Draft Employees Service Rules for GCISC is under process at Finance Division. GCISC's views on some critical

observations were conveyed in a meeting with Finance Division held on 17 May 2019 for further action by Finance Division;

- Submission of response to Ministry of Climate Change on National Assembly/ Senate's Starred/ Un-starred Questions and Motions and other queries and concerns raised by Ministry of Climate Change (MoCC) and other institutions;
- Prompt actions were taken and required information/ Reports were submitted to concerned quarters. Various in-house seminars and trainings events were successfully organized and the capacity of the scientists was built.

17. Collaborative Climate Change Related Research Studies:

(a) University Consortium:

TITLE OF STUDY	INSTITUTION
Identification of shifts in cropping patterns under 2 °C scenario	UAF-USPCAS-AFS
Obstacles to the adoption of climate friendly technologies in the farmer fields and possible solutions	UAF-USPCAS-AFS
Renewable Energy Technology Manufacturing Status in Pakistan and Future Road Map for Global Competitiveness	NUST
Quantification of the Impact of Climate Change on Electric Power Sector of Pakistan	NUST
Prospects of Renewable Energy in Pakistan to Meet INDC Commitments	NUST
Coping with the reducing water availability in the Indus Basin of Pakistan through changes in the Cropping Pattern	PCRWR
Re-allocation of water allowance in the irrigated area of Indus Basin under changing cropping pattern and climate	PCRWR
Energy Efficiency in Public Transport for City of Karachi, Pakistan	NED KHI
A Strategy of Enabling Pakistan's Construction Industry to Climate Friendly Buildings	NED KHI
Climate Change Impacts on the local Ecosystems of Kashmir Himalayas	University Of AJ&K
Hydrological information collection for improved agricultural water management as an enabler for broader climate informatics	LUMS
Assessment of Climate Change Impacts on rain-fed cropping systems under 2 °C scenario	PARC
Assessment of Climate Change Impacts on insect-pest proliferation in cotton-based cropping systems of Pakistan	PARC

Assessment of Climate Change Impacts on livestock production, adaptation and mitigation strategies	PARC
Climate Change and Future Climate Extremes & Rainfall Variability	PMD
Cost and benefit analysis of the Indus water supply to Quetta project	BUIITEMS
Future drought risk and adaptive capacity in Balochistan (including role of 100 dams project and CPEC)	BUIITEMS
Groundwater management and solar energy nexus in Balochistan	BUIITEMS
Spatio-temporal analysis of variation in soil salinity levels in the Indus delta using field and remote sensing data	MUET
Developing a linkage/relation of the current soil salinity profiles (observed spatially and vertically using state of the art field equipment/instruments) with the changes in freshwater supplies downstream of Kotri	MUET
Coastal area inundation under different sea level rise scenarios and estimation of associated environmental/economic loss	MUET
Study on the potential distribution of tree species and shifting of the tree species lines based on future climate change scenarios	IST
The health impacts of heatwaves over different regions of Pakistan / identification of vulnerable regions in Pakistan to heatwaves	NIH
The impacts of future climate changes in temperature on the movement of disease vector	NIH
To evaluate the health vulnerability to climate change and capacity of the public health system to cope with epidemics	NIH
Impact of debris cover thickness and temperature variations on glacier melting (in relation to Karakoram Anomaly) in the Upper Indus Basin	YU
Prospects of crop production in the mountainous ecosystems under changing climate	KIU
Climate induced disasters: community-based response to GLOFS	KIU
Spatio-temporal dynamics of greenhouse gas emissions from soils under various forest types of Pakistan	PMAS-UAAR
Development of database to submit Forest Reference Emission Levels (FRELs) for implementing REDD+ in Pakistan	PMAS-UAAR
Mobilizing climate finance for Pakistan's development agenda	PIDE
Payments of ecosystem services (for global, Regional and local scale) for KPK forests	PIDE
Assessment of Climate Change Impacts on wheat-rice and wheat-Miscellaneous cropping systems under 2 °C scenario	UAF

Assessment of Climate Change Impacts on high value crops under 2 °C scenario	UAF
Technical Manual on Climate Change Education and Awareness	SDPI
Linkages of climate change, ELAs and Zero-Degree isotherms in the Karakoram Himalayas (selected basins)	UET Peshawar

(b) GCISC Senior Fellows:

S#	NAME	AFFILIATION	EXPERTISE	Research Study
1	Professor Sajjad Ahmad	University of Nevada, Las Vegas, USA	Integrated Water Resource Management	Climate change impact on Pakistan's groundwater availability
2	Professor Saleem Hassan Ali	University of Delaware, USA	National Resources	Sustainable Mining
3	Professor Steve Burian	University of Utah, USA	Climate Impacts	Upper Indus Water Resilience Under Climate Change Scenarios
4	Dr. Tom Downing	President and CEO Global Climate Adaptation Partnership, Oxford, UK	Climate Adaptation Modeling	Climate change adaptation in the irrigated farming region of Indus Basin
5	Professor Rick Forster	University of Utah, USA	Glaciology	High Elevation climate change and its impact on UIB cryosphere
6	Professor Adil Najam	Boston University, USA	Climate Change and Sustainable Development	Status of Climate Change in Pakistan; Science's message to policy makers
7	Dr. Youba Sokona	South Centre, Geneva, Switzerland	Climate Change and Energy Systems	Climate change and energy systems
8	Dr Saleemul Huq	Director, International Centre for Climate Change & Development (ICCCAD), Bangladesh	Climate Change Adaptation	Bridging Climate action and Sustainable Development Goals
9	Professor Asim Zia	University of Vermont, USA	Climate Policy	Early Warning Systems for Food, Water and Energy in Indus Basin