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

YEAR BOOK (2024-25)
(in pursuance of Rule 25 of Rules of Business 1973)

1. INTRODUCTION

The Global Climate-Change Impact Studies Centre (GCISC) was first set up in April 2002 as a development project to study climate change, its effects, and possible solutions. Later, it became a formal organization through the GCISC Act of 2013, passed by Parliament and published in the Gazette of Pakistan on March 26, 2013 (Act No. XVII of 2013), and later updated in 2023. Under this Act, GCISC functions as a corporate body managed by a Board of Governors, chaired by the Federal Minister in charge of the Ministry responsible for climate change.

The Centre is tasked with conducting scientific research on climate change at regional and sub-regional levels and assessing its effects on different sectors of socio-economic development. Its goal is to help the country prepare for and address the risks posed to water resources, agriculture, ecosystems, energy, health, and biodiversity.

2. ROLES & FUNCTIONS

GCISC, under the Act, is tasked with three functions, namely research, capacity building, 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 glaciers, aggregate and seasonal flows in the Indus River System, and changes in the hydrological extremes across the country.

- ***Agriculture, Forestry & Land Use****:* use of crop simulation models to predict the impact of projected changes in temperature, precipitation, and water availability on agriculture and food security of the country and to assess the impacts on 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 raise awareness of climate change among policymakers as well as the citizenry.

3. ACTIVITIES

The key research activities of the Research Sections revolve around following themes:

I. Climatology & Environment Section

The Climatology & Environment Section research areas focus on key aspects of climate variability and change, which can be summarized as follows:

- To assess historical climate trends over Pakistan and its regions;
- Climate profiling of Pakistan based on IPCC future climate scenarios (RCPs, SSPs etc.);
- To generate up-to-date information on changes in near to long term climate extremes and to study associated impacts;
- Study variations in summer monsoon patterns for impact assessments;
- High resolution climate information for future urban climate issues
- Intra seasonal to inter decadal climate predictions;
- Integrated modeling of air pollution and greenhouse gas emissions;
- Development & updating of GHG inventory of Pakistan for energy & industrial processes sectors;

II. Water Resources & Glaciology Section

- Application of advanced hydrological, cryospheric, and AI-based models to assess spatial and temporal variability of water availability and flows in the Indus River System (IRS) under updated socio-economic and climate scenarios.
- Climate change assessment for the Hindukush–Karakoram–Himalaya (HKH) region, focusing on impacts on hydrological extremes, droughts, and water resources at seasonal to sub-seasonal scales.

- Development of drought prediction tools and adaptation strategies aligned with national Climate Change and Water Policies to strengthen water security.
- Identification of spatio-temporal climate extremes (dry and warm phases) and their influence on surface and groundwater resources.
- Dissemination of research outputs through scientific publications, policy briefs, and media engagement.
- Capacity building, awareness, and institutional collaboration at national and international levels to enhance research and policy integration.

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;
- Assess food security in the face of future climate change and especially under reduced availability of irrigation water;
- Devise adaptation measures, including smart agriculture;
- Studies on water, food, energy nexus;
- Updating GHG emissions from agriculture, forestry and land use and waste sectors.
- Research dissemination (International and national science journals and books, newspaper articles and policy briefs etc.)
- Capacity building and awareness raising

4. GOALS & TARGETS

Over the year, GCISC contributed significantly to the international scientific discourse on climate change and its associated impacts, while providing valuable technical inputs to a range of research initiatives. The Centre also organized a series of workshops and seminars to disseminate knowledge, foster dialogue, and enhance awareness on critical climate-related issues.

The following is a summary of the accomplishments in 2024-25:

- Publication of key research findings in scientific journals = 23
- Contribution towards technical reports = 15
- Organization of scientific activities/workshops/seminars for information dissemination and awareness = 20

- Scientific contributions/ presentations and effort on capacity building of GCISC young scientists through academic and specialized trainings and participation in online conferences, workshops etc. at International level (Nos) = 31
- Effort on capacity building of GCISC young scientists through academic and specialized trainings and participation in conferences, workshops etc at National Level (Nos) = 98
- Scientific Contributions and Presentations in National Conferences and Workshops = 61
- Provision of training to university students across Pakistan in the field of climate change through GCISC internship program = 33
- Responses to NA/Senate starred questions and provided inputs (presentations/ briefs) for NA Standing Committee on Climate Change on the aspects of Climate Change = 15
- GCISC entered into several Memorandum of Understandings (MoUs) to enhance institutional collaboration, foster joint research efforts, and support the advancement of Pakistan's climate science and policy goals.
- Muhammad Arif Goheer, Executive Director of GCISC, served as a member of the UNFCCC Technology Executive Committee (TEC)**.** He actively contributed to the preparation of key reports, policy briefs, and sub-committee activities, supporting global efforts to enhance technology development and transfer for climate change mitigation and adaptation.
- Two GCISC scientists have been selected to serve as Lead Authors for the Seventh Assessment Cycle of the IPCC, contributing their expertise to the development of global scientific assessments on climate change.
- Muhammad Arif Goheer, Executive Director of GCISC, served as a Member of the Technical Expert Group (TEG) on Environment and Development under UNESCAP, contributing his expertise to regional initiatives and policy discussions on sustainable development and environmental management.
- Muhammad Arif Goheer, Executive Director–GCISC: Contributed in "Science Communication & Diplomacy Series-2: Addressing Climate Change through Effective Science Communication in OIC Member Countries"; A COMSTECH Publication (ISBN: 978-969-487-025/1/2024).
- Shahbaz Mahmood, Head of Climatology & Environment at GCISC, served on the Scientific Steering Committee of ScenarioMiP/WCRP**,** contributing to the design of scenarios for CMIP7 climate model experiments under the IPCC AR7**.**
- GCISC remained actively engaged in UNFCCC Technical Expert Review (TER) processes in 2024–25. One scientist from the Centre served as expert reviewer for Italy's GHG Inventory in Agriculture sector (2025), ensuring consistency with the Paris Agreement's Modalities, Procedures and Guidelines (MPGs).
- GCISC played a key role in developing Pakistan's Third National Communication (TNC)**,** submitted to the UNFCCC in June 2025**.** The Centre provided scientific

and technical inputs, including climate data analysis, greenhouse gas inventories, and vulnerability assessments, contributing to a comprehensive national report that highlights Pakistan's progress and challenges in addressing climate change.

- A National Greenhouse Gas (GHG) Inventory Management System has been established, ensuring the preparation of inventories on a biennial basis. Country-specific emission factors (Tier methodologies) are being developed for key sectors to enhance the accuracy and consistency of national emissions reporting.
- Operationalization of the National Measurement, Reporting, and Verification (MRV) System to ensure timely, accurate, and transparent climate data reporting in alignment with international climate transparency and compliance obligations.
- Development of a comprehensive climate change curriculum at the tertiary level to equip university students with the knowledge and skills necessary for informed climate action and policy engagement.
- The preparation and submission of Pakistan's third Nationally Determined Contributions (NDC 3.0) in fulfillment the country's international reporting obligations under the Paris Agreement and to reaffirm its commitment to global climate action.

5. ACHIEVEMENTS & SALIENT RESEARCH FINDINGS

A) Research

CLIMATOLOGY

a. Future climate projections for Pakistan: Insights from CMIP6 GCMs of IPCC AR6:

The research findings of Global Climate-Change Impact Studies Centre (GCISC), as show in Fig. 1, present a comparative analysis of annual mean temperature anomalies for Pakistan and the global average relative to the 1961–1990 baseline period. Notably, Pakistan's warming appears more pronounced and variable compared to the global trend, particularly from the late 1990s onwards, where the anomalies frequently exceed 1.0°C above the baseline.

Similarly, as per GCISC's latest research findings based on IPCC-AR6 SSP scenarios, Pakistan is likely to experience more intense warming than the global average across all future scenarios, especially under high-emission pathways as depicted in Fig 2. In the near term, Pakistan is projected to warm slightly more than the global average in all scenarios. For instance, under SSP1-2.6, Pakistan warms by 1.0°C compared to the global 0.7°C. In the long term, the warming gap between Pakistan and the globe widens significantly, particularly under high-emission pathways. Under SSP5-8.5, global temperatures are expected to rise by 4.0°C, while Pakistan could experience a much higher 5.8°C increase, highlighting Pakistan's

greater climate sensitivity and regional amplification of global warming. This stark rise highlights the country's heightened vulnerability to climate change reinforcing the urgent need for aggressive mitigation globally and robust adaptation strategies nationally to protect vulnerable sectors such as water, agriculture, and public health.

Consequently, the country faces disproportionately severe climate impacts owing to its geographic location, socio-economic conditions, and dependence on climate-sensitive sectors. The communities, across the country, are increasingly exposed to a spectrum of escalating climate hazards that vary in intensity and nature by region. In the northern mountains of Gilgit-Baltistan, record-breaking summer temperatures of up to 48.5 °C in 2025 have accelerated glacial melt, triggering unstable glacial lakes and deadly flash floods and landslides that have claimed lives, destroyed vital infrastructure, and displaced communities. In 2025, the rainfall from June 24 to July 23 was 10% to 15% heavier because of climate change, leading to many building collapses in urban and rural Pakistan. The government has reported at least 300 deaths and 1,600 damaged houses due to the floods, heavy rain and other weather during this period. On the other hand, an intense heatwave in June 2024 in Sindh claimed more than 568 lives, with hospitals in Karachi overwhelmed with heatstroke patients. Similarly, the rainfall between September 2024 and mid-January 2025 was 40% below normal, leaving parts of Sindh, Balochistan, and Punjab dry and pushing communities toward drought conditions, exacerbating water scarcity and agricultural losses. The geographic spread of these hazards, from melting glaciers in the north to lethal heatwaves in the south, and from flash floods in the highlands to prolonged droughts in the plains, underscores the country's acute exposure to climate extremes.

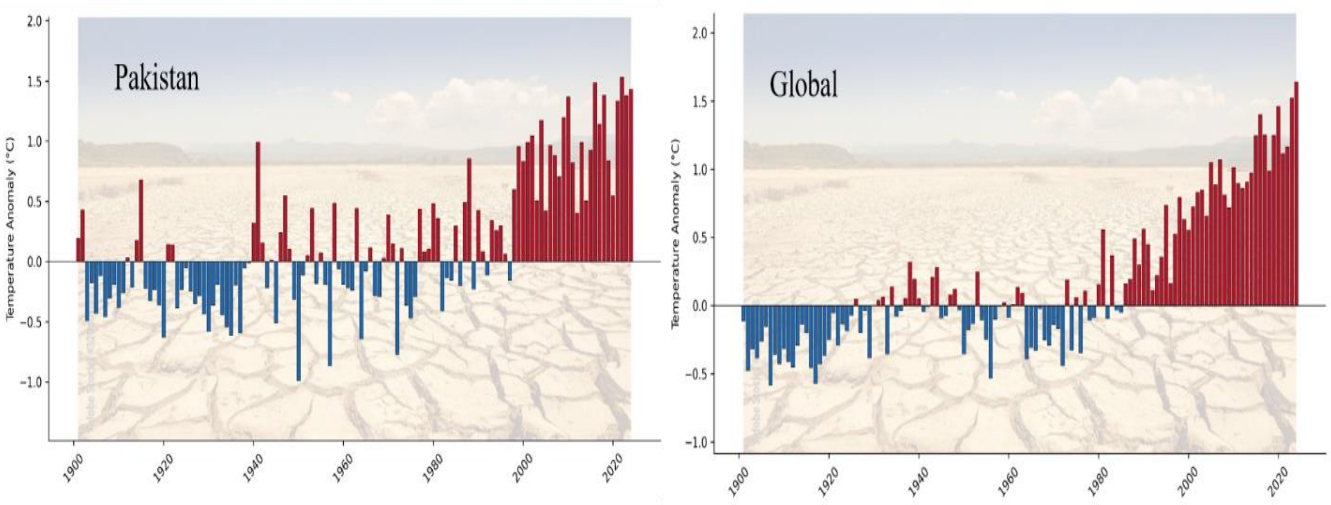
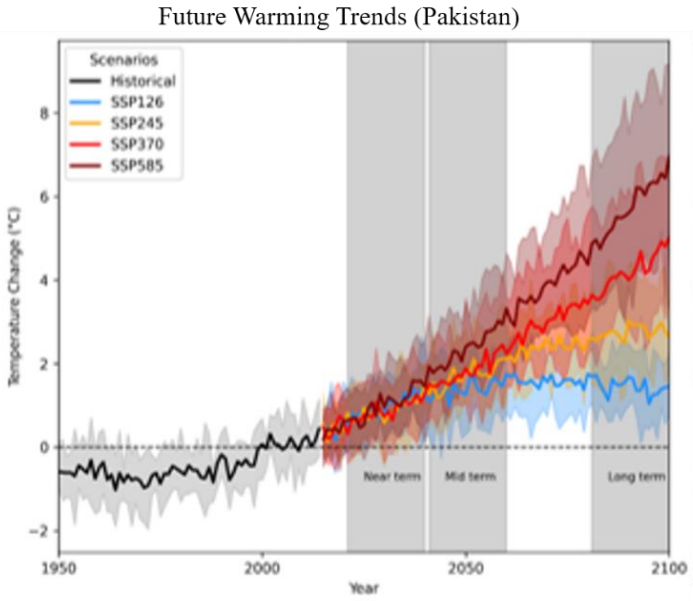


Fig. 1: Mean temperature change; Pakistan vs Global w.r.t 1961–1990 – **GCISC Research Findings**.



Projected Temperature Changes (Global & Pakistan)

Scenario	Near Term (2021–2040)		Long Term (2081–2100)	
	Global	Pakistan	Global	Pakistan
SSP1-2.6	0.7 °C	1.0 °C	1.2 °C	1.4 °C
SSP2-4.5	0.7 °C	0.9 °C	2.0 °C	2.8 °C
SSP3-7.0	0.7 °C	0.9 °C	3.1 °C	4.2 °C
SSP5-8.5	0.8 °C	1.1 °C	4.0 °C	5.8 °C

Source: Lee et al., 2021; IPCC AR6 WGI Chapter 4)

Fig. 2: 21st century climate warming trends over Pakistan (left) and comparison of projected temperature changes over Pakistan with the global changes – **GCISC Research Findings**.

b. The impact of tropical sea surface temperature on extreme precipitation in Pakistan during the summer of 2022:

In August 2022, Pakistan experienced an unprecedented precipitation event that caused significant damage. Analysis of the observations reveals that this extreme rainfall is primarily driven by anomalous atmospheric zonal advection, resulting in an anomalous water vapor concentration in Pakistan. The climatological meridional advection also contributes to this flooding. Anomalous easterly winds and low-level vertical convection combine to be critical factors contributing to the moisture concentration over the country (Fig. 3).

Further investigation identifies the air-sea interaction over the tropical Indian Ocean and abnormal warming over the Arabian Sea are crucial factors influencing this extreme flooding event. The concurrent occurrence of a negative Indian Ocean Dipole event and the warming sea surface temperature anomalies in the northern Arabian Sea intensifies the easterly winds over Pakistan, helping to transfer the anomalous water vapor from the remote region into Pakistan, ultimately contributing to the extreme flooding in 2022 (Fig. 4).

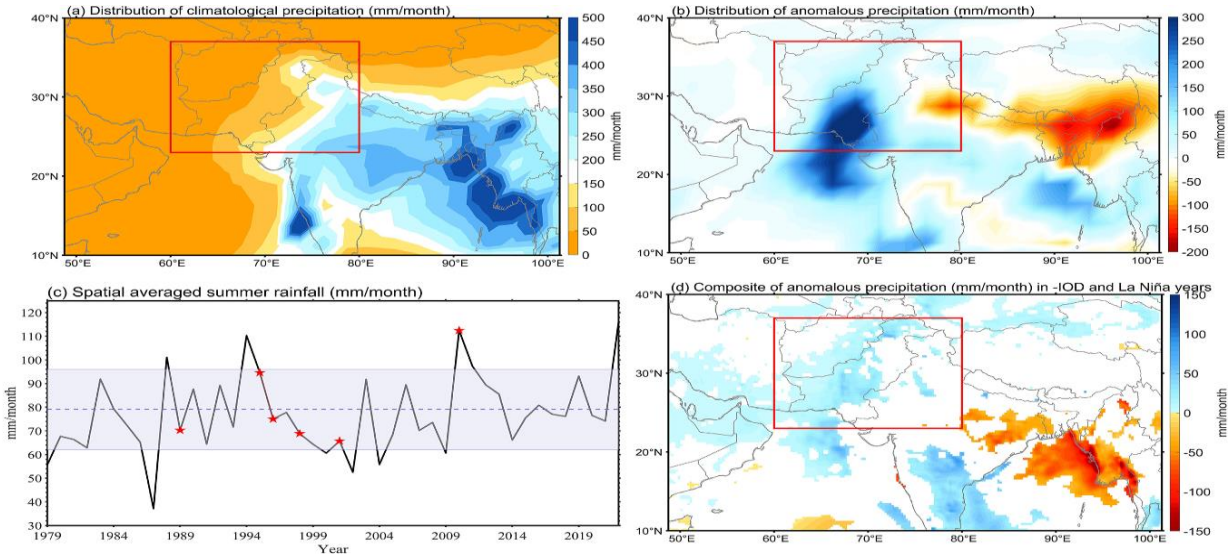


Fig. 3: *(a) Climatological precipitation in August. (b) Anomalous distribution of precipitation in August 2022. The location of the red box is 23◦ N–37◦ N, 60◦ E–80◦ E. (c) Time series of averaged Pakistan rainfall in the summer season. The red points indicate the years of negative IOD and La Ni˜na. (d) The composite map of precipitation anomaly in August season during LaNi˜na and negative IOD events.*

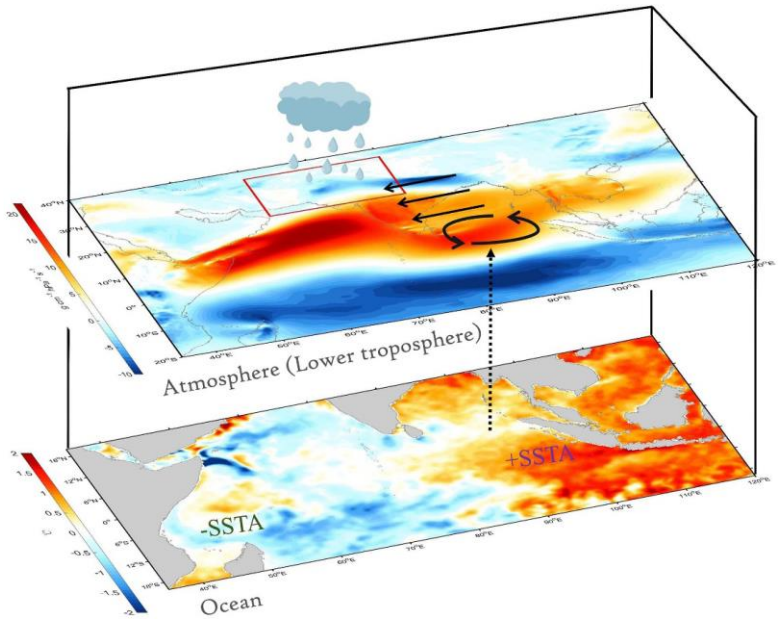


Fig. 4: *Schematic map of the mechanism responsible for the flooding in Pakistan. In the upper layer (lower troposphere), the shading indicates the water vapor transportation in August 2022 (g · cm−1 · hPa−1 · s−1), the red box is the study region, and the black solid vectors denote atmospheric circulation. In the bottom layer (ocean), the shading denotes SSTA in August 2022 (◦C), and the dashed line indicates the atmospheric circulation is stimulated with the local SSTA distribution*

c. Characterization and source identification of PM2.5 during intense haze episodes in an urban environment of Lahore:

In the backdrop of persistent haze occurrences affecting Southeast Asia and Pakistan's environmental landscape, this study delves into an in-depth analysis of atmospheric Particulate Matter (PM2.5) during intense haze episodes prevalent in Lahore throughout October, November, and December 2019. Employing advanced analytical techniques encompassing Scanning Electron Microscopy (SEM) coupled with Energy-Dispersive Spectroscopy (EDX), X-ray Diffraction (XRD), and Raman Spectroscopy (RS), this investigation meticulously scrutinized PM2.5 samples. The findings showcased substantial variability in PM2.5 concentrations, peaking notably in December within the range of 43.2–301 μgm−3, averaging 168 ± 88.3 μgm−3, whereas lower concentrations ranging from 30.9 to 268 μgm−3, with an average of 106 ± 66.1 μgm−3, were observed in October. These concentrations displayed correlations with meteorological parameters, demonstrating a direct association with relative humidity and varying relationships with temperature and wind speed. The maximal PM2.5 concentrations aligned with lower temperatures (19.1 °C), while higher temperatures (26.1 °C) coincided with the lowest concentrations, illustrating distinct relationships with relative humidity percentages and wind speeds. Advanced spectroscopic analyses (RS and XRD) confirmed the presence of various minerals and elements within PM2.5 samples, encompassing calcite, calcium aluminosilicate, hematite, barite, quartz, gypsum, organic carbon, and nineteen elements identified by EDX. Morphological evaluations unveiled diverse particle shapes, from round, pointed, and irregular to rod-like, and agglomerate structures. SEM investigations delineated distinctive groups of anthropogenic and geogenic particles, emphasizing emission sources such as automobile emissions, crop residue burning, biomass burning, construction activities, soil dust, and industrial emissions. This comprehensive study lays the groundwork for source apportionment, vital for understanding consequential impacts on climate, visibility, and human health, fostering future investigations in this domain (Fig. 5).

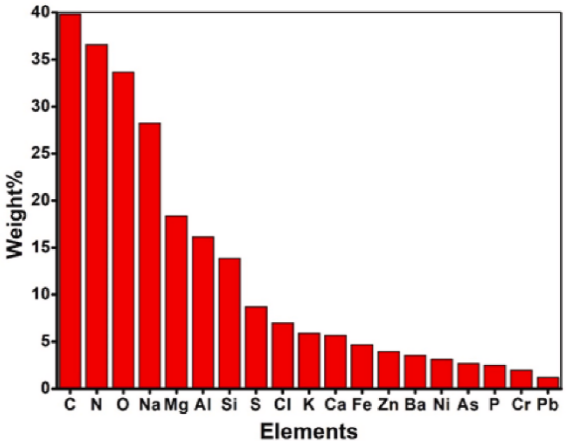


Fig. 5: *The average weight percent of individual elements in the study area.*

d. Association of precipitation extremes and crops production and projecting future extremes using machine learning approaches with CMIP6 data:

Precipitation extremes have surged in frequency and duration in recent decades, significantly impacting various sectors, including agriculture, water resources, energy, and public health worldwide. Pakistan, being highly susceptible to climate change and extremes, has experienced adverse events in recent times, emphasizing the need for a comprehensive investigation into the relationship between precipitation extremes and crops production. This study focuses on assessing the association between precipitation extremes on crops production, with a particular emphasis on the Punjab province, a crucial region for the country's food production (Fig. 6). The initial phase of the study involved exploring the associations between precipitation extremes and crops production for the duration of 1980-2014. Notably, certain precipitation extremes, such as maximum CDDs (consecutive dry days), R99p (extreme precipitation events), PRCPTOT (precipitation total) and SDII (simple daily intensity index) exhibited strong correlations with the production of key crops like wheat, rice, garlic, dates, moong, and masoor. In the subsequent step, four machine learning (ML) algorithms were trained and tested using observed daily climate data (including maximum and minimum temperatures and precipitation) alongside model reference data (1985-2014) as predictors. Gradient boosting machine (GBM) was selected for its superior performance and employed to project precipitation extremes for three distinct future periods (F1: 2025-2049, F2: 2050-2074, F3: 2075-2099) under the SSP2-4.5 and SSP5-8.5 derived from the CMIP6 (Coupled Model Intercomparison Project Phase 6) archive. The projection results indicated an increasing and decreasing trend in CWDs (maximum consecutive wet days) and CDDs, respectively, at various meteorological stations. Furthermore, R10mm (the number of days with precipitation equal to or exceeding 10 mm) and R25mm displayed an overall increasing trend at most of the stations, though some exhibited a decreasing trend. These trends in precipitation extremes have potential consequences, including the risk of flash floods and damage to agriculture and infrastructure. However, the study emphasizes that with proper planning, adaptation measures, and mitigation strategies, the potential losses and damages can be significantly minimized in the future.

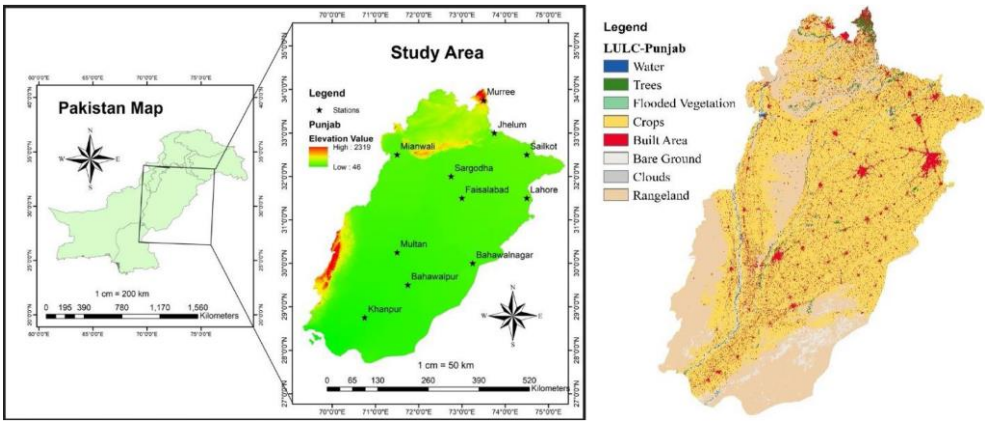


Fig. 6: *Area under study with the geographical presentation of the selected stations located in Punjab province, Pakistan is given in the left-side panel while the land use and land cover is presented in the right-side panel. The unit of the elevation is meters above mean sea level. The land use and land cover data are acquired from Senintinel-2 with the resolution of 10 m.*

WATER

e. CMIP6-Based Climate Projections and Trends for exploring Adaptations and Policies in Pakistan

Pakistan is largely dependent on agriculture; climate change induces considerable complexities for its anthropogenic systems, requiring detailed climate projections at fine spatio-temporal scales. This study employs bias-corrected daily climate data based on 13 CMIP6 General Circulation Models (GCMs), which were validated against CRU TS4. 03 datasets to comparatively assess past and projected climate conditions among SSP245 and SSP585 pathways. For two cropping season (Rabi, and Kharif) temperature and precipitation trends were investigated for Pakistan's main agricultural provinces, Punjab and Sindh. Mann-Kendall and Sen's slope tests were employed to investigate temperature and precipitation variations over time and space. Our CMIP6 based results reproduce reliable historical data both spatially and temporally, supporting its use in regional climate impact studies (Fig. 7). At national scale, Tmin increase more than Tmax. In SSP585, Tmin is projected to increase by 5.22°C, while Tmax is expected to rise by 4.02°C, by 2100. Precipitation too has a more or less steady upward trend by 28% and 53% under SSP245 and SSP585, respectively. Summer and winter temperatures increase strongly in Punjab. Tmin is likely to rise between 1.6°C–4.8°C by 2100 across the different scenarios. Summer precipitation rises moderately under SSP245 at around 20–40% and increases steeply up to 100% under SSP585. In Sindh, both summer and winter temperature increases follow similar trends; summer Tmax can reach up to 4°C in SSP585. Precipitation in Sindh may increase as much as 187% during the summer season in late century. Under SSP585, projections of increasing temperatures indicate growing trends of heat stress across Pakistan, which is impactful for agricultural productivity and water resource management.

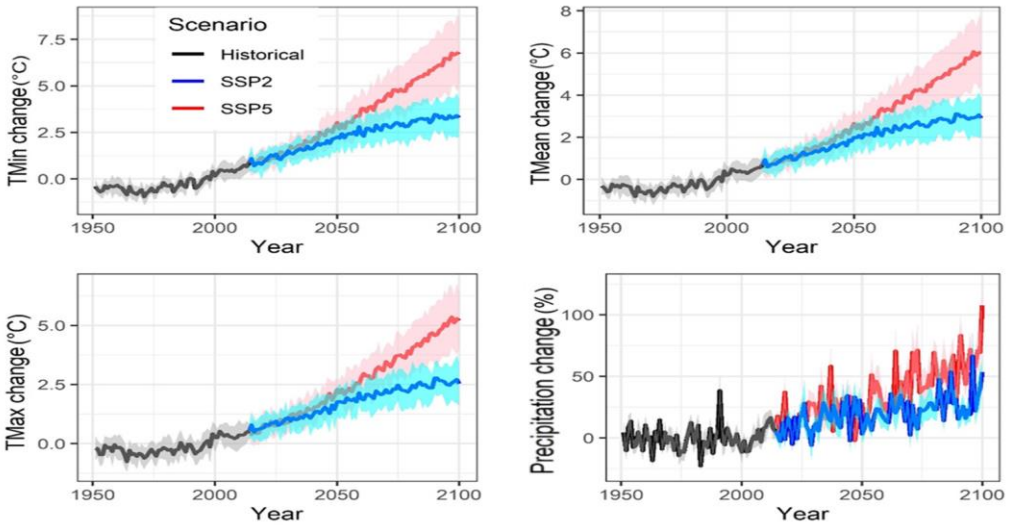


Figure 7: *Temporal evolution of historical and projected changes in minimum temperature (Tmin), mean temperature (Tmean), maximum temperature (Tmax), and precipitation over the study region for the period 1950–2100. Historical changes are shown relative to the reference period, while future projections are presented for the mid- to late-21st century under two emission scenarios, SSP2 (moderate emissions) and SSP5 (high emissions). Shaded bands indicate the associated uncertainty ranges across model simulations.*

The results in Figure 7 indicate robust warming across all temperature indices, with substantially greater increases under the high-emissions scenario (SSP5) compared to the moderate-emissions pathway (SSP2). By the end of the century, minimum, mean, and maximum temperatures rise by about 2–3 °C under SSP2 and 5–7 °C under SSP5, with stronger nighttime warming suggesting a reduced diurnal temperature range. Precipitation is also projected to increase, by roughly 20–40% under SSP2 and 40–100% under SSP5, accompanied by greater variability. Overall, the findings highlight that higher emissions markedly intensify both warming and hydrological changes, thereby amplifying future climate risks.

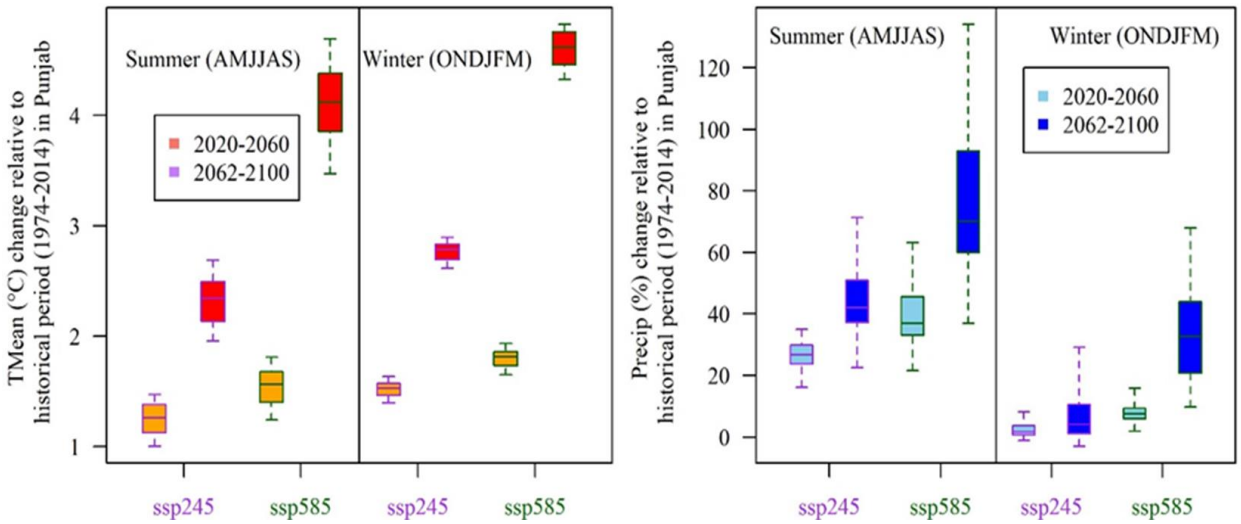


Figure 8: *Projected summer (AMJJAS) and winter (ONDJFM) changes in mean temperature and precipitation over Punjab for 2020–2060 and 2062–2100 relative to 1974–2014 under SSP245 and SSP585*.

The figure 8 shows projected increases in mean temperature and precipitation over Punjab during summer (AMJJAS) and winter (ONDJFM) for 2020–2060 and 2062–2100 relative to 1974–2014 under SSP245 and SSP585. Mean temperature rises in all cases, with summer warming increasing from about 1.2–2.0 °C in the near future to 2.3–4.0 °C by late century, and winter warming from about 1.0–1.4 °C to 1.8–3.5 °C, with larger changes under SSP585. Precipitation also increases, particularly in summer, ranging from roughly 25–45% in 2020–2060 to 40–90% in 2062–2100, while winter increases are smaller (~5–45%). Overall, stronger warming and wetter conditions are projected under higher emissions and toward the end of the century.

The findings underscore the importance of high-resolution climate models in formulating evidence-based adaptation plans. Major recommendations encompass heat-resilient crop species, improved irrigation infrastructure, and early warning systems. These are critical measures to protect food security and threats from climate change to Pakistan's agriculture and water sectors.

f. Spatio-Temporal Analysis and Mapping of Land Surface Temperature and Climatic Extremities in the Upper Indus Basin:

The Upper Indus Basin (UIB), spanning the Himalayan, Karakoram, and Hindu Kush (HKH) mountain ranges, is a critical region for understanding the impacts of climate change due to its glacial and snow-fed hydrological systems. This study conducts a detailed spatio-temporal analysis of Land Surface Temperature (LST) and associated climatic extremities in the UIB over a 25-year period (2000–2024). Using MODIS MOD11A2 8-day composite data, LST trends were mapped and analyzed across different sub-regions and timescales (Fig. 9). Climatic extremities were identified through statistical thresholding methods and cross-validated using external data sources and literature. The analysis reveals significant spatial variability and an upward trend in temperature anomalies, particularly in lower-elevation zones. The project contributes to a deeper understanding of climate dynamics in the UIB and offers a foundation for further research in regional climate modeling, risk assessment, and water resource planning.

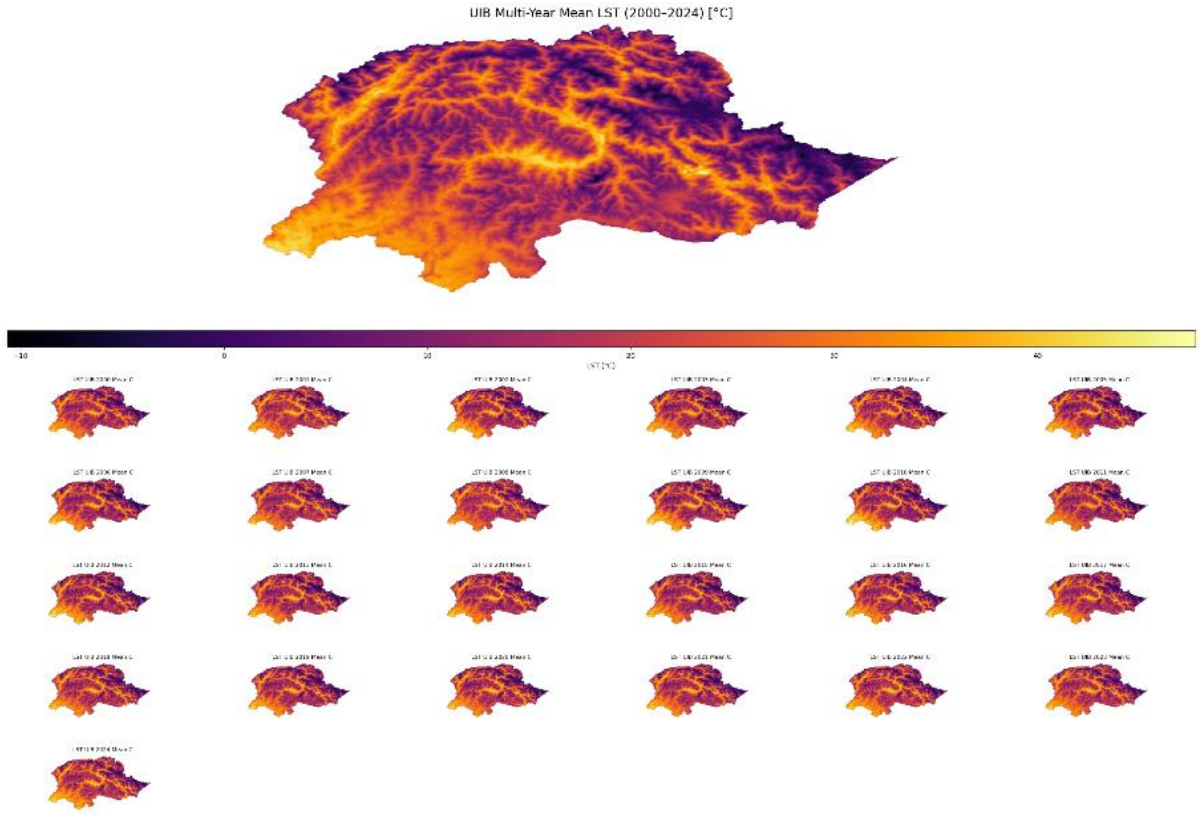


Figure 9: *Spatial distribution of Land Surface Temperatures (LST) for each year from 2000 to 2024 and average over whole period*

This composite visualization presents yearly mean Land Surface Temperature (LST) maps for the Himalayan, Hindukush and Karakorum sub-region of the Upper Indus Basin (UIB), spanning from 2000 to 2024 (Fig. 9). Each small panel shows the spatial LST distribution during May–August of a given year, revealing both inter-annual variability and long-term patterns. Warmer areas are represented in orange-yellow shades, while cooler zones appear in purples and blues. The topmost large map aggregates these into a multi-year mean LST map, clearly showing warmer valleys and cooler high-altitude zones. This allows a visual understanding of how temperature varies spatially within the Himalayan belt.

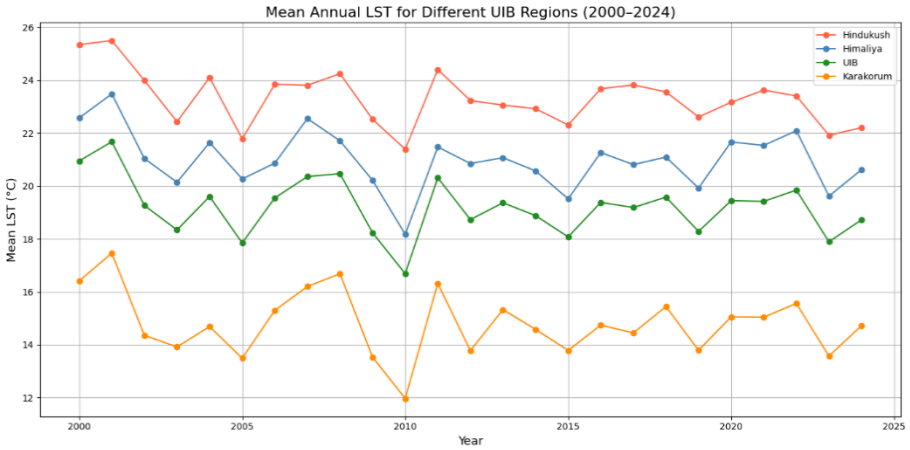


Figure 10: *Temporal patterns of temperature profile in HKH and individual ranges over period 2000 to 2024.*

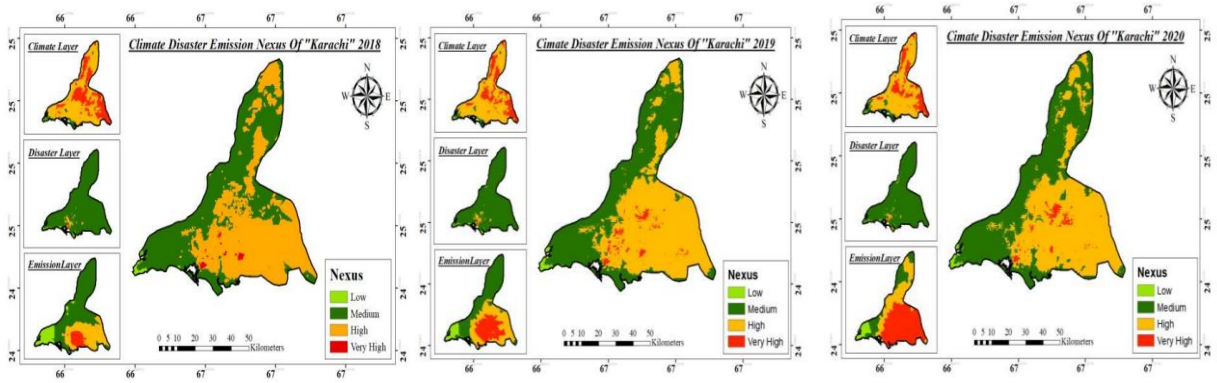
This time series plot shows the mean annual LST (°C) trends from 2000 to 2024 for four zones: the entire UIB, and the Hindu Kush, Himalayan, and Karakoram sub-regions. The Hindu Kush consistently exhibits the highest LST values, followed by the Himalayas and UIB average, with Karakoram being the coolest. The graph captures year-to-year fluctuations and illustrates a pattern of variability rather than a strictly linear warming trend. However, the overall visual suggests some regional warming phases, particularly in the early 2000s and early 2010s (Fig. 10). This visualization supports spatial findings and provides a temporal dimension for interpreting climate behavior in UIB.

h. Climate Disaster Emission Nexus Mapping of Karachi (2018-2023)

This study investigates the spatiotemporal dynamics of climate stress, disaster vulnerability, and emission hotspots in Karachi, Pakistan, through an integrated Climate–Disaster–Emission Nexus framework. Using multi-source remote sensing datasets and geospatial analysis for the period 2018–2023, the research combines four interlinked layers i.e.,

climate, disaster, emission, and nexus to evaluate the interactions between land surface temperature (LST), precipitation variability, population exposure to heatwaves, and atmospheric pollutant concentrations (NO_2, SO_2, CO, $PM_{2.5}$). The climate layer identifies thermal stress zones, the disaster layer quantifies population vulnerability, the emission layer maps pollutant intensities, and the nexus layer synthesizes these components to pinpoint composite risk zones. Data were sourced from global satellite repositories and processed using geospatial techniques, with hotspot intensity classified into low, moderate, high, and very high categories. In addition to spatial analysis, temporal trend evaluation was conducted to capture inter-annual variability and anomaly patterns. The methodological approach integrates both climatic and anthropogenic drivers, ensuring a holistic representation of urban environmental risks. Comparative assessment across years allowed the identification of emerging hotspots and the persistence of chronic risk zones. This integration strengthens the predictive capability of the framework for future climate–emission scenarios.

Results indicate a notable decline in annual LST from 2018 to 2023 (Fig. 11), with a slight rise in 2020, alongside spatial shifts in high- and very-high-risk zones. Coastal and low-lying areas generally exhibited lower nexus risk due to moderated temperatures and higher precipitation, whereas inland urbanized districts displayed persistent high thermal and emission stress, often coinciding with densely populated zones. The findings highlight the compounded risk from climatic extremes, urban heat, and anthropogenic emissions, underscoring the urgency of targeted urban planning, emission control measures, and climate adaptation strategies. This research provides a methodological framework for integrated risk mapping in rapidly urbanizing coastal cities and offers evidence-based insights for sustainable urban resilience planning in the face of climate change.



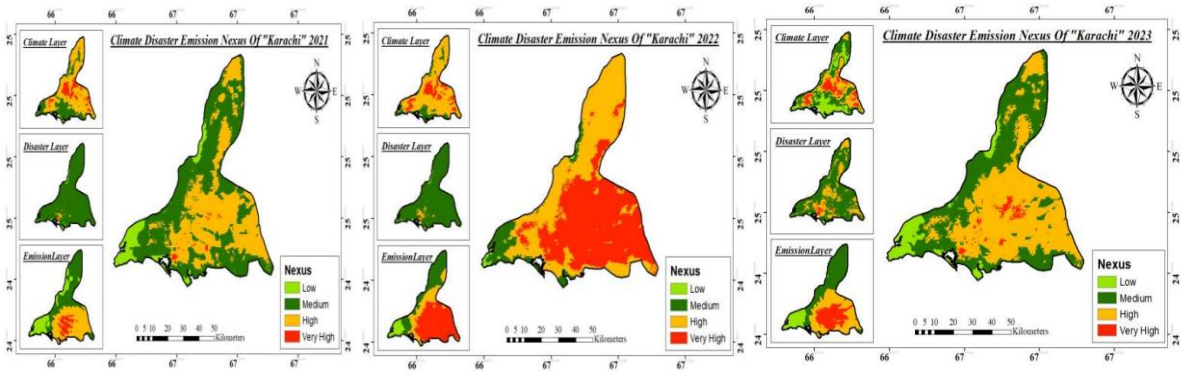


Figure 11: *Spatial variations of Climate-Disaster-Emission Nexus Maps of Karachi during period 2018-2023*

Analysis from 2018–2023 reveals that while some climatic indicators, like land surface temperature, have declined slightly, persistent high-risk zones remain due to non-climatic factors such as dense urbanization, degraded vegetation, weak infrastructure, and high pollution levels. Vulnerability is especially severe in densely populated, low-income areas, underscoring the need for targeted, place-based interventions rather than citywide uniform policies.

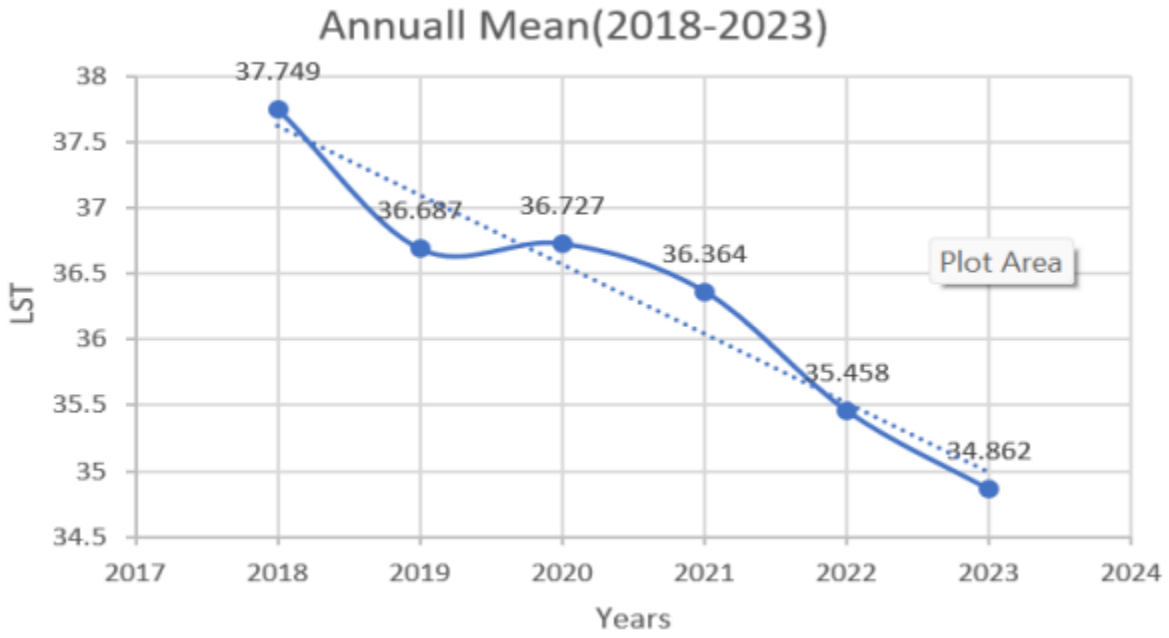


Figure 12: *LST trends over Karachi during study period from 2018-2023*

The annual LST trend graph provides a crucial temporal perspective on these spatial patterns. It indicates a general decrease in temperature from 2018 to 2023, with a slight increase observed in 2020 (Fig. 12). This temperature decline suggests a potential reduction in the magnitude of heat stress over time; however, localized hotspots remain persistent in the nexus maps. The persistence of high-risk and very high-risk zones in certain parts of the city, despite the overall temperature reduction, implies that factors beyond LST such as

urban morphology, land use changes, emission intensities, and population density play a significant role in maintaining vulnerability levels.

AGRICULTURE

i. Machine learning-based province-level annual air pollutants assessment using Sentinel-5P TROPOMI, Google Earth Engine, and GIS

Air pollution is one of the most critical environmental challenges worldwide, threatening both ecological balance and human health. It affects urban and rural regions alike, with pollutant emissions resulting from industrial activities, vehicular exhaust, biomass burning, and energy production. To better understand spatial and temporal trends of air pollution, this study applied a satellite-based remote sensing approach combined with geospatial analysis tools. Data from the Sentinel-5P TROPOMI and MODIS sensors were analyzed using the Google Earth Engine (GEE) cloud platform to assess key atmospheric pollutants—Aerosol Optical Depth (AOD), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Methane (CH_4), and Ozone (O_3)—over the period 2018 to 2024. ArcMap 10.8 was used to generate maps and visualize annual variations and spatial distribution patterns. This integrated methodology enabled efficient monitoring of pollutant concentrations, trend identification, and hotspot detection across the province

Aerosol Optical Depth (AOD) analysis revealed that the lowest values (0–0.32) occurred in 2019 and 2020, indicating relatively cleaner atmospheric conditions, while 2021 exhibited the highest AOD levels (2.21–4.00), likely due to intensified dust activity or increased anthropogenic emissions. The years 2022–2024 showed moderate AOD levels, with noticeable concentrations in the eastern and western regions. Carbon Monoxide (CO) concentrations ranged between 0.021 and 0.039 mol/m^2, with higher levels consistently observed in the eastern and southeastern districts—areas characterized by dense populations and substantial vehicular and industrial activity. Nitrogen Dioxide (NO_2) concentrations were elevated mainly in urban and industrial centers such as Quetta and Hub, reflecting strong associations with transportation and combustion-based emissions. Sulfur Dioxide (SO_2) levels peaked during 2018–2019 at 0.00096 mol/m^2, likely linked to industrial and energy generation sources, but showed a declining trend afterward, suggesting improvements in fuel quality or emission control measures. Methane (CH_4) concentrations displayed spatial and temporal variation, ranging from 1820 ppbv in northern regions during 2023 to 2020 ppbv in the eastern part of the province in 2021, potentially influenced by agricultural practices and localized climatic factors. Ozone (O_3) exhibited a consistent annual increase from 2018 to 2024, with higher concentrations in the northeastern areas and lower levels in central and southern regions. This upward trend indicates enhanced photochemical reactions driven by precursor gases (NO_x and VOCs) and changing meteorological conditions. Overall, the assessment identified clear pollution hotspots for NO_2 and CO in industrial and densely populated zones, alongside a general rise in O_3 concentration across the province, while the variability in AOD and CH_4 underscores the combined influence of natural and anthropogenic factors on regional air quality.

j. Spatial Soil Salinity Assessment by Using Principle Component Analysis and Geospatial Techniques in Central Punjab, Pakistan

Both natural and man-made soil salinity is a chief geological disaster in semi-arid and arid parts. In cultivated land, it has a negative impact on plant development and harvests, while in semi-arid and arid non-agricultural zones, due to subsidence, corrosion and groundwater quality, it affects urban structures, leading to additional soil erosion and land deprivation. The study was conducted at central Punjab, Pakistan with the aim to develop a baseline and to show the precision and accuracy of Geographic Information System (GIS) technology for delineating soil salinity in no data region. The samples of soil were gathered at deepness of 0-15 and 15-30 cm, and three factors (pH, Electrical Conductivity, and Sodium Adsorption Ratio) were analyzed in the laboratory (Fig. 13). Landsat 8 OLI imagery were used for salinity indices development. A statistical index association was found between soil salinity noted in soil samples of field and 13 GIS-based salinity indices. The effect importance and model parameters for various soil salinity indices were assessed using regression model fitting. The data were divided into 3 categories: i) ground or field data, ii) brightness/intensity indicators, and iii) salinity indicators. Data were analyzed using principal component analysis (PCA). The results indicated that salinity indices were favorably related with ground data sets, but brightness/intensity indices had no significant relationship with ground or field data (Fig. 14).

The integration of remote sensing and field observations proved highly effective for detecting soil salinity in the study area. Salinity indices such as NDSI, II-1, SI-4, SI-6, and SI-7 were identified as the most suitable for representing salinity variations across the region. High-resolution multispectral imagery demonstrated strong reliability in mapping and modeling soil salinity, enabling accurate spatial assessment. Furthermore, temporal monitoring of salinity dynamics is essential for informed decision-making and promoting sustainable natural resource management.

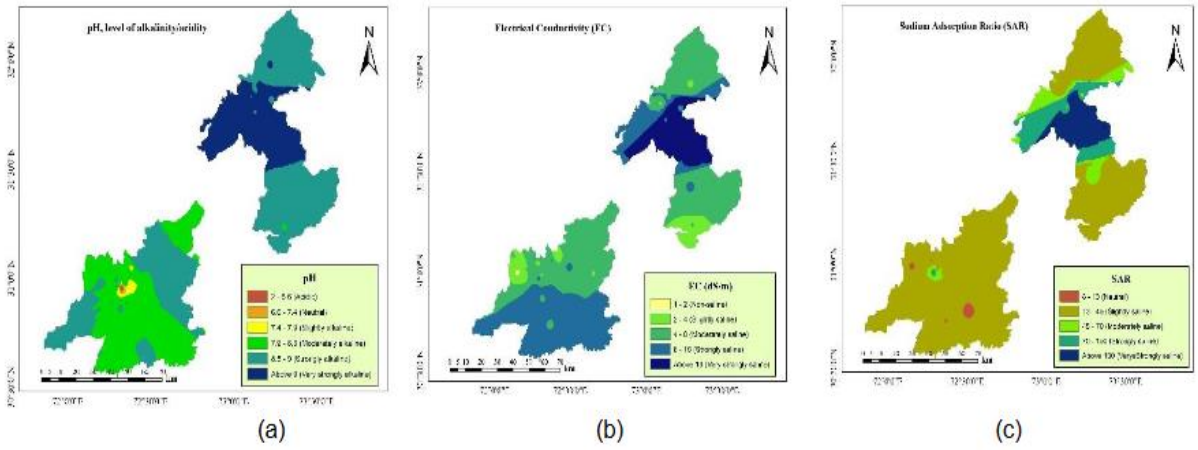


Figure 13: *Soil pH (a), EC (b), and SAR (c) taken from exclamation of research location observation data*

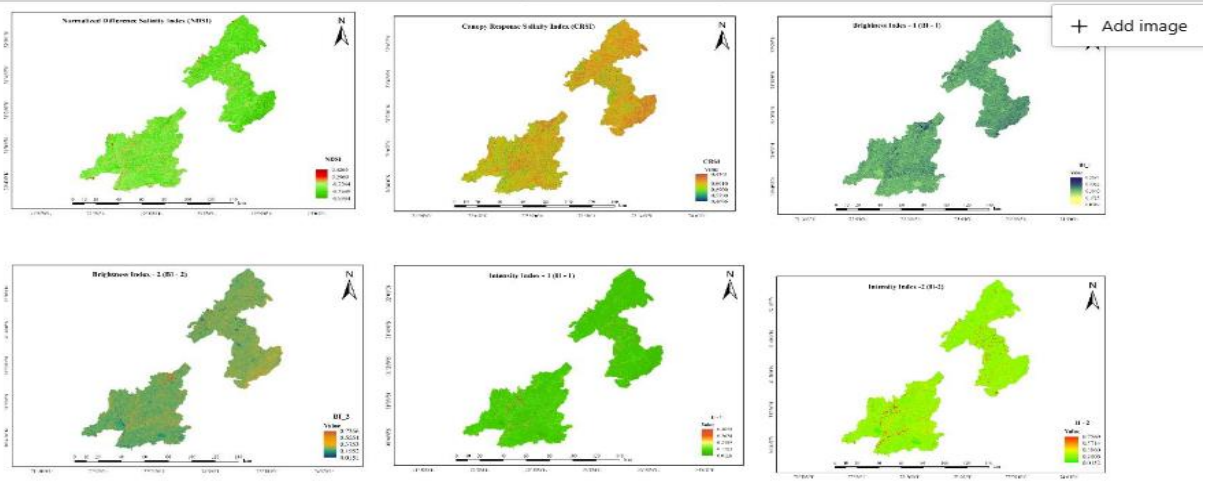


Figure 14: *Brightness or Intensity Indices maps of the research site created through Landsat 8 OLI*

k. Modelling the Wheat crop water and irrigation water requirements Using CROPWAT model: A Case study of Arid and semi-arid regions of Pakistan (2025)

Water is a key factor in global food security, which is critical to agriculture. Dwindling water resources and increasing food demands require greater efficiency in water use, particularly in arid and semi-arid regions. Regulated deficit irrigation provides a means of reducing water consumption while minimizing adverse effects on yield. Models can play a useful role in developing practical recommendations for optimizing crop production under water-scarce conditions. Therefore, the current study was conducted to estimate crop water requirements (CWRs), net irrigation requirements (NIRs), and effective rainfall (Peff) for wheat crop in arid (Bahawalpur) and semi-arid regions (Faisalabad) of Pakistan. Precipitation and temperature data predictions are derived from four pre-validated Coupled Model of the Inter comparison Project Phase 5 (CMIP5) of Global Climate Models (GCMs), namely i) MIROC5, ii) IPSL-CM5A_MR, iii) NorESM1-M and iv) CCSM4. Model data, including the geo-coordinates of the area, temperatures, relative humidity, solar radiation/sunshine hours, crop evapotranspiration and soil data, have been used as input to CROPWAT for simulation of CWR, NIR and Peff in a historical period (1986-2005) and four consecutive future time series (2020-2039, 2040-2059, 2060-2079 and 2080-2099). The results showed that during the wheat growing season, CWR and NIR continued to increase. By the end of the 21st century, the CWR in semi-arid and arid areas of representative concentrated pathways (RCPs 4.5 and 8.5) increased by 3.01-6.86% and 2.46-5.64%, respectively. By 2099, under RCPs 4.5 and 8.5, the NIR in semi-arid and arid areas will increase by 5.49-10% and 2.41-5.86%, respectively. In the semi-arid and arid areas, the average seasonal Peff will be reduced by 9.79% (RCP 4.5), 10.07% (RCP 8.5), 2.81% (RCP 4.5), and 3.16% (RCP 8.5) respectively. Therefore, semi-arid areas will be more affected than arid areas, and changes in climatic conditions will threaten the agricultural system by reducing Peff.

The study revealed that semi-arid regions are more affected by current climate change compared to arid zones. Under RCP 4.5 and RCP 8.5 scenarios, the crop water requirement (CWR) for wheat in semi-arid regions is projected to increase by 3.01% and 6.86%, respectively, while in arid regions, the increase is relatively lower at 2.46% and 5.64% (Fig. 15). Similarly, the net irrigation

requirement (NIR) is expected to rise by 5.49% and 10% in semi-arid areas and by 2.41% and 5.86% in arid areas under RCPs 4.5 and 8.5, respectively. A decline in effective precipitation (Peff) of 9.79% and 10.07% is predicted for semi-arid zones by the end of the 21st century under both emission pathways, whereas arid areas are likely to experience a modest increase of 3.16% and 2.81% in Peff under RCPs 4.5 and 8.5, respectively (Fig. 16). An inverse relationship was observed between NIR and Peff in both climatic regions across all scenarios. The study recommends extending this analysis to other arid and semi-arid regions of Pakistan to validate the coupled CMIP5 GCMs and CROPWAT model projections. Moreover, the NorESM1-M model's precipitation outputs under RCPs 4.5 and 8.5 should be further cross-verified with regional climate models. Given the projected increase in NIR, the adoption of highly efficient irrigation techniques is strongly advised to enhance water conservation and reduce losses associated with conventional irrigation practices.

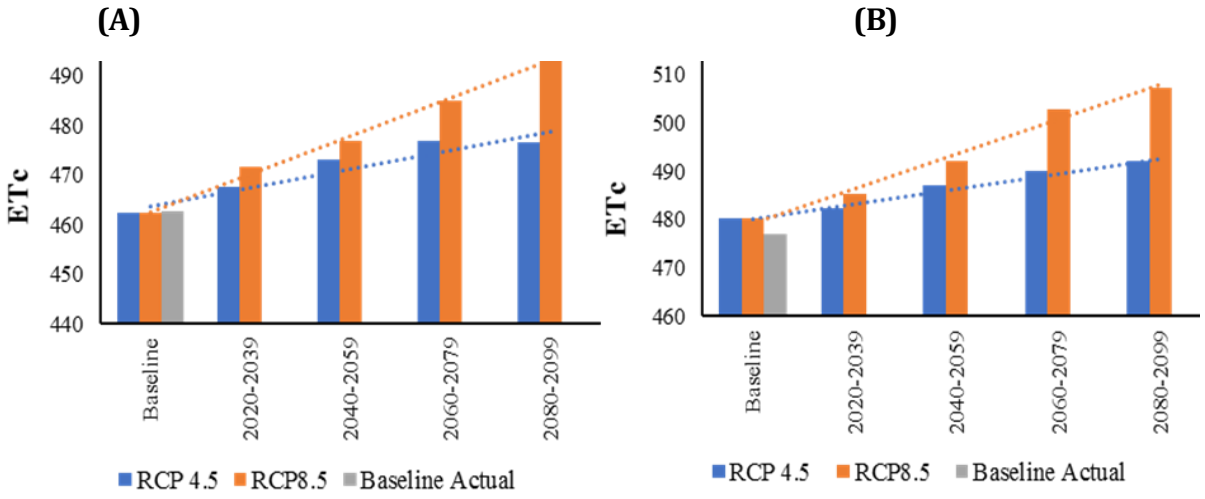


Fig 15: *Changes in future crop water requirements (ETc) for wheat crop in (A) Semi-arid (Faisalabad) and (B) Arid area (Bahawalpur). Three treatments RCP 4.5, RCP 8.5 and Baseline actual. The lines on the bars are trend lines*

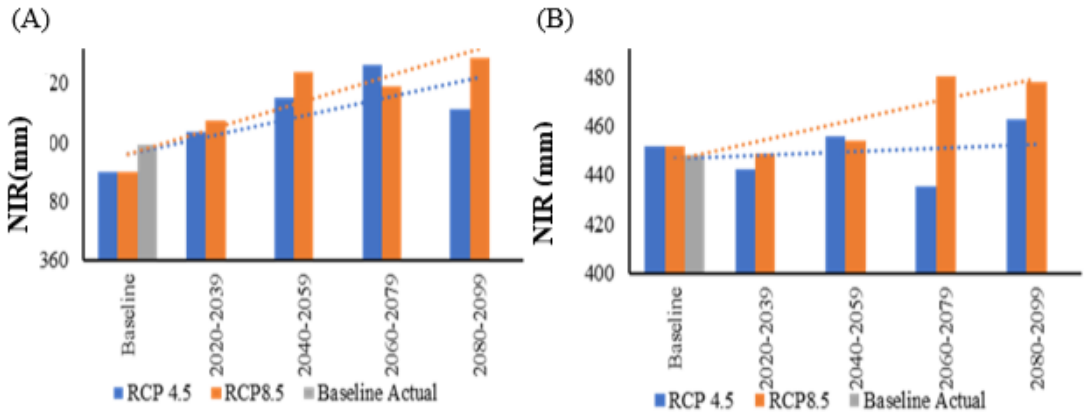


Fig 16*: Changes in future net irrigation requirement (NIR) for wheat crop in (A) Semi-arid (Faisalabad) and (B) Arid (Bahawalpur) areas. Three treatments RCP 4.5, RCP 8.5 and Baseline actual. The lines on the bars are trend lines.*

l. Towards sustainable waste management in peri-urban areas: A comprehensive analysis of household practices in Rawalpindi, Pakistan

Inefficient waste management poses a significant challenge to solid-waste management at the household level. A comprehensive understanding of current practices and perceptions of solid-waste management at this level is crucial for making informed decisions and establishing an integrated, sustainable waste-management system. Rawalpindi, the fourth most populous city in Pakistan, faces obstacles in infrastructure development and the effective delivery of utility services, including solid-waste management, due to its rapidly growing population and unplanned expansion of peri-urban areas. While limited studies have explored household solid-waste-management practices in urban centers, peri-urban zones have been largely overlooked. This study focuses on comprehensive assessment and comparison of household waste management under both public and private sector systems in the peri-urban areas of Rawalpindi. The data collection was done employing a household survey and cross-sectional questionnaire, utilizing a simple random sampling technique. Analysis involved cross-tabulation and chi-square tests.

The study indicates that the private sector demonstrates better performance than the public sector in waste management operations. Waste segregation practices show only a slight variation between public (46%) and private (54%) systems. Residents under both systems commonly perceive waste as aesthetically unpleasant and detrimental to health. Approximately 21.7% of respondents expressed negative perceptions toward waste, while 11.7% held neutral or differing views. Socio-demographic characteristics were found to significantly affect household waste management behaviors and perceptions. The findings highlight substantial potential for improving household-level waste segregation through targeted awareness and education campaigns. Strengthening public awareness can play a pivotal role in establishing an integrated and sustainable waste management framework.

B. Capacity Building:

GCISC periodically organizes capacity-building workshops and training sessions aimed at equipping students, researchers, and academicians at both national and subnational levels with advanced research methodologies and state-of-the-art modeling techniques. Additionally, the Centre extends its expertise by providing resource persons to various research and development institutions, universities, and community organizations, thereby fostering knowledge dissemination and technical training on critical climate change issues. Under the GCISC Internship Program, training has been imparted to BS/MS-level students from diverse universities. Furthermore, the Centre plays a pivotal role in strengthening provincial research departments by integrating them as collaborative partners in internationally funded projects, thereby enhancing their research capabilities and technical expertise.

GCISC's scientists, during 2024-25, contributed as resource persons in workshops and seminars organized by various entities. The scientists at the Center also actively participated in numerous national and international training workshops, acquiring expertise in a broad spectrum of areas, including climate science, climate modeling, seasonal forecasting, early warning systems, drought monitoring and assessment, hydrological modeling, crop

simulation, water management, water surface runoff analysis, water-food-energy nexus, earth observation systems, space technology, and remote sensing/geographic information systems (RS/GIS) tools. These newly acquired skills are being effectively utilized in both ongoing and planned research endeavors at the Center. Furthermore, thirty-three students from prominent institutions such as the 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 participated in internships at GCISC for periods ranging from 2 to 3 months. During their tenure, the Center's researchers provided them with orientation lectures on climate science, modeling, and other analytical skills. These interns were supervised by GCISC researchers and assigned various studies by their university teachers and GCISC mentors, enabling them to gain practical experience and contribute to ongoing research initiatives.

Capacity Building Trainings on National GHG Inventory of Pakistan

Under its mandate to support evidence-based climate policy and enhance national technical capacity, the Global Change Impact Studies Centre (GCISC) led a series of provincial capacity-building workshops on the National Greenhouse Gas (GHG) Inventory system as part of Pakistan's Third National Communication (TNC) to the UNFCCC. These workshops were conducted in Karachi (23–26 August 2024), Quetta (26–30 August 2024), and Lahore (23–26 September 2024), targeting key stakeholders from provincial departments, research institutions, and academia. The trainings aimed to build participants' technical understanding of the 2006 IPCC Guidelines for National GHG Inventories, with a focus on sectoral emissions from Energy, IPPU, Agriculture, FOLU, and Waste. Sessions covered essential topics such as inventory planning, data collection, emission estimation methods, QA/QC, uncertainty assessment, and the use of IPCC inventory tools and common reporting tables (CRTs), in line with the requirements of the Biennial Transparency Report (BTR) under the Paris Agreement's Enhanced Transparency Framework (ETF). Through these workshops, GCISC directly contributed to strengthening sub-national capacity for climate transparency, promoting TACCC principles (Transparency, Accuracy, Completeness, Consistency, Comparability), and improving coordination between national and provincial actors in inventory preparation. Over 100 professionals were trained, laying the groundwork for a more robust and decentralized national GHG inventory system that supports Pakistan's climate commitments and long-term policy planning.

Stakeholder Consultations and Field Visits for Vulnerability & Adaptation (V&A) Assessment

These field visits focused on Vulnerability and Adaptation (V&A) assessments in key socio-economic sectors, including energy, agriculture, water, coastal management, forests & ecosystems, and public health. The consultative process aimed to seek input from the relevant stakeholders on potential climate induced risks and to identify suitable adaptation measures tailored to the local environment drawing upon collective expertise. These visits served as a basis for collecting data, assessing risks, and identifying adaptation measures to facilitate a robust assessment of the region's vulnerability to climate change impacts. The field visits, through involvement of local communities, stakeholders, and indigenous knowledge holders, ensured that adaptation strategies are rooted in local realities and

inclusive of diverse perspectives. The whole activity provided a more realistic assessment of on-ground conditions. Besides, the visits helped capacitating and empowering local stakeholders enabling them to effectively contribute towards the sustainable development and well-being of local communities and ecosystems.

Mass Awareness / Media Appearance:

The scientists at the Center disseminated numerous articles across prominent national newspapers, covering diverse facets of climate science and its implications for water resources, agriculture, and forestry. Additionally, these experts engaged as Keynote Speaker/ Panelist/ Resource Person/ Opening Remarks during the events and in interviews and offered insights into pressing matters such as heatwaves, glacier retreat, monsoon disruptions, food insecurity, challenges in wheat production, efficient irrigation practices, and other related concerns linked to climate change.

C. Memorandum of Understandings (MoUs)

During the reporting period, the Global Change Impact Studies Centre (GCISC) signed several Memoranda of Understanding (MoUs) to strengthen institutional partnerships, promote collaborative research, and advance Pakistan's climate science and policy objectives. These strategic collaborations focus on key areas including greenhouse gas accounting, climate finance, glacier monitoring, and climate-resilient development. Through these agreements, GCISC continues to expand its engagement with universities, research organizations, and development partners to enhance technical capacity, facilitate knowledge exchange, and support evidence-based climate action.

The details of the MoUs signed by GCISC are as follows:

- **GCISC and Islamic Relief Pakistan (IRP):** Collaboration on climate science and climate finance, IRP Office, Islamabad — 10 December 2024.
- **GCISC and Karakoram International University (KIU):** Joint research on glacier melting and mitigation strategies to protect glaciers and vulnerable communities, GCISC Office, Islamabad — 31 January 2025.
- **GCISC and Climate Resourcing Coordination Centre (CRCC):** Cooperation on climate science, GHG accounting, and climate finance, GCISC Office, Islamabad — 05 March 2025.
- **GCISC and University of Sargodha (UOS):** Partnership to promote collaborative research in climate science, Agriculture and Forestry, Islamabad — 10 March 2025.
- **GCISC and NED University of Engineering and Technology (NED UET), Karachi:** Agreement to jointly plan, develop, and implement projects contributing to educational, social, and economic development, GCISC Office, Islamabad — 13 June 2025.
- **GCISC and Dr. Sadiq Foundation (DSF):** Collaboration titled "Transformative Collaborations for Climate Resilience: Pioneering Thematic Financing Solutions", GCISC Office, Islamabad — 23 June 2025.

D. Support & Services to the MoCC&EC

Preparation of the National GHG Inventory for UNFCCC Reporting

The compilation of greenhouse gas (GHG) inventories remained an overlooked domain in Pakistan until the Global Climate-Change Impact Studies Centre (GCISC) pioneered this effort. In adherence to Article 4, Paragraph 1(a), and Article 12, Paragraph 1(a) of the United Nations Framework Convention on Climate Change (UNFCCC), all non-Annex I countries, including Pakistan, commenced the development of GHG inventories. Through its pioneering initiatives, GCISC has now attained both national and international recognition as a leading institution with established expertise in the systematic compilation of GHG inventories.

During the year 2024, the national greenhouse gas (GHG) inventory was compiled for submission under the UNFCCC, forming a key component of the Third National Communication (TNC) and the First Biennial Transparency Report (BTR1). The 2021 GHG inventory was prepared in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, applying a Tier 1 methodological approach with default emission factors. Total estimated GHG emissions for 2021 demonstrate a notable increase compared to inventories for 1994, 2008, 2012, 2015 and 2018. In 2021, total emissions stood at 521.46 MtCO2e, up 31.6 MtCO2e from the last reporting period (2018). This upward trend is predominantly driven by sectors that are key to economic development: energy, agriculture, industry and waste management. This highlights the challenge for countries like Pakistan of cutting emissions without adversely affecting economic activities. In the 2021 inventory, the AFOLU sector emerged as the largest emitter, accounting for 46.75% of total emissions, followed by energy at 40.90%. The waste sector was responsible for 6.22% of emissions, while the IPPU sector accounted for 6.13%.

Furthermore, the methodological improvements were undertaken in line with the IPCC 2006 Guidelines and 2019 Refinement, incorporating specific updates in Tier 2 livestock emissions, rice cultivation, and the sanitation sectors. Additionally, a UNICEF-supported Tier 2 GHG inventory was developed for sewered and non-sewered sanitation systems in Khyber Pakhtunkhwa (KP) province, enhancing the accuracy and regional relevance of emissions reporting.

Pakistan's Third National Communication on Climate Change (TNC) to the UNFCCC

GCISC played a pivotal role in supporting the Ministry in the preparation of Pakistan's Third National Communication on Climate Change (TNC) submitted to the UNFCCC. The Centre led the development of four major chapters of the report, namely: (1) National Circumstances & Institutional Arrangements, (2) National Greenhouse Gas Inventory (2020–21), (4) Vulnerability & Adaptation, (5) Constraints, Gaps, and Financial, Technical & Capacity Needs, and (7) Research & Systematic Observation. Under these components, GCISC provided comprehensive analytical and technical inputs, ensuring methodological consistency with the IPCC 2006 Guidelines and 2019 Refinement. The Centre coordinated data collection and validation across multiple sectors, developed the national GHG inventory using updated IPCC

methodologies. The total estimated emissions in $MtCO_2e$ for 2021 indicate a rise in overall GHG emissions compared to previous inventories (1994, 2008, 2012, 2015, and 2018). The total estimated GHG emissions for 2021 amount to 518.9 $MtCO_2e$, with contributions from: i) Energy sector (212.83), ii) IPPU (25.52), iii) AFOLU (244.11), and iv) Waste (32.44) $MtCO_2e$.

The Centre also conducted climate vulnerability and adaptation assessments across agriculture, water resources, coastal areas, forests & ecosystem, energy, and health sectors. Furthermore, GCISC identified institutional and technical gaps, financial constraints, and capacity-building needs to enhance national climate action and reporting capabilities. In addition, the Centre documented Pakistan's progress in research and systematic observation, emphasizing advancements in climate modeling, data systems, and scientific collaboration. Through its leadership and technical expertise, GCISC strengthened the scientific foundation of the TNC, reinforcing Pakistan's commitment to transparency and evidence-based policymaking under the UNFCCC framework.

Preparation of Pakistan's Third Nationally Determined Contributions (NDC3.0)

Under Article 4 of the Paris Agreement, all Parties are required to prepare, communicate, and maintain successive Nationally Determined Contributions (NDCs) that reflect progressively enhanced ambition over time. GCISC served as the NDC secretariat and led the process of NDC3.0 preparation. As part of the preparation of Pakistan's Third Nationally Determined Contribution (NDC-3), a series of provincial consultations were organized to ensure an inclusive and representative process. These consultations brought together key stakeholders from all provinces and regions, including government departments, academia, civil society organizations, and the private sector. The sessions provided a platform for participants to share regional priorities, challenges, and opportunities related to climate mitigation and adaptation. Inputs from these dialogues were crucial in identifying province-specific actions, aligning them with national targets, and ensuring that local contexts and needs are reflected in the NDC-3 framework. This participatory approach not only strengthened ownership among provincial stakeholders but also enhanced coordination for effective implementation of climate commitments across Pakistan.

The NDC 3.0 reaffirms Pakistan's adherence to the principles of equity and Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC), emphasizing that effective climate action requires shared but fair responsibilities across nations. Pakistan's NDC 3.0 builds upon its earlier submissions and reflects significant progress made since the first NDC (2016) and its update (2021). Pakistan remains on track to achieve its target of reducing projected emissions by 50% between 2015 and 2030, 15% through domestic resources and an additional 35% contingent on international financial support; however, the required international financial support has not been received. Through NDC3.0, Pakistan would like to voluntarily reduce its GHG emissions up to 50% by 2035. Of this, 17% will be achieved unconditionally through domestic resources and policy measures, while the remaining 33% is conditional on the provision of adequate mostly grant-based or

concessional international climate finance, complemented by technology transfer and capacity-building support. The estimated investment required to achieve these goals is USD 565.7 billion. According to World Bank's Pakistan Country Climate and Development Report 2022, an indicative estimation of total investment needs for Climate-resilient and Low-Carbon development up to 2023 are USD 348 billion. The additional investment of USD 217.7 billion will be required by 2035. The National Economic Transformation Plan (2024-2029) also known as the 'URAAN Pakistan' provides the overarching development pathway for integrating climate action into Pakistan's economic and social agenda. It ensures that climate commitments are not treated in isolation, but as drivers of sustainable growth, resilience, and green transformation. Given Pakistan's acute vulnerabilities and the capital-intensive transition required for low carbon transition, financial support remains a critical enabler. Pakistan seeks enhanced access to international climate finance from both public and private sources, aligned with principles of equity and common but differentiated responsibilities. The country also intends to employ the cooperative approaches and market mechanisms available under Article 6 of the Paris Agreement, creating opportunities for enhanced ambition, innovation, and cost-effective emissions reductions. NDC 3.0 reflects Pakistan's dual approach: pursuing low carbon transition while building resilience against climate shocks. The submission emphasizes that the scale of ambition is far beyond what can be achieved through domestic capacity alone. Therefore, international cooperation, technology partnerships, and financial assistance are indispensable to enable Pakistan to deliver on its commitments while safeguarding human development gains

E. Inputs for parliamentary Business

As the research arm of the Ministry, GCISC plays a pivotal role in furnishing technical expertise on climate change, its impacts, and corresponding response strategies for parliamentary deliberations. In this capacity, GCISC regularly provides comprehensive inputs for National Assembly and Senate proceedings, including responses to parliamentary questions and substantive contributions to the deliberations of standing committees addressing climate-related concerns. The Centre has delivered detailed responses to National Assembly and Senate starred questions while also presenting technical briefs and analyses to the National Assembly Standing Committee on Climate Change, particularly concerning the intersections of climate change, agriculture, and food security. Furthermore, GCISC has actively contributed to various policy reports, furnished technical insights for joint and inter-ministerial coordination meetings, and provided responses to ministerial queries, memorandums, and other strategic documents, thereby strengthening evidence-based decision-making at the highest legislative levels.

F. Administrative Matters

- **Appointment of Head of the Organization (Executive Director, GCISC).**

  In line with the amended SRO approved by Federal Government, the administrative ministry [MoCC & EC] initiated the recruitment process for appointment of ED-GCISC. Upon completion of the required official recruitment procedures, the Prime Minister appointed the new Executive Director of the Centre in MP-I scale, who assumed the charge of the post in October 2024.

- **<u>Composition of Board of Governors, GCISC.</u>**

  Pursuant to the amendments to the GCISC Act, 2013 ratified by Parliament in January 2023 and in accordance with Section 5(3), the composition of the Board of Governors (BoG-GCISC) has been revised with the Prime Minister's approval to include seven non-ex officio members (three distinguished scientists, two eminent private-sector representatives, and two from civil society), as formally notified by MoCC&EC through correspondence F. No. 5(6)/2024/SO-AOs dated 04-11-2024 and 14-01-2025

- Additionally, under Section 5(3)(i) of the GCISC Act, 2013, Provincial Secretaries of Environment were requested to nominate one Technical Expert/Scientist from their respective provinces. After a lengthy process by Provinces, the nominations received and completed the Board's composition in May 2025, bringing the BoG-GCISC membership to 33.

- **<u>Technical CC Related Input</u>**.

  During the year, consistently provided inputs on the most immediate letters / notes, queries of the ministry through hard letters and now via e. office system on the following official business;

  - Technical input on Pakistan foreign affairs matters with other countries on bilateral, interministerial, joint commission, joint sessions, SDGs, MoUs, Technical Cooperation Agreements, Strategic Partnership, Globalization require climate change related information on PM visits, Pak-Azerbaijan, Pak-Belarus, Pak-EU, Pak-Uzbekistan, Pak-Korea, Pak-Jorden, Pak-France, Sukuk Securities, Green Taxonomy, OIC programme, SCO related, Pak-China, Pak-Germany, Pak-Oman, UNEA-7, FAO, Green Finance, G2F, Indus Water Treaty, IPU, NDCs;

  - Submission of responses on technical / non-technical inquiries on Material for Economic survey of Pakistan, Annual progress reports, Year books, Performance monitoring, KPIs, Principle of policies, Budget speech material, National security policy implementation process, institutional reforms related, Datea base information, Audit related responses, different appointment, quota vacant posts related etc.

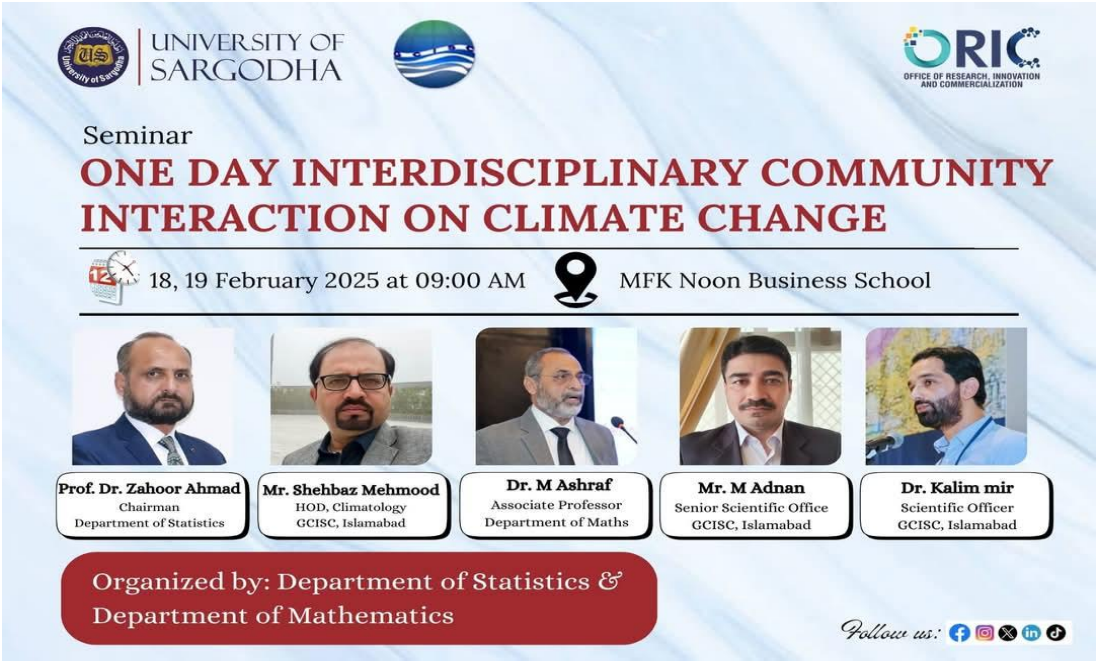
  - The Centre has also provided responses on the letters of other Govt. Departments /non-government relevant stakeholders., MoFA, MoST, Planning Commission, FFC, etc.

Glimpses of GCISC major activities:

GCISC and Karakoram International University (KIU) signed an MOU at GCISC

Ms. Aisha Humera Ch, Secretary Ministry of Climate Change & Environmental Coordination (MoCC&EC), visited the GCISC – 4 March 2025

Mr. Muhammad Arif Goheer, Executive Director, GCISC delivered presentation at Workshop on "Climate Resilient and Low Carbon Agriculture in Pakistan", being organized by Asian Development Bank at Marriott Hotel, Islamabad. February 06, 2025:



GCISC in collaboration with Department of Statistics and Mathematics, University of Sargodha (UoS) jointly organized a two-day interdisciplinary seminar on "Environment and Climate Change and Community Interactions" from February 18-19,

NDC 3.0 Consultation Workshop jointly organized by GCISC and Planning and Development Department, Government of Punjab, Lahore - January 22, 2025

One-Day Consultation Meeting on NDC 3.0 Preparation, being organized by GCISC and P&D Department, AJ&K, Muzaffarabad, January 28, 2025

Executive Director, GCISC Active Participation in CoP-29 and Technical Input to Climate Negotiations

GCISC Active Participation in Negotiation Streams on Agriculture, Adaptation, Technology and Transparency, Panel Discussions, Side Meetings.

GCISC organized a National Consultative Workshop on “Research and Systematic Observation” Chapter of Pakistan’s Third National Communication (TNC) to United Nations Framework Convention on Climate Change (UNFCCC) at Best Western Hotel, Islamabad, on October 8, 2024

Developing Inclusive Climate Commitments: NDCs 3.0 for Pakistan, Workshop co-hosted by GCISC & SDPI, December 18, 2024

ICIMOD, Nepal Team Visits GCISC – 10 September 2024

Climate Change Awareness in Media

ARY NEWS LIVE STREAMING