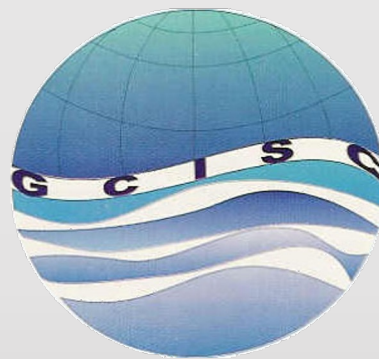


Workshop on Building Resilience for Data-scarce Water Systems

Water Security in a Changing Climate: Catalyzing Resilience in
Pakistan's Data-Scarce Systems



Dr. Amjad Masood

Water Resources and Glaciology Section

Global Change Impact Studies Centre (GCISC), Islamabad



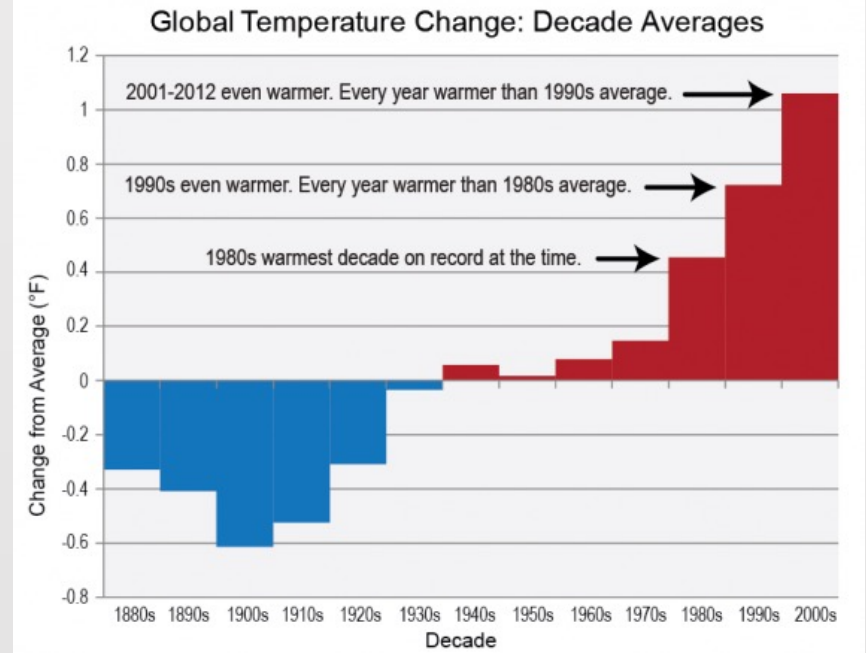
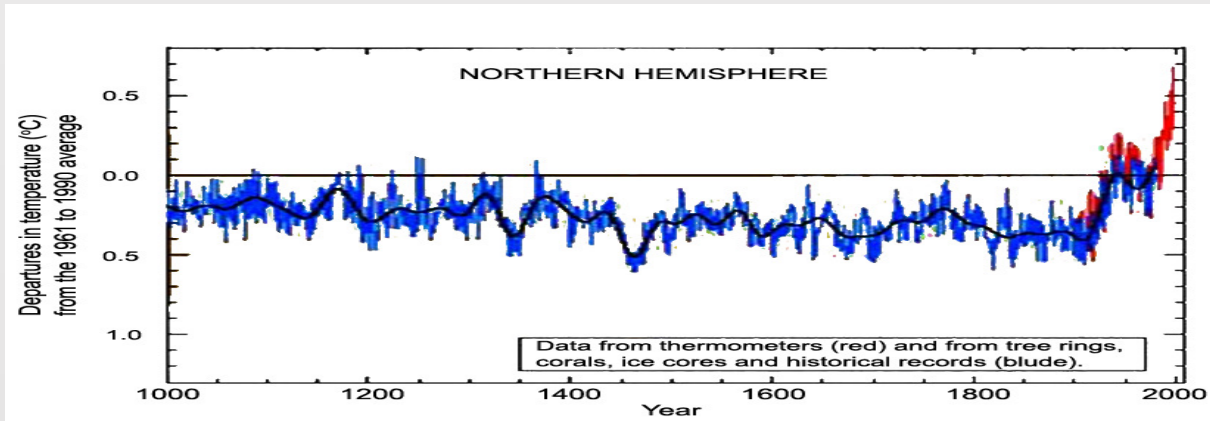
The Centre for Water Informatics and Technology (WIT), Lahore University of
Management Sciences (LUMS)

07 July 2023

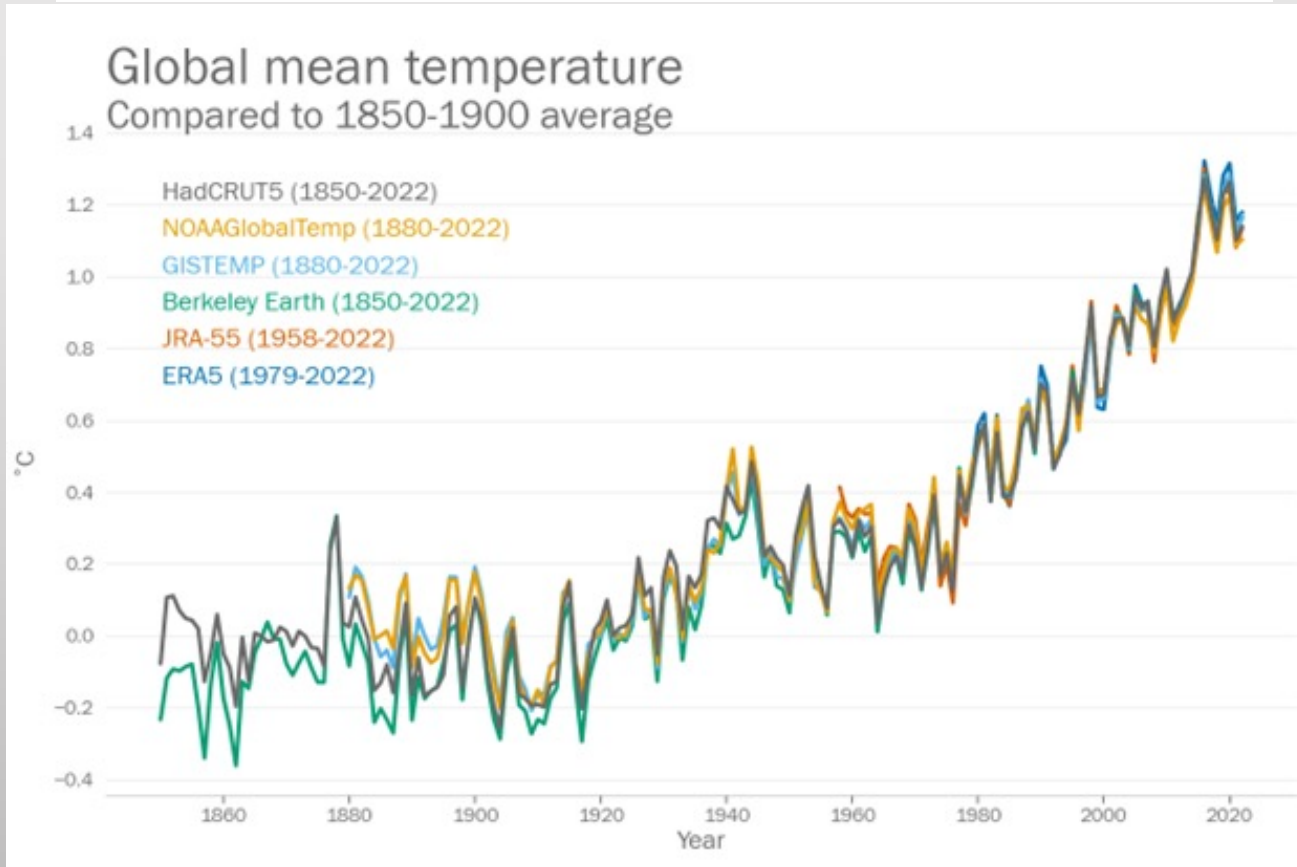
Outline:

- Climate Change and its Impacts (Global perspective)
- Pakistan's Water Resources and climate change
- Some Findings from GCISC Studies
- Ongoing and near future GCISC water related works
- Recommendations

Climate Change (Global Perspective)



<https://www.globalchange.gov/browse/multimedia/global-temperature-change-decade-averages>



Top 10 warmest years (data from NOAA) (1880-2022)

Rank	Year	Anomaly °C	Anomaly °F
1	2016	1.00	1.80
2	2020	0.98	1.76
3	2019	0.95	1.71
4	2015	0.93	1.67
5	2017	0.91	1.64
6	2022	0.86	1.55
7	2021	0.84	1.51
8	2018	0.82	1.48
9	2014	0.74	1.33
10	2010	0.72	1.30

https://en.wikipedia.org/wiki/Instrumental_temperature_record#cite_note-2-21

Global Climate Change and its Implications

(Based on IPCC Fifth and sixth Assessment Reports, 2013 & 2021)

- 0.6 °C increase in average global temperature during the last century (During the first 22 years of this century the temperature has increased further by about than 0.5 °C);
- Increase by 1.5 – 4.6 °C projected over the 21st Century (In the extreme case the temperature may increase by up to 6 °C);
- Large changes (both, increases and decreases) of temperature and precipitation in different world regions;
- Considerable increase in Frequency and Intensity of Extreme Climatic Events (cyclonic storms, floods, droughts etc.)
- Large scale melting of mountain glaciers and polar ice caps, particularly the Arctic;
- Sea level rise (19 cm over 20th Century; further rise by 44-73 cm projected over 21st Century)

Extreme weather Events hurricanes / cyclones



Hurricane Michael is expected to make landfall along the Gulf Coast on Wednesday (Image: WFTV)

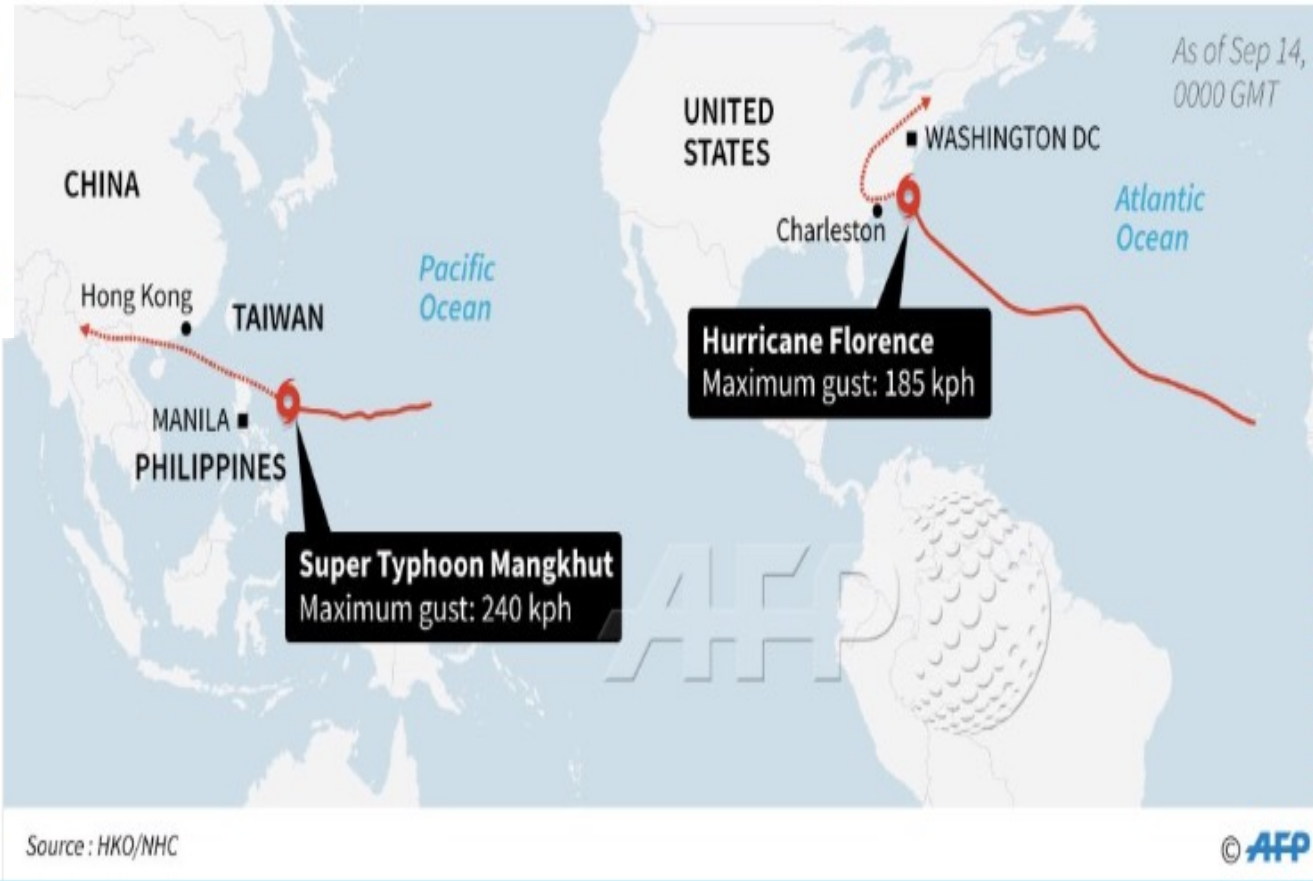
Hurricane Michael devastated Florida, Georgia and nearby areas in US



Hurricane Maria has left Puerto Rico “totally devastated”

Source: <https://www.nationalgeographic.com.au/nature/exclusive-aerial-photos-capture-puerto-ricos-devastation.aspx>

Big cyclones in the Pacific and Atlantic



Hurricane	year
Fionna (Canada, Green land etc.)	2022
IDA (US)	2021
Zeta and Delta (US)	2020
Idai (Africa)	2019
Michal (US)	2018
Florence (US)	2018
Mankhat (Asia)	2018
IRMA (US)	2017
Maria (US)	2017
Harvey (US)	2017

Droughts, Flooding, Heat Waves, and wildfire

- ❖ From North America to Africa to Europe to Asia, huge swaths of the planet were parched in 2022. Lakes and rivers in several countries shrank to extreme lows and dry conditions threatened crops and fueled destructive wildfires across the globe.
- ❖ The most drought prone countries in the world are Ethiopia, Kenya, Sudan, Afghanistan, Iran, Pakistan, Somalia, Eritrea, China, Uganda, Morocco etc.
- ❖ From June to August 2022, persistent heatwaves affected parts of Europe, causing evacuations and over 20,000 heat-related deaths, making these heat waves the deadliest meteorological events in 2022. The highest temperature recorded was 47.0 °C in Pinhao, Portugal, on 14 July 2022, then in June 2022, 38 to 43 °C France, Spain and UK etc.
- ❖ As a result of the heatwaves, widespread droughts occurred across the continent.



California Wildfire; 63 people died and more than 600 missing
<https://www.thenews.com.pk/latest/394513-number-of-missing-in-california-fire-jumps-past-600>



Europe heat wave



A dried out dam, north of Cape Town, March 7, 2018
as a result of a three year long drought



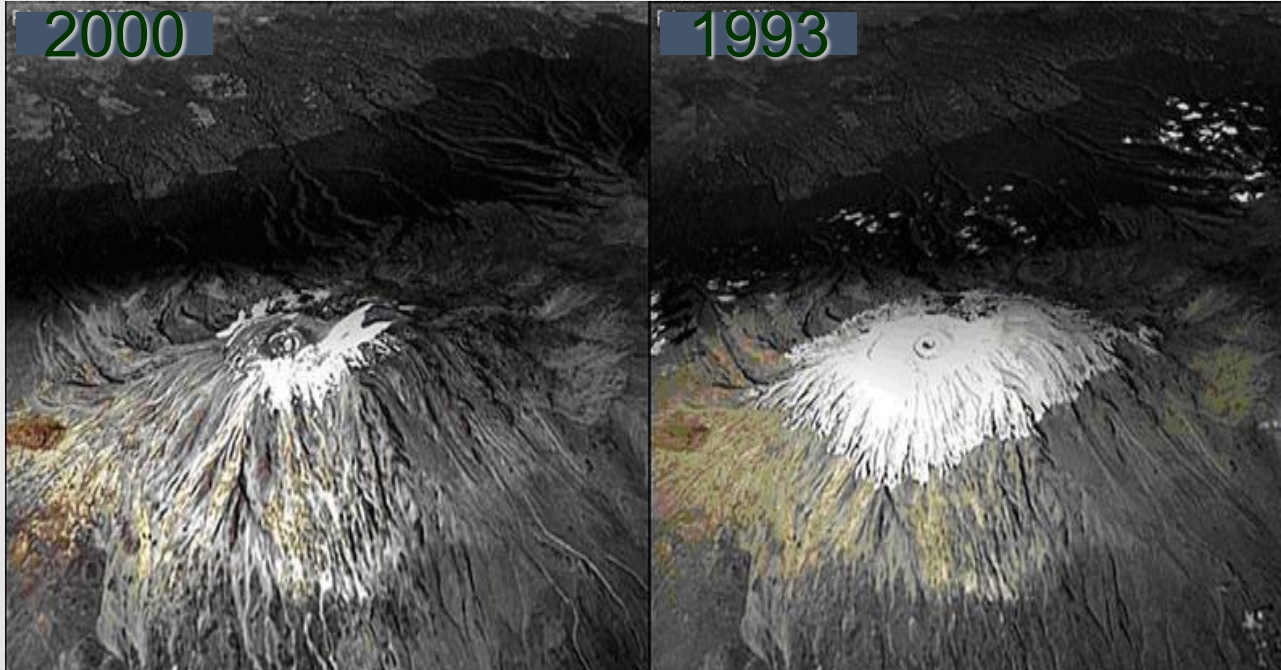
Drought in Afghanistan
http://outlookafghanistan.net/topics.php?post_id=21039



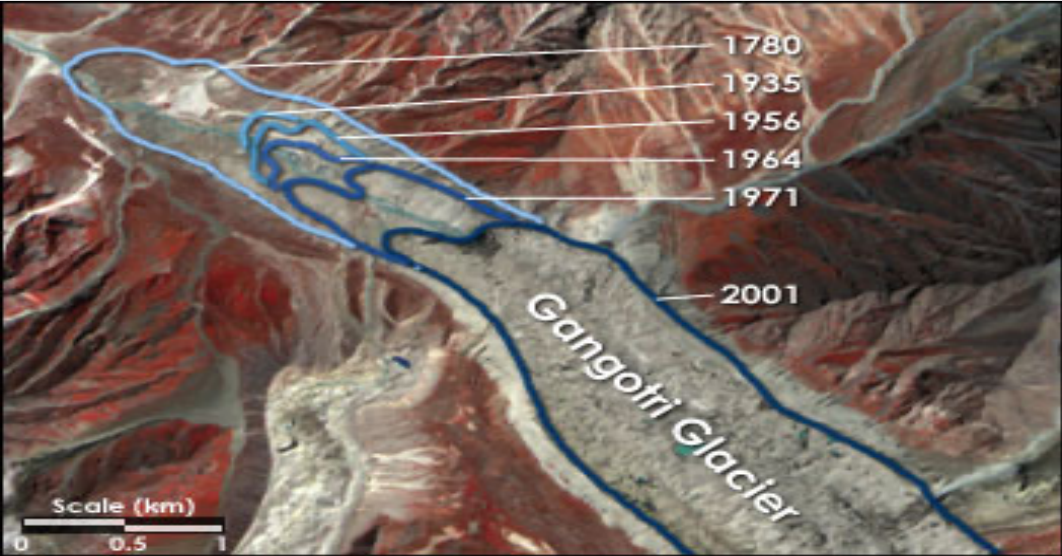
Saudi Arabia: <https://www.mdpi.com/2073-4441/11/9/1887> (2018)

Melting glaciers world-wide

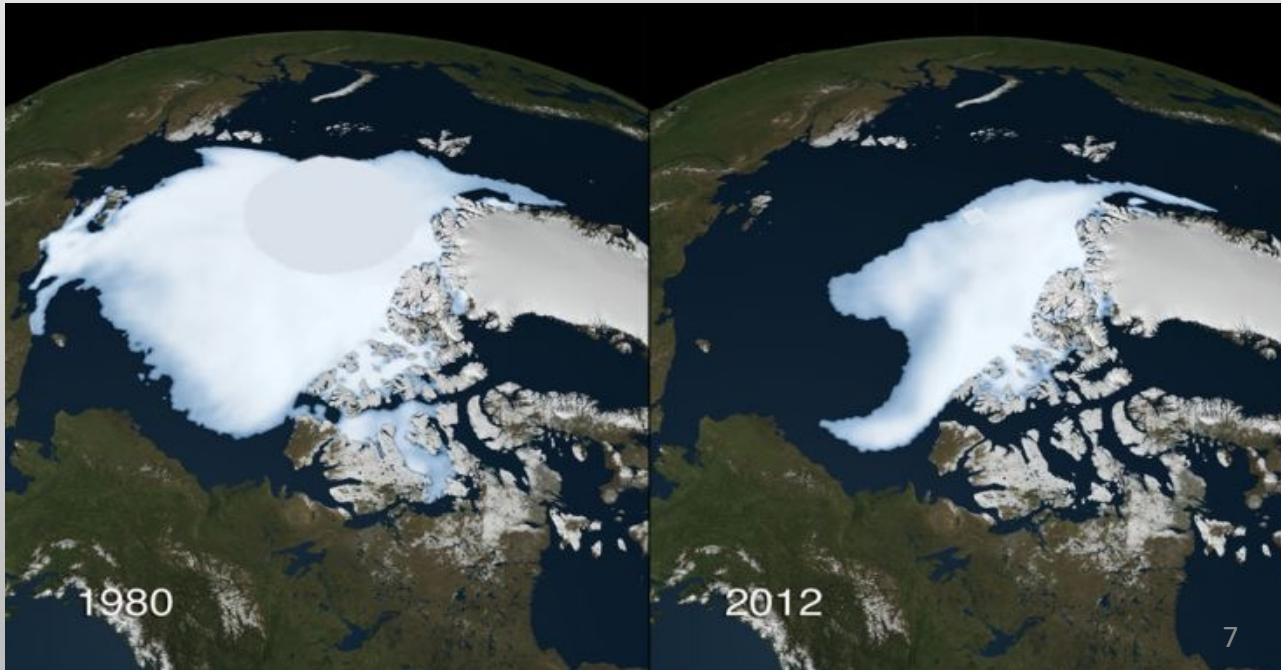
Melting of the Ice Cap of Mount Kilimanjaro, Tanzania



Changes in Gangotri Glacier, Indian Himalaya

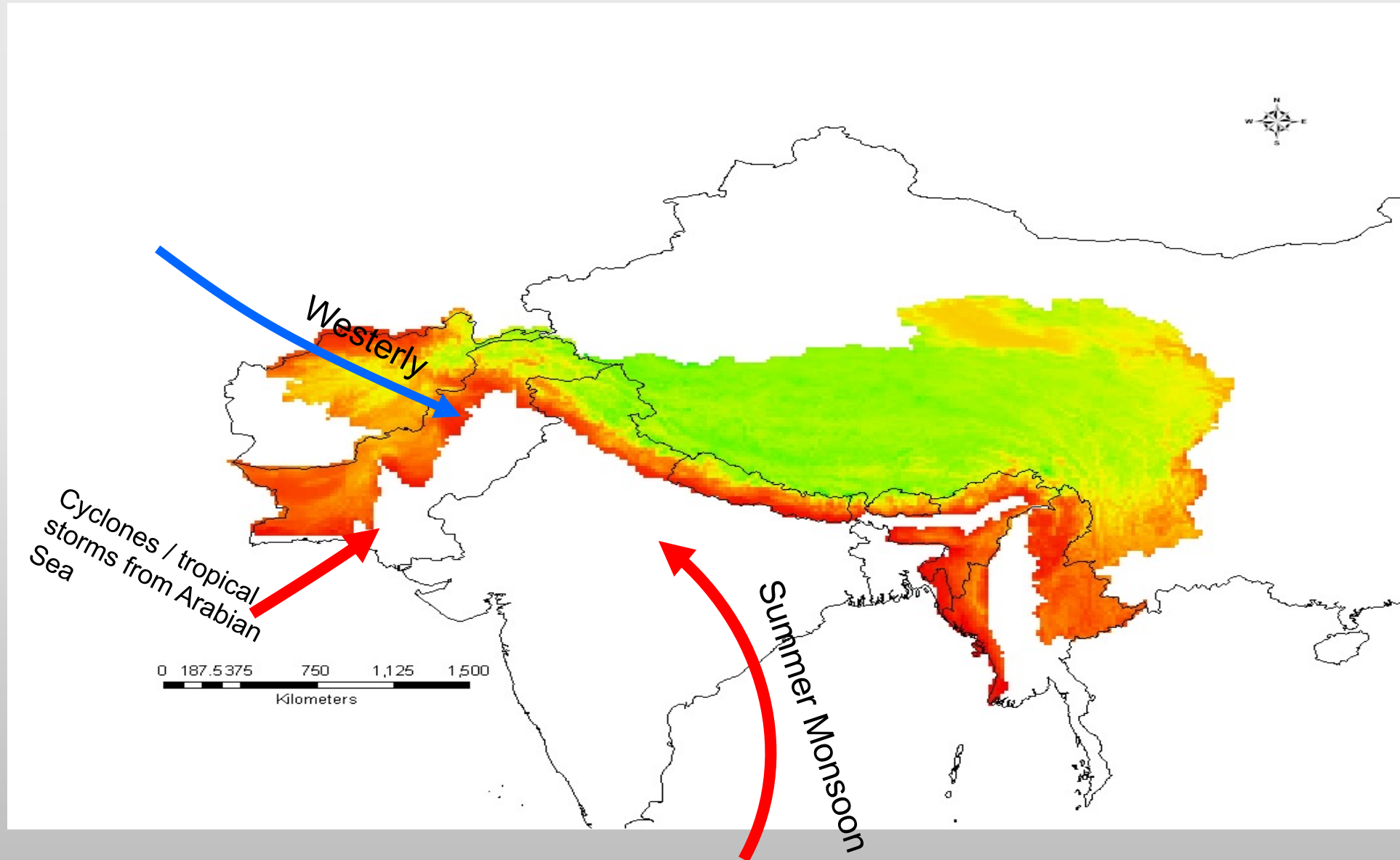


Temporal Change in Arctic Ice

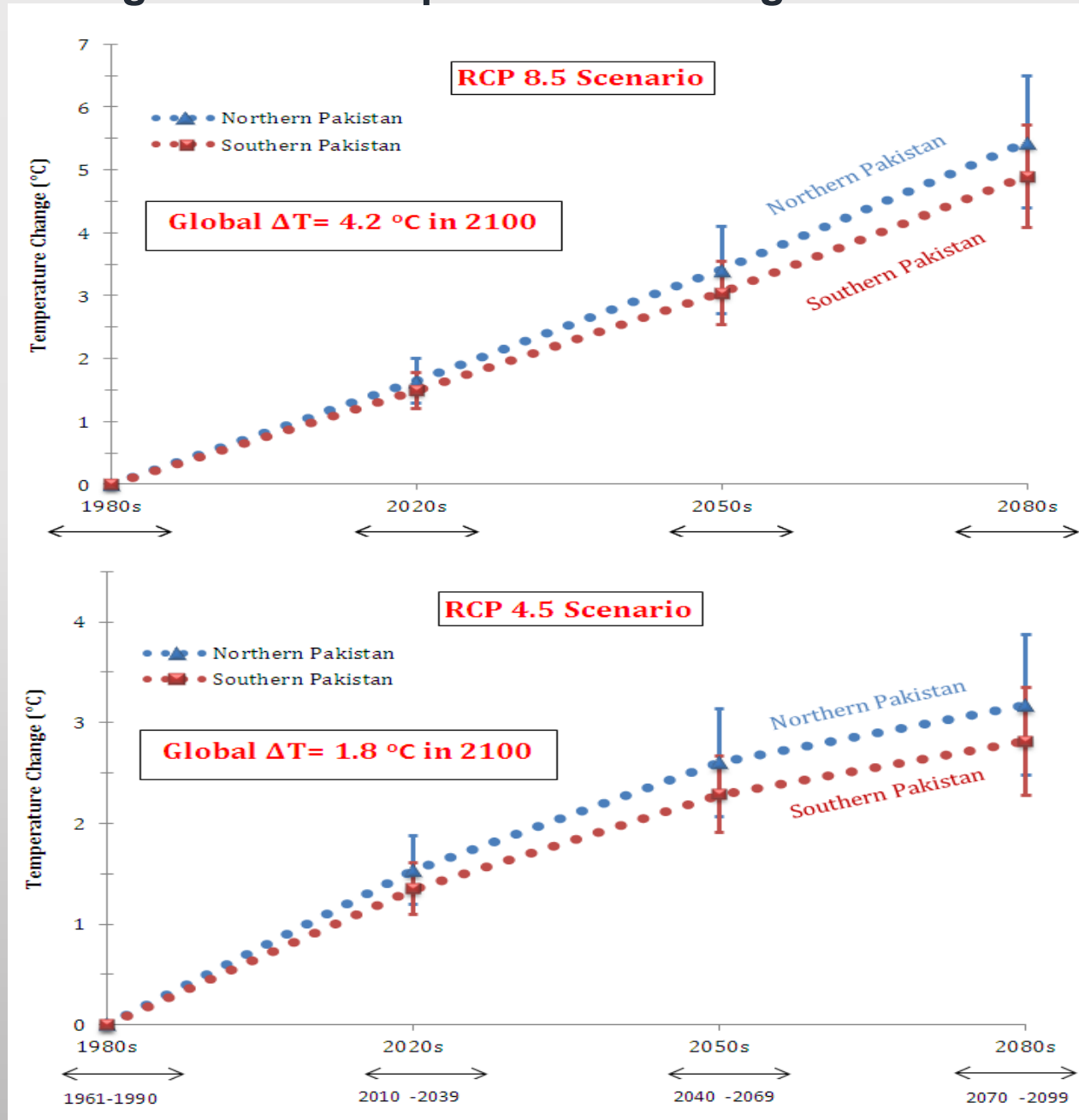
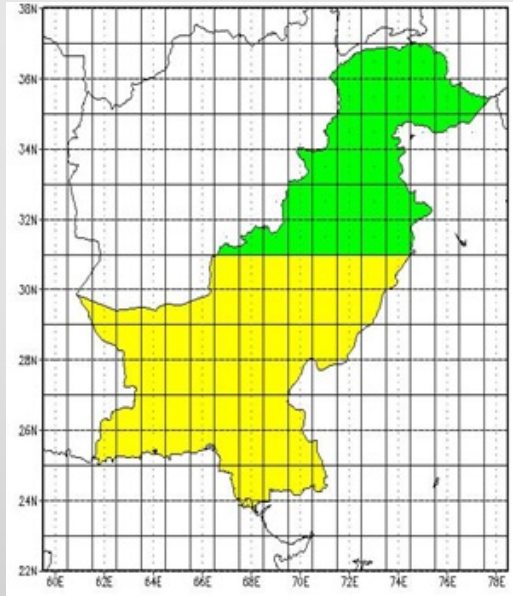


Climate change and Water resources of Pakistan

Major Weather System in the Pakistan

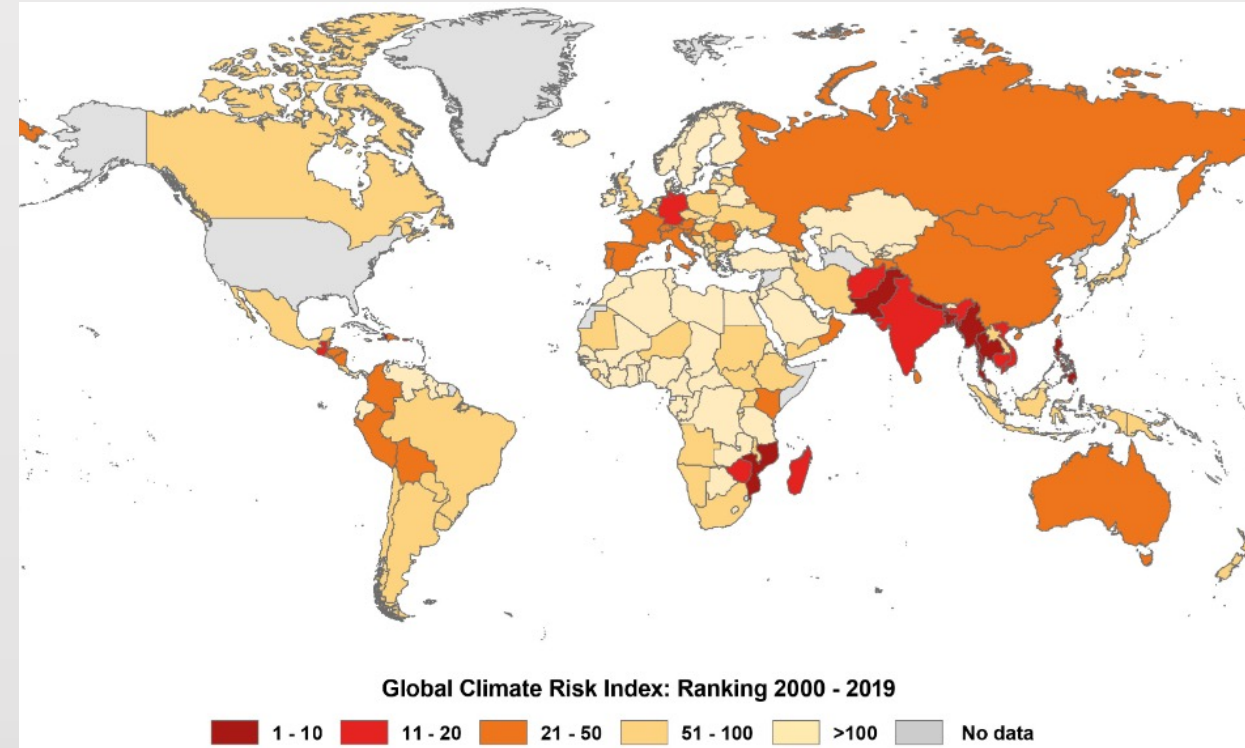


Projected Changes in Average Temperature of Northern and Southern Pakistan also indicating Elevation Dependent Warming



Vulnerability of Pakistan to Climate Change

- Pakistan is among top 10 most climate affected country
- Large Floods 2010, 2022 including number of other floods in the last decades
- Between 1997 and 2017, Pakistan lost an average of 523.1 lives per year i.e. 10,462 lives in 20 years, which comes to 3.27 lives per million population.
- Pakistan was ranked 4th in terms of property damage and the largest contribution to these damage numbers came from the 2010 floods.
- Between June and August 2022, torrential rains and a combination of riverine, urban, and flash flooding led to an unprecedented disaster in Pakistan.
- According to the National Disaster Management Authority (NDMA), around 33 million people have been affected by the floods, including nearly 8 million displaced. The floods have taken the lives of more than 1,700 people, one-third of which were children.
- Biparjoy cyclone, category III



Super Floods in Pakistan 2010, 2022

Recent Heat waves and Drought events

- ❖ The country has suffered from prolonged droughts (1998-2002, 2014-17, 2020-2022),
- ❖ Heat waves in recent years 2015, 2018 & 2022.
- ❖ UN lists Pakistan among drought-hit countries based upon 2020-2022 droughts along with 22 more countries such as Afghanistan, Iran, Iraq, Zambia, Chile, Ethiopia, Brazil, Somalia, Malawi, Madagascar, Kazakhstan, Sudan, Syria, Mali etc.

Source:

<https://www.aninews.in/news/world/asia/un-lists-pakistan-among-drought-hit->



Heat wave in Pakistan 2015, 2022

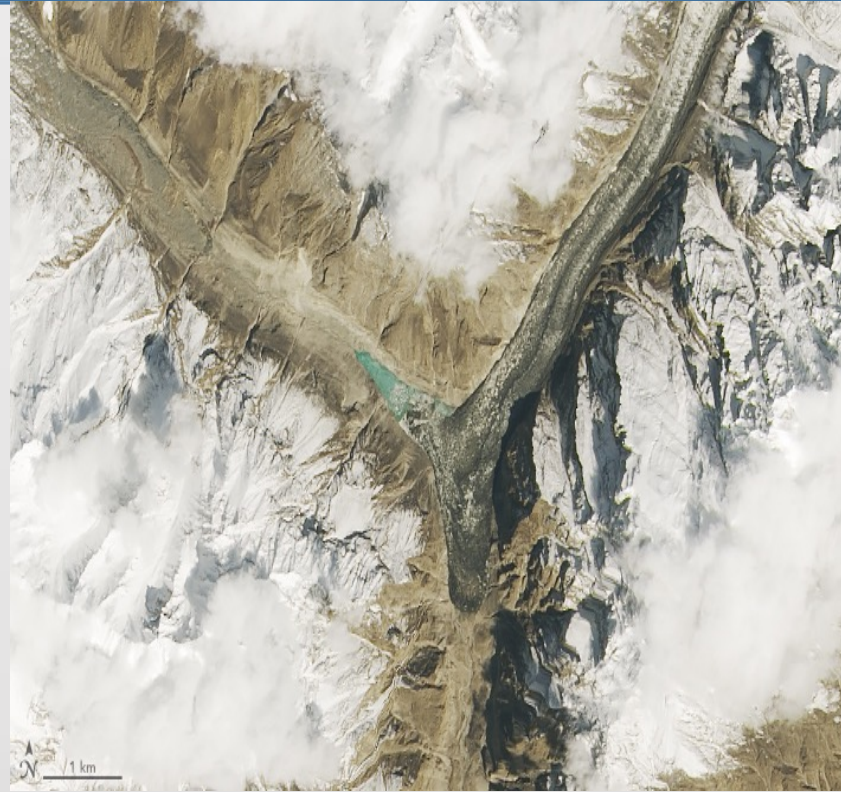


Villagers lead livestock from the drought-hit Tharparkar district in southern Sindh province on March 11, 2014, and 2022 drought above

GLOF Events

Shishpar Glacier Outburst flood:

- In April 2018, the debris-covered glacier started to accelerate, and blocked a meltwater stream flowing from the neighboring Muchuhar Glacier, it used to drain and block the other stream repeatedly from 2018 to 2022.
- The major destruction caused in May 2022 by GLOF when an RCC Bridge, a section of the Karakoram -Highway (KKH), retaining walls, orchards, agriculture land, water courses and two power plants and seven local house were destroyed.



Shishpar Glacier Outburst flood



Chitral Gloain GLOF 2019

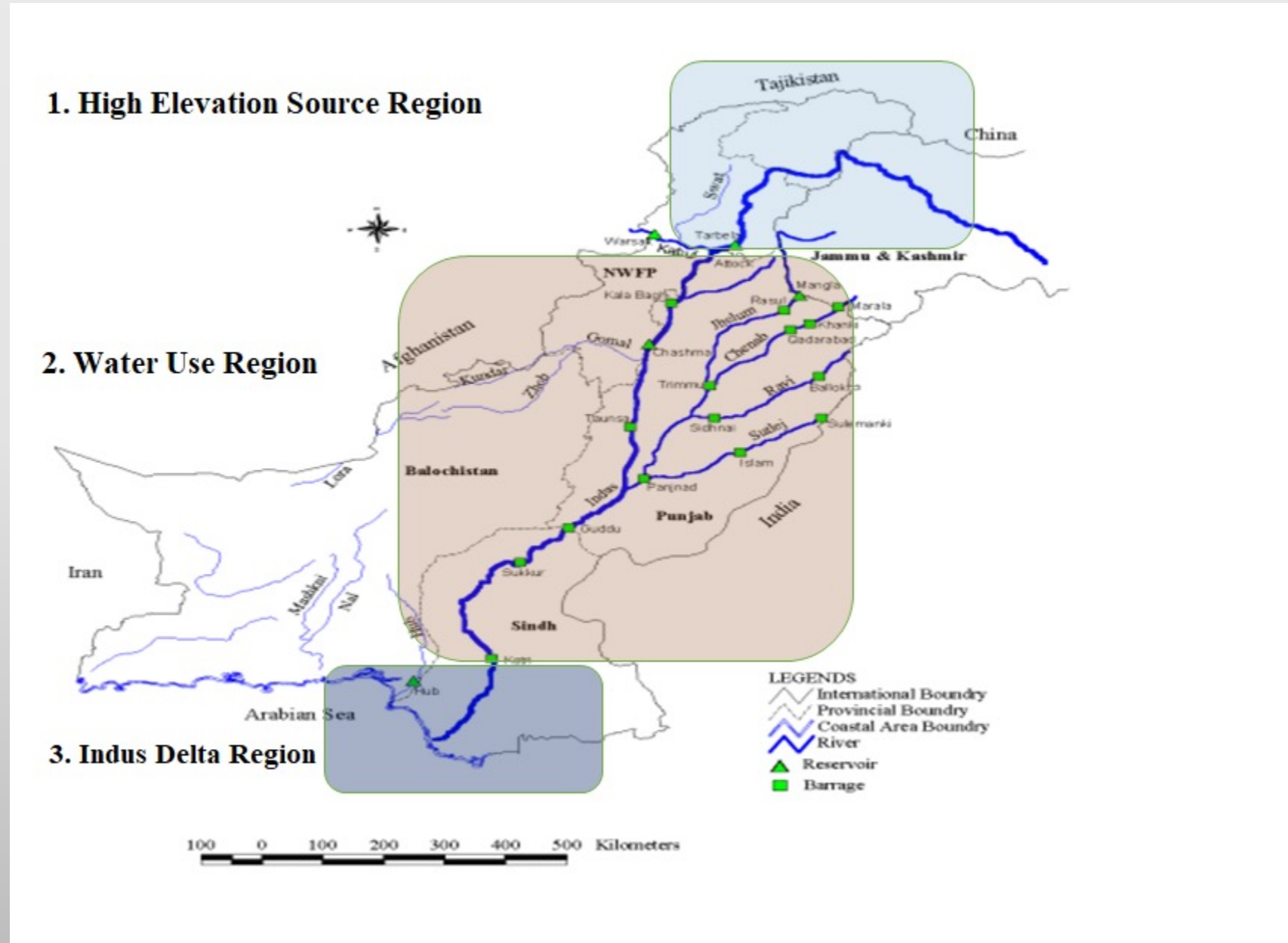


Chitral GLOF 2015

Golain Chitral GLOF Event:

- On 7th July, 2019, a GLOF event was reported in Rogheli, Golain Valley Chitral which affected a mega Hydel Power Station of 112 Mega Watt, population of 1000 people, main Chitral-Mastuj Road and Agriculture lands

Pakistan's Water Resources in changing climate world



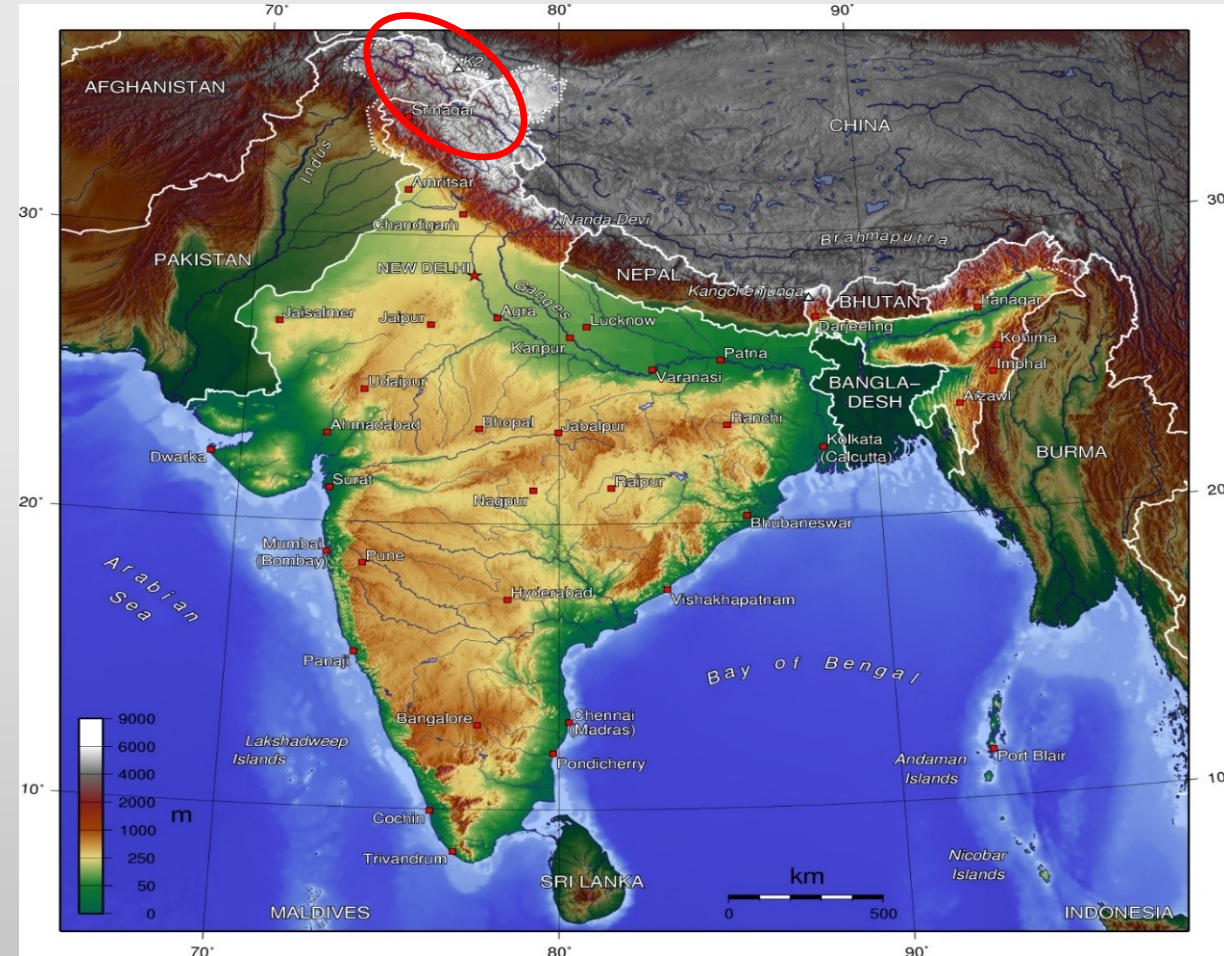
Climate Change and Water Resources of Pakistan

Major Concerns

- Data scarcity and Absence of High Elevation Climate data
- Heavy dependence of IRS flows on Karakorum glaciers and snow melt (60-80 % vs 10-15 % for India)
- Large year to year variability of IRS flows
- Decreasing per capita water availability (decreased from 5800 m³ in 1950 to less than 1000 m³ at present)
- Trans-boundary Waters issues
- Low storage capacity of Pakistan; only equivalent to 30 days of river flows while it is 120 days for India, 700 days in Egypt, while USA and Australia 900 days each
- Deteriorating Groundwater quality in the coastal/Indus delta region due to reduced Kotri downstream flows and Sea Level Rise
- Ecosystem: Increased risk of extinction of many species and Increased threat to the stability of wetlands, mangroves and coral reefs.

Cryosphere of HKH Region (UIB)

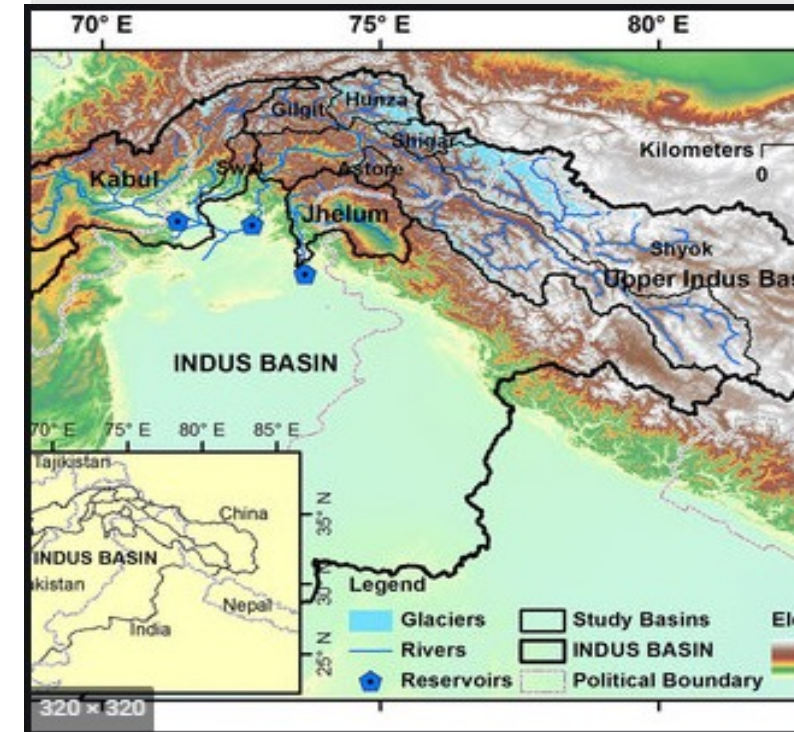
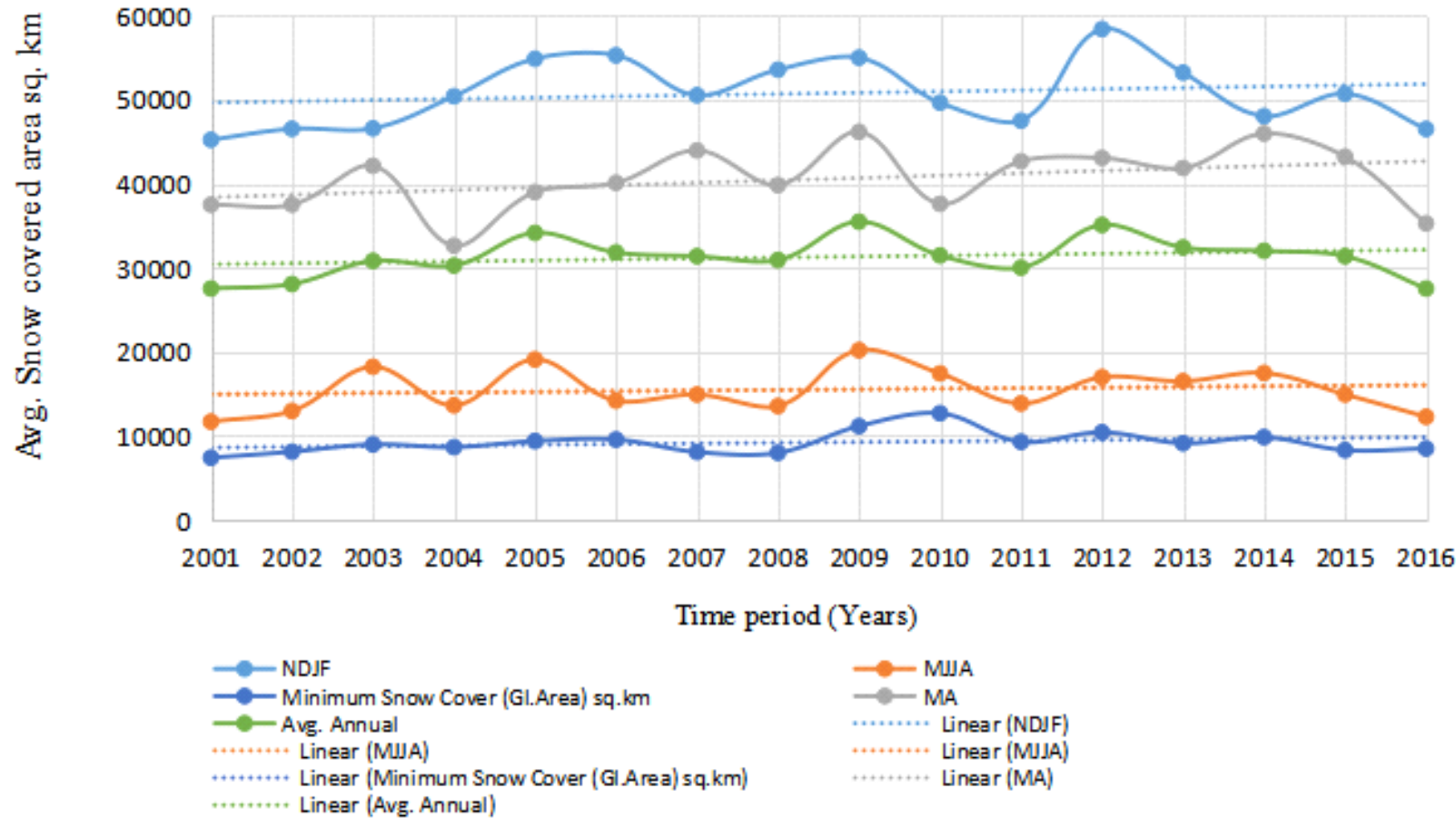
- ❖ A number of studies suggest that the glaciers in the Himalayan and Hindukush region have been declining, while those in the Karakoram region are still relatively stable “**Karakoram Anomaly**”.
- ❖ However, there are significant gaps in the current state of knowledge, including lack of direct information on the precipitation at elevations above 4700 meter and current glacier behavior.



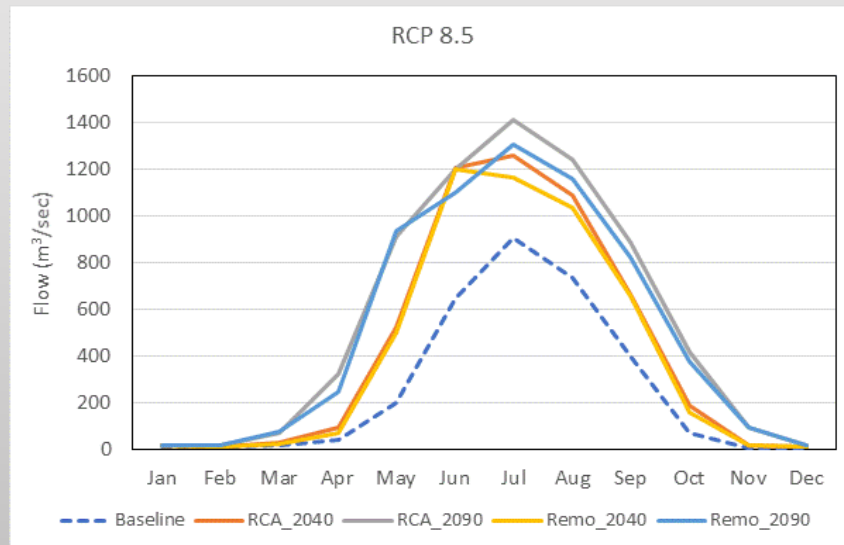
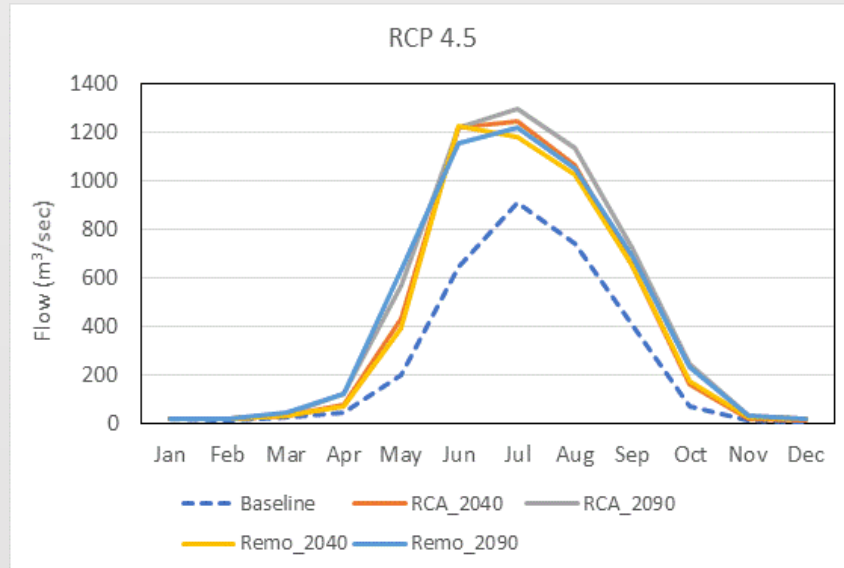
Some Recent GCISC Research work

Results of our recent study

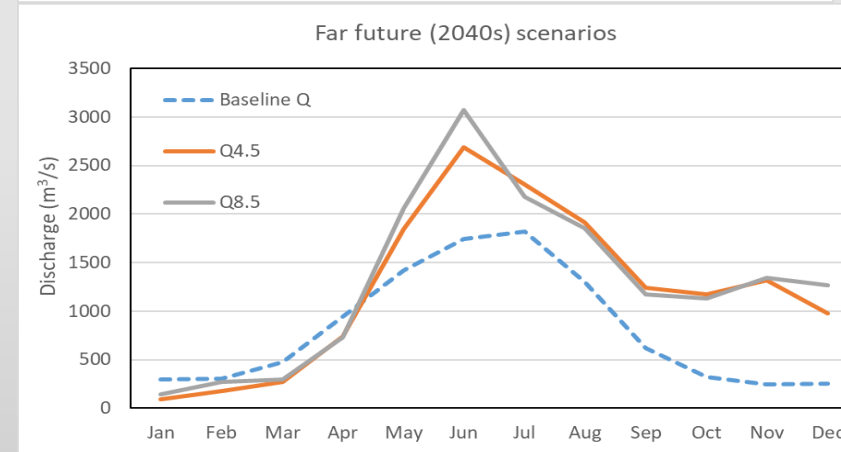
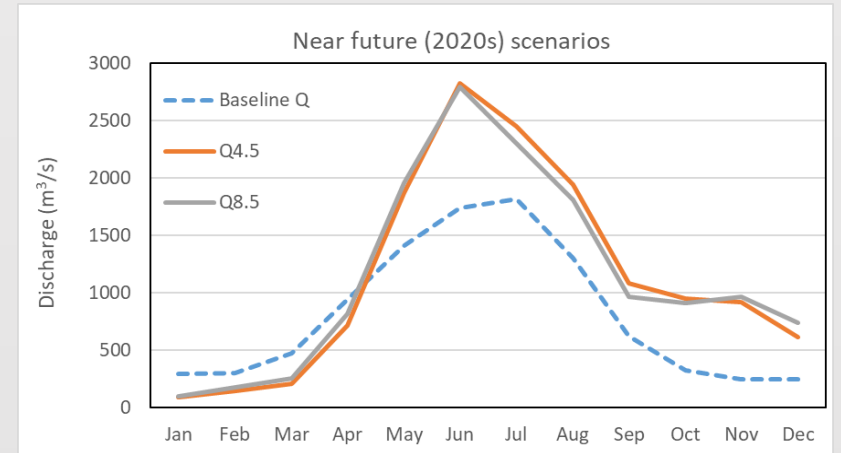
Annual and seasonal Snow Cover distribution for the Kabul river basin over the period 2001-2016



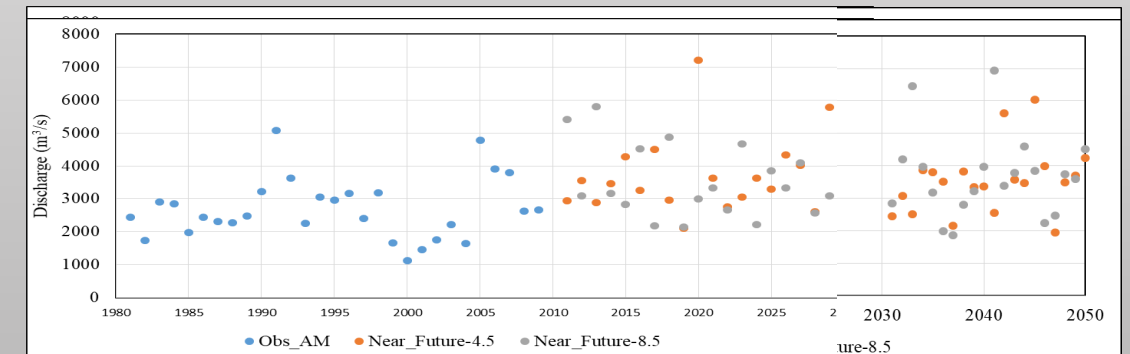
Glacier rich basin (Gilgit)



SNOW RICH BASIN (KABUL)



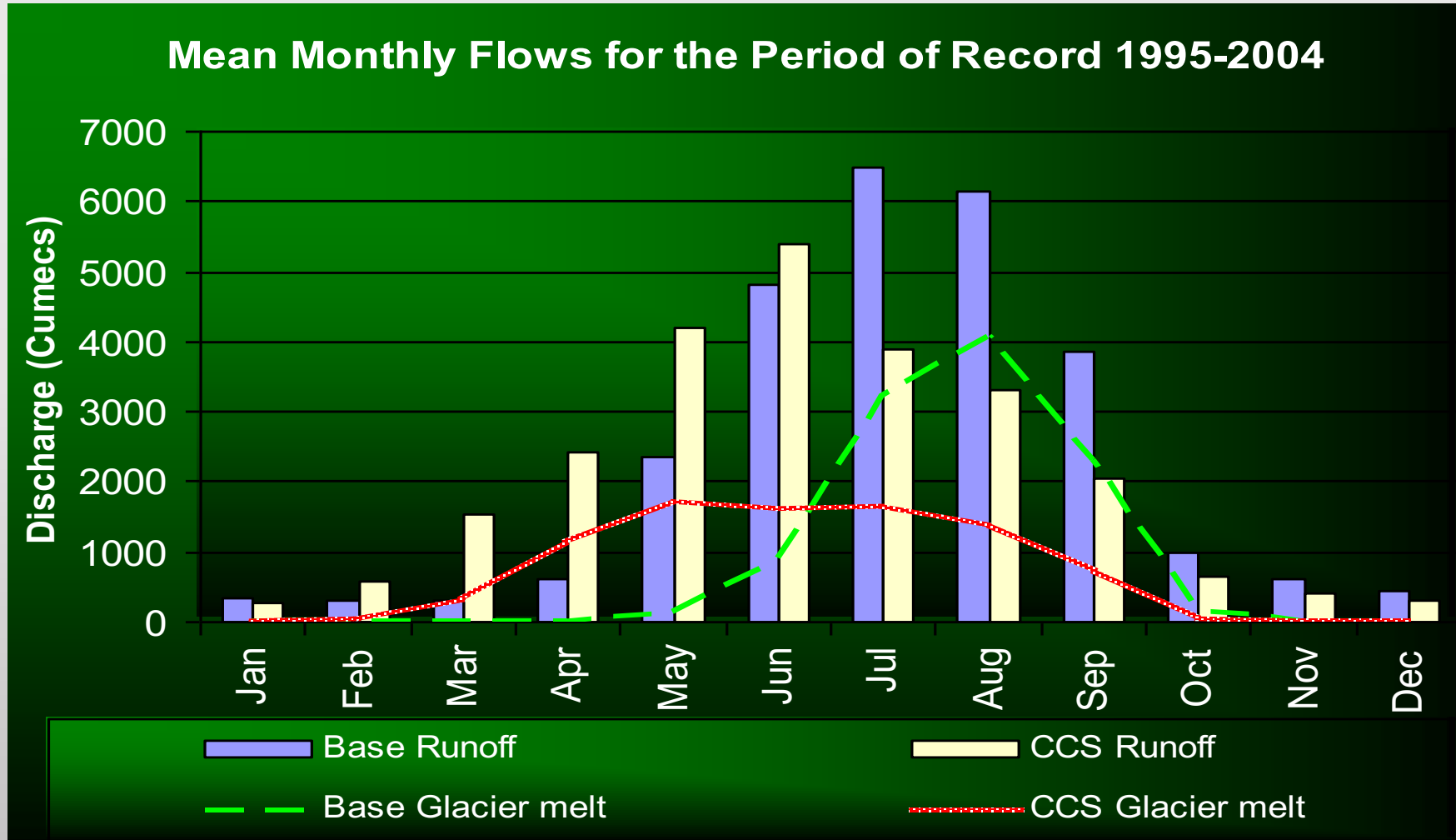
Future flood events



Impact of Climate Change and Glacier retreat on UIB Flows

Assumed Climate Change Scenario (CCS):

Δ Temp: +3°C, Δ Glacier Area: - 50%



Main Results:

1. Annual flows reduced by 15%
2. Intra-Annual flow pattern considerably changed

GLOF risk assessment for hydropower projects in mountainous areas of Chitral River Basin

- Hydro-Meteorological Data Analysis with high Resolution Future Climate Projections
- RS/GIS Based Lakes Identification and Risk Analysis
- High-Resolution Satellite Image Analysis of the Main River Channel and Surroundings for Detecting Boulder Size and Movement
- Other Risk factors (Land Slides)
- Lake volume and GLOF Peak discharge Estimations

Ongoing and near future GCISC water related works

1. Spatiotemporal Analysis of Selected Glaciers in Hunza River Basin, Pakistan
2. Spatio-temporal characterization of drought over the country through drought indices
3. Groundwater modeling and validation of GW resources with existing available data and with GRACE Satellite
4. Impacts of climate change on groundwater resources of Pakistan especially Doabs areas (Bari, Rechna, Chaj and Thal Doabs)
5. Third UNFCCC National Communication

Recommendations

1. More research is required to monitor the glaciers of HKH region of Pakistan especially of Karakorum's glaciers
2. Application of State-of-the-art RS & GIS Tools & Techniques to assess present status of Karakoram Glaciers using high resolution Satellite data
3. Field Measurements on selected glaciers for validation of RS/GIS results
4. Groundwater measurement and monitoring with application of State-of-the-art RS & GIS Tools & Techniques using satellite data
5. Develop appropriate Adaptation Measures to counter the negative impacts of climate change
6. Regional, sub-regional and national coordination and collaboration to manage the water resources under changing climate
7. Funding availability

Thank you



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