# Climate Change Challenges faced by Agriculture in Punjab

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Seminar on 'Impacts of Climate Change on Agriculture in Punjab',
TAP-CC, Lahore

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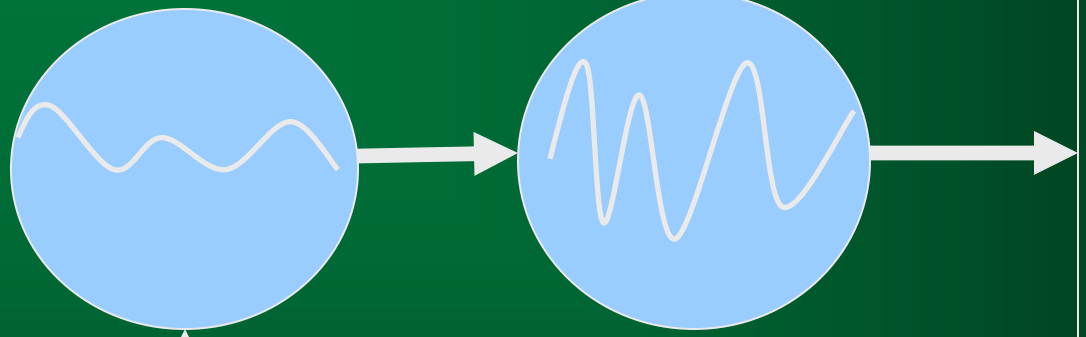
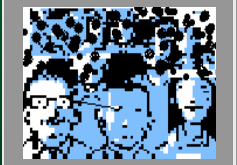
Natural Climate Variability

Climate Change
Natural + Anthropogenic

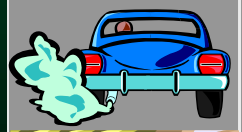


Anthropogenic Influences since the Industrial revolution



Spiraling Population

High pace of Industrialization



Increasing use of Fossil Fuels in Industry & Transport

Deforestation for Agriculture and Urbanization

## CLIMATE CHANGE

Global Warming

Increased Precipitation & its Uneven Distribution

Melting of Glaciers & Snow

Sea level Rise

Increase in Frequency & Intensity of Extreme Weather Events

## IMPACTS

Uncertainty in Water Availability

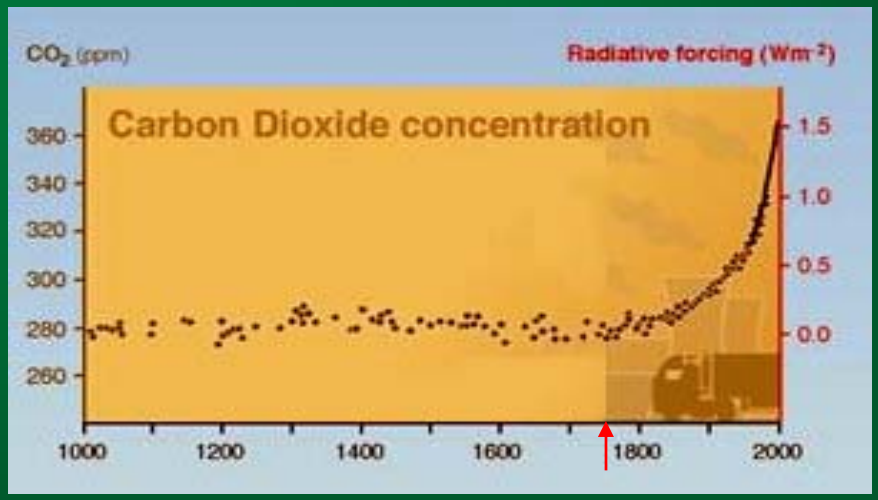
Decrease in Crop Yields

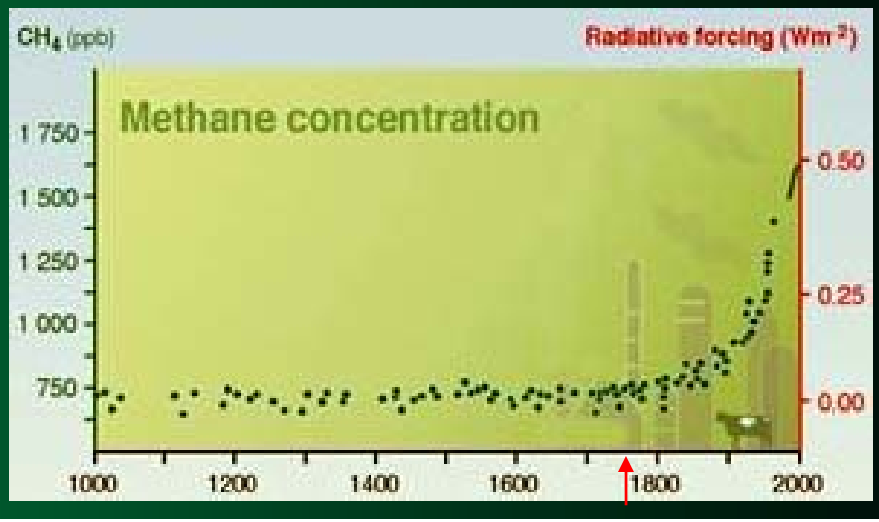
Newer perspective for sources of energy

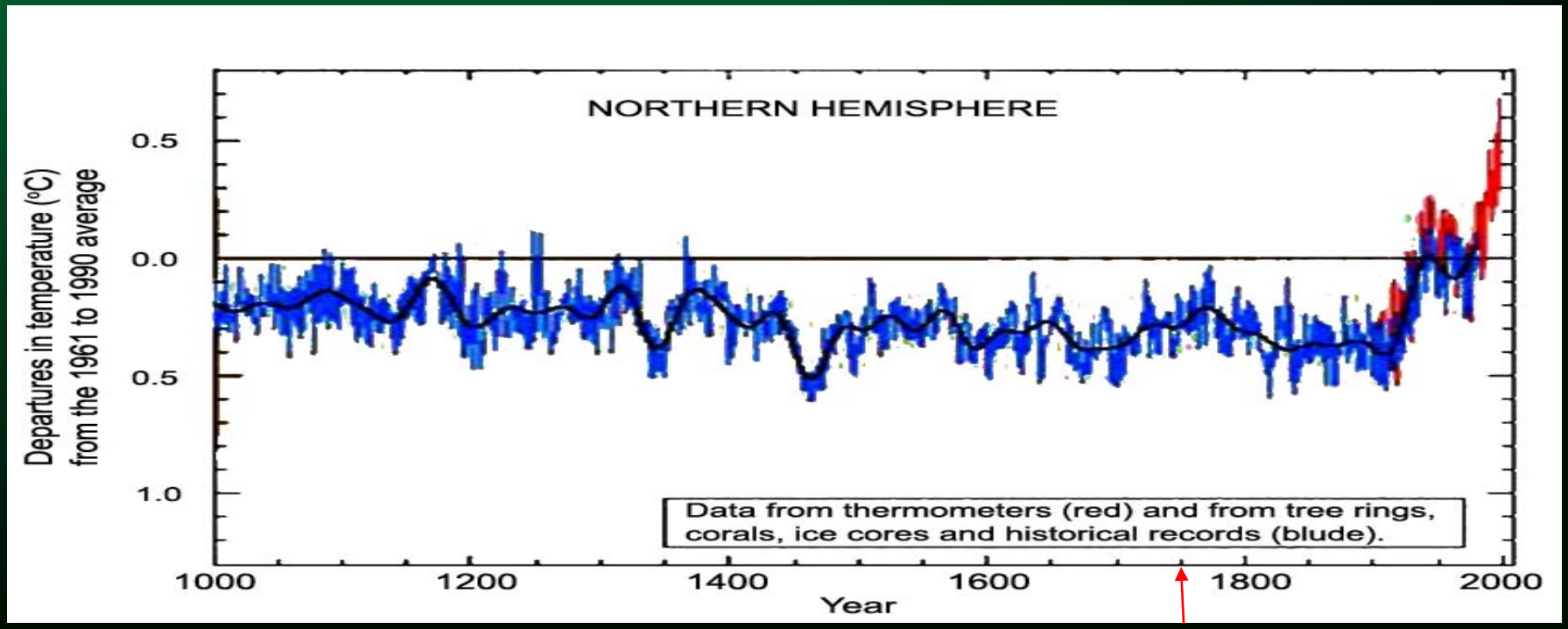
Loss of Biodiversity

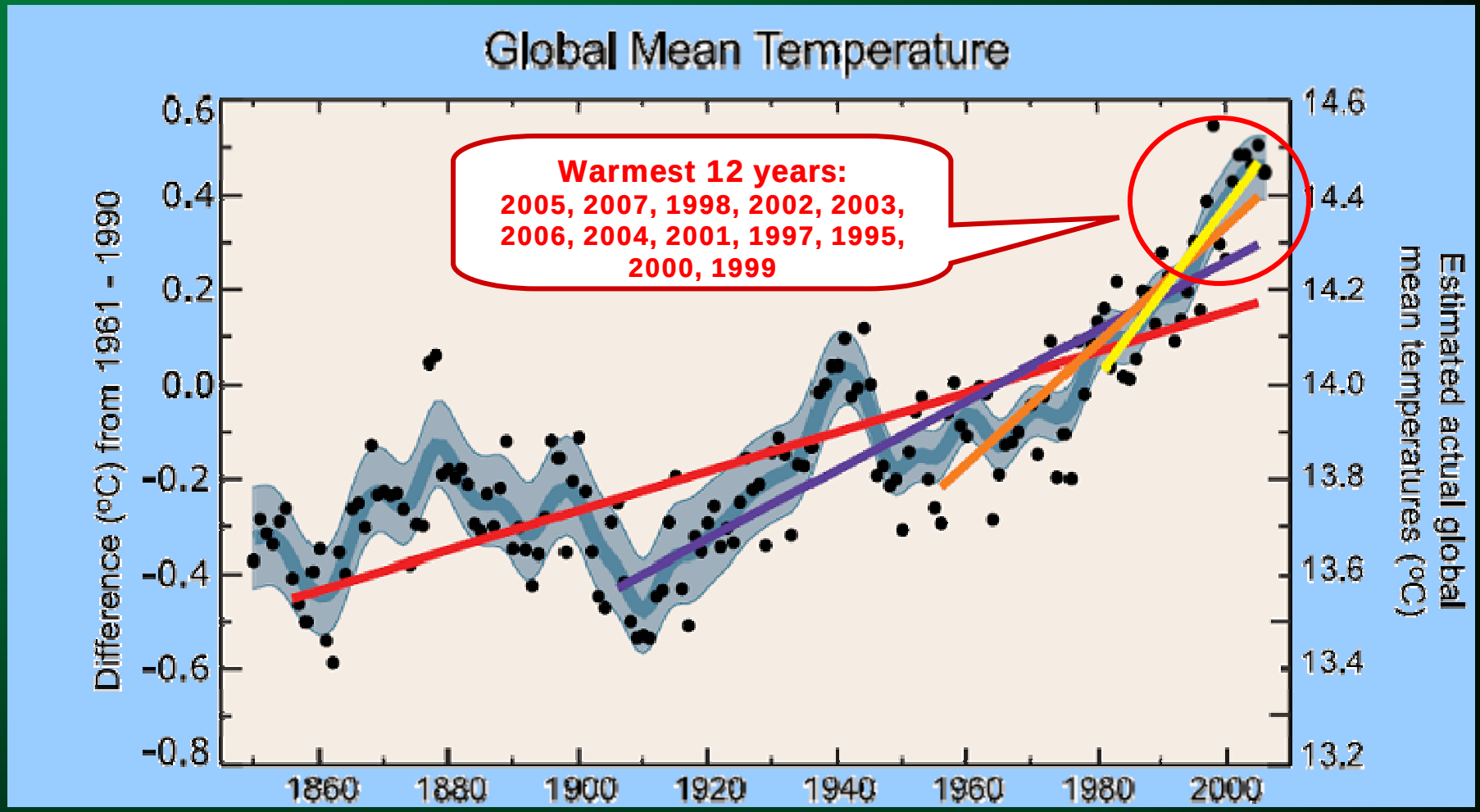
Increased Health Risks

# Past 1000 Year Changes in Temperature and $CO_2$ & $CH_4$ Concentrations






**Rate of Change (°C per decade)**

| | |
|---|---|
| 1850 – 2005 | 0.045 |
| 1905 – 2005 | 0.074 |
| 1955 – 2005 | 0.128 |
| 1980 – 2005 | 0.177 |

**Average Global Temperature °C**

| | |
|---|---|
| 1999 | 14.38 |
| 2000 | 14.40 |
| 1995 | 14.48 |
| ⋮ | |
| 1998 | 14.57 |
| 2007 | 14.60 |
| 2005 | 14.63 |

# Some Major Findings of IPCC Fourth Assessment Report (AR4), 2007

- 0.6 $^{0}$ C increase in average global temperature during the last century; (2005 warmest year followed by 2007, 1998, 2002, 2003, 2006 etc.)
- Increase by 1.8 – 4.0 $^{0}$ C projected over the 21$^{st}$ Century;
- Associated to this will be large changes (both, increases and decreases) of temperature and precipitation in different world regions;
- Frequency and intensity of extreme climatic events (severe cyclonic storms, floods, droughts etc.) will increase considerably;
- Large scale melting of mountain glaciers and polar ice caps, particularly the Arctic;
- Substantial rise in sea level.

# Major CC-related Concerns of Pakistan

Water and Agriculture sectors at the greatest risk;

- Increased variability of Monsoon;
- Increased risks of floods and droughts;
- Severe water-stressed conditions in arid and semi-arid region;

# Major CC-related Concerns of Pakistan (Contd.)

- Recession of HKH Glaciers;
- Food Insecurity due to reduced agriculture productivity;
- Upstream incursion of saline water in the Indus delta; and risk to mangroves, coral reefs and breeding grounds of fish.

# Vulnerability of Agriculture in Punjab to Climate Change Stresses

- **Increasing temperatures**
- **Erratic and unpredictable rainfall**
- **Increased variability of Monsoon**
- **Changes in river flows (irrigation water)**
- **Severe water shortage in Arid and Semi-arid areas**
- **Extreme climate events, such as floods, droughts, heat waves, cold waves, etc.**

# Changes in Irrigation Water

**IPCC AR4 (2007)**

Glacier melt in the Himalayas is projected to increase flooding within next two to three decades. This will be followed by decreased river flows as the glaciers recede.

**World Bank (2006)**

Western Himalayan glaciers will retreat for the next 50 years causing increase of Indus River flows. Then the glacier reservoirs will be empty, resulting in decrease of flows by 30-40% over the previous 50 years.

- Since Indus river flows originate mainly from Karakoram (snow and glacier melt contributes some 60-80% to IRS flows), there is an obvious need for an improved understanding of the temporal behavior of these glaciers.

- Studies are in progress at GCISC to assess the overall effect of precipitation change and glacier melt on IRS flows using fine resolution RCM climate change scenarios.

# Irrigated and Rainfed areas in Pakistan

- **Total land area: 79.61mha**
- **Cultivated area: 22.05 mha** (28% of total)
- **Irrigated area : 19.12 mha** (84% of cultivated)
- **Rainfed cultivated area**
  **: 3.67 mha** (16% of cultivated)

# Irrigated areas of Pakistan
(equipped with irrigation infrastructure)

- Punjab : 10.33 mha (71% of total)
- Sindh : 2.52 " (17% " )
- NWFP : 0.80 " ( 1% " )
- Balushistan: 0.81 " ( 1% " )

Total : 14.46 "

(Ref: FAO Aquastat, Global Map of Irrigation, 2000)

# Extent of Dry Areas in Pakistan*

(Classified on the basis of Aridity Index)

- Total cultivated: 22.05 mha
- Semi-arid areas: 2.3 mha(10% of cultivated)
- Arid areas :10.7 mha (48% " " )
- Hyper-arid area: 7.3 mha (37% " " )

* includes irrigated + rainfed as well as totally rainfed

# Dry Areas

(% of cultivated area in different provinces)

- Punjab : 23
- Sindh : 54
- NWFP : 60
- Baluchistan : 60

- FATA : 50

# Land Degradation in Pakistan

Due to:

- Water Erosion : 17%
- Wind Erosion : 8%
- Salinity and Sodicity: 9%
- Waterlogging : 5%
- Low organic matter : 96% (< 1%)

# Vulnerable agricultural areas in Punjab

- Water-logged and saline areas
- Desert areas
- Arid and Semi-arid areas
- Mountainous area

# Vulnerable communities in Punjab

- Small land holders (>80% in Pakistan)
- Poor and resource impoverished farmers
- Farmers of degraded (waterlogged and saline) lands
- Farmers of arid and desert area
- Farmers of mountainous areas

# Non-Climatic Challenges to Agriculture in Punjab

- Rapid population growth
- Shift of government attention from agriculture sector to industry
- Encroachment of agricultural lands by urbanization
- Industrialization – affecting land, water and environment
- Lack of technological interventions
- Poverty

# Salient Research Results Obtained by GCISC

# Climate Trends (1951-2000)

**Regions**

**I (a):**
**Greater Himalayas**

**I (b):**
**Sub-montane**

**II:**
**Western Highlands**

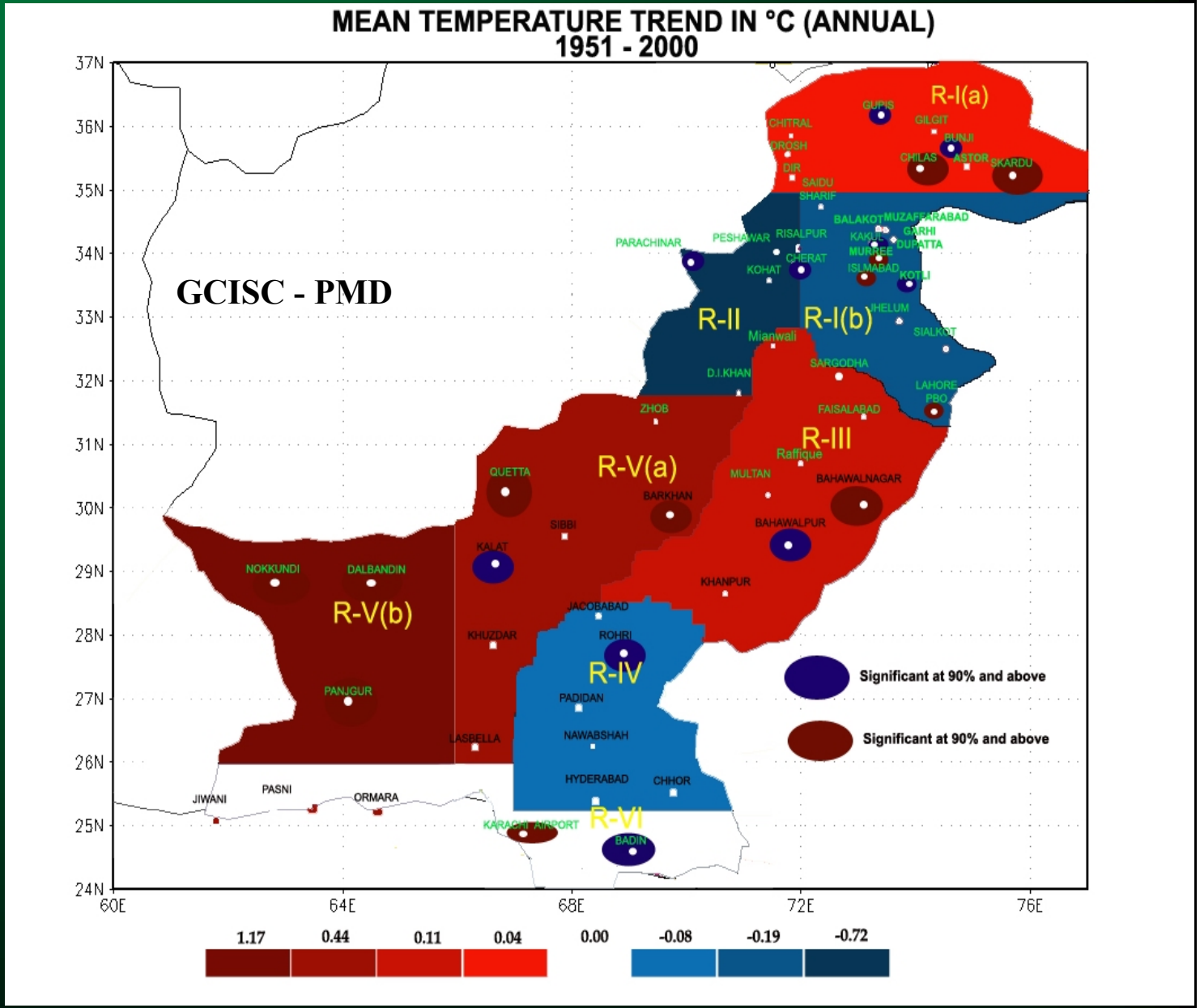
**III**
**Central & Southern Punjab**

**IV**
**Lower Indus Plains**

**V (a)**
**Balochistan Plateau (East)**

**V (b)**
**Balochistan Plateau (West)**

**VI**
**Coastal Areas**




**Negative Trends in Region II, Ib and IV; Positive Trends in other regions**

# Precipitation Trend
## (% Change per year, 1951 – 2000)

**Regions**

**I (a):**
**Greater Himalayas**

**I (b):**
**Sub-montane**

**II:**
**Western Highlands**

**III**
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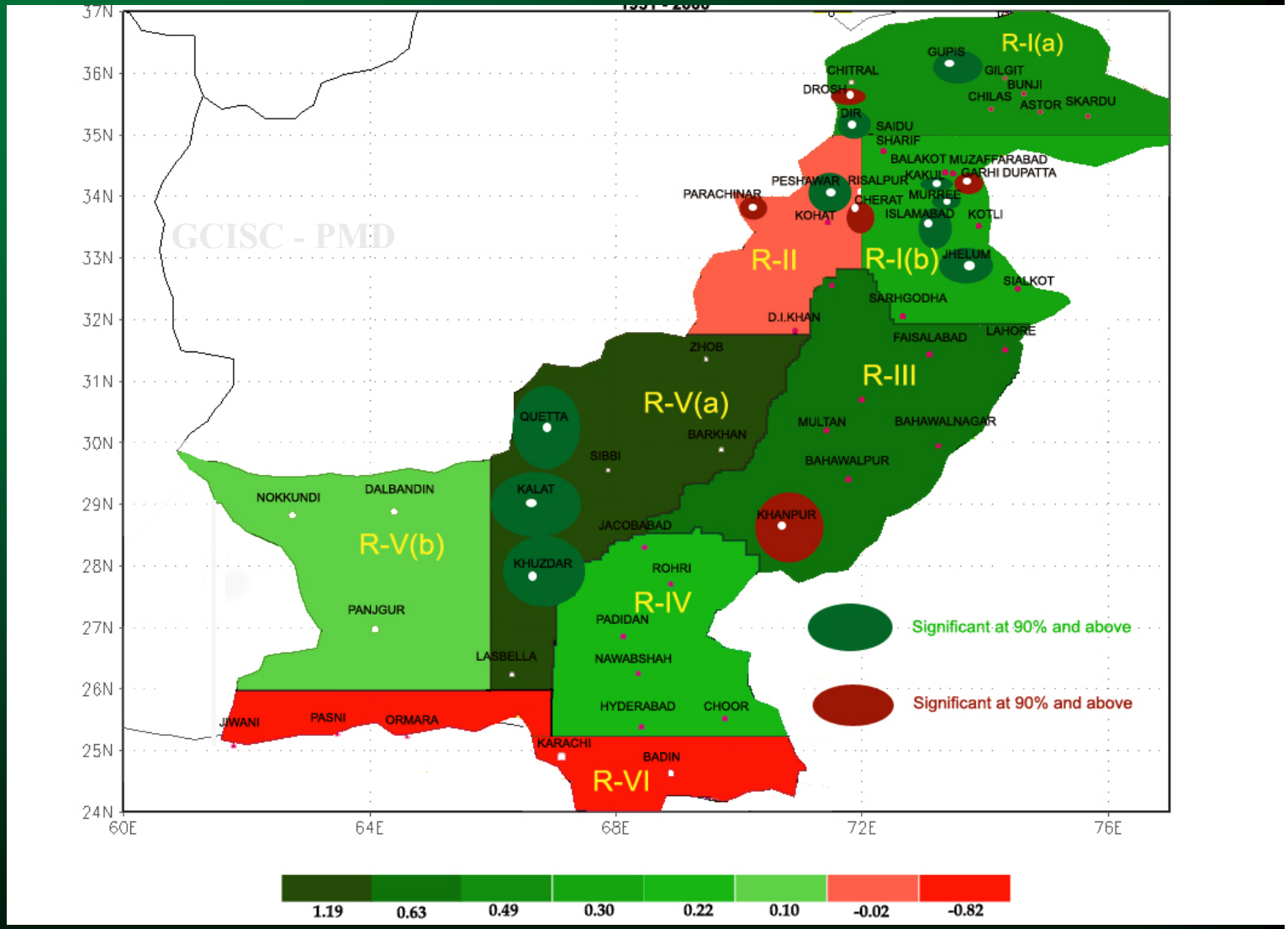
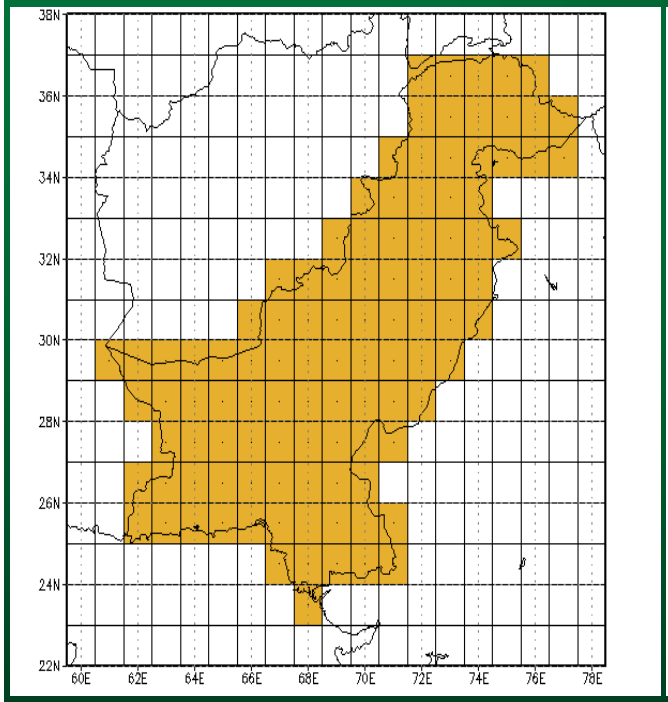


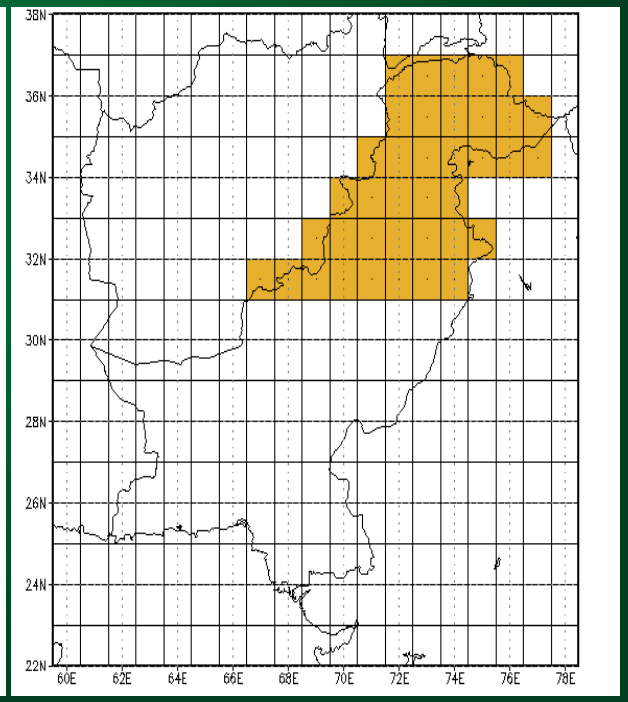

**Negative Trend in Region II and VI ; Positive Trends in other regions**

# Climate Change Projections

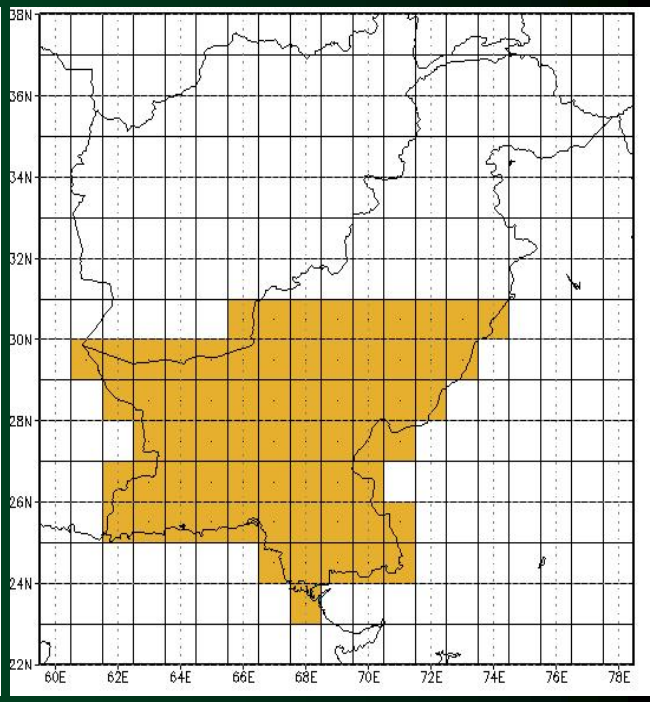
# Pakistan and its Northern & Southern Parts




(a)




(b)



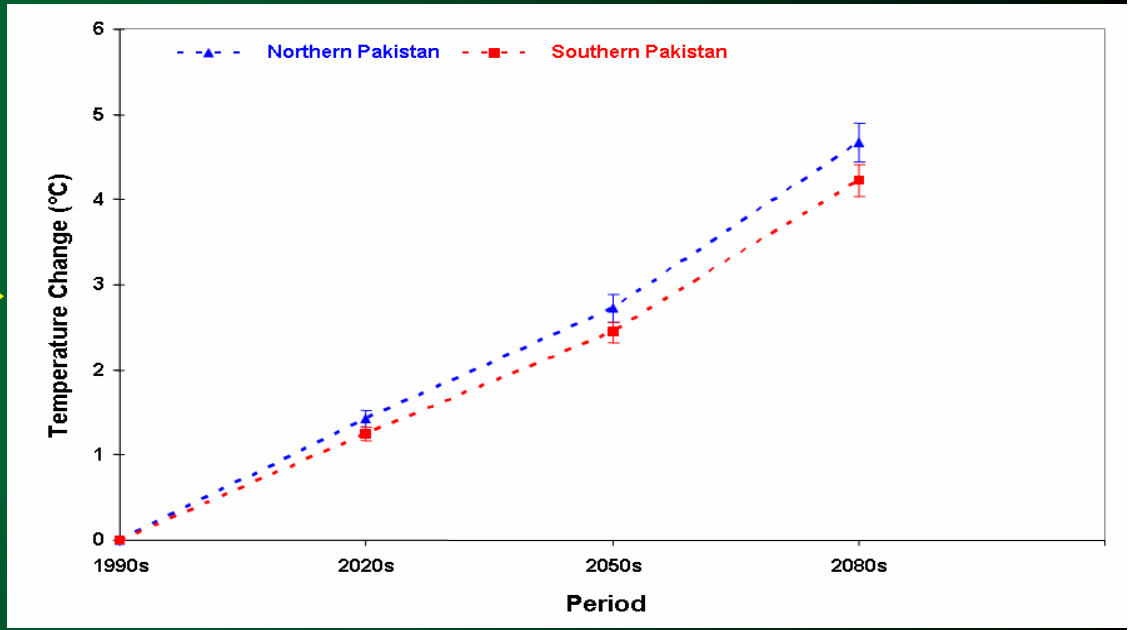

(c)

a) Pakistan
b) Northern Pakistan
c) Southern Pakistan

# Projected Changes in Average Temperature of Northern and Southern Pakistan

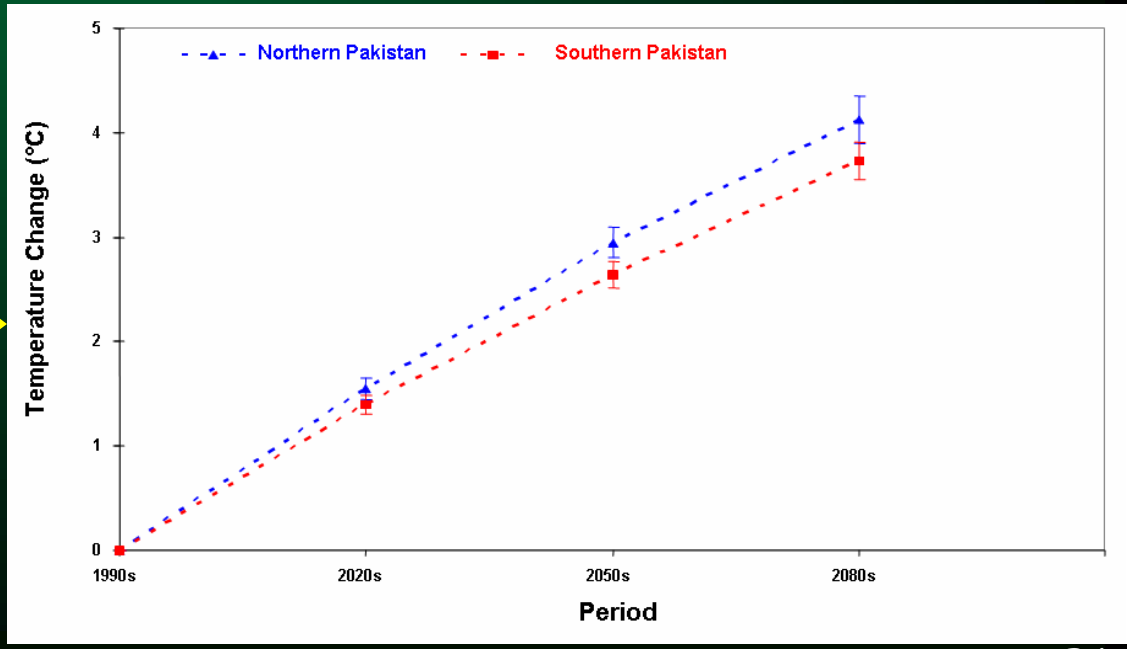
For A2 Scenario, based on Ensemble of 13 GCMs

(Global ΔT = 4.0 °C in 2100)




For A1B Scenario, based on Ensemble of 17 GCMs

(Global ΔT = 2.8 °C in 2100)

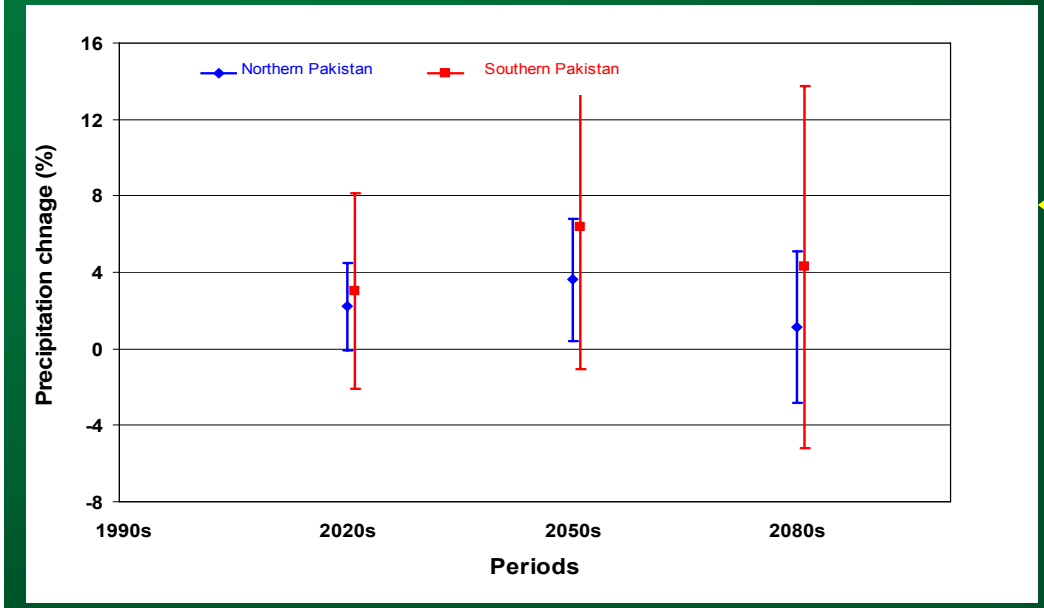


# Projected Temperature Changes in 2080s, ΔT (°C) by GCM Ensemble for A2 Scenario

| | Pakistan | Northern Pakistan | Southern Pakistan |
|---|---|---|---|
| Annual | 4.38 ± 0.44 | 4.67 ± 0.23 | 4.22 ± 0.18 |
| Summer | 4.13 ± 0.26 | 4.56 ± 0.28 | 3.90 ± 0.26 |
| Winter | 4.47 ± 0.20 | 4.72 ± 0.24 | 4.33 ± 0.18 |

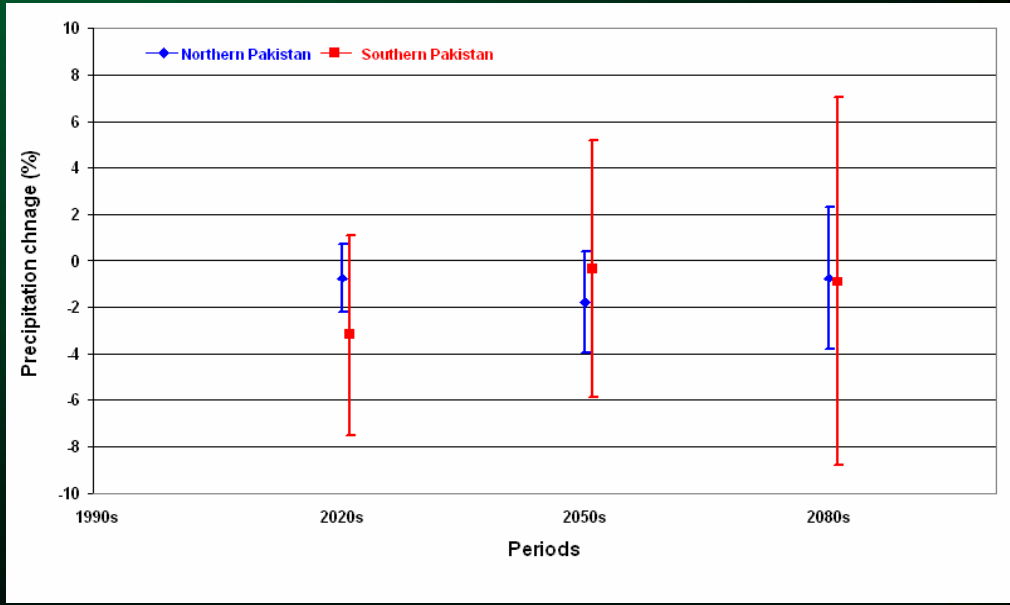
- Temperature increases in both summer and winter are higher in Northern Pakistan than in Southern Pakistan
- Temperature increases in Northern and Southern Pakistan are higher in winter than in summer

# Projected Changes in Average Precipitation of Northern and Southern Pakistan

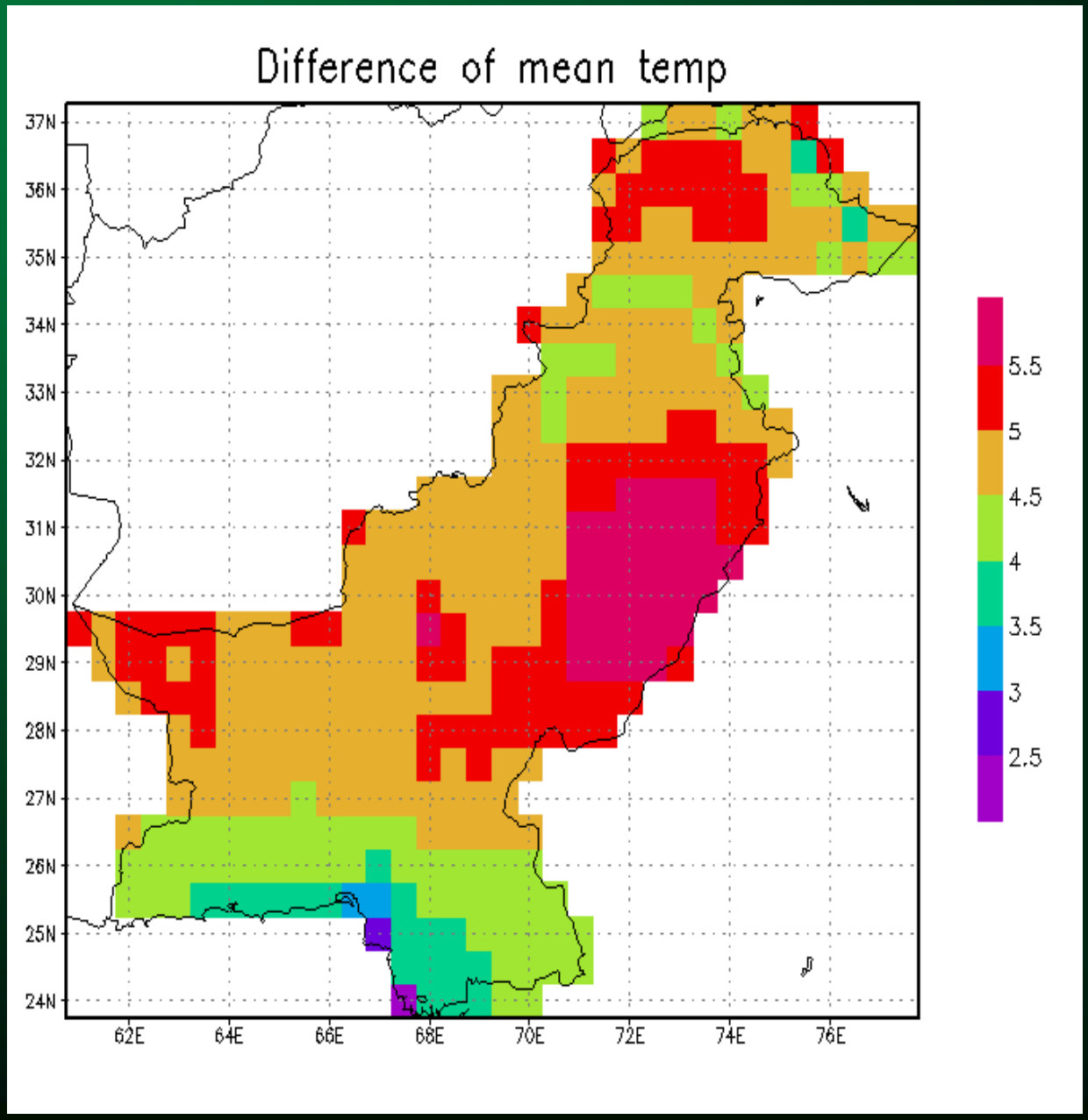



(Corresponding to IPCC A2 Scenario)
Based on Ensemble of 13 GCMs

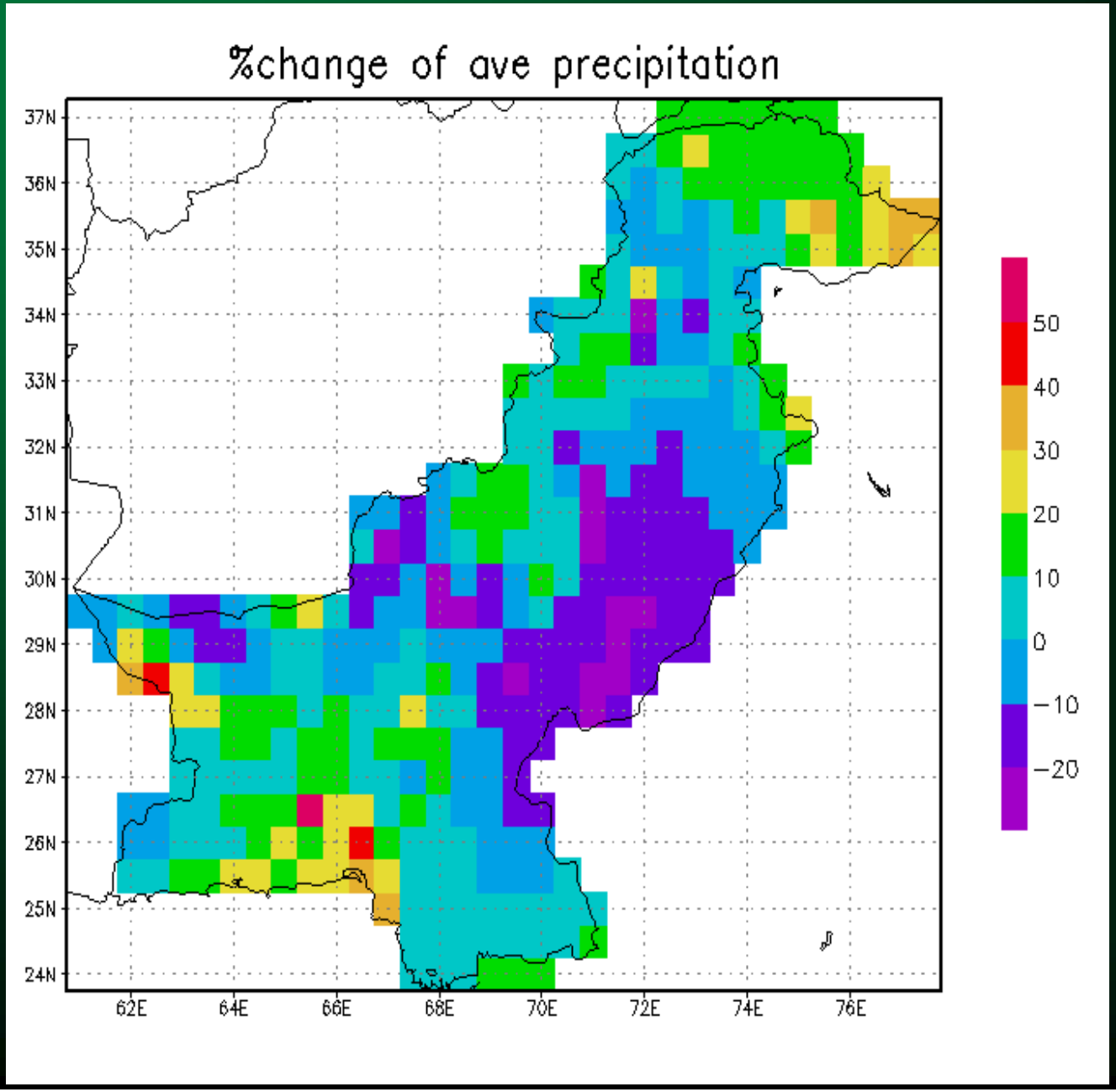
(Corresponding to IPCC A1B Scenario)
Based on Ensemble of 17 GCMs



# Projected Temperature Change (°C) for 2080s by PRECIS (A2 Scenario)



# Projected Precipitation Change (%) for 2080s by PRECIS (A2 Scenario)

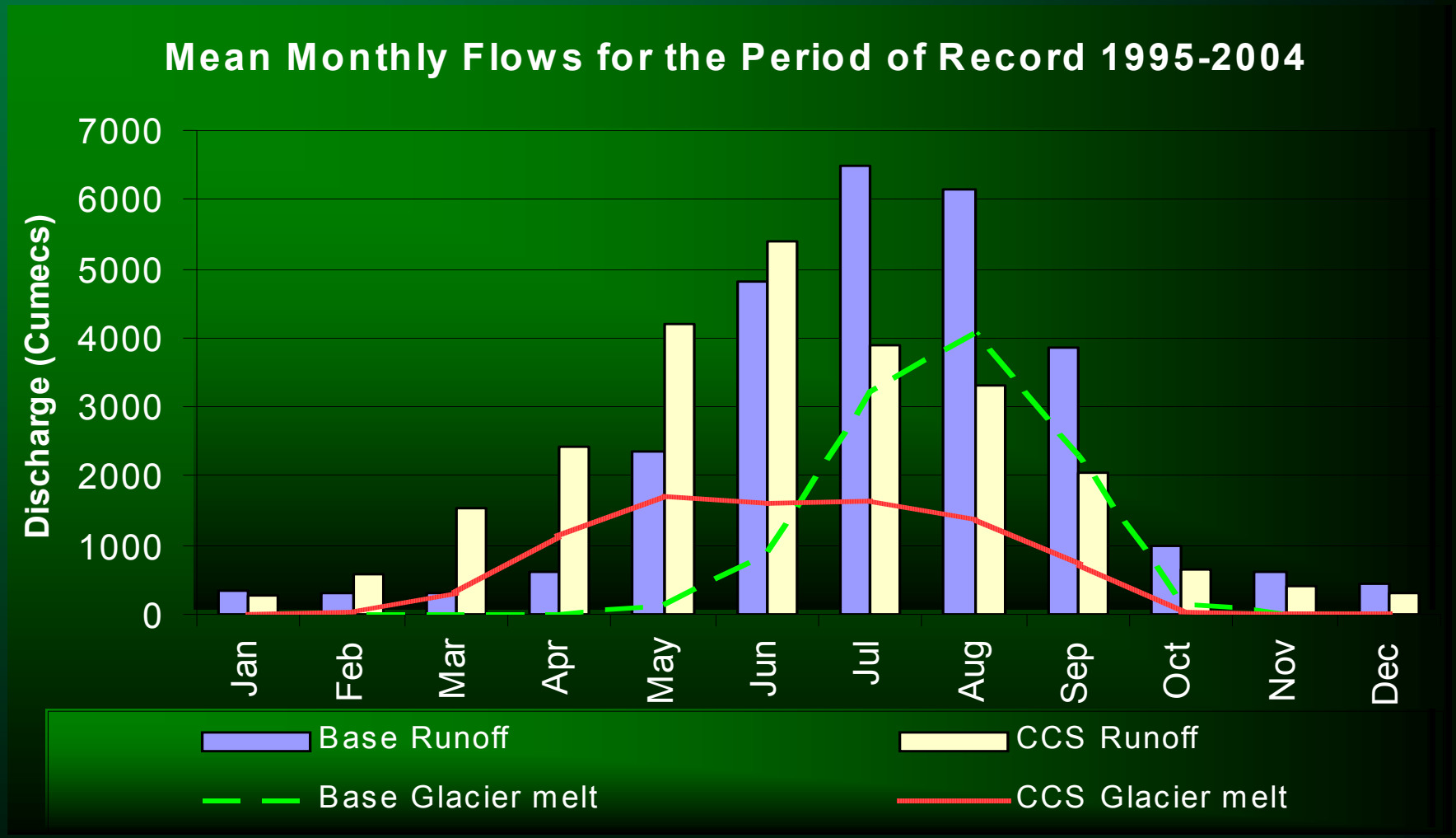


# Impacts of Climate Change on Water Resources of Pakistan

# 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**

# Melting of Glaciers in Pakistan

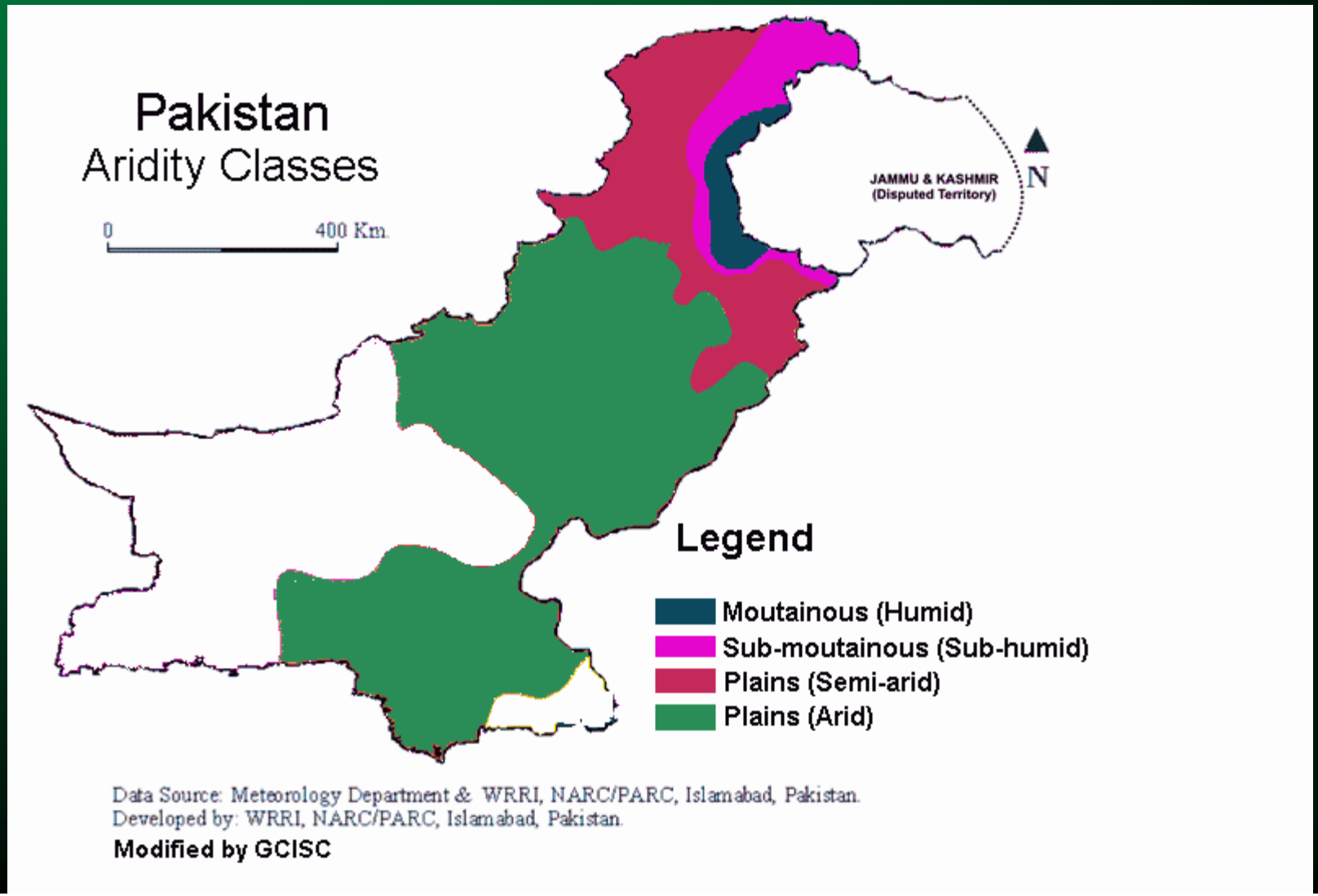
- Glaciers in Pakistan form 13% of mountain regions of the Upper Indus Basin (UIB). Melt water from these Glaciers contributes more than 60% to the flows from UIB.
- “Glaciers in Himalayas are receding faster than in any other part of the world and, if the present rate continue, the likelihood of them disappearing by the year 2035 is very high” .(Report of *International Commission for Snow and Ice* ,1999)
- In 2005, Hewitt reported widespread evidence of glacier expansion in the late 1990s in the Central Karakoram, in contrast to a worldwide decline of mountain glaciers.
- These conflicting findings make the impact of climate change on Karakoram glaciers and Indus River flows very uncertain.

# Study of HKH Glaciers by GCISC

- GCISC has joined hands with the GLIMS (Global Land Ice Measurements From Space) project of Southwest Asia Regional Centre, University of Nebraska at Omaha, USA to delineate the boundaries of various HKH glaciers using satellite imageries.
- A 3-year Pak-US S&T Cooperation Project (GCISC-GLIMS) has been approved in 2008.
- GCISC plan to use the above experience to study expansion/shrinkage behavior of major UIB glaciers, using time series satellite data.

# Impacts of Climate Change on Agriculture in Pakistan

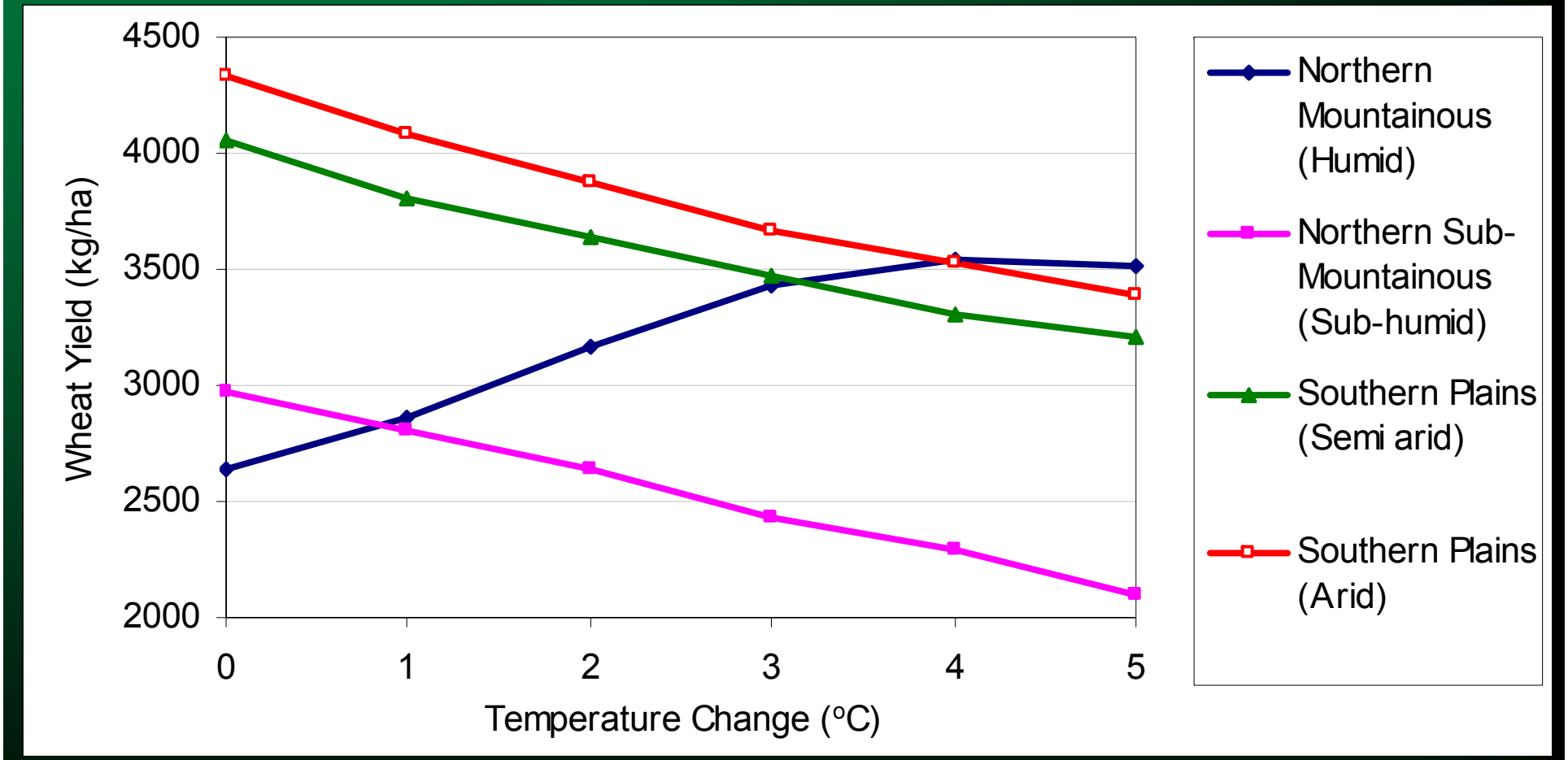
# Agro-climatic zones used by GCISC for Climate Change Impact Studies on Agriculture



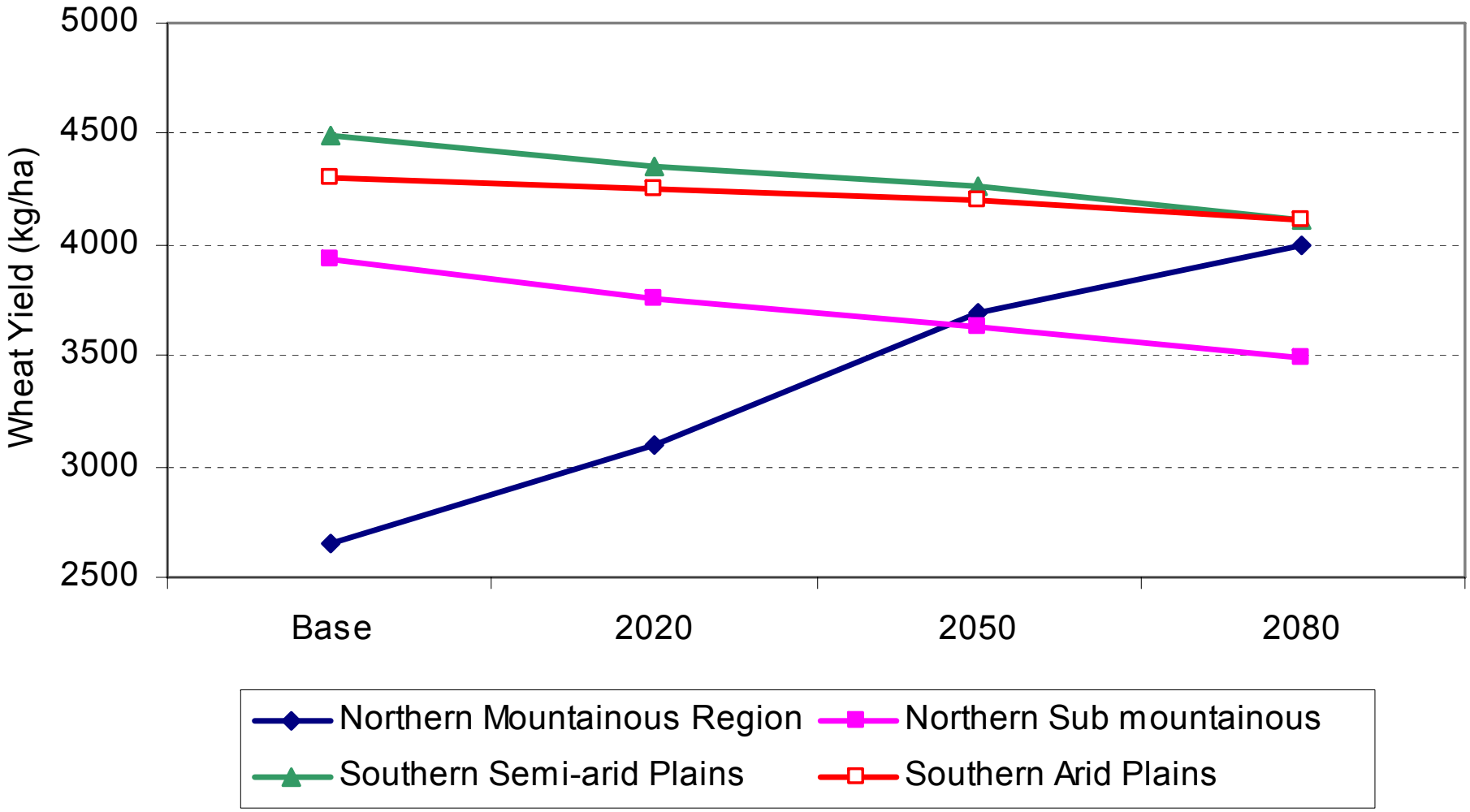
# Impact of rise in temperature on wheat Growing Season Length in Northern and Southern parts of Pakistan

| Temperature °C (increase over baseline) | Growing Season Length (Days) | | | |
|---|---|---|---|---|
| | Northern Pakistan | | Southern Pakistan | |
| | Mountainous Region (Humid) | Sub-Mountainous Region (Sub-humid) | Plains (Semi-arid) | Plains (Arid) |
| Baseline | 246 | 161 | 146 | 137 |
| 1 | 232 | 155 | 140 | 132 |
| 2 | 221 | 149 | 135 | 127 |
| 3 | 211 | 144 | 130 | 123 |
| 4 | 202 | 138 | 125 | 118 |
| 5 | 194 | 133 | 121 | 113 |

# Effect of increase in temperature on Wheat yields in different agro-climatic zones of Pakistan (other factors remaining constant)



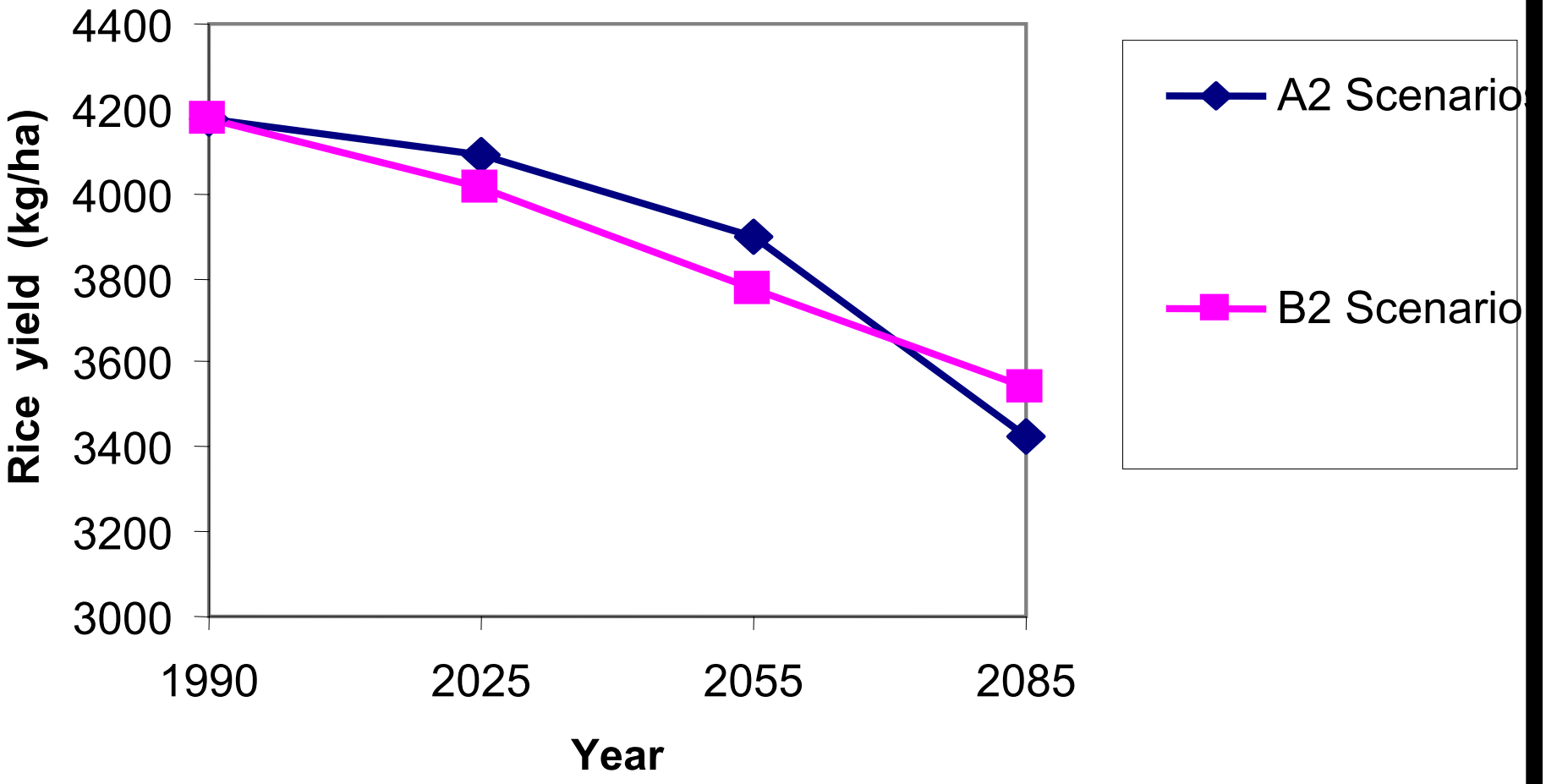
# Wheat Yield in different agro-climatic zones of Pakistan under A2 Scenarios



# Climate Change Impact on Wheat Production in Pakistan by 2085 under A2 and B2 Scenarios

| Region | % Share in National Production | Baseline Yield (kg $ha^{-1}$) | % Change in yield in 2085 | |
|---|---|---|---|---|
| | | | A2 Scenario | B2 Scenario |
| Northern Mountainous | 2 | 2658 | +50 | +40 |
| Northern Sub-mountainous | 9 | 3933 | -11 | -11 |
| Southern Semi arid Plains | 42 | 4306 | -8 | -8 |
| Southern Arid Plains | 47 | 4490 | -5 | -6 |
| Pakistan | 100 | 4326 | -5.7 | -6.4 |

# Basmati Rice Yield in Southern Semi-arid Plains of Pakistan under A2 and B2 Scenarios




Yield decrease by 2085:18% in A2 and 15% in B2 Scenarios

# Some Adaptation Possibilities

- **Alteration in sowing dates***
- **Use of new crop varieties**
- **Advance seasonal weather forecast**
- **Changes in Irrigation methods***
- **Changes in planting techniques for rice***
- **Use of resource conservation technologies**

*Options currently being studied at GCISC

# CONCLUSIONS

- Punjab is the main food basket of Pakistan. Any factor affecting its productive resources, such as climatic change, will exert adverse impact on food production of the country
- The agriculture production system of Punjab is predominantly irrigated, which derives 60-80% of its water from snow/ice melt. The large variability of river flows caused by glacier melt will make irrigated areas highly vulnerable,

## Contd…..

- Variability in frequency and intensity of rainfall will also adversely affect productivity of rainfed areas.
- Drop in crop yield due to rising temperatures also is likely to cause shortfall in wheat production by about 6-8% and rice by about 15-20% towards the end of this century
- The land resources are also likely to be degraded further due to water logging and salinization, water and wind erosion

## Contd…..

- Added to the above will be loss in production caused by increased frequency and intensity of floods and droughts
- Most of the above challenges can be met by developing appropriate Adaptive Measures well in time to counter the negative impacts

# Thank You