Modeling the Monsoon Variability and its Implications for Food productivity in South Asia

Murari Lal

Halcrow Consulting India Ltd., Delhi

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Agriculture in South Asia - Strengths & Challenges

Strong strides made in increasing the production in the past 50 years mainly due to adoption of HYVs and other technological developments in India and elsewhere,

Subsistence agriculture with small land holdings and skewed distribution of land,

Wide variation in regional productivities,

Majority still depend on rainfed agriculture,

Frequently affected by extreme weather events such as heat waves, droughts, floods and cyclones,

Significant proportion of population still reels under poverty, malnutrition and chronic hunger, and

Emerging challenges - Climate change, WTO, economic liberalization etc.

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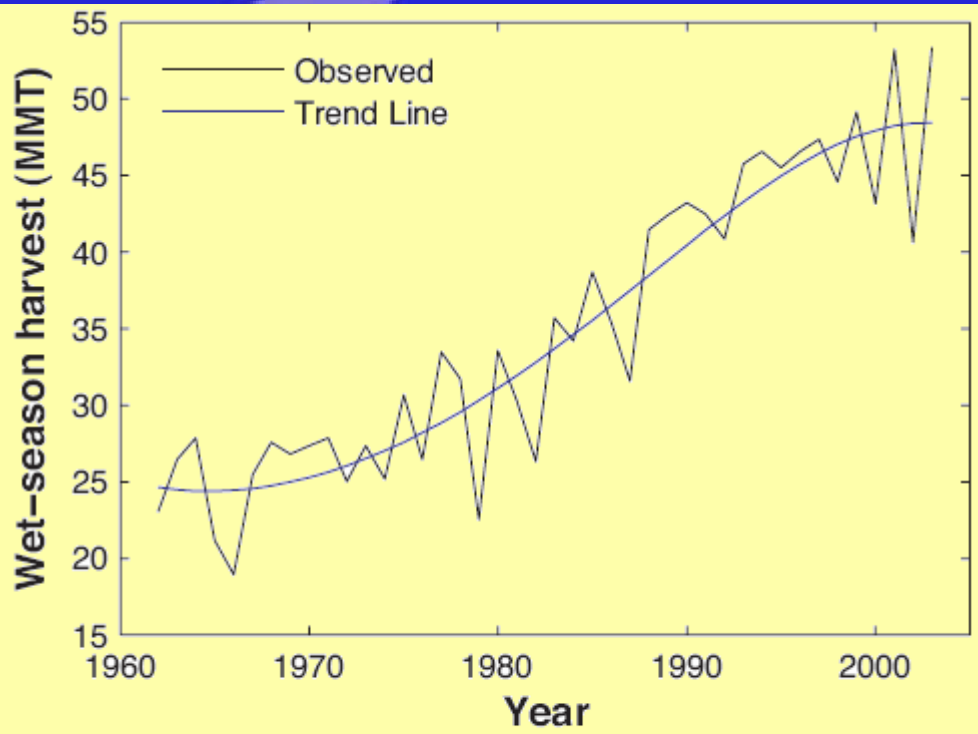
Per capita availability of food grains in India has increased in the 1990s: up by 12 grams a day from 472 grams per day in 1990 to 485 grams per day in 2000.

But the deceleration in food grains production in the 1990s creates the spectre of food shortage in the years ahead.

The fortunes of the agricultural sector in South Asia are heavily dependent on monsoon making it highly vulnerable to mercies of weather.

The agricultural sector contributes 25% to the economy and 65% to the employment in India; this sector is crucial to the economy of most other countries in the region as well.



Historical trend in wet-season rice harvest in India. MMT, million metric tons. Observed values (black) are summed across the nine predominantly rain-fed rice-growing states in the country. The trend line (blue), a cubic polynomial relating ln(harvest) to year, was fitted using ordinary least squares regression. The annual growth rate along the trend line peaked at 2.70% in 1984–1985.

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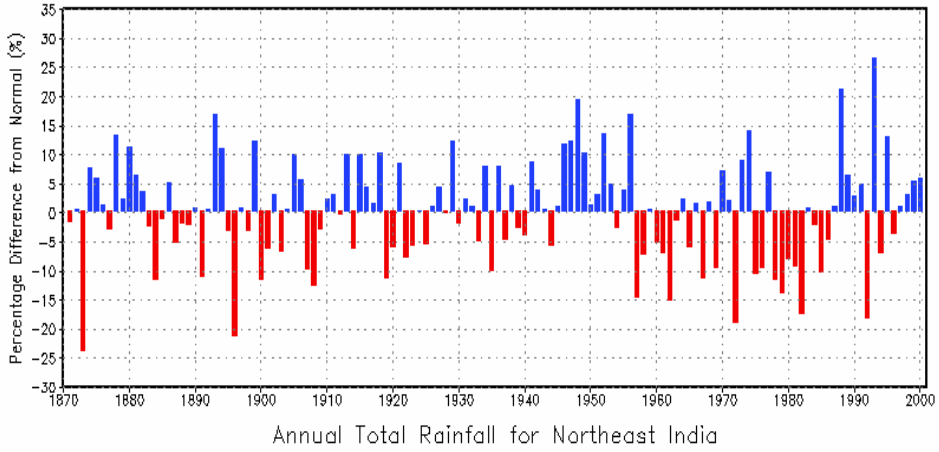
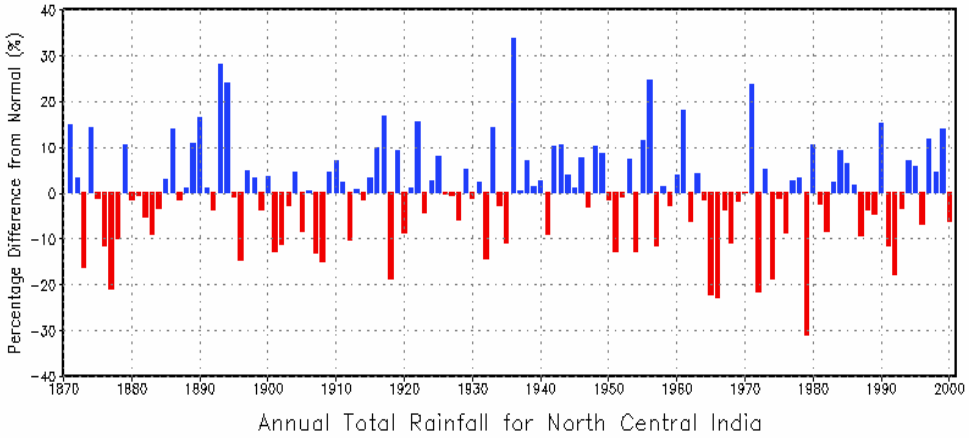
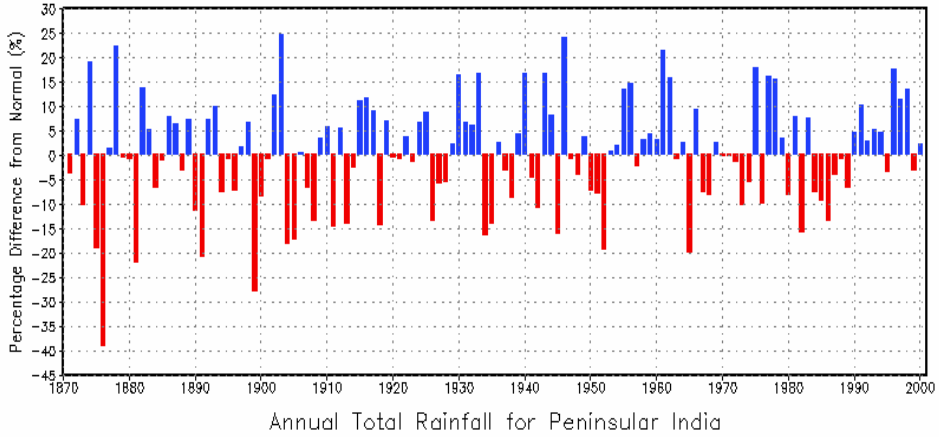
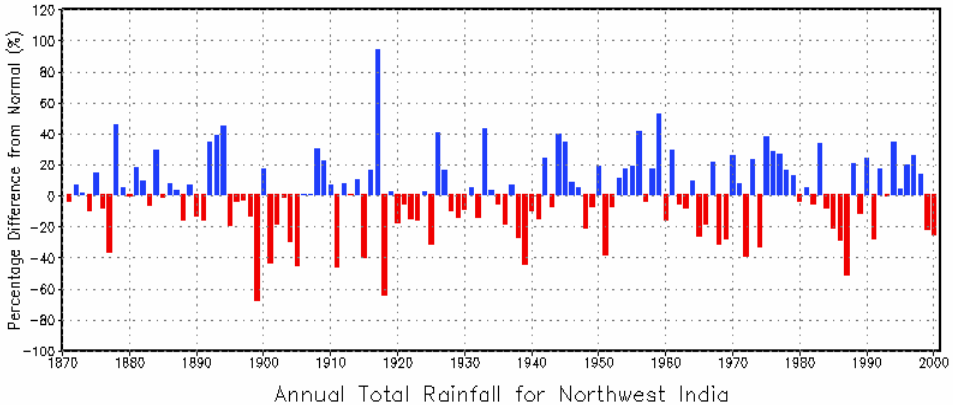
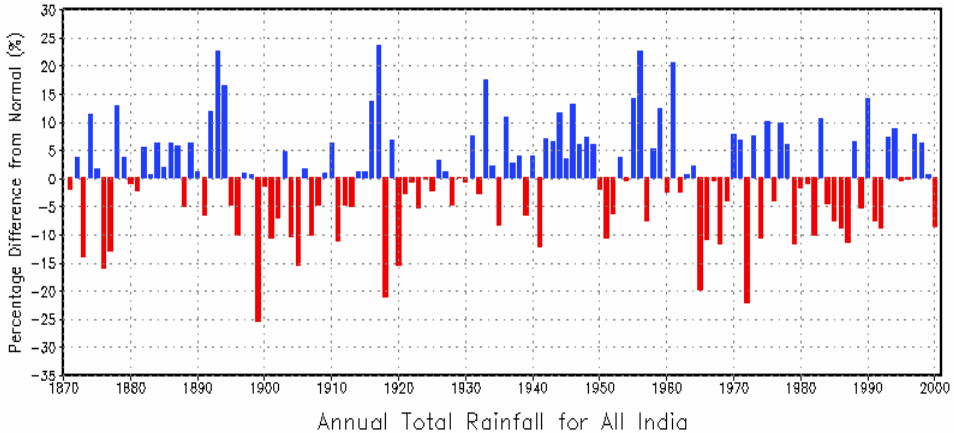
Observed Rainfall Variability in India











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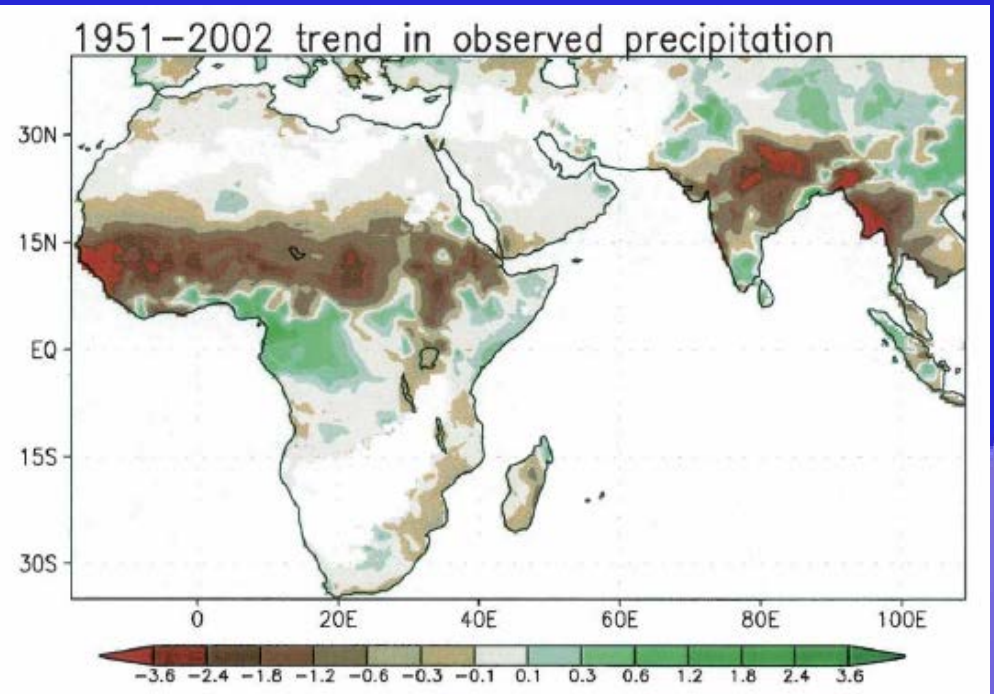
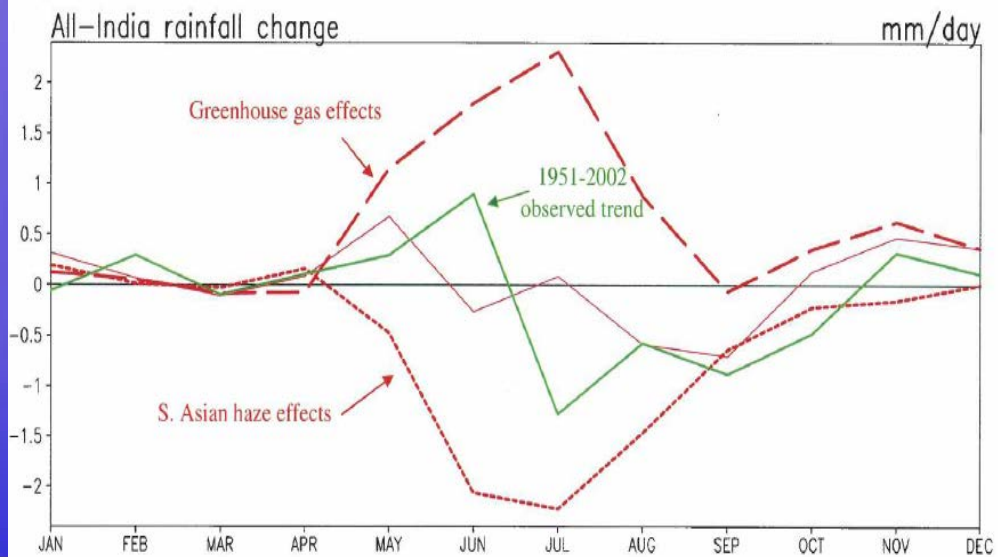
Observed changes in rainfall over south Asia



Role of GHG and Aerosol Forcings in observed precipitation change over south Asia



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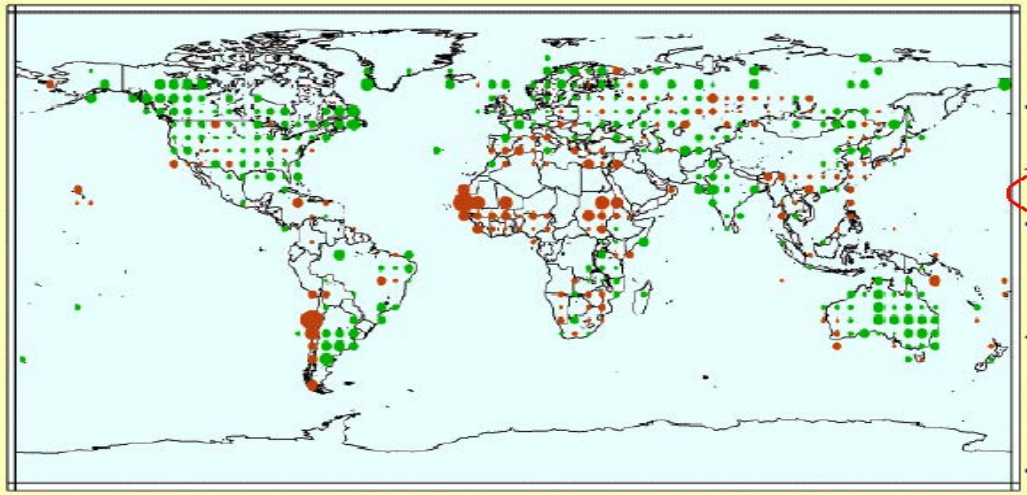
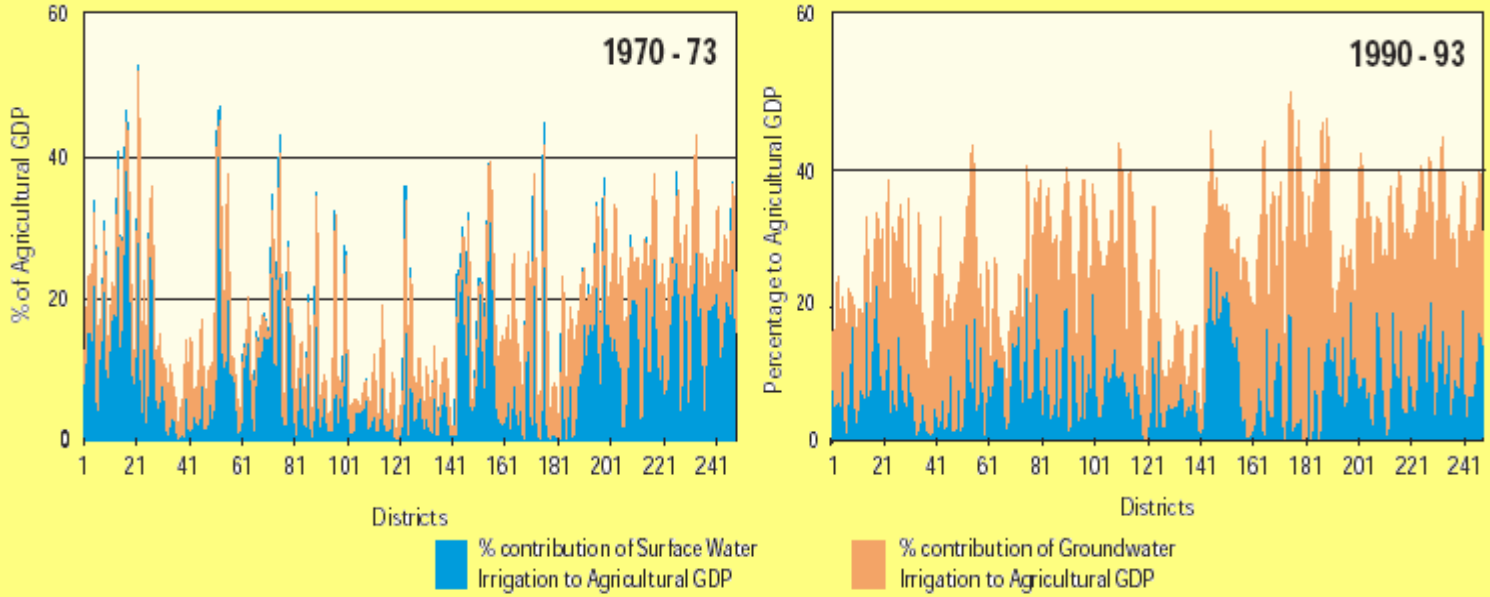
Trends (%/century) in Annual Precipitation

1900 - 1999



Change in contribution of groundwater and surface-water irrigation to agricultural GDP in India



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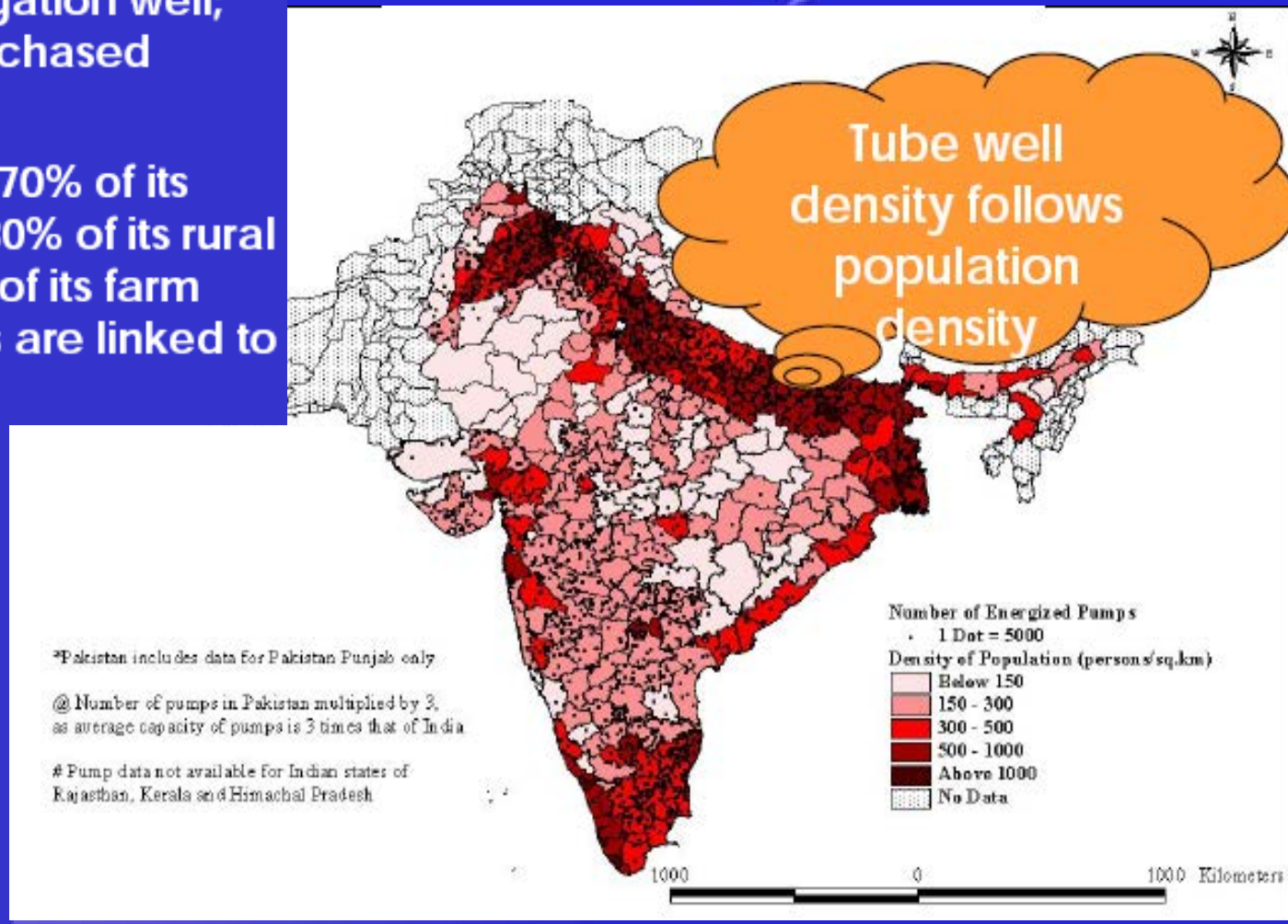
India's groundwater juggernaut is accelerating !!

One in four farming households in India owns an irrigation well; and the rest use purchased pump irrigation.

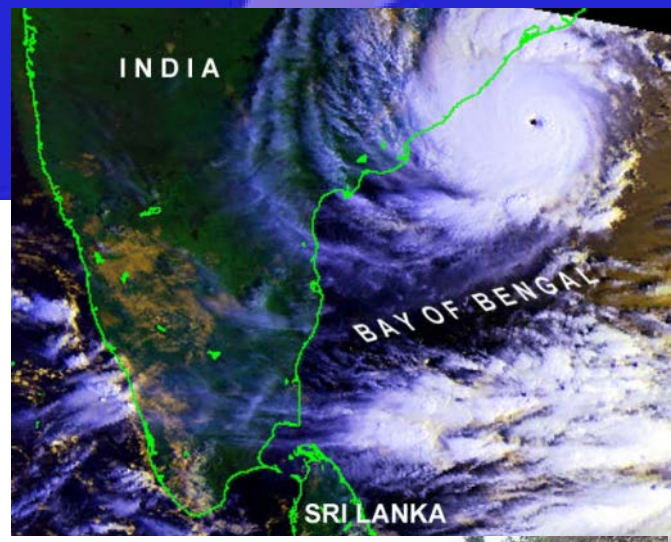
10% of India's GDP, 70% of its irrigated areas, 70-80% of its rural population, 60-70% of its farm output and incomes are linked to groundwater.

Livelihood-supporting GwSEs have high population pressure on land, large agricultural population, semi-arid monsoon climate. India is a typical case.

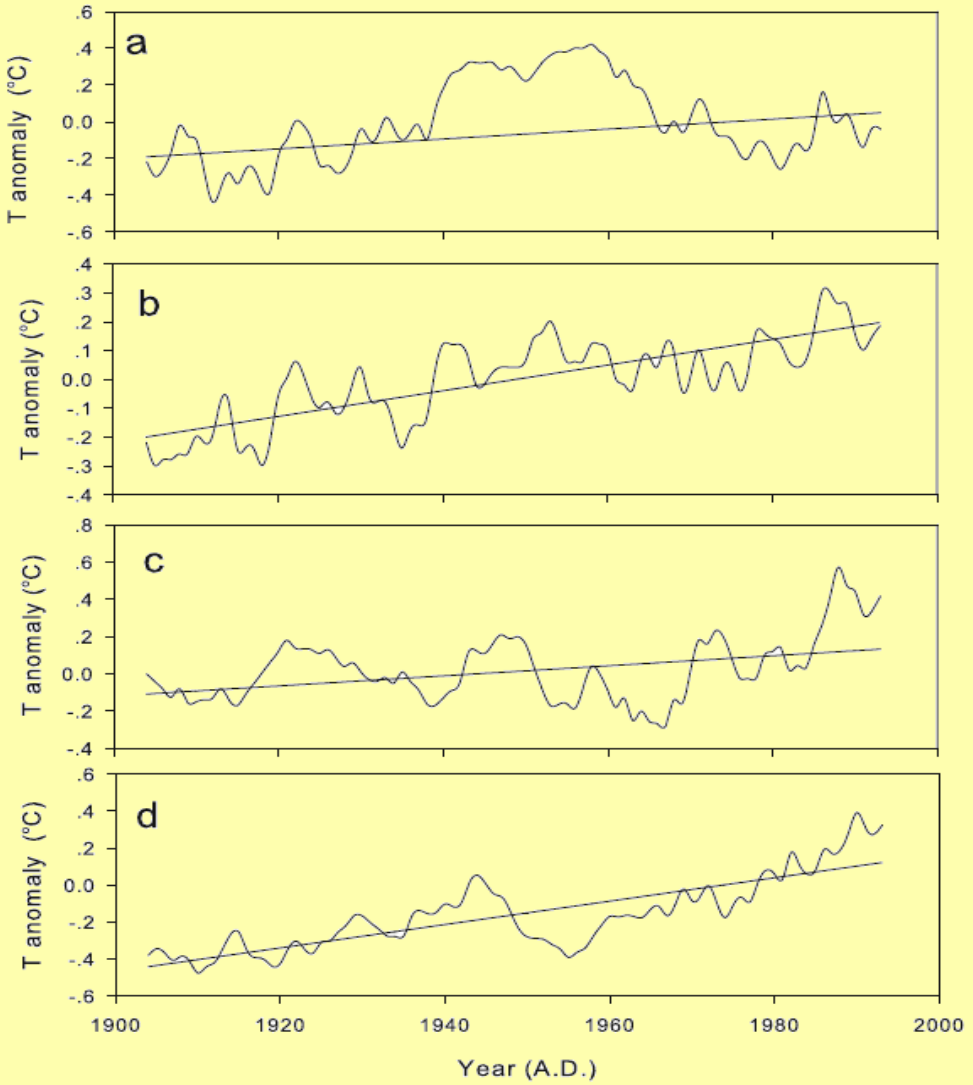


Key Vulnerabilities

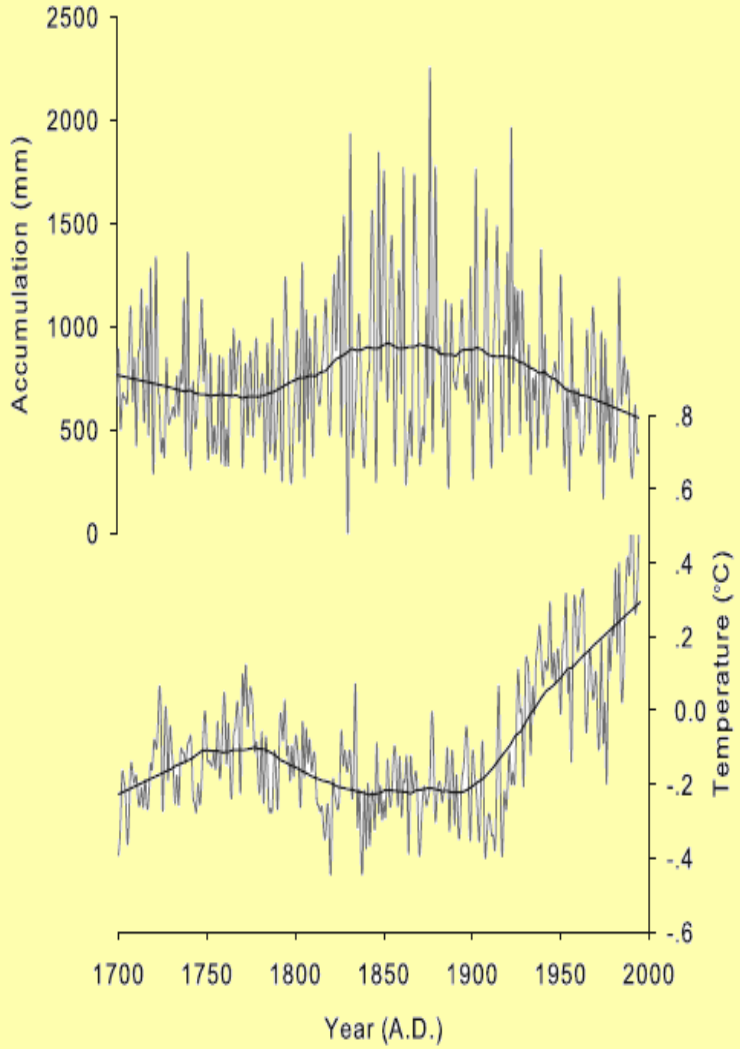
- Coastal states, particularly in the east coast and Gujarat are vulnerable to cyclones.
- 40 million ha land mass is vulnerable to floods.
- 68 per cent of net sown area is vulnerable to droughts.
- Sub-Himalayan region/ Western Ghats are vulnerable to land slides.



Observed Climate Change over South Asia



Reconstructions of 5-year running mean annual temperature anomaly for (a) Nepal, (b) India, (c) Tibetan Plateau and (d) tropic Indian Ocean. The straight lines are linear trends of temperature reconstructions.



Time series of snow accumulation for the Dasuopu ice core and of Northern Hemisphere temperature [*Mann et al.*, 1999]. Solid curves denote century timescale trend.

Climate Variability and Climate Change over South Asia

Warming trend over India has been reported to be 0.57°C per 100 years.

Floods, droughts and cyclones are key extreme climatic events.

Permanent glaciers in upper Himalayas have vacated large areas, resulting in an increase in glacial runoff.

Plausible annual changes in area-averaged surface air temperature and precipitation over south Asia as a result of future increase in greenhouse gases

2020s	2050s	2080s
Temperature change, °C		
1.36	2.69	3.84
Precipitation change, %		
2.9	6.8	11.0

Source: Lal et. al.,2004

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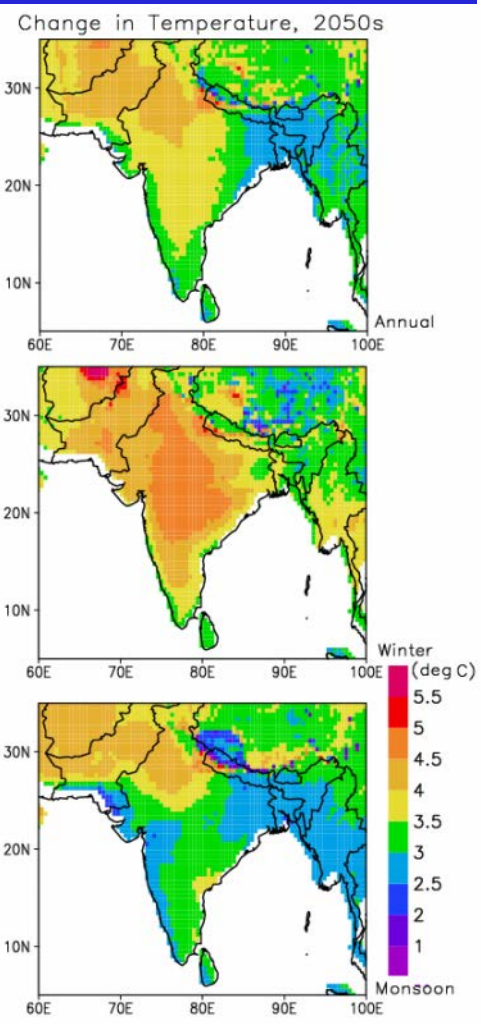
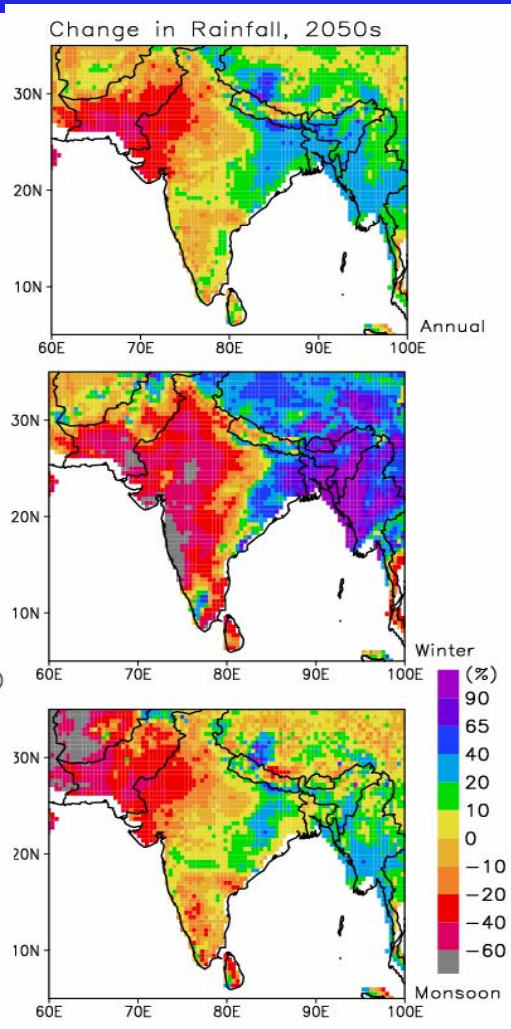
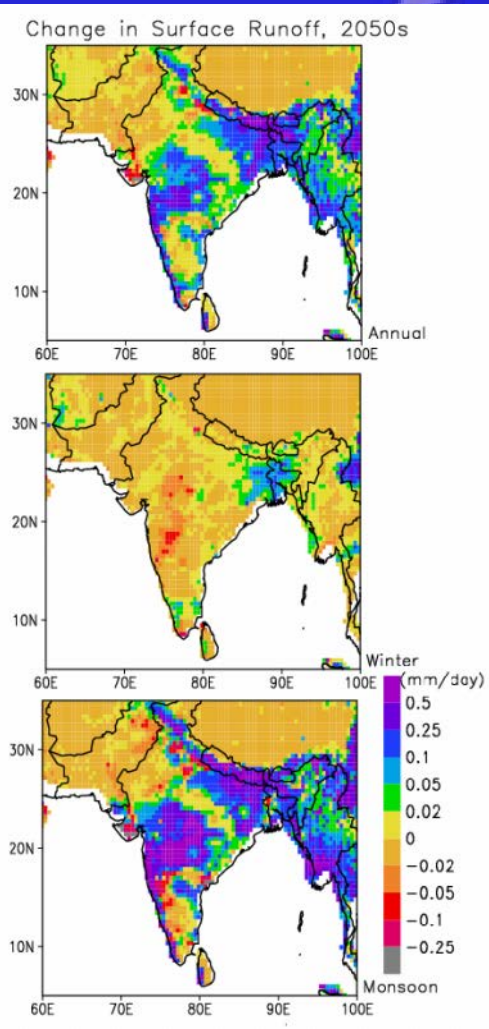
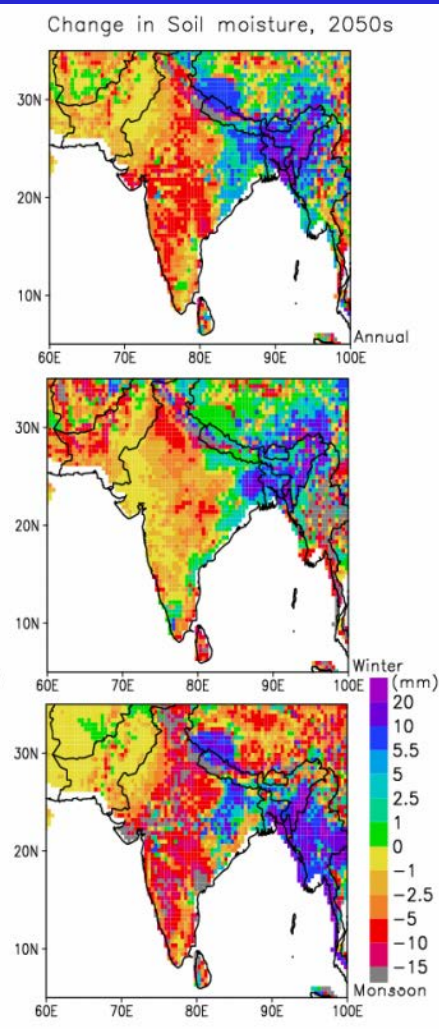
Projected Seasonal Changes in Surface Air Temperature, Rainfall, Surface Runoff and Soil Moisture over South Asia

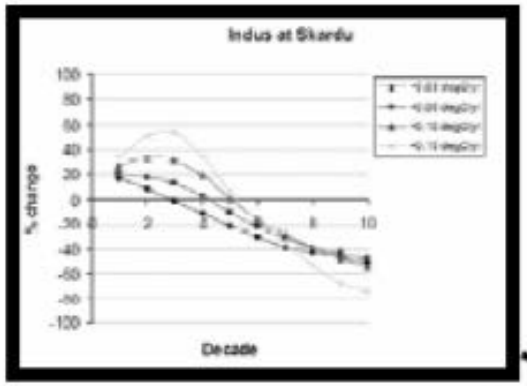


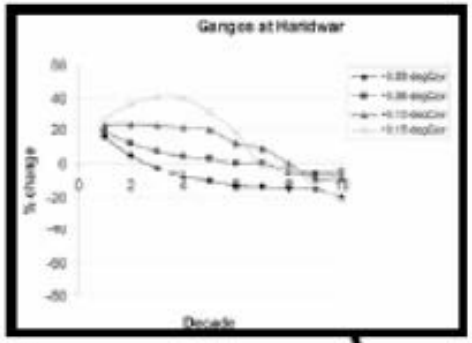


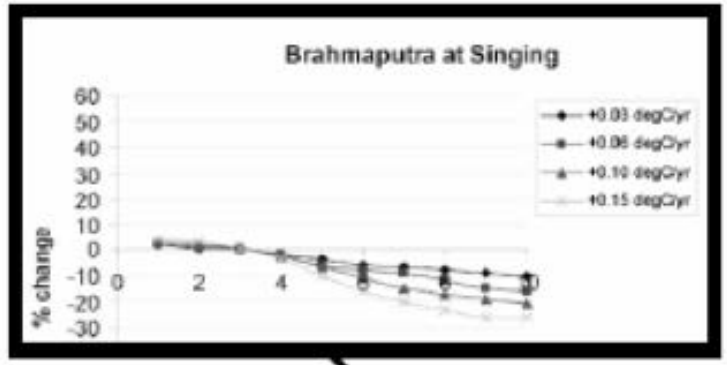


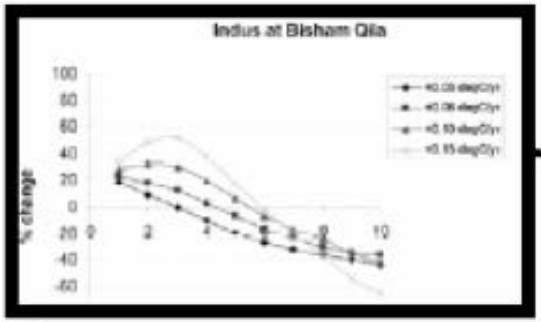


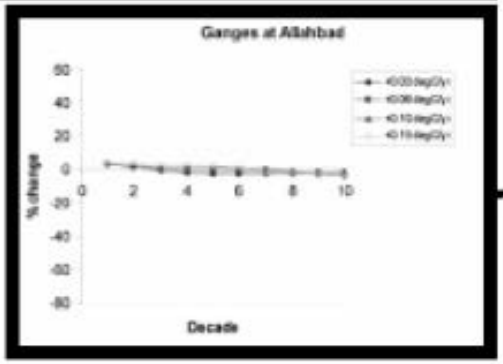
Simulated effects of de-glaciation on Himalayan river flows over a century

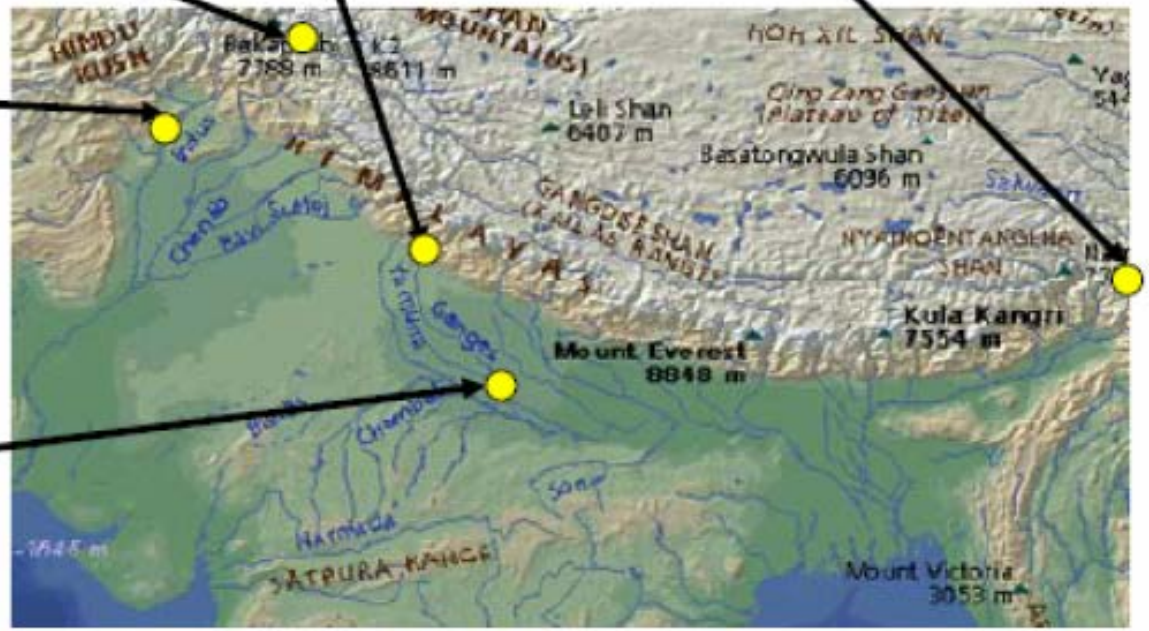




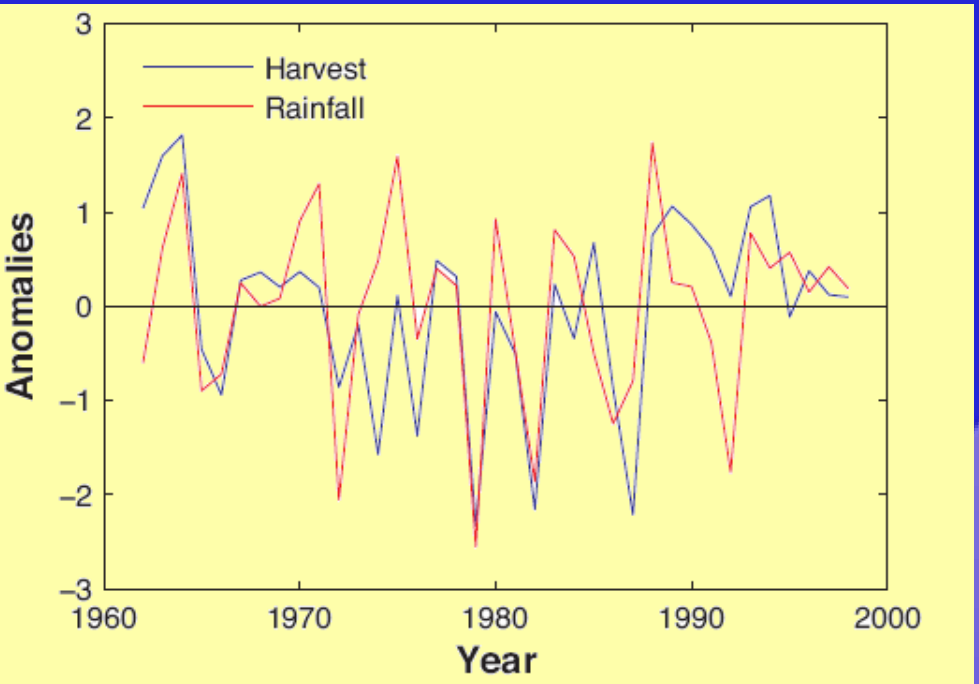




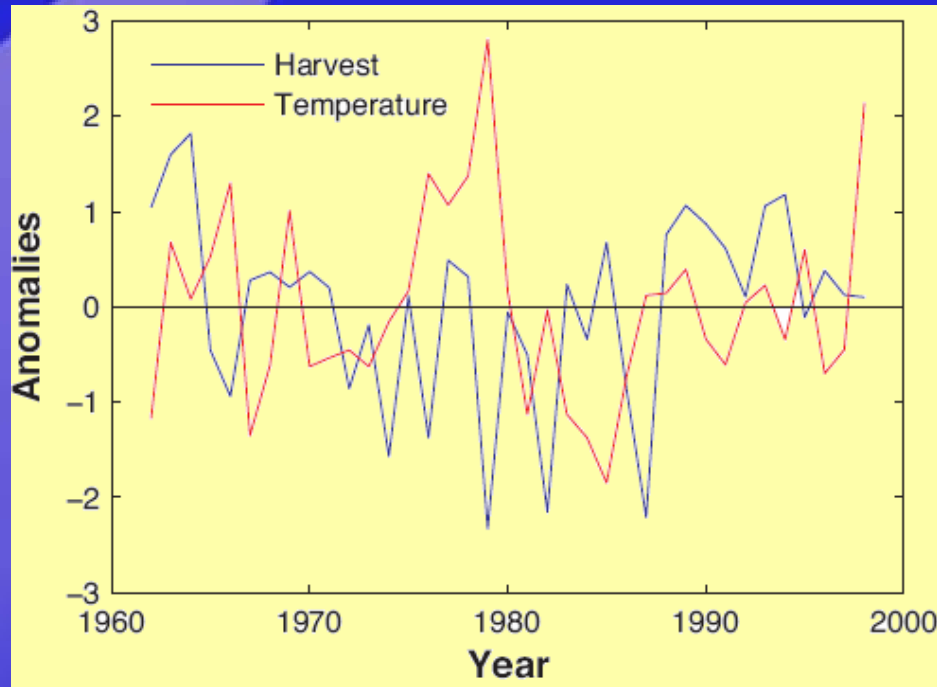




Climate Variability & Rice Harvest in India



Anomalies in June–September rainfall (red) and wet-season rice harvest (blue) in India. Data were aggregated across the nine predominantly rain-fed rice-growing states in the country and then detrended and normalized. Anomalies are expressed in terms of numbers of standard deviations. The pattern indicates a strong positive correlation between the two series.



Anomalies in October–November minimum temperature (red) and wet-season rice harvest (blue) in India. The pattern here suggests a weak negative correlation between the series.

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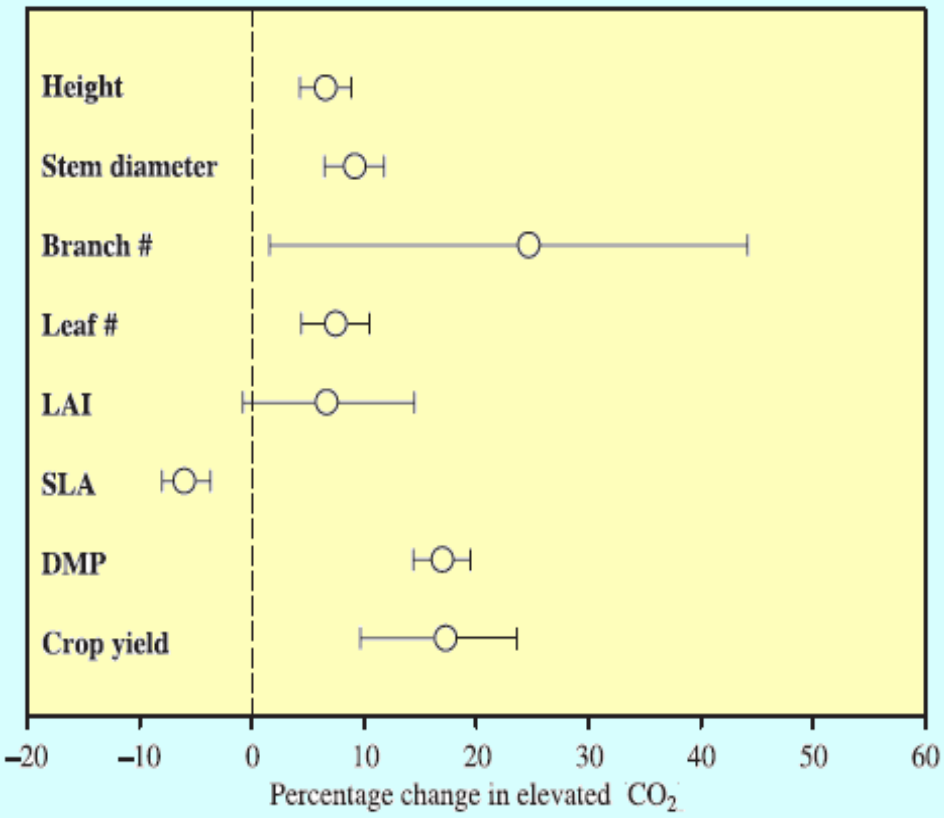
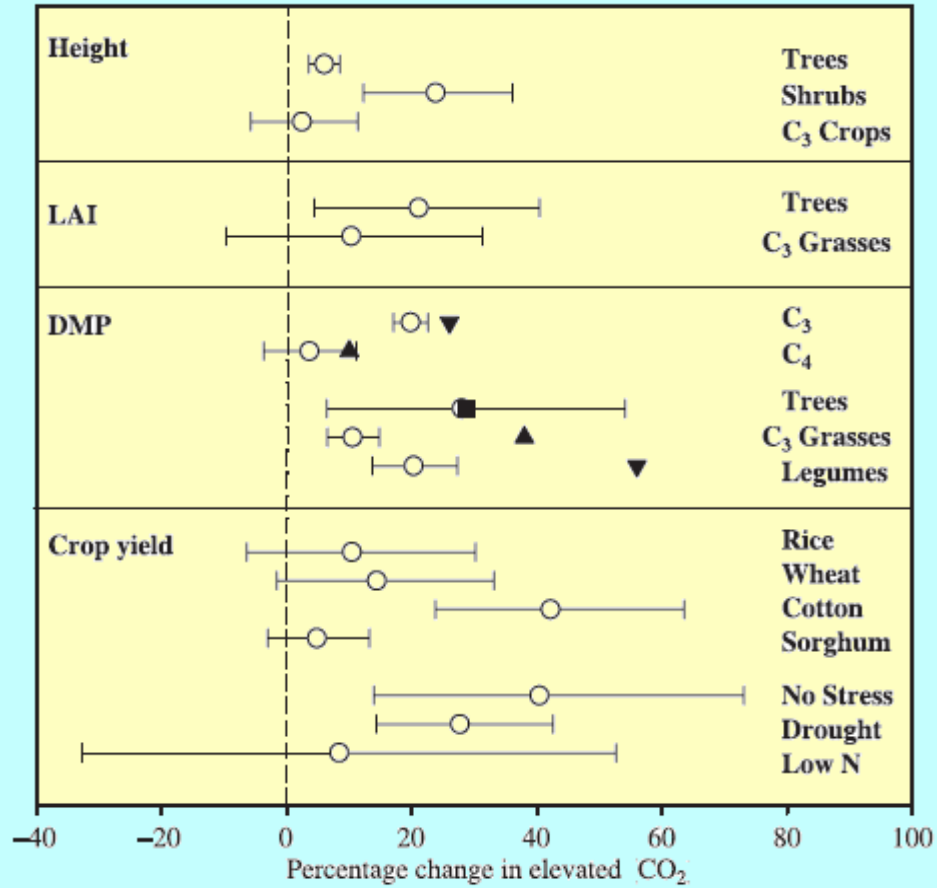
CO_2 Fertilization – Crop Productivity

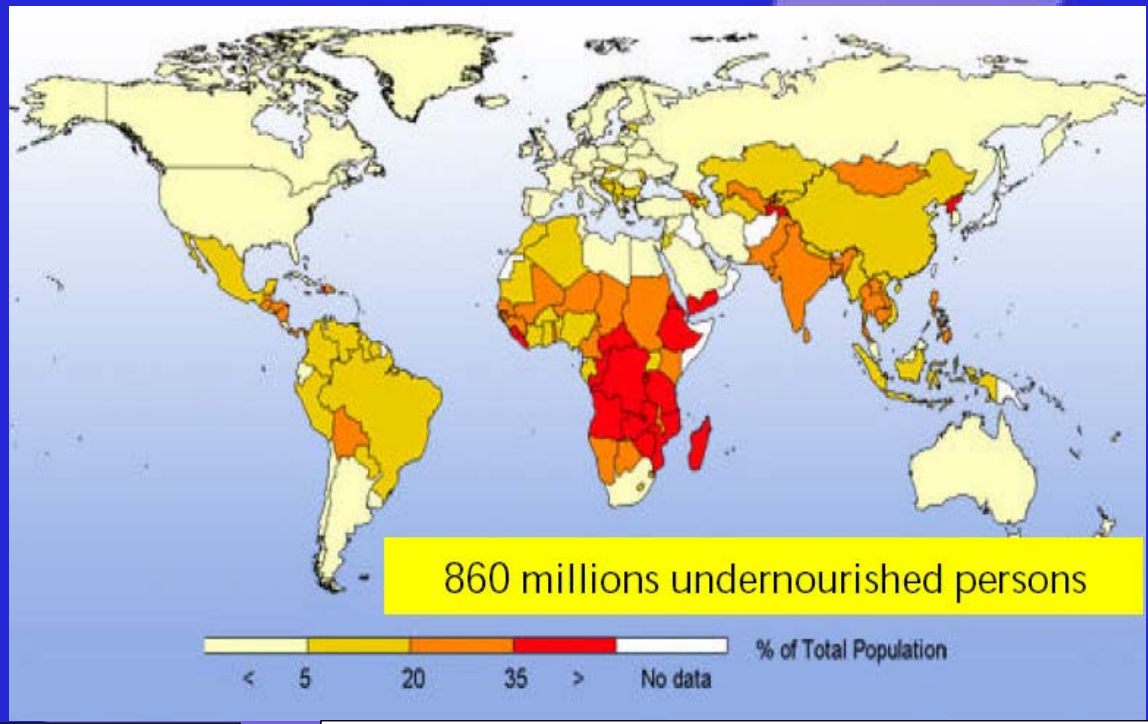


Mean response to elevated CO_2 of plant height, stem diameter leaf number, leaf-area index (LAI), specific leaf area (SLA), above-ground dry matter production (DMP), and crop yield.

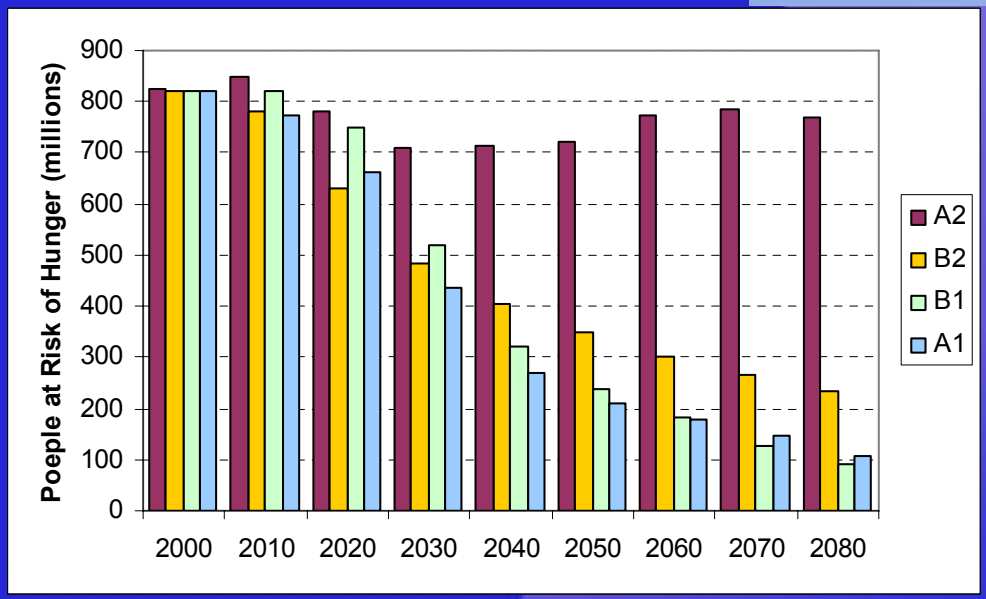


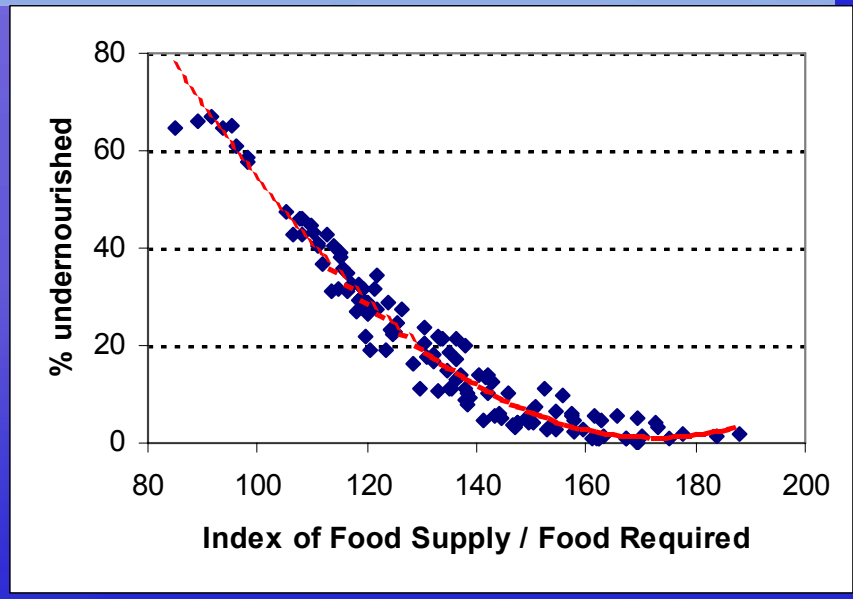
Comparative responses to elevated CO_2 of different functional groups and experimental conditions on growth and yield variables.

Why Global Food Security?



Number of People at Risk of Hunger





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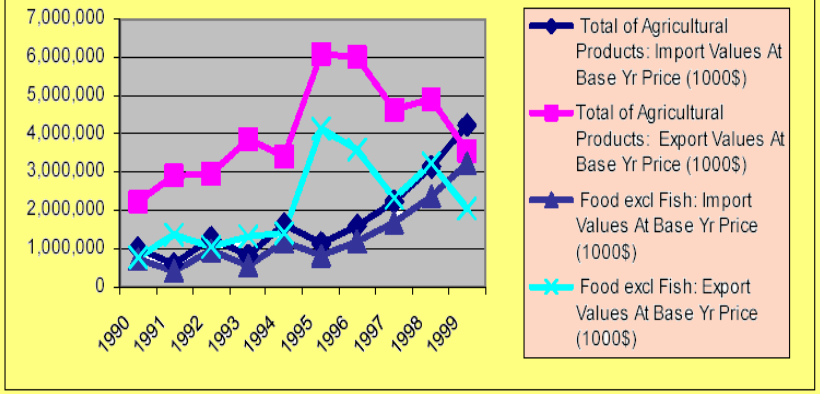
India's Current Food Production and Targets

	Production (Mt), 2000	Target Production (Mt),	
		2010	2020
Rice	85.4	103.6	122.1
Wheat	71.0	85.8	102.8
Coarse grains	29.9	34.9	40.9
Total Cereals	184.7	224.3	265.8
Pulses	16.1	16.1	27.8
Food Grains	200.8	245.7	293.6



Supply and demand projections of rice and wheat crops ('000 tons) for South Asia to 2020

Country	Crop	Projections for 2020	
		Supply	Demand
Bangladesh	Rice	26270	27070
	Wheat	2185	4885
India	Rice	120100	120976
	Wheat	94780	100595
Pakistan	Rice	6524	4826
	Wheat	25963	33517
South Asia**	Rice	157940	158710
	Wheat	127370	147060

** Includes Bangladesh, India, Pakistan, Nepal, Afghanistan, Maldives and Sri Lanka

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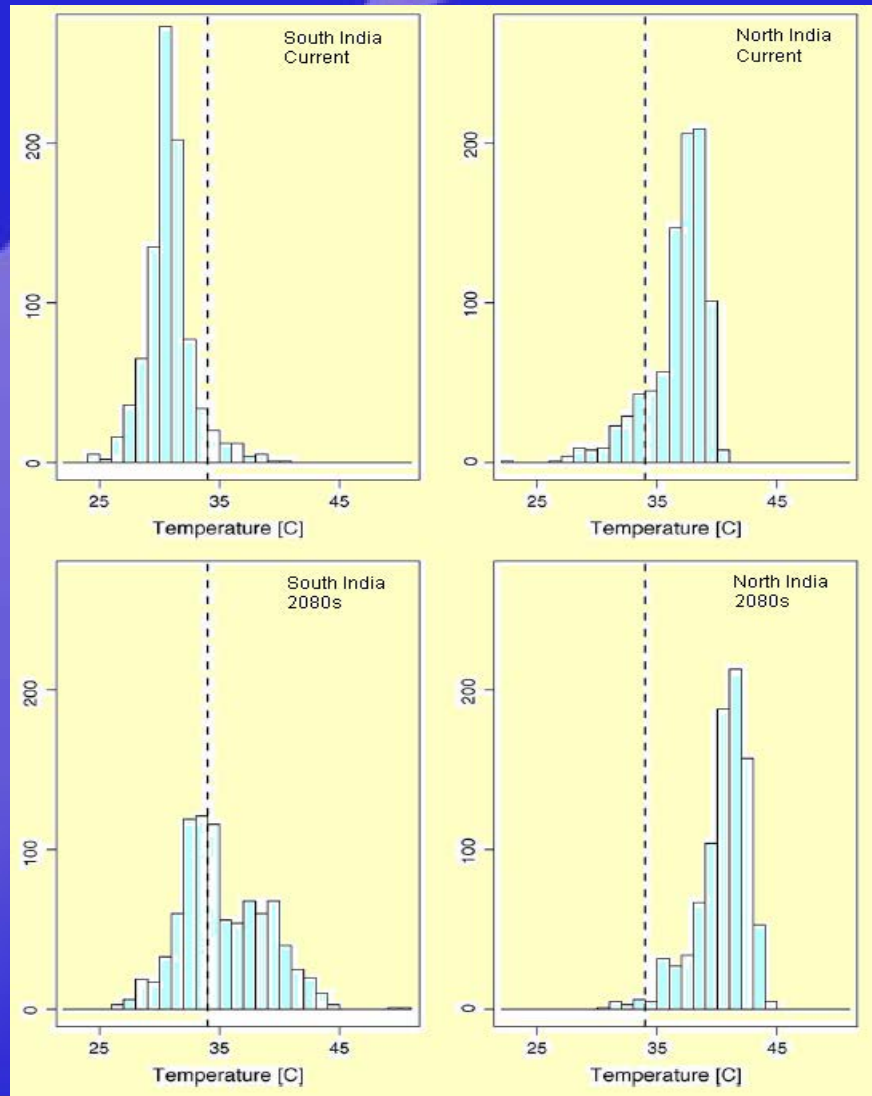
Food Security in South Asia - Climate Variability and Climate Change

Climate variability will continue to affect strategic grain supplies and food security of many nations in South Asia.

The rising surface air temperatures and carbon dioxide and enhanced variability in rainfall associated with global warming could have serious direct and indirect consequences on crop production and hence food security.

In the 21st century, South Asian countries have to produce more food and other agricultural commodities under conditions of diminishing per capita arable land and irrigation water resources and expanding biotic as well as abiotic stresses including the climatic constraints.

Frequency distribution of daily maximum temperatures



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Observed response of wheat to climate variability in South Asia

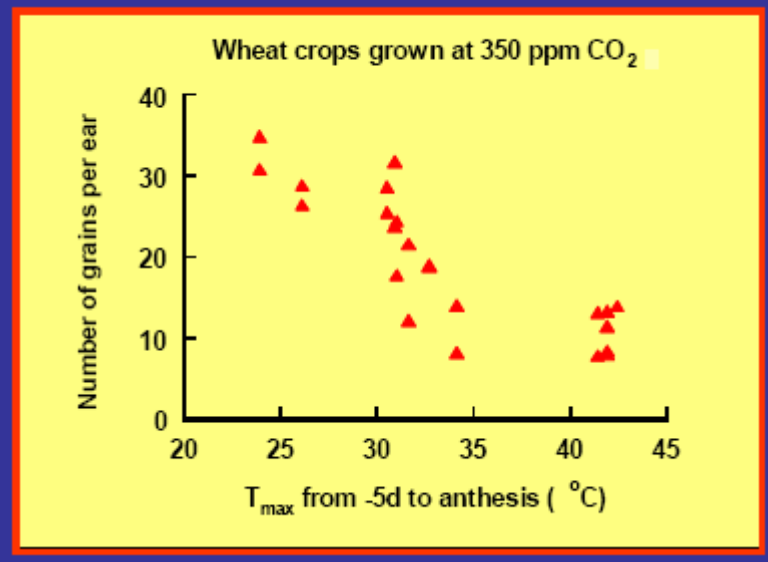
CO_2 and mean temperature

- Grain yields increase by 7 - 11% per 100 ppm rise in CO_2 under well-watered and fertilised conditions.
- Grain yields decrease by 6% per 1°C increase in mean seasonal temperature.

Temperature stress

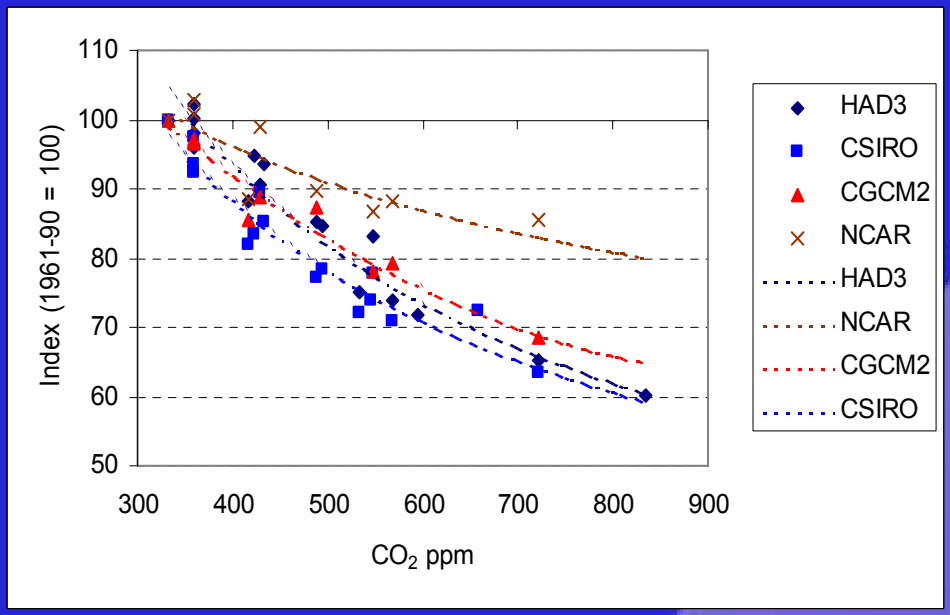
- Grain yields reduced when maximum daily temperatures exceed 31°C close to the time of anthesis.

Grain set reduction at T>31 °C in wheat

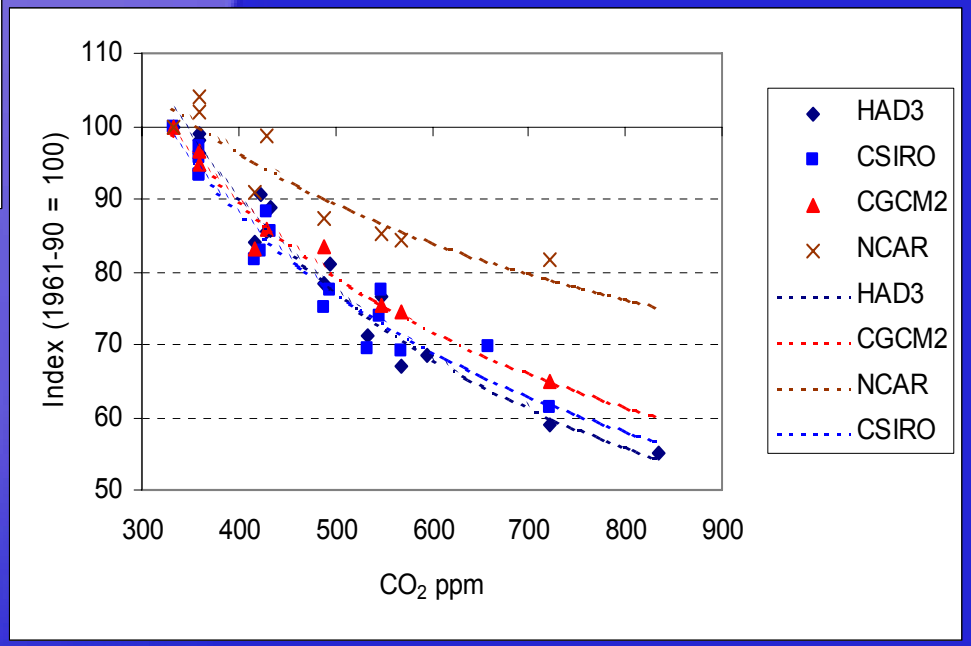


Changes in wheat-production potential versus increase in atmospheric CO2 concentrations and related global warming in South Asia

Current cultivated land

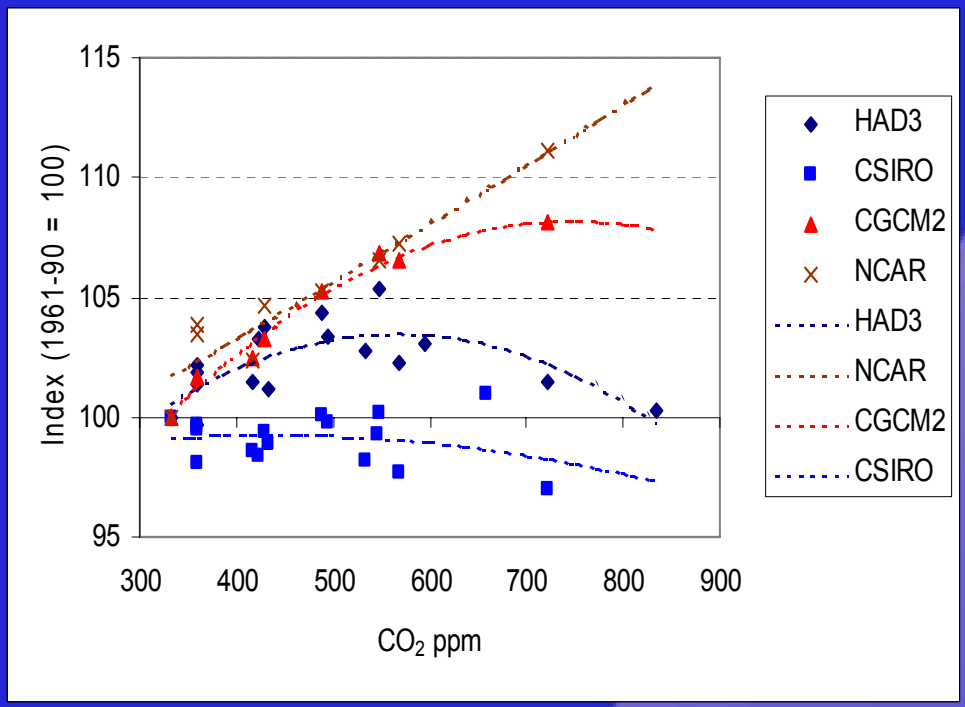


All cultivable land

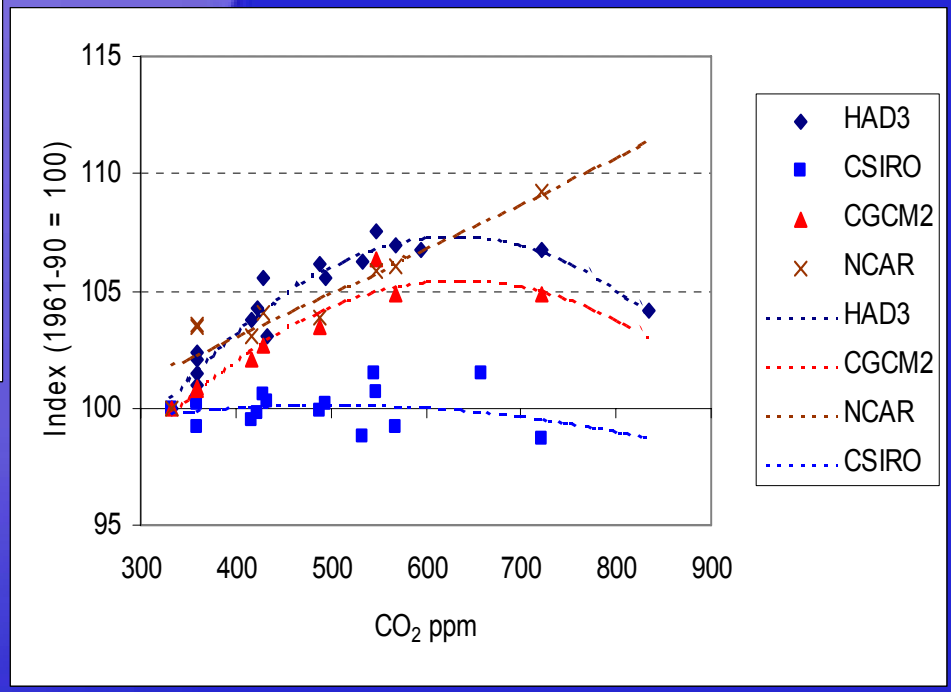


Changes in cereal-production potential versus increase in atmospheric CO2 concentrations and related global warming in South Asia

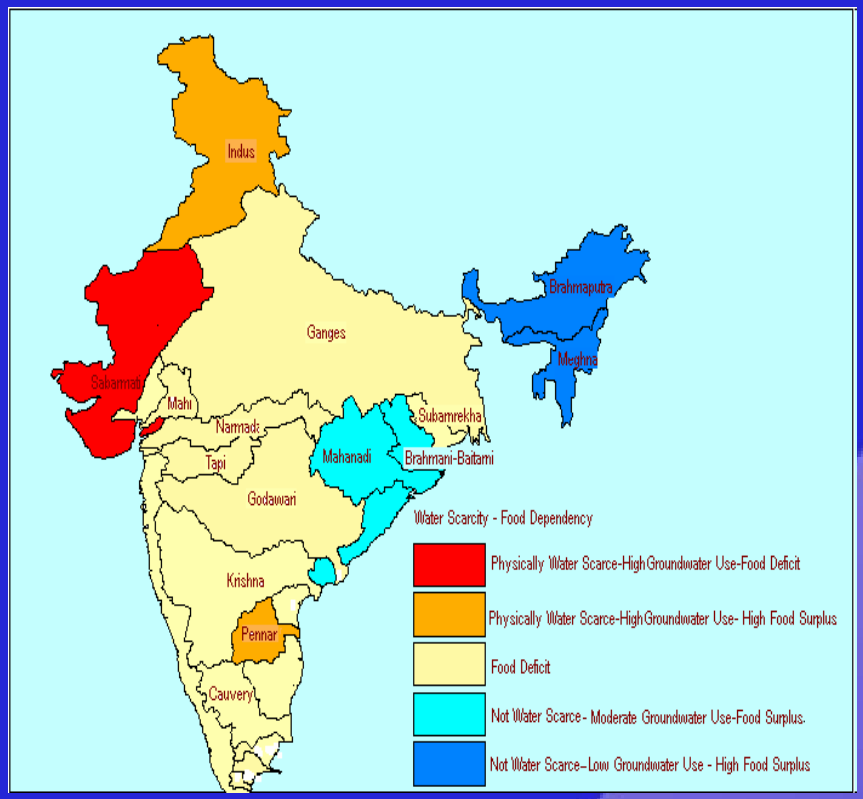
Current cultivated land



All cultivable land



Adaptation Practices in Agriculture



- Agronomic management
- Water harvesting and exploitation
- Water Use efficiency
- Crop intensification
- Alternate enterprises
- Post harvest practices

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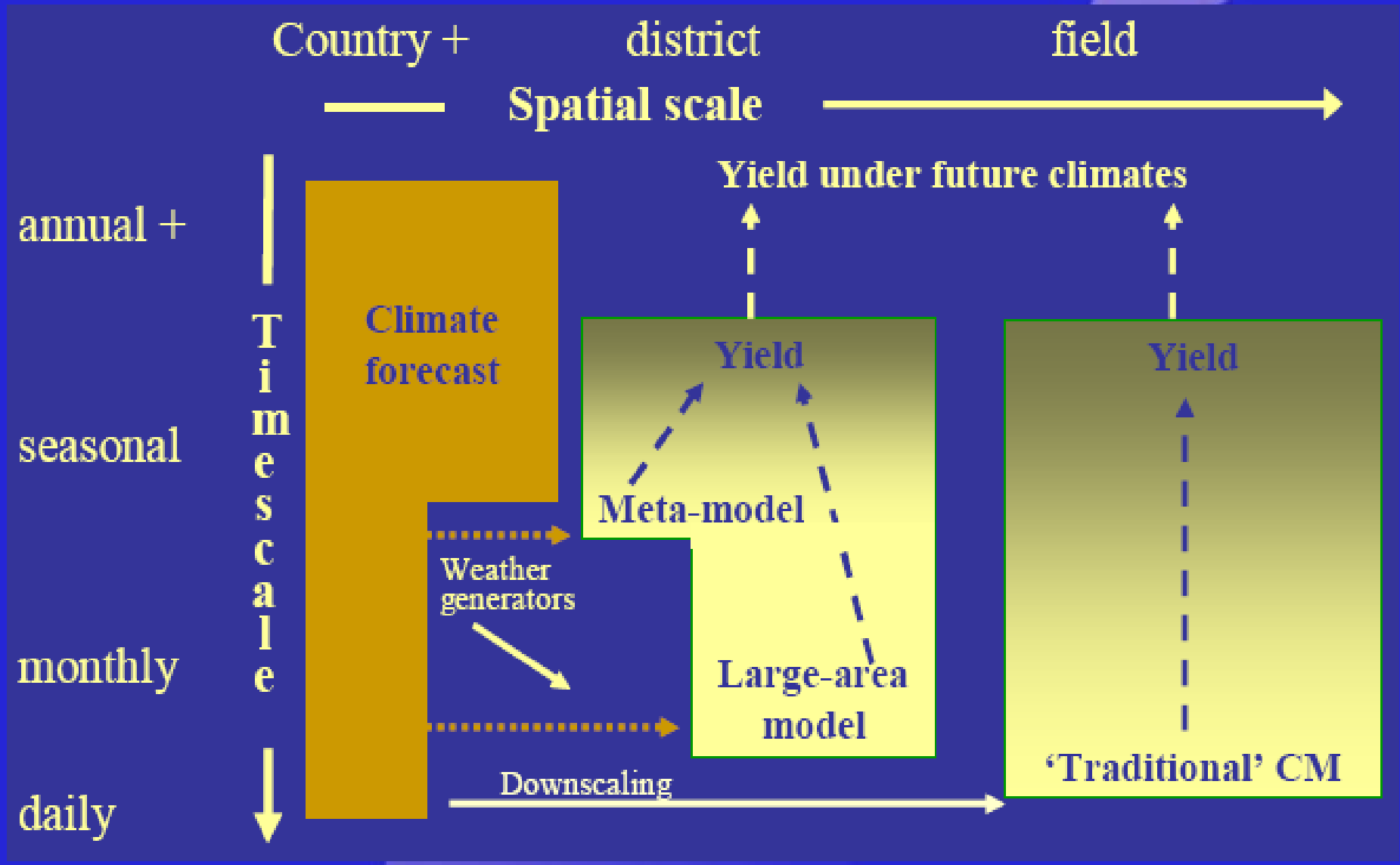
Spatial and temporal scales in crop simulation modeling



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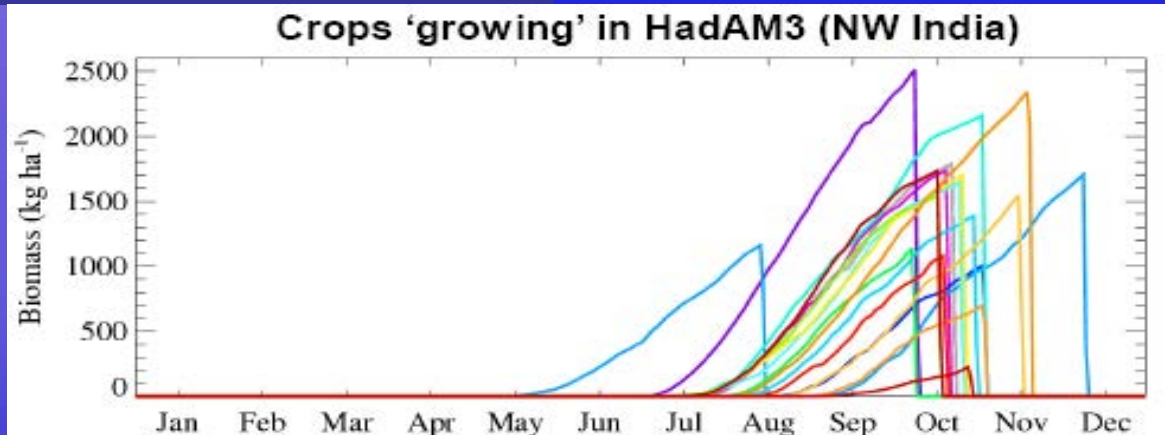
An Integrated Approach to Impact Assessment

- Crops can modify their own environment
  - The water cycle and surface temperatures vary according to land use
- Integrate biological and physical modelling
  - By working on common spatial scale
  - By fully coupling the models

- Resolve diurnal cycle
- Study feedbacks
- Integrate land-use patterns

- Depends on the balance between the impact of mean temperature and CO_2 increases
- Treatment of weather extremes is crucial
- A process-based approach is needed



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Future Water Availability in South Asia: Issues to be addressed

- How much more water (agriculture, industry and domestic needs) would be required at various temporal and spatial scales and which basins have the potential to contribute to this demand?
- How can the productivity of water use be increased?
- What can be done to capture / tap the unutilized return flows?
- What is the potential for water transfers in and out of major river basins?
- What would be the potential contribution from groundwater for meeting future water demand?

Development and Management of Water Resources including Institutional Capacity Building

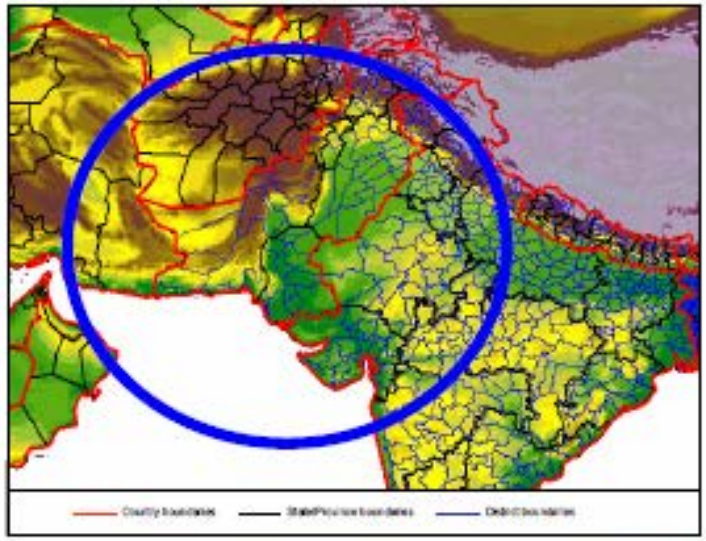
- Enhance water storage capacity, especially in Himalayan region
- Conduct strategic analysis of NRLP and implement the inevitable
- Improved design standards in disaster prone areas
- Enhance water productivity at all levels
- Invigorate the traditional institutions at local levels
- Promote private partnership in critical functions

- Integrated planning for extreme climatic events at all levels
- Modern unified legislation for disaster management
- Comprehensive, robust and accessible database
- National network of all knowledge-based institutions

Drought Management

Drought management is still an ad-hoc and empirical famine intervention for providing instant relief to prevent starvation.

Vulnerability mapping, community involvement; prevention, mitigation and quick response, use of modern tools and and procedures of monitoring, impact documentation and capacity building is not yet fully in place in India



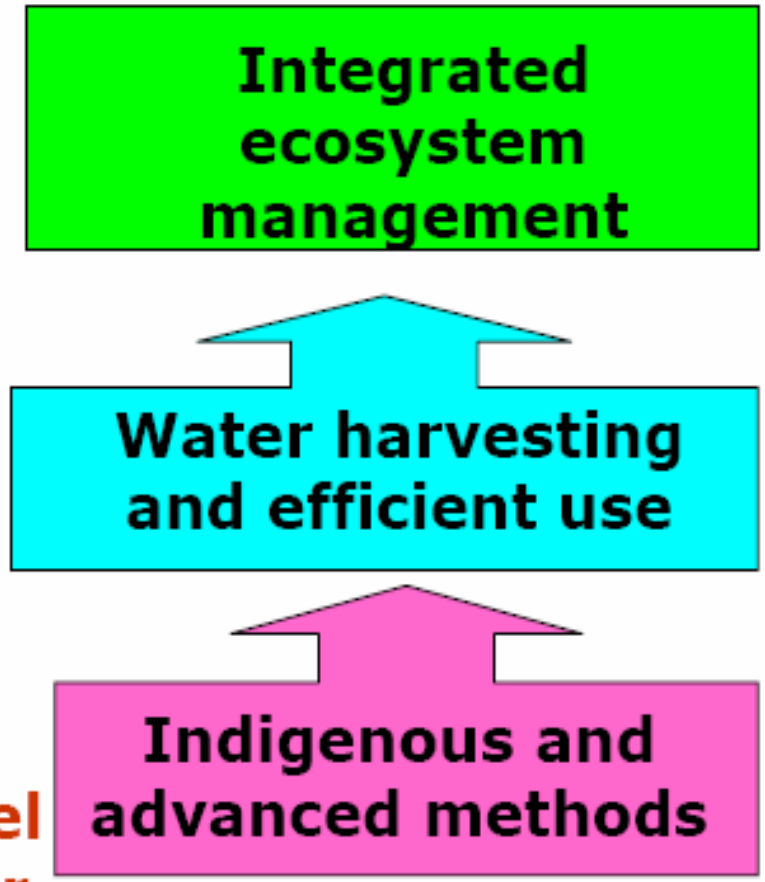
Prevention & Management of Droughts

Comprehensive, decentralized system of drought declaration and management

Vulnerability-level based system of drought response

Shift in favor of robust and integrated system of livelihood opportunities

Water harvesting at local, community and strategic level as a strategic intervention for mediating drought impacts



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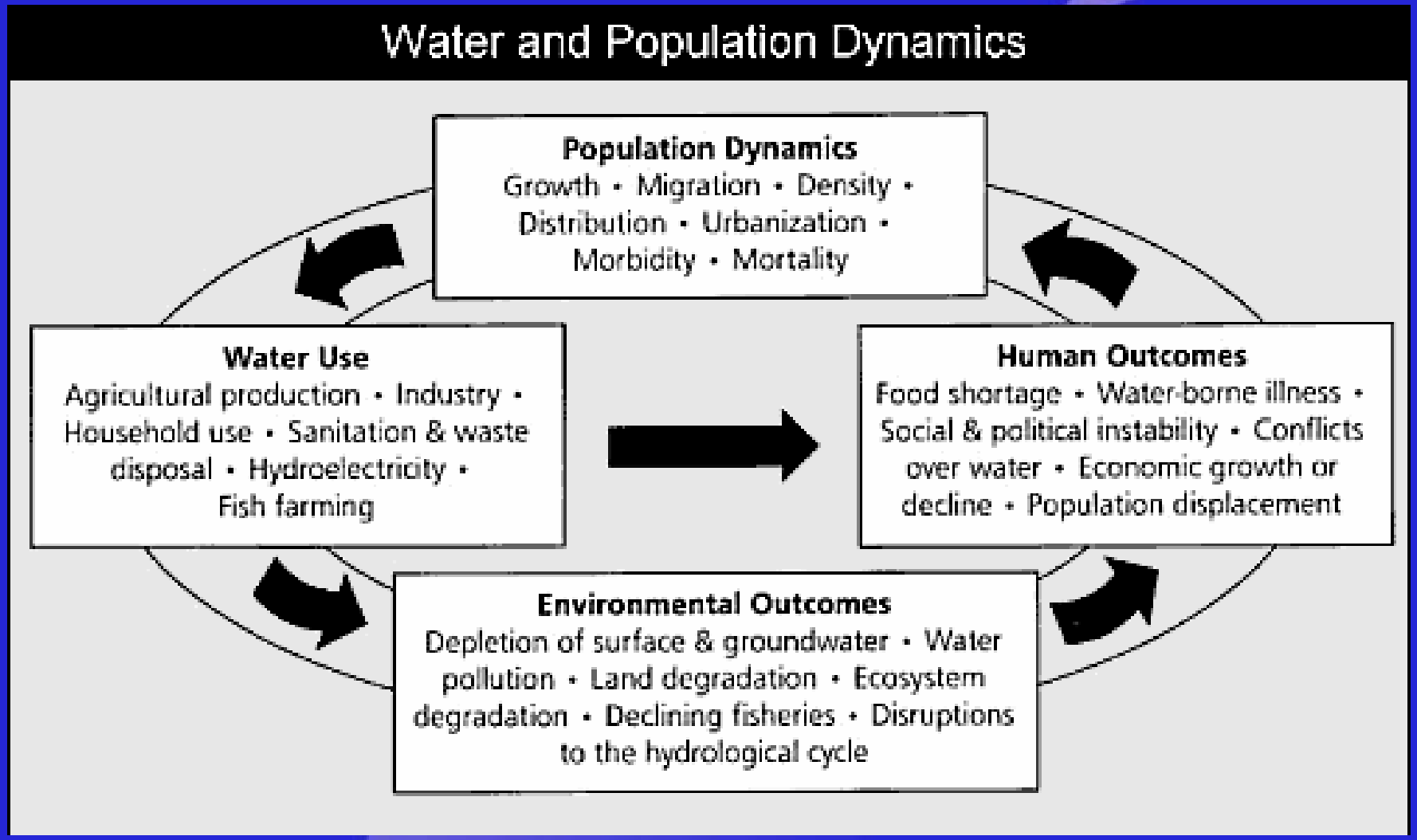
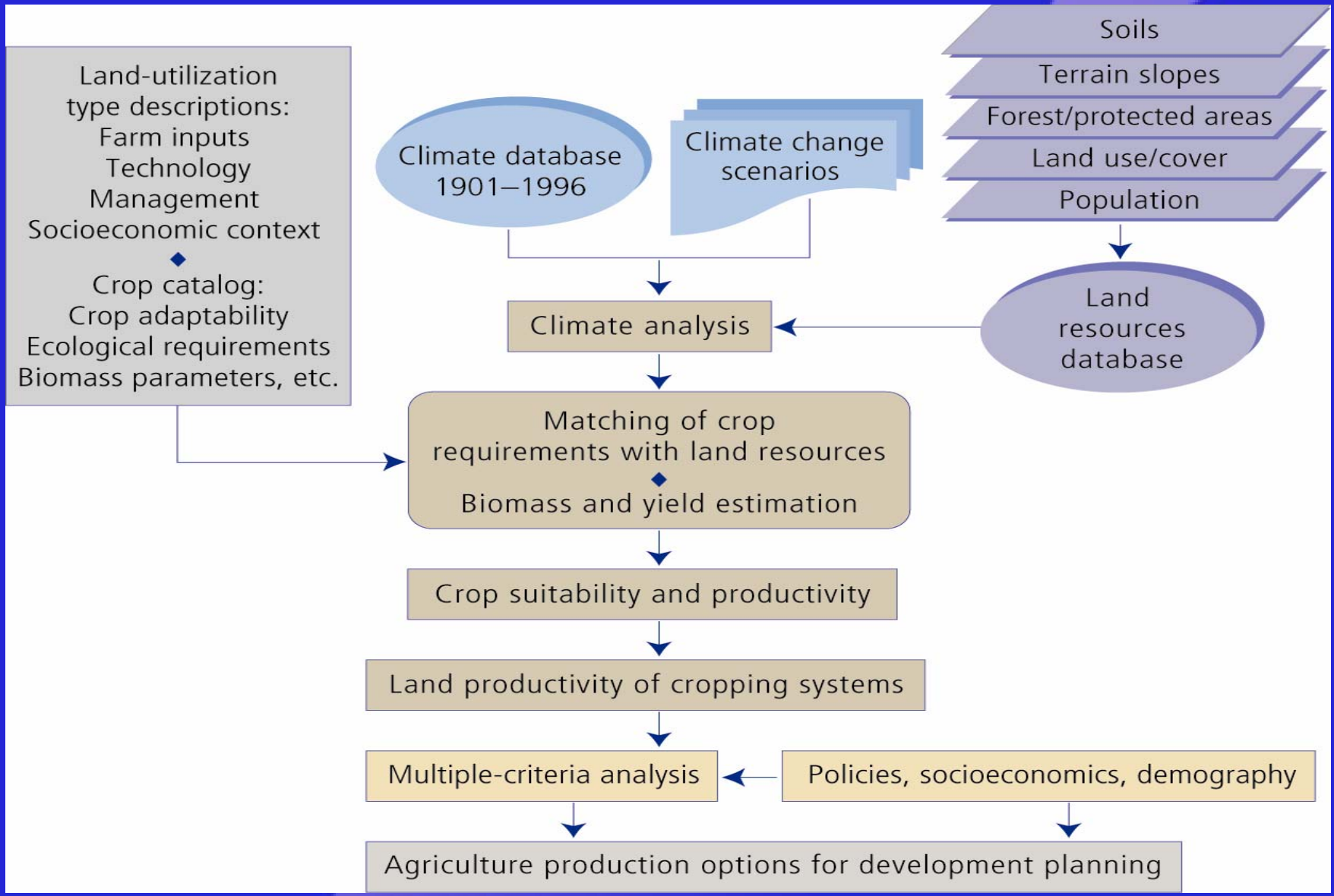
Adaptation to Floods

- Learning to live with the floods
- Improved flood forecasting
- Area inundation forecast
- Flood plain zoning , enforcement of regulations
- Community participation in flood management

Mainstreaming the climate change into framing policy options for water resource management

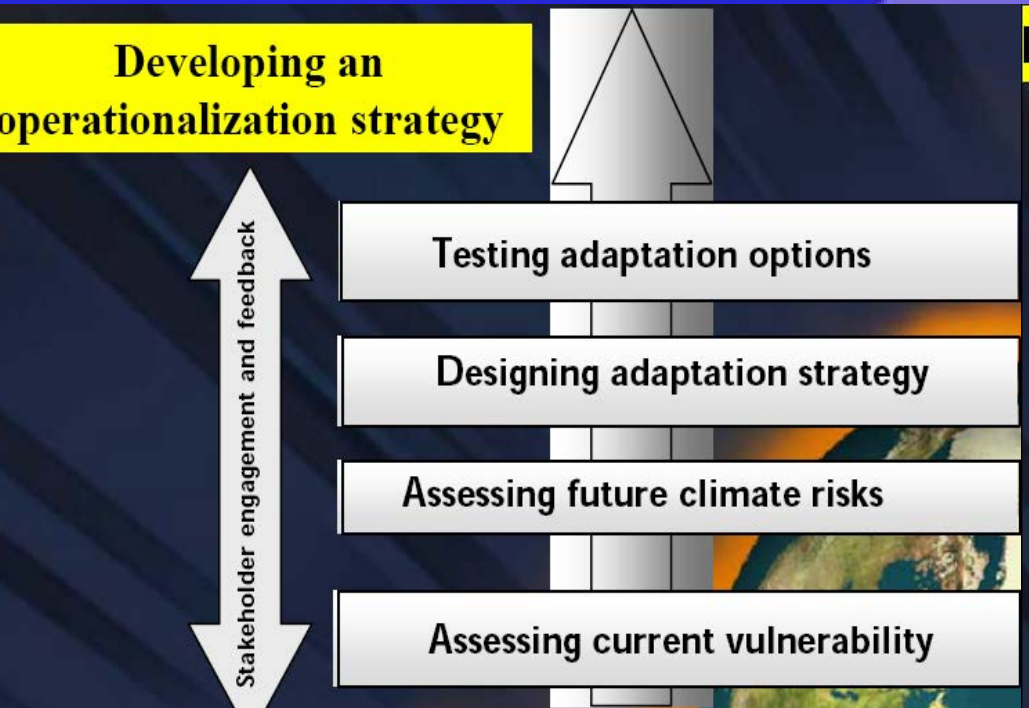


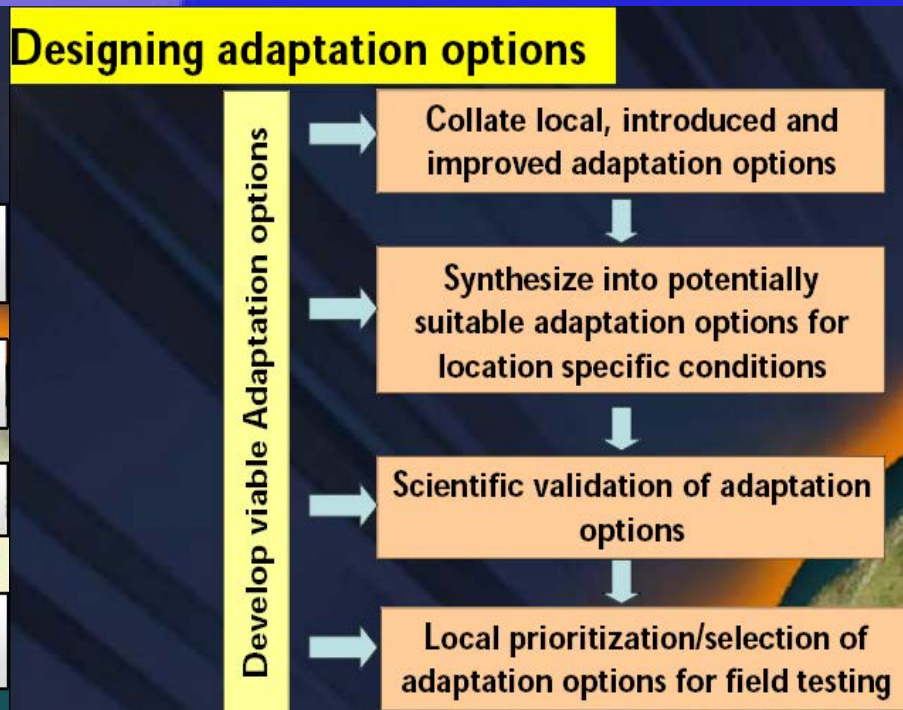
Sustainable Production - Methodology



Managing Climate Variability and Climate Change

The knowledge and technology required for adaptation includes understanding the patterns of variability of current and projected climate, seasonal forecasts, hazard impact mitigation methods, land use planning, risk management, and resource management.





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Thanks !

M. Lal
Sr. Environmentalist - Climate Change
HCIL, New Delhi