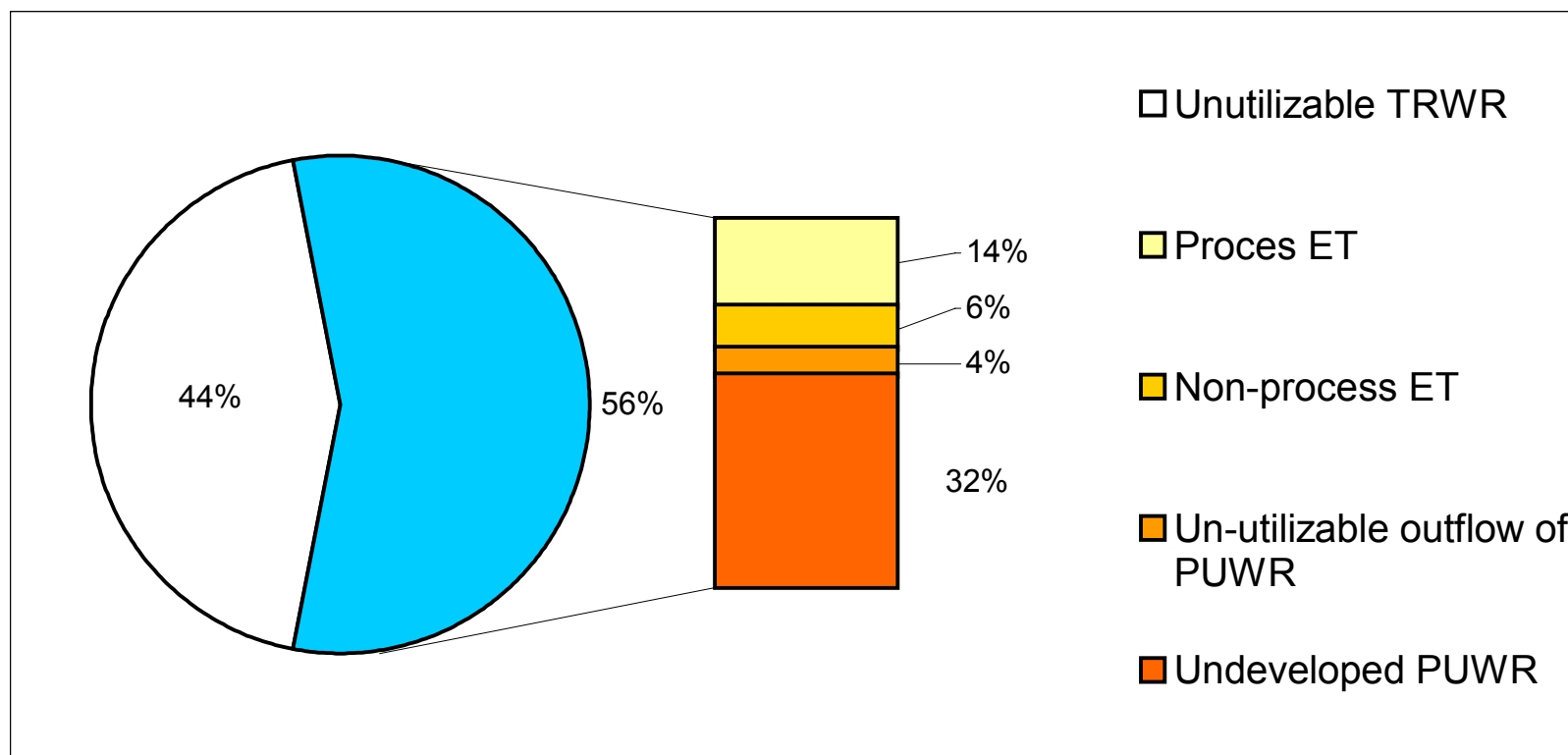


Domestic Policy Framework on Adaptation to Climate Change in Water Resources: Case Study for India



"Working Together to Respond to Climate Change"

WATER ACCOUNTING OF INDIA'S TOTAL WATER RESOURCES



Sources: Authors estimates and CWC 1998

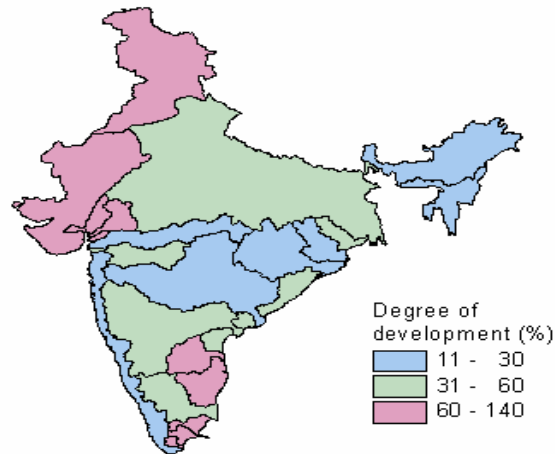
Water Availability of River Basins - Issues

India's Water Resources km³

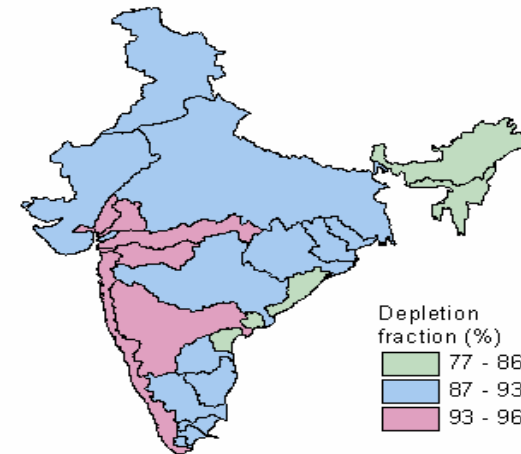
Surface water produced internally	418
Ground water produced internally	1220
Over lap	380
Flows from other countries	638
Totally Renewable Water Resources	1896

Source: FAO AQUASTAT

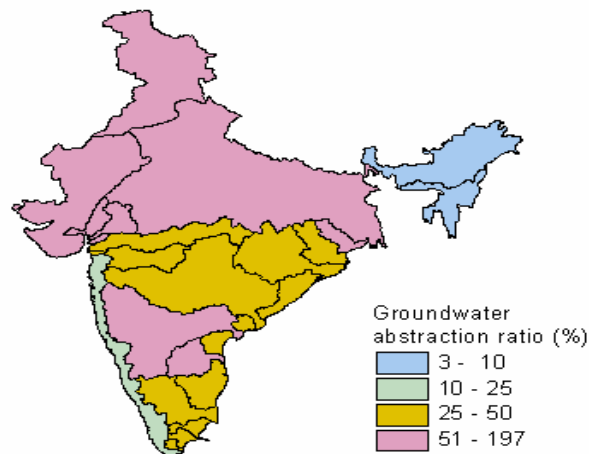
Degree of development



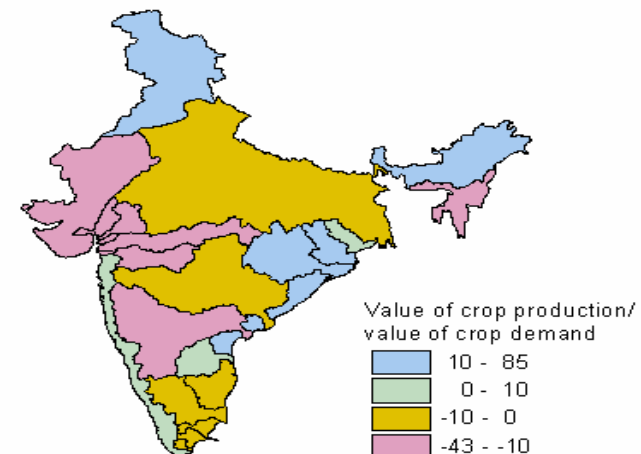
Depletion fraction



Groundwater abstraction ratio

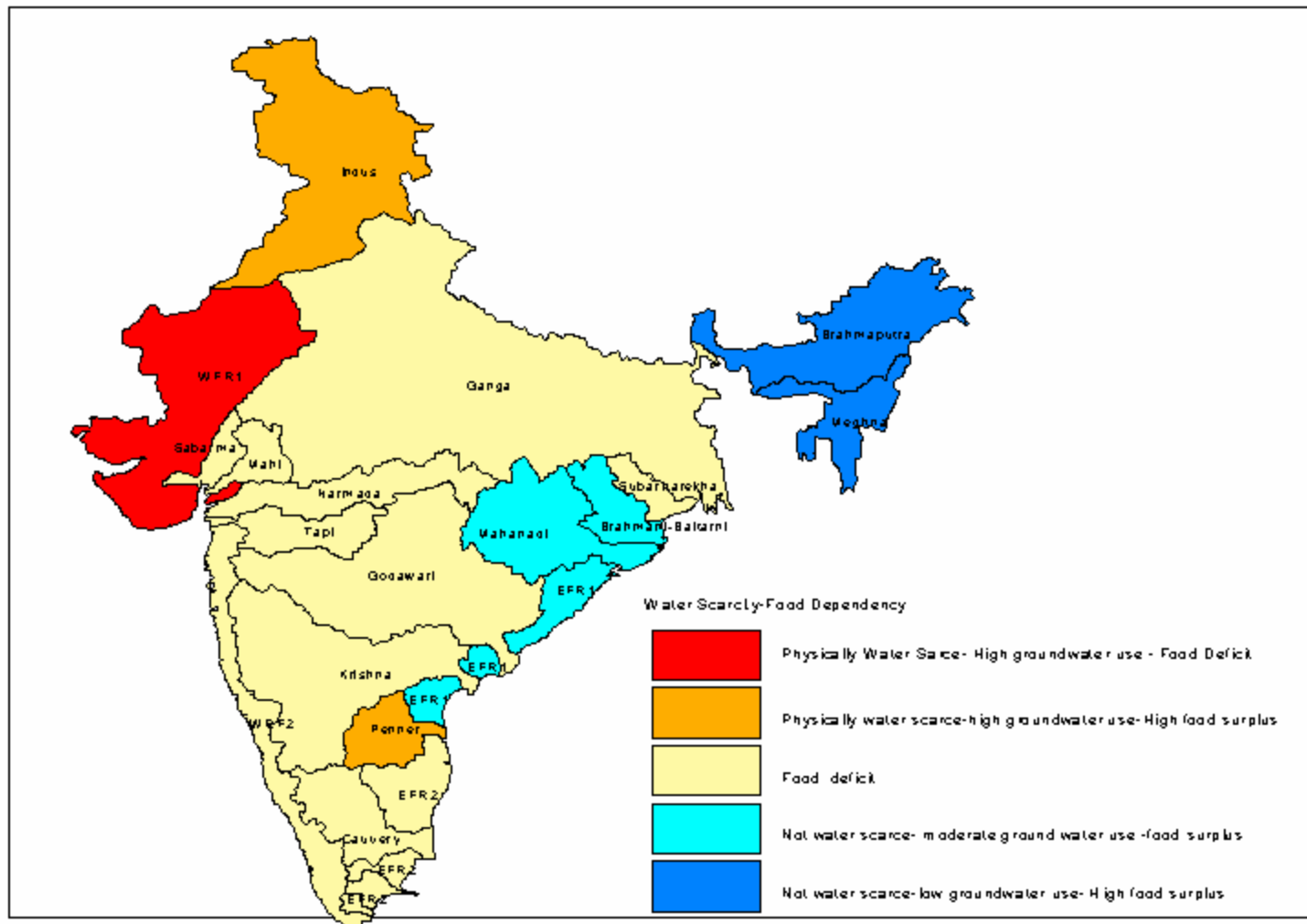


Ratio of value of crop production to value of crop demand

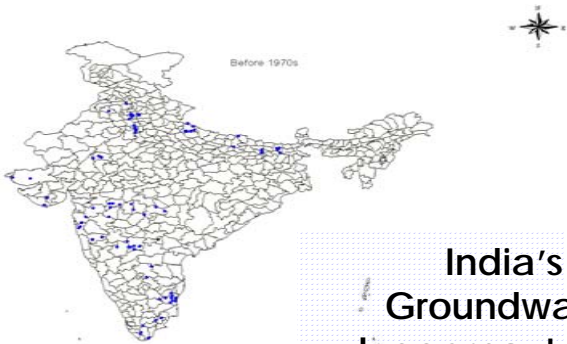


Indicators of water and food accounting in Indian river basins

WATER SCARCITY AND FOOD DEFICIT OR SURPLUS RIVER BASINS

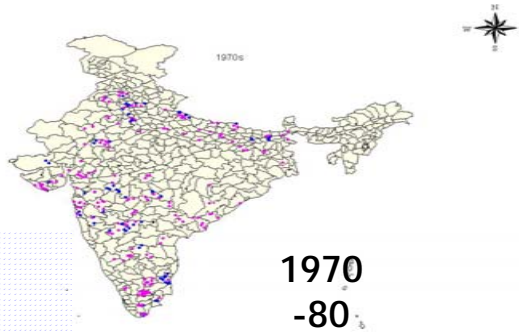


Pre-1970

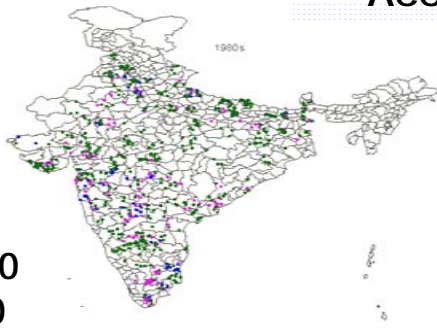


India's Groundwater Juggernaut is still Accelerating!!

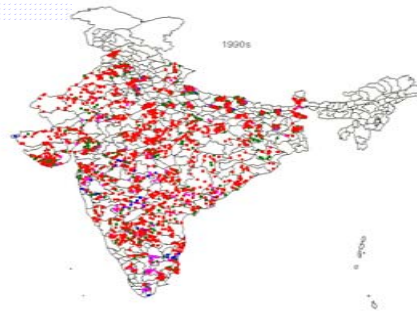
1970-80



1980-90



Post-1990

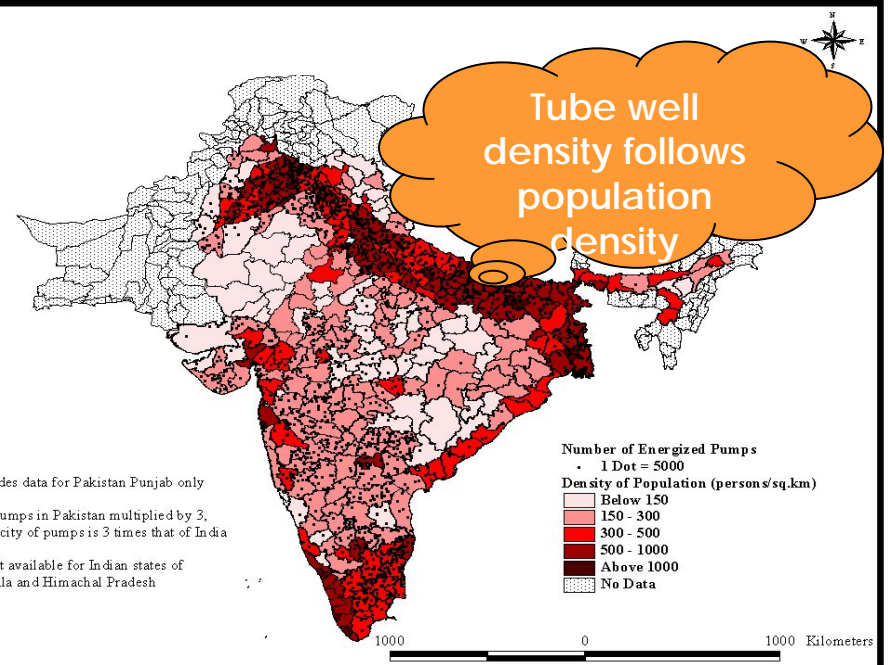


1000 0 1000 Kilometers

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

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.



*Pakistan includes data for Pakistan Punjab only

@ Number of pumps in Pakistan multiplied by 3, as average capacity of pumps is 3 times that of India

Pump data not available for Indian states of Rajasthan, Kerala and Himachal Pradesh

Institutional Arrangements

- **Union Ministry of Water Resources is the nodal agency. NWRC, NWB, CWC, CGWB, CPCB etc.**
- **Water is a state subject – responsible for financing, cost recovery, management.**
- **Administration and functional responsibilities are unclear and spread over a number of institutions.**
- **India has developed a relatively sound technical information base and expertise for resource development.**
- **Regulatory mechanisms are inadequate to generate incentives to enhance water use efficiency.**

Legal and Policy Frameworks

- **No separate and exclusive water law and legal framework specifying water rights.**
- **State has an absolute right over all lakes and rivers. Groundwater is considered as an easement of land.**
- **Water charges are very low and energy costs for irrigation are subsidized. Industrial and domestic charges reflect real value of water.**
- **NWP sets the priorities for different sectors but fails to address economic and institutional issues.**
- **Existing local and public institutions are too weak to address the complex emergent issues.**

Impact of Climate Change on Water Resources

- Near temperate climate in north, arid/semi-arid in central and west and tropical in east and south.
- 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.

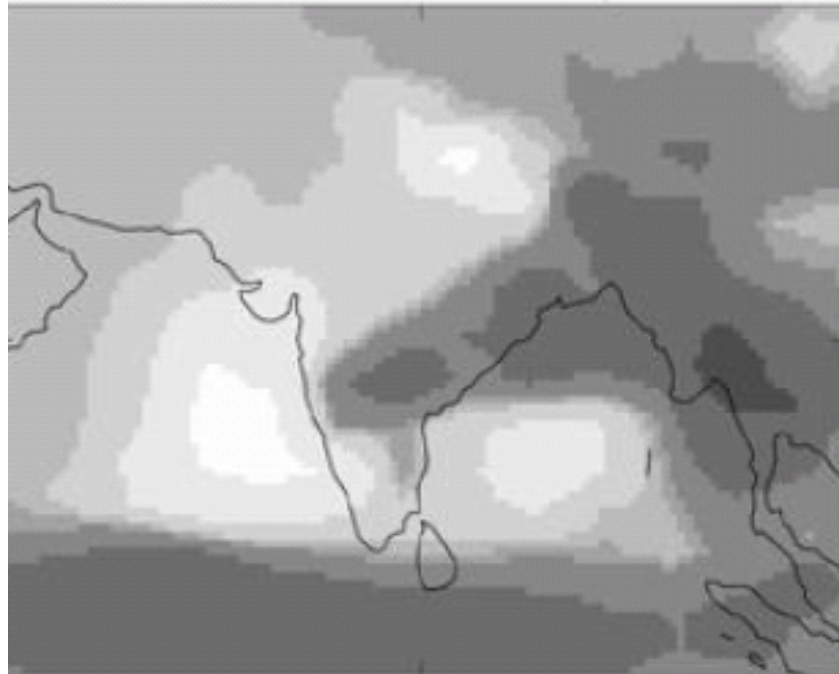


Plausible annual changes in area-averaged surface air temperature and precipitation over south Asia as a result of future increase in greenhouse gases

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

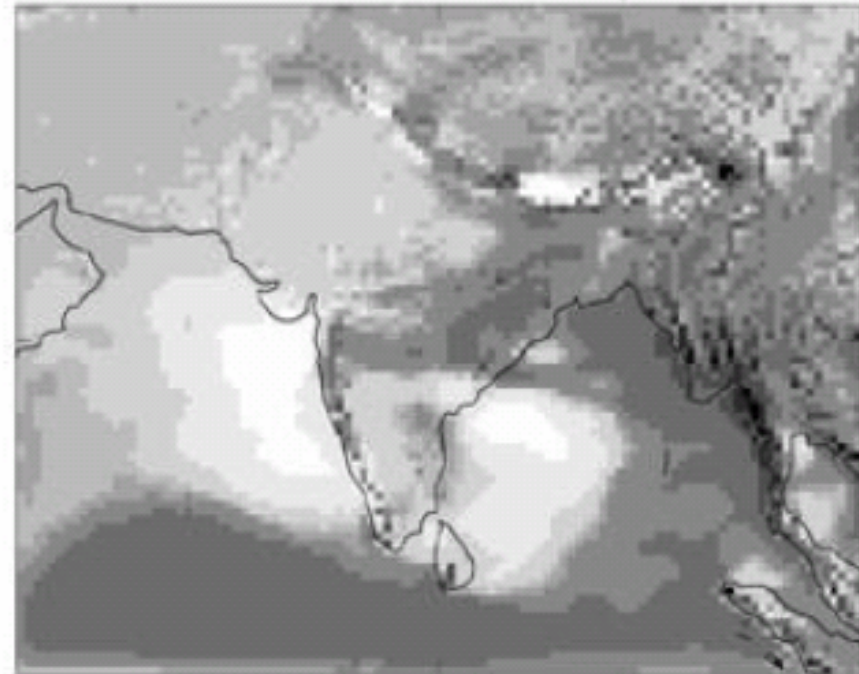
Source: Lal et. al.,2004

GCM GHG-Control, JJAS



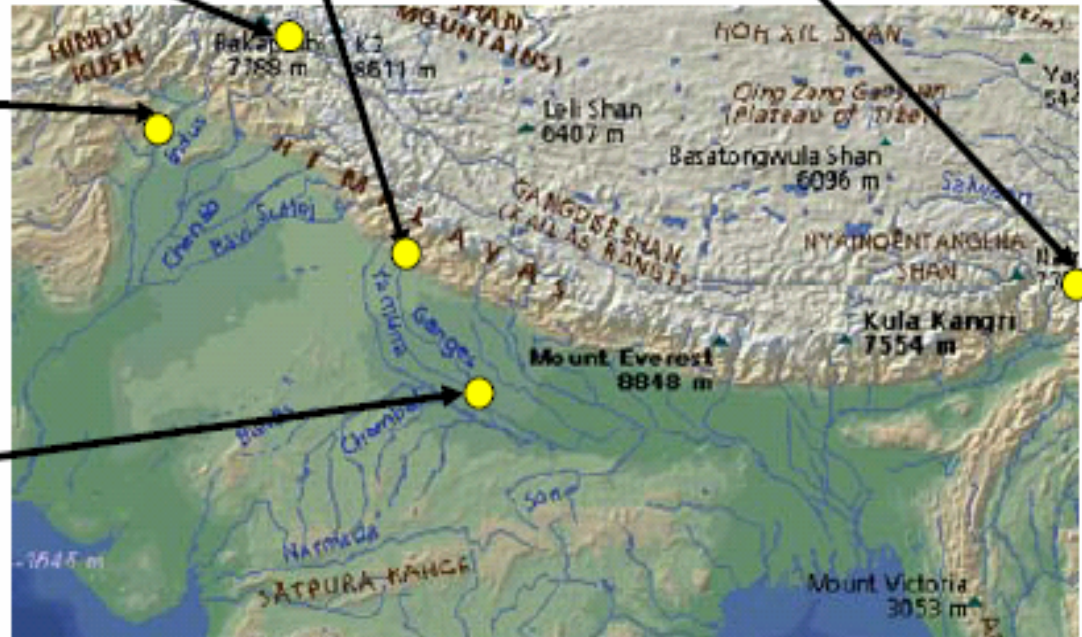
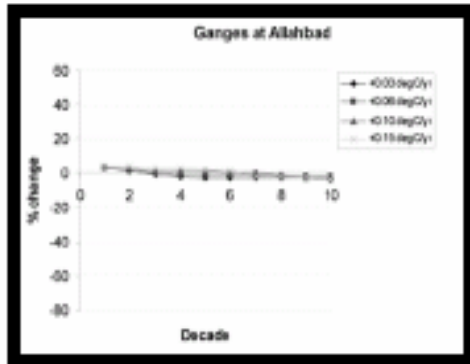
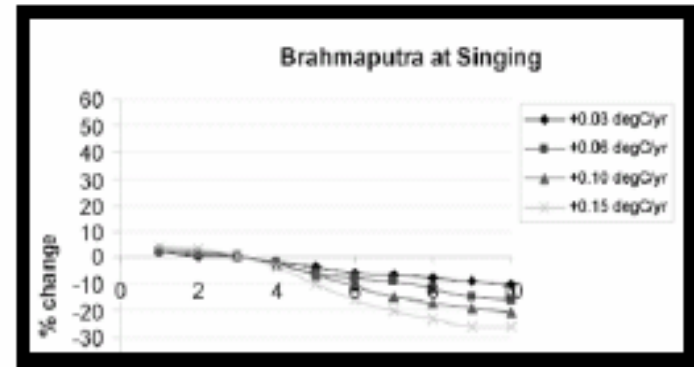
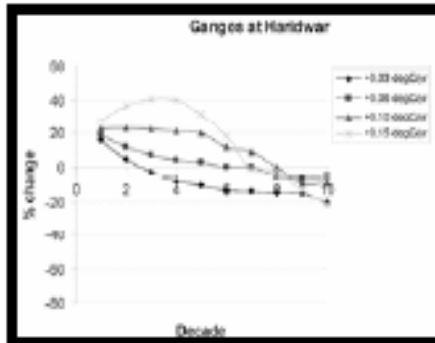
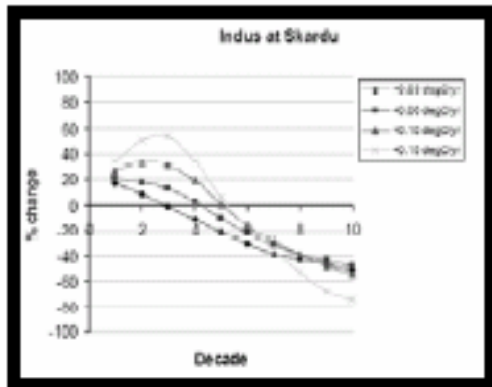
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RCM GHG-Control, JJAS



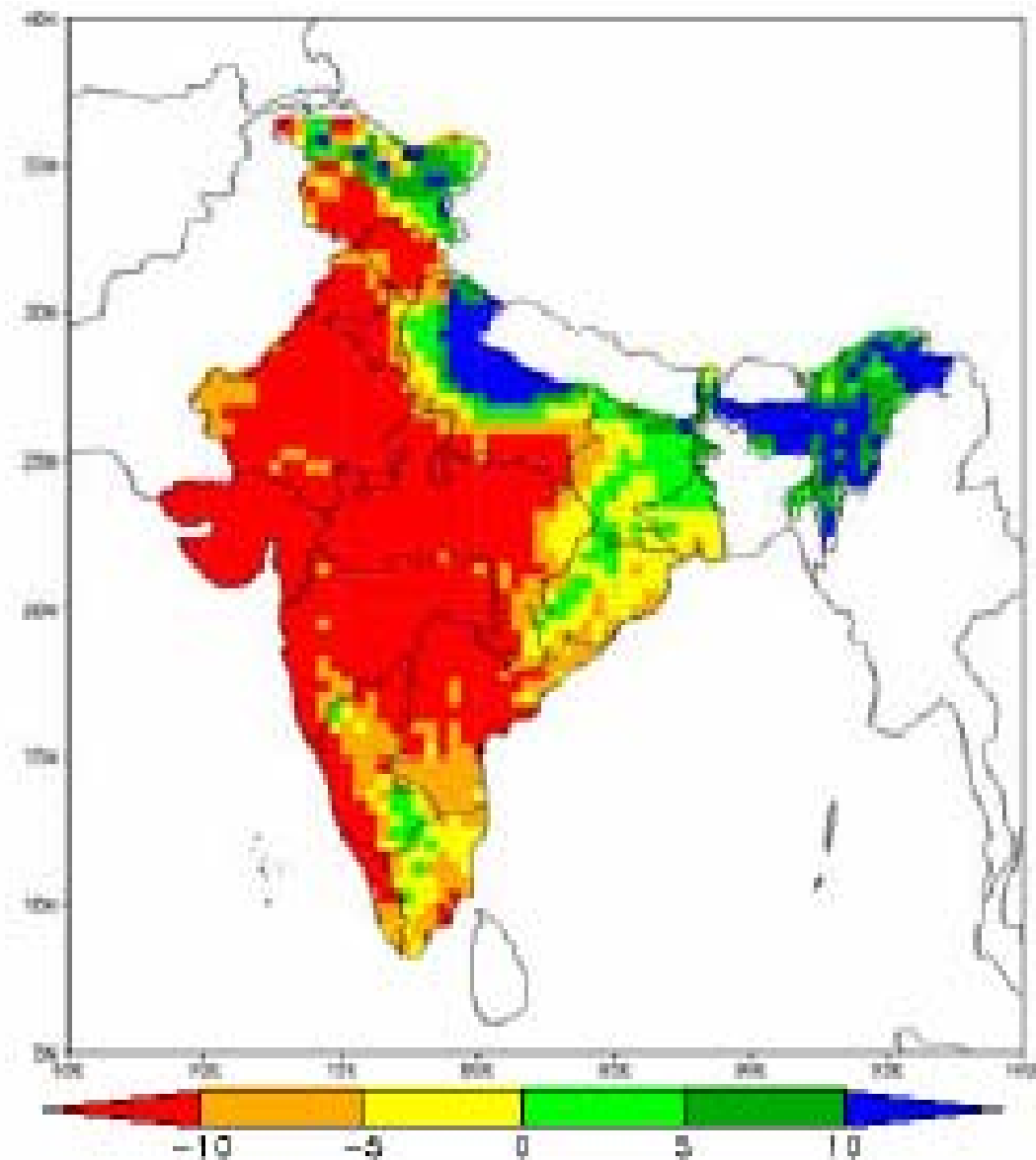
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Spatial distribution of changes in monsoonal rainfall at the time of doubling of CO₂ in the atmosphere



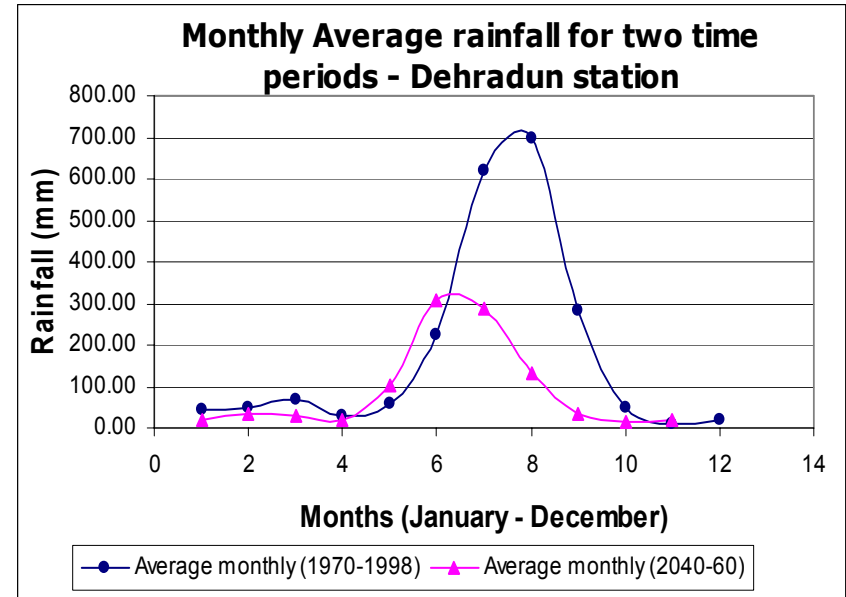
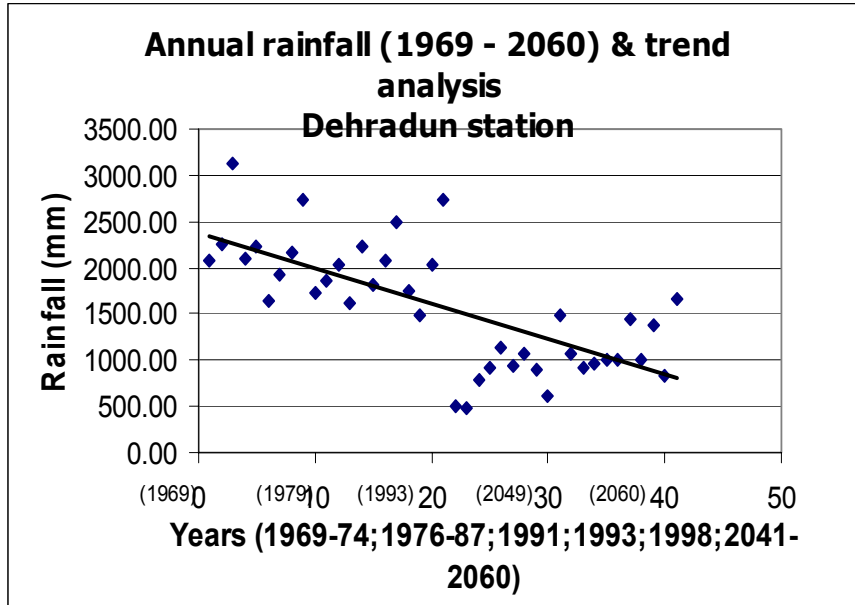
Simulated effects of de-glaciations on Himalayan river flows over ten decades

Gwyn Rees
et,al.,2005



Predicted changes in number of rainy days from the 'decreased rainfall' IPCC model

Lakhwar Catchment, Himalayas



The entire region would experience severe water stress as the monthly flows shall reduce by 20-30%. Annual groundwater recharge may go down by 30-35% by 2060. Fall in groundwater tables is estimated as 6-8 m on account of climate change and cost of extraction would go up by at least 3 to 4 folds by 2060. (www.teri.org.in)

India's 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.**

PREPAREDNESS

AND

ADAPTATION

TO

CLIMATE CHANGE

- ➔ **Institutional Arrangements**
- ➔ **Warning and Prevention of Floods**
- ➔ **Management of Droughts**
- ➔ **Adaptation of Indian Agriculture**

Improving Institutional Capacity

- **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**
- **Introduction of weather-indexed insurance**
- **Provision of adequate financial support for adaptation/ vulnerability reduction schemes**

Development and Management of Water Resources

- **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**

Adaptation to Floods

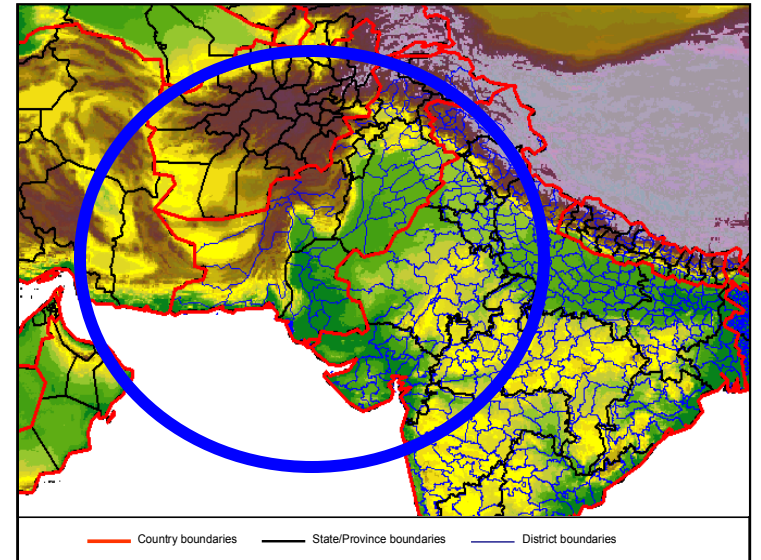
- **Learning to live with the floods**
- **Improved flood forecasting**
- **Area inundation forecast**
- **Flood plain zoning , enforcement of regulations**
- **Community participation in flood management**



Droughts in India

- 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 procedures of monitoring, impact documentation and capacity building is not yet fully in place in India



Prevention and 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**

Integrated ecosystem management

Water harvesting and efficient use

Indigenous and advanced methods

Adaptation of Indian Agriculture

- **Use of biotechnology to formulate suitable gene constructs to impart drought resistance and heat and cold tolerance.**
- **Improved crop production techniques to enhance input use efficiency, use of resource conservation technologies, attain higher yields .**
- **Special efforts for coastal, hilly and other critical and fragile areas.**





Thank you

