Climate Change: Impacts on Fresh Water and Adaptation of South Asian Agriculture

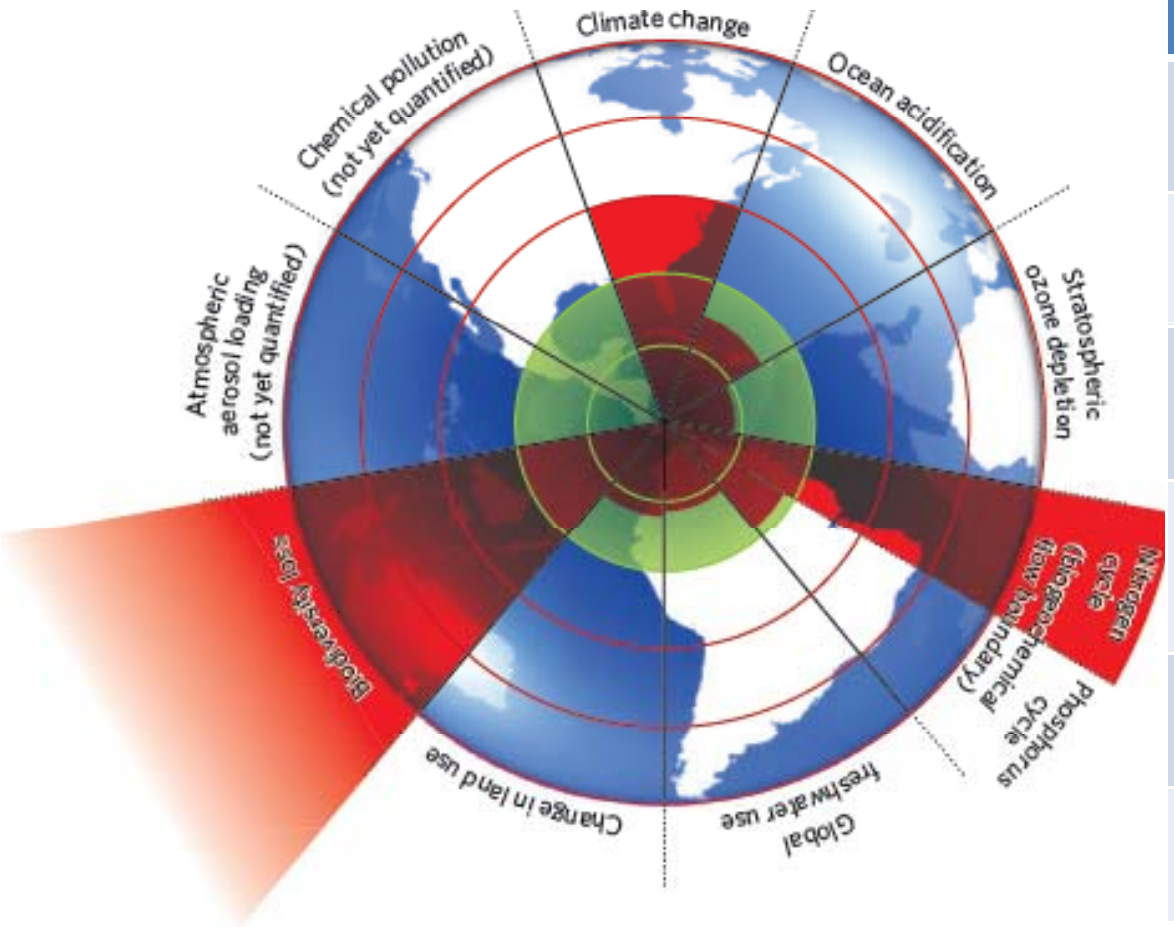
Bharat R Sharma

South Asia Media Briefing on Climate Change- 2012

November 16-17, 2012

India Habitat Centre, New Delhi

Breaching the Boundary

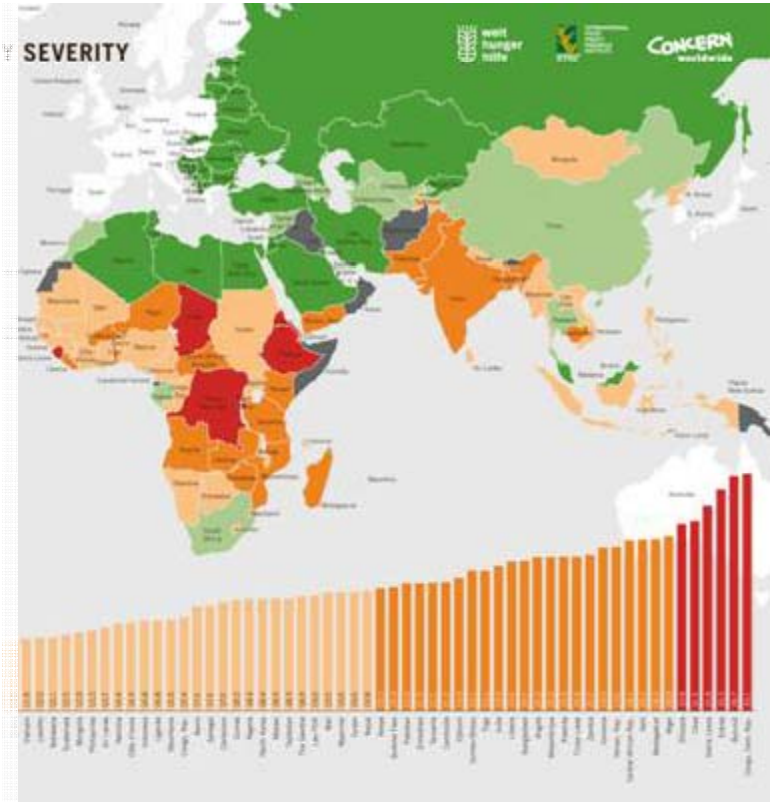


Planetary Boundaries				
Earth-system Process	Parameter	Prop. boundary	Current status	Pre-industrial value
Climate Change	**CO_2, ppmv**	350	**387**	280
	Rad. Forcing w/m^2	1.0	**1.5**	0.0
Rate of biodiversity loss	**Extinct. rate, per m species**	10	**>100**	0.1-1
N cycle	**N_2 removed, m t/y**	**35**	**121**	**0**
Fresh Water use	**Consu. km^3/y**	**4,000**	**2,600**	**415**

Source: Rockstrom, 2009

South Asia:
Home for 40% of World's Poor

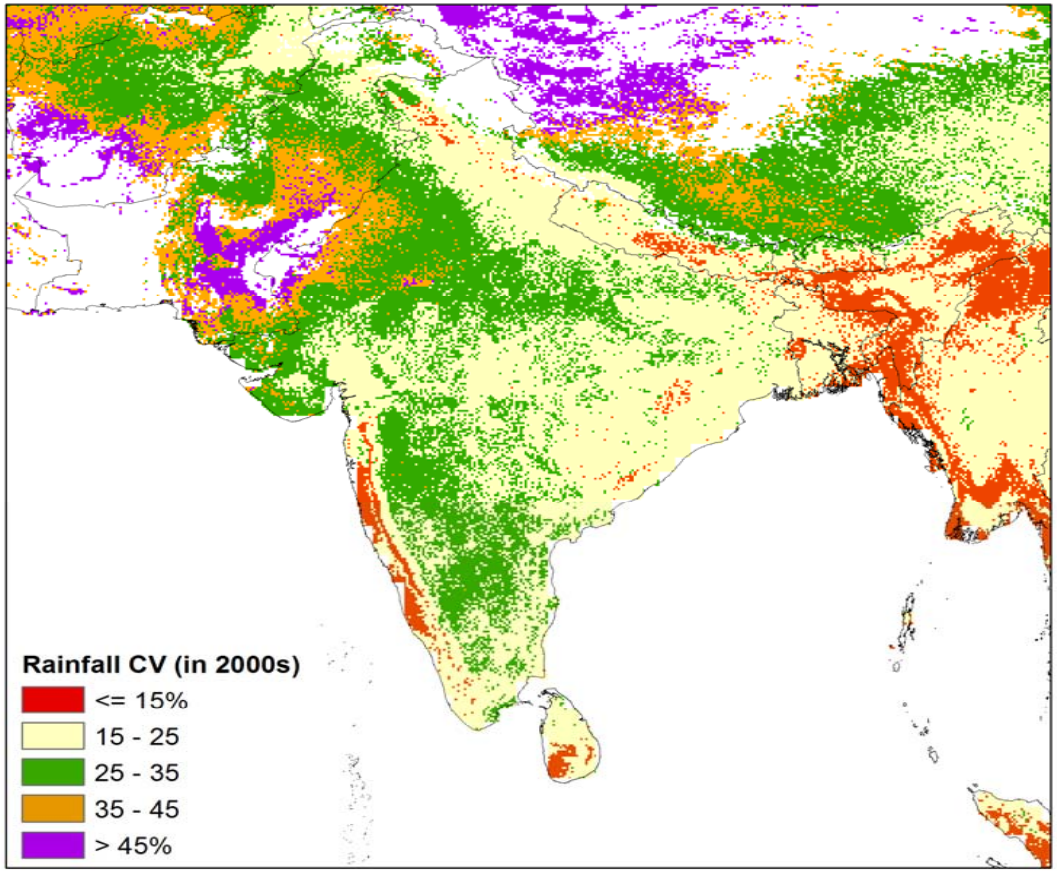
- > 1.6 billion people, 23% of world population
- Still has high growth rate of population
- Tremendous progress in last 4 decades
  - Food consumption increased from 1900 kcals to > 2500 kcals
  - Average GDP growth >7%
  - Little food imports now
- Yet, 1/4th of the world's hungry; 40% of the world's malnourished children and women
- Lagging in MDGs
- Agriculture important for livelihood security of > 50% population
- Projected to be very vulnerable to climatic risks



Source: IFPRI, 2009

Climatic stresses are common in South Asia

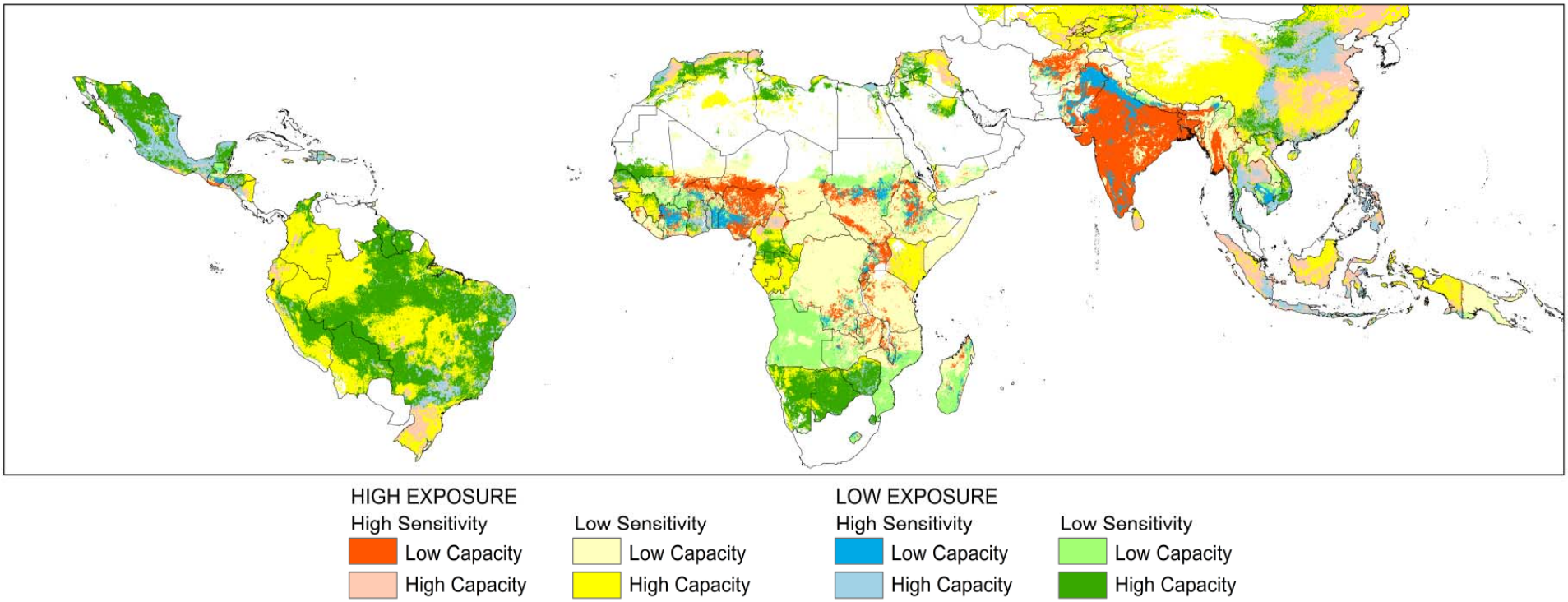
High CV of rainfall in Pakistan; northwest and south India



(Source: Erickson et al., 2011)

- Drought: >26 droughts in last 130 years
- Frost: common in northern regions
- Heat: frequent episodes at many places
- Frequent floods and cyclones in several regions

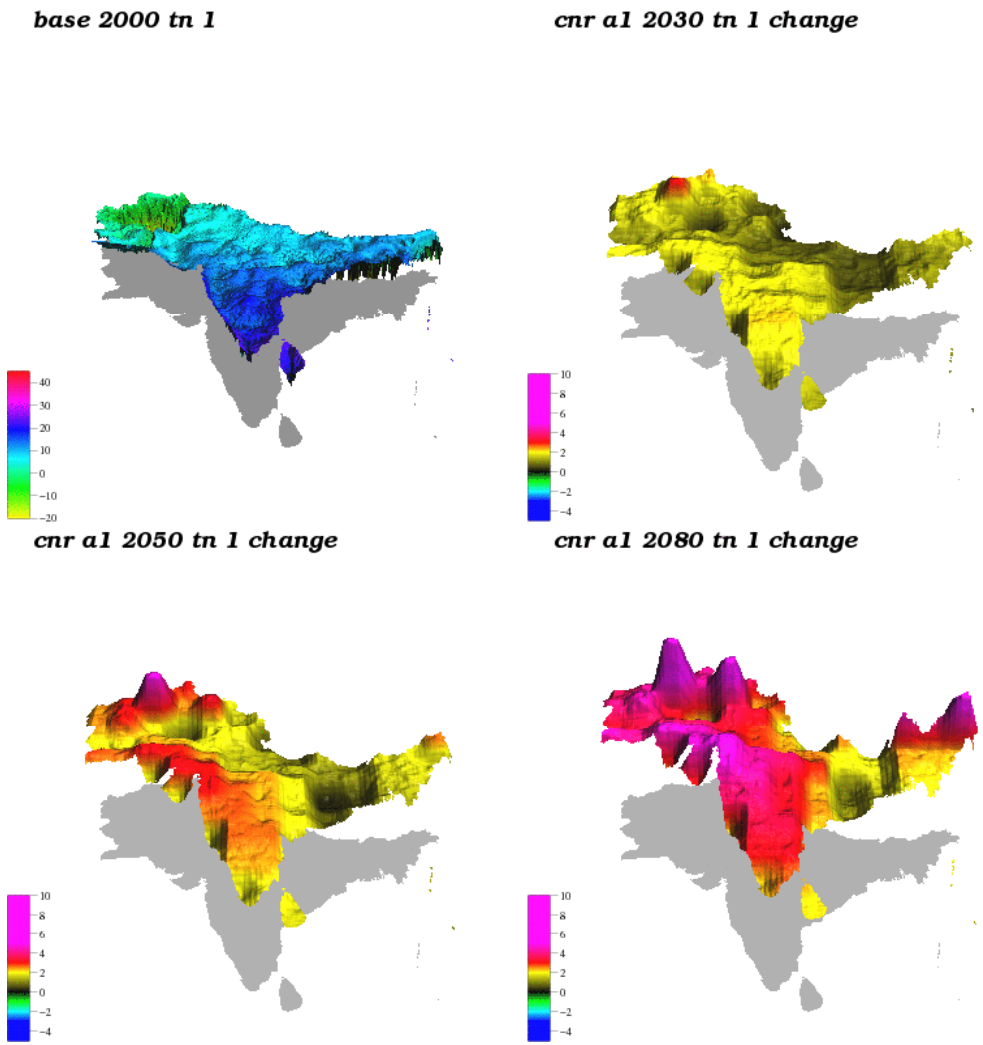
Vulnerability of agriculture to climate change: South Asia a major hotspot



(Source: Erickson et al., 2011)

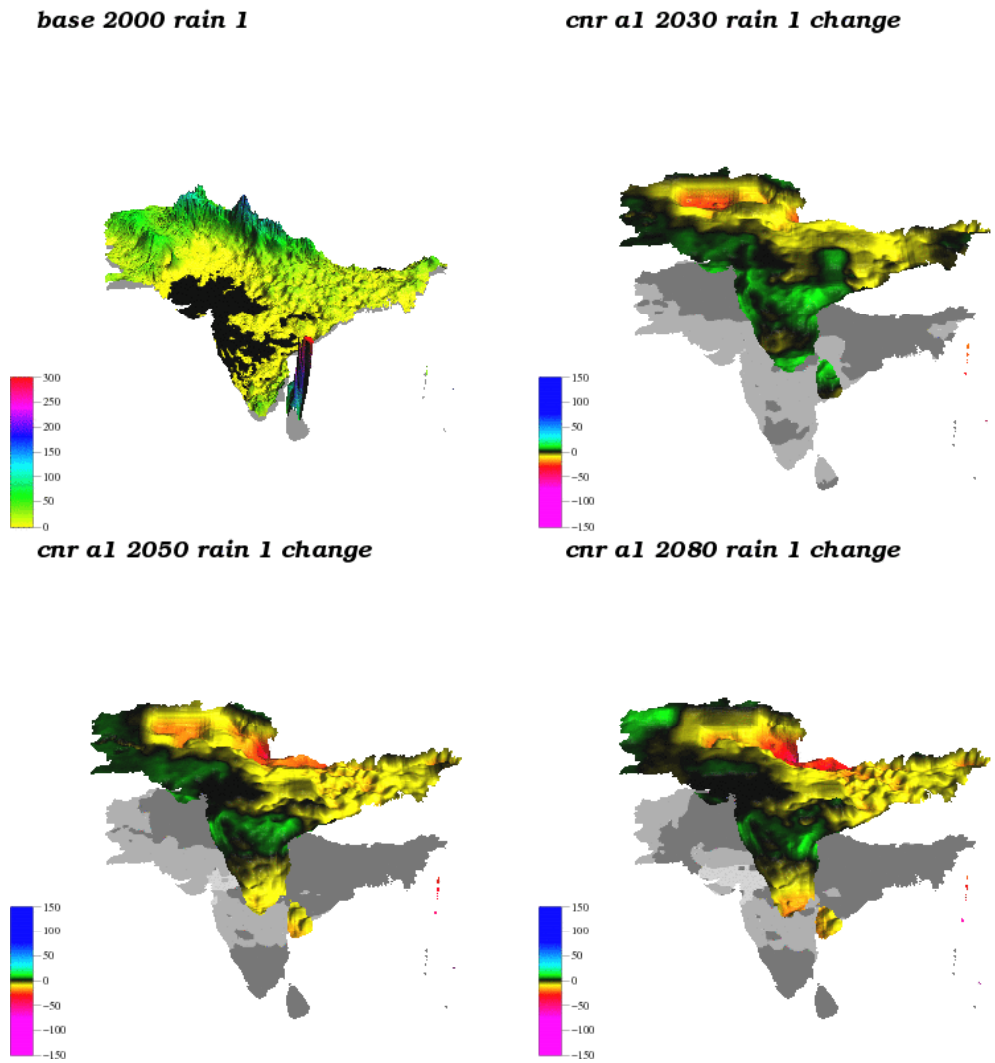
Climate is likely to change faster in future

Minimum temperature changes, 2000 to 2030, 2050, and 2080, CNR GCM



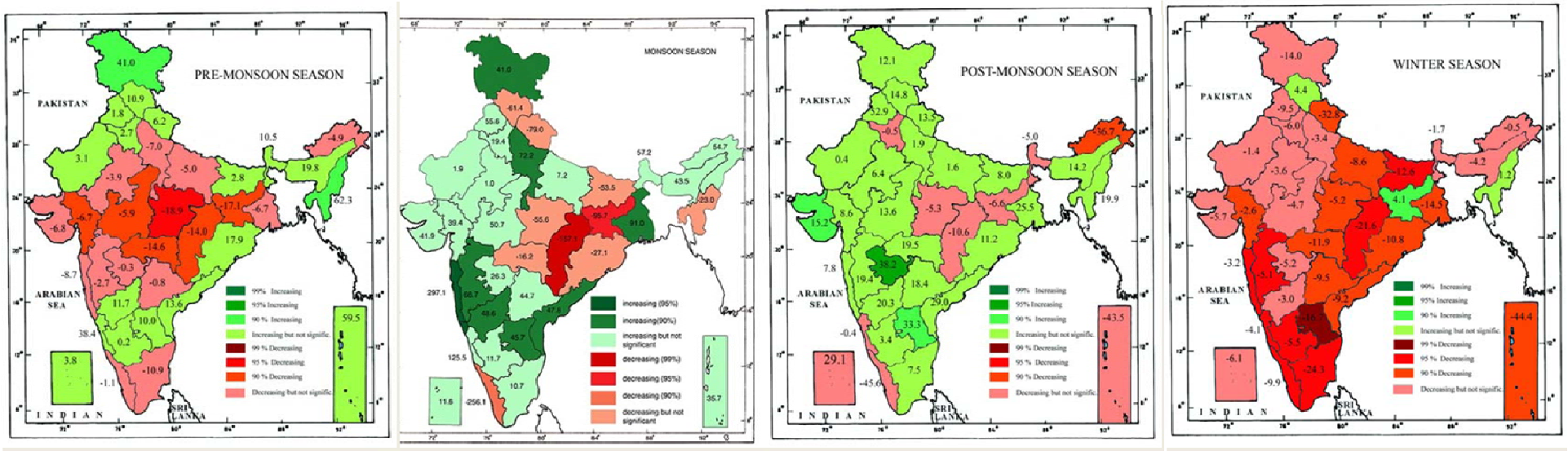
Climate is likely to change faster in future

Precipitation changes, 2000 to 2030, 2050, and 2080, CNR GCM



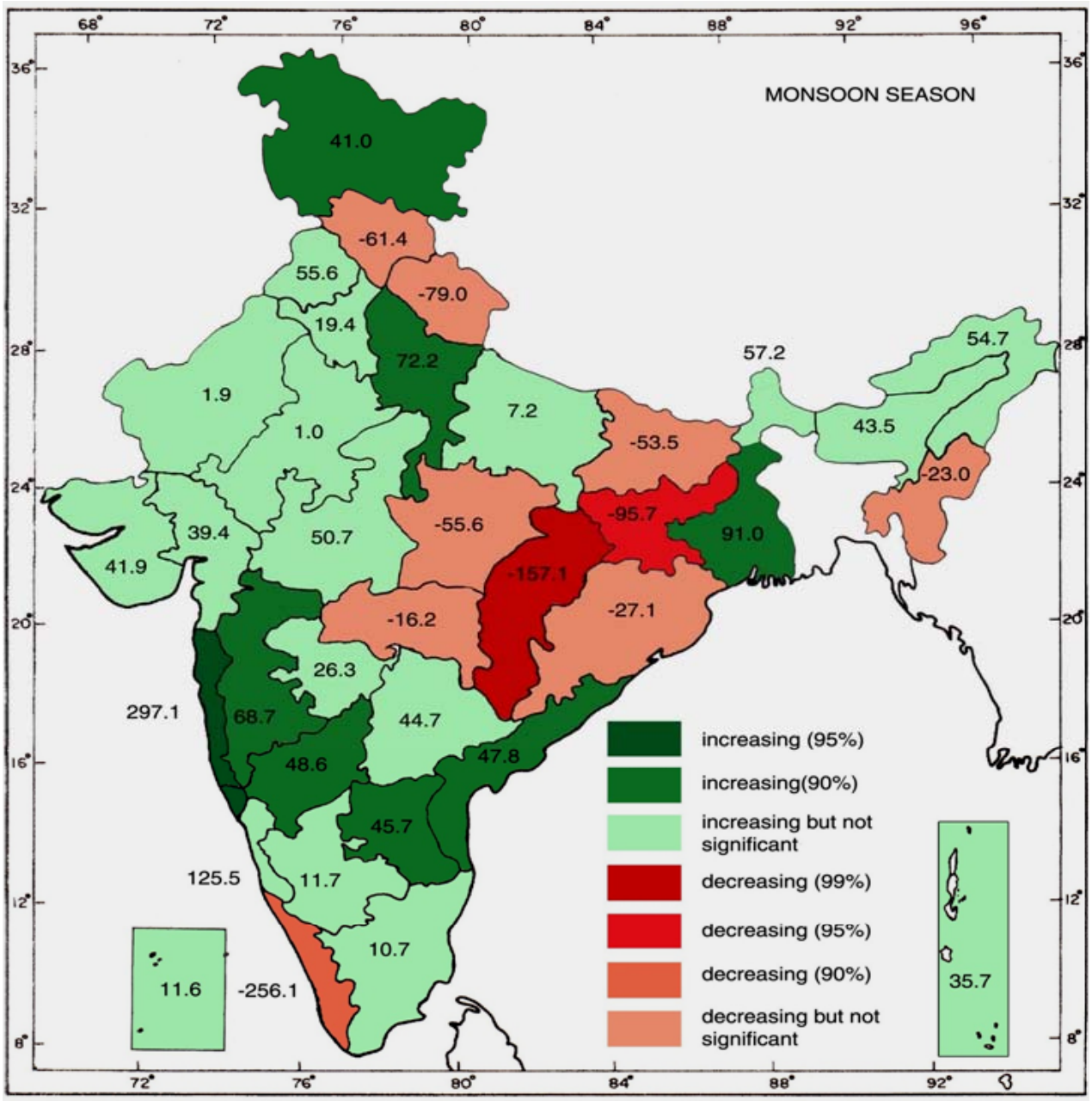
Trends in sub- divisional rainfall data for different seasons (1901-2003).

Different levels of significance are shaded with colors

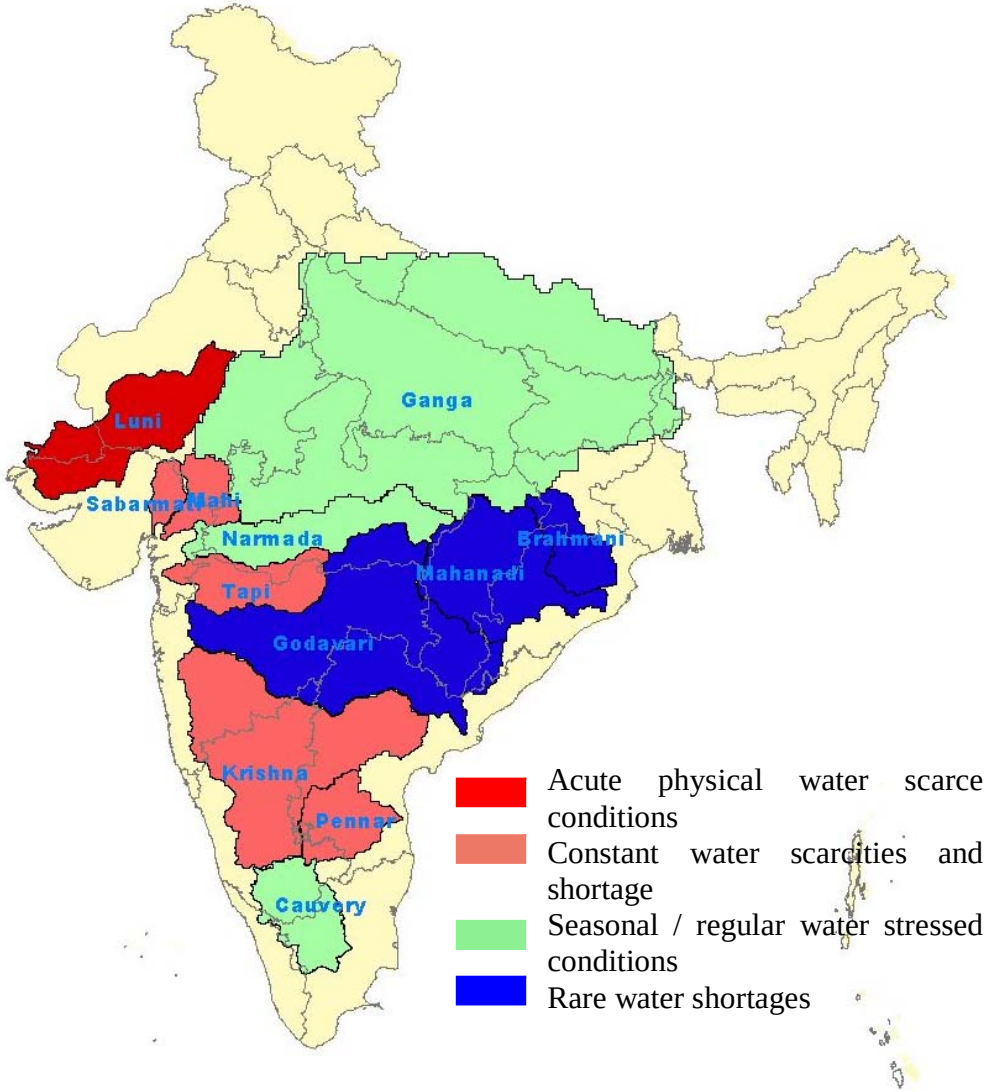


Source: IMD, 2010

Spatial changes in precipitation over the last 100 years



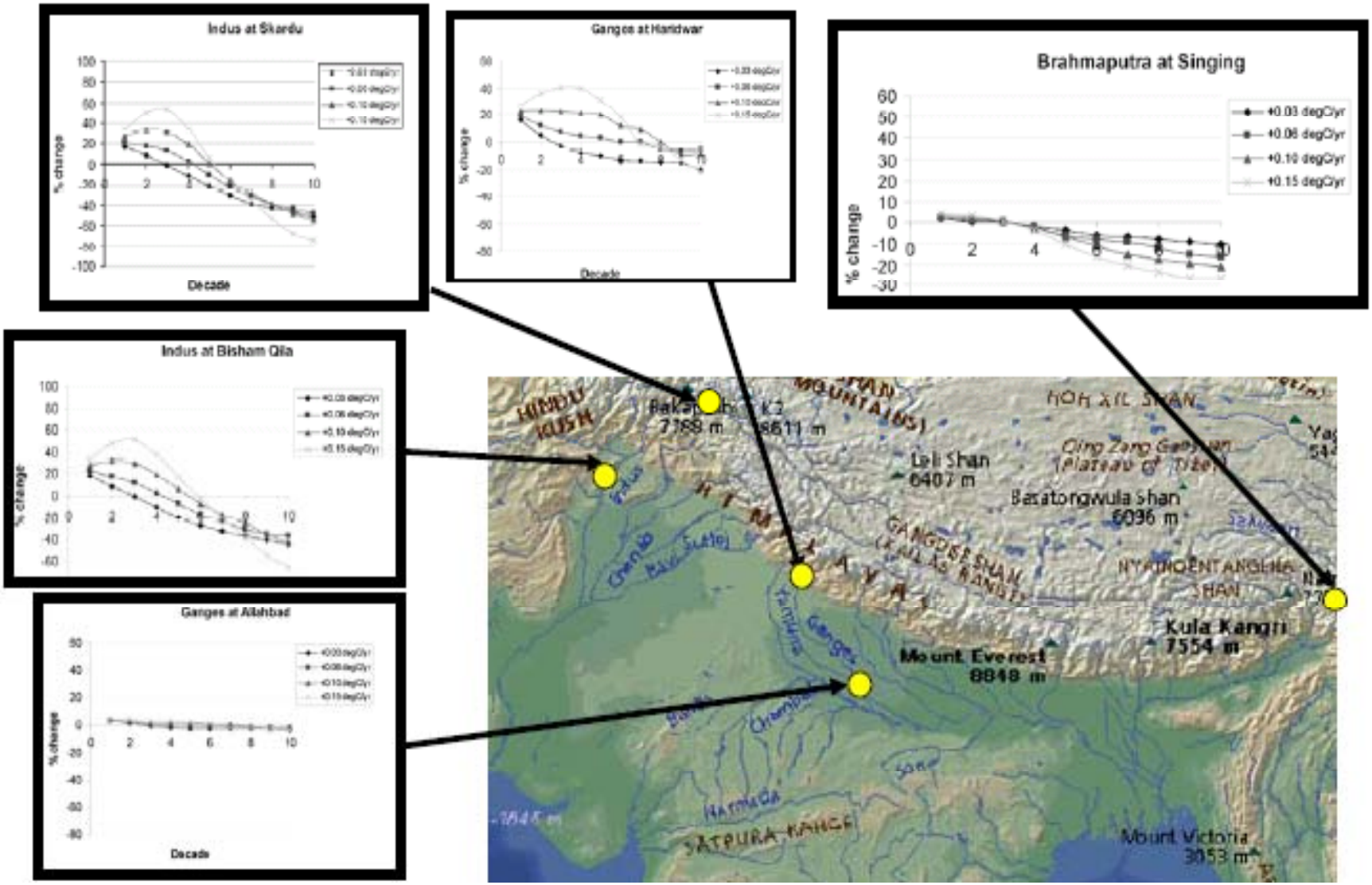
What are the projected changes in river water availability on a regional scale?



River basins of Mahi, Pennar, Sabarmati and Tapi are likely to experience constant water scarcity and shortage.

River basins of the Cauvery, Ganga, Narmada and Krishna are likely to experience seasonal or regular water stressed conditions

Source: India's Initial National Communication, 2002



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

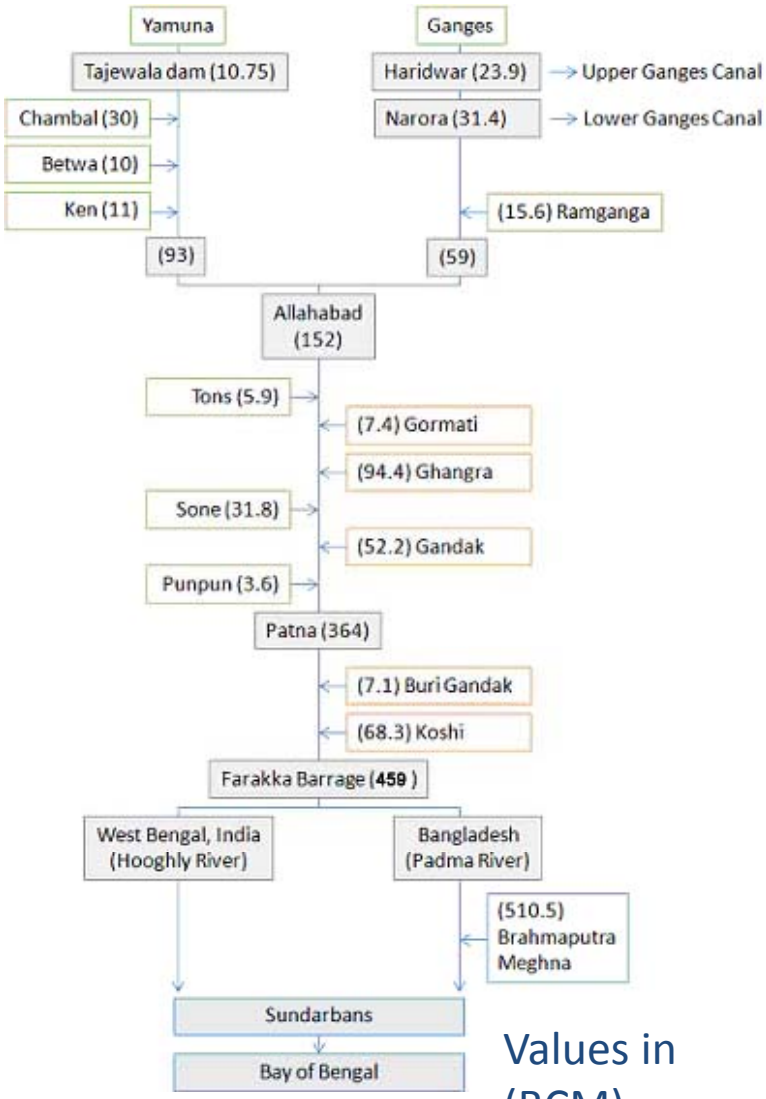
Gwyn Rees et,al.,2005

Retreat of Glaciers in Himalaya and Karakoram

Mountain Range	Name of Glacier	Periods	Year	Total Retreat, m	Average Retreat (m/ year)
Himalaya	Milam	1849-1957	108	1350	12.5
	Pindari	1845-1966	121	2840	23.5
	Gangotri	1934-1976	41	600	14.6
		1962-2000	38	1341	35.4
	Zemu	1975-1990	15	297	19.8
	Sonapani	1906-1963	57	905	15.9
Karakoram	Siachin	1929-1958	29	914	31.5
	Yengutsa	1892-1925	33	4134	125.3

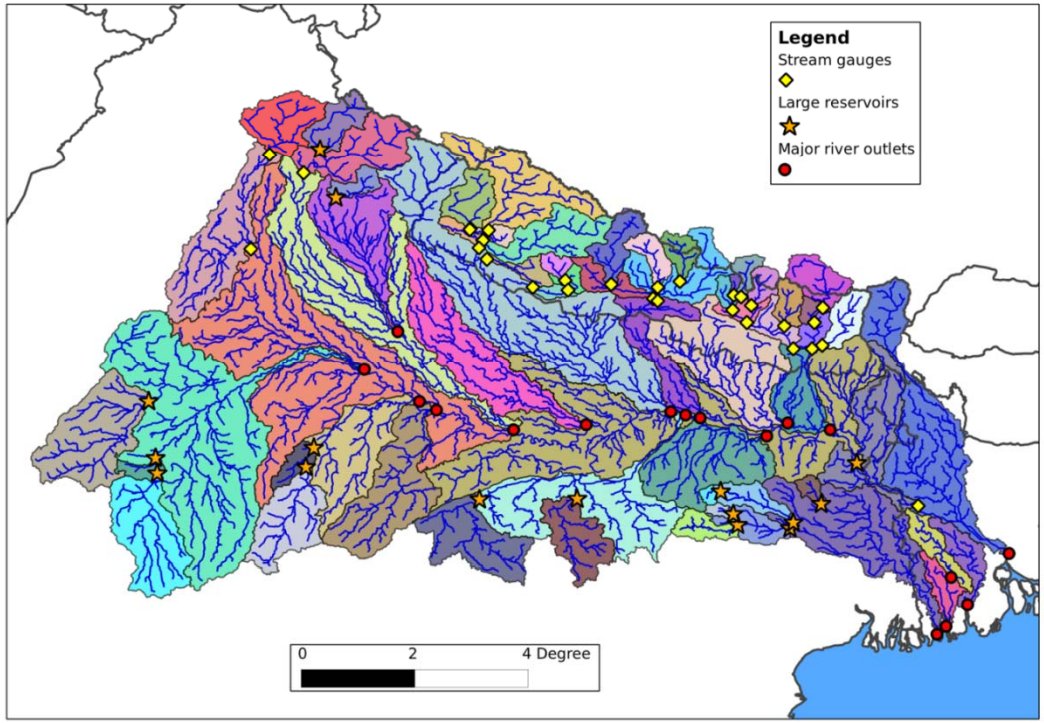
Retreat of the Gangotri glacier snout during the last 220 years (from 1780 AD to 2001) (ICIMOD, 2007)

Water Resources in the Ganges Basin



Values in (BCM)

- Gangotri glacier in Gomukh
- 1.09 m km^2 (79-I, 13-N, 4-C, 4-B)
- Tehri Dam, Farakka Barrage



CGIAR Challenge Program on WATER & FOOD

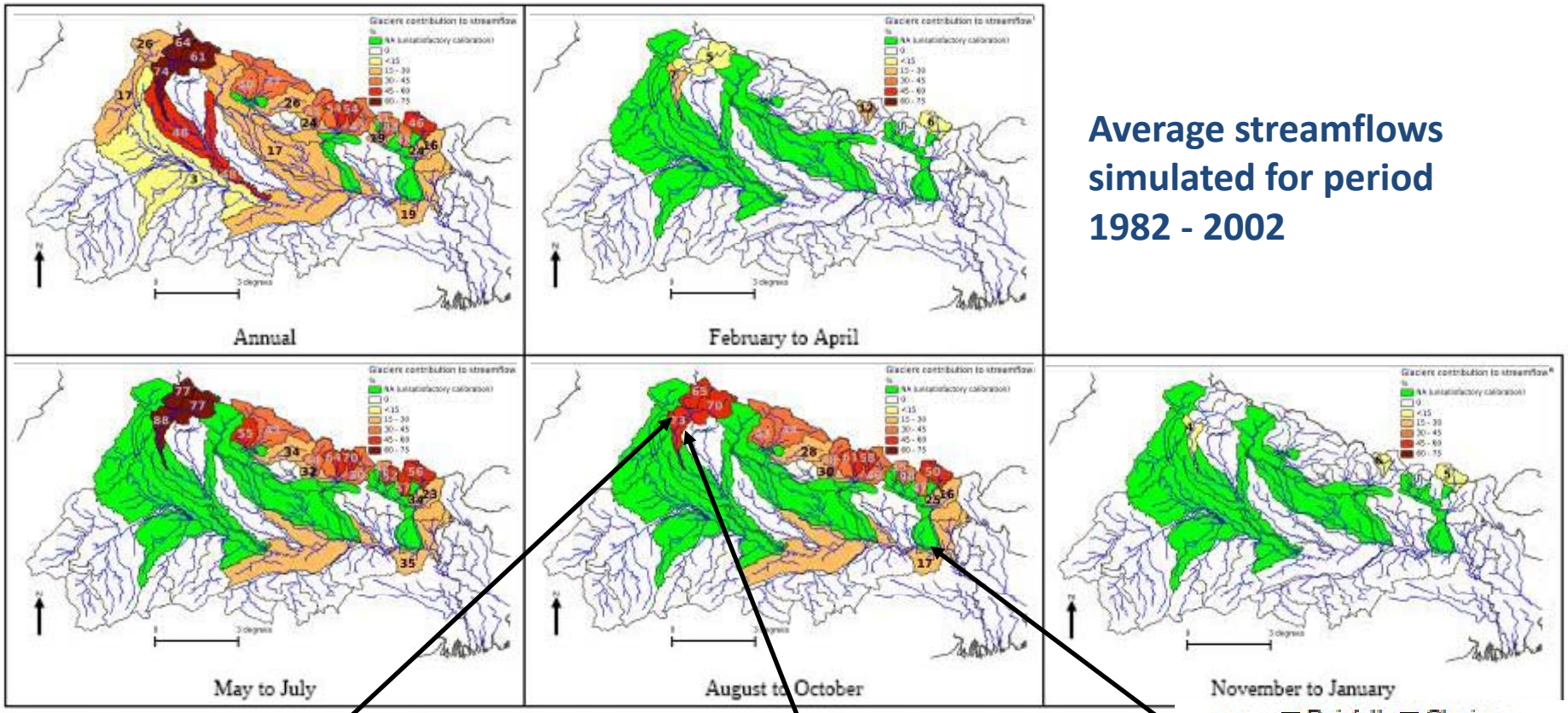
IWMI International Water Management Institute

IWMI Celebrating 25 years

Average contribution from melting of snow and ice in glaciated areas simulated for some sub-basins where WEAP-Ganga's setting is very good to good.

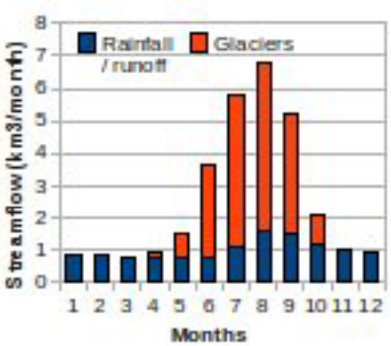
N°	Sub-basin	Average proportion of annual streamflows from glaciated areas		
		For years 1982 to 2002	For 3 wet years	For 3 dry years
44	Busti	44%	40%	46%
46	Rabuwa Bazar	45%	40%	50%
51	Chatara Kothu	24%	22%	26%

Analysis of current situation: contribution from glaciers

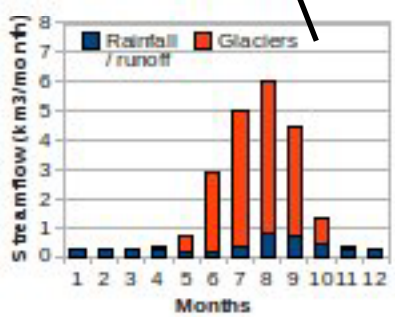


Average streamflows simulated for period 1982 - 2002

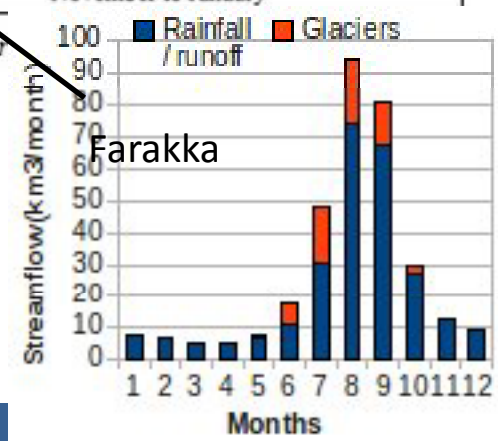
Figure 16: Average contribution of glaciers to annual and seasonal streamflows in the Ganges basin down to Far 2002



Haridwar
Before canal



Haridwar
After canal

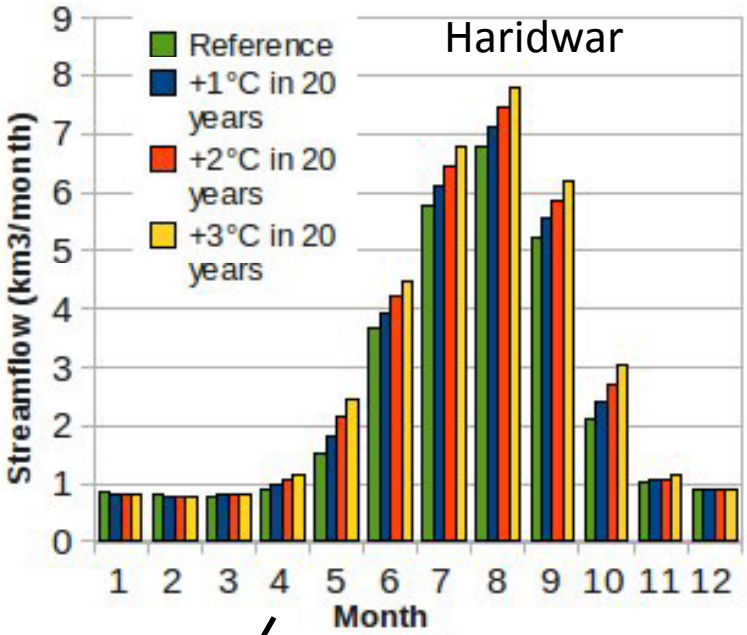


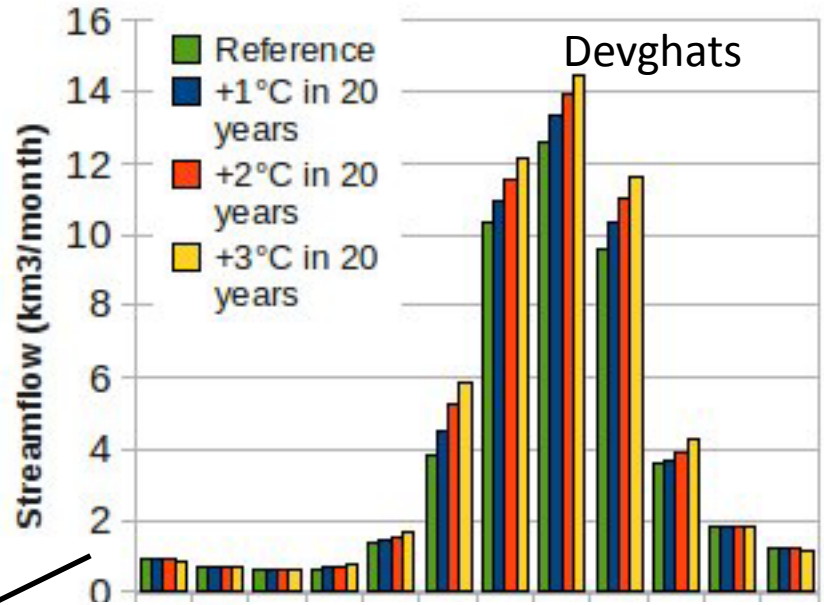
Farakka

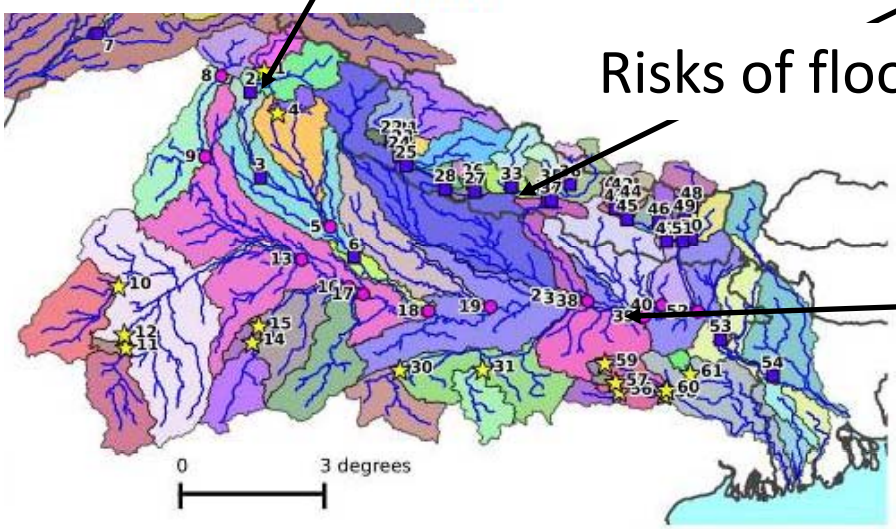
Scenario Analysis: Increase in Temperature

- According to the IPCC: temperature +3.8 °C at the end of the century in the Tibetan region.
- Same order by ICIMOD.
- ⇒ considered 3 scenarios for 20 years:
  - +1°C after 20-years, i.e., a rate of +0.05°C/year,
  - +2°C after 20-years, i.e., a rate of +0.10°C/year,
  - +3°C after 20-years, i.e., a rate of +0.15°C/year.
- Compared to the reference scenario = period 1982 to 2002.

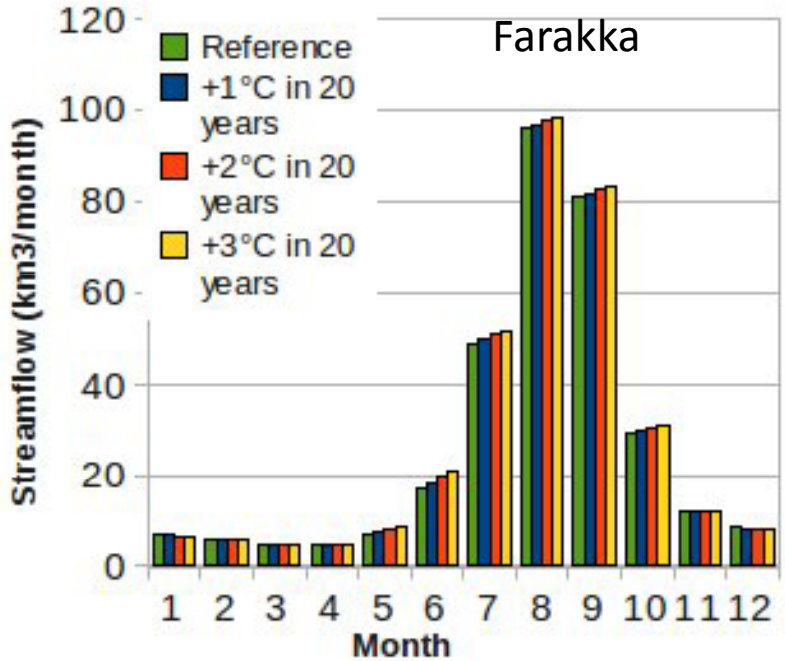
Scenario Analysis: Increase in Temperature







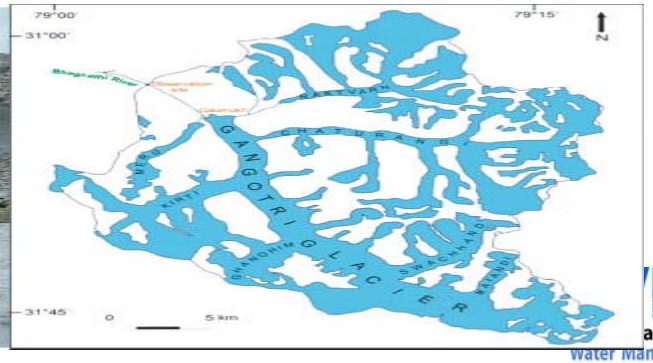
Risks of floods



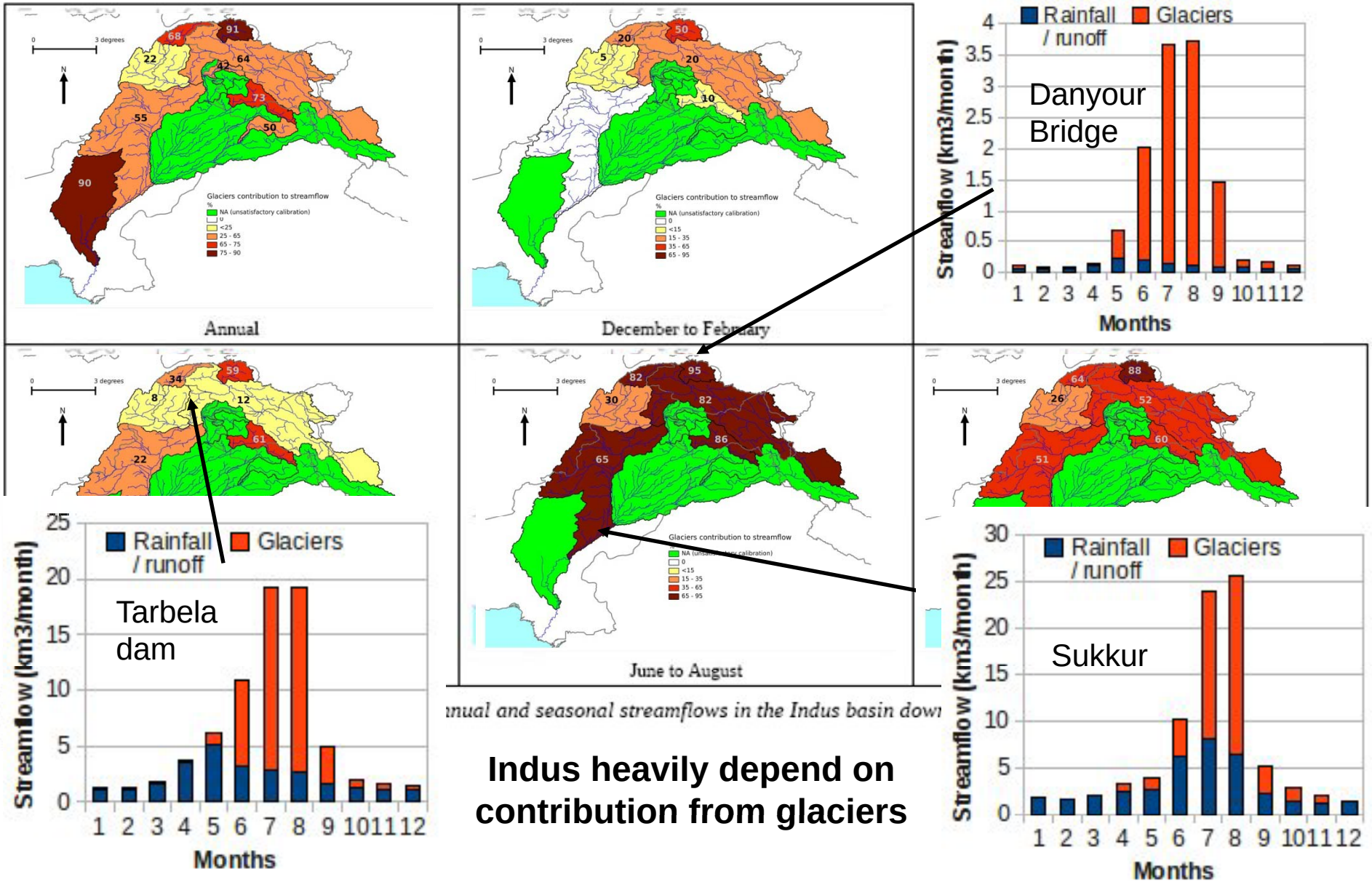
Scenario analysis: increase in temperature
Additional annual flow

- Additional annual flow:

Ganges	km3/year					
	Tehri dam	Haridwar	Narora	Tajewala	Delhi	Farakka
+1°C over 20 years	+0.6 (+8%)	+1.9 (+6%)	+1.8 (+8%)	+0.2 (+2%)	negligible	+4.2 (+1%)
+2°C over 20 years	+1.2 (+17%)	+3.9 (+13%)	+3.6 (+15%)	+0.3 (+4%)	negligible	+8.8 (+3%)
+3°C over 20 years	+1.9 (+26%)	+6.0 (+20%)	+5.4 (+23%)	+0.4 (+5%)	negligible	+13.4 (+4%)



Analysis current situation: contribution from glaciers



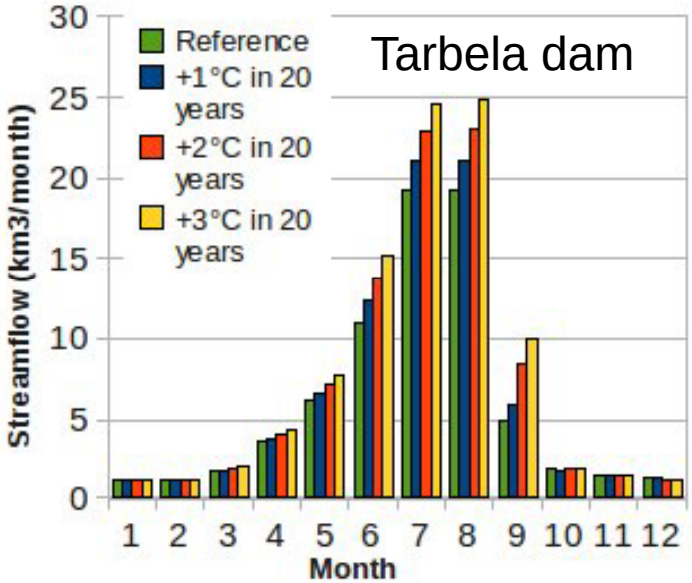
nual and seasonal streamflows in the Indus basin down

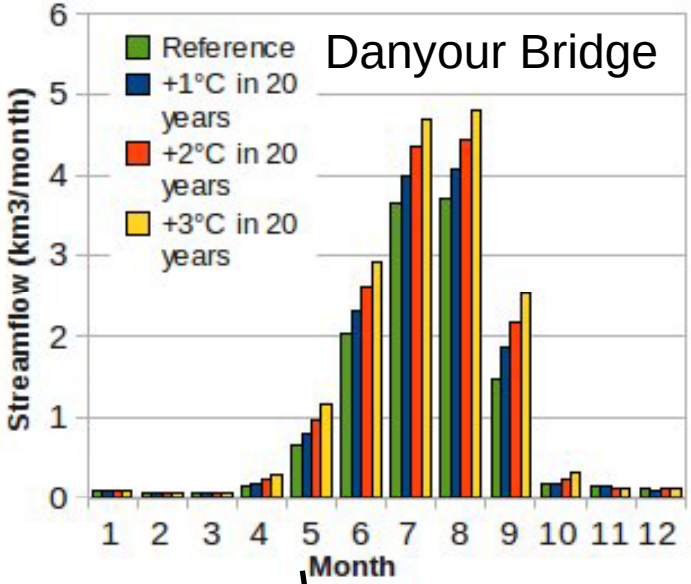
Indus heavily depend on contribution from glaciers

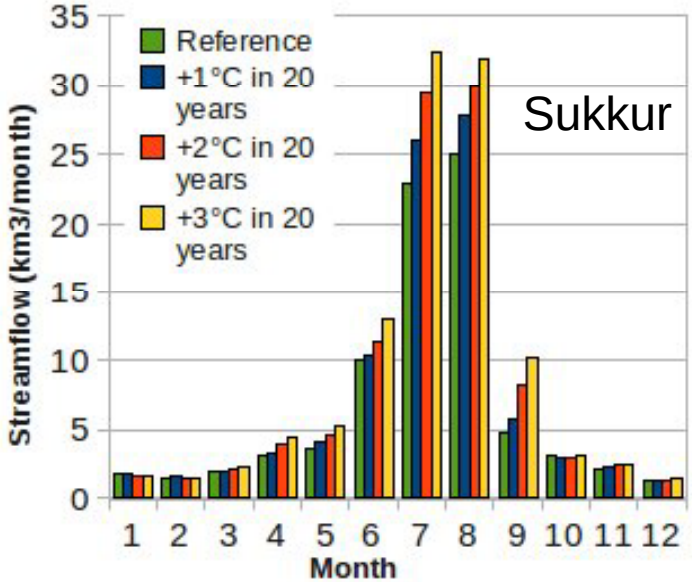
IWMI International Water Management Institute

SEI STOCKHOLM ENVIRONMENT INSTITUTE

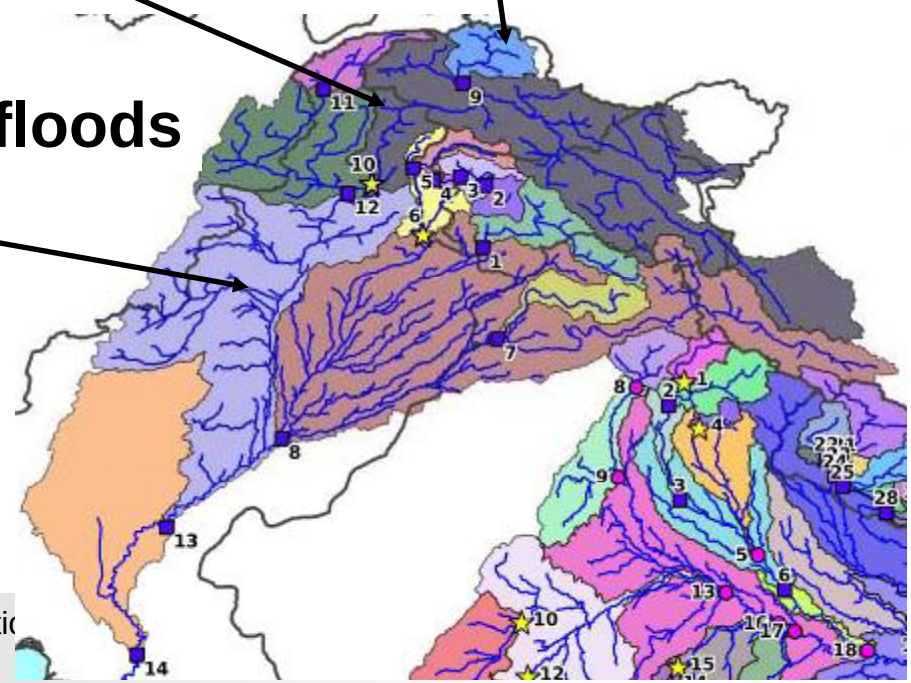
Scenario analysis: increase in temperature







Risks of floods



Scenario analysis: increase in temperature

- Additional annual flow in Indus

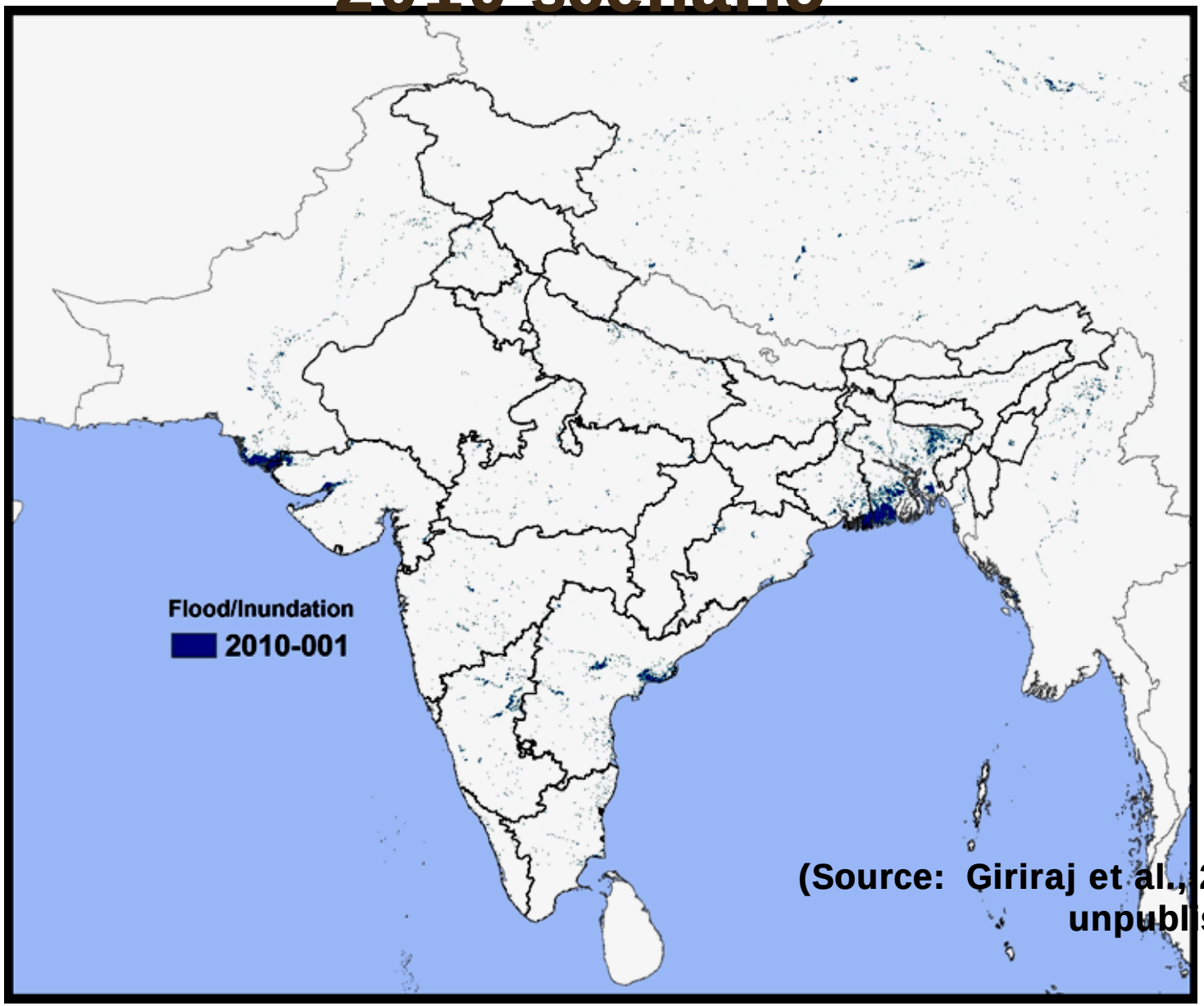
	km3/year	
	Inflow to Tarbela dam	Flow at Sukkur barrage
+1°C over 20 years	+6.6 (+9%)	+8.1 (+10%)
+2°C over 20 years	+15.2 (+21%)	+16.4 (+22%)
+3°C over 20 years	+22.6 (+31%)	+28.5 (+34%)

- Additional flow mainly during the high flow season ⇒ how to use it?
- Tricky as high discharge.
- Maybe extra flows in April, May & June + September & October?

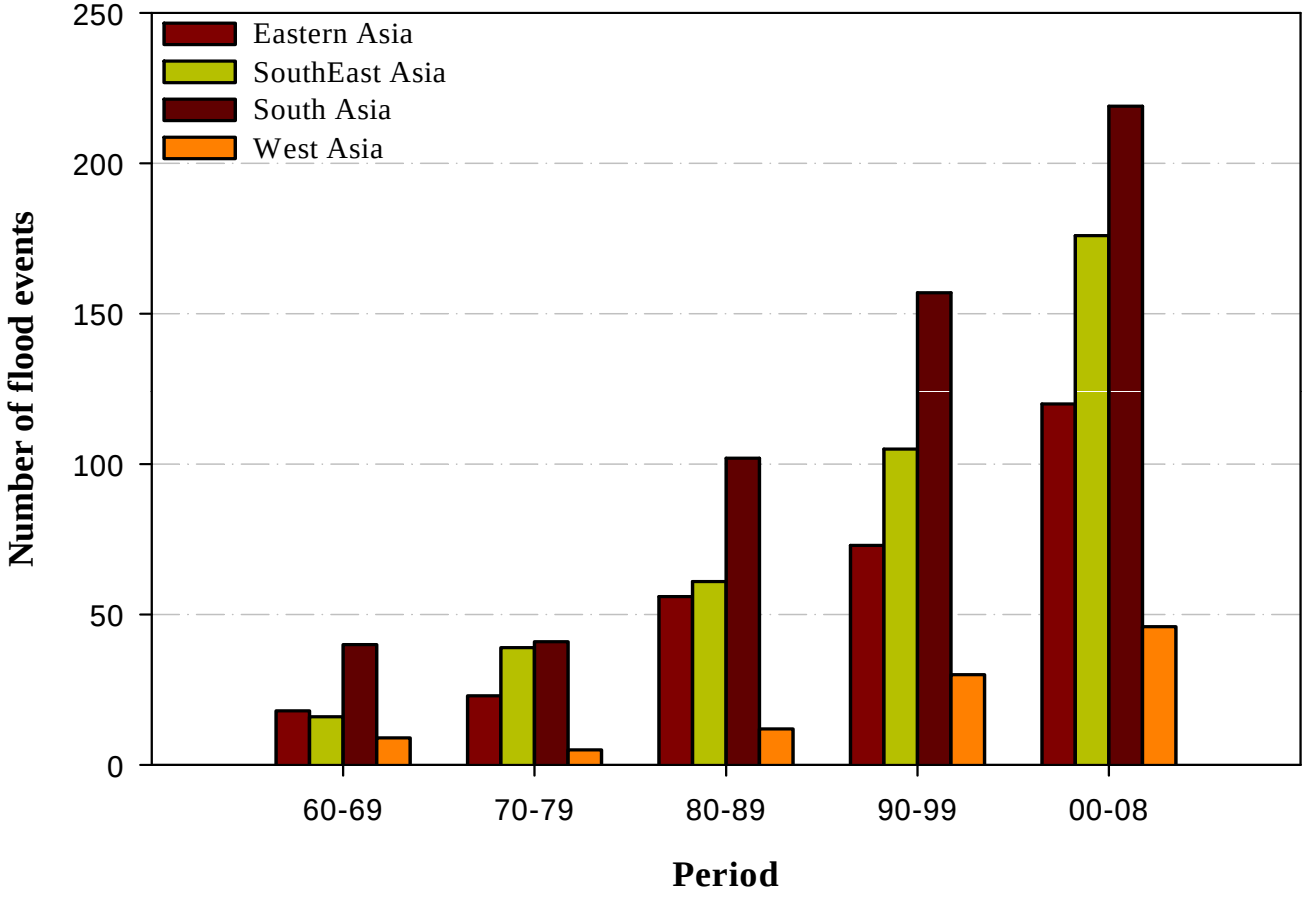
The extra water from the glaciated areas in the short to medium term presents a set of potential opportunities and some threats.

Potential threats in the form of floods in the upper catchments, which generally have not witnessed these kind of phenomenon.

Flash flood hotspots in South Asia: 2010 scenario



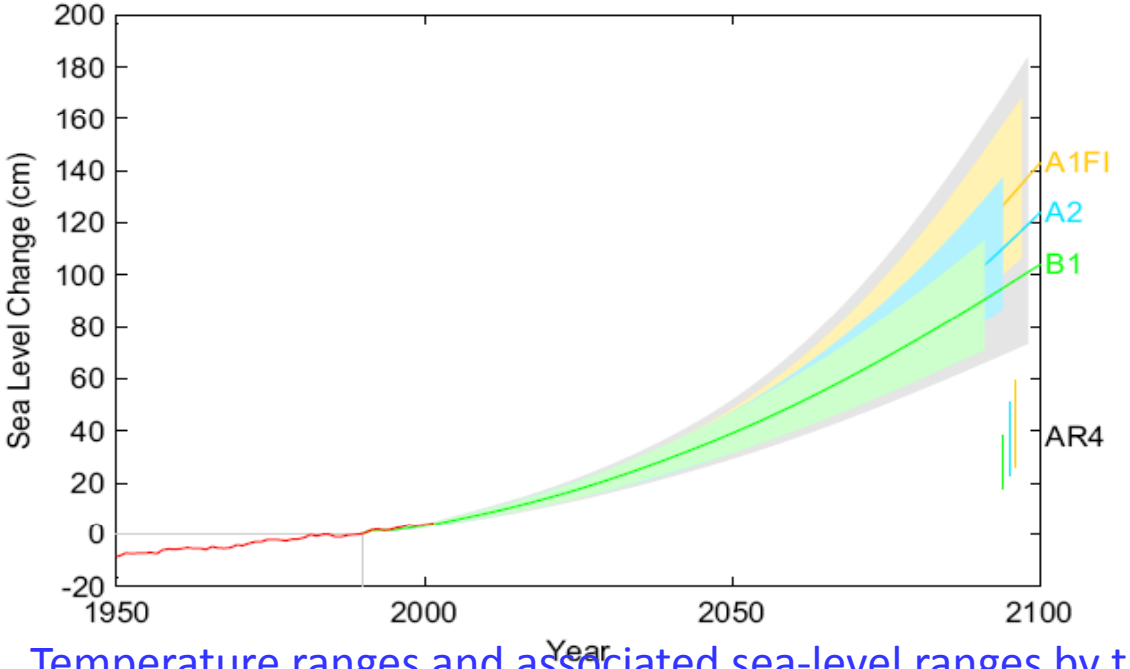
(Source: Giriraj et al., 2012; unpublished)



Flood disaster trend in Asia in the last 48 years

Sea Level Rise in Pussur & Sibsa River System

Projection of SLR from 1990-2100,based on IPCC temperature projections for three different emission scenarios(Rahmstrof,2009)

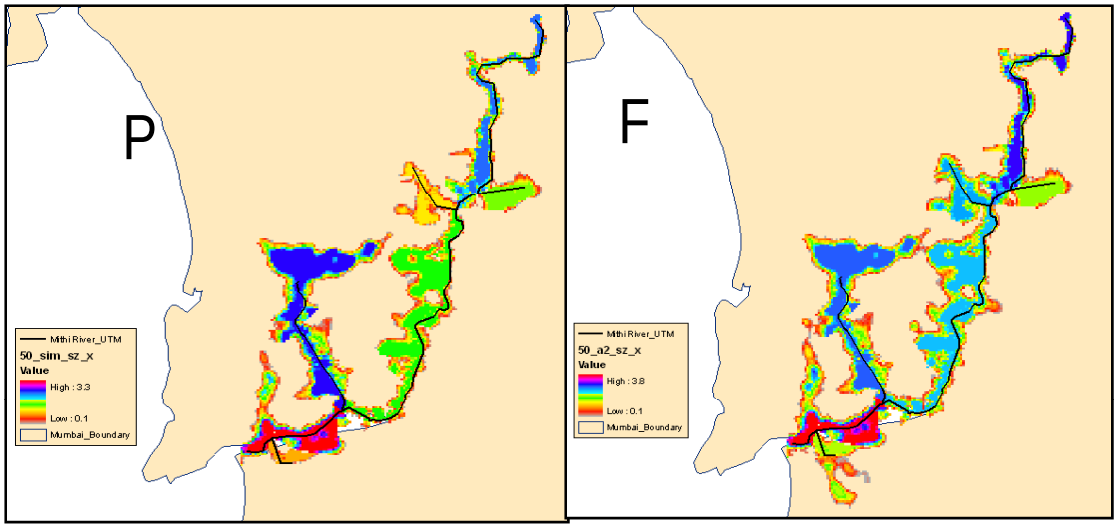


Rahmstorf (2009) prediction for Global SLR is 124cm, A1B in 2100 over 2000

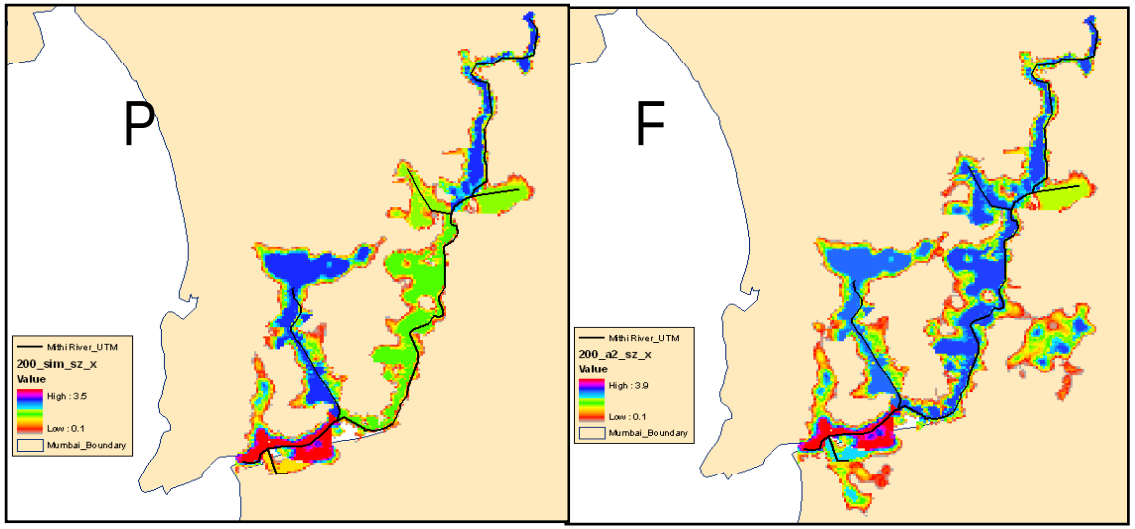
Temperature ranges and associated sea-level ranges by the year 2100 for different IPCC emission scenarios

Scenario	Temperature range, °C above 1980–2000	Model average, °C above 1980–2000	Sea-level range, cm above 1990	Model average, cm above 1990
B1	1.4–2.9	2.0	81–131	104
A1T	1.9–3.8	2.6	97–158	124
B2	2.0–3.8	2.7	89–145	114
A1B	2.3–4.3	3.1	97–156	124
A2	2.9–5.3	3.9	98–155	124
A1FI	3.4–6.1	4.6	113–179	143

Projected flooding: Extended footprint & Deeper flooding



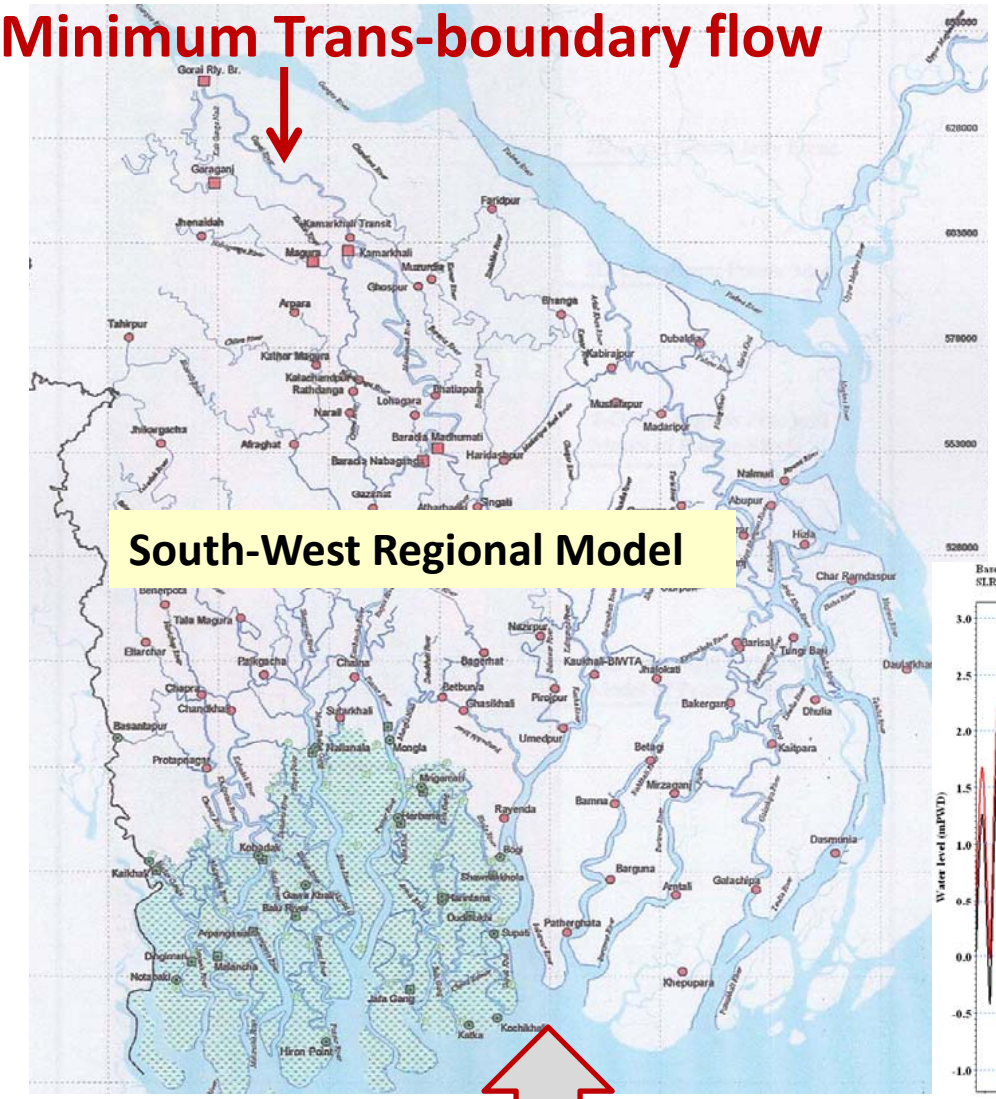
50 year return period flood maps for present day (left) and 2080s (right)



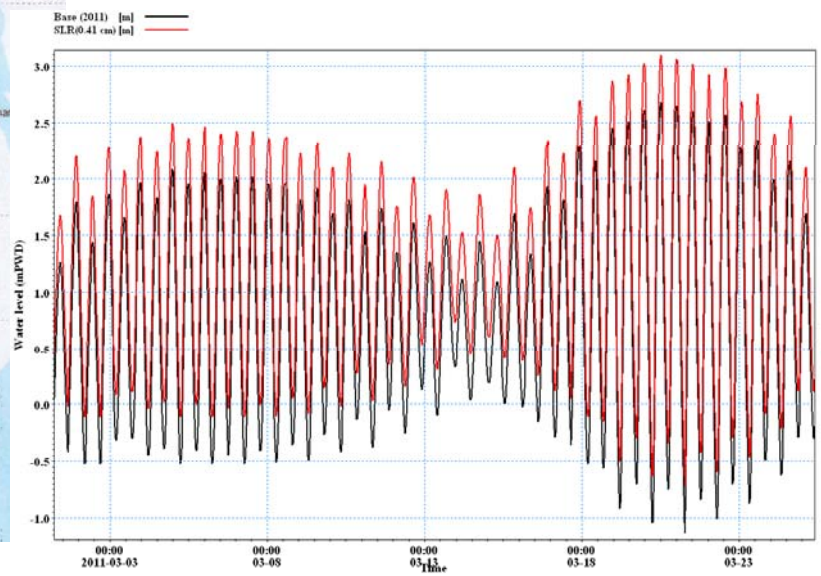
2005-like event in 2080s – larger flood area, deeper flood waters

Simulation of External Driver of Change

Minimum Trans-boundary flow

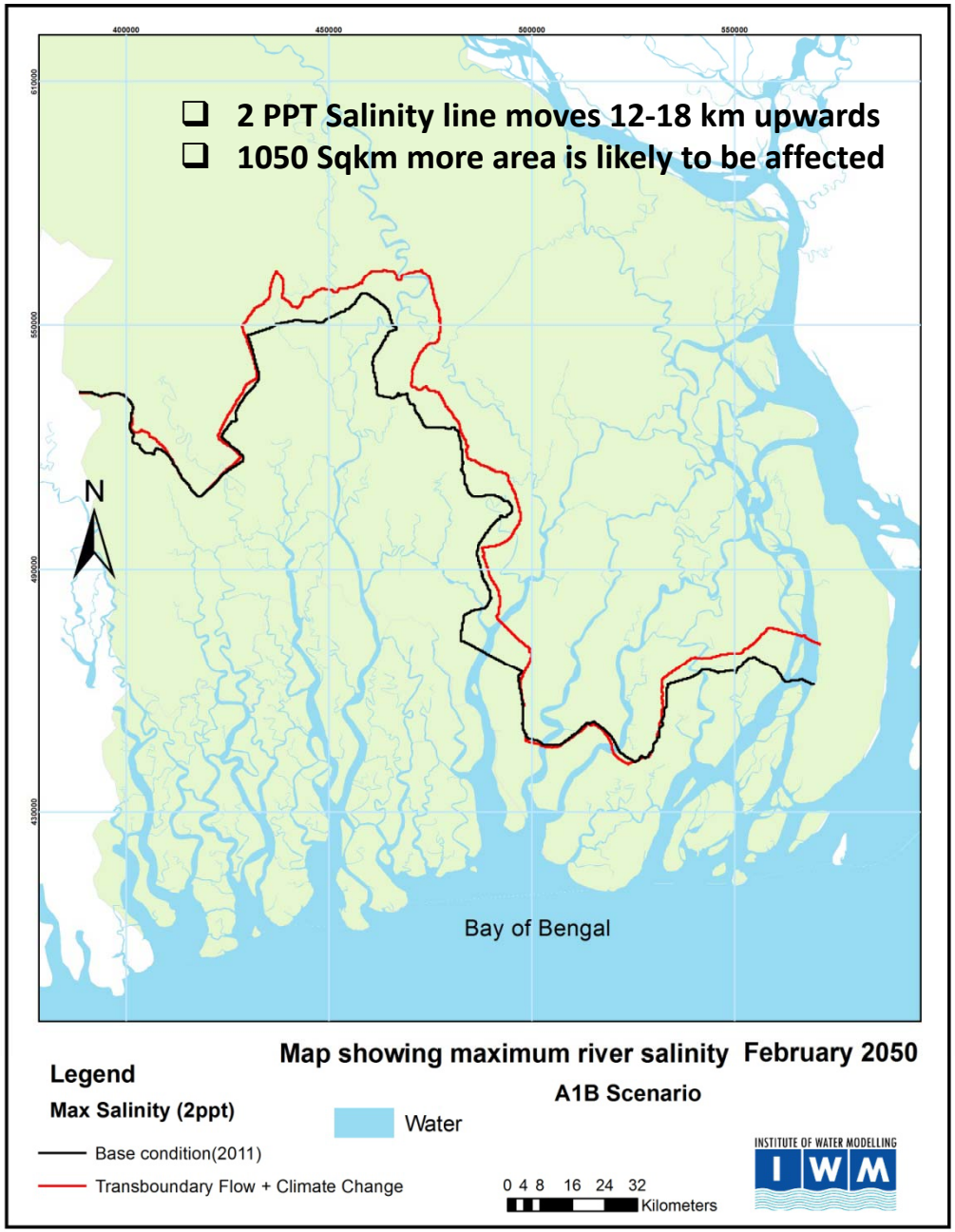


South-West Regional Model

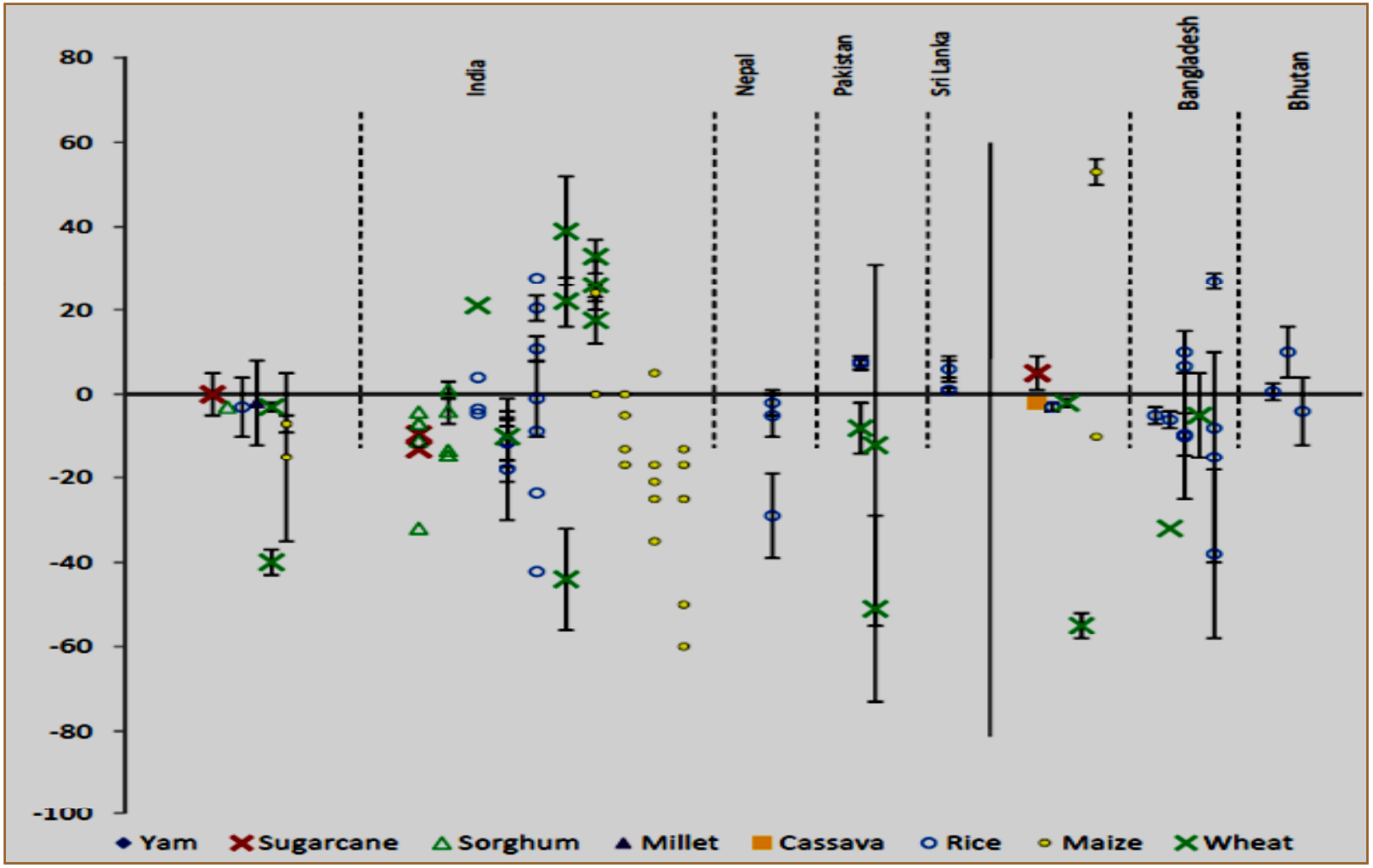


Sea level Rise (A1B-2030,2050)

Effects of External drivers on Salinity intrusion and Fresh water availability

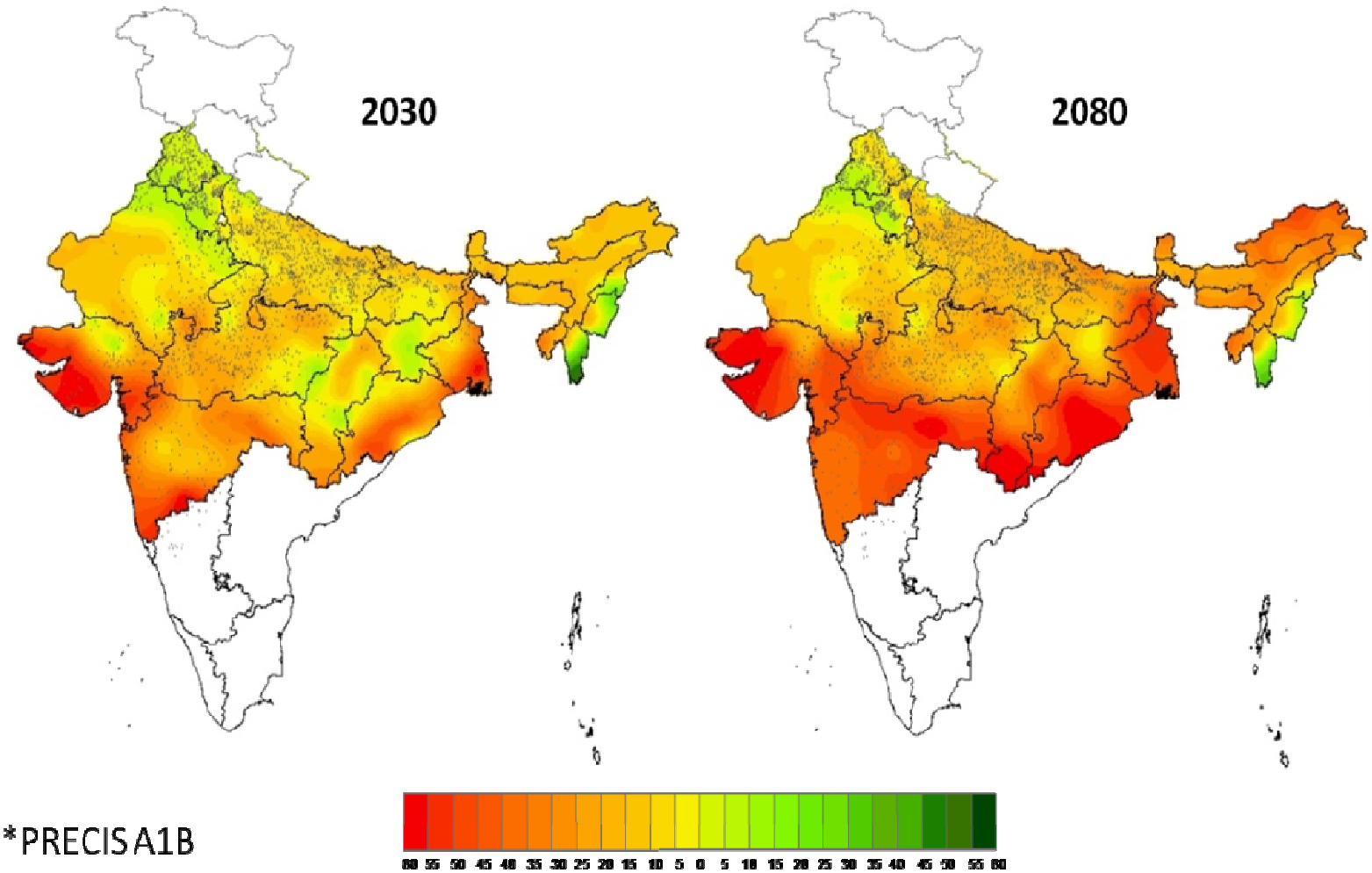


Impact of climate change on crop yields in South Asia



Source: Knox et al., 2011

Climate change impacts on crop yields in India: Wheat

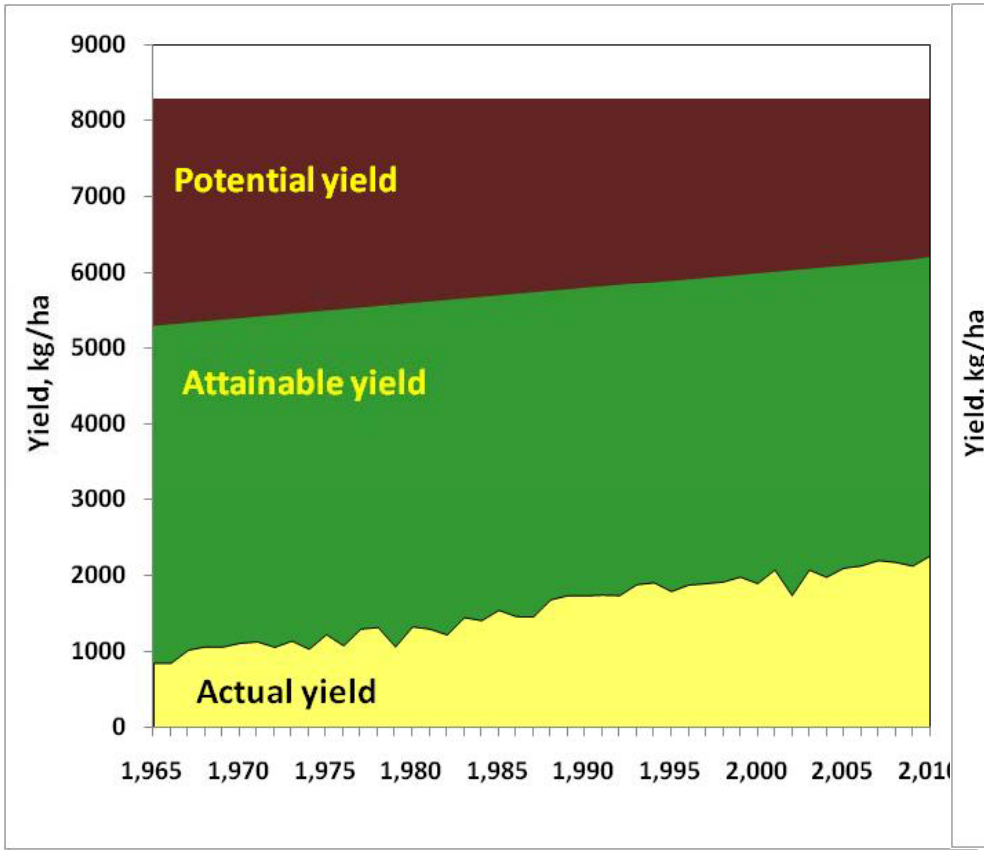


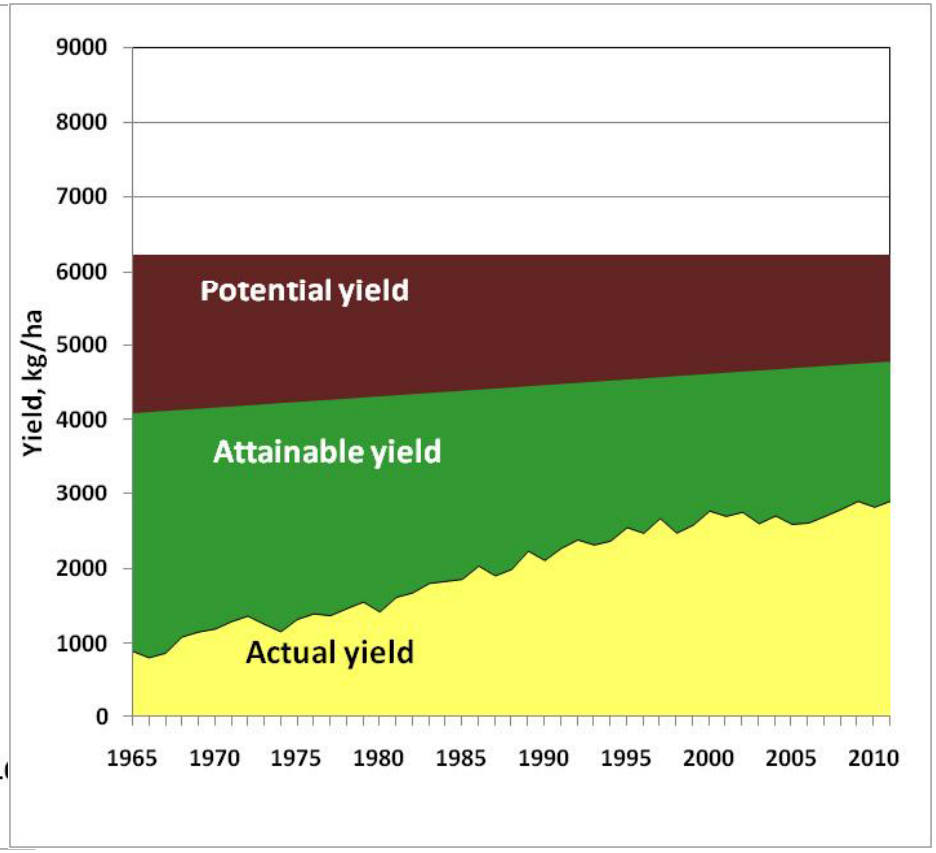
*PRECIS A1B

Projected impacts of climate change on agriculture in South Asia

- **Increase in CO_2 (550 ppm) increases yields of most C3 crops by 10-20%.**
- **A 1°C increase in temperature may reduce yields of some crops by 0-7%. Much higher losses at higher temperatures.**
- **Productivity of most crops to remain unaffected/ marginally decrease by 2030 but decrease by 10-50% by 2100.**
- **Increased droughts, floods, and heat events will increase production variability**

There is a large untapped potential of currently available agricultural technologies

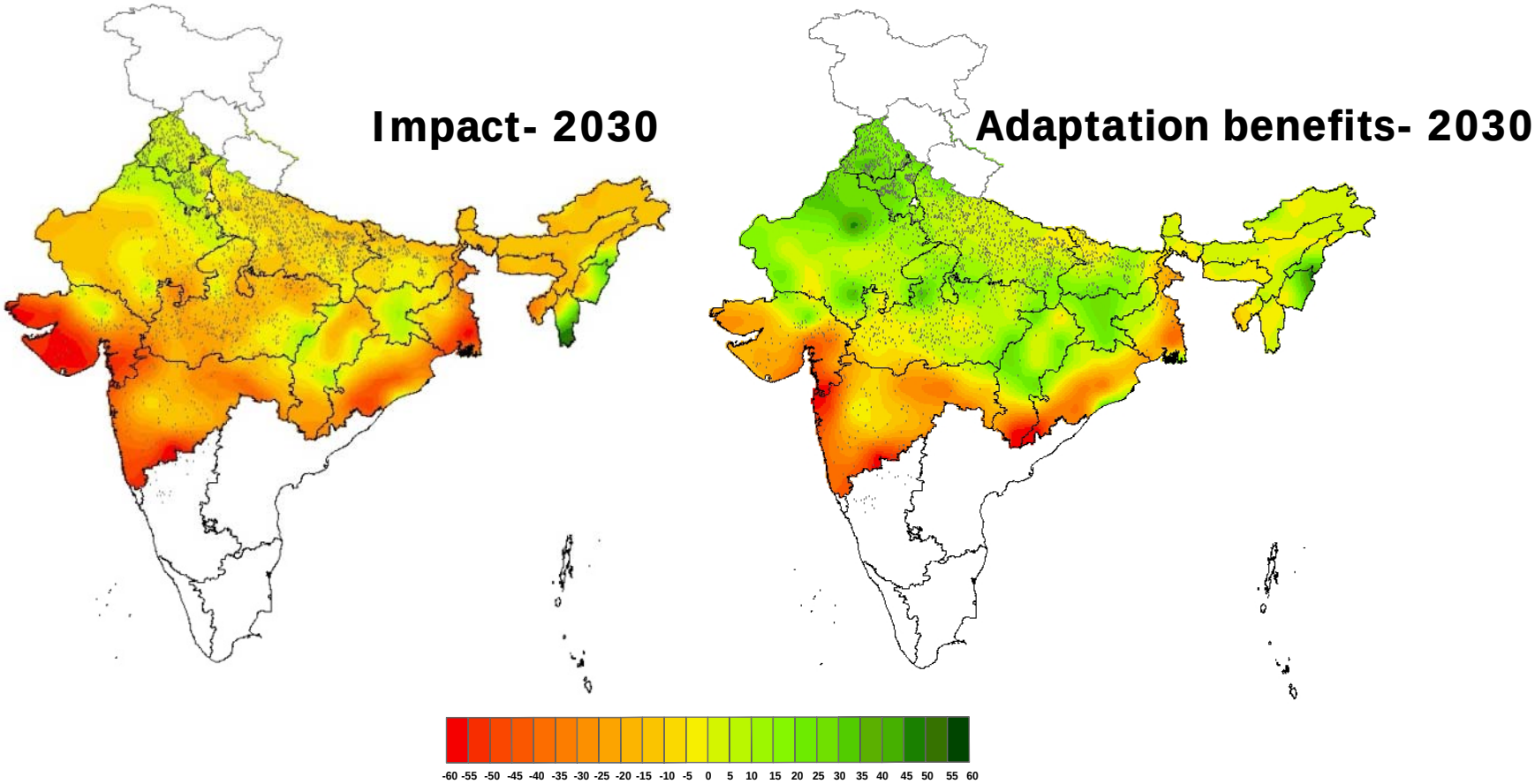




Rice

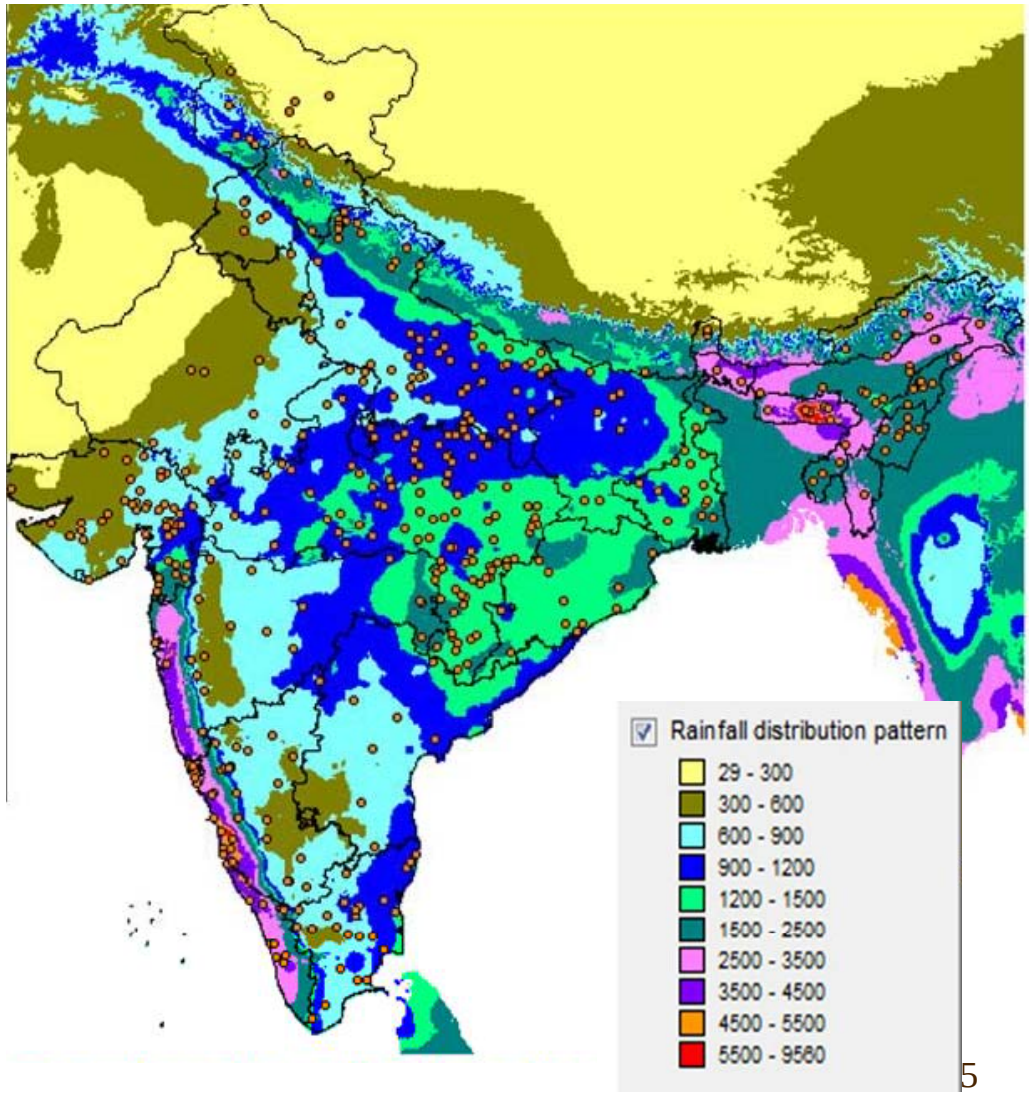
Wheat

Simple agronomic adaptation options can help increase yields- wheat



Farms of the future

- Use of climate analogues for germplasm characterization, conservation and evaluation
- Partners: Bioversity, NBPGR, India; Gene Bank of Nepal

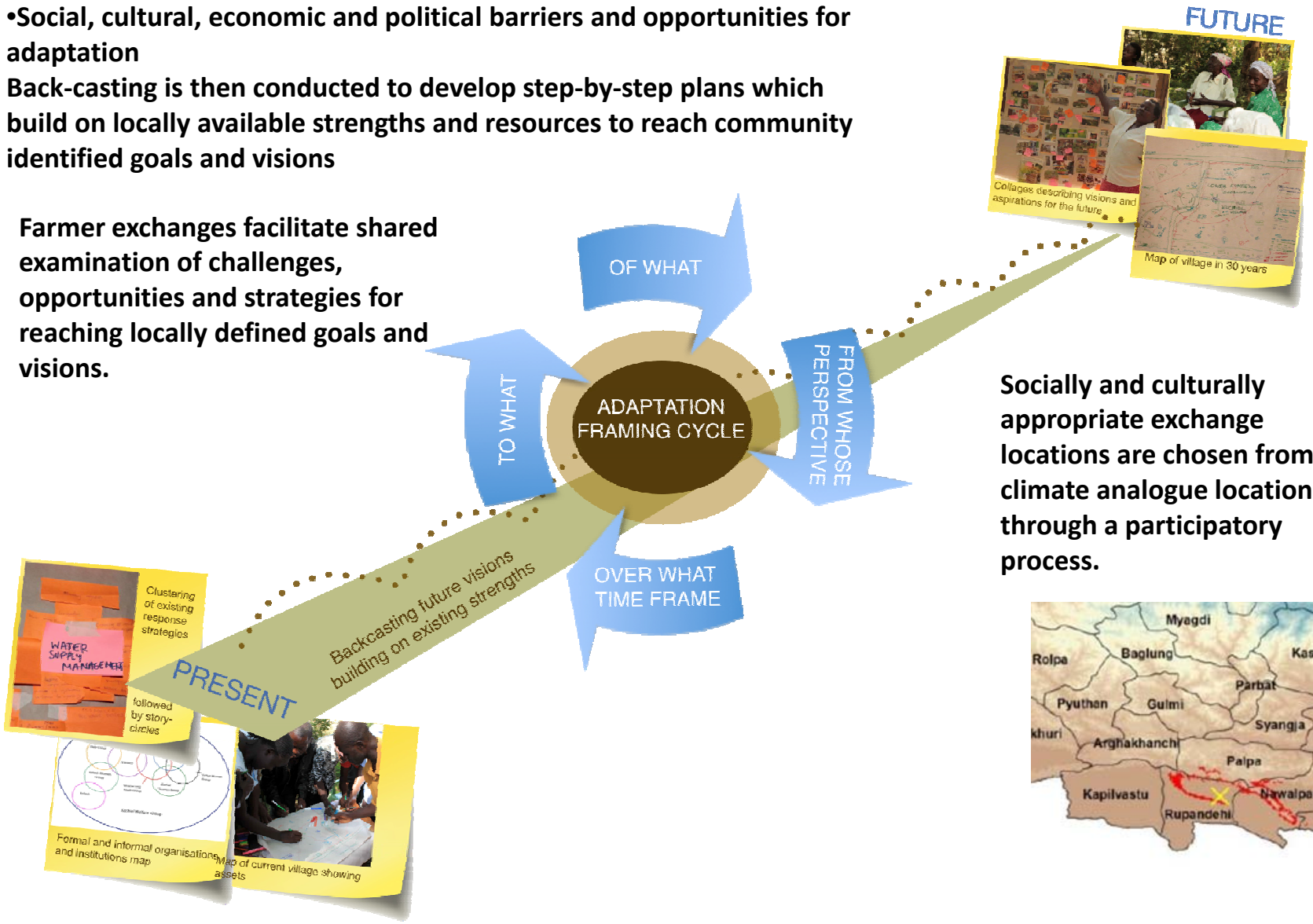


Farms of the Future:
Farmer exchanges at analogue sites

•Social, cultural, economic and political barriers and opportunities for adaptation

Back-casting is then conducted to develop step-by-step plans which build on locally available strengths and resources to reach community identified goals and visions

Farmer exchanges facilitate shared examination of challenges, opportunities and strategies for reaching locally defined goals and visions.



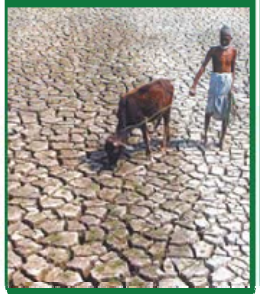
Socially and culturally appropriate exchange locations are chosen from climate analogue locations through a participatory process.

Linking knowledge to action-Climate smart villages/farms: Key agricultural activities for managing risks

CLIMATE SMART VILLAGE / FARM

Weather smart

- Seasonal weather forecasts
- ICT based agro-advisories
- Index based insurance
- Climate analogues



Water smart

- Aquifer recharge
- Rainwater harvesting
- Community management of water
- Laser leveling
- On-farm water management

Carbon smart

- Agroforestry
- Conservation tillage
- Land use systems
- Livestock management

Nitrogen smart

- Site specific nutrient management
- Precision fertilizers
- Catch cropping / legumes

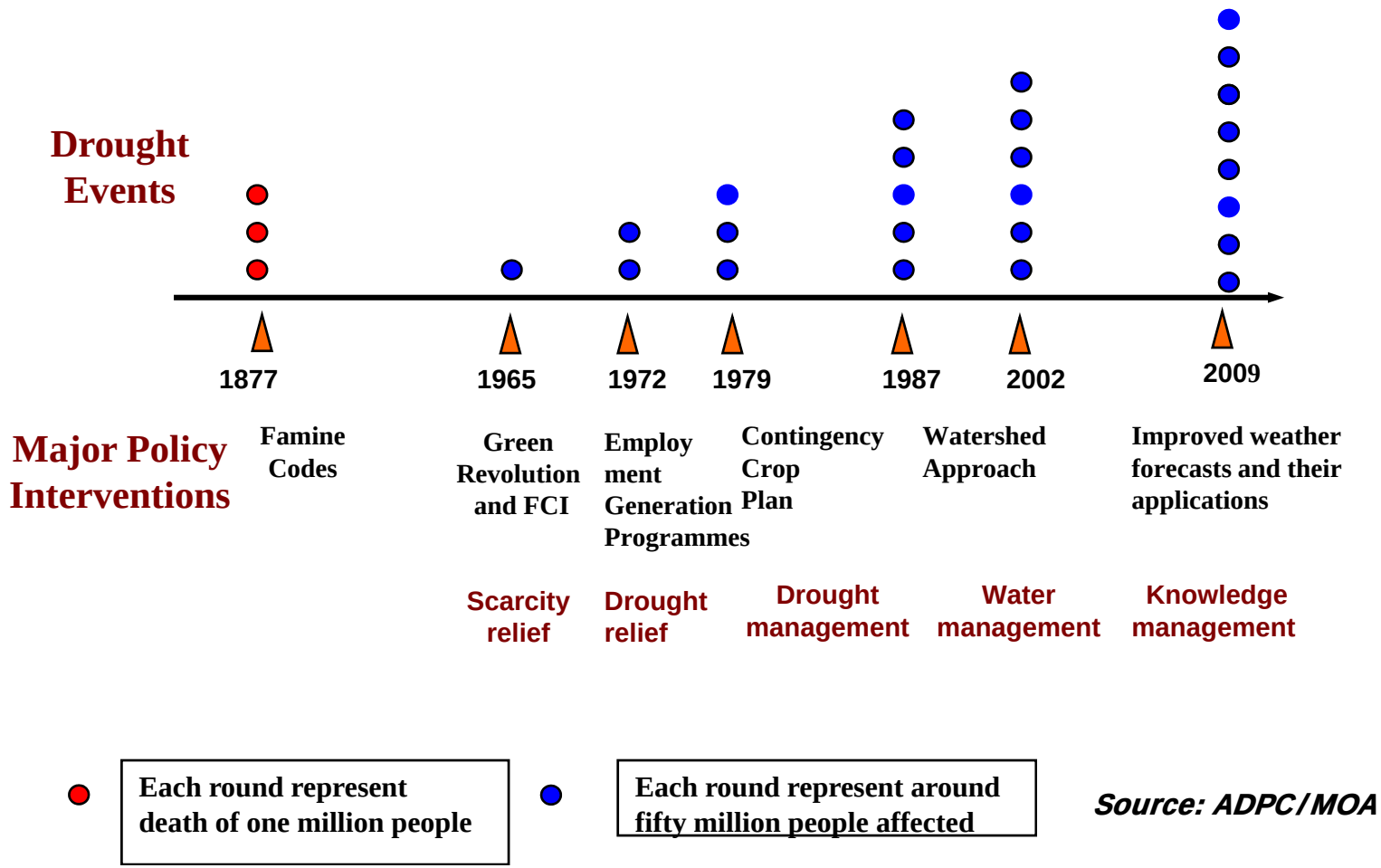
Energy smart

- Biofuels
- Fuel efficient engines
- Residue management
- Minimum tillage

Knowledge smart

- Farmer-farmer learning
- Farmer networks on adaptation technologies
- Seed and fodder banks
- Market info
- Off-farm risk management-kitchen garden

Policy innovations induced by droughts in India



Source: ADPC/MOA

Response-I

Realise the potential of rainfed agriculture through small but 'critical' irrigation:

Employ appropriate measures of rainwater/ streamwater harvesting

Response-2

Provide access to groundwater sustainably and smartly, mediate groundwater-energy nexus:

Access to GROUNDWATER is the best insurance against an uncertain monsoon.

Response-3

Undertake Big and Bold interventions now to tackle the perpetual uncertainty:

- ***Interlink surplus and deficit basins***
- ***Managed Aquifer Recharge***
- ***Underground Taming of Floods***

Response-4

Improved and enhanced protection through use of Science, ICT, Safety nets:

Reach the 'unreached', protect the 'vulnerable ' and enhance the system resilience

Response-5

Greater focus on climate risk management

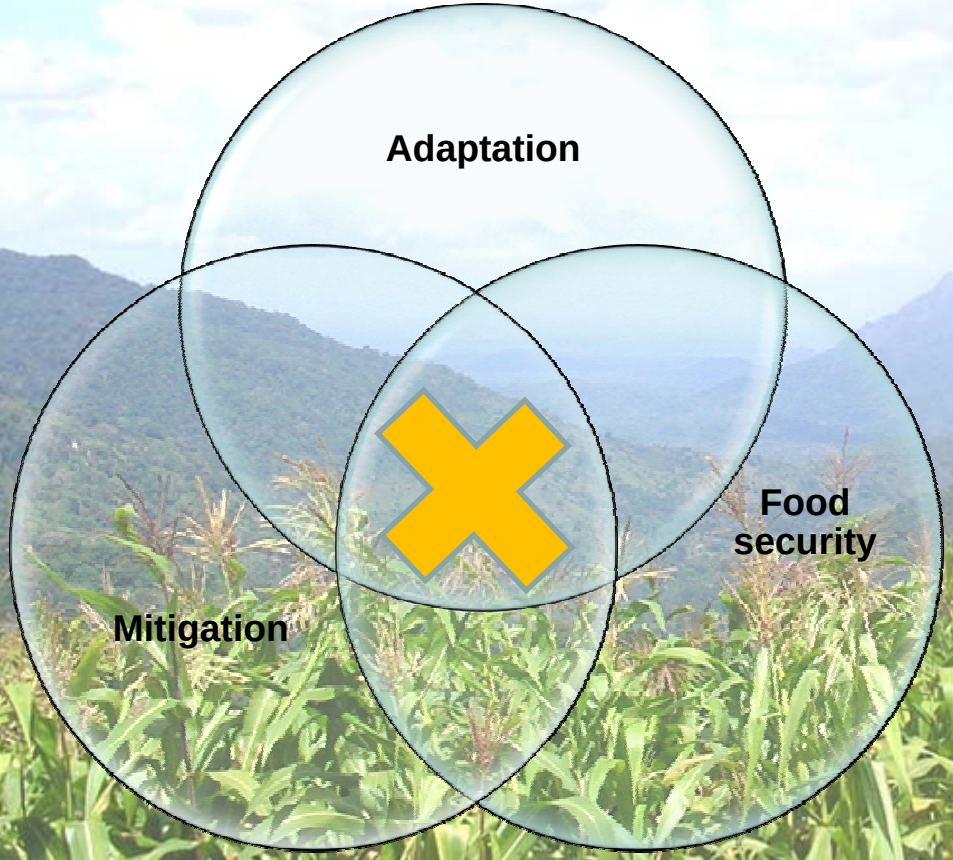
Forecasting	From satellite to cell phone
Risk insurance	Rapid payments so assets are protected
Technologies and practices	That cope with extremes

Response-6

Assisting farmers to cope with current climatic risks

- **Providing value-added weather services**
  - Weak weather infrastructure; data protocols, storage, access and dissemination
- **Promoting insurance for climatic risk management**
  - scientific and economically validated schemes; weather derivatives; awareness
- **Facilitating community partnership in food, forage and seed banks**
  - Technical know-how; capital costs; reduced acceptance if successive years are risk free
- **Compensating farmers for environmental services**
  - Technical know-how; costs of production go up
- **Sharing experiences across similar regions**
  - Validation in emerging scenarios of development and climate risks

Conclusion: Adapting South Asian Agriculture to Climate Change and Declining Resources: Four Key action points



1. Invest in management of land and water resources, and input delivery and market linkage mechanisms, to fully exploit the benefits of available technologies.
2. Manage current climatic risks for poverty alleviation and for equitable development
3. Exploit large mitigation co-benefits of adaptation options
4. Address issues of poverty, governance, institutions and human capital which limit agriculture growth even today.

Thank You for being a wonderful audience!!

Bharat Sharma, IWMI-New Delhi
b.sharma@cgiar.org