Climate Change Impacts and Vulnerabilities

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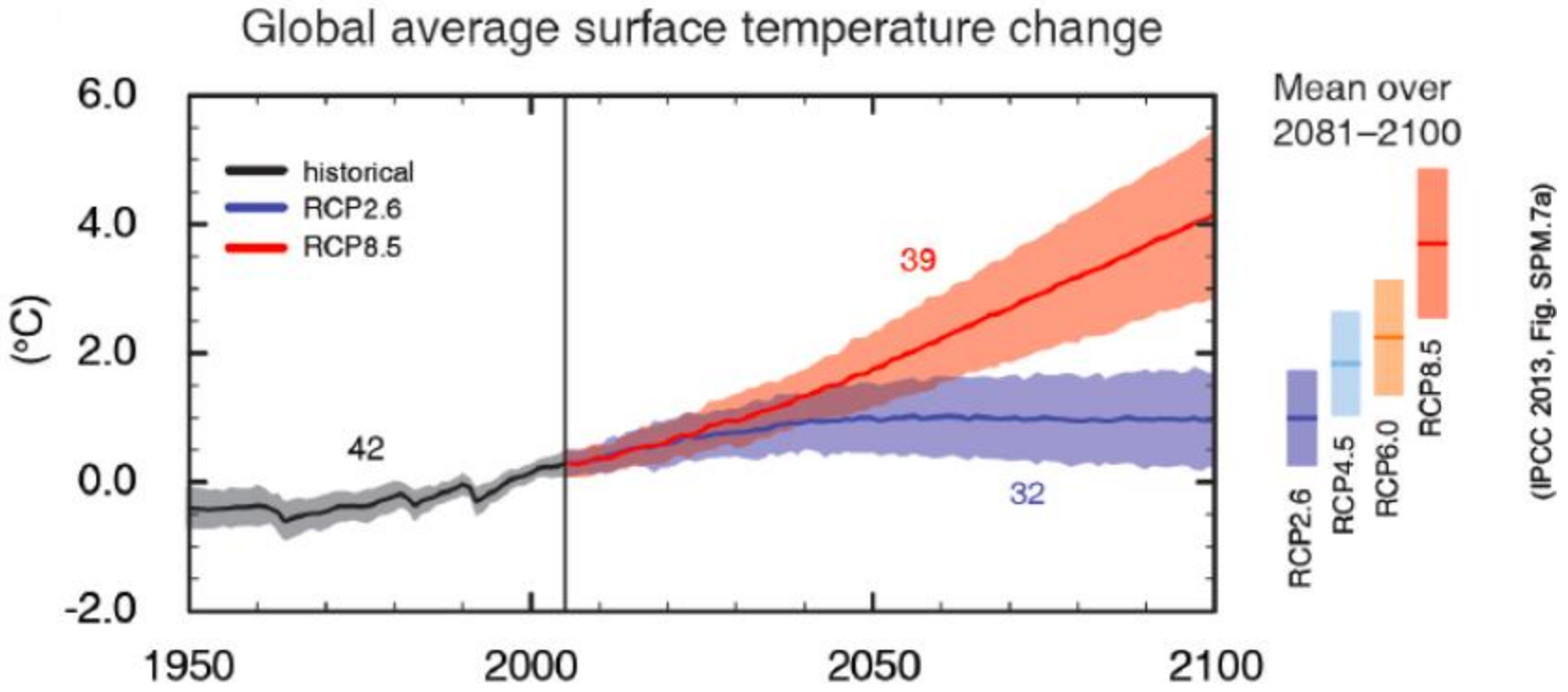
IPCC Report Findings: 20th century

- Increase in global mean temperature by over 0.7^{0}C
- Decrease in snow cover and ice extent
  - 10 % reduction in snow cover since late 1960s
  - 10 -15 % reduction in spring/ summer ice content since 1950s
- 0.1– 0.2 m rise in global sea level
- 1990s the warmest decade of the millennium

IPCC Report: 21st century projections

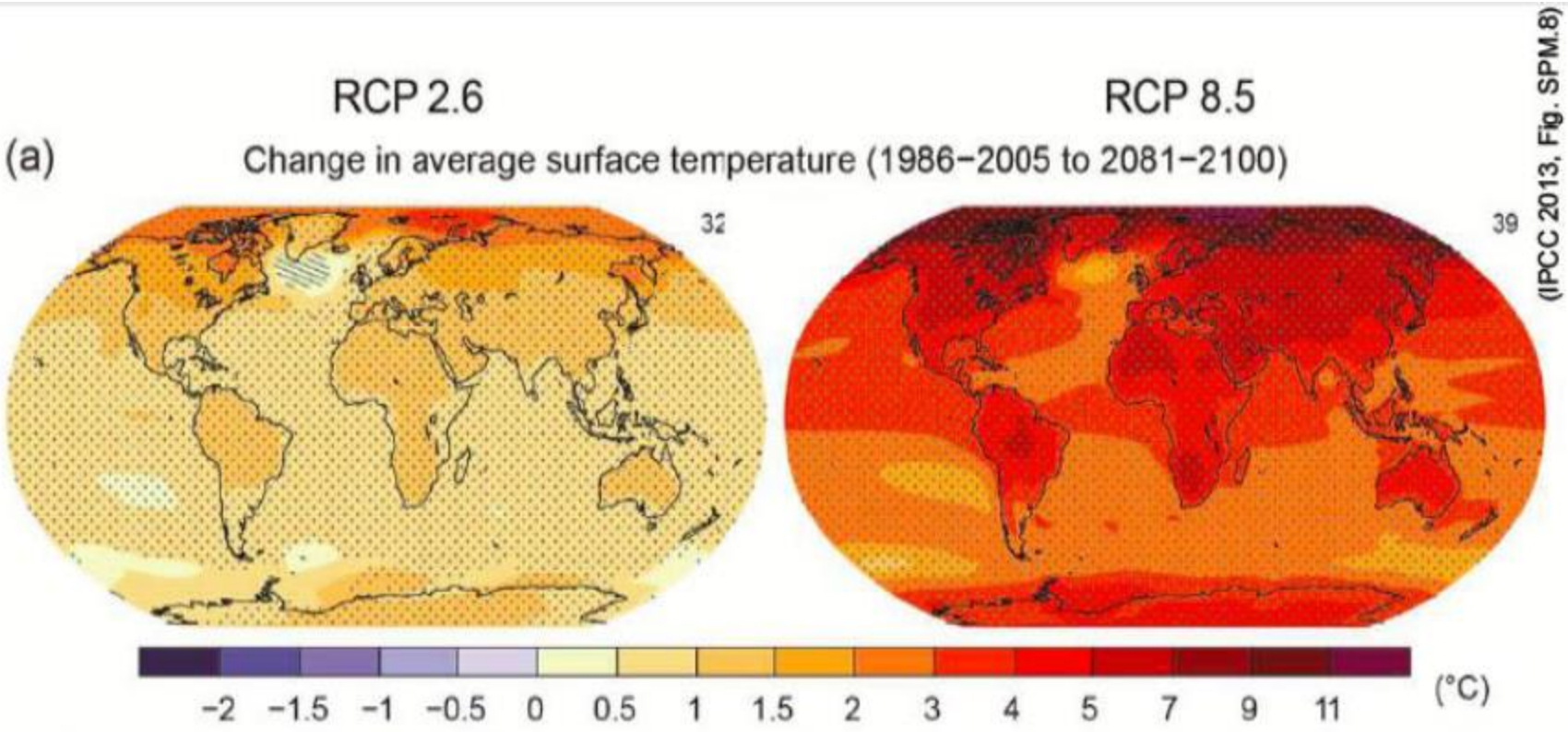
Global mean temperatures and sea level projected to rise under all IPCC scenarios

- Mean surface temperature to increase by 1.1 to 6.4 ^{0} C
- Mean sea level to rise by 0.09 to 0.88 m as compared to 0.18 to 0.59 m in the AR4
- Decrease in Northern Hemisphere snow cover and sea-ice extent
- Increase in summer flows of river systems followed by reductions as glacier disappears



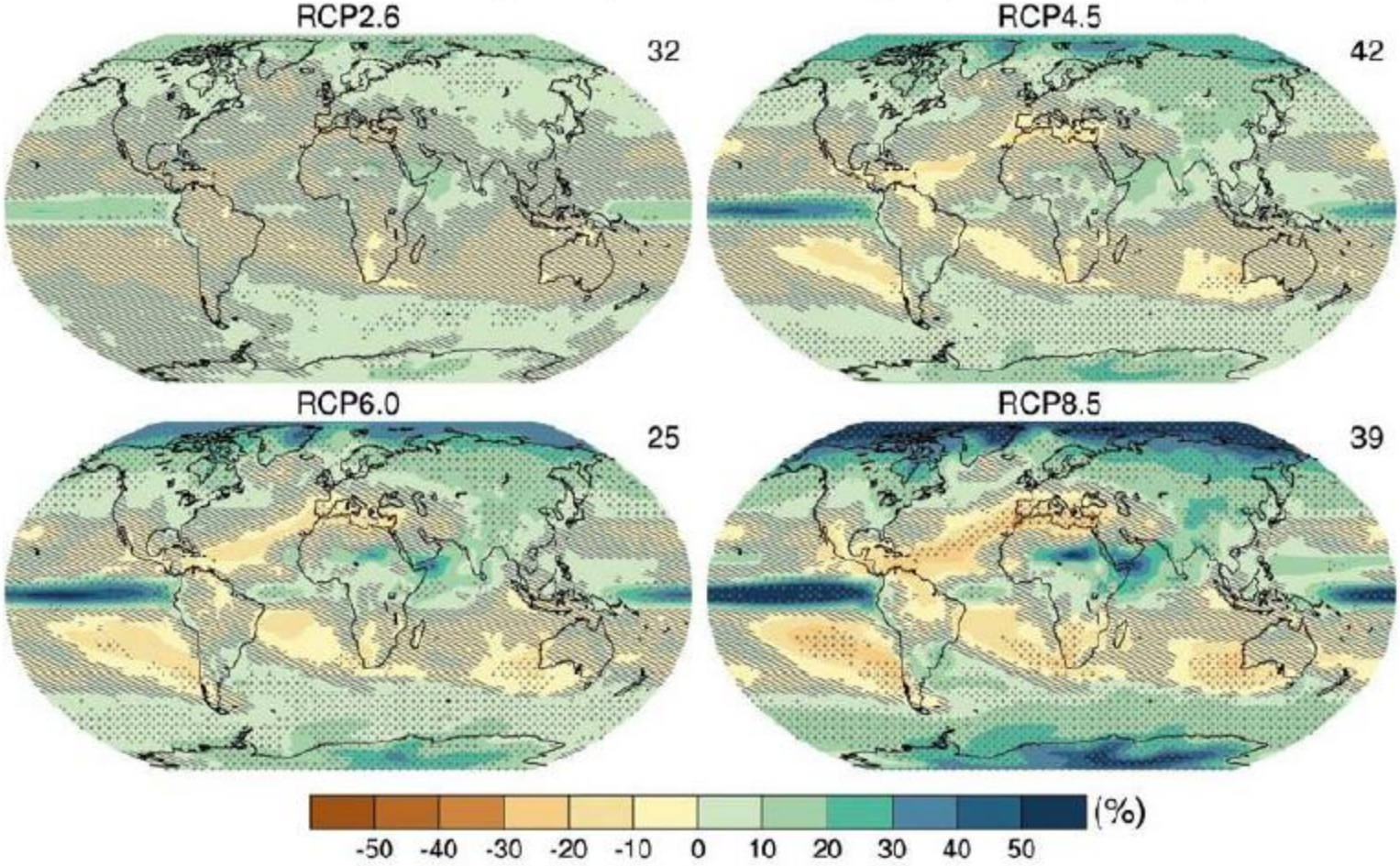
Global surface temperature change for the end of the 21st century is *likely* to exceed 1.5°C relative to 1850 for all scenarios

Changes in precipitation patterns, evapotranspiration rates, humidity levels and increase in the frequency and intensity of extreme events



Increase of global mean surface temperatures for 2081–2100 relative to 1986–2005 is projected to likely be in the ranges derived from the concentration driven CMIP5 model simulations, that is, 0.3°C to 1.7°C (RCP2.6), 1.1°C to 2.6°C (RCP4.5), 1.4°C to 3.1°C (RCP6.0), 2.6°C to 4.8°C (RCP8.5).

Annual mean precipitation change (2081-2100)



IPCC AR5

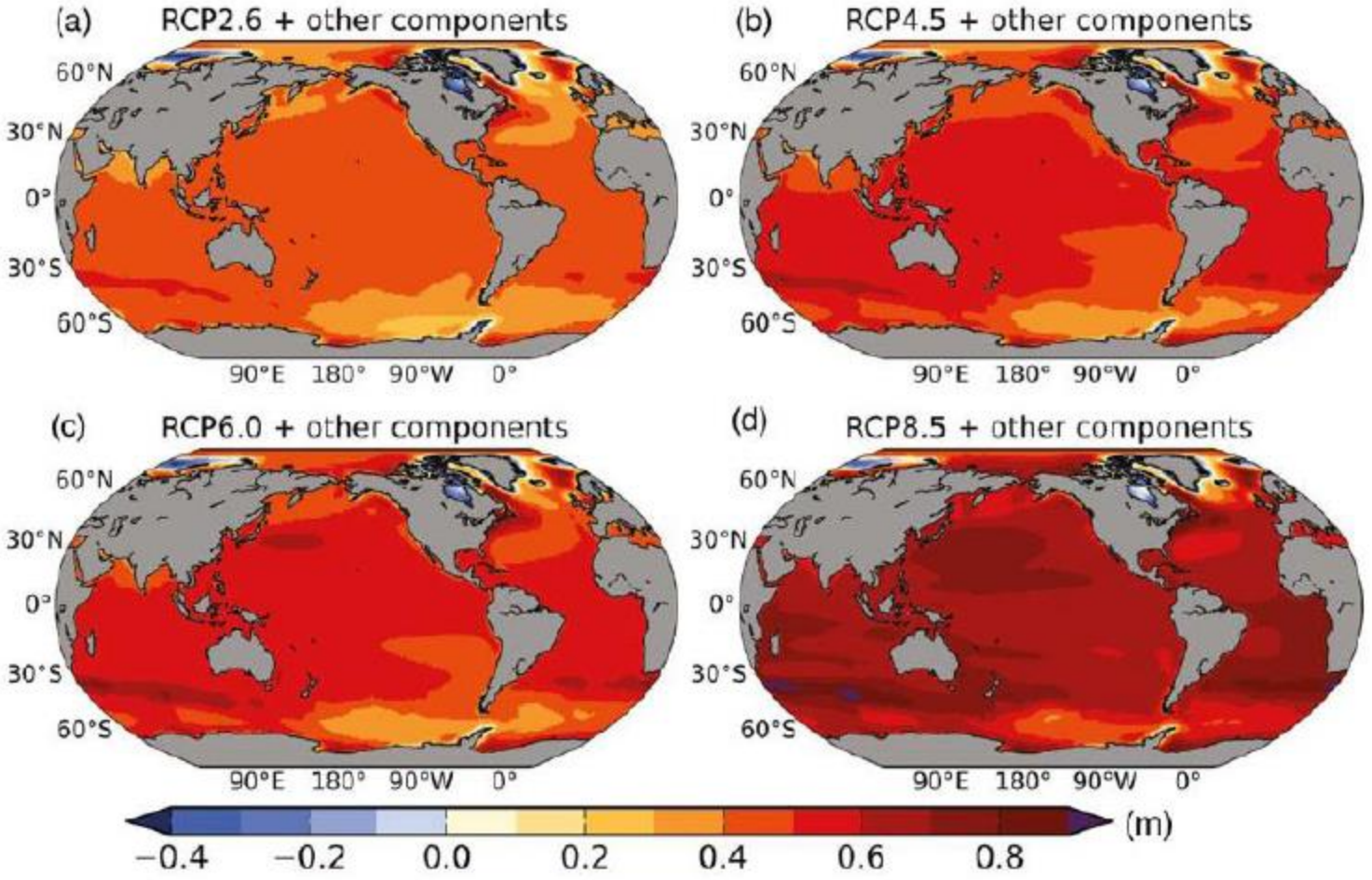
More heavy precipitation and more droughts….

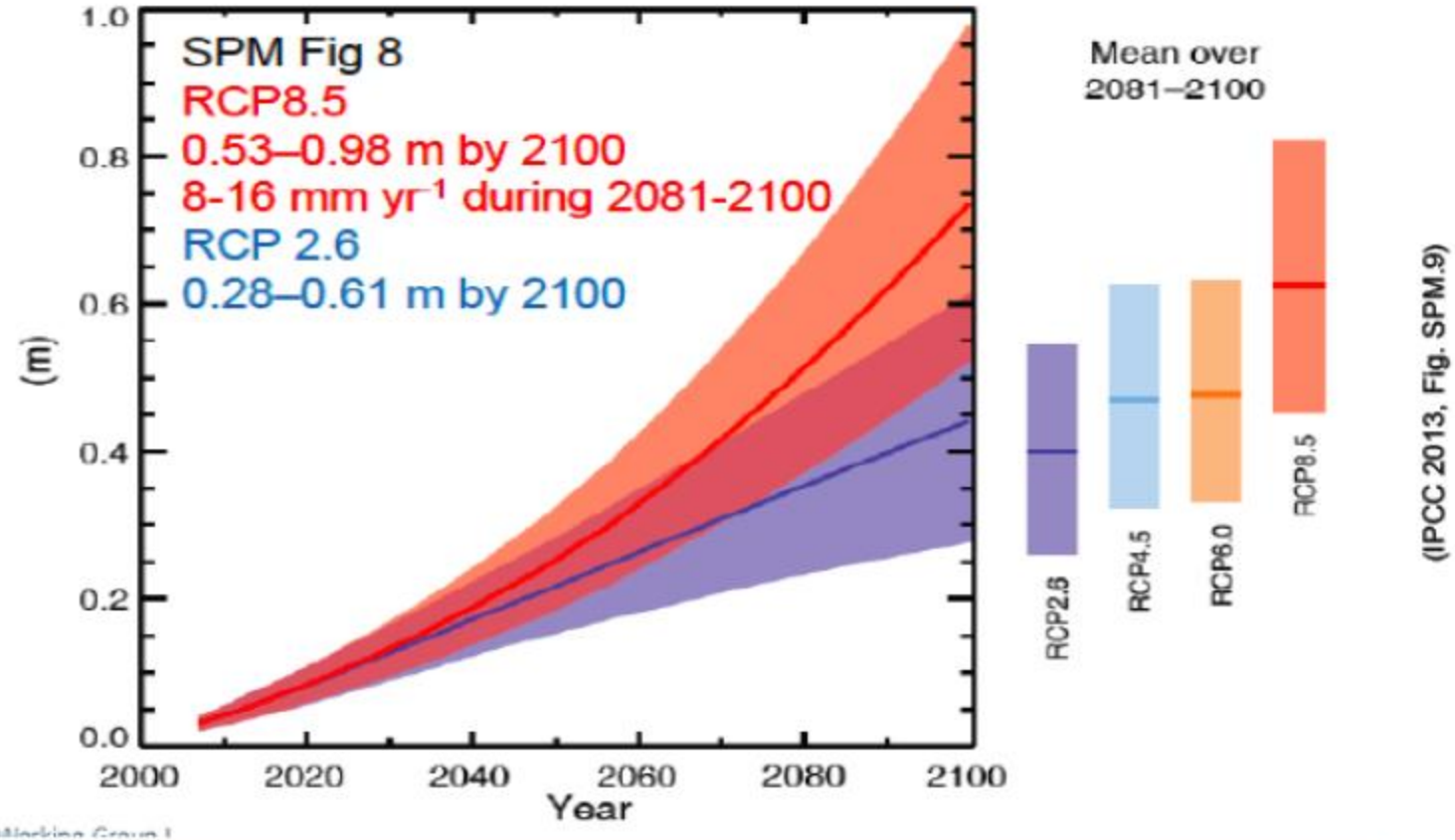
Sea Level Variations

Observed rate of global sea level rise and estimated contributions from different sources		
	Rate of sea level rise (mm/year)	
Source of sea level rise	1961–2003	1993–2003
Thermal expansion	0.42 ± 0.12	1.6 ± 0.5
Glaciers and ice caps	0.50 ± 0.18	0.77 ± 0.22
Greenland Ice Sheet	0.05 ± 0.12	0.21 ± 0.07
Antarctic Ice Sheet	0.14 ± 0.41	0.21 ± 0.35
Sum of individual climate contributions to sea level rise	1.1 ± 0.5	2.8 ± 0.7
Observed total sea level rise	1.8 ± 0.5	3.1 ± 0.7
Difference (Observed minus sum of estimated climate contributions)	0.7 ± 0.7	0.3 ± 1.0
Note: Data prior to 1993 are from tide gauges and after 1993 are from satellite altimetry.		

Source: Bindoff *et al.*, 2007

Sea Level


(a) RCP2.6 + other components
(b) RCP4.5 + other components
(c) RCP6.0 + other components
(d) RCP8.5 + other components
60°N
30°N
0°
30°S
60°S
90°E
180°
90°W
0°
−0.4
−0.2
0.0
0.2
0.4
0.6
0.8
(m)



Global mean sea level will continue to rise during the 21st century

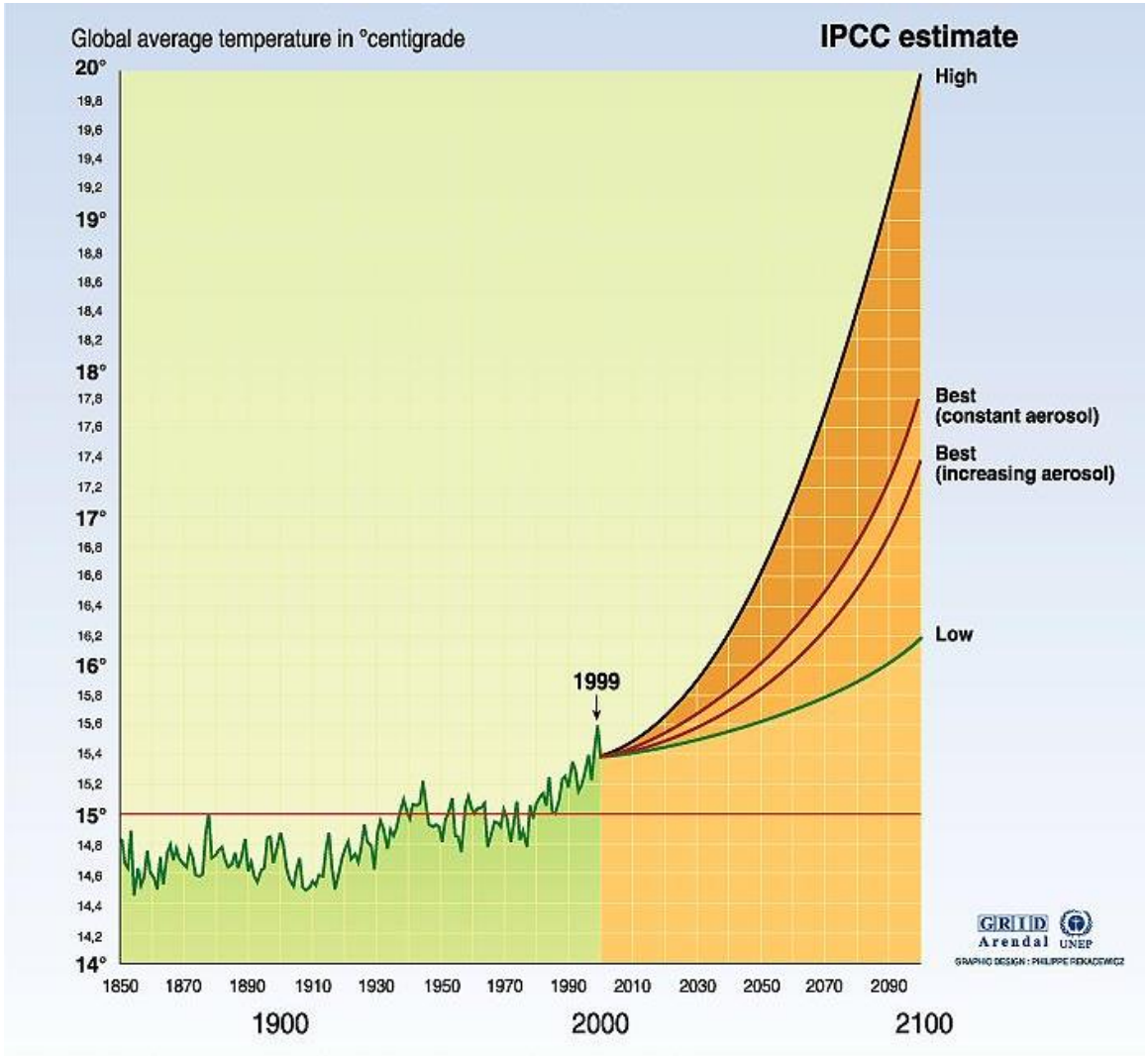
Potential land loss and population exposed in Asian countries (assuming no adaptation measures)

Country	Sea level rise (cm)	Potential land loss		Population exposed	
		(km^2)	(%)	(millions)	(%)
Bangladesh	45	15668	10.9	5.5	5.0
	100	29846	20.7	14.8	13.5
India	100	5763	0.4	7.1	0.8
Indonesia	60	34000	1.9	2.0	1.1
Japan	50	1412	0.4	2.9	2.3
Malaysia	100	7000	2.1	>0.05	>0.3
Pakistan	20	1700	0.2	n.a.	n.a.
Vietnam	100	40000	12.1	17.1	23.1

n.a. = not available

Source: IPCC (2001) WG II

Climate change introduces huge unknowns

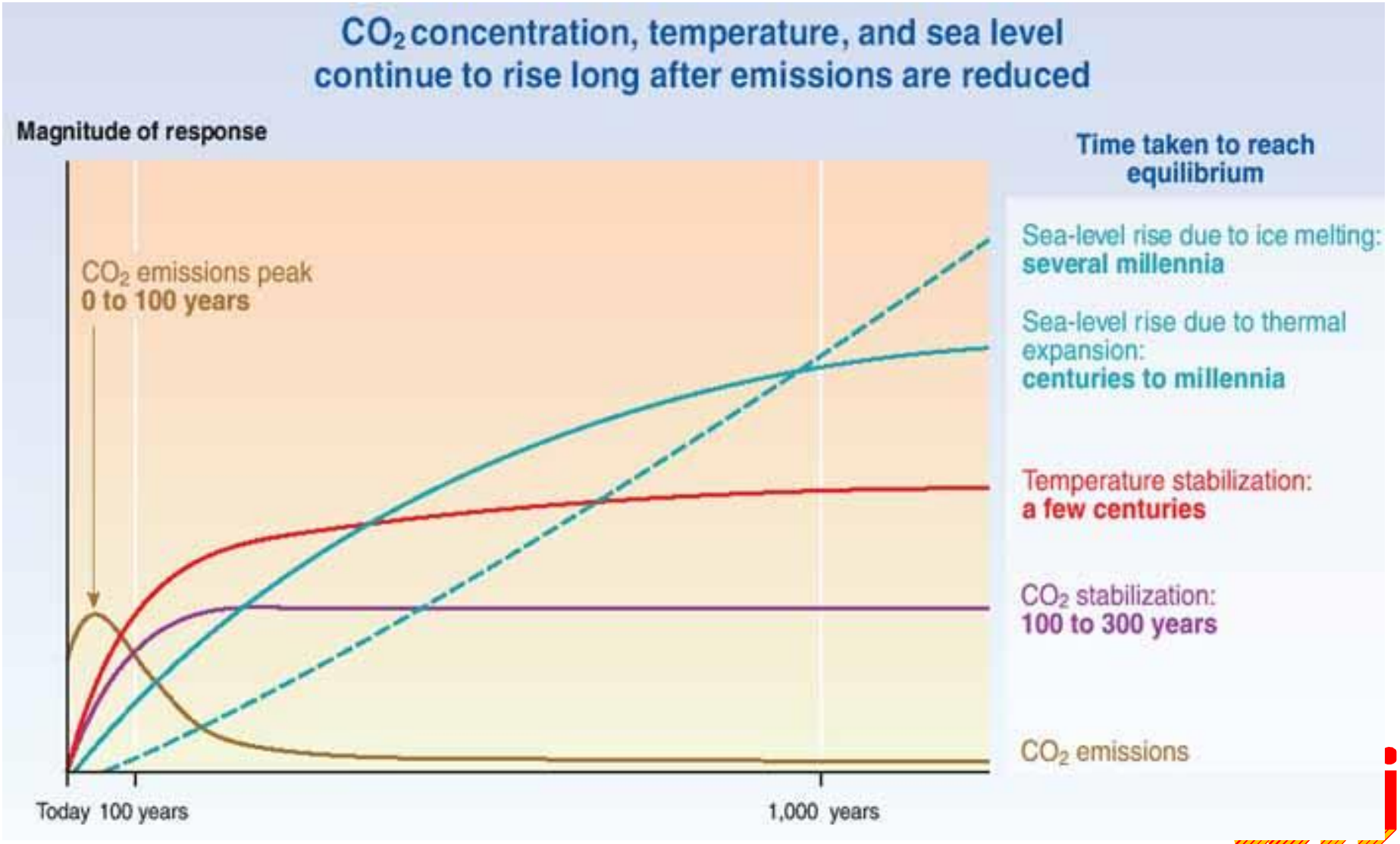


Source : Temperatures 1856 - 1999: Climatic Research Unit, University at East Anglia, Norwich UK. Projections: IPCC report 95.

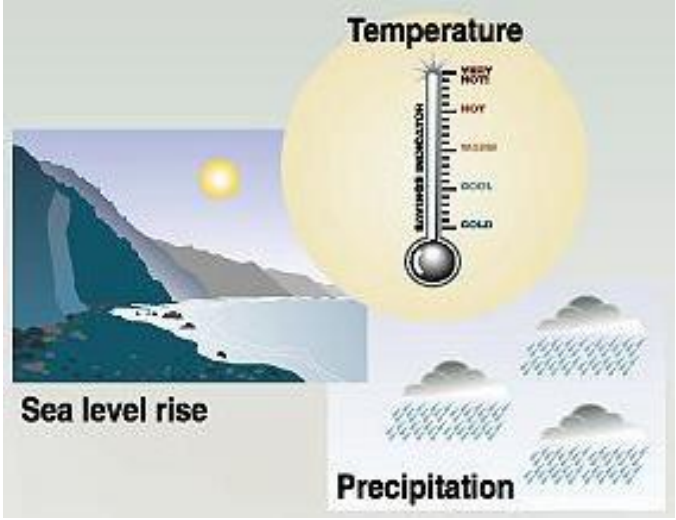
Human-induced climate change has the potential to trigger large-scale changes in Earth systems that could have severe consequences at regional or global scales. The **probabilities of triggering such events though limited** should not be ignored, **given the severity of their consequences.**

Source: IPCC, Climate Change 2001: Synthesis Report

Time scales


CO_2 concentration, temperature, and sea level continue to rise long after emissions are reduced
Magnitude of response
CO_2 emissions peak 0 to 100 years
Today
100 years
1,000 years
Time taken to reach equilibrium
Sea-level rise due to ice melting: several millennia
Sea-level rise due to thermal expansion: centuries to millennia
Temperature stabilization: a few centuries
CO_2 stabilization: 100 to 300 years
CO_2 emissions

Source: GRID Arendal



Impacts

Health

Weather-related mortality
Infectious diseases
Air-quality respiratory illnesses

Agriculture

Crop yields
Irrigation demands

Water resources

Water supply
Water quality
Competition for water

coastal areas

Erosion of beaches
Inundation of coastal lands
additional costs to protect coastal communities

Species and natural areas

Loss of habitat and species
Cryosphere: diminishing glaciers

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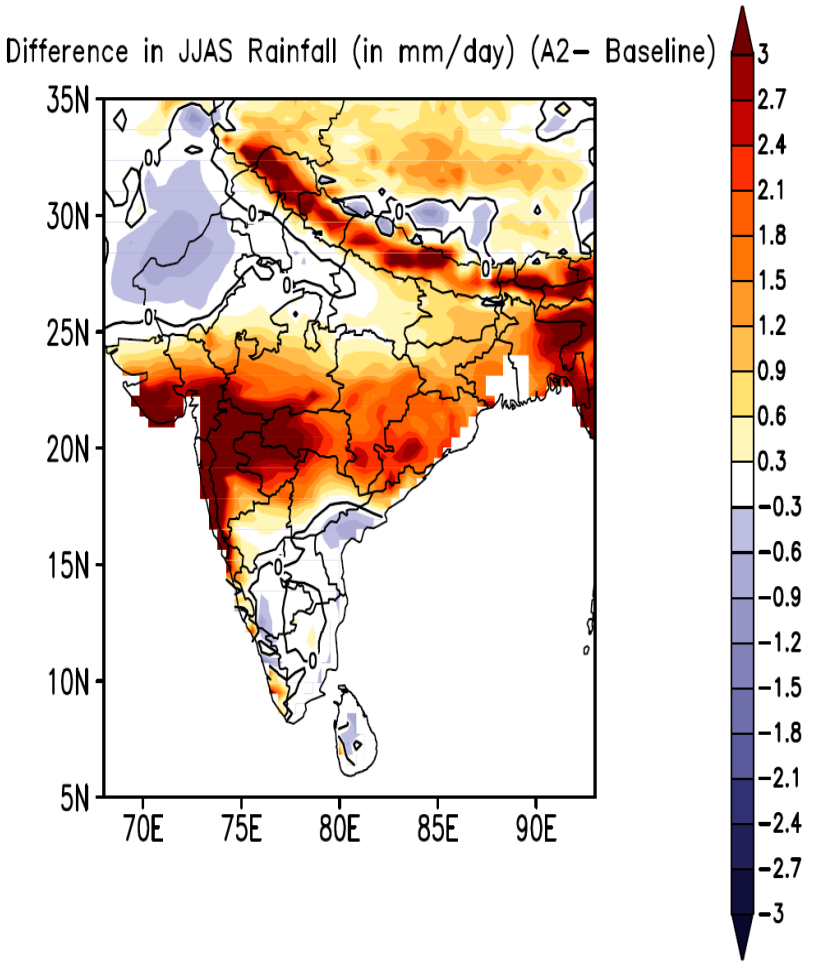
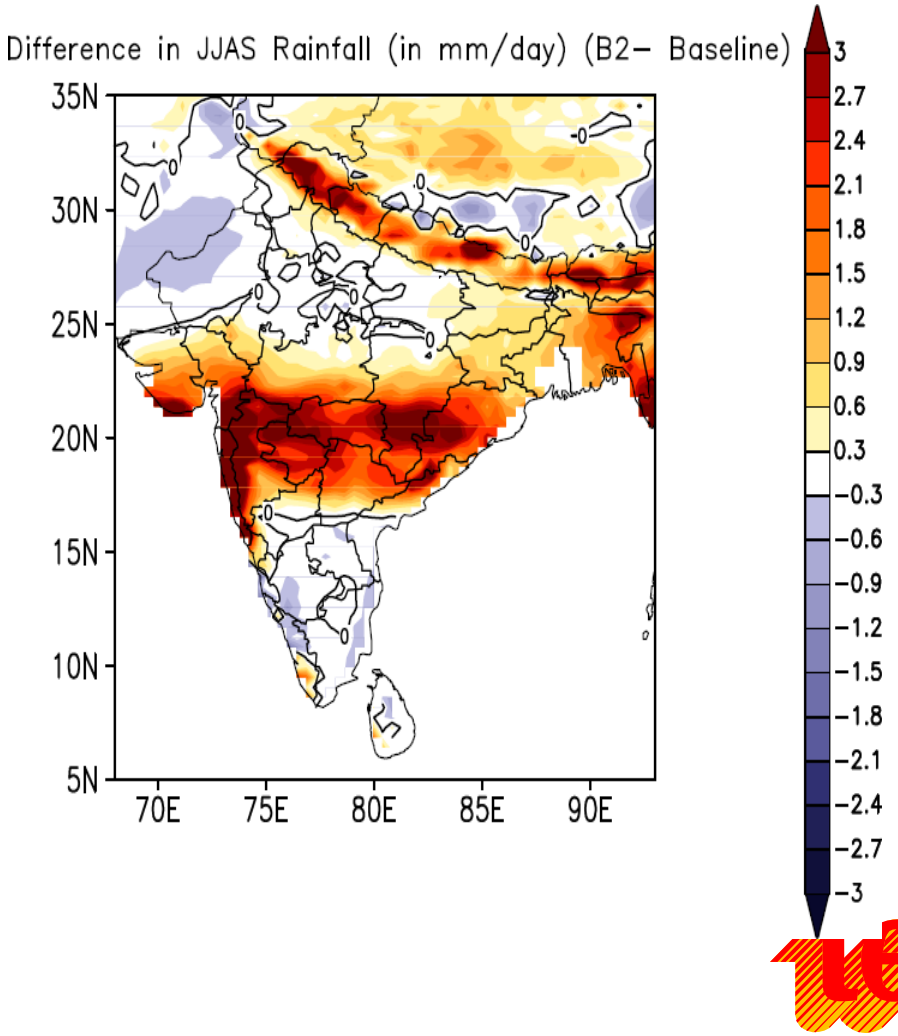
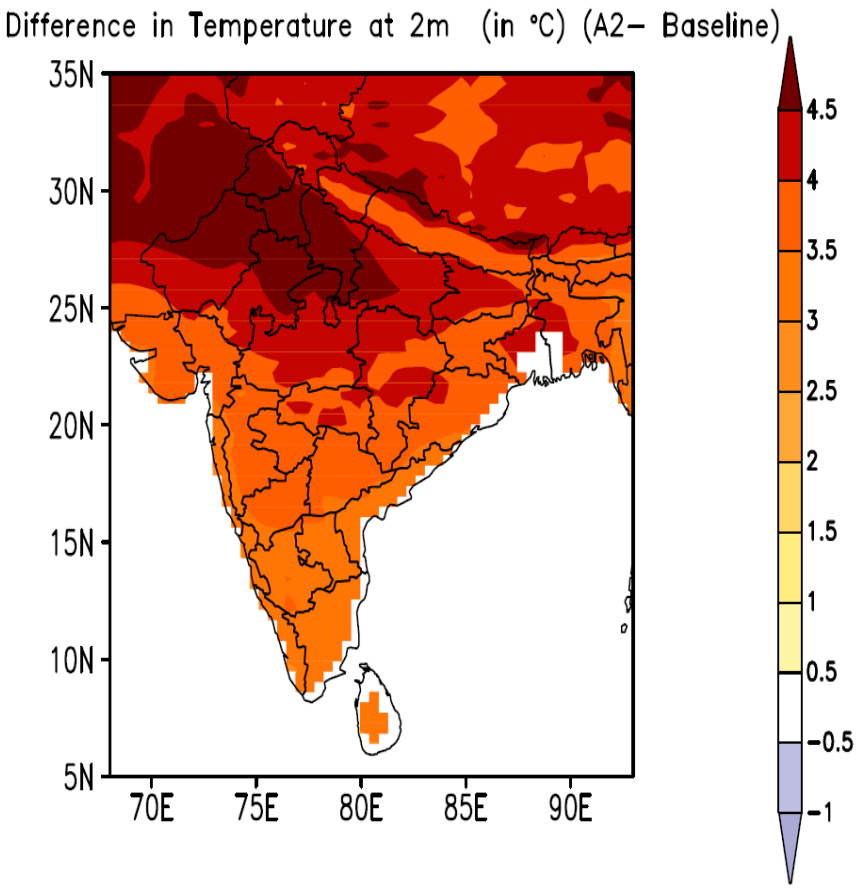
Extreme - scenario



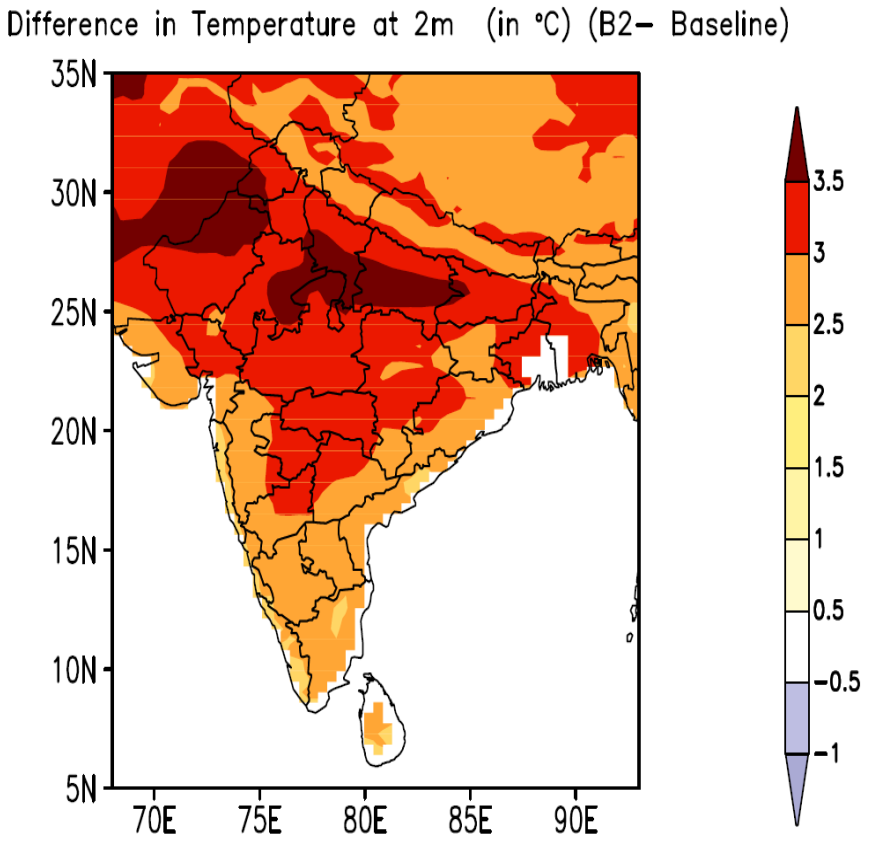
Moderate-scenario



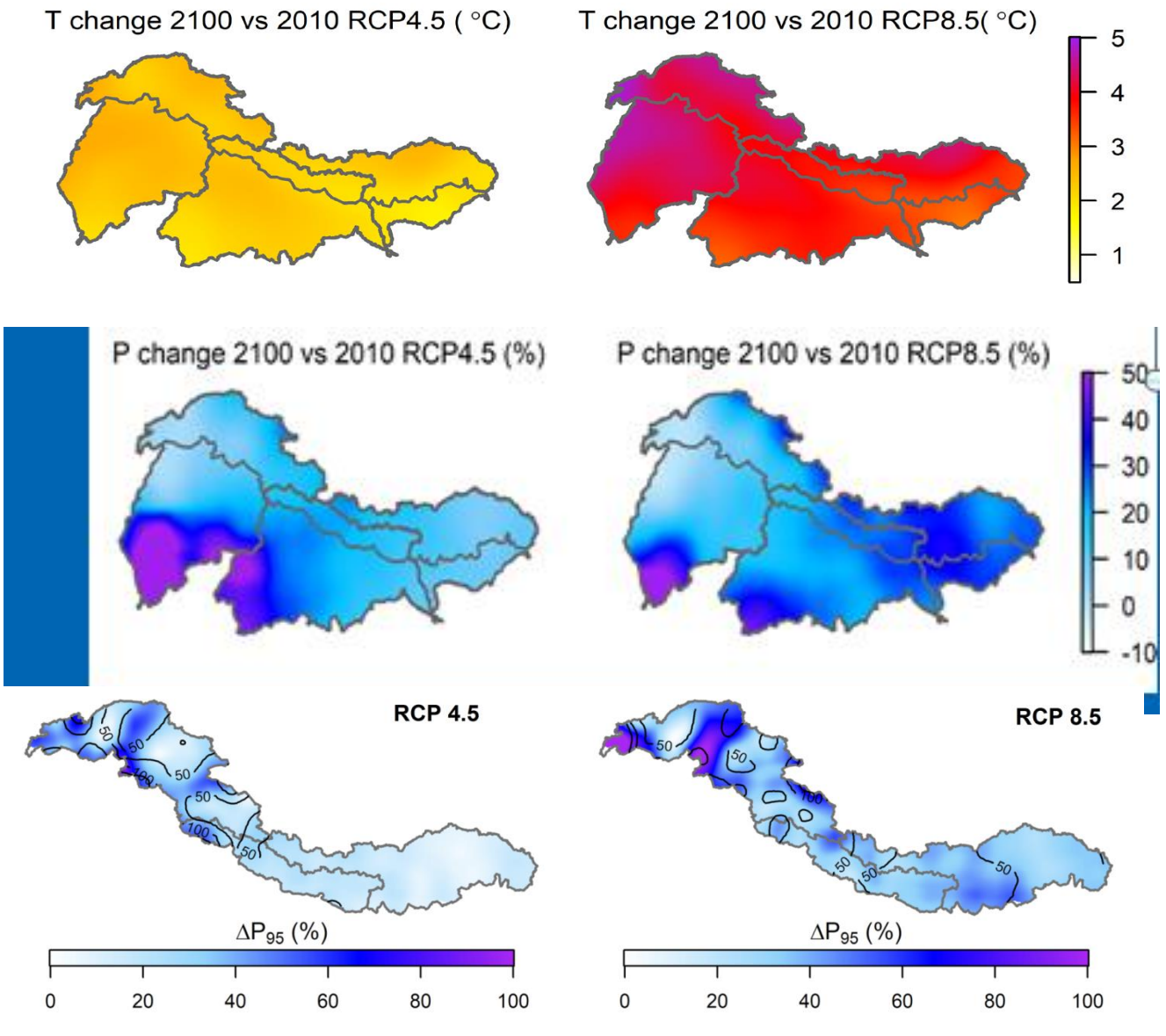
Extreme-scenario



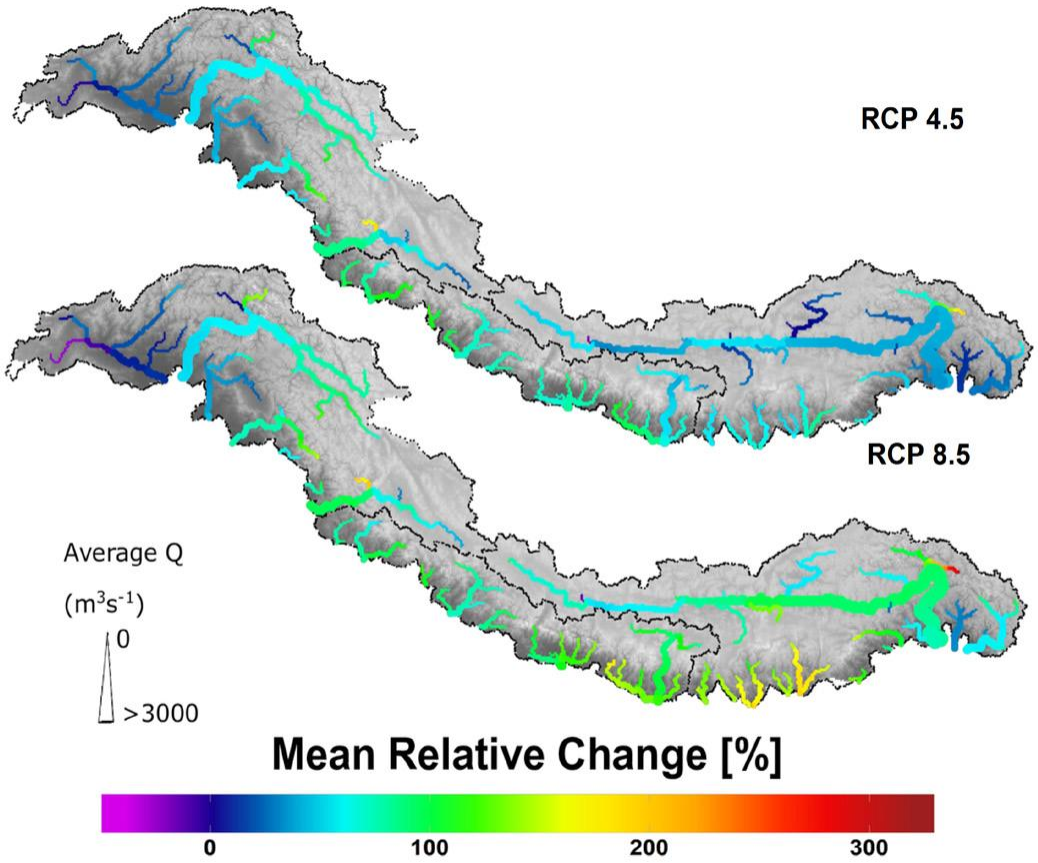
Moderate-scenario



Rising temperatures and wetter futures in South Asian glacier and snow-fed river basins



Changes in Return Periods of floods



The average river flow is projected to increase : roughly 30%–40% in the upper Ganga, and 25%–50% in the upper Brahmaputra towards the end of the century.

Depending on the scenario, the intensities of 'once in 50 years' flood events are expected to increase by 40%–110% on average in the upstream areas and 115%–150% in the downstream areas of the river basins towards the end of the century.

Adverse effects likely on various social and economic sectors

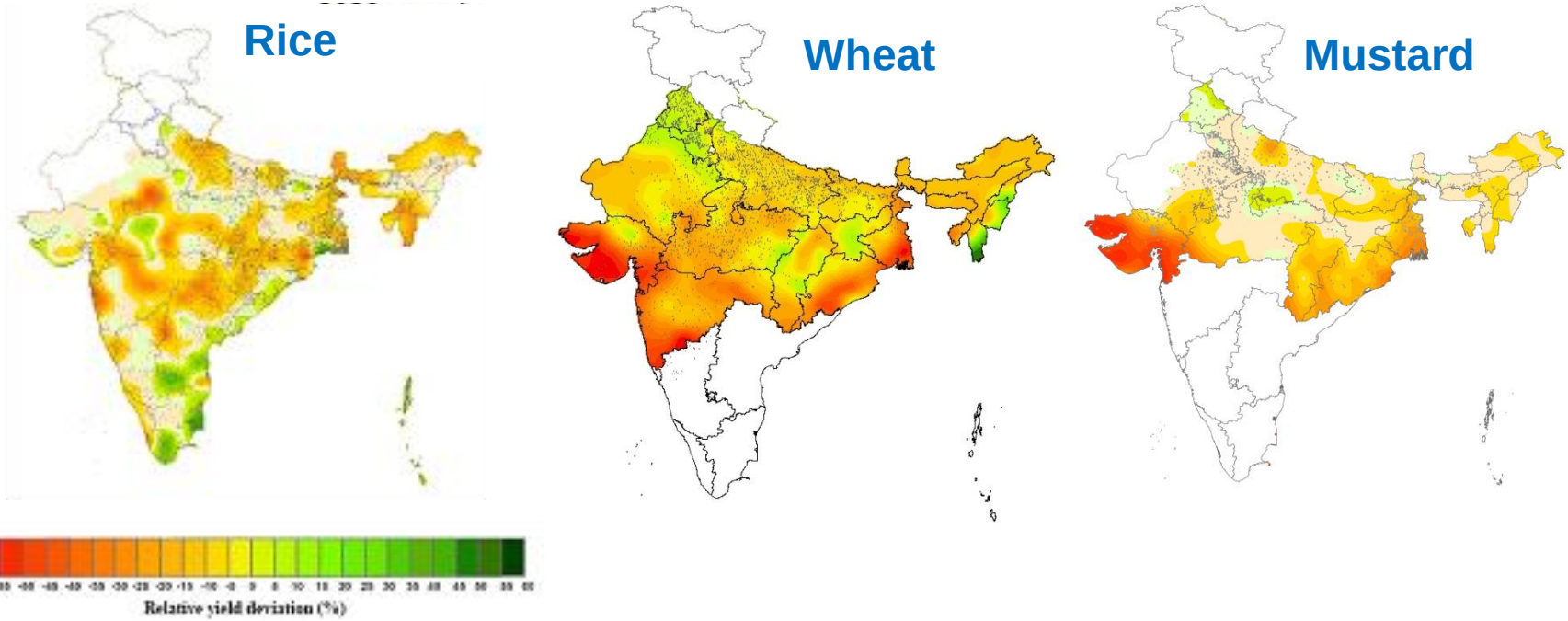
- *Changes in 50-year return period discharge (flood event which has a 1 in 50 chance of occurring in any given year)*

Impact on Agriculture and food security

- Direct Impacts
  - Due to changes in temperatures, CO_2 fertilization effect
- Indirect Impacts
  - Water Scarcity, Extremes, Pests and Diseases

- **Yields and Production to be affected**
- Substantial **decreases in cereal production** especially in case of the tropics

Impacts of climate change in 2020 scenario on various crops



- **Irrigated rice, wheat and mustard productions may be reduced by 6%, 4% and 4%, respectively.**
- **Adaptation strategies can compensate the reductions.**

Source: H Pathak, 2013

Impact on hydrology and water resources

- **Water availability and its quality to be affected**
- **Intense rain occurring over fewer days**,
  - Implies increased frequency of floods during the monsoon, will also result in loss of the rain water as direct runoff resulting in reduced groundwater recharging potential.

Sectoral Impacts: Coastal Areas

Agriculture

- loss of agricultural land
- sea water intrusion and coastal erosion would degrade coastal soil fertility and reduce yields

Water resources

- contamination of fresh water by salt water causing deterioration of quality and decline in availability of fresh water resources

Fisheries

- loss of marine habitats
- primary activity of economic importance in coastal areas to be affected

Settlement

- more than half the world's population lives within 60 km of the sea
- average growth rate of coastal population is higher than that of global population
- dislocation and resettlement of people - difficult, expensive, cause hardship

Infrastructure

- important infrastructure located along coast (port/ tourism) to be affected
- threatened by inundation, increased flooding, coastal erosion, land loss, extreme events

Tourism

- loss of beaches due to erosion, inundation
- degradation of ecosystems (mangroves/ coral reefs)
- damage to tourist infrastructure

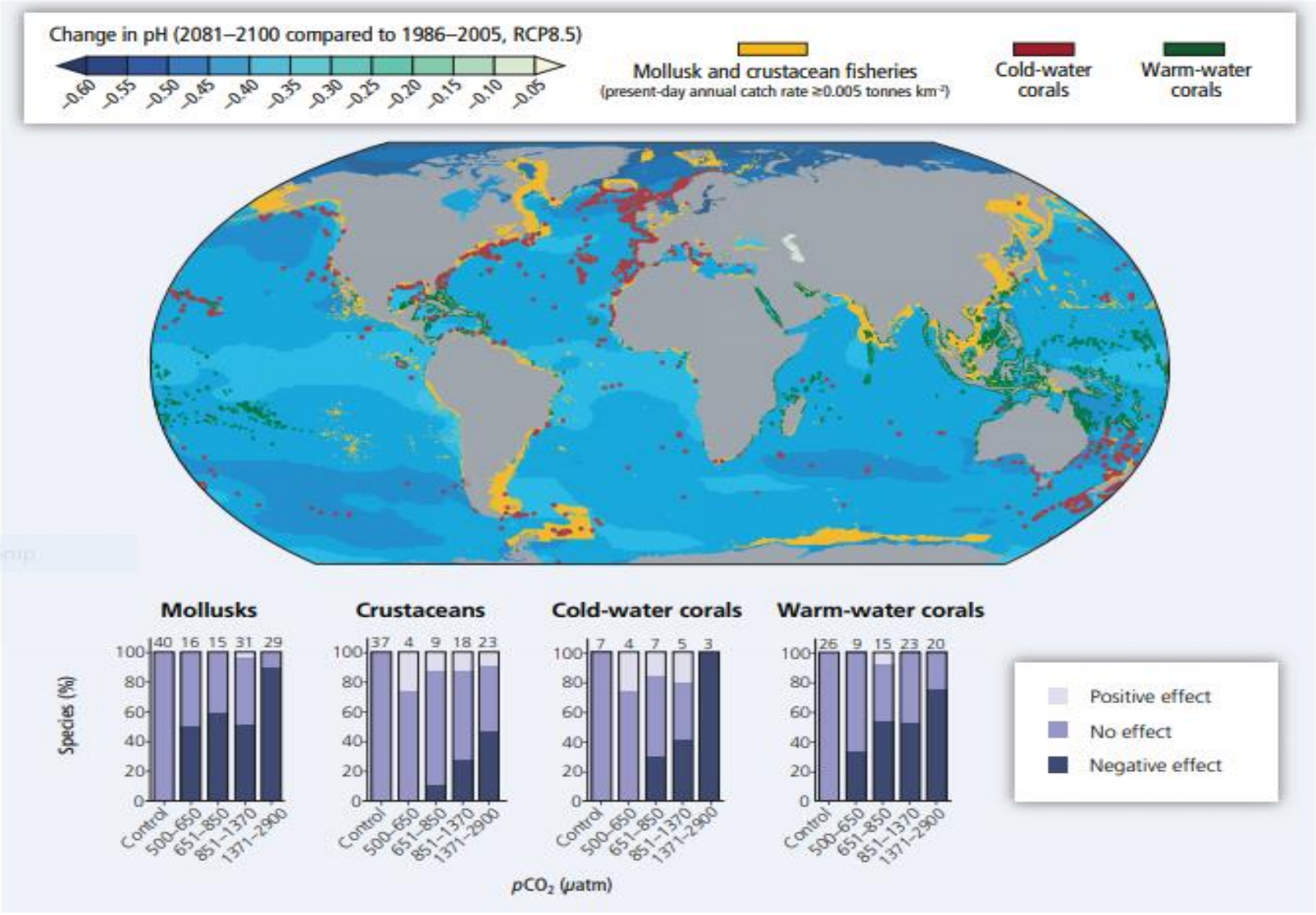
Human health

- fresh water salinization and contamination
- changes in distribution of disease vectors
- loss of life, population displacement

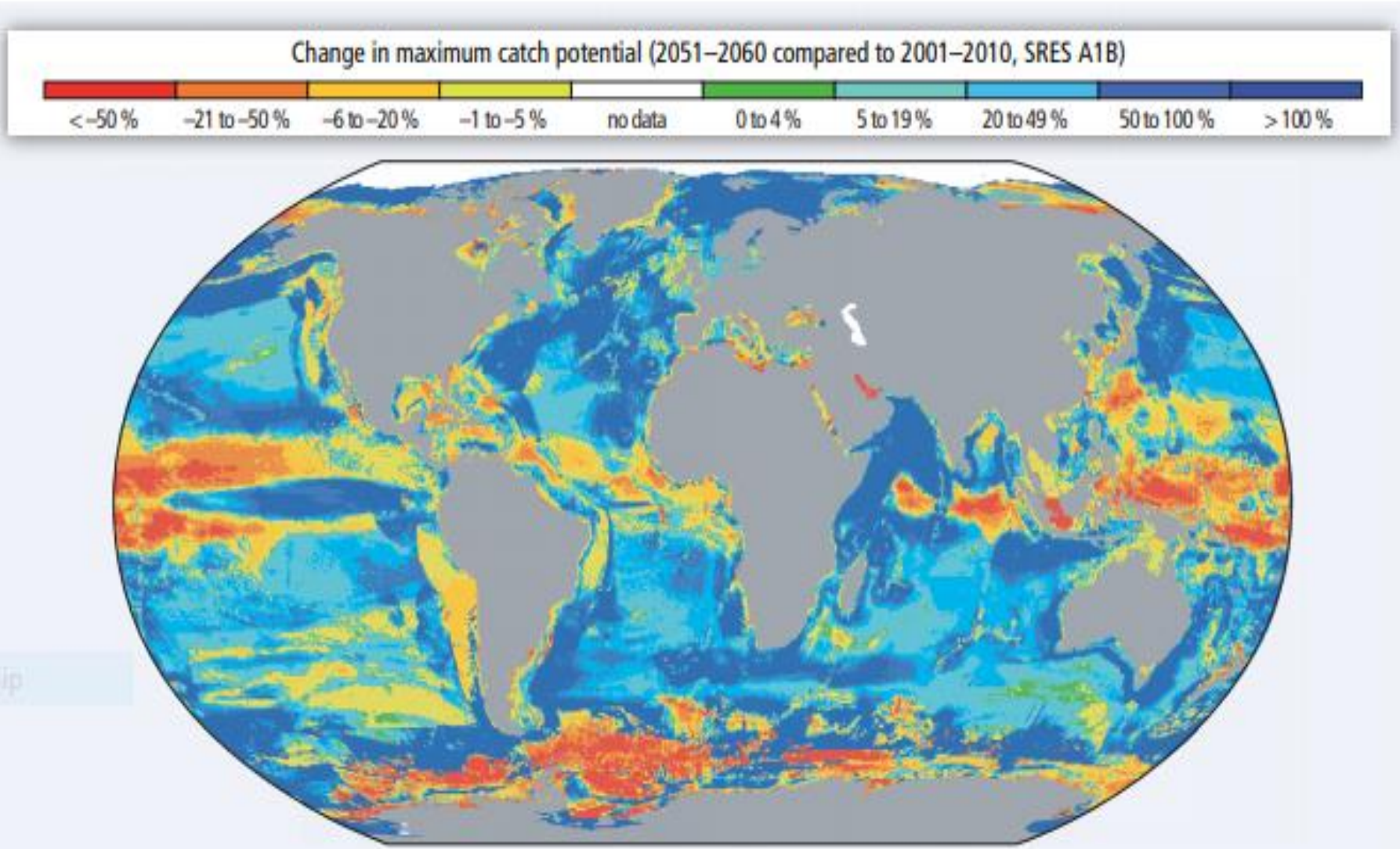
Impact on Coastal and low lying areas

- **Projected sea level rise would affect millions of people living in the low lying area**s of South, Southeast and East Asia such as in Vietnam, Bangladesh, India and China
- Even under the most conservative scenario, sea level **will be about 40 cm higher than today by the end of 21st century and projected to increase the annual number of people flooded in coastal population from 13 million to 94 million**
- **Expected that almost 60% of the increase will be in South Asia** (along coasts from Pakistan, through India, Sri Lanka and Bangladesh to Burma)

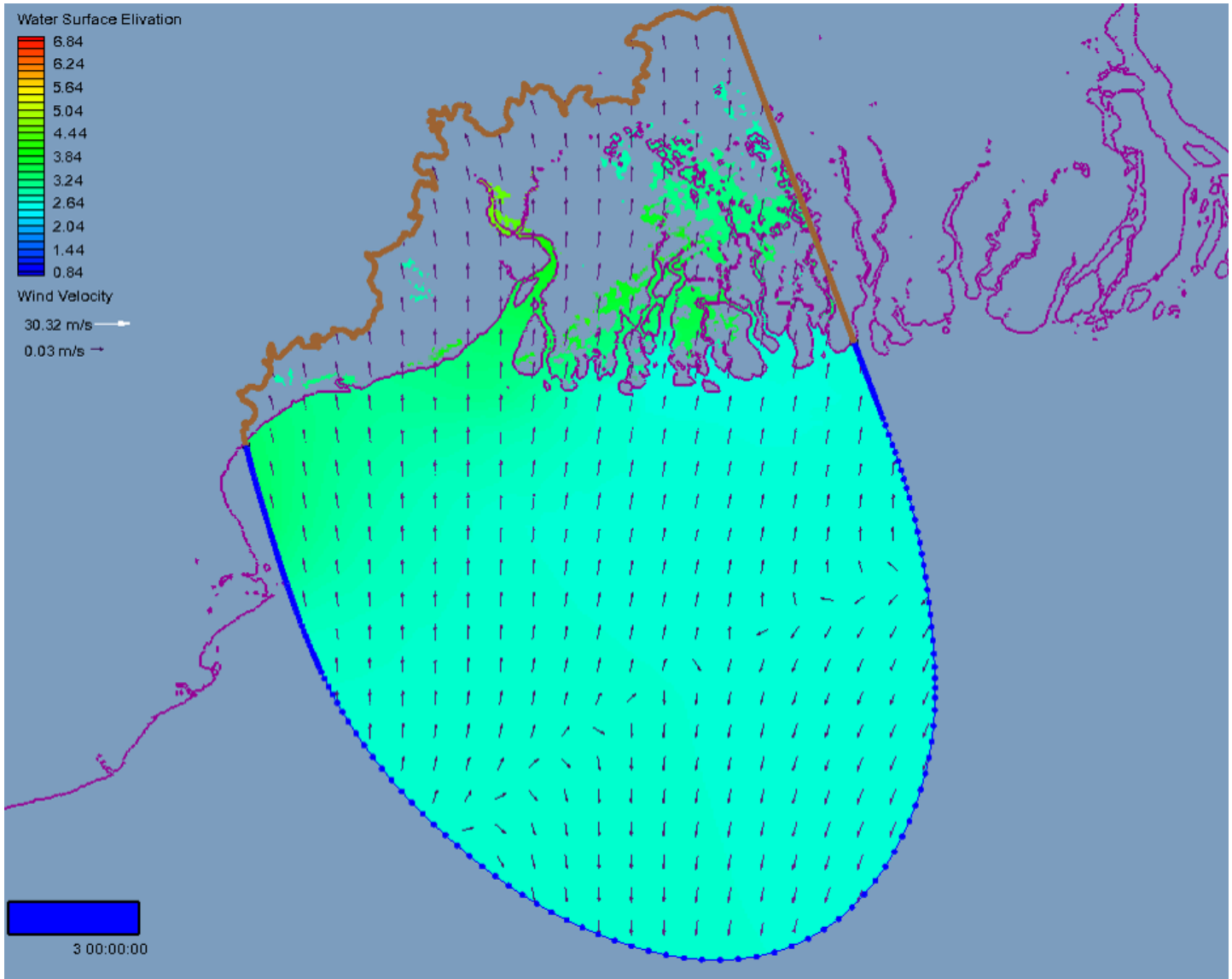
(B)


Change in pH (2081–2100 compared to 1986–2005, RCP8.5)
-0.60
-0.55
-0.50
-0.45
-0.40
-0.35
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
Mollusk and crustacean fisheries
(present-day annual catch rate ≥0.005 tonnes km⁻²)
Cold-water corals
Warm-water corals
Mollusks
Crustaceans
Cold-water corals
Warm-water corals
Species (%)
40 16 15 31 29
37 4 9 18 23
7 4 7 5 3
26 9 15 23 20
100
80
60
40
20
0
Control
500–650
651–850
851–1370
1371–2900
Positive effect
No effect
Negative effect
pCO2 (μatm)

(A)

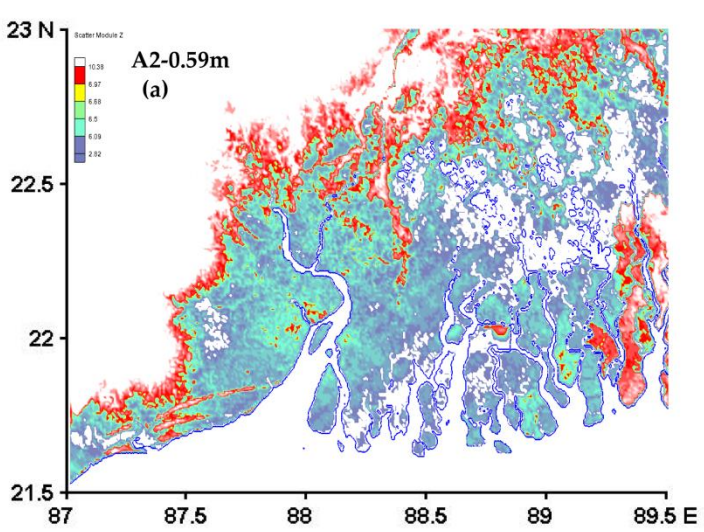

Change in maximum catch potential (2051–2060 compared to 2001–2010, SRES A1B)
< –50 %
–21 to –50 %
–6 to –20 %
–1 to –5 %
no data
0 to 4 %
5 to 19 %
20 to 49 %
50 to 100 %
> 100 %

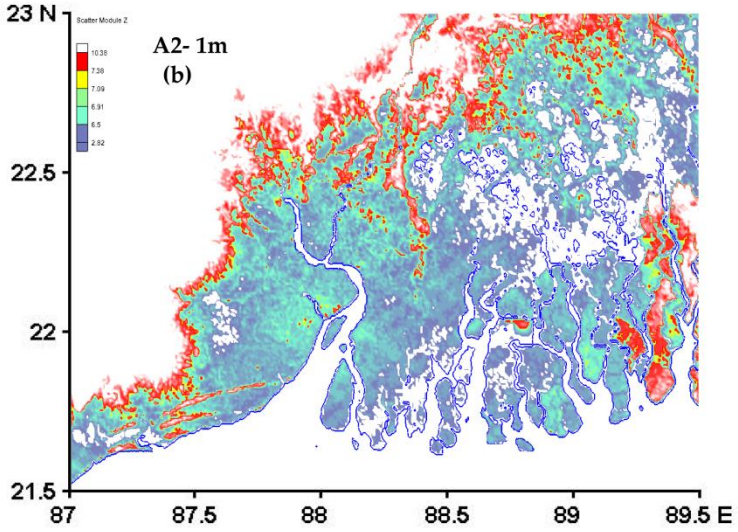
STORM SURGE SIMULATION: WETTING AND DRYING MECHANISM

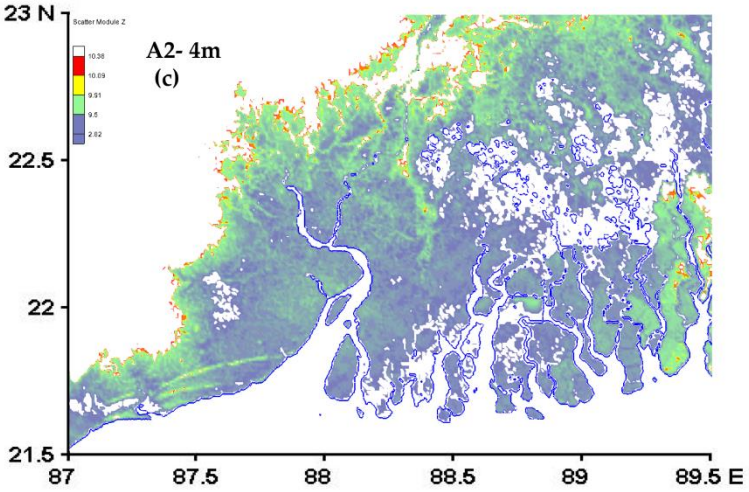


TERI (2012)

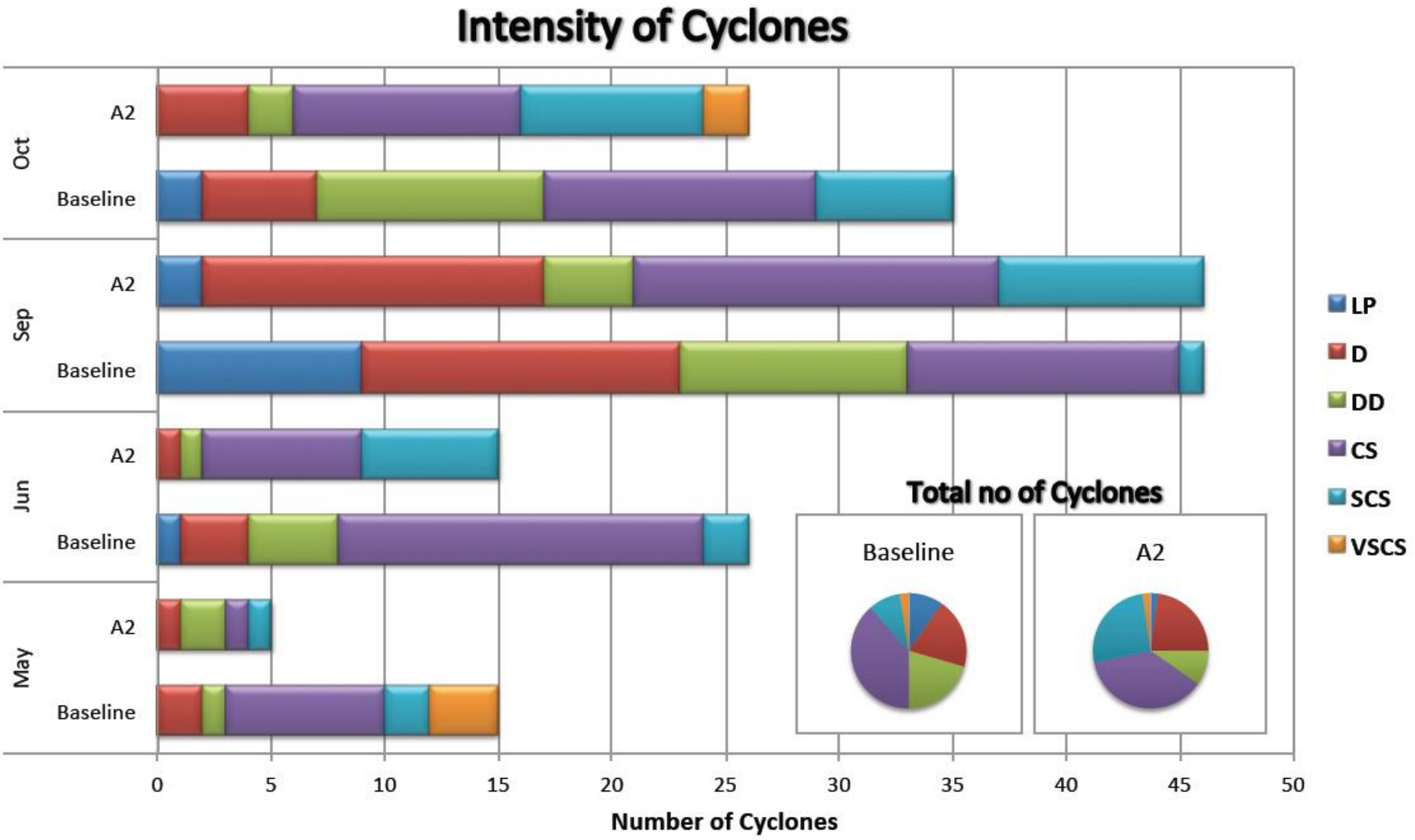
PLAUSIBLE SLR INCREASE + STORM SURGE SCENARIO over WB



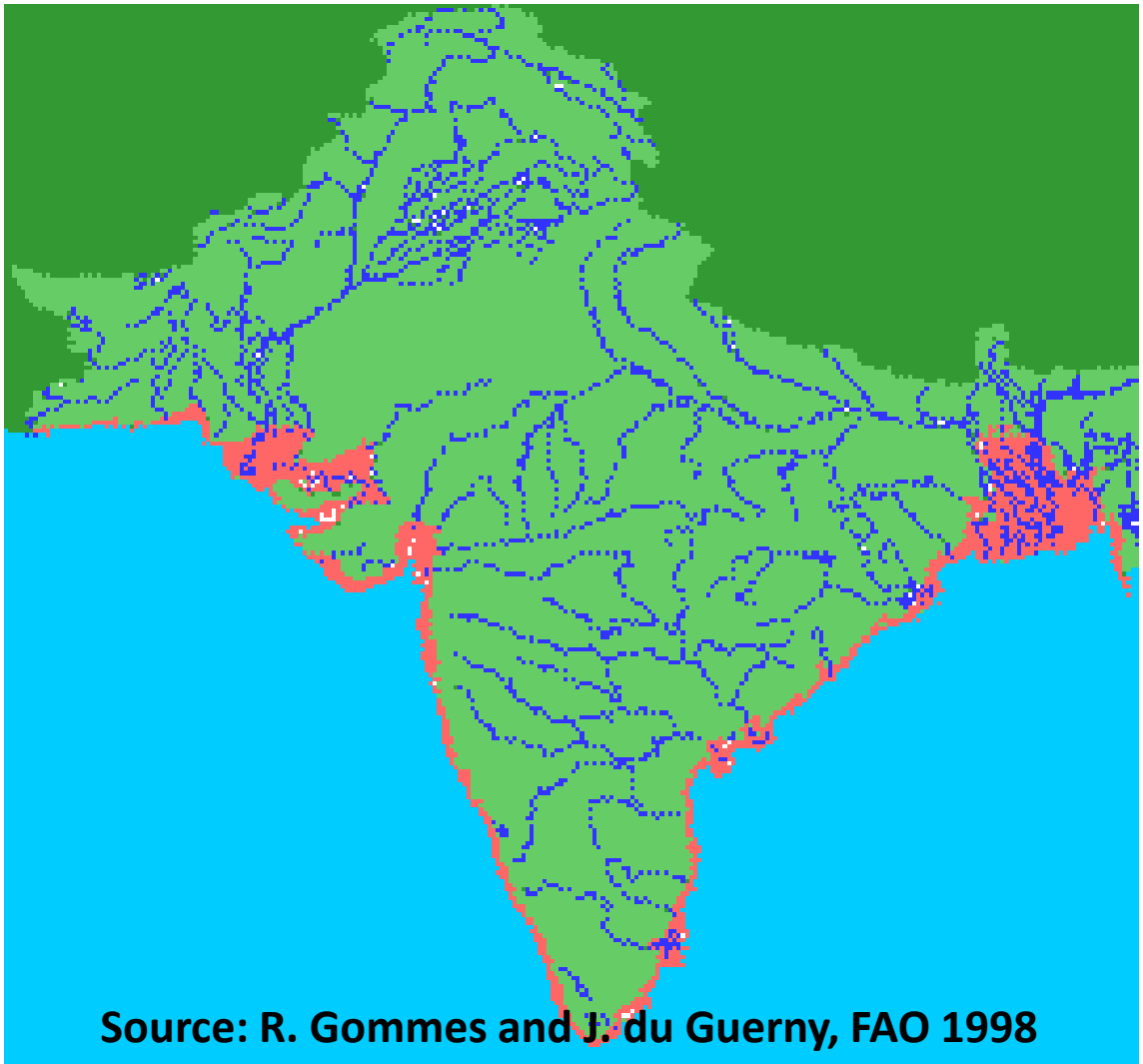




TERI (2012)


Intensity of Cyclones
Oct
A2
Baseline
Sep
A2
Baseline
Jun
A2
Baseline
May
A2
Baseline
0
5
10
15
20
25
30
35
40
45
50
Number of Cyclones
LP
D
DD
CS
SCS
VSCS
Total no of Cyclones
Baseline
A2

Densely populated coastal lowlands of India, Bangladesh, and Pakistan under threat due to sea level rise



Source: R. Gommes and J. du Guerny, FAO 1998

Health

- Changes in weather and climate exert a major influence on human health
  - direct effects …….of extreme events such as heat waves, floods and storms
  - indirect influences …..on the distribution and transmission intensity of infectious diseases
- IPCC projects with high probability increase in human morbidity and mortality, associated with changes in temperature and precipitation patterns as well as with expected rise in the frequency and intensity of extreme events
- Tropics uniquely placed with high temperatures and its exposure to extremes….

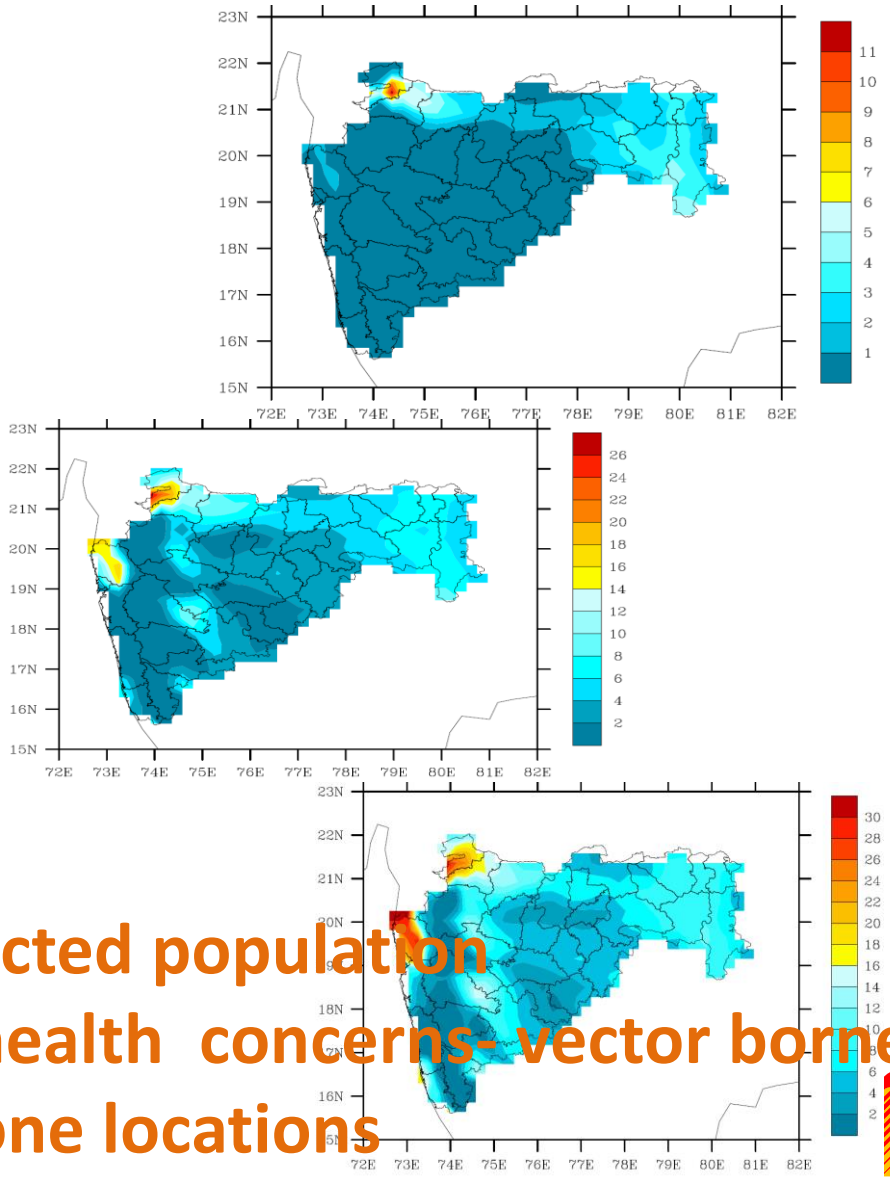
For instance, in case of malaria

Malaria transmission (via *P. falciparum*) in period between May to October for 3 time periods: Baseline (1971-2000); 2030s (2021-2040) and 2050s (2041-2060):

Average relative humidity varies between 55-80%

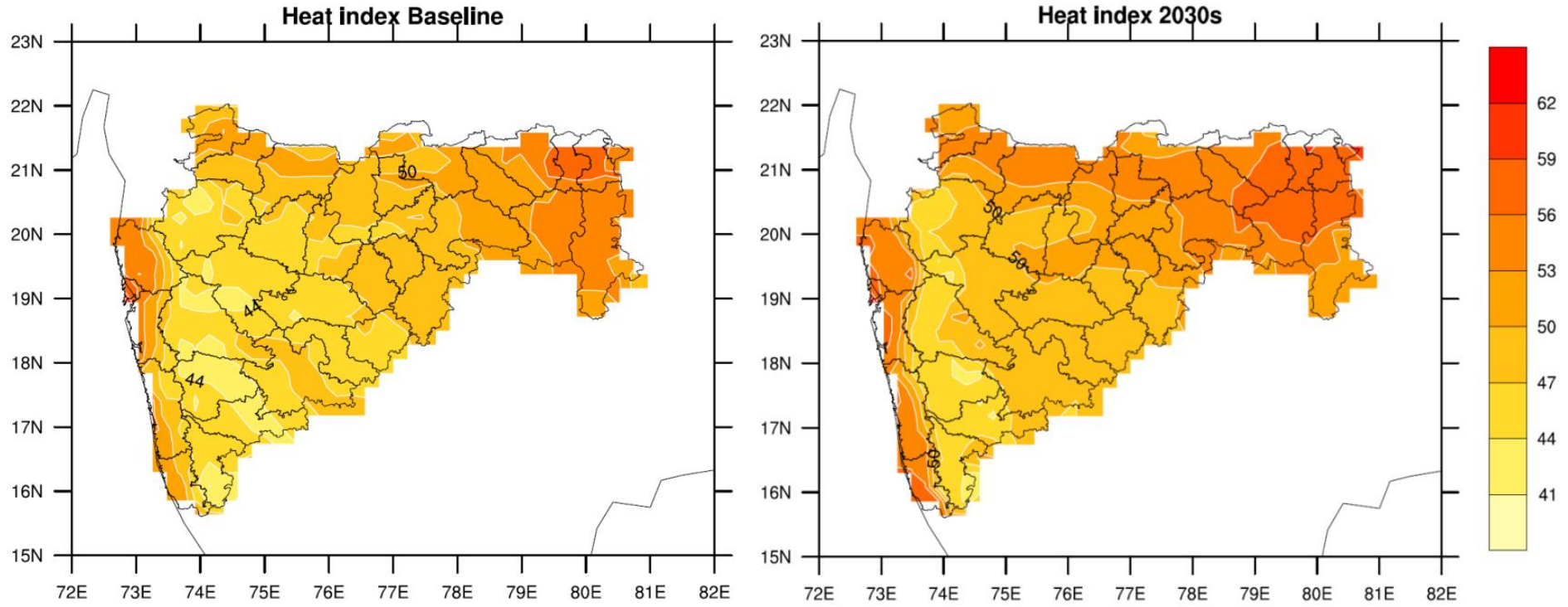
Three temperature (mean) classes with the following ranges:

- **Transmission Window Class I: 20-25 °C**
- **Transmission Window Class II: 25-30 °C**
- **Transmission Window Class III: 30-35 °C**



Identify priority areas and affected population for Interventions and related health concerns- vector borne diseases, heat stress, flood prone locations

Heat Index: an index that combines air temperature and relative humidity in an attempt to determine the human perceived equivalent temperature- how hot it feels, termed as the felt air temperature



Heat and Discomfort Index

	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
42°	48	50	52	55	57	59	62	64	66	68	71	73	75	77	80	82
41°	46	48	51	53	55	57	59	61	64	66	68	70	72	74	76	79
40°	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75
39°	43	45	47	49	51	53	55	57	59	61	63	65	66	68	70	72
38°	42	44	45	47	49	51	53	55	56	58	60	62	64	66	67	69
37°	40	42	44	45	47	49	51	52	54	56	58	59	61	63	65	66
36°	39	40	42	44	45	47	49	50	52	54	55	57	59	60	62	63
35°	37	39	40	42	44	45	47	48	50	51	53	54	56	58	59	61
34°	36	37	39	40	42	43	45	46	48	49	51	52	54	55	57	58
33°	34	36	37	39	40	41	43	44	46	47	48	50	51	53	54	55
32°	33	34	36	37	38	40	41	42	44	45	46	48	49	50	52	53
31°	32	33	34	35	37	38	39	40	42	43	44	45	47	48	49	50
30°	30	32	33	34	35	36	37	39	40	41	42	43	45	46	47	48
29°	29	30	31	32	33	35	36	37	38	39	40	41	42	43	45	46
28°	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
27°	27	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
26°	26	26	27	28	29	30	31	32	33	34	34	35	36	37	38	39
25°	25	25	26	27	27	28	29	30	31	32	33	34	34	35	36	37
24°	24	24	24	25	26	27	28	28	29	30	31	32	33	33	34	35
23°	23	23	23	24	25	25	26	27	28	28	29	30	31	32	32	33
22°	22	22	22	22	23	24	25	25	26	27	27	28	29	30	30	31

http://www.eurometeo.com/

Up to 29 C°	*No discomfort*
From 30 to 34 C°	*Slight discomfort sensation*
From 35 to 39 C°	*Strong discomfort. Caution: limit the heaviest physical activities*
From 40 to 45 C°	*Strong indisposition sensation. Danger: avoid efforts*
From 46 to 53 C°	*Serious danger: stop all physical activities*
Over 54 C°	*Death danger: imminent heatstroke*

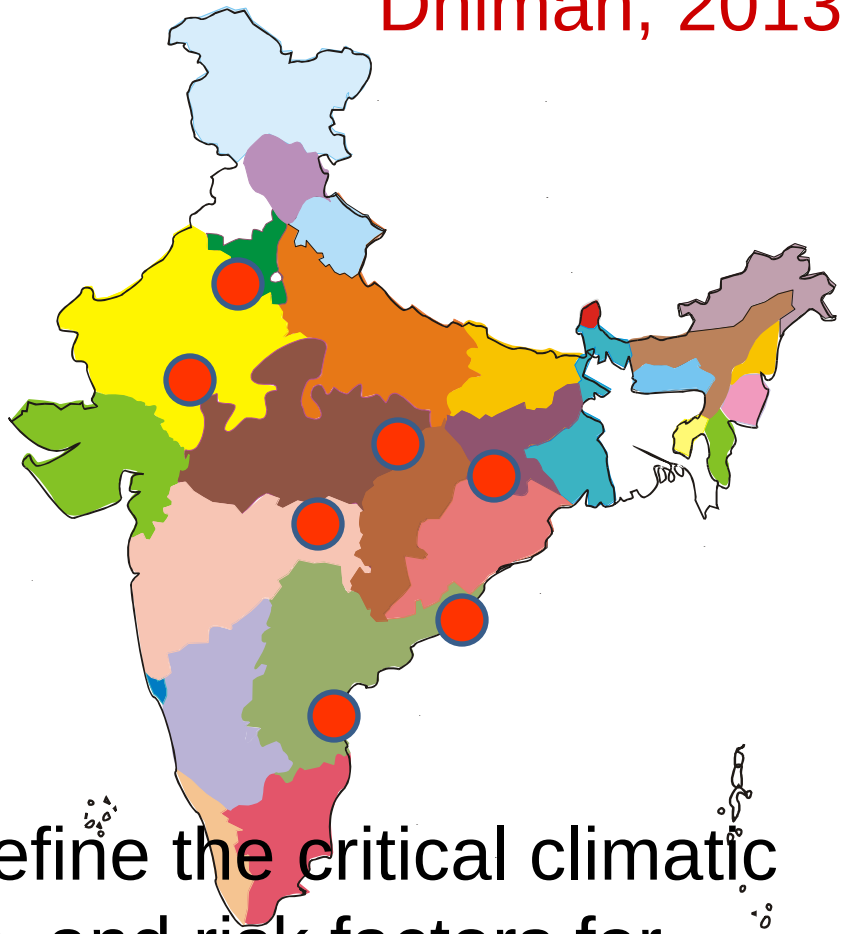
teri

Mortality due to Heat wave

Heat waves occur in the month of March to June. Maximum deaths (1658) occurred in the year 1998. Andhra Pradesh, Orissa, Punjab, Uttar Pradesh, Rajasthan, Bihar and Madhya Pradesh suffer the most.

(Akhtar R 2007. Global Environ. Research 11(1): 51-57)

Dhiman, 2013



Heat stress sector should define the critical climatic conditions, nutritional status and risk factors for mortality so that health advisory may be possible

In conclusion

- There is a need to frame responses to the likely risks of climate change and adapt effectively
- Adaptation will be able to reduce the risks to a certain extent but it may not be possible to address all losses
- While there are programmes that are already in place with the potential for adaptation that require scaling up to address the incremental risk, in other cases, the need for introduction of new programmes and schemes will be felt and required to be implemented

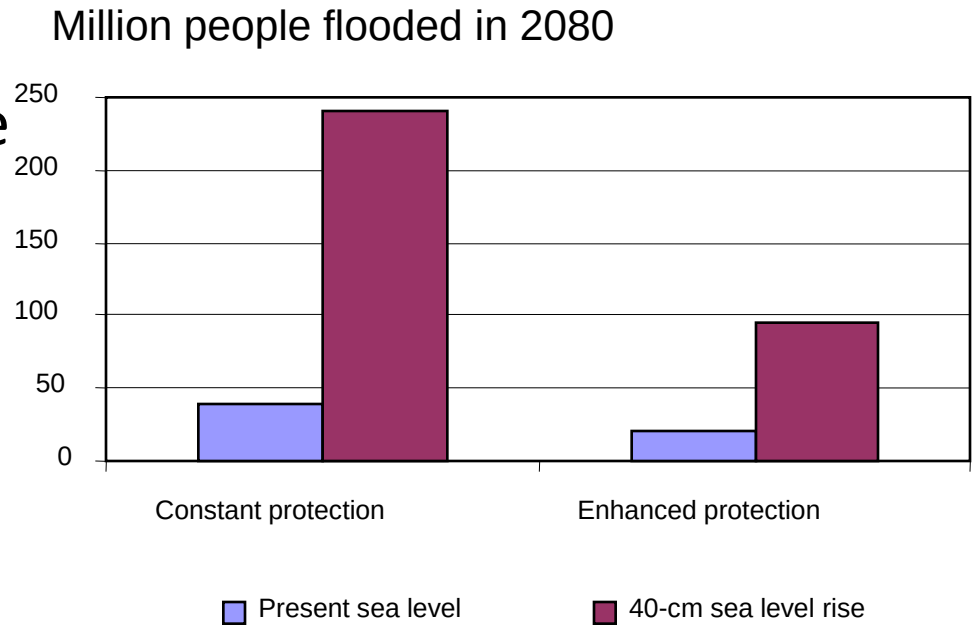
- Therefore…..gives a new focus to development, although not entirely a novel one
- Also is not primarily a “bau” development

Adaptation

		Anticipatory	Reactive
Natural Systems			• Changes in length of growing season • Changes in ecosystem composition • Wetland migration
Human Systems	*Private*	• Purchase of insurance • Construction of houses on stilts • Redesign of oil rigs	• Changes in farm practices • Changes in insurance premiums • Purchase of air-conditioning
Human Systems	*Public*	• Early-warning systems • New building codes, design standards • Incentives for relocation	• Compensatory payments, subsidies • Enforcement of building codes • Beach nourishment

Adaptation to climate change

- Potential to reduce adverse impacts of climate change
- Necessary strategy at all scales
- Planned adaptation can supplement autonomous adaptation



- Can often produce immediate ancillary benefits
- Draw on experience with adaptation to climate variability and extremes

Adaptation Implementation Needs

- Depends upon –
  - Where you are …….
  - Who you are……. and
  - What you need to do about it…….

CCA implementation and key aspects to be considered

- May align with some development activities
  - It may **reduce** vulnerability to **other forms of environmental stress** for instance in terms of impacts on water quantity and quality, land degradation
- **May require a sectoral/ cross-sectoral** focus
- May need **mix of measures**, **existing and new** measures to be explored and defined
- **Thematic focus** to measures could be given – for eg., explore the risks and measures from a livelihoods angle

Particularities of the action defined and its implementation

- Its interrelationship and overlap with sustainable development, disaster risk management and other development activities
- Specifics of climate change adaptation – **additionality component**
- Degree of **uncertainty – "win-win"** opportunities
- **Trade offs** between short term costs - long terms benefits
- **Any spill over effects**

Other aspects

- Is the measure replicable, scalable and sustainable
- Has practical applicability- feasibility
- Innovative and creative
- Address non-discrimination/equity of access
- Involve and impacts a range of stakeholders
- Have local/community-level engagement

All adaptation activities must address climate change and/or variability - Does it address climate change?

Mode for implementation of adaptation

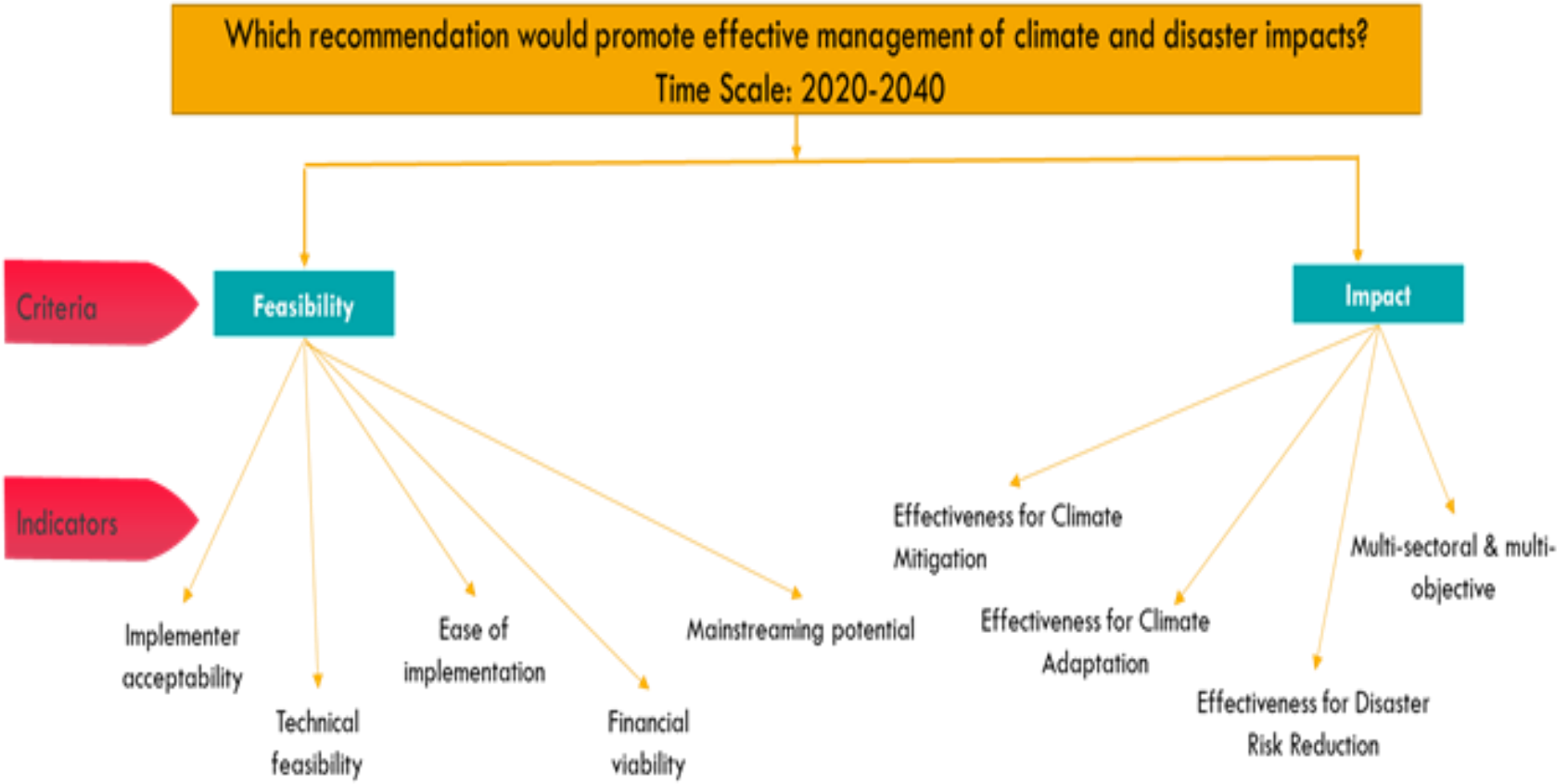
Consider the best mode for implementation or execution of the adaptation action

- **involve** elected representatives, institutions/ departments, local activists and identify leadership entities for the action proposed, reach out to the community
- **engage** expertise to communicate the risks and define actions – may select based on economic and fiscal instruments, technical support for design and implementation of actions

Mainstreaming Climate and Disaster Risks into State Policy and Planning

FOREST AND BIODIVERSITY SECTOR						
Proposed Recommendation	Type of Action	Gaps Identified	Rationale for Action	Convergence with existing state policies/schemes	Contribution to SDGs	
Adopt measures to alleviate dependence of communities on forests for fuel wood by providing alternate energy options like LPG, Chir-Pine needle briquettes, solar energy etc	Policy Action, Technology Action	Lack of alternatives to reduce the dependency of communities on forest	Since the creation of the State, there has been a net increase in forest area indicating that it has been able to protect, regenerate and stabilize its forest cover. However, while forest loss due to deforestation may no longer be a significant issue, forest degradation continues to be a problem, given the enormous dependence on the forests for fuelwood, fodder and other NTFPs. Remote sensing data of the Forest Survey of India (FSI) indicate that there has been a decrease in dense forests in 6 districts of the State. Ground-level studies also point to forest degradation in the State on measures of forest quality such as canopy cover, tree lopping and forest regeneration. Promoting measures that promote alternate sources of energy like LPG, Chir-Pine needle briquettes, solar energy etc can control degradation of forests in the long run by reducing community dependence on fuel wood	1) Policy for Power Generation from Pine Leaves and Other Biomass – 2018, 2) Chir Pine Resin Policy- 2003, 3)Uttarakhand: Decentralized Renewable Energy Plan 2018-2025, 4) Indian Forest Act 1927	SDG 2: Zero Hunger SDG 3:Good Health and Well being SDG 5: Gender Equality SDG 6: Clean Water and Sanitation SDG 13: Climate Action SDG 15 : Life on Land SDG 17: Partnership for Goals	

Prioritization of actions



TIMELINE

	Current Status	2020-2025	2025-2030
Projected Overview		If pine needles consumption is 1.5 kg/kWH then 1.5 MT will be required by 2019 and 7.5 MT by 2021	If pine needles consumption is 1.5 kg/ kWH, then 150 MT will be required by 2030 which can be met from other biomass as well. In addition 1000 MT of biomass is required for 50 briquetting/ bio-oil plants.

KEY RECOMMENDATIONS

Policy & Governance	1. Policy for Power Generation from Pine Leaves and Other Biomass, 2018 2. Chir Pine Resin Policy, 2003 3. Uttarakhand: Decentralized Renewable Energy Plan 2018-2025 4. Fire Management Plans prepared annually by FD 5. National guidelines on Forest Fire Prevention and Management (FFPM), 2000	1. Implement and follow all the detailed guidelines provided in the State policy for power generation from pine leaves, 2018, 2. Constitute a state level committee & district level committees comprising of DF&E, UREDA & DOI in order to discuss matters related to collection & use of pine needles 3. Exempt chir pine from the state policy that puts a ban on green felling of trees above 1000 msl, and allow its silvicultural operations through controlled felling & burning by following scientific prescriptions given in the working plans 4. Replace Chir Pine with better local alternatives and phase it out in moist & good soil areas with oak, kafal, kachnar, rhododendron, apricot, aamla, walnut that provice better ecosystem services 5. Use REDD+ policy once implemented to develop carbon markets especially for Chir-Pine 6. Encourage local use and collection of pine needles leaves used for livestock bedding, field mulching & building local check dams 7. Ensure scientific resin tapping with sufficient rest periods as prescribed in the Chir Pine resin extraction policy 2003.	1. Revise state policy for power generation from pine leaves 2018 as per the need & requirement as well as suited best to the prevailing conditions. 2. Ensure biannual meetings of state level committee & district level committee in porter to discuss matters related to collection & use of pine needles 3. Revise Chir pine resin extraction policy 2003 as per the need & requirement as well as suited best to the prevailing conditions
Financial	1. Forest Department has fixed a rate of INR 1.00 per Kg of pine needles 2. Forest Department is expected to collect a royalty fee of INR 20 per ton of pine needles from developer setting up power plant, 3. A Briquette Making Machine (500- 1000 kg/hr capacity) costs about 5 lakhs.	1. Revision the fixed rate of collection of pine needles to INR 3/Kg 2. Allot an additional fund of INR 1.2 crore per year to 6 forest divisions with maximum pine forests for purchasing briquetting machines 3. Extend the existing available subsidy of 40% for developing a power project using pine needles or other biomass to other businesses 4. Allot a budget of INR 45 lacs per year to 6 divisions for capacity building of communities in order to learn technical & entrepreneurial skills 5. Allot an additional budget of INR 2 crores per year for marketing of products based on pine needles & for creating awareness	1. Revision of rate of collection of pine needles to INR 5/Kg 2. Adjust the subsidy given for power projects or industries using pine needles 3. Allot additional budget for training requirements 4. Allot additional budget for purchasing machinery and marketing of products using pine needles based on the requirement.
Fiscal	1. State budget of INR 16 crores for firefighting in year 2020 2. Subsidy of 40% on the total cost of developing a power project using pine needles or other biomass.	1. Develop commercially-viable schemes to remove pine needles from forests and also to engage local communities in income generation activities 2. Allot additional budget to the existing fire protection budget by including collection of pine needles as a key strategy	Evaluate the commercially-viable schemes meant to remove pine needles from forests and also to engage local communities in income generation activities
Institutional Strengthening	The forest divisions with maximum Chir Pine forests including Almora (74.5%), Champawat (59.2%), Nainital (56%), Pithoragarh (45%), Tehri Garhwal (43.5%) & Chakrata (29%)	1. Maintain a real-time database on forest fires especially in chir pine forests 2. Build capacity of communities in order through regular training programmes 3. Improve market linkages through buy-back mechanisms for products made using pine needles 4. Organise a public function at the district level after every fire season to acknowledge the communities/panchayats/ BMC's.	1. Upgrade the databases for extent of chir-pine forest, its carbon content, quantity of pine needles collected, number of industries using pine needles & economic gains as well as the extent of forest fires 2. Evaluate buy-back mechanism schemes for products using pine needles to encourage demand & supply 3. Design & upgrade existing capacity building programmes to suit the need of the communities.

Thank you

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