

Challenges and opportunities in Managing Climate Change Induced Flood Risk in SAARC Region: Reflections

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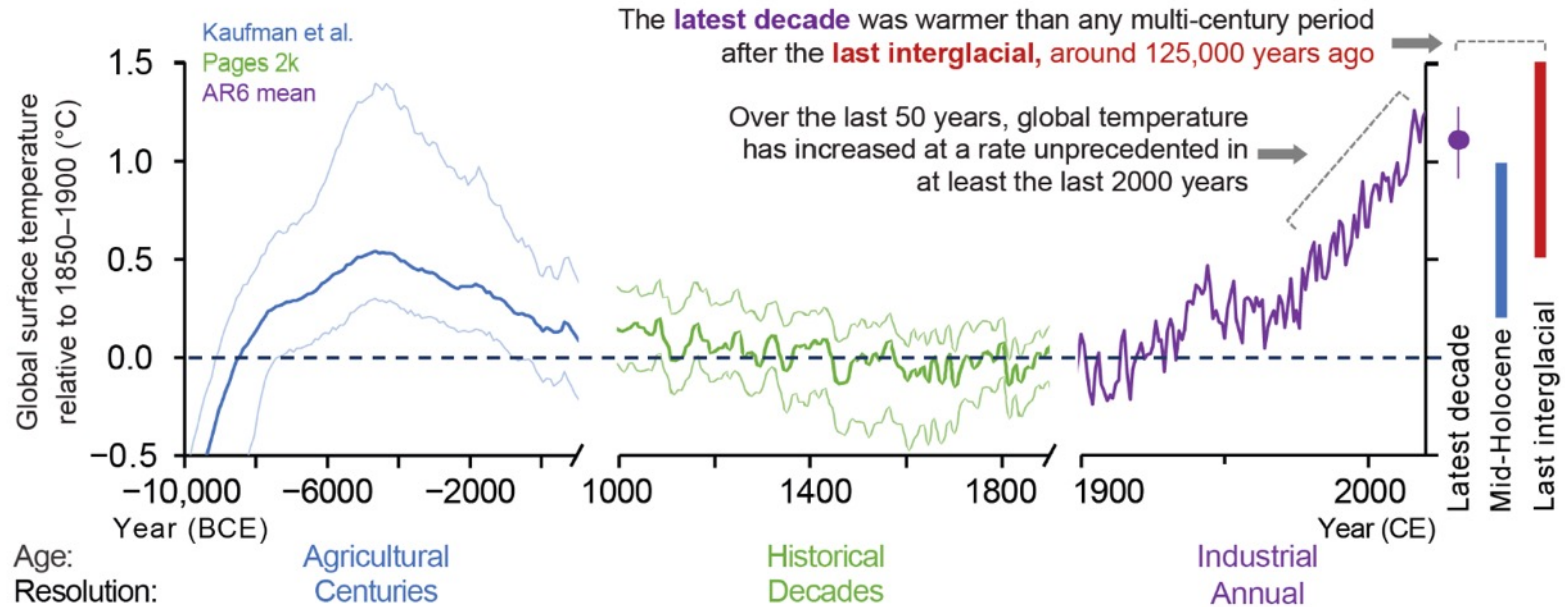
Professor Centre for Atmospheric Sciences

Associate Faculty School of Public Policy

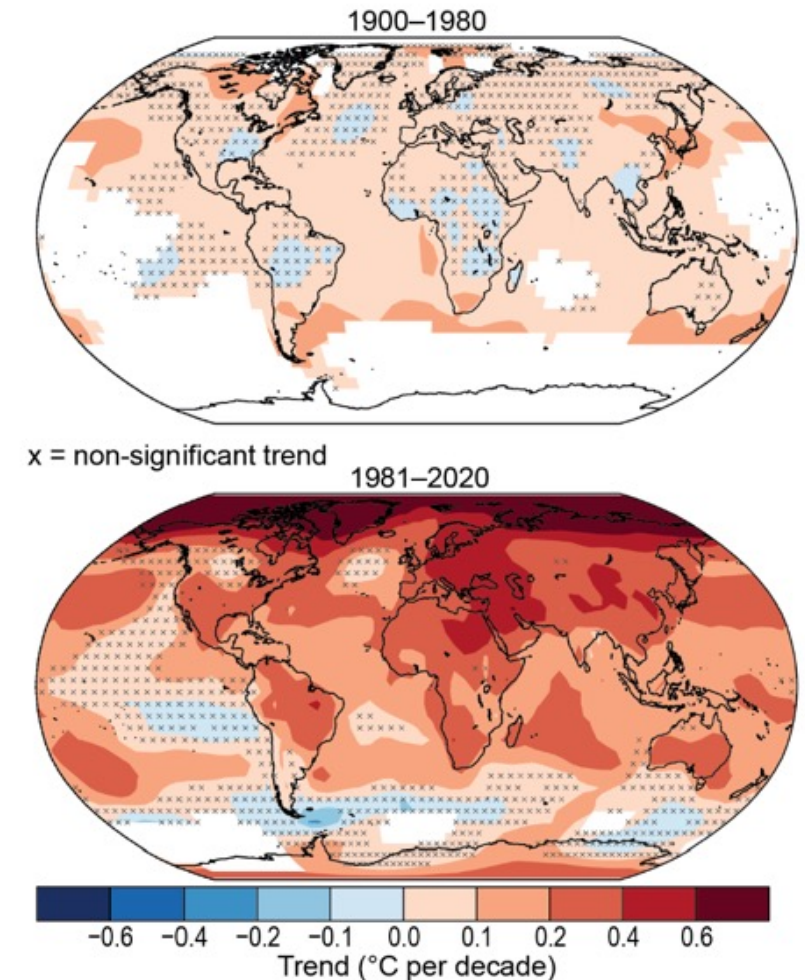
IIT Delhi

Changes in Surface Temperature

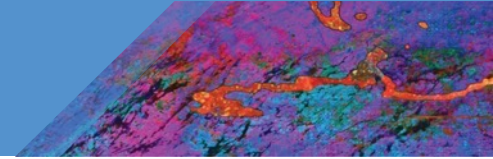
(a) Global surface temperatures are more likely than not unprecedented in the past 125,000 years



(b) Warming accelerated after the 1970s, but not all regions are warming equally



IPCC AR6 WG-I Figure 2.11



What does warmer temperature mean for the water cycle

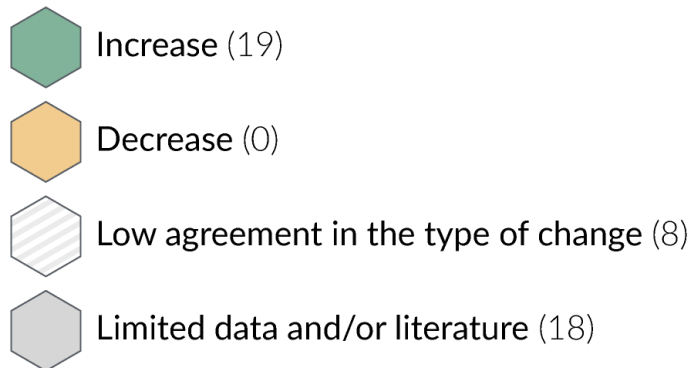
- A warmer climate increases moisture transport into weather systems, which intensifies wet seasons and events (**high confidence**).
- Increases in near-surface atmospheric moisture capacity of about 7% per 1°C of warming lead to a similar response in the intensification of heavy precipitation increasing the severity of flood hazards (**high confidence**).
- Water cycle variability and related extremes are projected to increase faster than mean changes in most regions of the world

Climate change is already affecting every inhabited region across the globe, with human influence contributing to many observed changes in weather and climate extremes

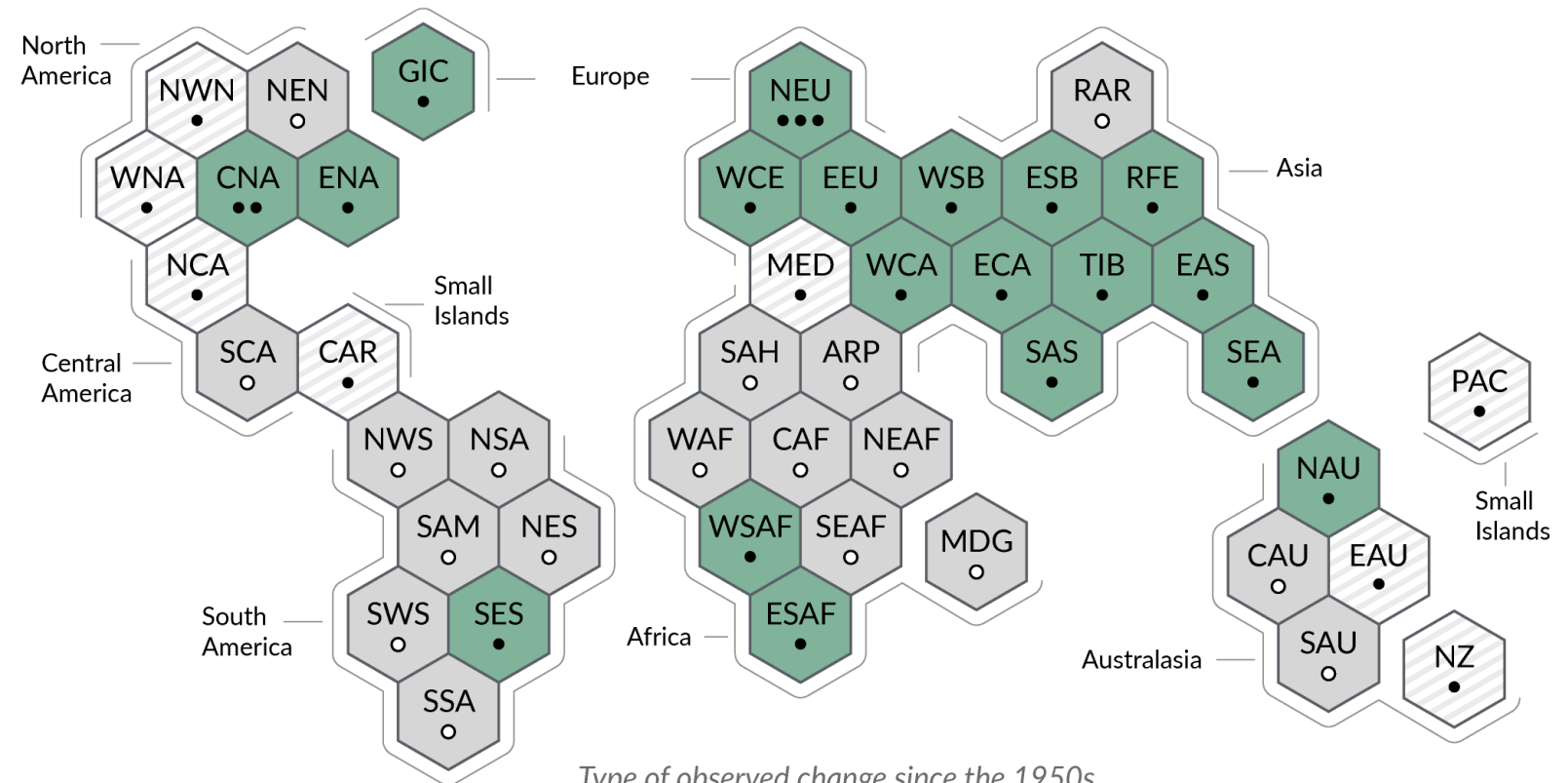
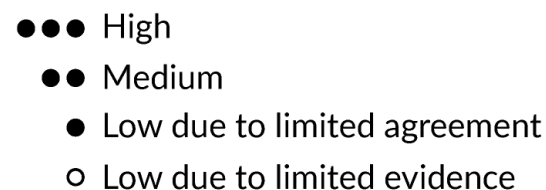
Figure SPM.3

b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions

Type of observed change
in heavy precipitation



Confidence in human contribution
to the observed change



Type of observed change since the 1950s

	Climatic Impact-driver																													
	Heat and Cold				Wet and Dry						Wind				Snow and Ice						Coastal and Oceanic				Other					
	Mean air temperature	Extreme heat	Cold spell	Frost	Mean precipitation	River flood	Heavy precipitation and pluvial flood	Landslide	Aridity	Hydrological drought	Agricultural and ecological drought	Fire weather	Mean wind speed	Severe wind storm	Tropical cyclone	Sand and dust storm	Snow, glacier and ice sheet	Permafrost	Lake, river and sea ice	Heavy snowfall and ice storm	Hail	Snow avalanche	Relative sea level	Coastal flood	Coastal erosion	Marine heatwave	Ocean and lake acidity	Air pollution weather	Atmospheric CO ₂ at surface	Radiation at surface
Asia																														
Arabian Peninsula	↗	↗ ***	↘ **	↘																			↗		1	↗			↗	
West Central Asia	↗	↗ ***	↘ ***	↘	5		↗		↗			↘					↘						↗		1,2	↗			↗	
West Siberia	↗	↗ ***	↘ ***	↘	↗		↗					↗					↖	↗											↗	
East Siberia	↗	↗ ***	↘ ***	↘	↗		↗					↗					↖	↗											↗	
Russian Far East	↗	↗ ***	↘ ***	↘	↗		↗					↗					↖	↗					↗		1,2	↗	↗		↗	
East Asia	↗	↗ ***	↘ ***	↘			↗			↗		↗			↗ 3				↗				↗		1,2	↗			↗	
East Central Asia	↗	↗ ***	↘ ***				↗					↘						↗	↗											
Tibetan Plateau	↗	↗ ***	↘ ***	↘			↗					↗					↗	↗											↗	
South Asia	↗	↗ ***	↘ ***	↘	↘		↗					↗					↗	↗					↗		1	↗				
South East Asia	↗	↗ ***	↘ ***		4		↗								↗ 3								↗		1,2	↗			↗	

Note: There are several region-specific qualifiers/exceptions attached to some of the directions of change/confidence levels indicated above. {12.4}

Key for observational trend evidence ↗ Past upward trend (medium or higher confidence) ↘ Past downward trend (medium or higher confidence)

Key for attribution evidence *** High confidence (or more) ** Medium confidence

Key for level of confidence in future changes High confidence of increase (or more) Medium confidence of increase (or more) Low confidence in direction of change Medium confidence of decrease High confidence of decrease Not broadly relevant

IPCC AR6 Technical Summary Table TS.5

Flood



Heavy rain

Compound event flood



Heavy rain



Ocean levels



Wet soil



Climate patterns

Source: ARC Centre for Excellence in Climate Extremes

The probability of compound flooding (storm surge, extreme rainfall and/or river flow) has increased in some locations and will continue to increase due to both sea level rise and increases in heavy precipitation, including changes in precipitation intensity associated with tropical cyclones (**high confidence**)

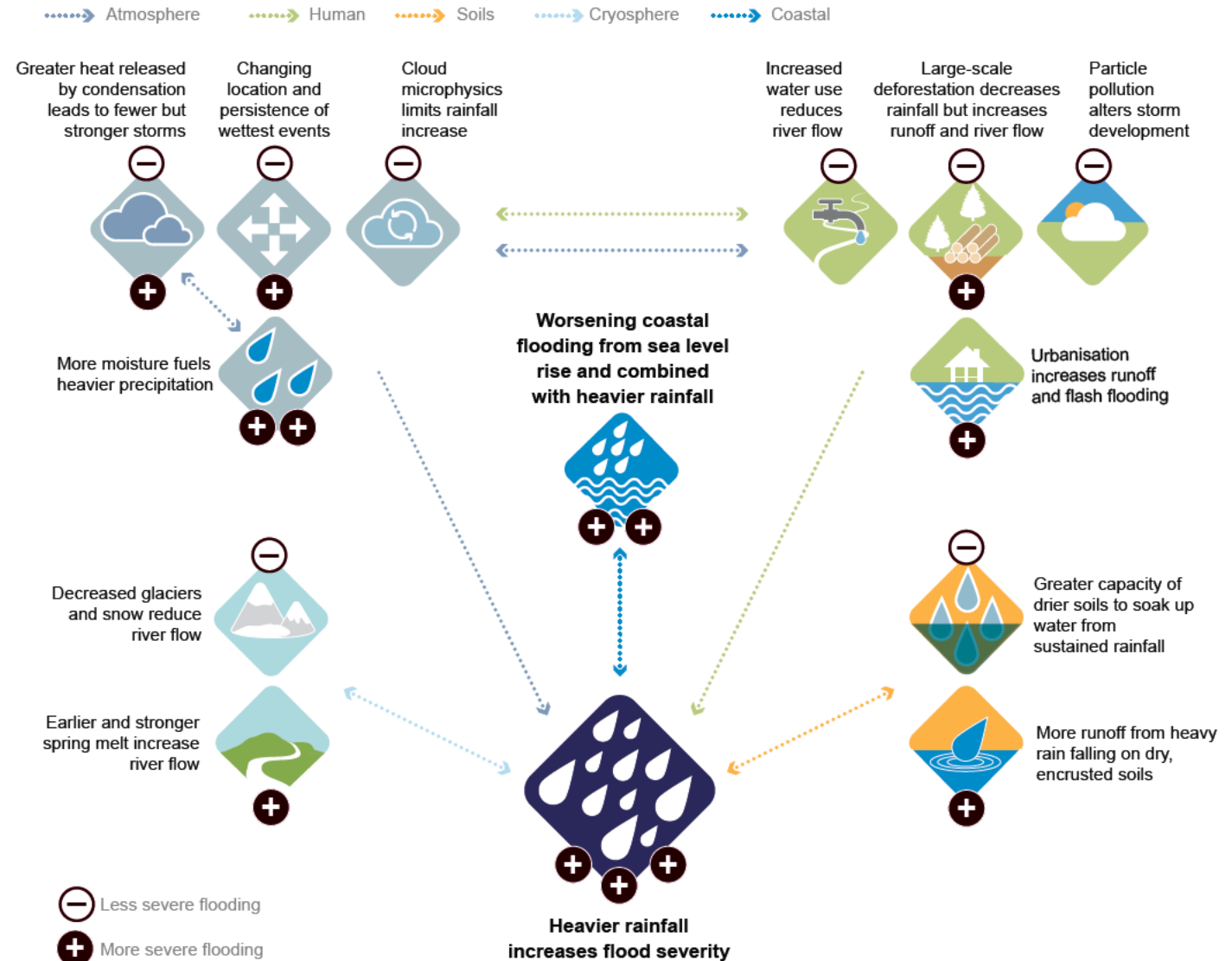
FAQ 8.2 I

Will Floods Become More Severe or More Frequent as a Result of Climate Change?

FAQ 8.2: Causes of more severe floods from climate change

Flooding presents a hazard but the link between rainfall and flooding is not simple.

While the largest flooding events can be expected to worsen, flood occurrence may decrease in some regions.

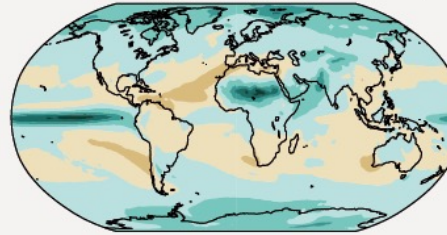


Future Changes in Precipitation, Annual maximum daily precipitation, and Soil Moisture

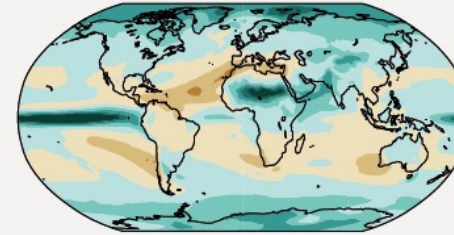
(c) Annual mean precipitation change (%) relative to 1850–1900

Precipitation is projected to increase over high latitudes, the equatorial Pacific and parts of the monsoon regions, but decrease over parts of the subtropics and in limited areas of the tropics.

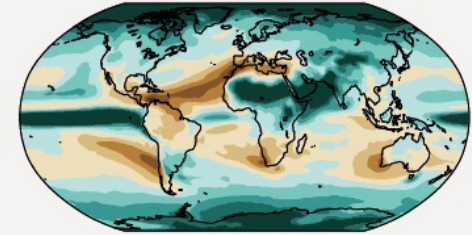
Simulated change at 1.5°C global warming



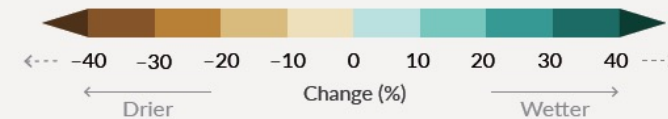
Simulated change at 2°C global warming



Simulated change at 4°C global warming

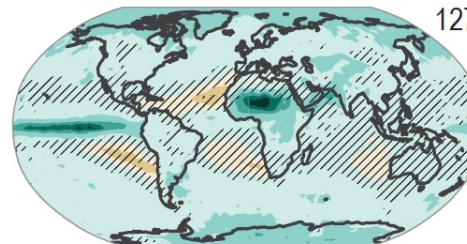


Relatively small absolute changes may appear as large % changes in regions with dry baseline conditions.

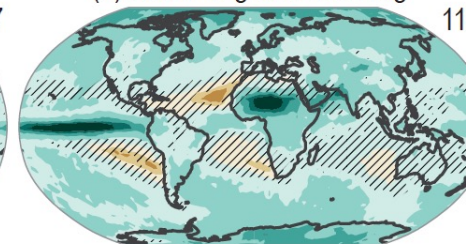


Change in Annual maximum daily precipitation

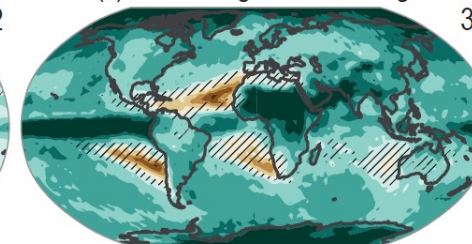
(a) At 1.5°C global warming



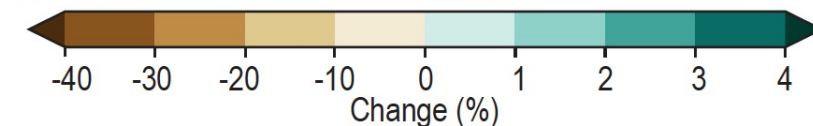
(b) At 2.0°C global warming



(c) At 4.0°C global warming

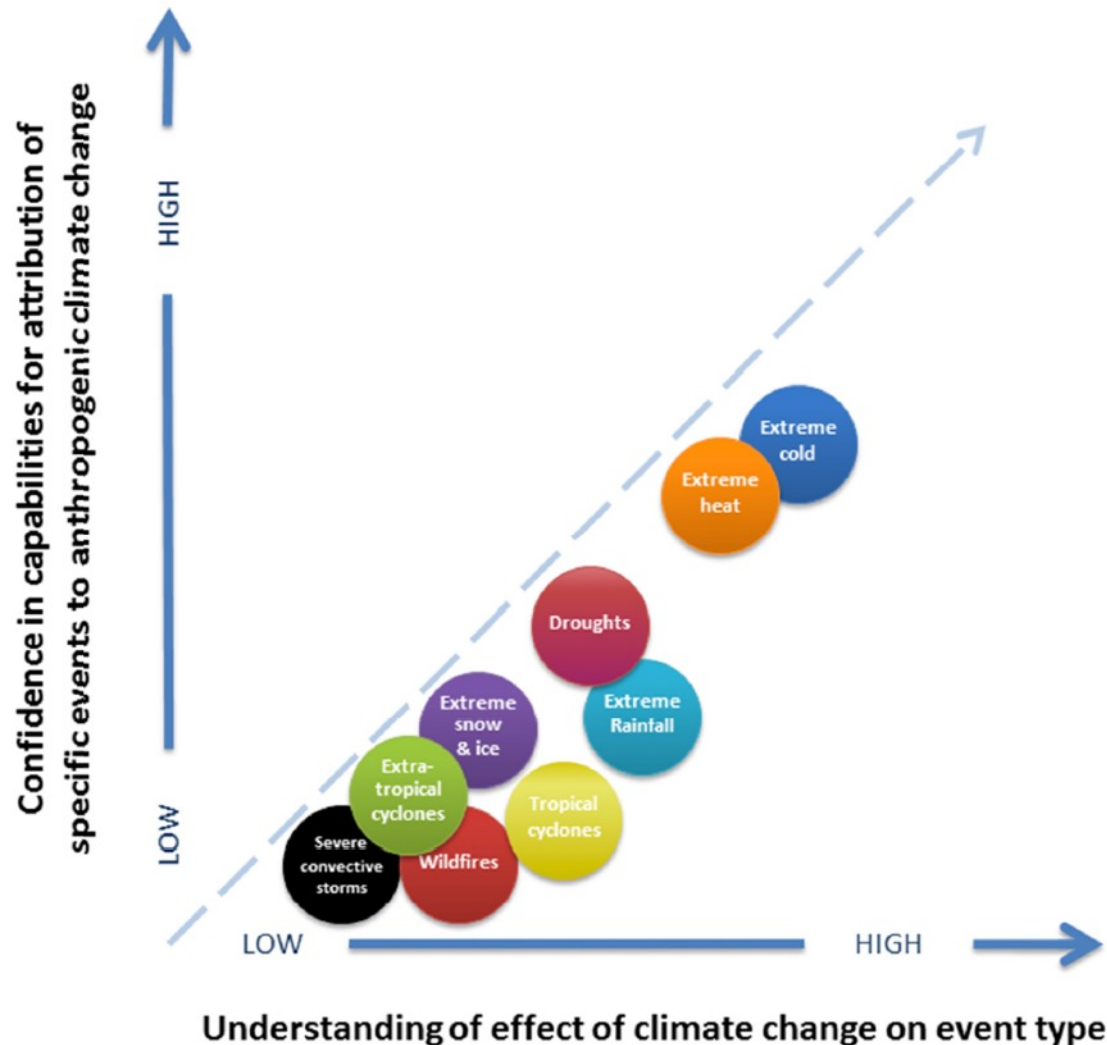


Colour High model agreement
Diagonal lines Low model agreement



Can we tell when a weather
event was affected by climate
change?

Level of confidence in extreme event attribution depends on the type of event



Source: *Attribution of Extreme Weather Events in the Context of Climate Change* (National Academies Press)

Event Attribution: Pakistan Floods (2022)



Home > Extreme rainfall > Climate change likely increased extreme monsoon rainfall, flooding highly vulnerable communities in Pakistan

Climate change likely increased extreme monsoon rainfall, flooding highly vulnerable communities in Pakistan



world weather attribution

- 60-day and 5-day maximum rainfall during the monsoon season for the Indus basin and the provinces of Sindh & Balochistan
- Return time ~ 1 in 100 years in today's climate.
- 5-day maximum rainfall over Sindh and Balochistan is now about 75% more intense than it would have been without the 1.2C warming
- 60-day rain across the basin is now about 50% more intense.
- Climate models struggle to simulate these rainfall characteristics.
- The devastating impacts were also driven by the proximity of human settlements, infrastructure (homes, buildings, bridges), and agricultural land to flood plains, inadequate infrastructure, etc.....

Household (HH) factors contributing to vulnerability to floods

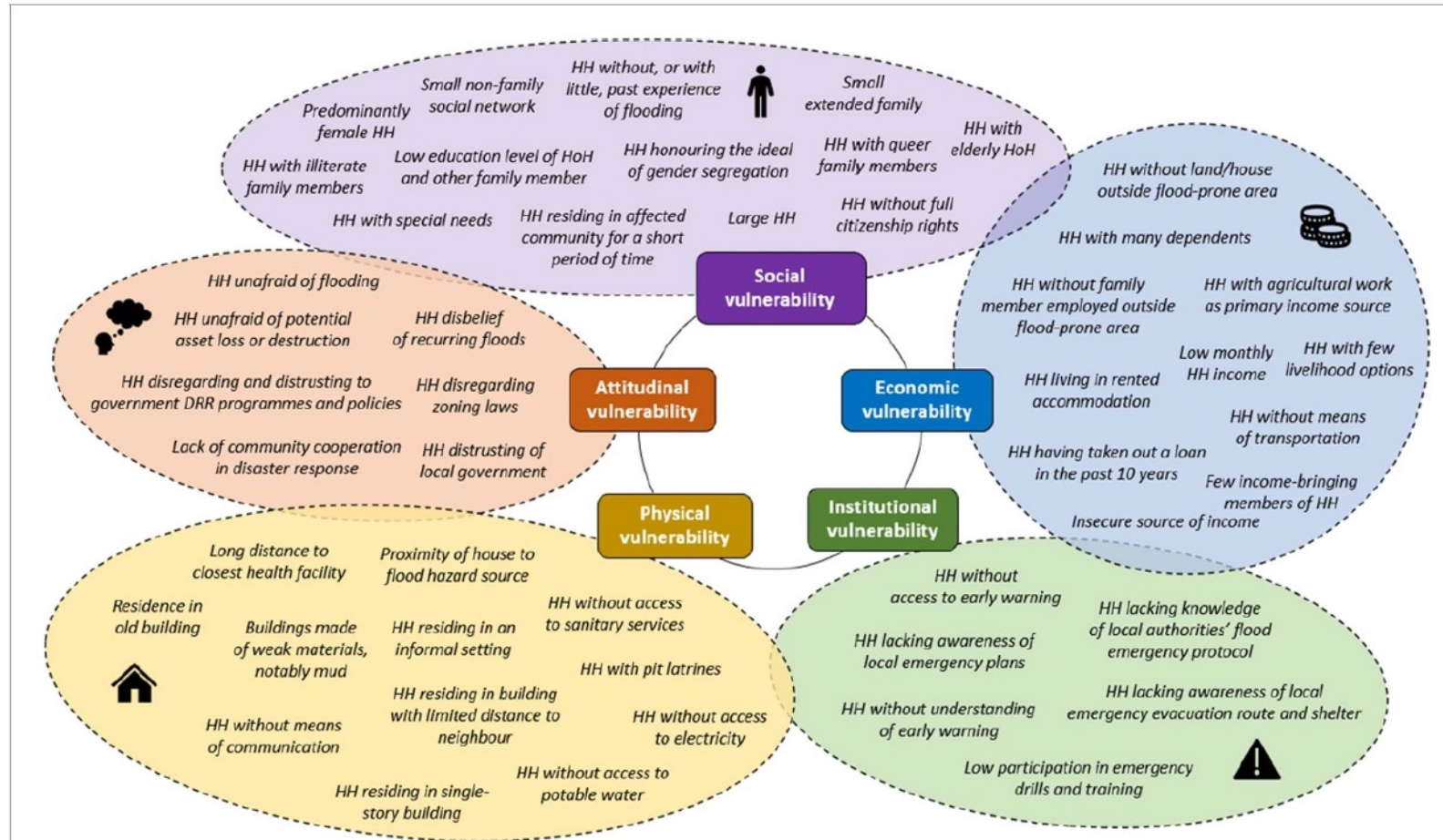


Figure 15. A visual representation of household (HH) factors contributing to vulnerability to floods in Pakistan categorised by types of vulnerability developed in (Rana and Routray 2018) based on empirical evidence and evidence from studies across Pakistan (Mustafa *et al* 2015, Sadia *et al* 2016, Shah *et al* 2018, Memon 2020, Ajani and van der Geest 2021, Anjum and Fraser 2021).

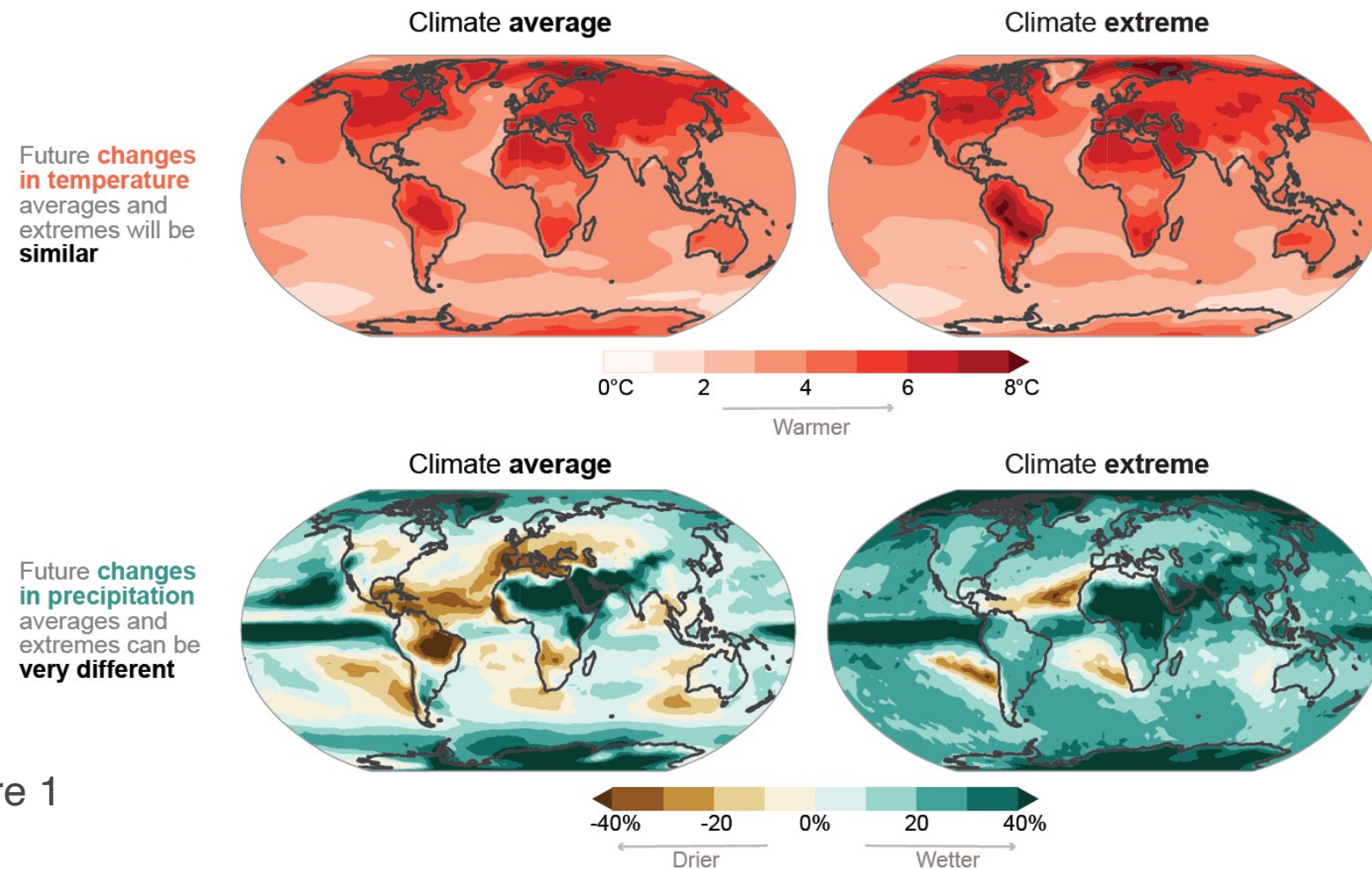
Source: Otto *et. Al*. *Env. Res. Clim.* (2023)

Thanks

- The projected increase in heavy precipitation extremes translates to an increase in the frequency and magnitude of pluvial floods (**high confidence**)

FAQ 11.1: How will changes in climate extremes compare with changes in climate averages?

The direction and magnitude of future changes in climate extremes and averages depend on the variable considered.



IPCC AR6 WG-I FAQ 11.1, Figure 1