



International Institute for
Applied Systems Analysis

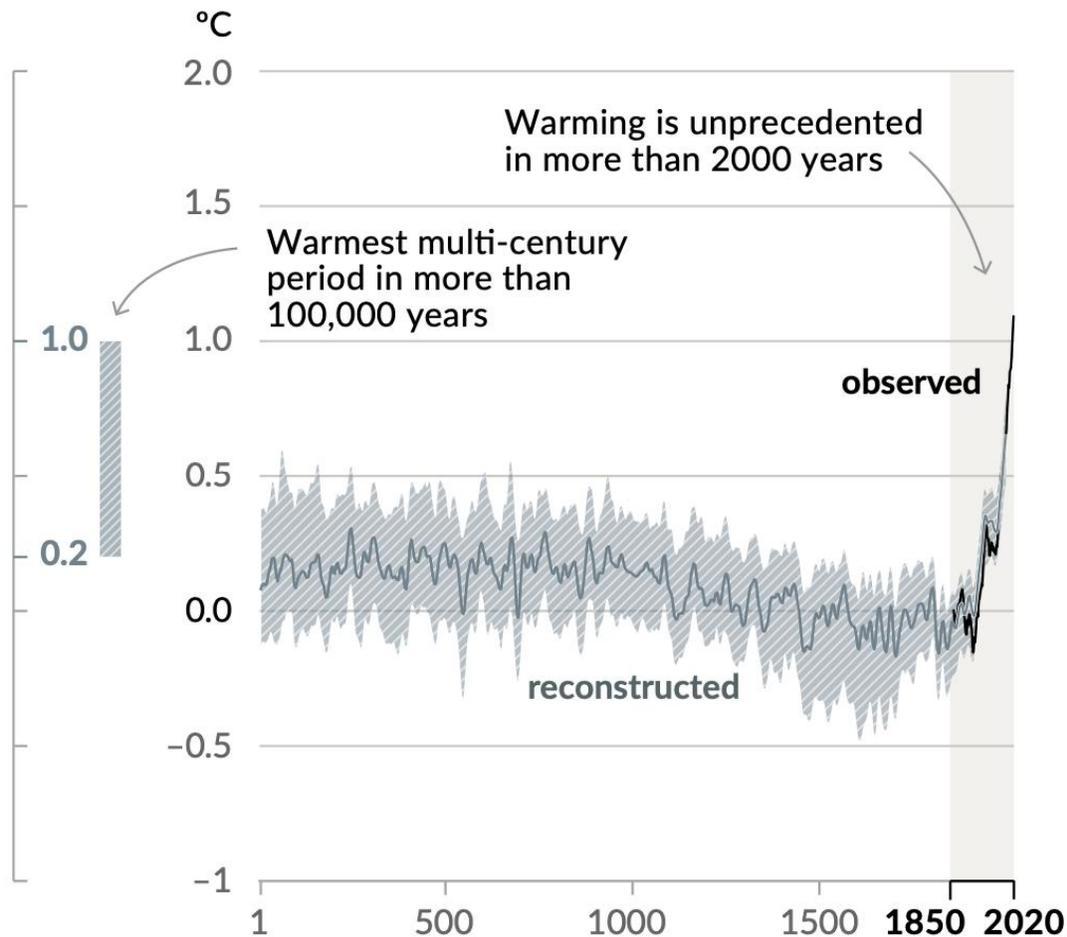
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Foundations of Climate Adaptation: Scientific evidence and Key Concepts

Carl Schleussner

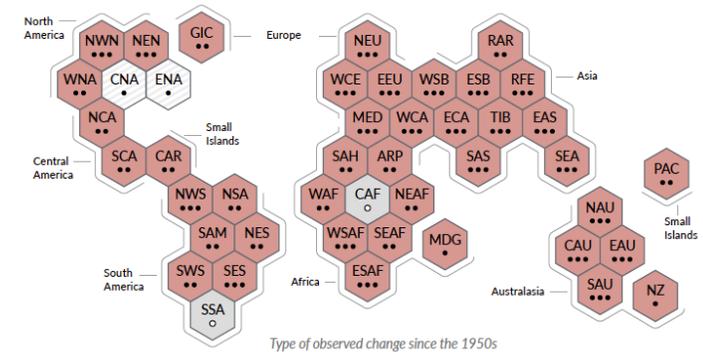
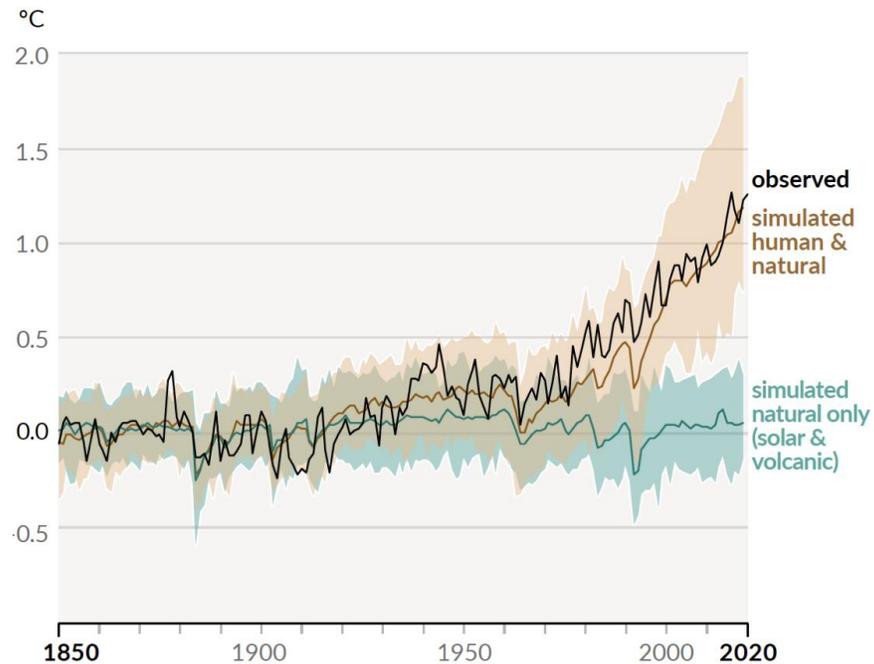
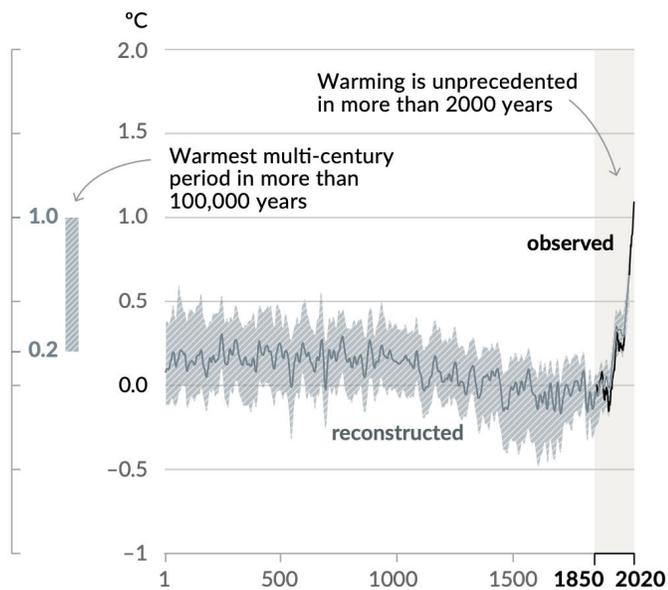
Oct 14 2024

Unprecedented Climate Change is here



- Many changes in the climate system are **unprecedented over many centuries to many thousands of years.**
- **CO2 concentrations: Highest in >2 million years**
- **CH4 and N2O highest in 800.00 years**
- **Global Temperatures: above any period in the last 125.000 years**

Unprecedented Climate Change is here



Many changes in the climate system are **unprecedented over many centuries to many thousands of years.**

It is **unequivocal** that human influence has warmed the atmosphere, ocean and land. – by about 1.3°C so far.

Human-induced climate change is affecting **extreme events in every region** across the globe.

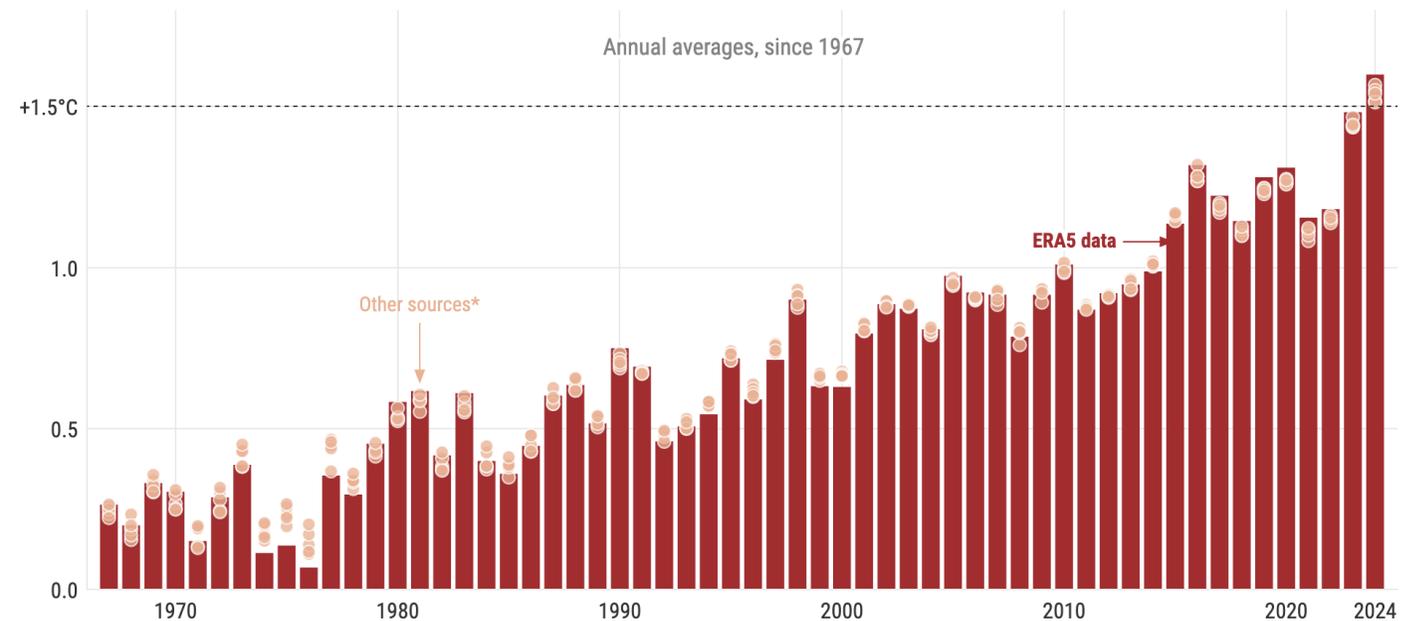
The first year above 1.5°C and more to come

- Climate change is accelerating and the planet warms at a record rate of about 0.25°C per decade
- 2024 was in most records the first year above 1.5°C – doesn't mean we are at 1.5°C yet but might reach it around 2030
- Indication that this means that we need to expect that the impacts of a 1.5°C world will emerge



Global surface temperature: increase above pre-industrial

Reference period: pre-industrial (1850–1900) • Credit: C3S/ECMWF

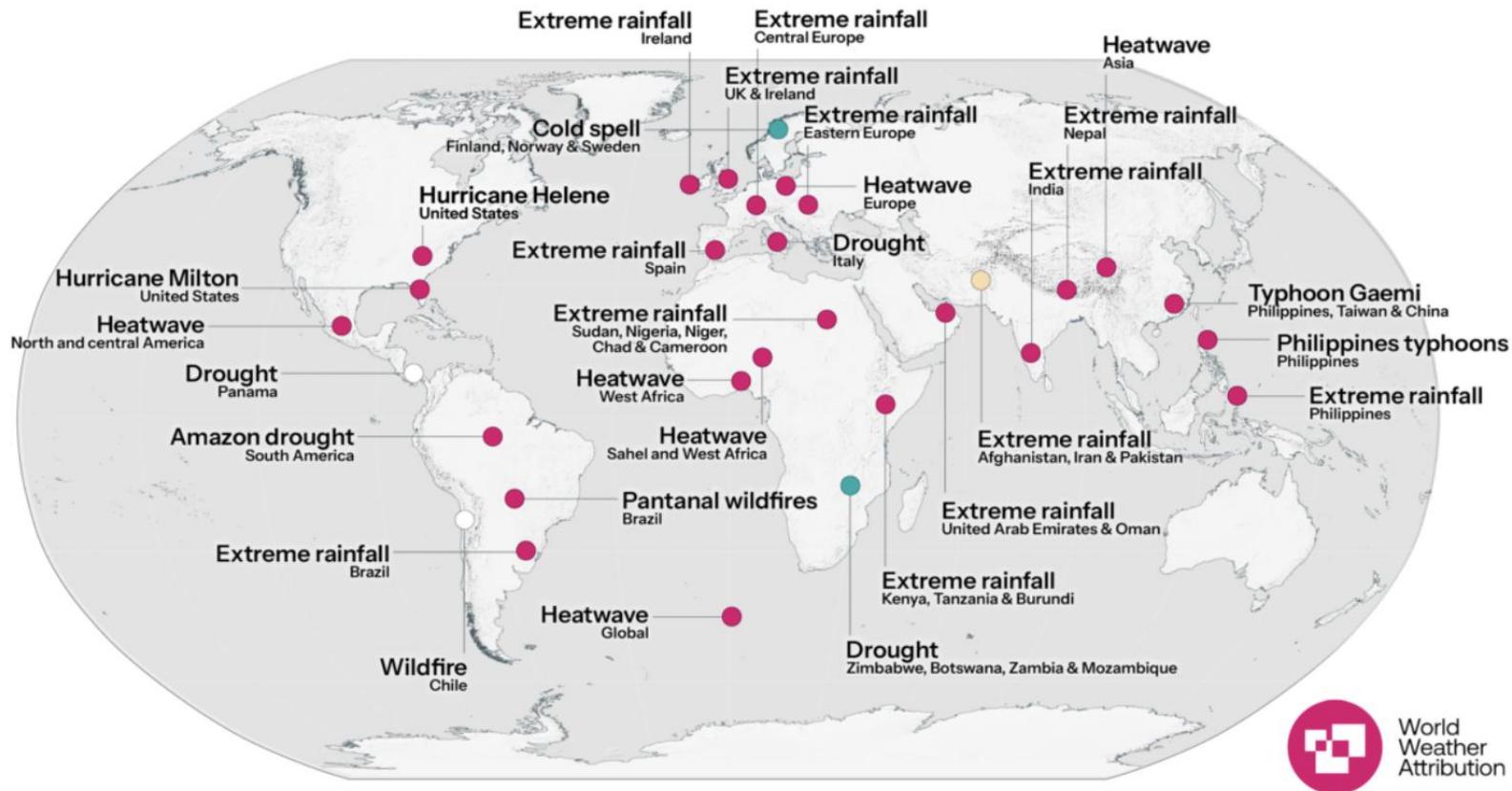


*Other sources comprise JRA-3Q, GISTEMPv4, NOAA GlobalTempv6, Berkeley Earth, HadCRUT5.

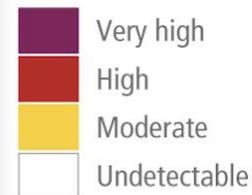
Expe

World Weather Attribution studies 2024

● More severe / likely ○ No evidence of change ● Less severe / likely ● Inconclusive



Risk/impact



Transition range

Confidence level assigned to transition range



▶ Historical average temperature increase in 2011–2020 was 1.09°C (dashed line) range 0.95–1.20°C



- Impacts & risks for threatening low lying coral reefs
- High risk weather

systems systems impacts systems

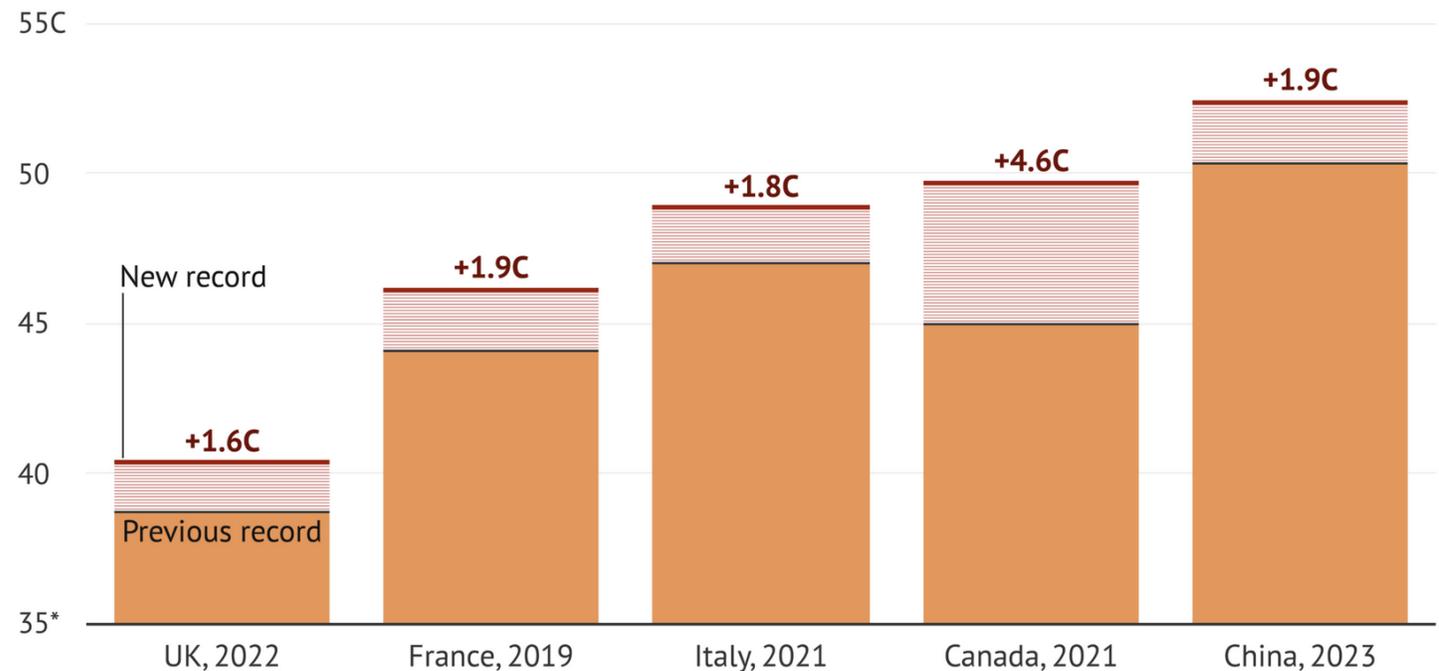
IPCC (2022)

Records are being shattered

- Climate change is accelerating and so are extreme events
- This leads to a rise in record shattering extremes and the widening of the 'climate experience gap'

'Record-shattering' heat extremes are on the rise

National maximum temperature records that were broken by large margins over 2019-23, C

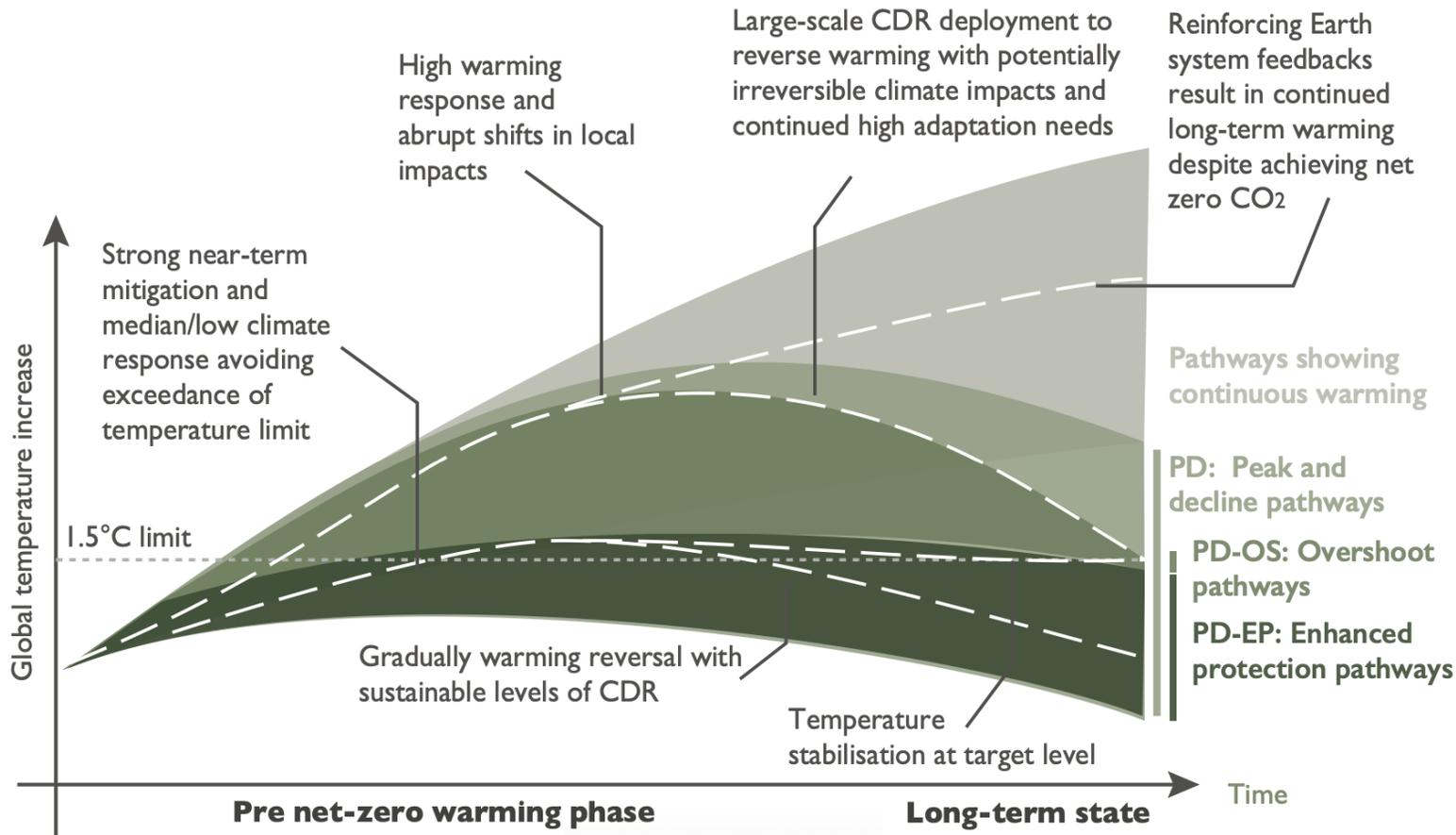


*Truncated axis

Source: World Weather Attribution and media reports

CarbonBrief
CLEAR ON CLIMATE

Overshoot, peak and decline pathways



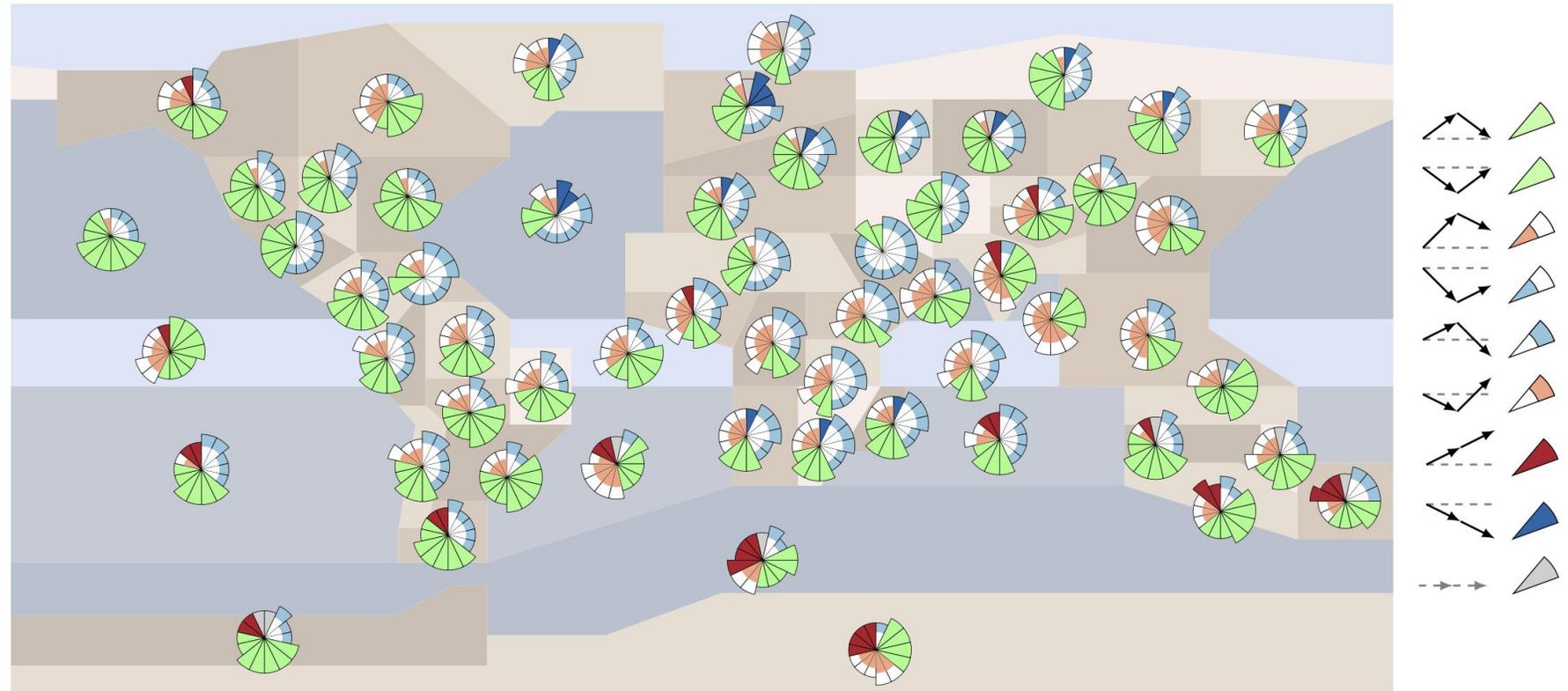
Schleussner et al (2024)

- Overshoot is not 'another' way to achieve the same climate outcome
- Need to consider a wide range of possible climate outcomes rather than 'narrowing in' on best estimate outcomes
- **Overshoot is just one outcome for peak and decline pathways**

Reversibility of regional climate after overshoot?

- Wide range of different long-term outcomes after overshoot in particular over oceans (only light green is actual reversal)
- Both continuous cooling and warming are possible
- Even less clear picture for precipitation and extreme event indicators

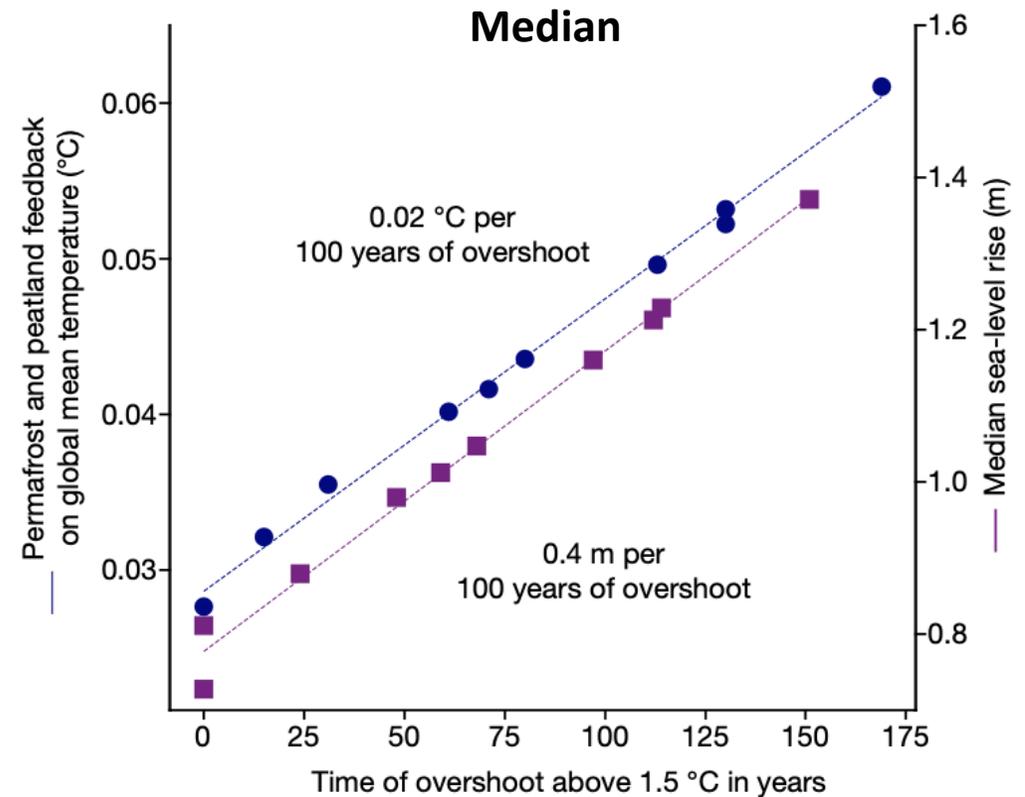
Evolution of regional annual mean temperature around peak warming



Pfleiderer et al (2024)

Irreversible impacts – the overshoot legacy

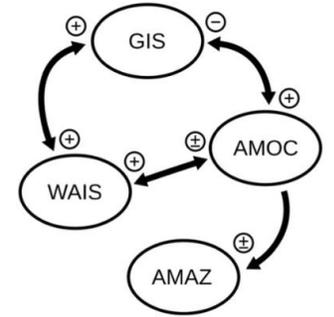
- Wide range of potentially irreversible impacts
- Cryosphere impacts largely irreversible on human timescales
- What about biodiversity risks, species extinction?



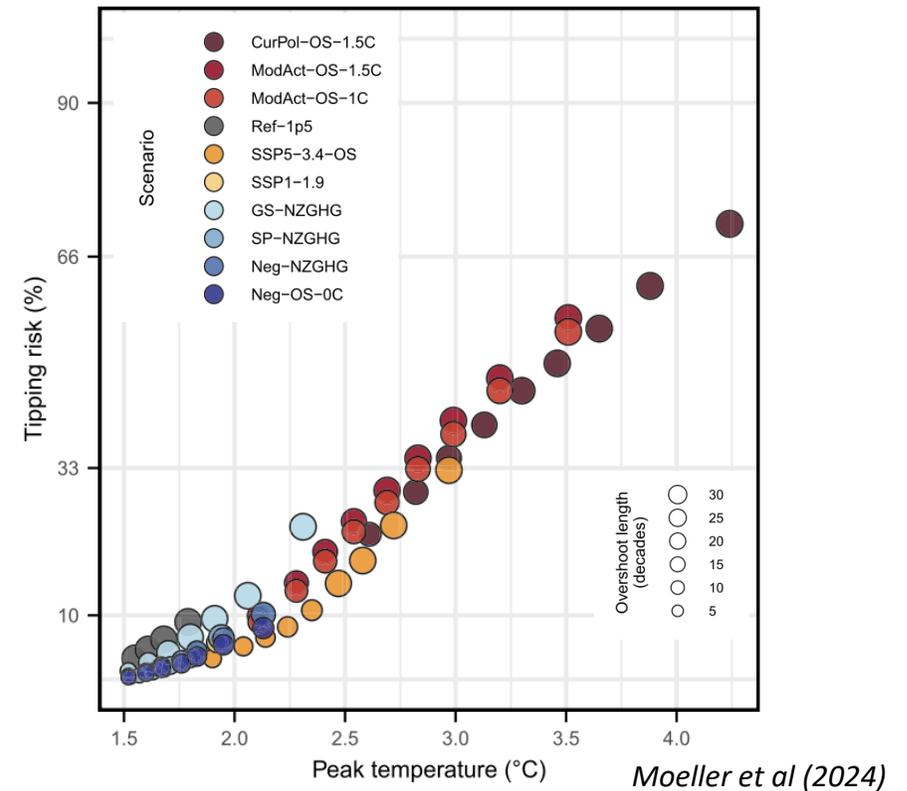
Schleussner et al (2024)

Tipping risks under overshoot

- 45% tipping risk by 2300 for current policy scenarios even if temperatures are brought back to below 1.5 °C.
- Tipping risk by 2300 increases with every additional 0.1 °C of overshoot above 1.5 °C and strongly accelerates for peak warming above 2.0 °C.
- **Caveats:** Neither tipping points nor response times well constrained



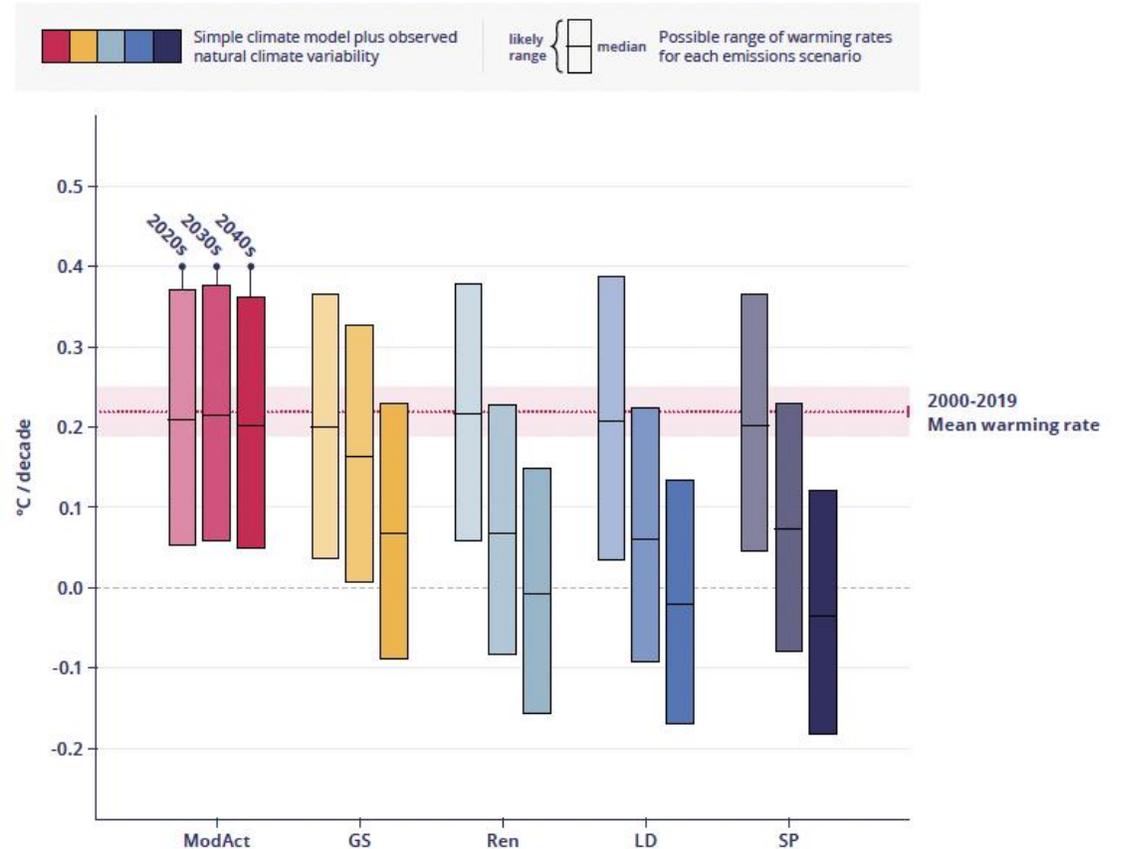
Tipping risk by 2300 for all overshoot trajectories



The imperative of near-term emission reductions

- Halving emissions in the 2020s (in line with C1 pathways) means **halving the warming rate in the 2030s**, and halting warming in the 2040s
- Slowing-down climate change critical to enable adaptation – **but climate risks will increase for decades to come**

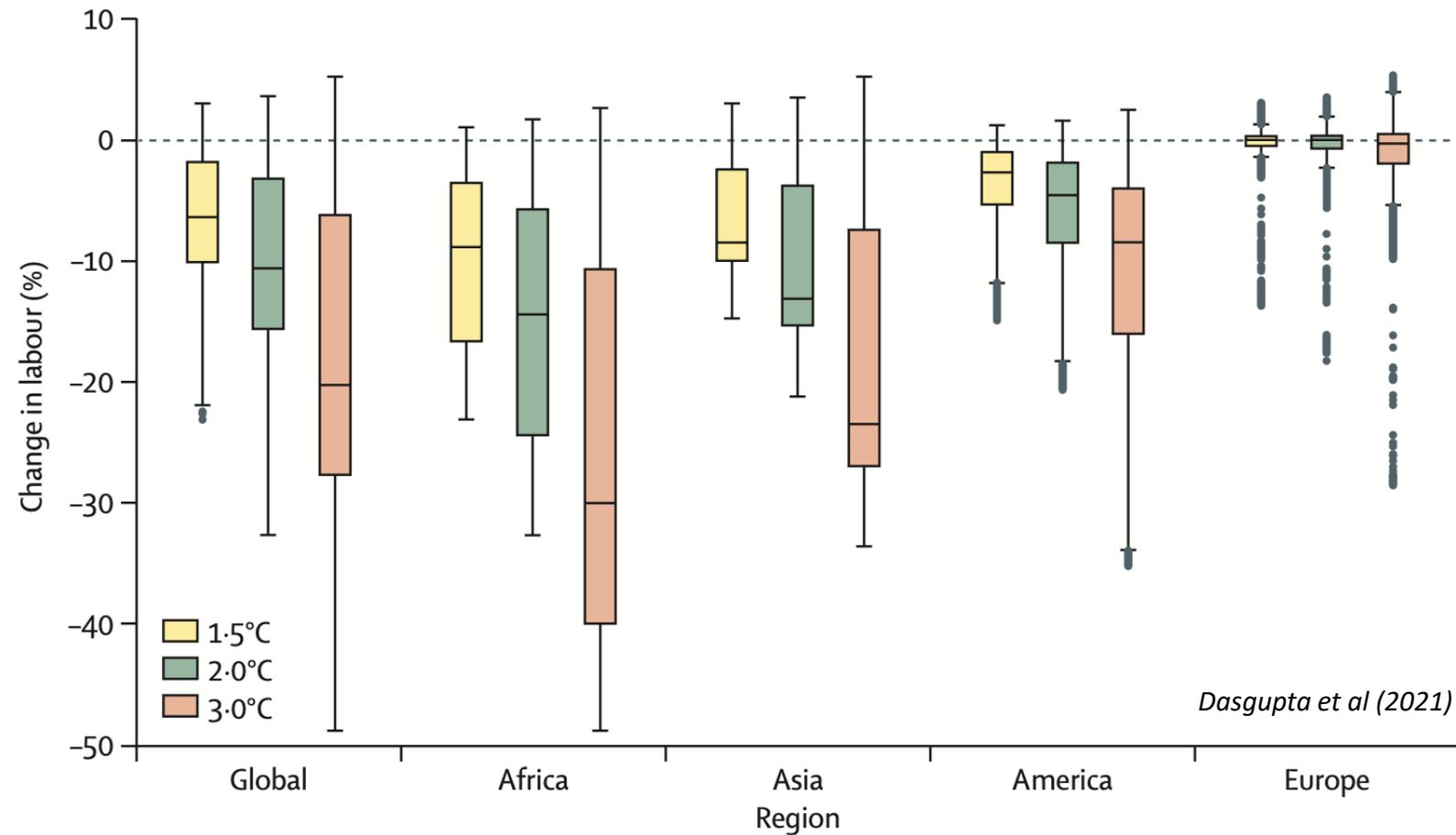
NEAR-TERM GLOBAL WARMING RATES



CONSTRAN (2022)

A hot future is a less productive one

- Substantial reductions in physical labour productivity (outdoor) with climate change
- Particularly pronounced in tropical regions
- Fundamental risk to sustainable development objectives

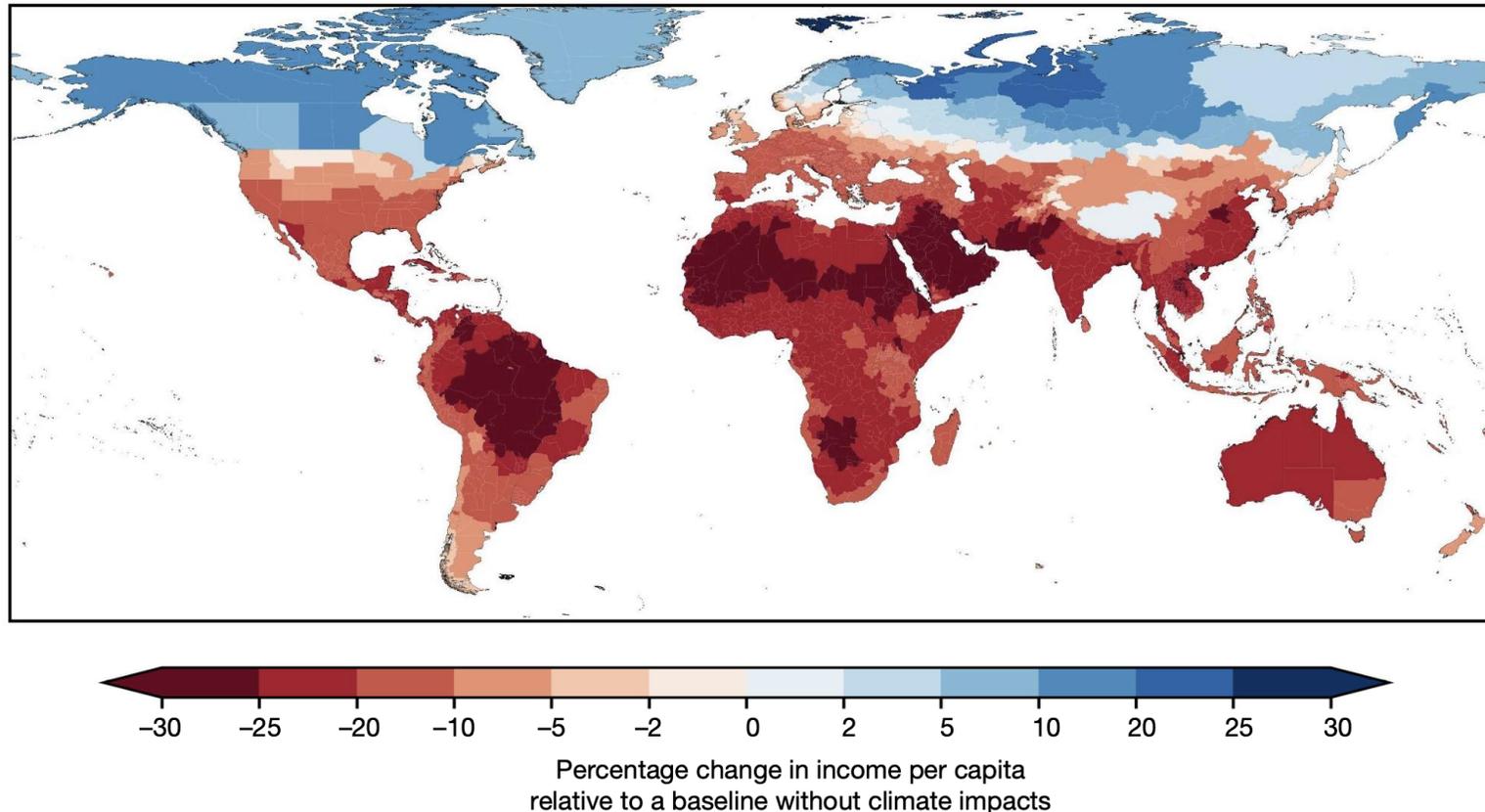


Dasgupta et al (2021)

Climate change impedes economic prospects

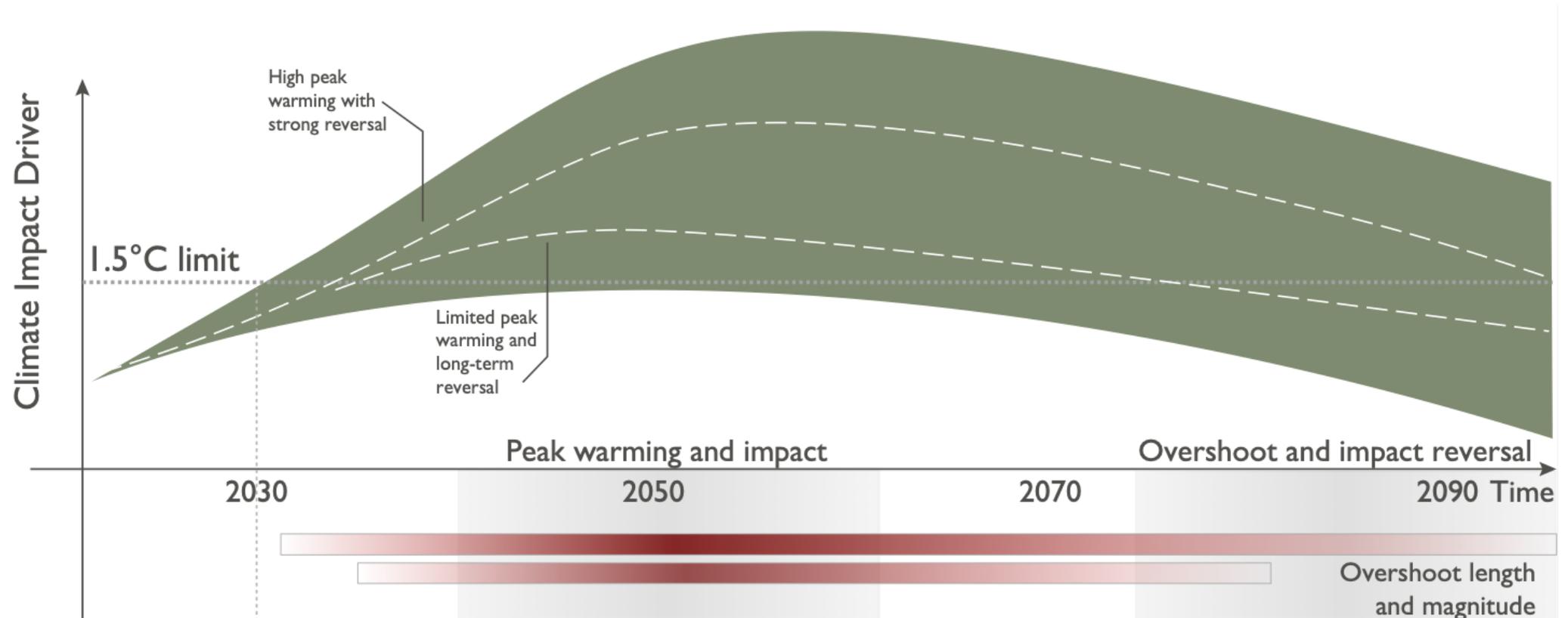
- Relative to no-CC baseline, climate change might result in income reduction by about 20% in 2050 – more than 6x the global mitigation costs
- Losses concentrate in tropical regions

The committed economic damages of climate change in 2050



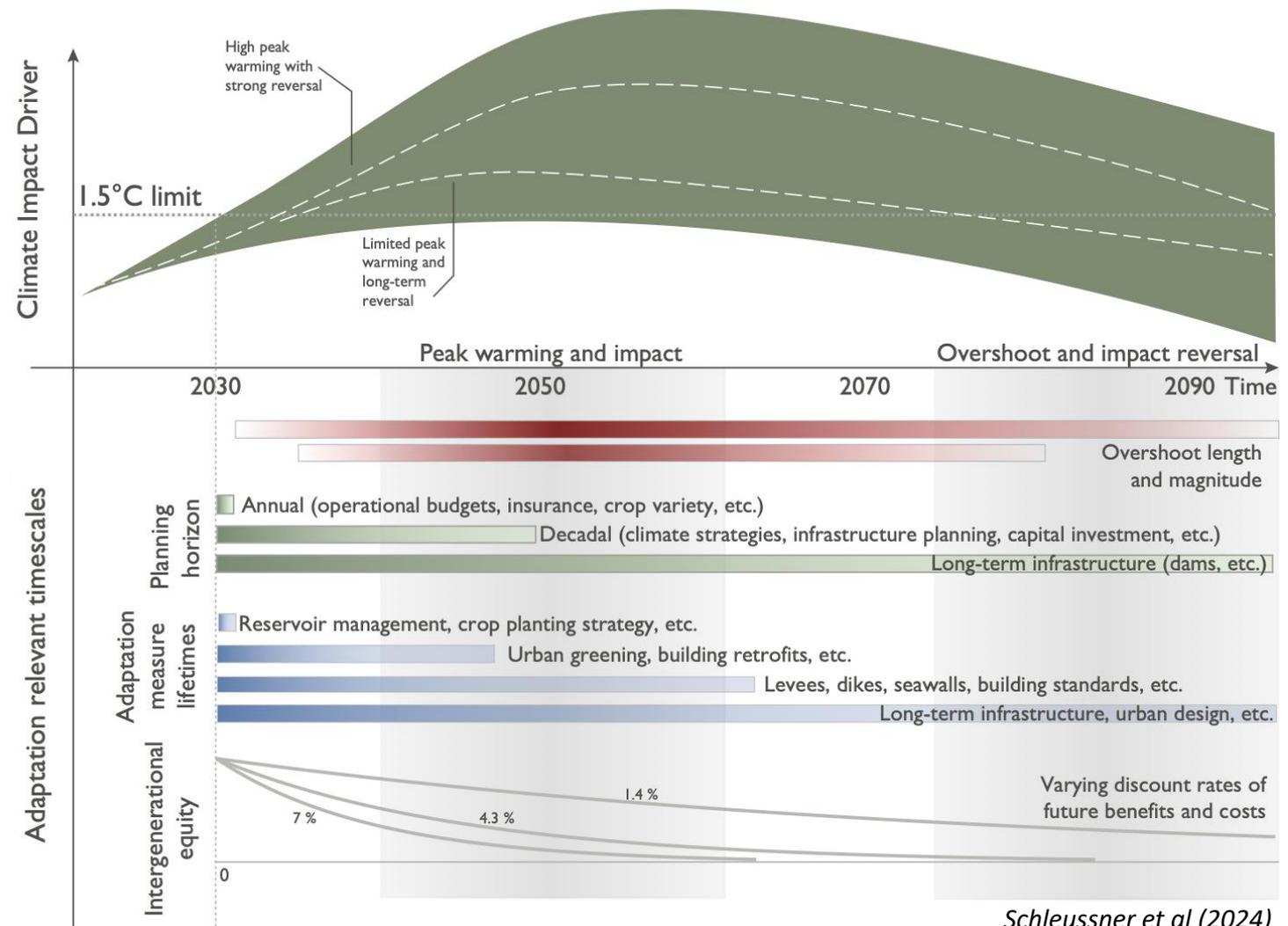
Kotz et al (2024)

Overshoot is at best a multi-decadal commitment



Overshoot and adaptation

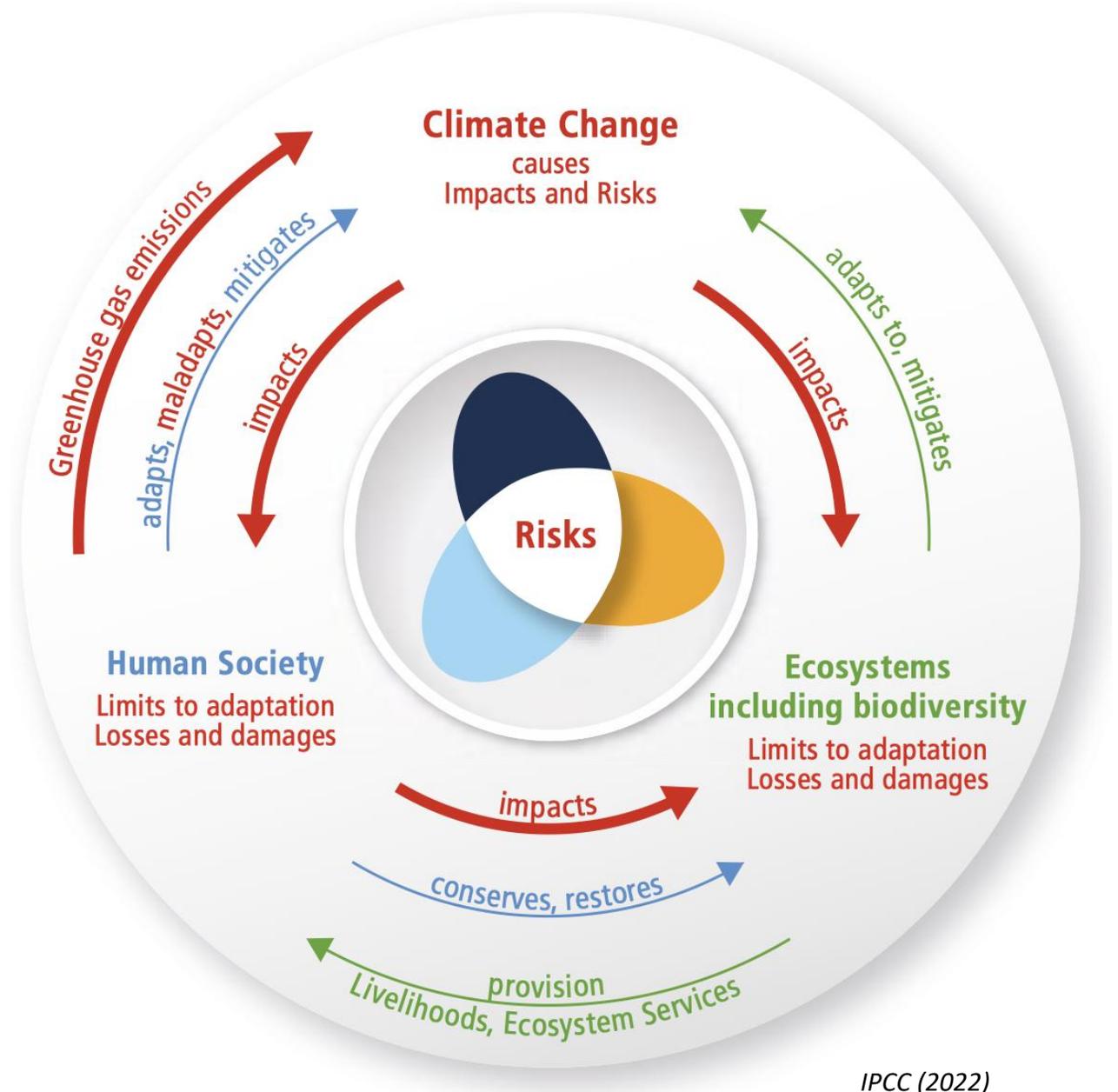
- Timescales of temperature reversal exceed most planning horizons and adaptation measure lifetimes
- Potential benefits in the far future are discounted 'away' in cost-benefit-analyses
- **Peak warming rather than long-term warming outcomes may drive adaptation needs and costs**



Schleussner et al (2024)

The imperative of climate adaptation

- Ever increasing climate risks require substantial efforts in adaptation
- Substantial adaptation gap apparent today



The risk propeller shows that risk emerges from the overlap of:

● Climate hazard(s)

● Vulnerability

● Exposure

...of human systems, ecosystems and their biodiversity

IPCC (2022)

Vulnerability, exposure and climate hazard

- Interaction of climate hazards with **exposure** and **vulnerability** drives climate risks
- Risks structurally depend on socio-economic development and other drivers -> but climate adaptation requires strong climate rationale



The risk propeller shows that risk emerges from the overlap of:

● Climate hazard(s)

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...of human systems, ecosystems and their biodiversity

IPCC (2022)

The challenge of climate attribution

(b) Observed impacts of climate change on human systems

Human systems	Impacts on water scarcity and food production				Impacts on health and wellbeing				Impacts on cities, settlements and infrastructure				Confidence in attribution to climate change
	Water scarcity	Agriculture/crop production	Animal and livestock health and productivity	Fisheries yields and aquaculture production	Infectious diseases	Heat, malnutrition and other	Mental health	Displacement	Inland flooding and associated damages	Flood/storm induced damages in coastal areas	Damages to infrastructure	Damages to key economic sectors	
Global	+	-	○	-	-	-	-	-	-	-	-	-	High or very high
Africa	-	-	-	-	-	-	○	-	-	-	-	-	Medium
Asia	±	±	-	-	-	-	-	-	○	-	-	-	Medium
Australasia	±	-	±	-	○	-	-	not assessed	○	-	-	-	Medium
Central and South America	±	-	±	-	-	-	not assessed	-	-	○	-	-	Medium
Europe	±	±	-	±	-	-	-	○	-	○	-	-	Medium
North America	±	±	-	±	-	-	-	-	-	-	-	-	High or very high
Small Islands	-	-	-	-	○	-	○	-	-	-	-	-	High or very high
Arctic	±	±	-	-	-	-	-	○	-	-	-	+	High or very high
Cities by the sea	○	○	○	-	○	-	not assessed	-	○	-	-	-	Evidence limited, insufficient
Mediterranean region	-	-	-	-	○	-	not assessed	○	±	○	○	-	Evidence limited, insufficient
Mountain regions	±	±	-	○	-	-	○	-	-	na	-	-	High or very high

Confidence in attribution to climate change

- High or very high
- Medium
- Low
- Evidence limited, insufficient
- na Not applicable

Impacts to human systems in panel (b)

- Increasing adverse impacts
- ± Increasing adverse and positive impacts

IPCC (2022)

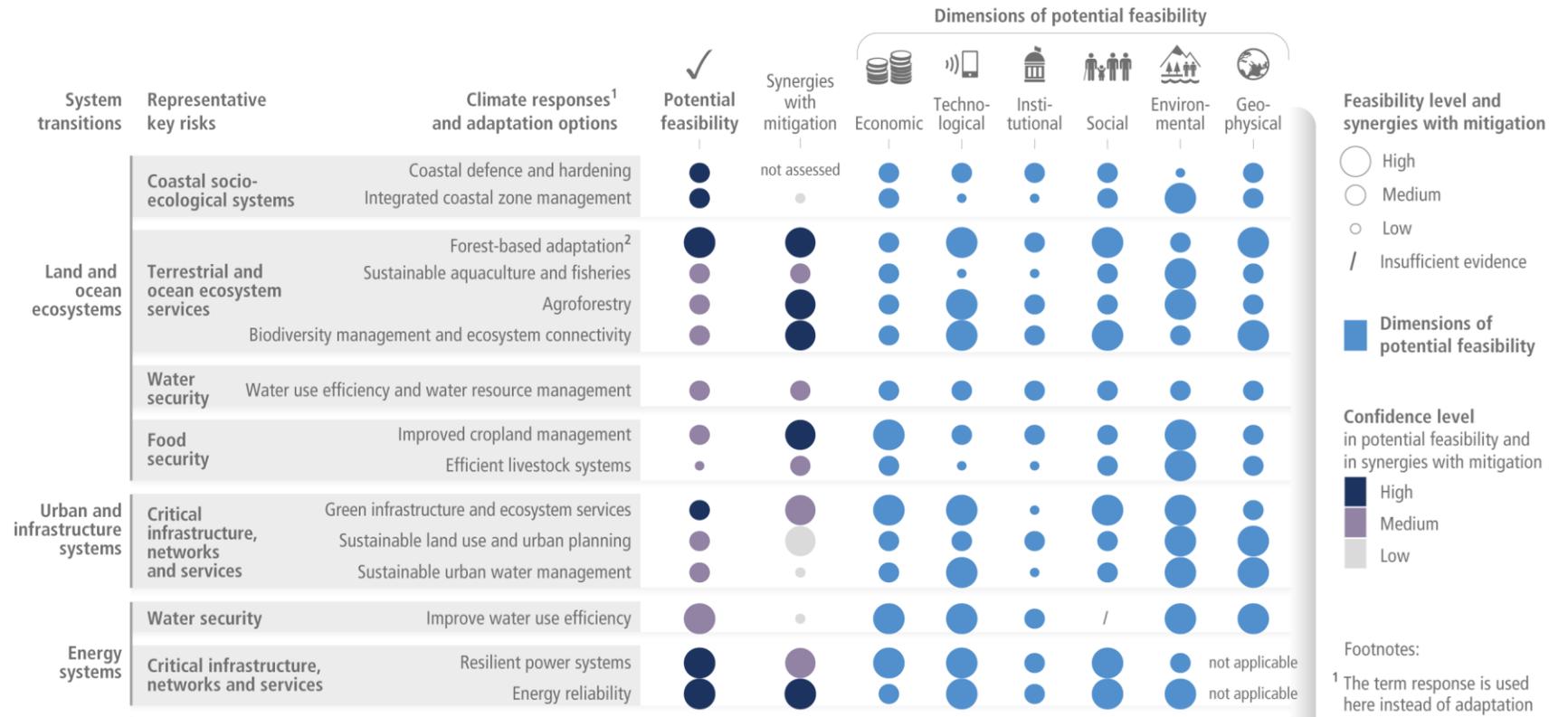
Typologies of climate impacts and adaptation actions



Adaptation need by climate impact type	Description	Recent climate impact examples
Hazard dominated	Climate pressure dominates; focus on climate information and attribution front and center, with a view to prepare for the unprecedented	Heat wave with more than 50°C in Saudi Arabia, June 2024
Exposure dominated	Responses to impact overlap with measures focusing on classical disaster risk reduction	Severe flooding in Brazil, April 2024
Vulnerability dominated	Responses overlap with measures focussing on sustainable development	Persistent drought in the Horn of Africa, since 2020

Adaptation options and development synergies

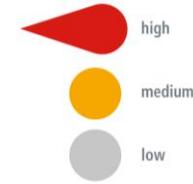
- Adaptation options need to be implemented locally and be feasible in a local context
- Substantial potential for synergies with mitigation



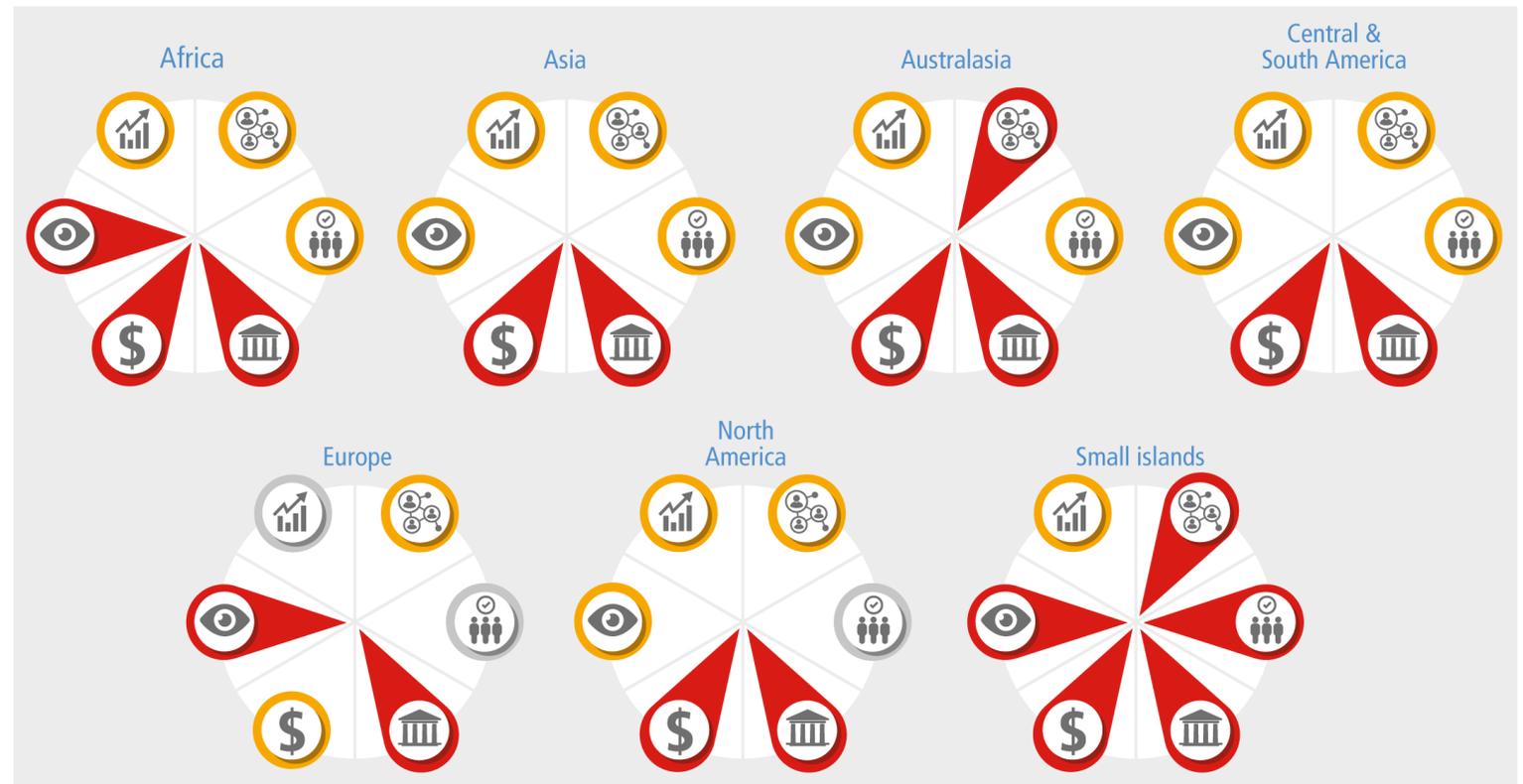
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Constraints to adaptation

Constraints associated with limits to adaptation for regions across

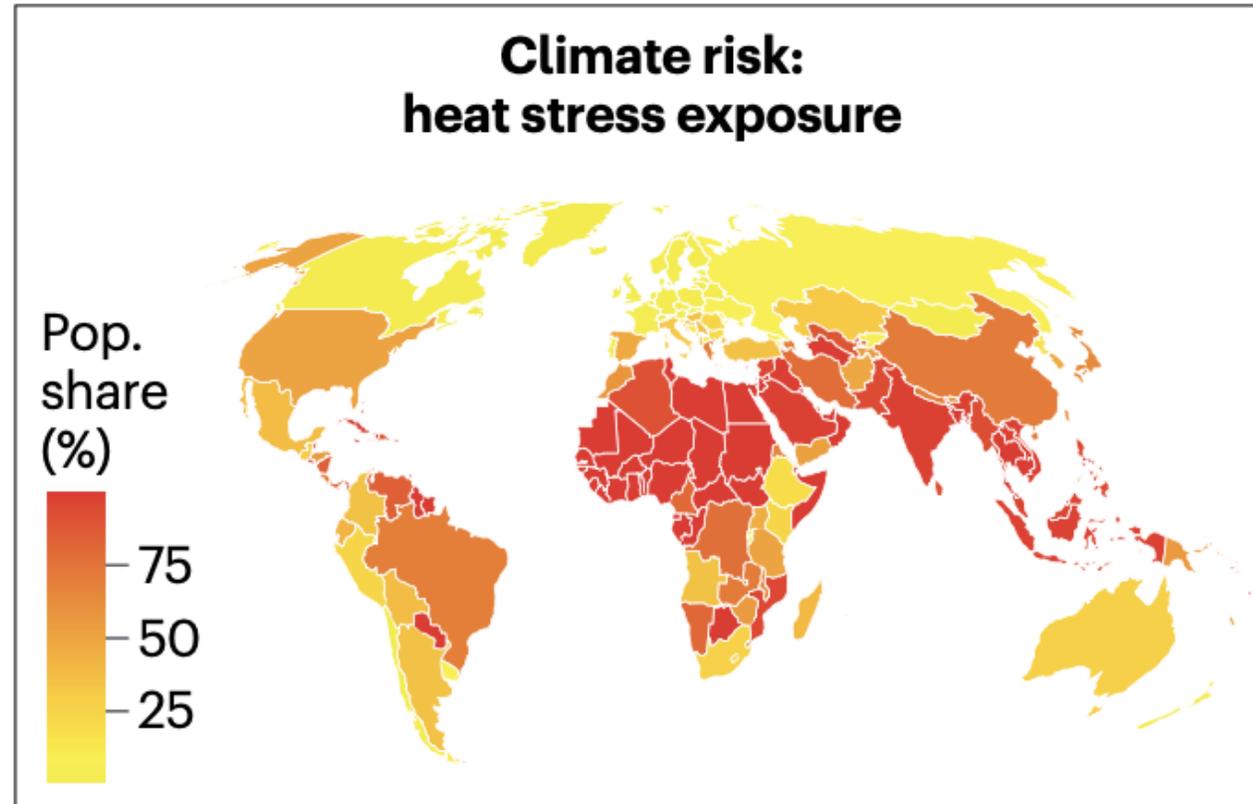


- Adaptation actions are constrained by different dimensions of socio-economic development
- Overcoming adaptation constraints key for climate resilience



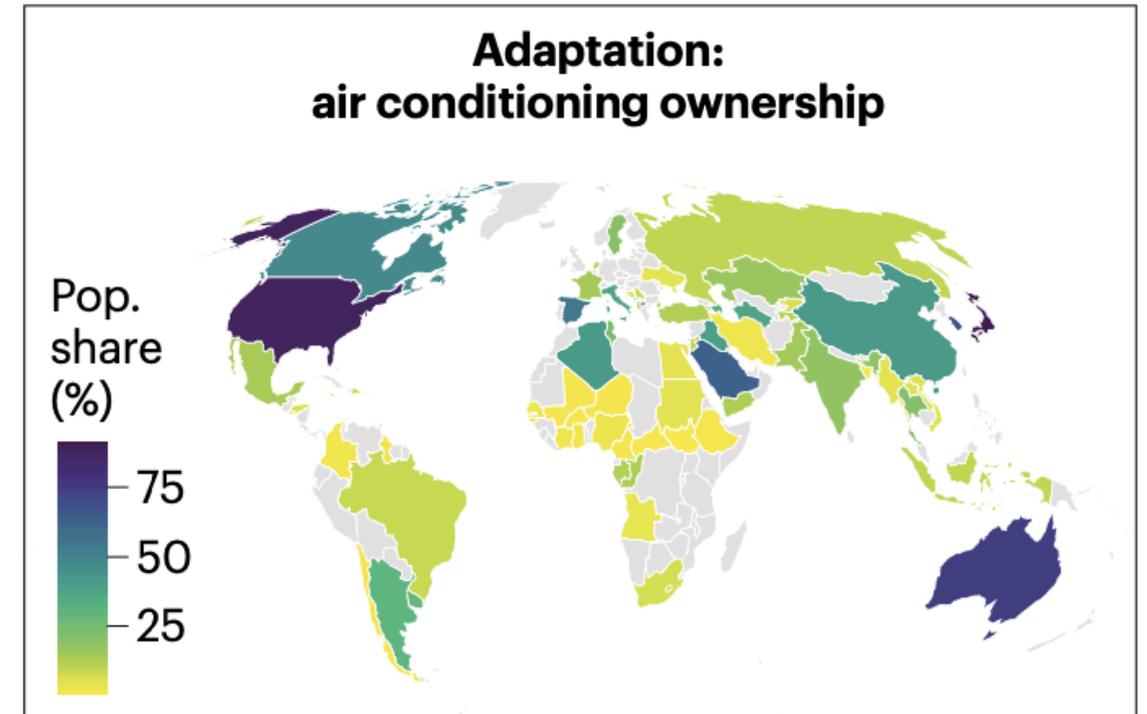
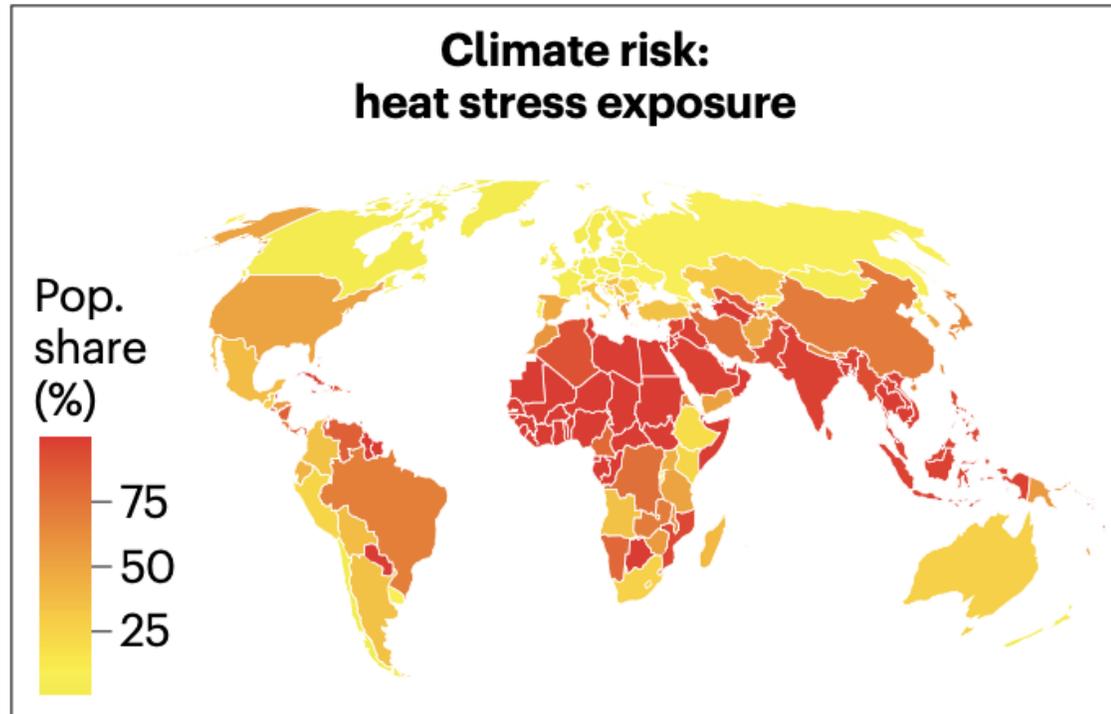
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Closing the adaptation gap – a long shot



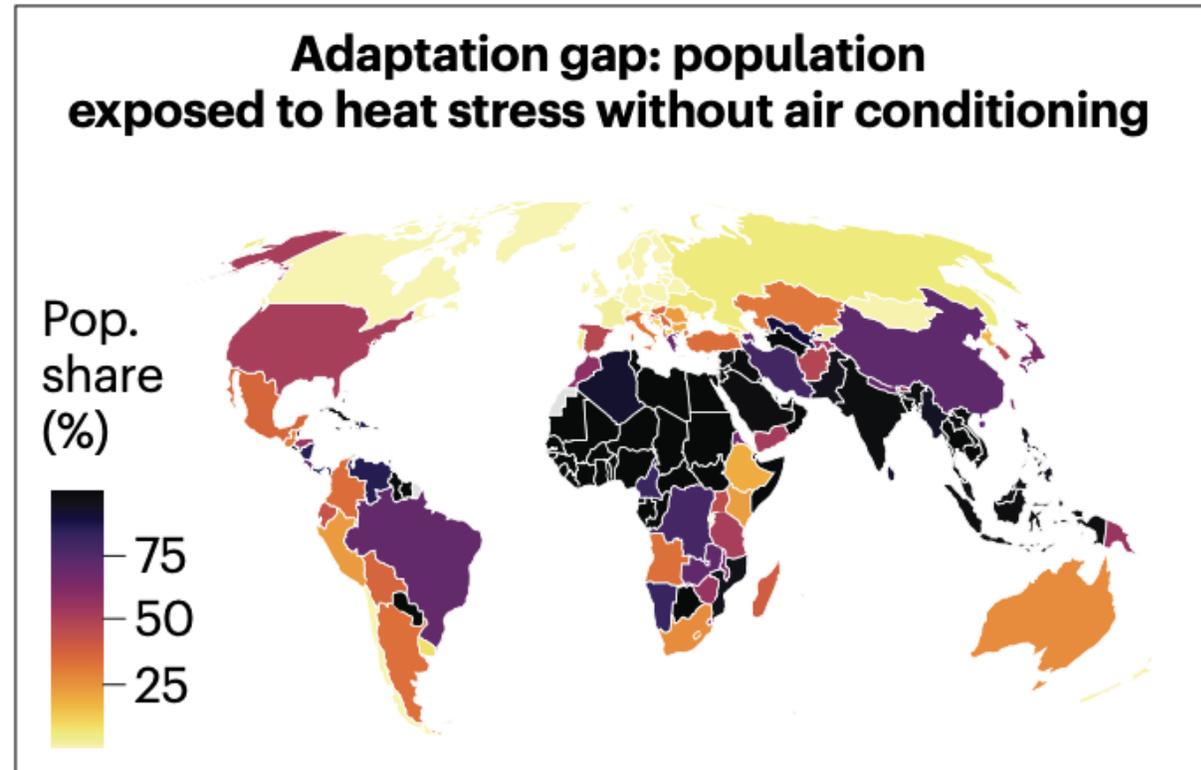
Andrijevic et al (2023)

Closing the adaptation gap – a long shot



Andrijevic et al (2023)

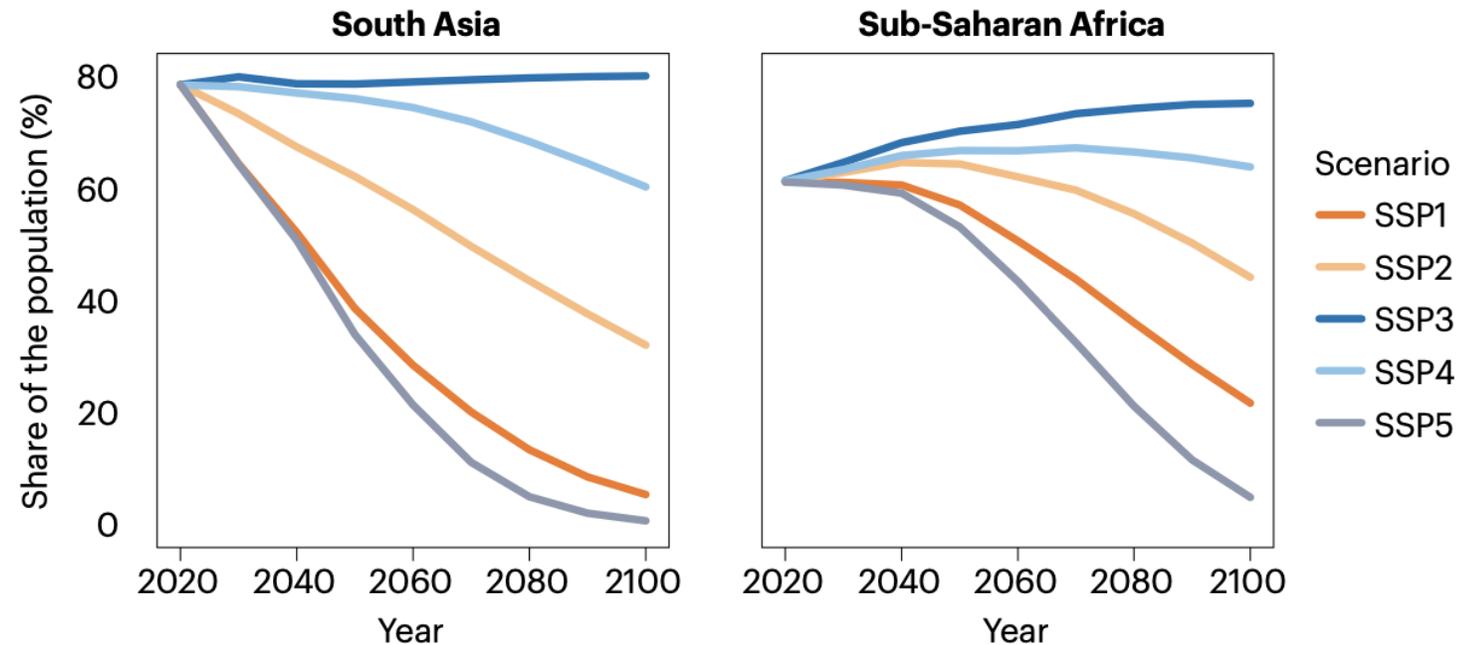
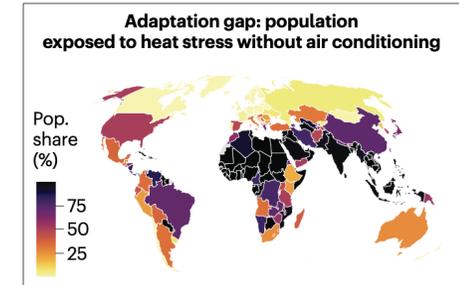
Closing the adaptation gap – a long shot



Andrijevic et al (2023)

Closing the adaptation gap – a long shot

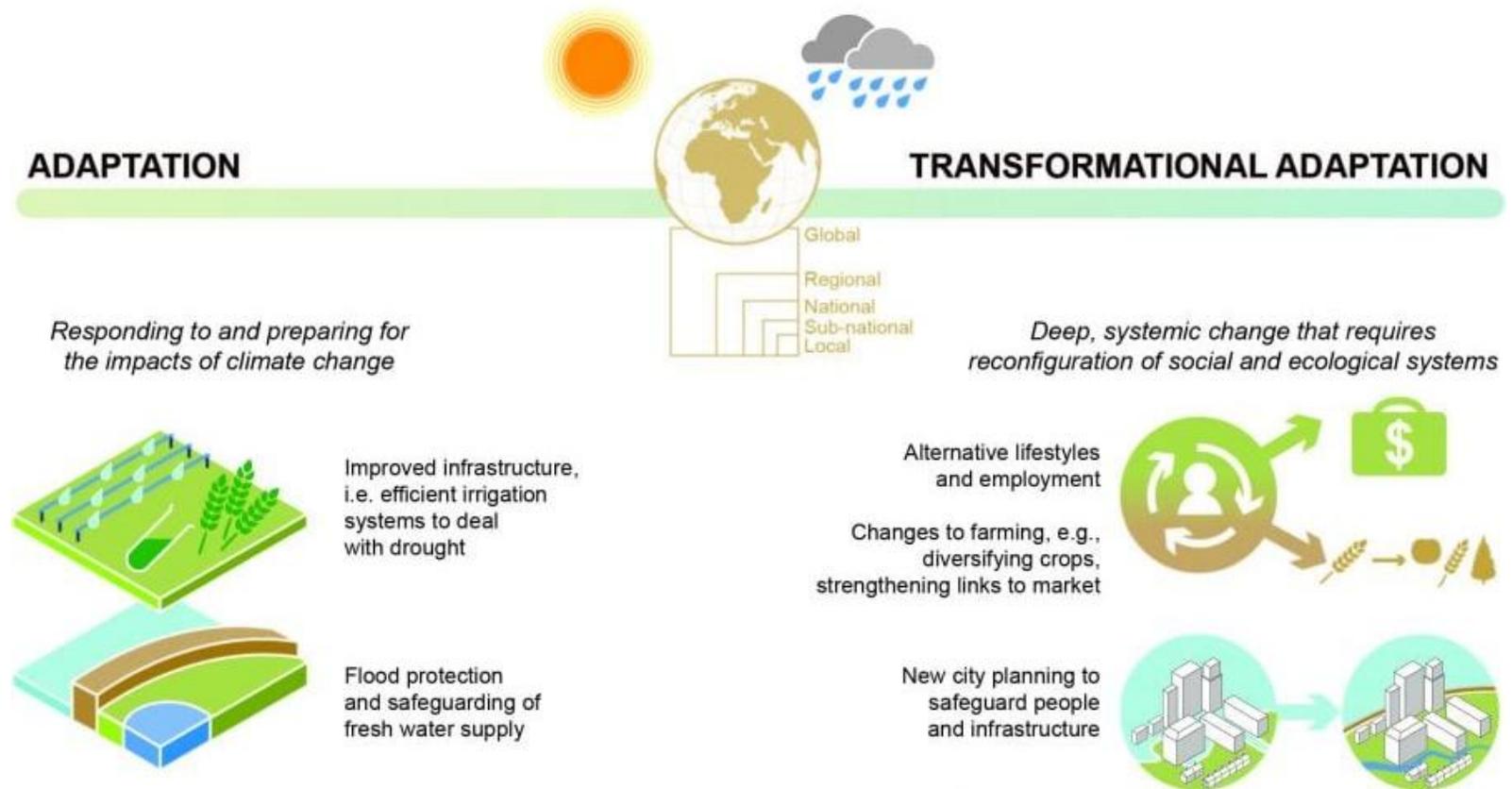
- Closing adaptation gaps may take decades
- Strongly depends on future evolution of socio-economic development
- **Adaptation is not an on/off state, but an ongoing challenge**



Andrijevic et al (2023)

Adaptation – from incremental to transformational system change

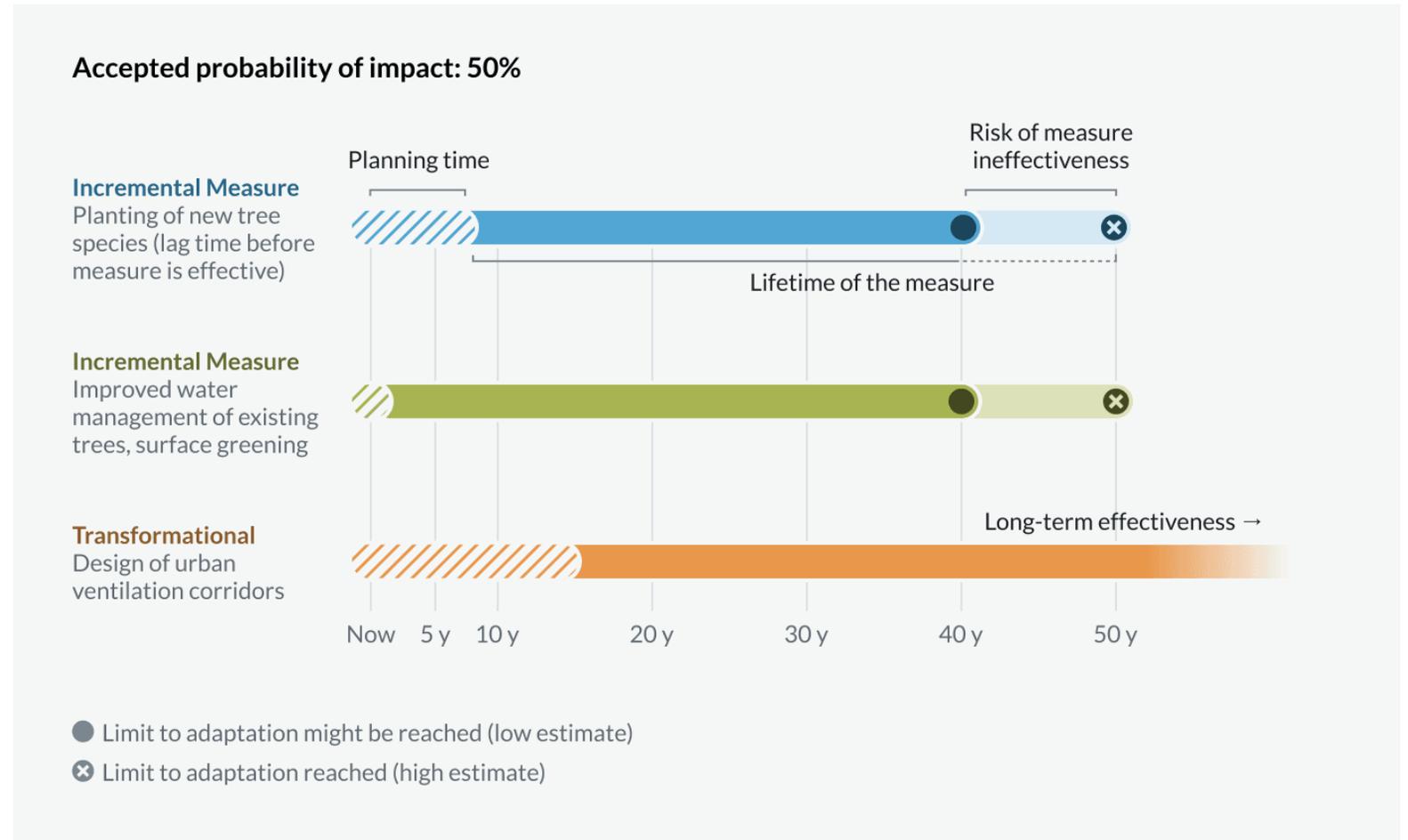
- Limits to adaptation options and incremental improvements within systems
- **Transformational adaptation can overcome limits, but requires system change**



IPCC (2022)

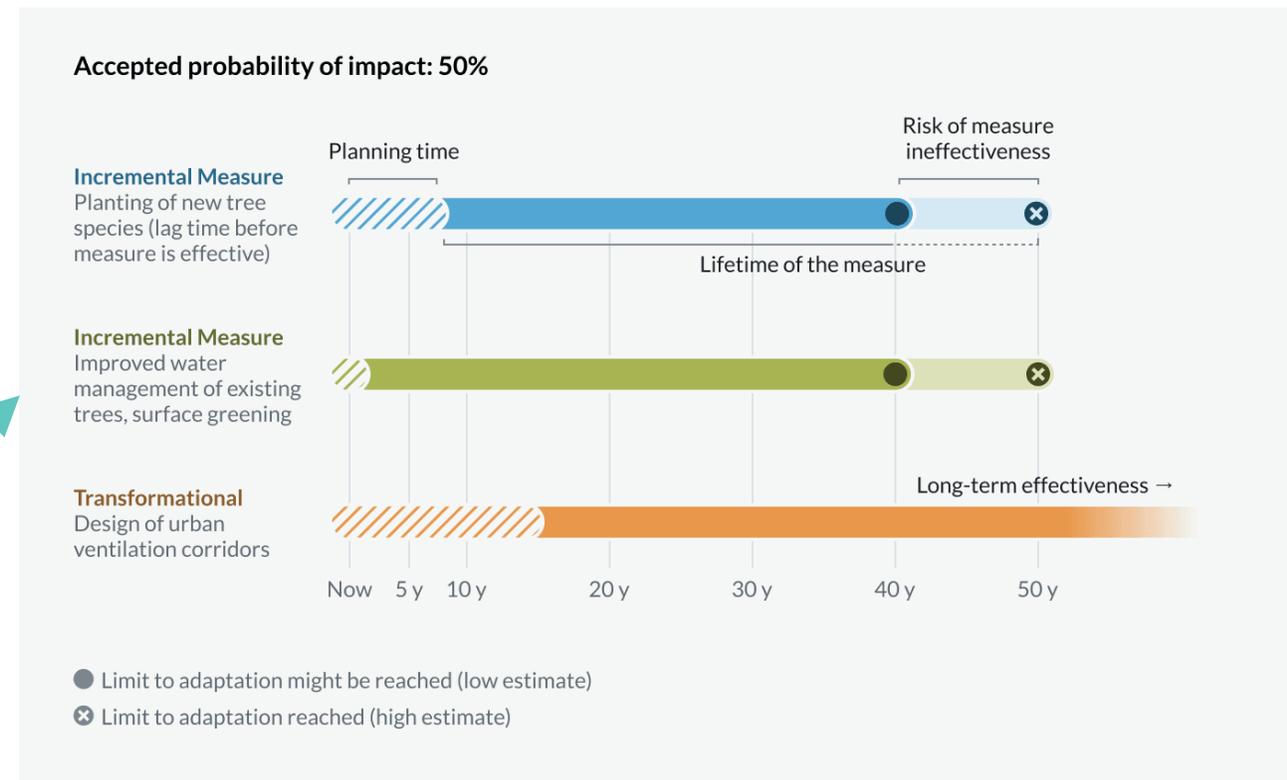
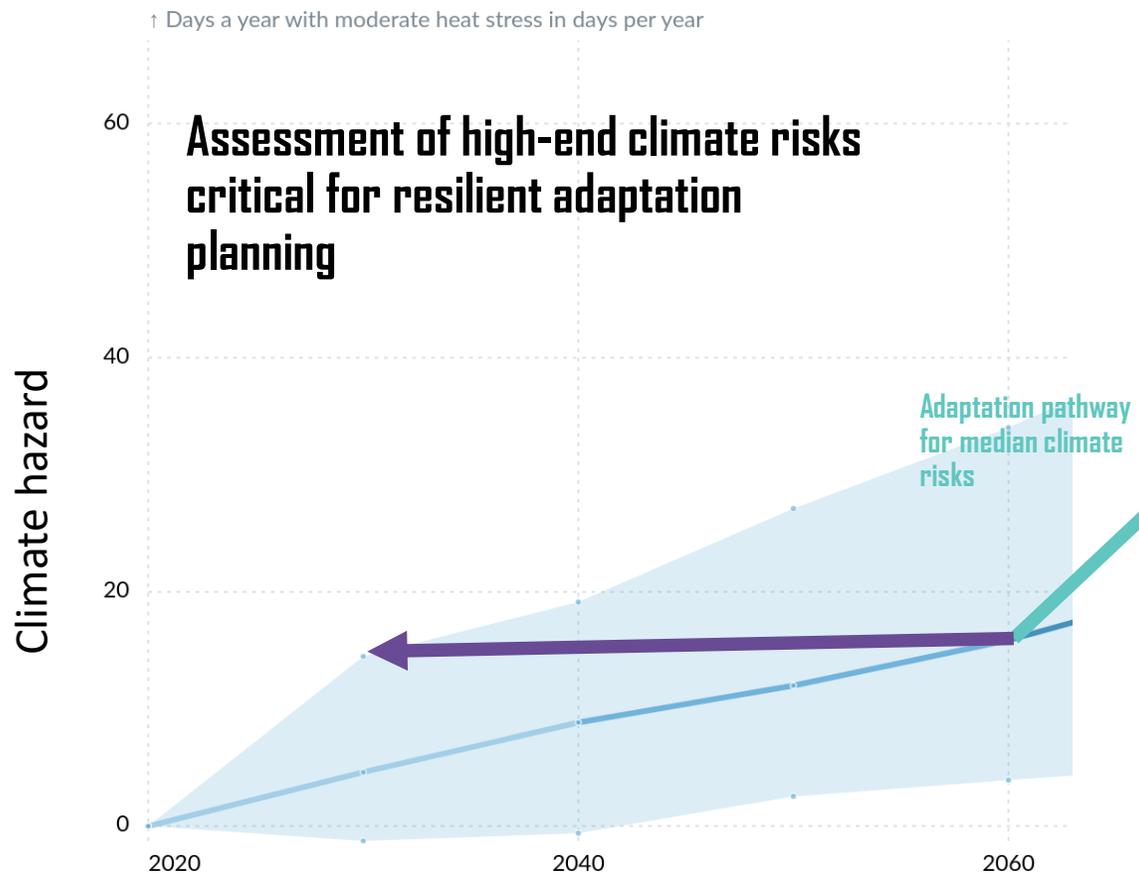
Towards adaptation pathways

- **Adaptation is a process**
- Dynamic adaptation pathways to plan for sequencing of adaptation implementation



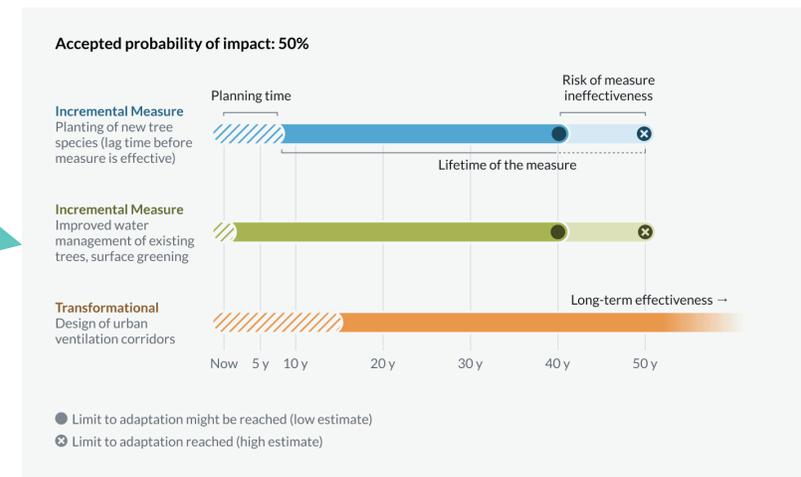
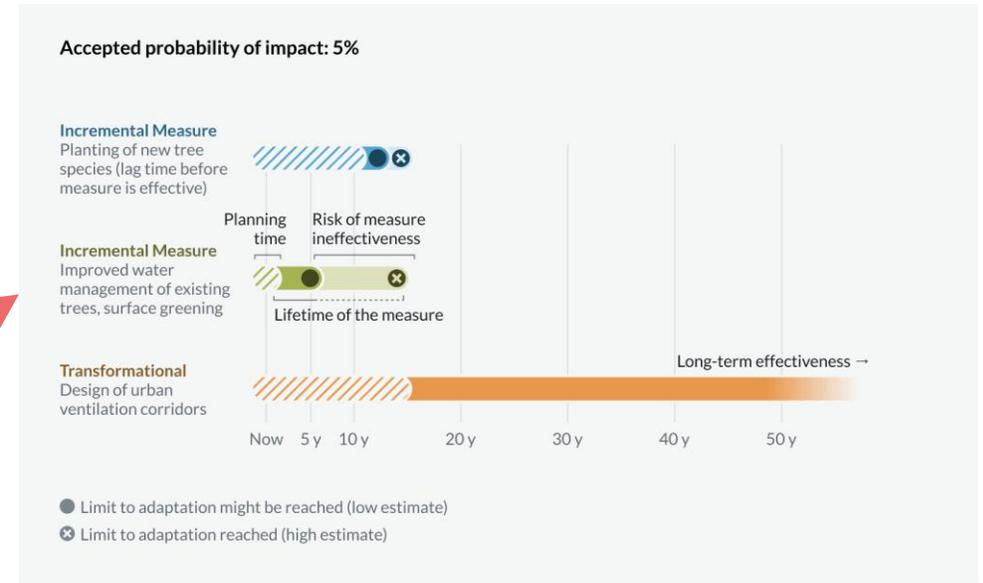
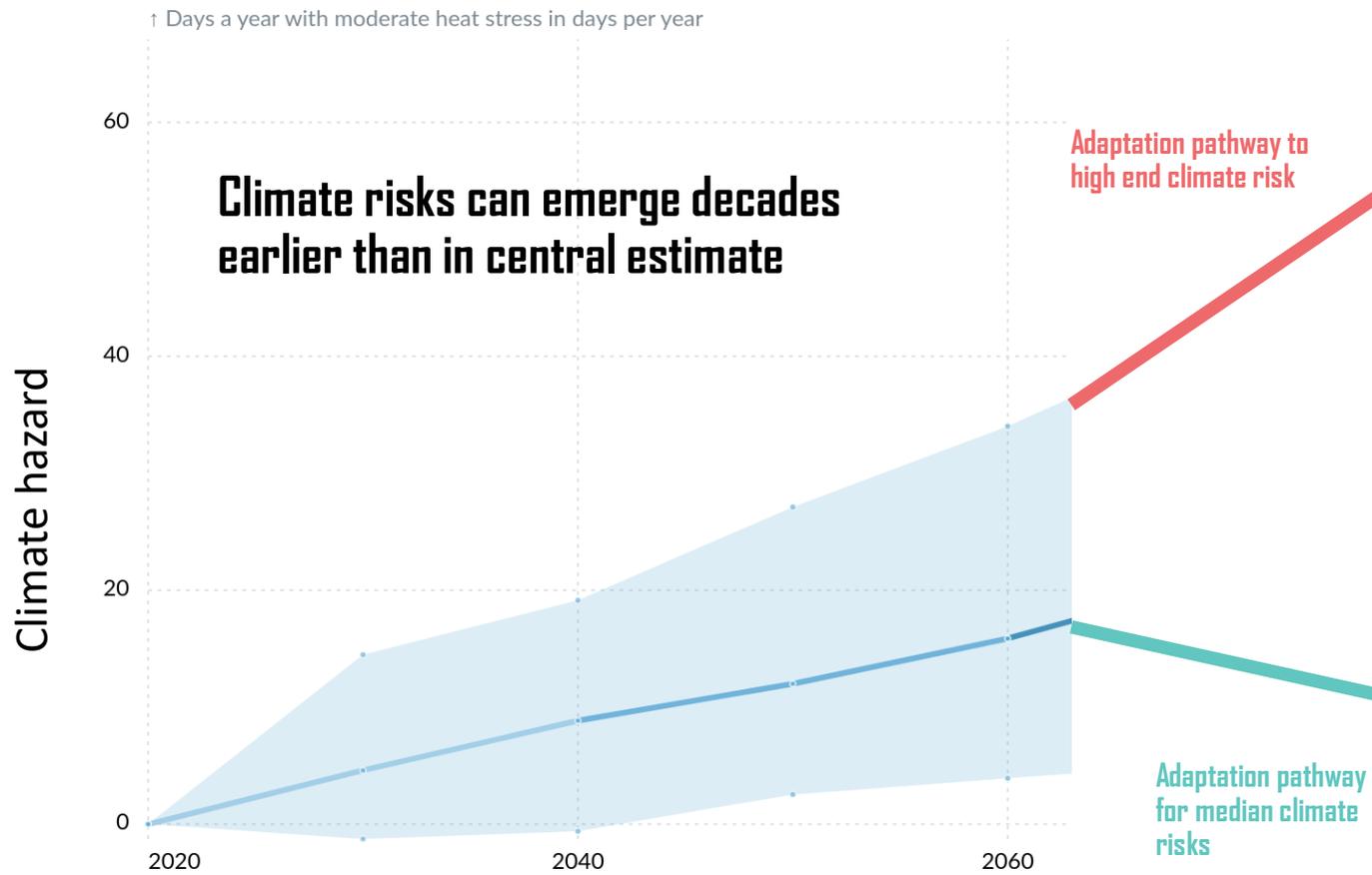
<https://climate-risk-dashboard.climateanalytics.org>

Towards adaptation pathways



<https://climate-risk-dashboard.climateanalytics.org>

Towards adaptation pathways



Towards mainstreaming adaptation

- **Adaptation is a process not an outcome**
- Requires continuous monitoring and evaluation
- Paramount importance of adaptation in a warming world



1. Preparing the ground for adaptation

2. Assessing climate change risks and vulnerabilities

3. Identifying adaptation options

4. Assessing adaptation options

5. Implementing Adaptation

6. Monitoring and Evaluating Adaptation

Thank you.

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