



# Climate change in mountain regions: key findings from the IPCC's sixth assessment and prospects for climate-resilient mountain social-ecological systems

**Carolina Adler, PhD**

Executive Director, Mountain Research Initiative (MRI)

LIFE PASTORALP final conference “GLOBAL CHALLENGES IN MOUNTAIN AGROPASTORAL SYSTEMS”

Bard, Aosta Valley (Italy) | 15 March 2023

[www.mountainresearchinitiative.org](http://www.mountainresearchinitiative.org)

Supported by

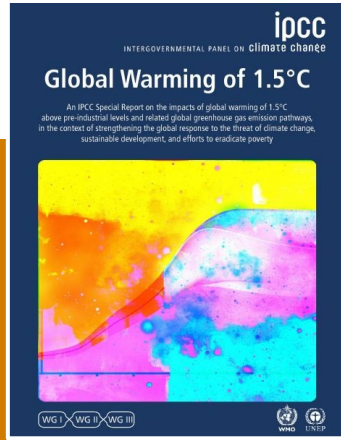


Hosted at

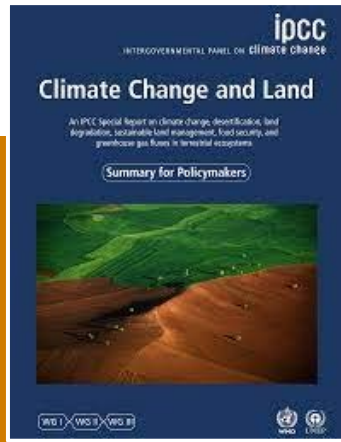
*u<sup>b</sup>*

UNIVERSITY  
OF BERN

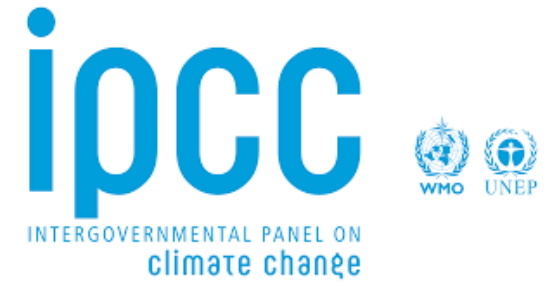
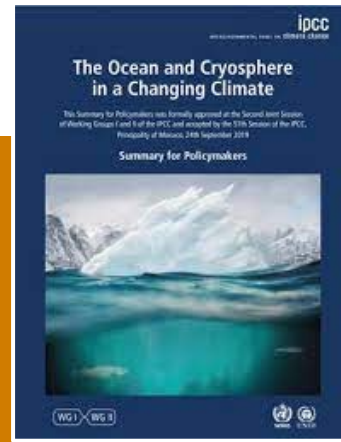
**October 2018**



**August 2019**

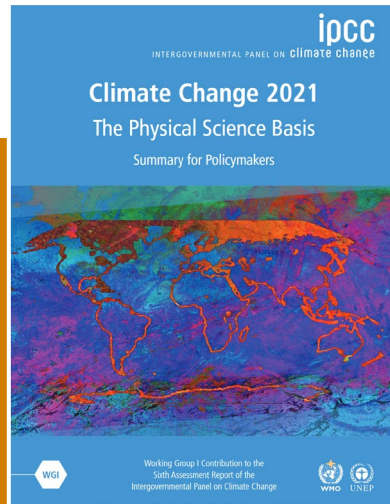


**September 2019**

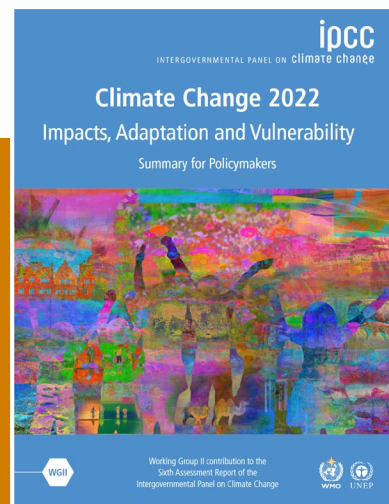


## IPCC - Sixth Assessment (AR6)

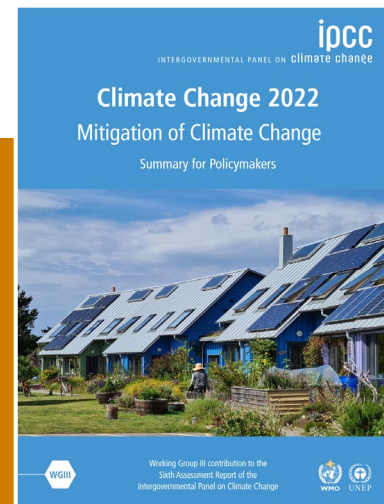
**August 2021**



**February 2022**



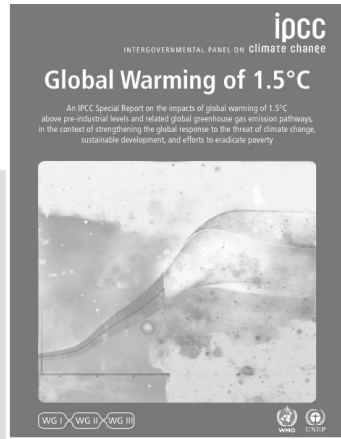
**March 2022**



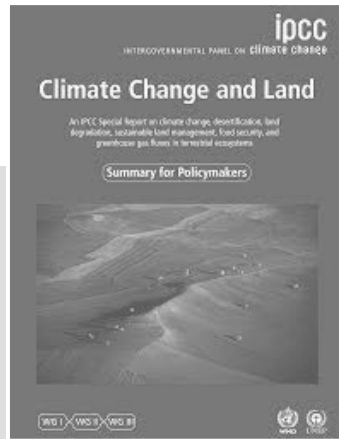
**Expected: 20 March 2023**

**AR6 Synthesis Report: Climate Change 2022**

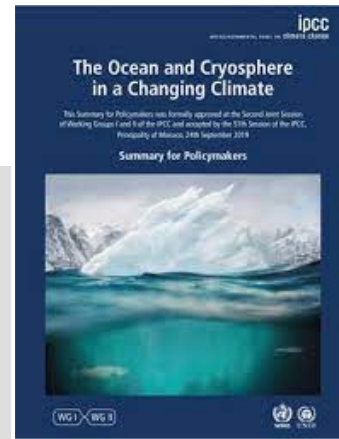
October 2018



August 2019



September 2019

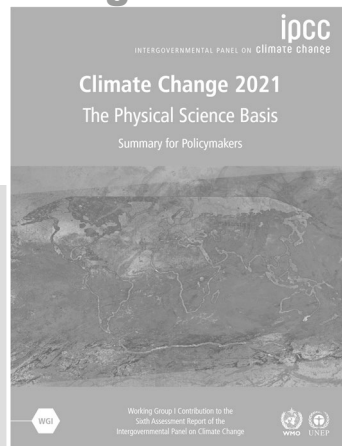


**SROCC: Chapter 2 “High Mountain Areas”**

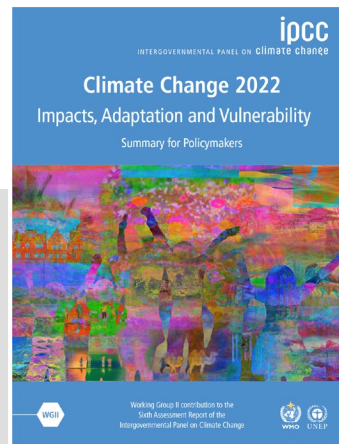
**WGII AR6: Cross-Chapter Paper: Mountains**

**NEW: Cross-Chapter Papers (CCP)**

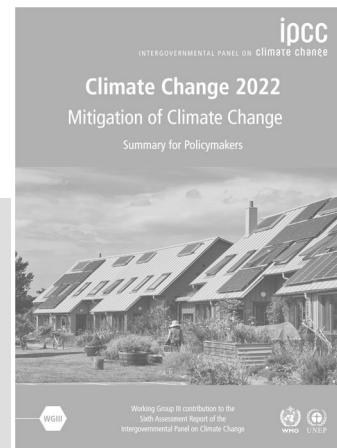
August 2021



February 2022



March 2022



- Biodiversity hotspots (land, coasts and oceans)
- Cities and settlements by the sea
- Deserts, semi-arid areas, and desertification
- Mediterranean region
- **Mountains**
- Polar regions
- Tropical forests

- Expanded treatment of particular systems or regions
- Integrative across chapters
- Allow updates since the Special Reports
- Follow broad scheme and structure of chapters
- Same audience as chapters
- Need to develop high level policy-relevant messages

**Expected: 20 March 2023**

**AR6 Synthesis Report: Climate Change 2022**

## Report by numbers AR6 WGII (CCP5)



270 (8)

Authors



67 (10)

Countries



43% (20%) Developing countries  
57 % (80%) Developed countries



41% (25%) Women

59% (75%) Men



675 (27) Contributing authors



More than  
34,000 (533) scientific papers



62,418 (2,083)  
Review comments

# CCP5

## Mountains

**Cross-Chapter Paper Leads:** Carolina Adler (Switzerland/Chile/Australia), Philippus Wester (Nepal/The Netherlands)

**Cross-Chapter Paper Authors:** Indra Bhatt (India), Christian Huggel (Switzerland), Gregory Insarov (Russian Federation), Michael Morecroft (UK), Veruska Muccione (Switzerland/Italy), Anjal Prakash (India)

**Cross-Chapter Paper Contributing Authors:** Irasema Alcántara-Ayala (Mexico), Simon K. Allen (Switzerland/New Zealand), Maaïke Bader (Germany), Sophie Bigler (Switzerland), James Camac (Australia), Ritodhi Chakraborty (New Zealand/India), Aida Cuni Sanchez (Norway/Spain), Nicolás Cuvi (Ecuador), Fabian Drenkhan (Peru/Germany), Abid Hussain (Nepal/Pakistan), Amina Maharjan (Nepal), Robert Marchant (UK), Graham McDowell (Canada/USA), Samuel Morin (France), Laura Niggli (Switzerland), Ana Ochoa (Ecuador), Avash Pandey (Nepal), Julio Postigo (USA/Peru), Estelle Razanatsoa (South Africa/Madagascar), Valeria M. Rudloff (Chile), Christopher Scott (USA), Madison Stevens (Canada), Daithi Stone (New Zealand), Jessica Thorn (UK/Namibia), James Thornton (Switzerland/UK), Daniel Viviroli (Switzerland), Saskia Werners (The Netherlands)

**Cross-Chapter Paper Review Editor:** Georg Kaser (Austria)

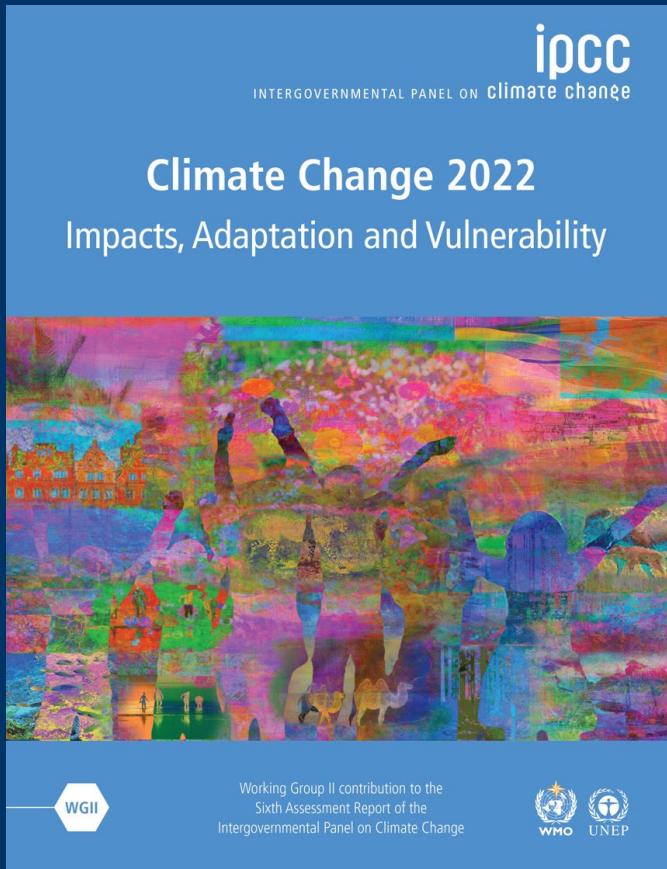
**Cross-Chapter Paper Scientist:** Valeria M. Rudloff (Chile)

This cross-chapter paper should be cited as:

Adler, C., P. Wester, I. Bhatt, C. Huggel, G.E. Insarov, M.D. Morecroft, V. Muccione, and A. Prakash, 2022: Cross-Chapter Paper 5: Mountains. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Lösschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2273–2318, doi:10.1017/9781009325844.022.

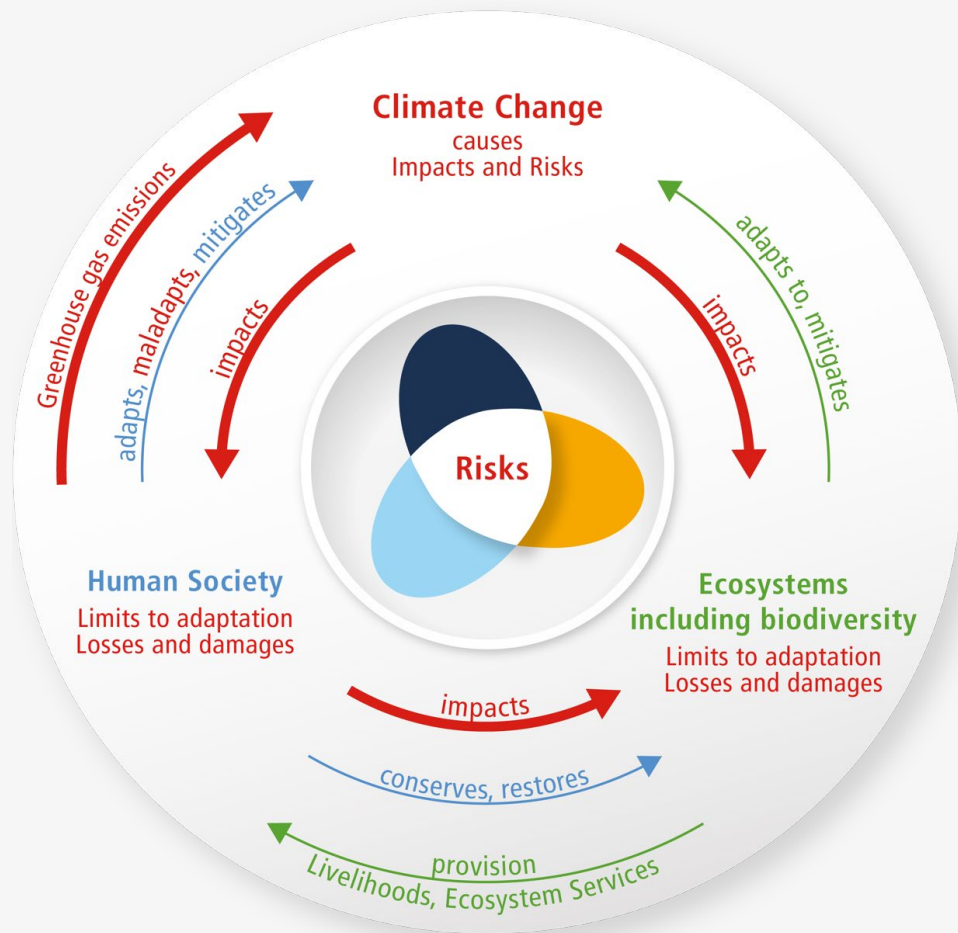
<https://www.ipcc.ch/report/ar6/wg2/downloads>





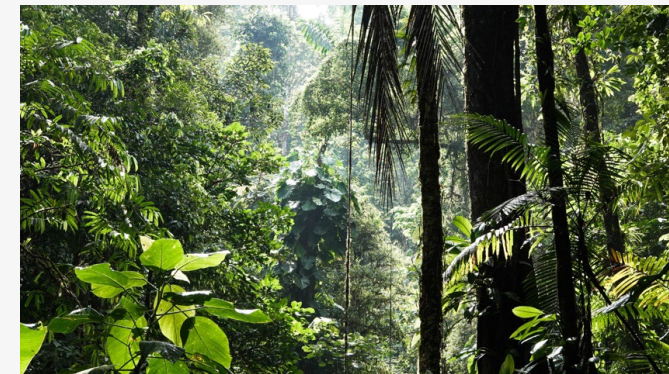
“ The scientific evidence is unequivocal: climate change is a threat to human well-being and the health of the planet. Any further delay in concerted global action will miss the brief, rapidly closing window to secure a liveable future. This report offers solutions to the world.

# New understanding of interconnections

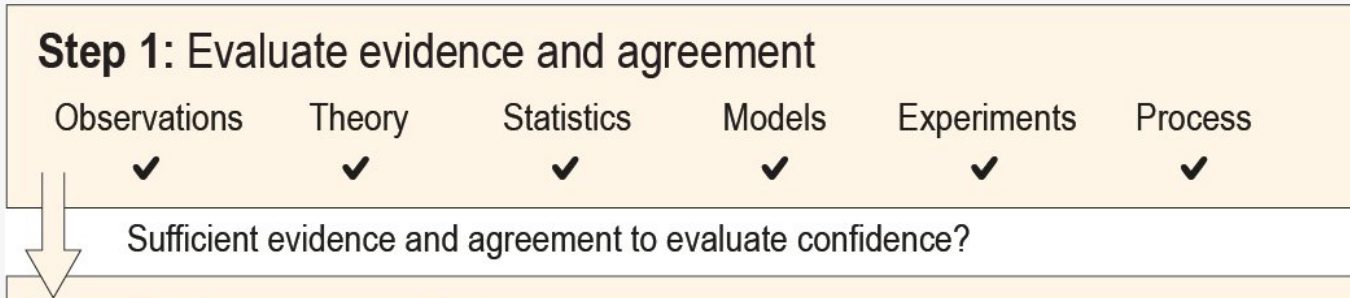


The risk propeller shows that risk emerges from the overlap of:

- Climate hazard(s)
  - Vulnerability
  - Exposure
- ...of human systems, ecosystems and their biodiversity

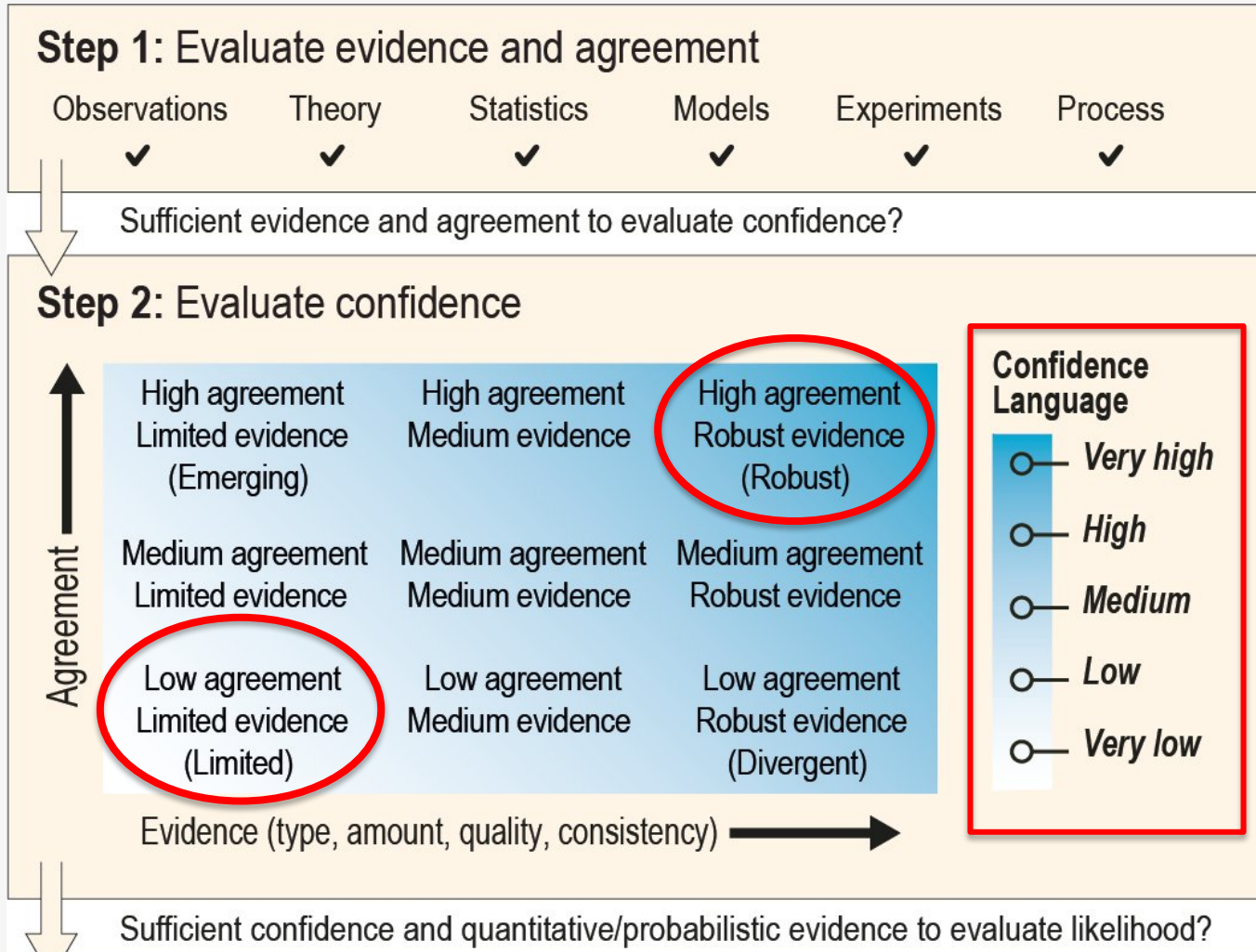


## How is evidence assessed?





## How is evidence assessed?





## How is evidence assessed?

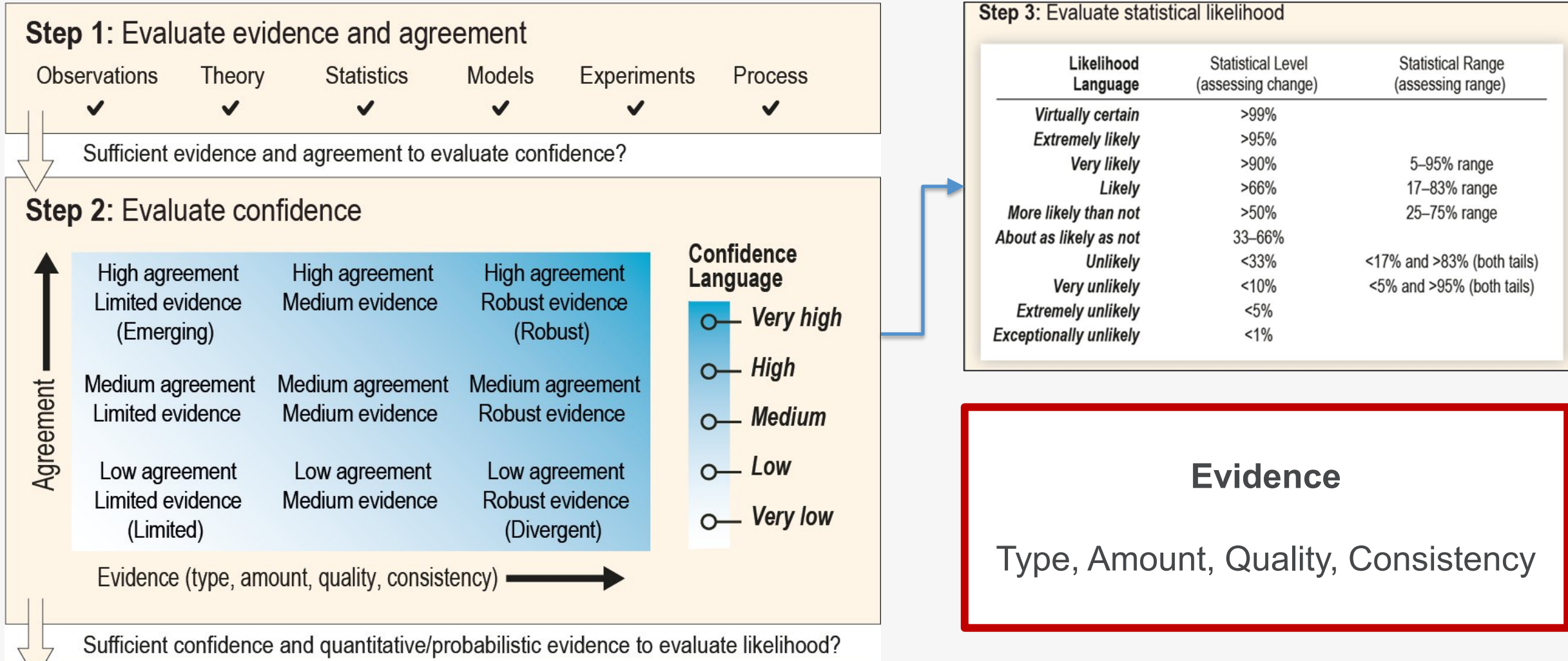


Figure SPM.2

# Impacts of climate change are observed in many ecosystems and human systems worldwide

(a) Observed impacts of climate change on ecosystems

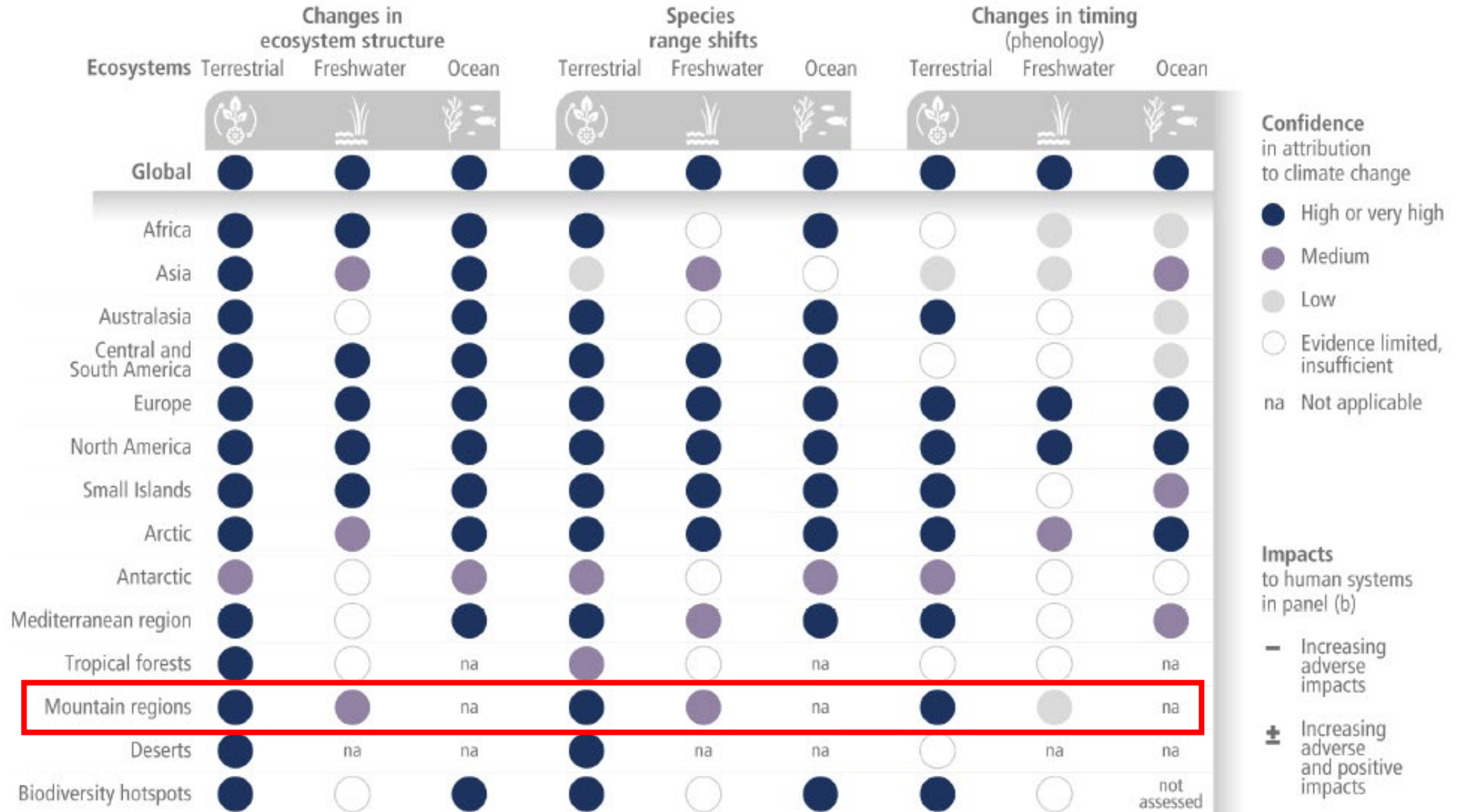
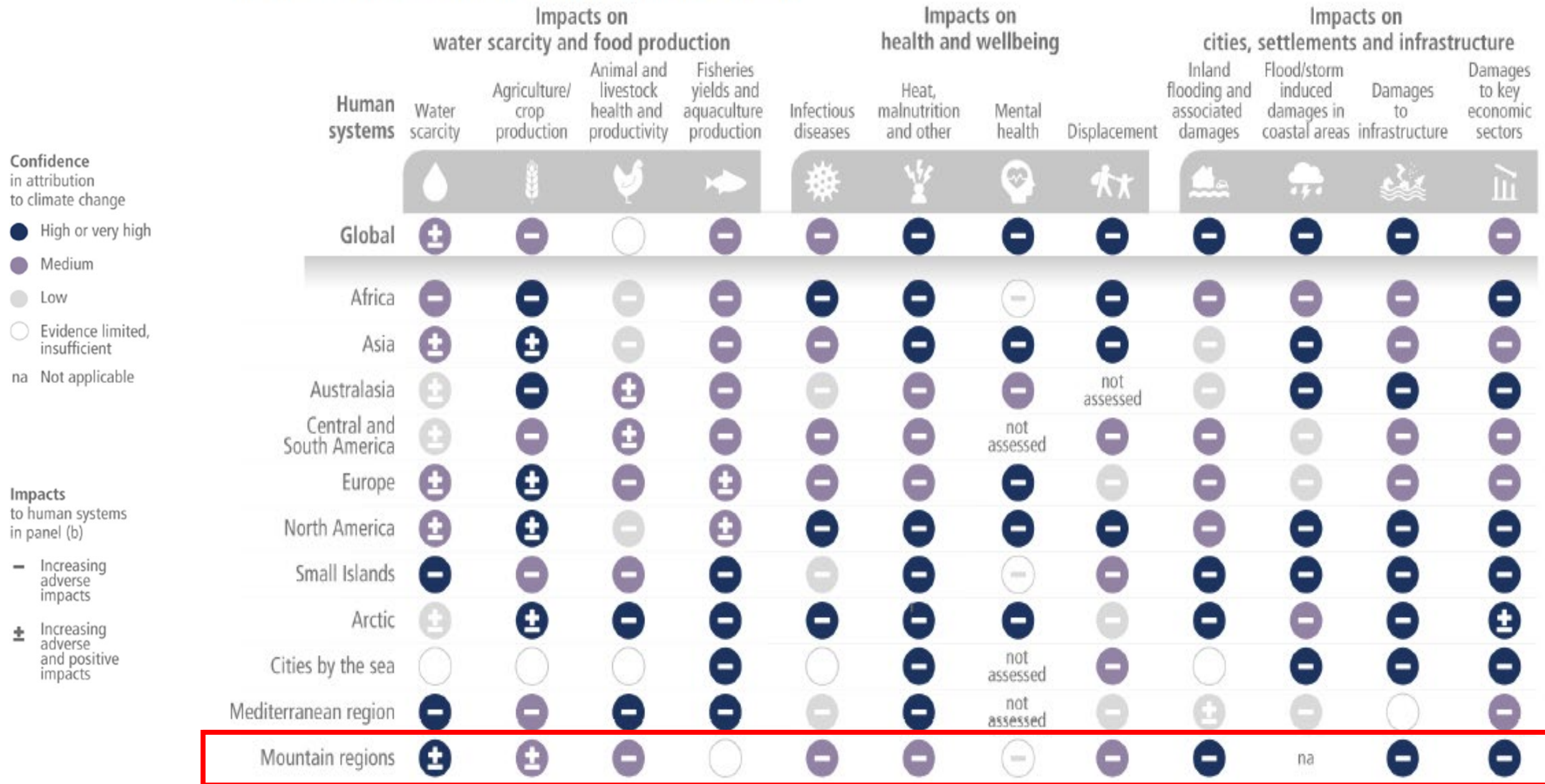


Figure SPM.2

(b) Observed impacts of climate change on human systems





**Figure CCP5.1**  
(Adler *et al.* 2022)

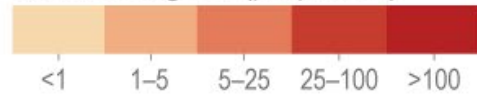
## Delineation of mountain regions, population densities and projections

(a) Delineations of mountain regions and population densities in 2015

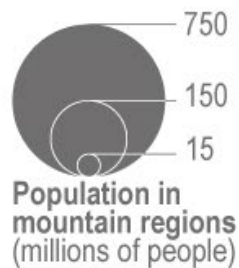
### IPCC WGII Continental Regions

- Asia
- Africa
- Small Islands
- Australasia
- North America
- Central and South America
- Europe

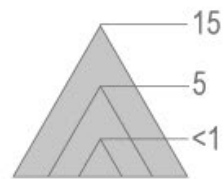
### Population density in mountain regions (people/km<sup>2</sup>)



□ Non-mountainous/ out of scope regions. The assessment excludes Svalbard, Greenland and Antarctica

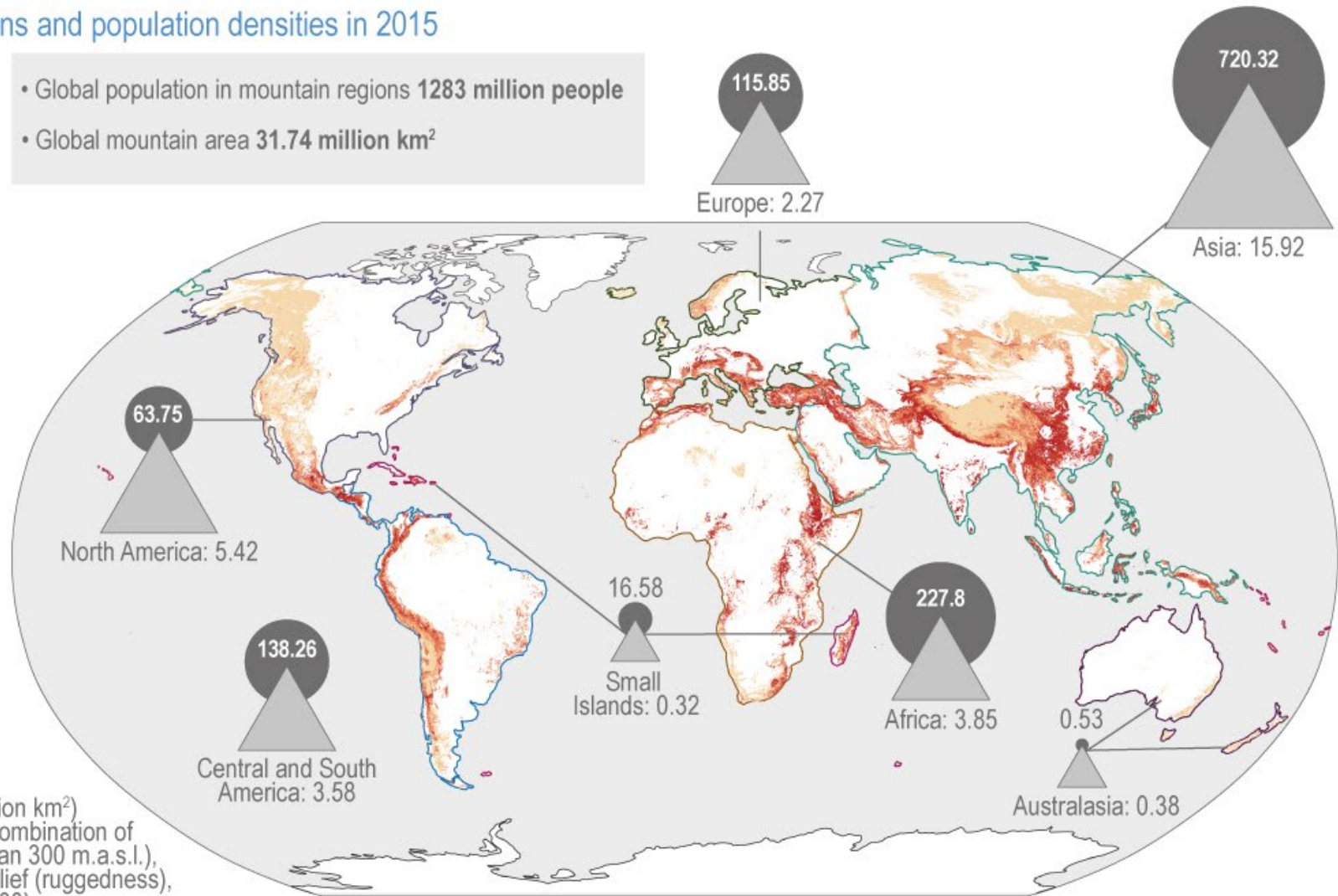


Population in mountain regions (millions of people)



Mountain area (million km<sup>2</sup>) characterised as a combination of elevation (greater than 300 m.a.s.l.), slope and relative relief (ruggedness), based on Kapos (2000)

- Global population in mountain regions 1283 million people
- Global mountain area 31.74 million km<sup>2</sup>



- Global mountainous area of **31.74 million km<sup>2</sup>** (approximately **23.5%** of the global land surface)
- In 2015, a total of **1.28 billion people** resided in mountain regions (SMCCP5.1)



[Damian Markutt – Unsplash]



[Prateek Katyt – Unsplash]



[Xavier von Erlach – Unsplash]

## Observed climate change and impacts in mountain regions

- **Climate change impacts**, and their attribution to human influence, **have increased** in many mountain regions – with serious consequences for people and ecosystems.
- **Two-thirds of irrigated agriculture depends on water from mountains**. Changes in water availability are specially impacting seasonally dry regions.
- **Seasonal changes** negatively affect tourism (e.g., snow-dependent winter activities).
- **Exposure to climate-related hazards**, e.g., (flash floods) and landslides, are **contributing to an increase in disasters** affecting a growing number of people in mountain regions and further downstream.





“ Increasing temperatures will continue to induce changes in mountain regions throughout the 21<sup>st</sup> century, with expected negative consequences for mountain cryosphere, biodiversity, ecosystem services and human well being

*(very high confidence)*  
{CCP5.3.1}



## Projected impacts at 1.5°C and beyond

- Low elevation and small glaciers will lose most of their total mass at 1.5°C GWL.
- In tropical and mid-latitude mountains, 50% ice volume lost under low-emission scenarios, but two-thirds to more than 90% lost under high-emission scenarios by 2100.
- Strongest impacts in glacier and snowmelt dependent regions, e.g., Central Asia, South Asia, western South America and southwestern North America
- A large majority of endemic mountain species (up to 84%) will be at increasing risk of extinction beyond 1.5°C (even under overshoot).





## Key risks assessment - **four key risks** in mountains



1. Loss of lives, harm to people, and damages to infrastructures from hazards such as **landslides and floods**.
2. Adverse impacts to livelihoods and risks to economic sectors, both for mountain communities and in the lowlands, from **changes in water availability** and its management.
3. Changes to **mountain ecosystems** and risks of mountain top species extinction.
4. **Intangible losses and harm** to people and loss of **cultural values** from decline of ice, snow cover and warming as well as increase in disasters.

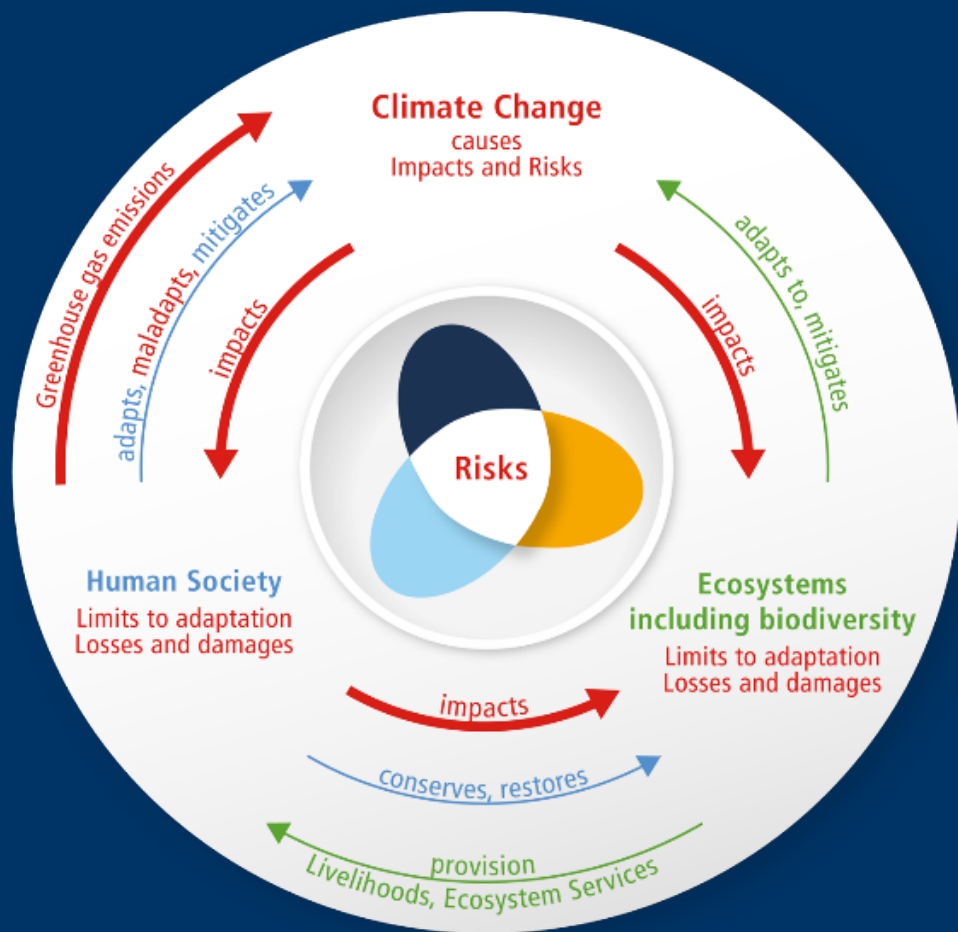




## There are limits to adaptation

- Even effective adaptation cannot prevent all losses and damages
- Above 1.5°C some natural solutions may no longer work.
- Above 1.5°C, lack of fresh water could mean that people living on small islands and those dependent on glaciers and snowmelt can no longer adapt.
- By 2°C it will be challenging to farm multiple staple crops in many current growing areas.





The current speed, scope and depth of adaptation in mountains are insufficient to address future (key) risks, particularly at higher warming (beyond 1.5°C) (*high confidence*).

*CCP5 Executive Summary*

Climate resilient development is already challenging at current global warming levels. The prospects will become further limited if warming exceeds 1.5°C and may not be possible if warming exceeds 2°C.

*SPM D.5.1*



[GovernmentZA\_DIRCO\_CC BY-ND 2.0;  
Marlon del Aguila/CIFOR CC BY-NC-ND 2.0



Regional cooperation and transboundary governance in mountain regions, supported by multi-scale knowledge networks and monitoring programmes, enable long-term adaptation actions where risks transcend boundaries and jurisdictions.

There are increasing calls for more ambitious climate action in mountains, providing impetus for stronger cooperation within and across mountain regions, and downstream areas.

*CCP5.4.2; CCP5.4.3*

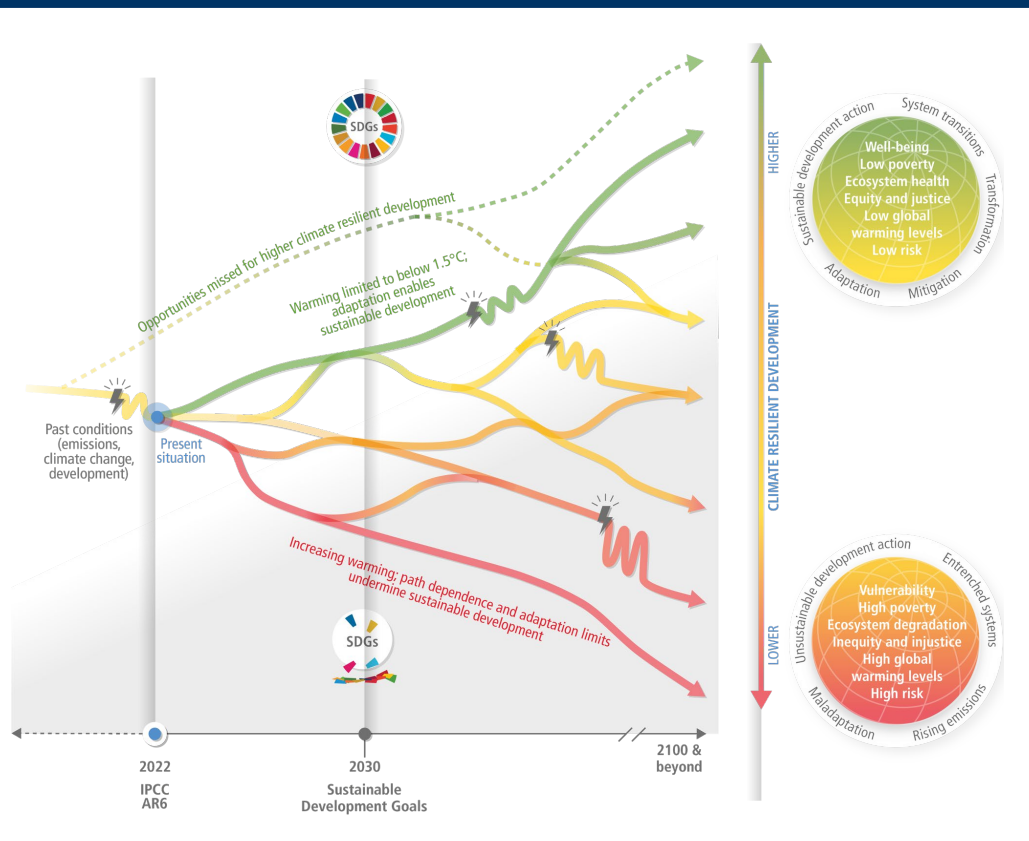


# Climate Resilient Development

## The solutions framework:

- Is considered across government and all of civil society
- Involves everyone – forming partnerships
- Draws on wide-ranging knowledge (scientific, Indigenous, local, practical)
- Conserves and restores ecosystems
- **Involves marginalized groups**
- **Prioritises equity and justice**
- Reconciles different interests, values and world views
- Requires scaled-up investment and **international cooperation**





With warming above 1.5°C, the need for adaptation to address key risks in mountains becomes increasingly urgent (*high confidence*).

Pathways and system transitions that strengthen climate-resilient sustainable mountain development are starting to receive attention, but current levels of resourcing are substantially insufficient to support timely action.


*Adler et al (2022) - Executive Summary*



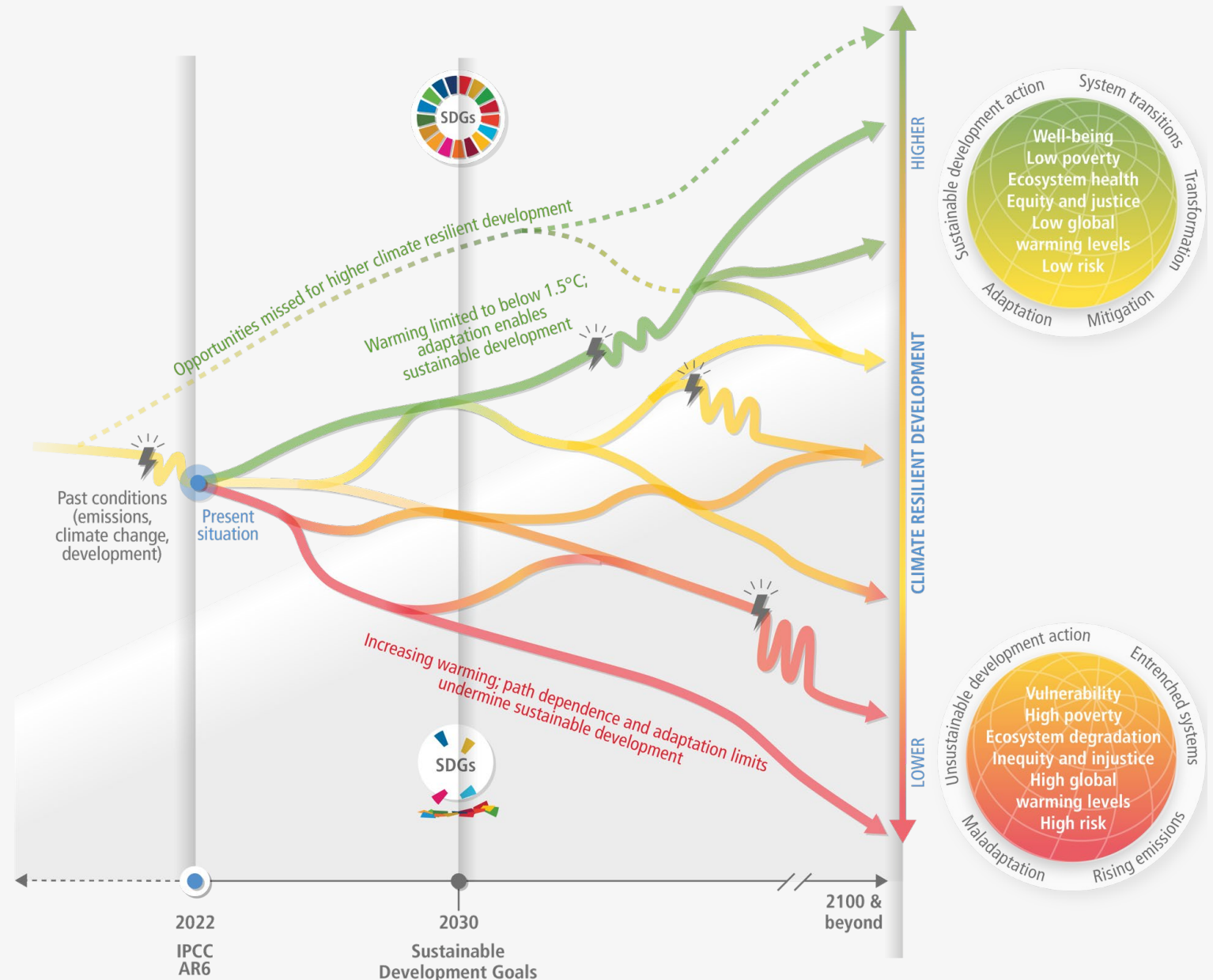
# Increasing urgency

## Starting today, every action, every decision matters.

Worldwide action is more urgent than previously assessed.

 Illustrative climatic or non-climatic shock, e.g. COVID-19, drought or floods, that disrupts the development pathway

 Narrowing window of opportunity for higher CRD





**Thank you**

**Carolina Adler, PhD – [carolina.adler@unibe.ch](mailto:carolina.adler@unibe.ch)**

**[www.mountainresearchinitiative.org](http://www.mountainresearchinitiative.org)**

**#OurChangingMountains**