Water availability

Climate Information for Risk Assessment and Regional Adaptation

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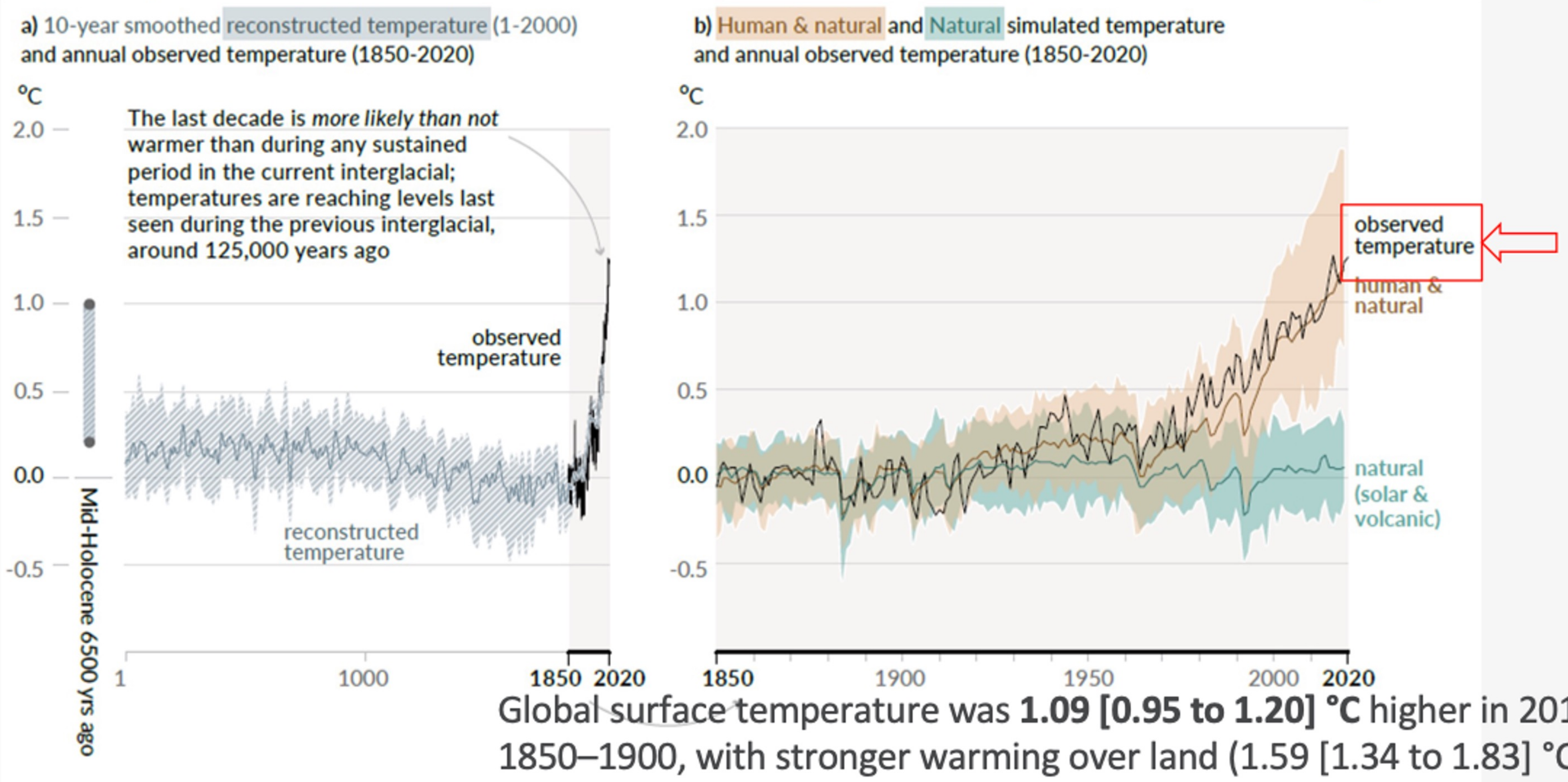
What do we want to achieve in this session:

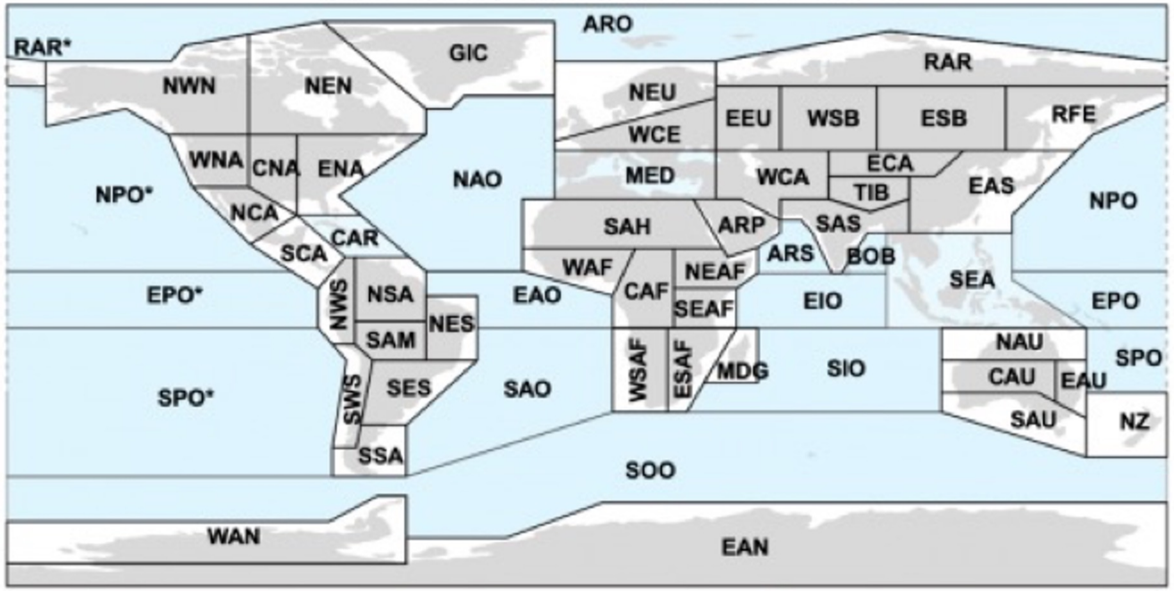
- Overview of methodologies used for water availability risk assessment carried on across WGI and WGII by mean of specific regional and topological region examples
- Start a discussion on the fit for purpose of this methodology from the end users point of view (YOU)
- Can you give us specific examples on what you find useful or what you would you like to change
- Try to reflect on how you could do it differently

Human influence has warmed the climate system at a rate that is unprecedented in at least the last 2000 years



{Figure SPM 1, SPM HS1}

Global surface temperature was **1.09 [0.95 to 1.20] °C** higher in 2011–2020 than 1850–1900, with stronger warming over land (1.59 [1.34 to 1.83] °C) than over the ocean (0.88 [0.68 to 1.01] °C).



1	GIC	Greenland/Iceland
2	NWN	N.W.North-America
3	NEN	N.E.North-America
4	WNA	W.North-America
5	CNA	C.North-America
6	ENA	E.North-America
7	NCA	N.Central-America
8	SCA	S.Central-America
9-10	CAR	Caribbean
11	NWS	N.W.South-America
12	NSA	N.South-America
13	NES	N.E.South-America
14	SAM	South-American-Monsoon
15	SWS	S.W.South-America
16	SES	S.E.South-America
17	SSA	S.South-America
18	NEU	N.Europe
19	WCE	Western&Central-Europe
20	EEU	E.Europe
21-22	MED	Mediterranean

23	SAH	Sahara
24	WAF	Western-Africa
25	CAF	Central-Africa
26	NEAF	N.Eastern-Africa
27	SEAF	S.Eastern-Africa
28	WSAF	W.Southern-Africa
29	ESAF	E.Southern-Africa
30	MDG	Madagascar
31	RAR	Russian-Arctic
32	WSB	W.Siberia
33	ESB	E.Siberia
34	RFE	Russian-Far-East
35	WCA	W.C.Asia
36	ECA	E.C.Asia
37	TIB	Tibetan-Plateau
38	EAS	E.Asia
39	ARP	Arabian-Peninsula
40	SAS	S.Asia
41-42	SEA	S.E.Asia

43	NAU	N.Australia
44	CAU	C.Australia
45	EAU	E.Australia
46	SAU	S.Australia
47	NZ	New-Zealand
48	EAN	E.Antarctica
49	WAN	W.Antarctica
50	ARO	Arctic-Ocean
51	NPO	N.Pacific-Ocean
52	EPO	Equatorial.Pacific-Ocean
53	SPO	S.Pacific-Ocean
54	NAO	N.Atlantic-Ocean
55	EAO	Equatorial.Atlantic-Ocean
56	SAO	S.Atlantic-Ocean
57	ARS	Arabian-Sea
58	BOB	Bay-of-Bengal
59	EIO	Equatorial.Indic-Ocean
60	SIO	S.Indic-Ocean
61	SOO	Southern-Ocean

{Figure 1.18, Figure Atlas.2}

46 Land regions
15 Ocean regions

Climate consistency and better representation of regional climate features

Sufficiente number of grid boxes represented in models

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

a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions

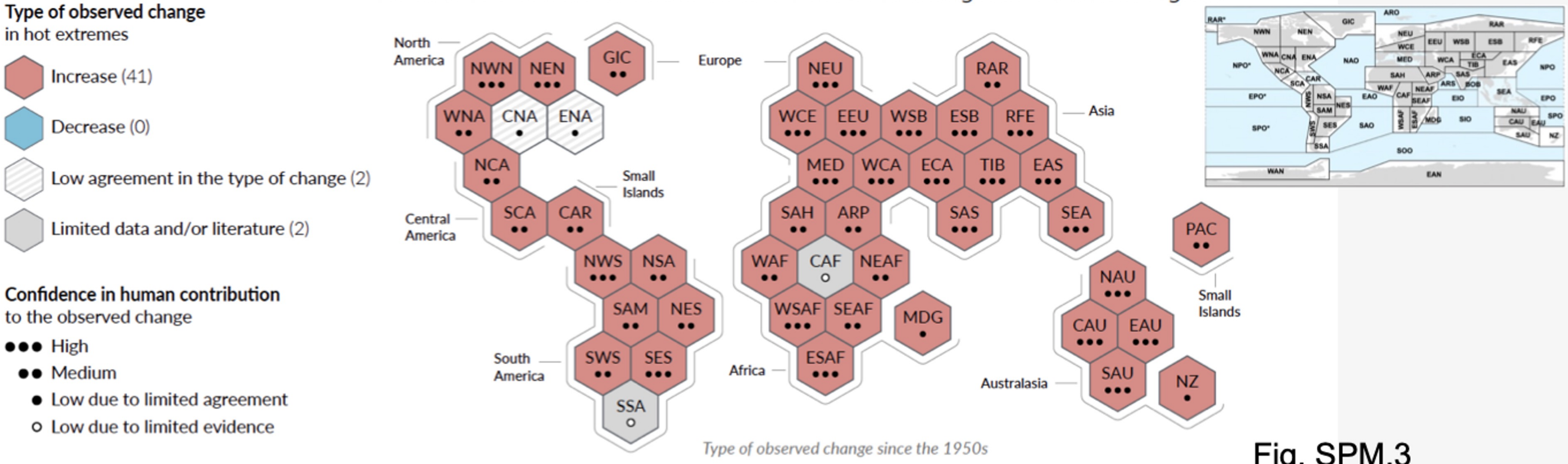


Fig. SPM.3

Some recent hot extremes observed over the past decade would have been extremely *unlikely* to occur without human influence on the climate system.

Human influence, in particular greenhouse gas emissions, is *likely* the main driver of the observed global scale intensification of heavy precipitation in land regions.

“The frequency and intensity of **heavy precipitation events** have increased since the 1950s over most land area for which observational data are sufficient for trend analysis (*high confidence*)

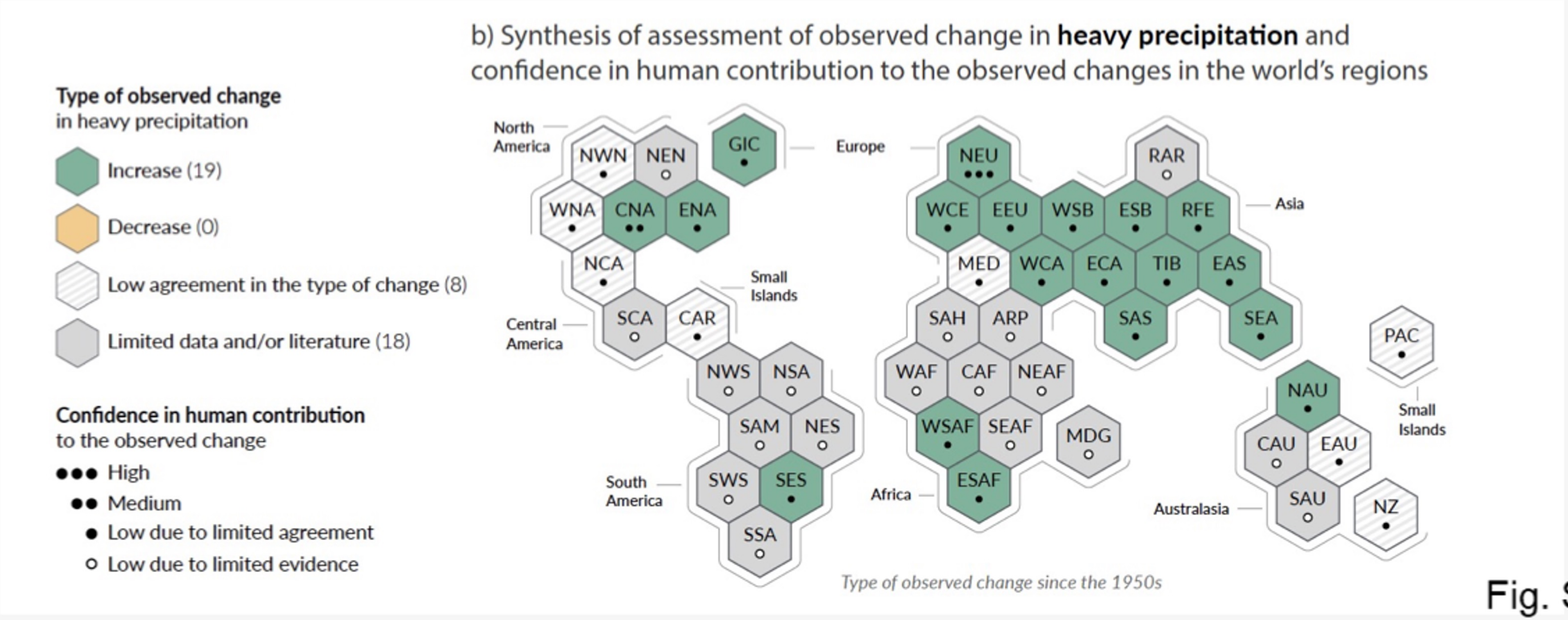


Fig. SPM.3

Human-induced climate change has contributed to increases in agricultural and ecological droughts in some regions **due to evapotranspiration increases** *(medium confidence)*.

c) Synthesis of assessment of observed change in **agricultural and ecological drought** and confidence in human contribution to the observed changes in the world's regions

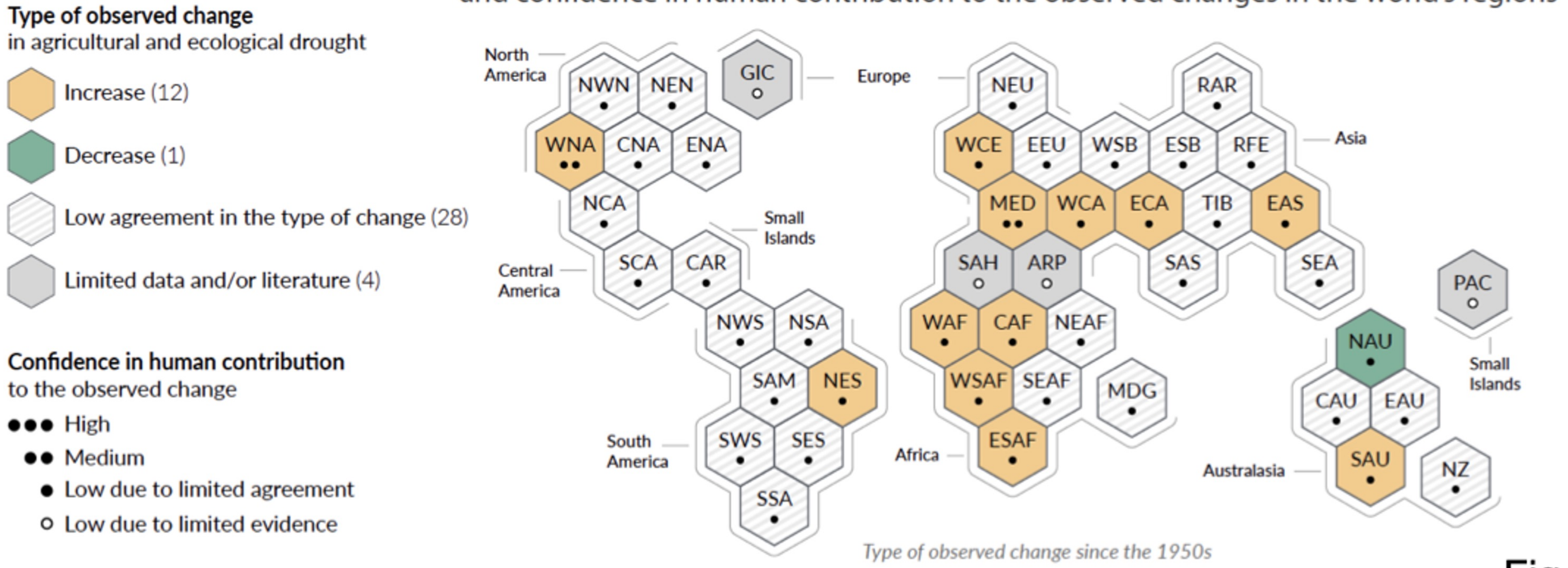


Fig. SPM.3

Observed changes in extremes & their attribution

- It is *likely* that the global proportion of major (Category 3–5) **tropical cyclone** occurrence has increased over the last four decades, These changes cannot be explained by internal variability alone (*medium confidence*)

- Human influence has likely increased the chance of compound extreme events since the 1950s.
- Increases in the frequency of **concurrent heatwaves and droughts** on the global scale (*high confidence*);
- Increases in fire weather in some regions of all inhabited continents (*medium confidence*);
- Increases in **compound flooding** in some locations (*medium confidence*).

Projected changes in extremes are larger in frequency and intensity with every additional increment of global warming

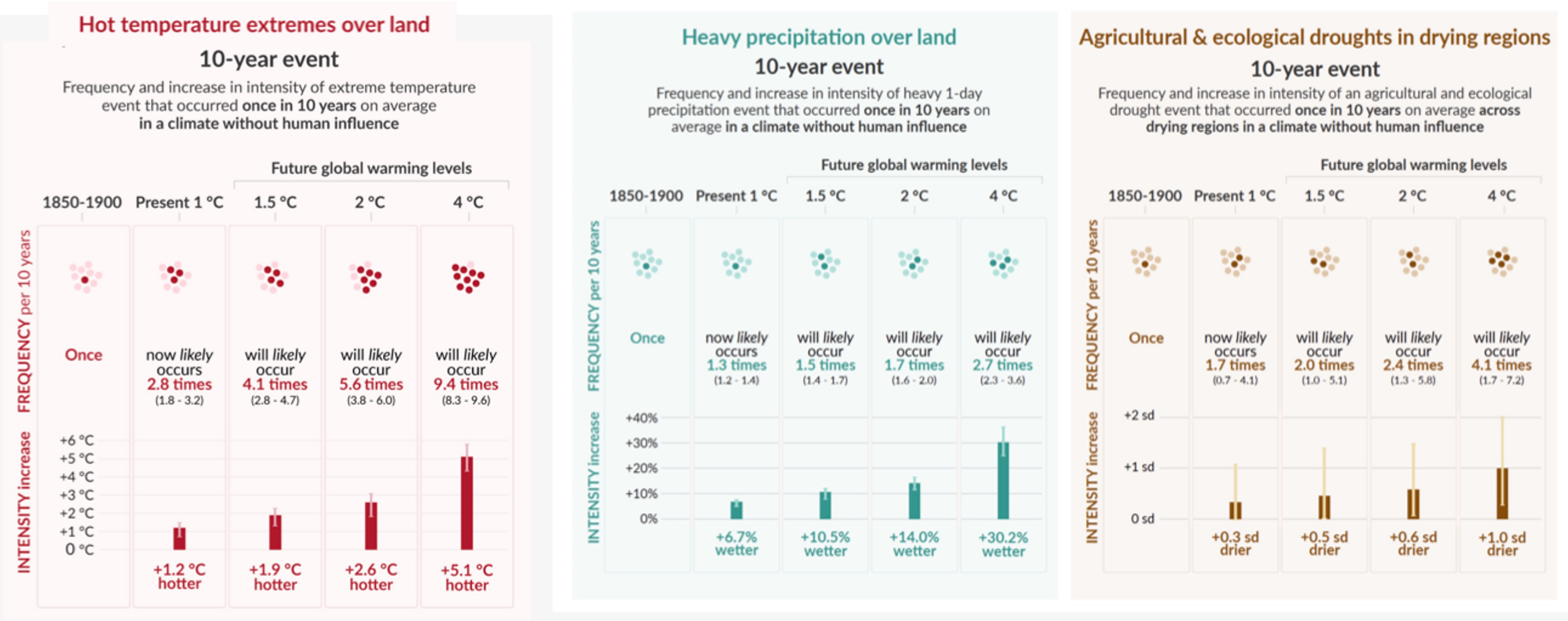
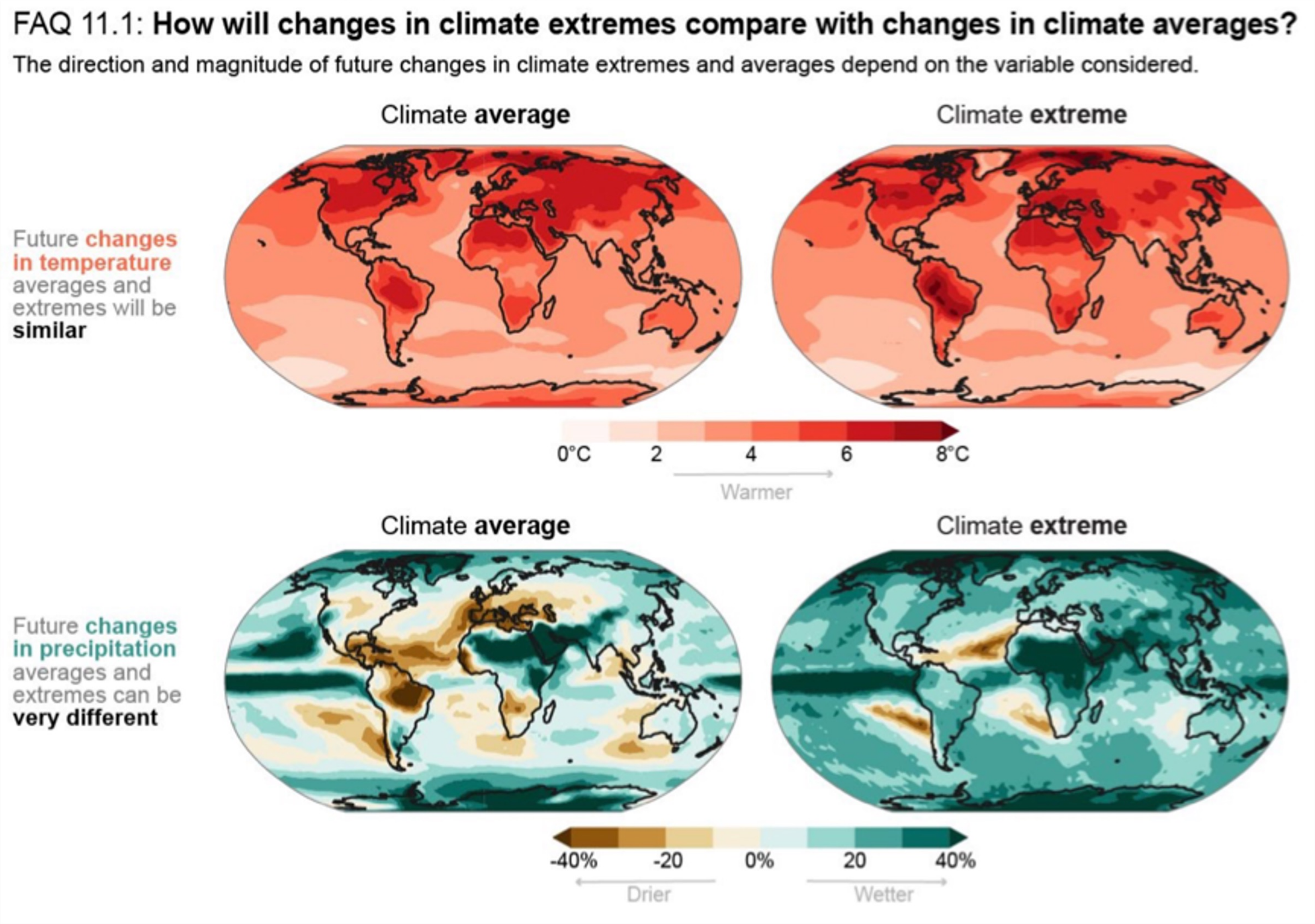


Figure SPM.6: Demonstrates extremes are already more likely and more intense due to current warming and these trends will continue with each additional fraction of warming.

Fig. SPM.6

Projected Changes in extremes vs means

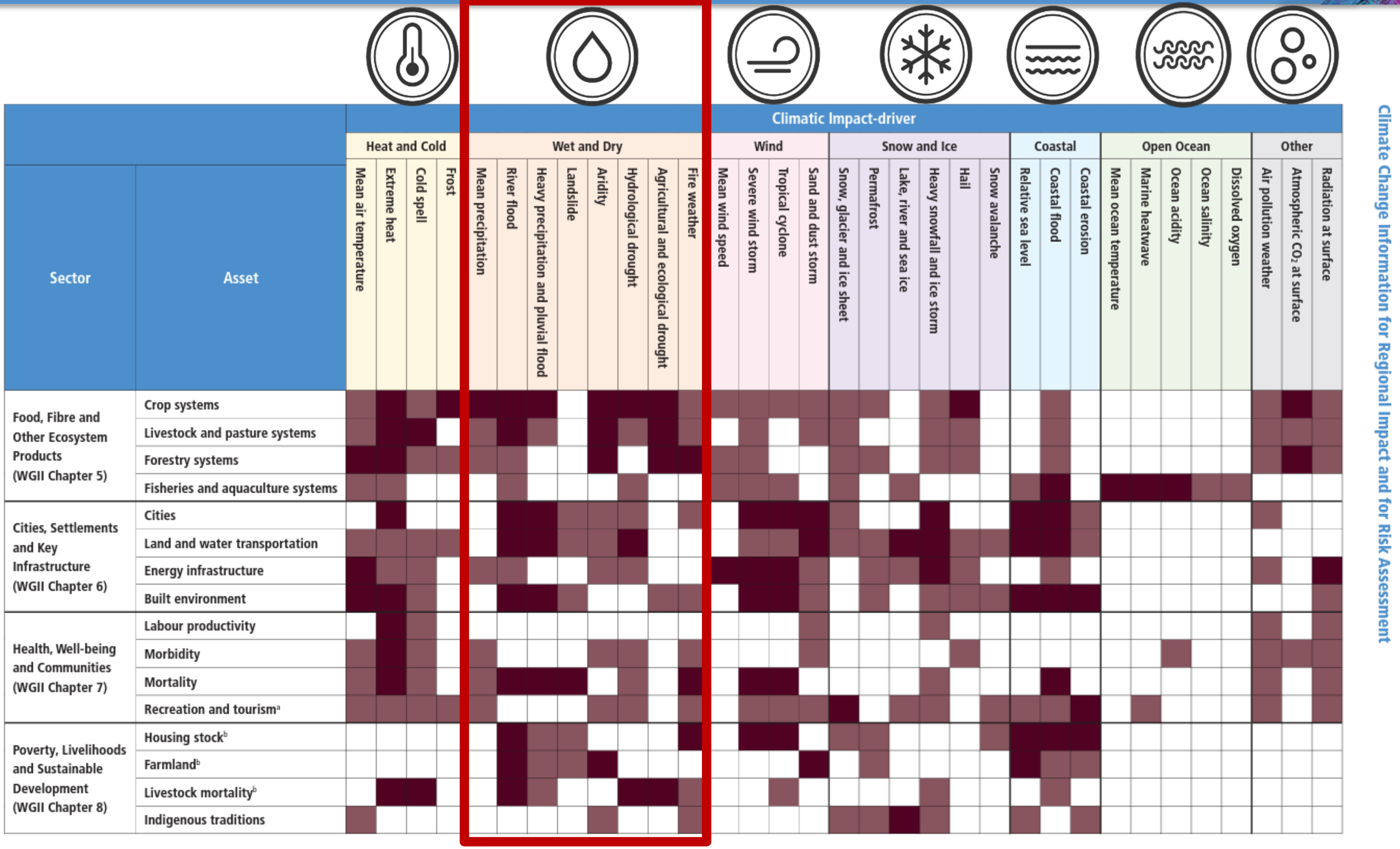


FAQ 11.1 Fig1

FAQ8.3: **Climate change and droughts**

In some regions, drought is expected to increase under future warming

Schematic map highlighting in brown the regions where droughts are expected to become worse as a result of climate change. This pattern is similar regardless of the emissions scenario; however, the magnitude of change increases under higher emissions.



[a] The Recreation and tourism asset category includes outdoor exercise and the tourism industry (including ecosystem services) assessed in many WGII chapters.
[b] This asset category is distinguished by the threat of a full loss of key investments and living environments rather than a recoverable damage or loss of productivity or profit.

Table 12.2 WGI AR6

None/low confidence | Low/moderate | High

Impacts and risk relevance

Each climate change can affect multiple sectors
Each sector is affected by multiple climate changes

Assessment of CIDs information at regional scale

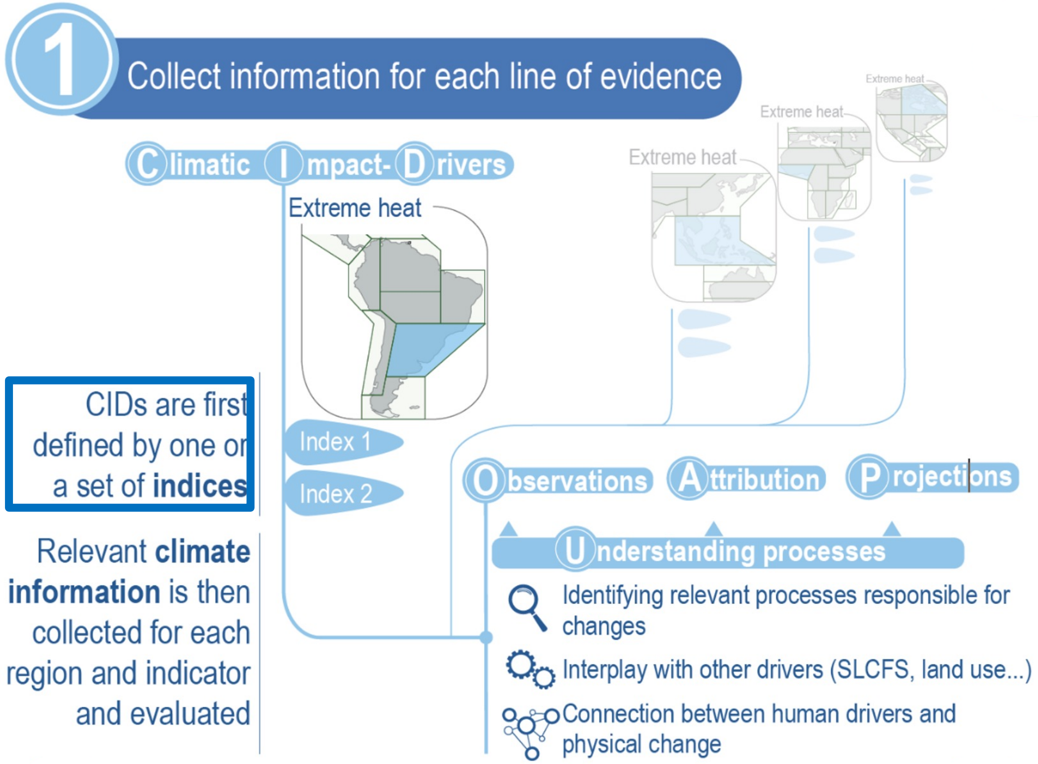


Table AVI.1 | Table listing extreme indices used in Chapter 11.

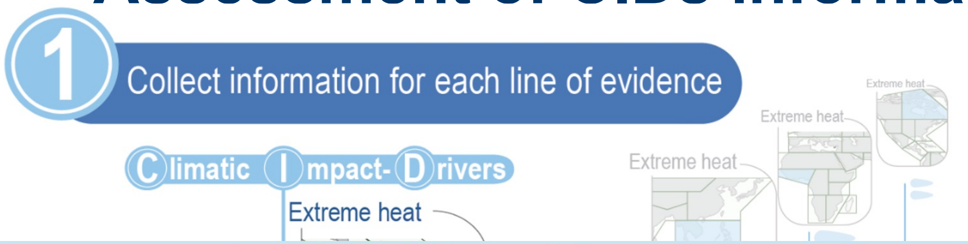
Extreme	Label	Index Name	Units	Variable
Temperature	TXx	Monthly maximum value of daily maximum temperature	°C	Maximum temperature
	TXn	Monthly minimum value of daily maximum temperature	°C	Maximum temperature
	TNn	Monthly minimum value of daily minimum temperature	°C	Minimum temperature
	TNx	Monthly maximum value of daily minimum temperature	°C	Minimum temperature
	TX90p	Percentage of days when daily maximum temperature is greater than the 90th percentile	%	Maximum temperature
	TX10p	Percentage of days when daily maximum temperature is less than the 10th percentile	%	Maximum temperature
	TN90p	Percentage of days when daily minimum temperature is greater than the 90th percentile	%	Minimum temperature
	TN10p	Percentage of days when daily minimum temperature is less than the 10th percentile	%	Minimum temperature
	ID	Number of icing days: annual count of days when TX (daily maximum temperature) <0°C	Days	Maximum temperature
	FD	Number of frost days: annual count of days when TN (daily minimum temperature) <0°C	Days	Minimum temperature
	WSDI	Warm spell duration index: annual count of days with at least six consecutive days when TX >90th percentile	Days	Maximum temperature
	CSDI	Cold spell duration index: annual count of days with at least six consecutive days when TN <10th percentile	Days	Minimum temperature
	SU	Number of summer days: annual count of days when TX (daily maximum temperature) >25°C	Days	Maximum temperature
	TR	Number of tropical nights: annual count of days when TN (daily minimum temperature) >20°C	Days	Minimum temperature
	DTR	Daily temperature range: monthly mean difference between TX and TN	°C	Maximum and minimum temperature
	GSL	Growing season length: annual (1 Jan to 31 Dec in Northern Hemisphere (NH), 1 July to 30 June in Southern Hemisphere (SH)) count between first span of at least six days with daily mean temperature TG >5°C and first span after July 1 (Jan 1 in SH) of six days with TG <5°C	Days	Mean temperature
	20TXx	One-in-20 year return value of monthly maximum value of daily maximum temperature	°C	Maximum temperature
	20TXn	One-in-20 year return value of monthly minimum value of daily maximum temperature	°C	Maximum temperature
	20TNn	One-in-20 year return value of monthly minimum value of daily minimum temperature	°C	Minimum temperature
	20TNx	One-in-20 year return value of monthly maximum value of daily minimum temperature	°C	Minimum temperature
Precipitation	Rx1day	Maximum one-day precipitation	mm	Precipitation
	Rx5day	Maximum five-day precipitation	mm	Precipitation
	R5mm	Annual count of days when precipitation is greater than or equal to 5 mm	Days	Precipitation
	R10mm	Annual count of days when precipitation is greater than or equal to 10 mm	Days	Precipitation
	R20mm	Annual count of days when precipitation is greater than or equal to 20 mm	Days	Precipitation
	R50mm	Annual count of days when precipitation is greater than or equal to 50 mm	Days	Precipitation
	CDD	Maximum number of consecutive days with less than 1 mm of precipitation per day	Days	Precipitation
	CWD	Maximum number of consecutive days with more than or equal to 1 mm of precipitation per day	Days	Precipitation
	R95p	Annual total precipitation when the daily precipitation exceeds the 95th percentile of the wet-day (>1 mm) precipitation	mm	Precipitation
	R99p	Annual precipitation amount when the daily precipitation exceeds the 99th percentile of the wet-day precipitation	mm	Precipitation
	SDII	Simple precipitation intensity index	mm day^{-1}	Precipitation
	20Rx1day	One-in-20 year return value of maximum one-day precipitation	mm day^{-1}	Precipitation
	20Rx5day	One-in-20 year return value of maximum five-day precipitation	mm day^{-1}	Precipitation
Drought	SPI	Standardized precipitation index	Months	Precipitation
	EDDI	Potential evaporation, evaporative demand drought index	Months	Evaporation
	SMA	Soil moisture anomalies	Months	Soil moisture
	SSMI	Standardized soil moisture index	Months	Soil moisture
	SRI	Standardized runoff index	Months	Streamflow
	SSI	Standardized streamflow index	Months	Streamflow
	PDSI	Palmer drought severity index	Months	Precipitation, evaporation
	SPEI	Standardized precipitation evapotranspiration index	Months	Precipitation, evaporation, temperature

Table AVI.2 | Regional CID indices table and relevant references.

CID Category	Climatic Impact-driver (from Table 12.1) and Potential Affected Sectors	Index	Required ECVs	Way to Calculate	Bias Adjustment	References
Heat	Change in cooling demand for energy demand and building consumption	Cooling degree days above 22°C	Tas, tasmin, tasmax	From projections	Yes	Spinoni et al. (2015, 2018)
	Heat, with thresholds important for agriculture	Number of days with Tmax >35°C or 40°C (TX35, TX40)	Tasmax	From projections	Yes	Hatfield and Prueger (2015); Hatfield et al., (2015); Grotjahn (2021)
	Heat stress index combining humidity used in occupational and industrial health	NOAA heat index (HI): number of days above 41°C threshold	Tasmax, huss, ps	From projections	Yes	Burkart et al. (2011); Lin et al. (2012); Kent et al. (2014)
Cold	Heating degree day for energy consumption	Heating degree days below 15.5°C	Tas, tasmin, tasmax	From projections	Yes	Spinoni et al. (2015, 2018)
	Frost	Number of frost days below 0°C (FD)	Tasmin	From projections	Yes	Barlow et al. (2015); Rawlins et al. (2016)
Wet	River flooding	Flood index (FI)	srroff/mrro	From projections and simplified routing model	No	Forzieri et al. (2016); Alfieri et al. (2017)
Drought	Aridity	Soil moisture (SM)	mrso	From projections	No	Cook et al. (2020)
	Droughts	Standardized Precipitation Index accumulated over 6 months (SPI-6)	Pr	From projections	No	Naumann et al. (2018)
Wind & storm	Mean wind speed	Annual mean wind speed	sfcWind	From projections	No	Karnauskas et al. (2018); Li et al. (2018)
Snow/ice	Snow season length	Number of days with snow water equivalent >100 mm (SWE100) over the snow season (Nov–Mar for NH)	Snw	From projections	No	Damm et al. (2017); Wobus et al. (2017)
Coastal	Extreme sea level (ETWL) inducing storm surges	1-in-100-year return period level (ETWL)		Data from authors	No	Vousdoukas et al. (2018)
	Coastal erosion	Shoreline retreat by mid- and end of century		Data from authors	No	Vousdoukas et al. (2020)

Annex VI: Climatic Impact-driver and Extreme Indices (IPCC Sixth Assessment Report – WG1)

Assessment of CIDs information at regional scale



1. Collection and assessment of the fitness-for-purpose of available information

Any specific climate change that is regionally relevant is assessed looking at lines of evidence, potentially across multiple indices. For example, several definitions of 'drought' exist that refer to a variety of the underlying processes, temporal and spatial scales, as well as sectoral applications and associated impacts (Sections 11.6 and 12.3). Such diverse definitions need to be gathered from the relevant literature, compared, and individually assessed if appropriate.

Once the indices of change are properly defined, the relevant climate information is collated from the available sources.

Regional assessment short summary ...

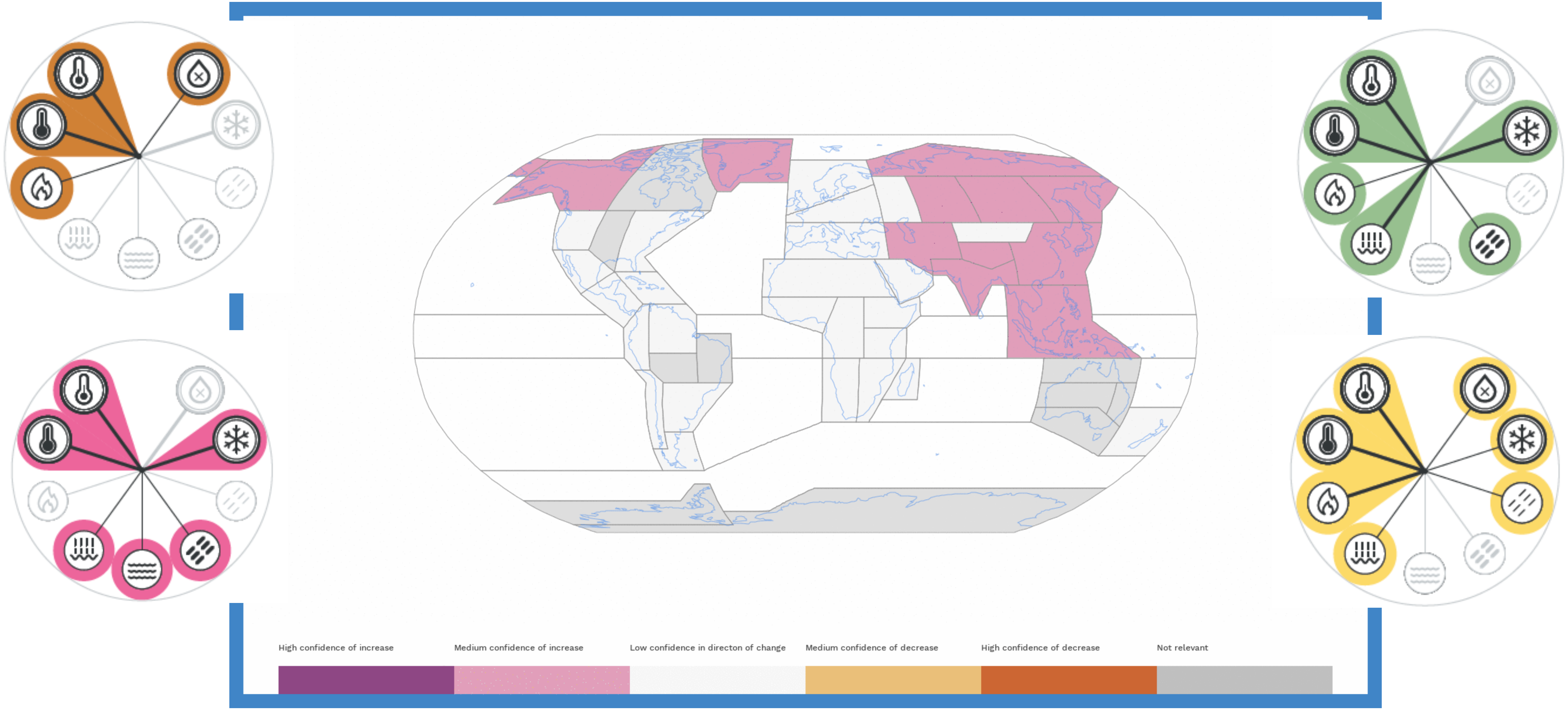
Number of land & coastal regions (a) and **open-ocean regions** (b) where each **climatic impact-driver** (CID) is projected to increase or decrease with ***high*** *confidence* (dark shade) or ***medium*** *confidence* (light shade)

Changes of CIDs related to the **water cycle** have a more region specific distribution

- All regions are projected to experience changes in at least 5 CIDs.
- 96% of regions are projected to experience changes in at least 10 CIDs.
- 50% of regions are projected to experience changes in at least 15 CIDs.

Figure SPM.9 WGI AR6

Multiple climatic impact-drivers will change in all regions of the world

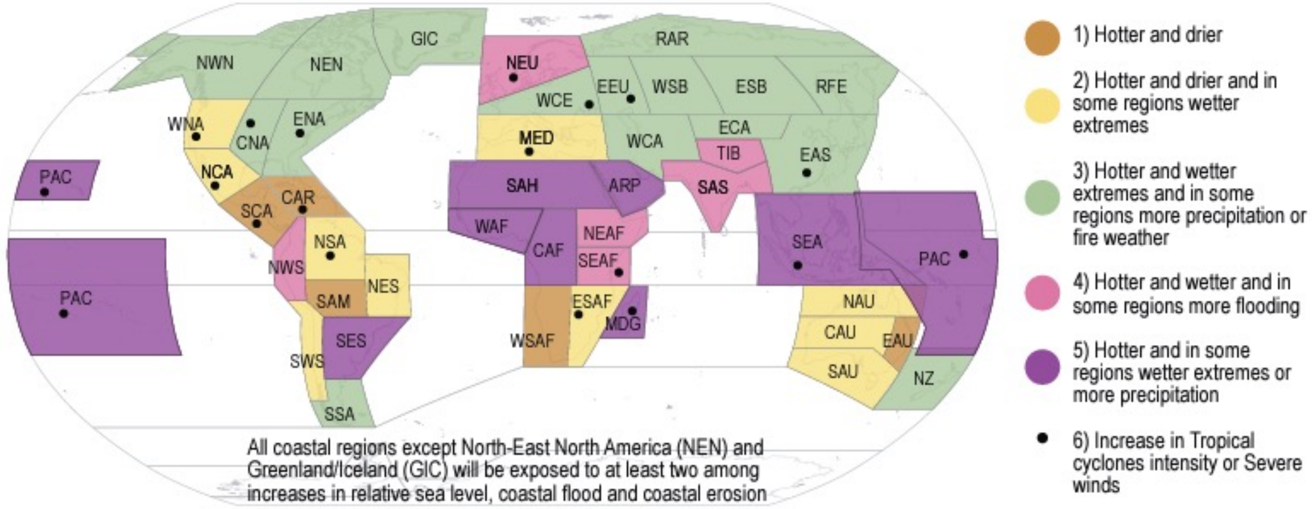


Multiple climatic impact-drivers will change in all regions of the world

While changes in climatic impact-drivers are projected everywhere, there is a specific combination of changes each region would experience

(a) World regions grouped into five clusters, each one based on a combination of changes in climatic impact-drivers

Assessed future changes: Changes refer to a 20–30 year period centred around 2050 and/or consistent with 2°C global warming compared to a similar period within 1960–2014 or 1850–1900.



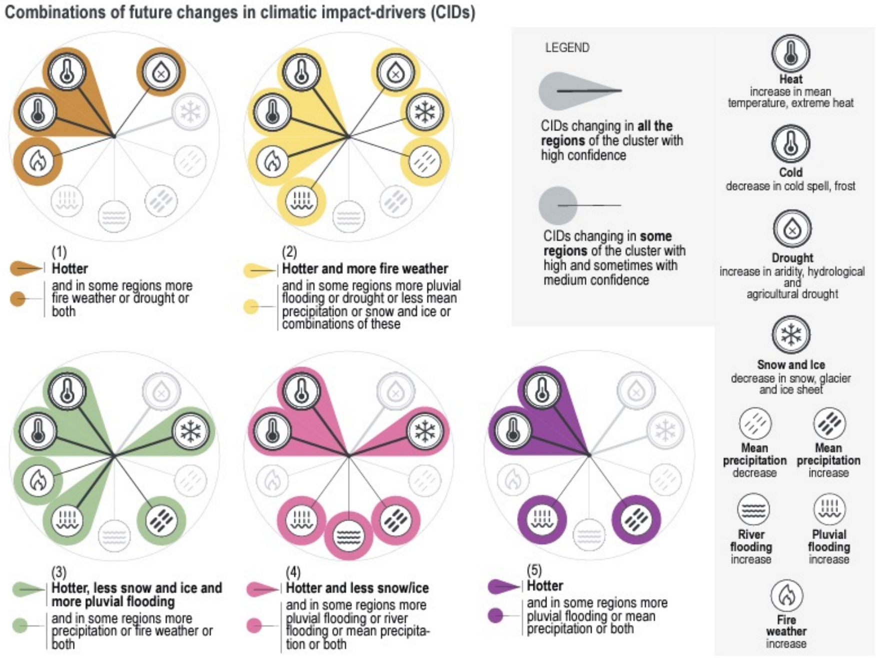
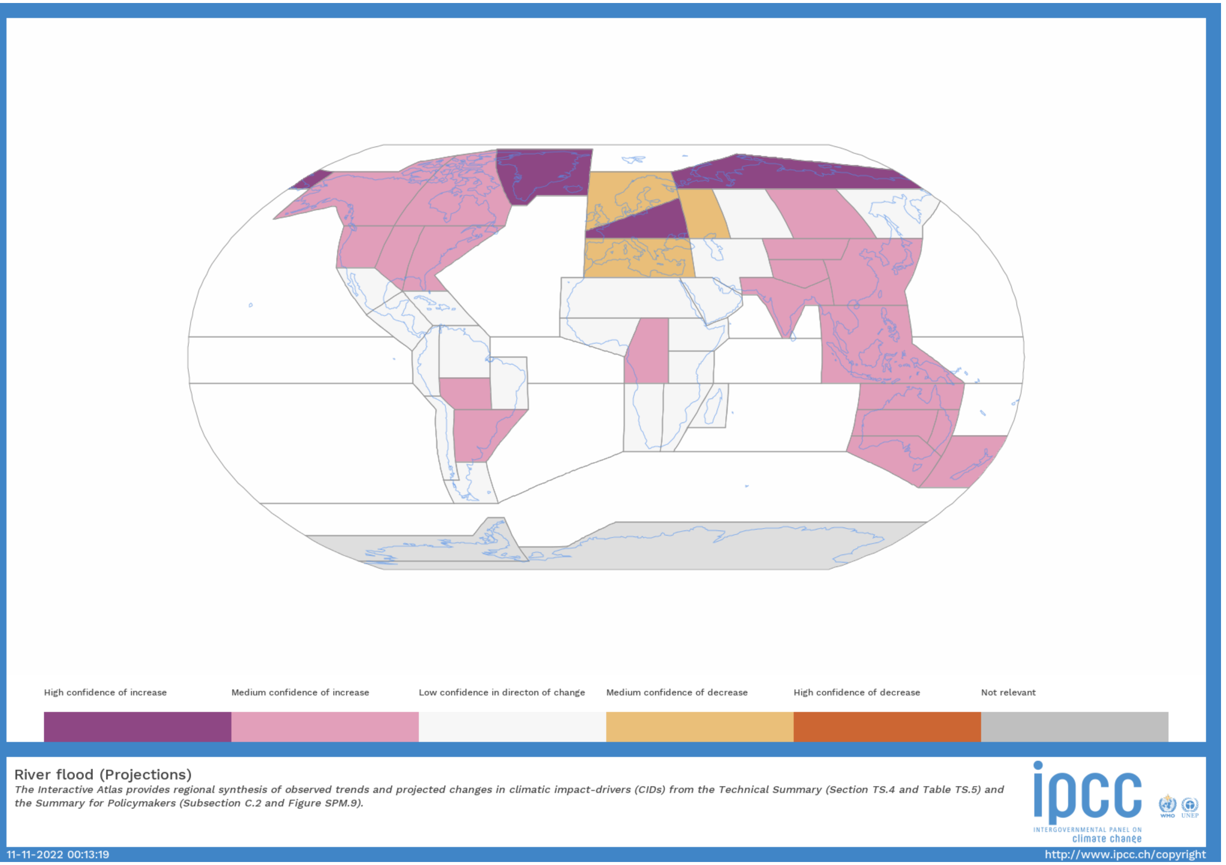
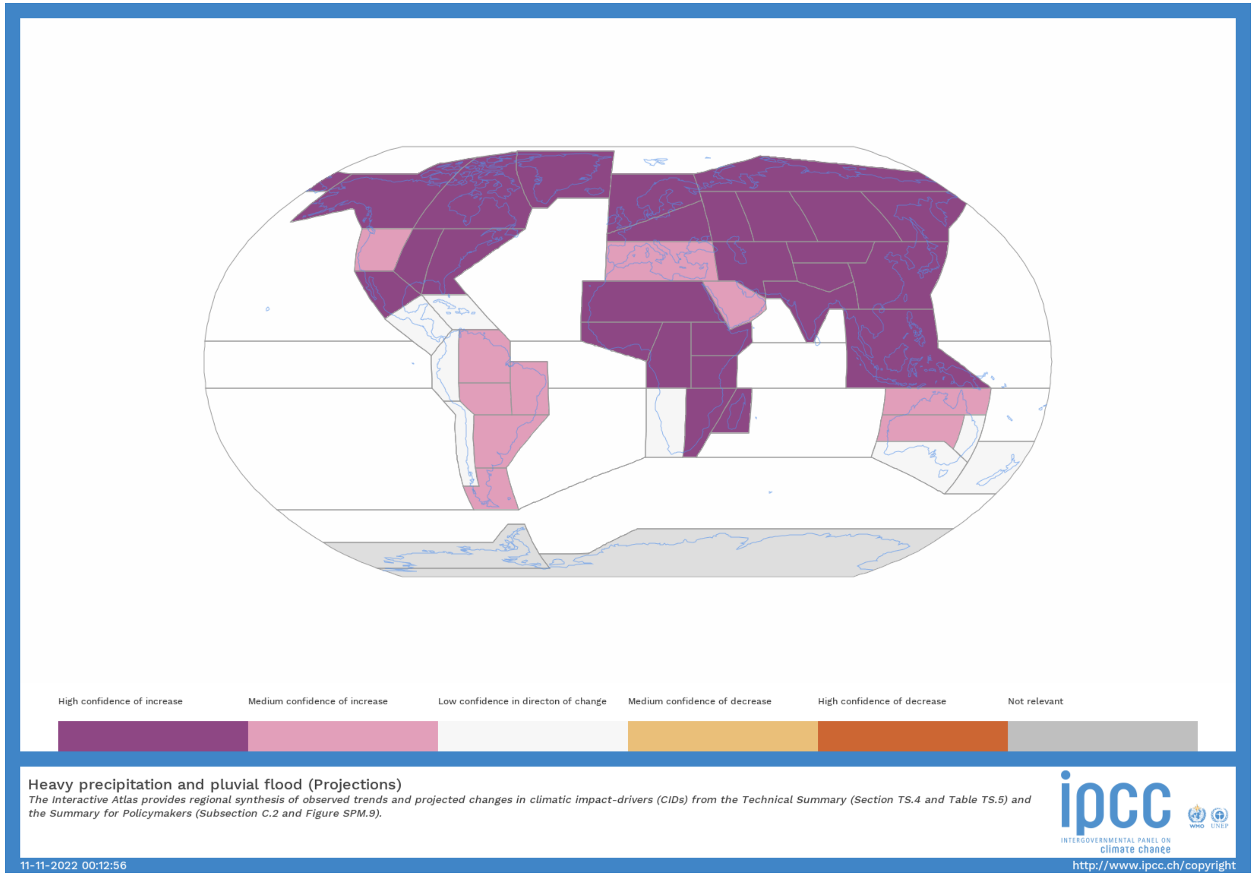


Figure TS.22 WGI AR6

River flood



Pluvial flood



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Interactive Atlas: interactive-atlas.ipcc.ch

WET AND DRY

- [x] Mean precipitation ✕
- [ ] River flood
- [ ] Heavy precipitation and pluvial flood
- [x] Landslide ✕
- [x] Aridity ✕
- [x] Hydrological drought ✕
- [x] Agricultural and ecological drought ✕
- [x] Fire weather ✕

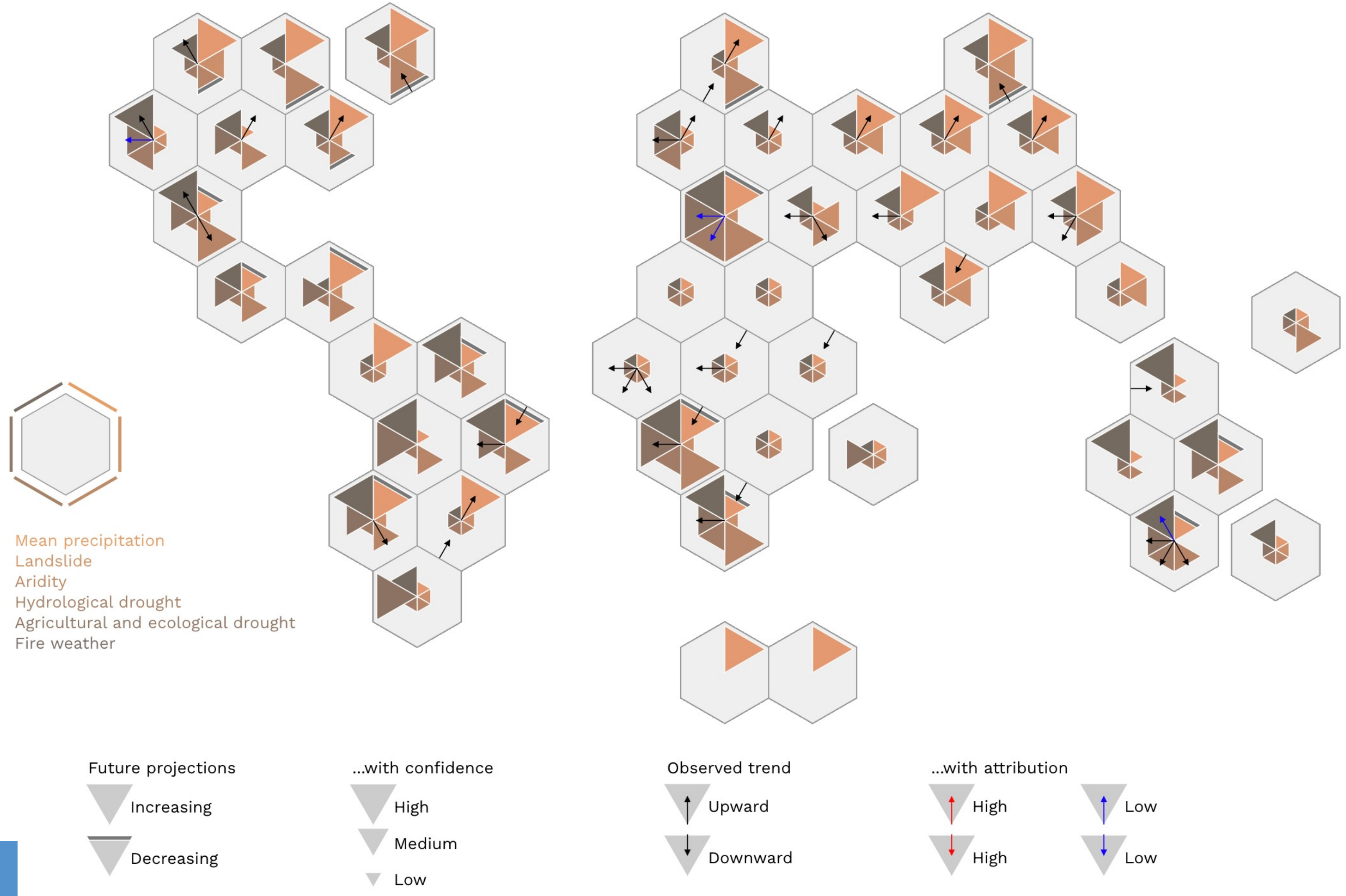
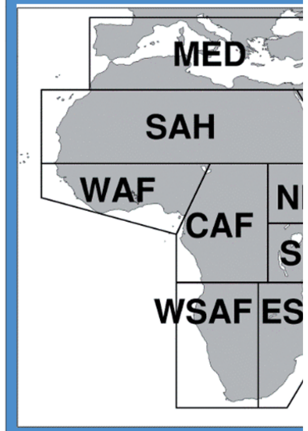


Table 12.7 | Summary of confiden[...] SRES A1B, or above within each AR[...] for more details of the assessment[...] in Section 12.5.2.

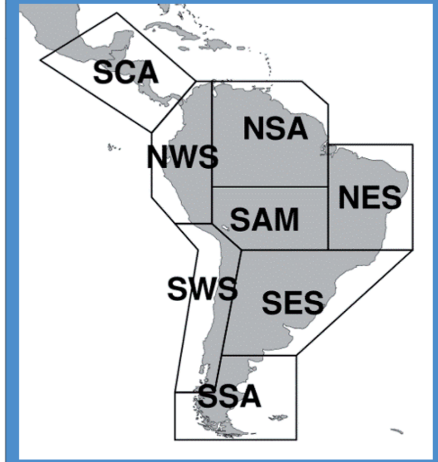
Region
Mediterranean (MED)
Western and Central Europe (WCE)
Eastern Europe (EEU)
Northern Europe (NEU)

Table 12.3 | Summary of confidence [...] SRES A1B, or above within each AR6 [...] for more details of the assessment r[...] in Section 12.5.2.



Region
North Africa[a]
Sahara (SAH)
Western Africa (WAF)
Central Africa (CAF)
North Eastern Africa (NEAF)
South Eastern Africa (SEAF)
West Southern Africa (WSAF)
East Southern Africa (ESAF)
Madagascar (MDG)

Table 12.6 | Summary of confidence in direction of projected change in climatic impact-drivers in Central and South America, representing their aggregate characteristic changes for mid-century for scenarios RCP4.5, SSP2-4.5, SRES A1B, or above within each AR6 region (defined in Chapter 1), approximately corresponding (for CIDs that are independent of sea level rise) to global warming levels between 2 and 2.4°C (see Section 12.4 for more details of the assessment method). The table also includes the assessment of observed or projected time-of-emergence of the CID change signal from the natural interannual variability if found with at least *medium confidence* in Section 12.5.2.



Region	Heat and Cold: Mean air temperature	Extreme heat	Cold spell	Frost	Wet and Dry: Mean precipitation	River flood	Heavy precipitation and pluvial flood	Landslide	Aridity	Hydrological drought	Agricultural and ecological drought	Fire weather	Wind: Mean wind speed	Severe wind storm	Tropical cyclone	Sand and dust storm	Snow and Ice: Snow, glacier and ice sheet	Permafrost	Lake, river and sea ice	Heavy snowfall and ice storm	Hail	Snow avalanche	Coastal and Oceanic: Relative sea level	Coastal flood	Coastal erosion	Marine heatwave	Ocean acidity	Other: Air pollution weather	Atmospheric CO_2 at surface	Radiation at surface
Southern Central America (SCA)	●	●	●												2								●		3		●		●	
North-Western South America (NWS)	●	●	●																				●		3,4		●		●	
Northern South America (NSA)	●	●	●												2								●		3,4		●		●	
South American Monsoon (SAM)	●	●	●			1																							●	
North-Eastern South America (NES)	●	●	●																				●		3,4		●		●	
South-Western South America (SWS)	●	●	●																				●		3		●		●	
South-Eastern South America (SES)	●	●	●																				●		3		●		●	
Southern South America (SSA)	●	●	●																				●		3		●		●	

- ● Already emerged in the historical p[...]
- ● Emerging by 2050 at least in scenarios RCP8.5/SSP5-8.5 (*medium t*[...]
- ● Emerging after 2050 and by 2100 at least in scenarios RCP8.5/SSP5-8.5 (*medium to high confidence*)

High confidence of decrease | Medium confidence of decrease | Low confidence in direction of change | Medium confidence of increase | High confidence of increase | Not broadly relevant

AR6 WGI-Chapter 12, **Table 12.17**

Roughly half the world's population currently experience severe water scarcity at some point each year, partly due to climate change

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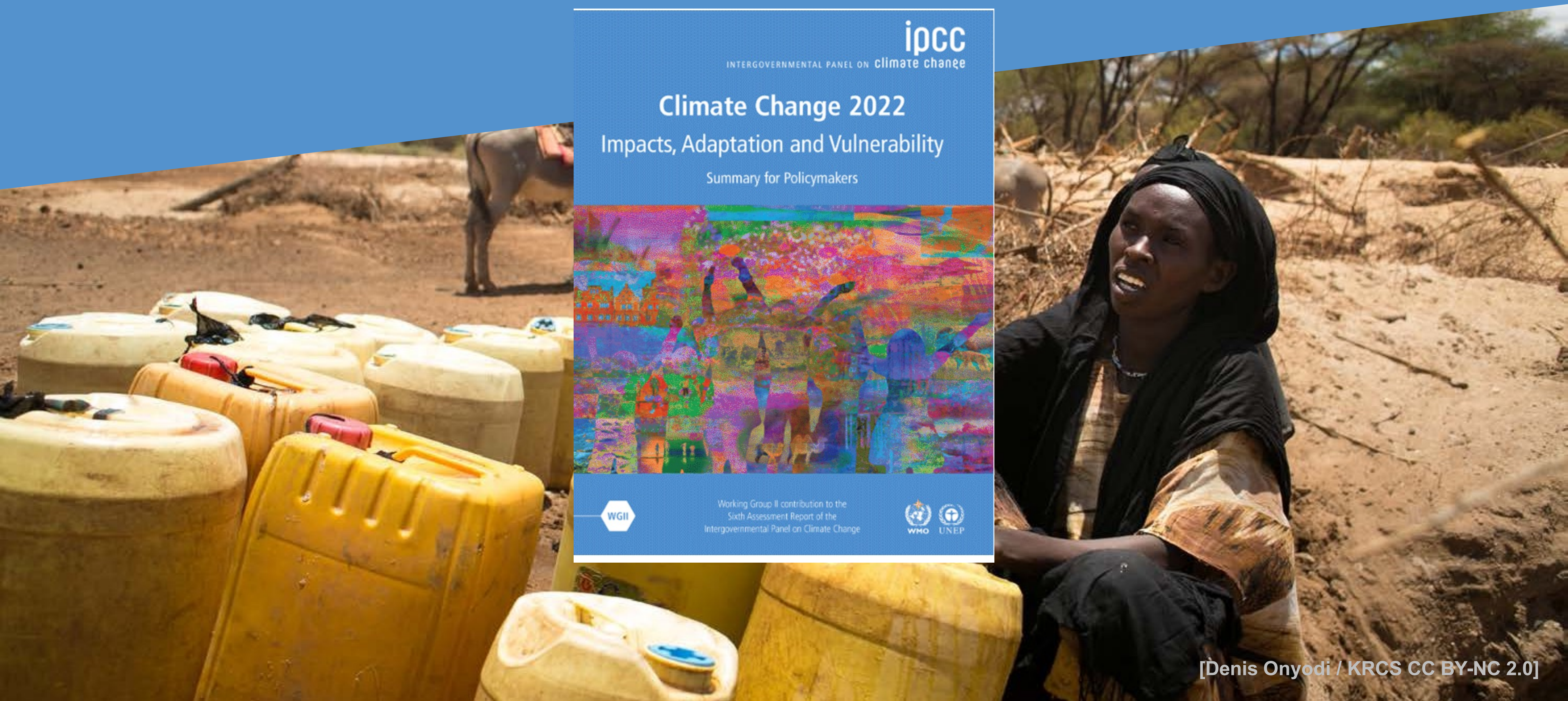
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP



[Denis Onyodi / KRCS CC BY-NC 2.0]

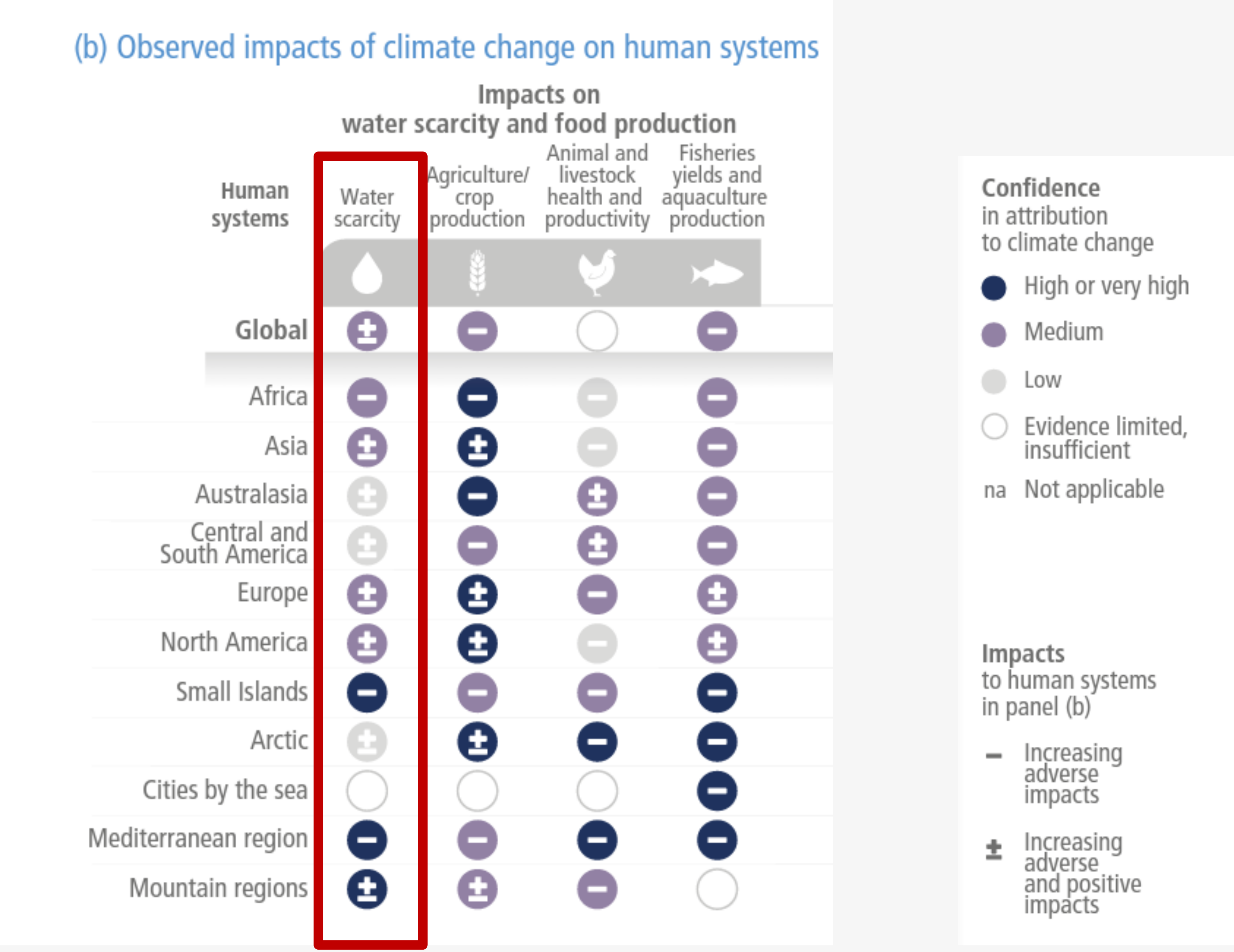


Figure SPM.2 WGII AR6

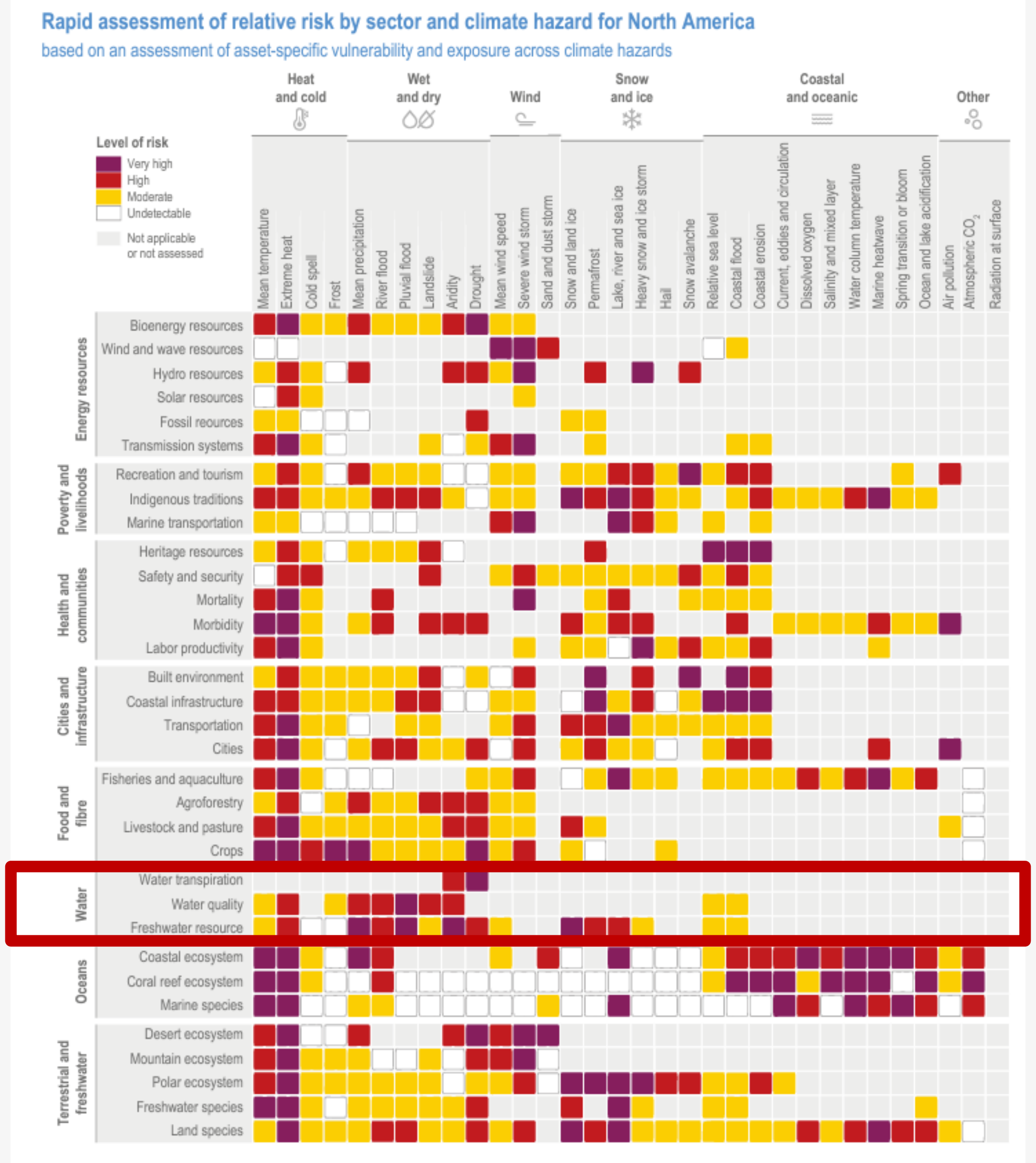
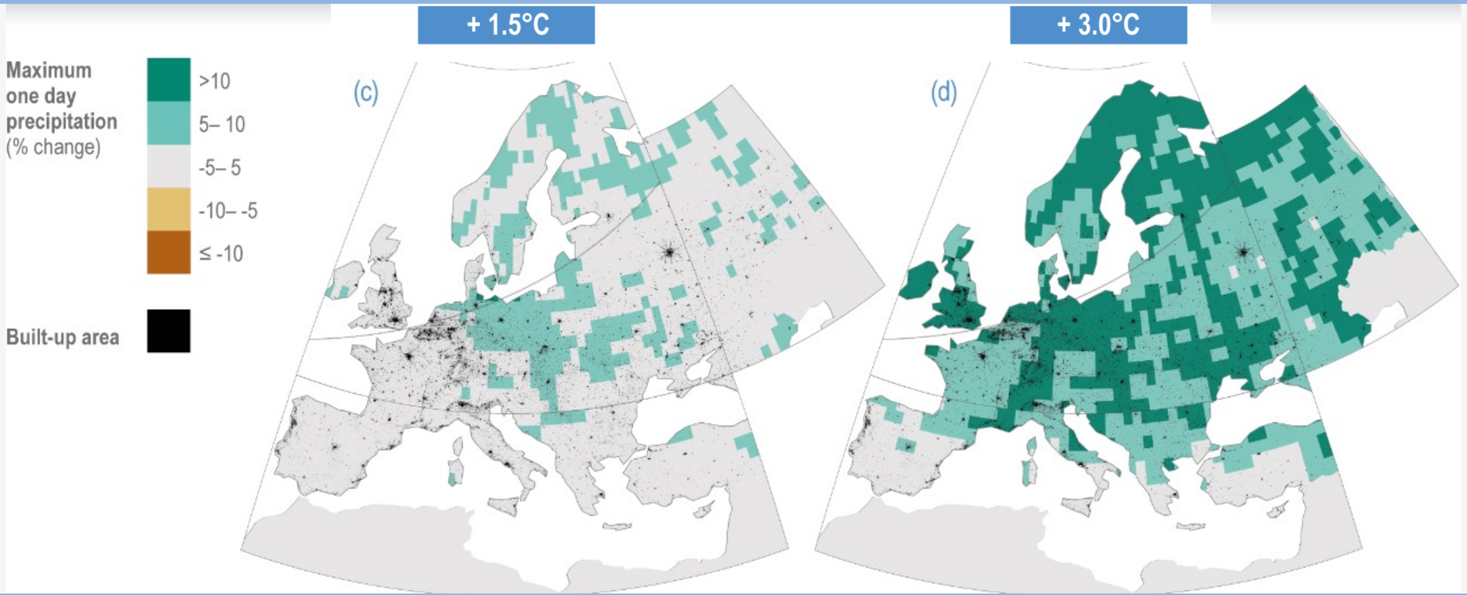


Figure 14.11 WGII AR6

Climate impact-driver and socio-ecological vulnerability

Pluvial flooding & build-up area



drought & annual harvested rainfed areas

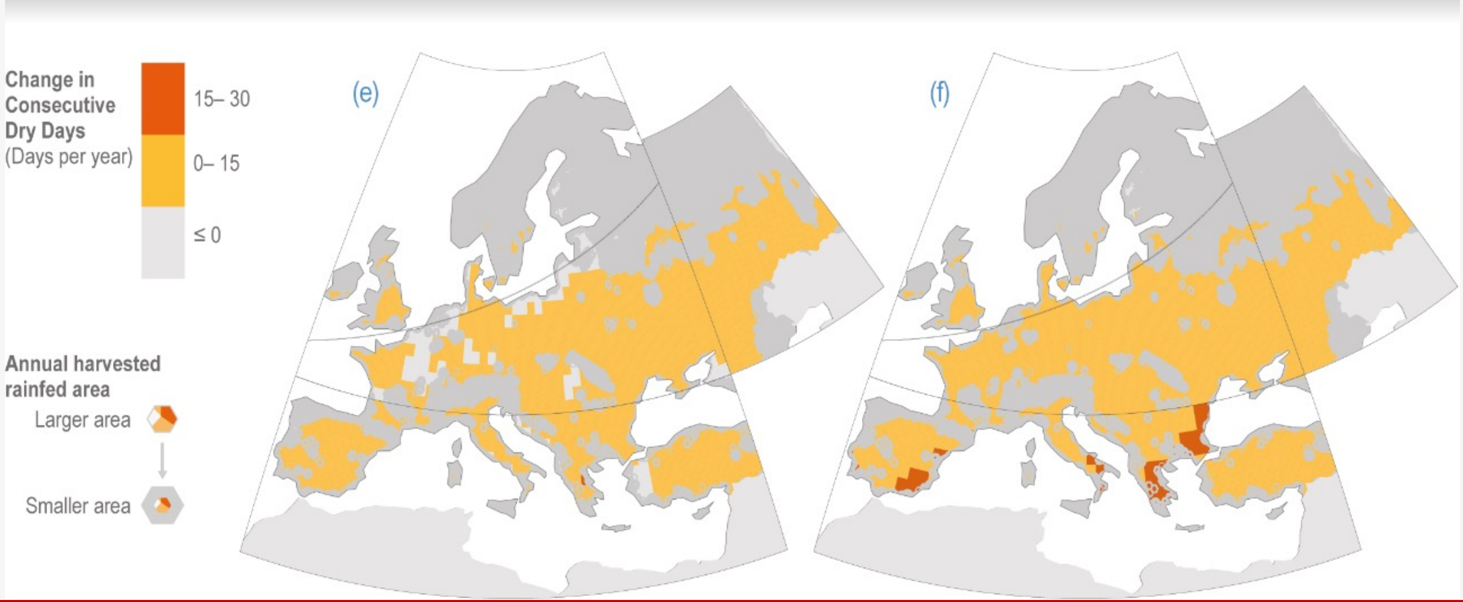


Figure 13.4 WGII AR6

Risk of pluvial flooding and meteorological drought

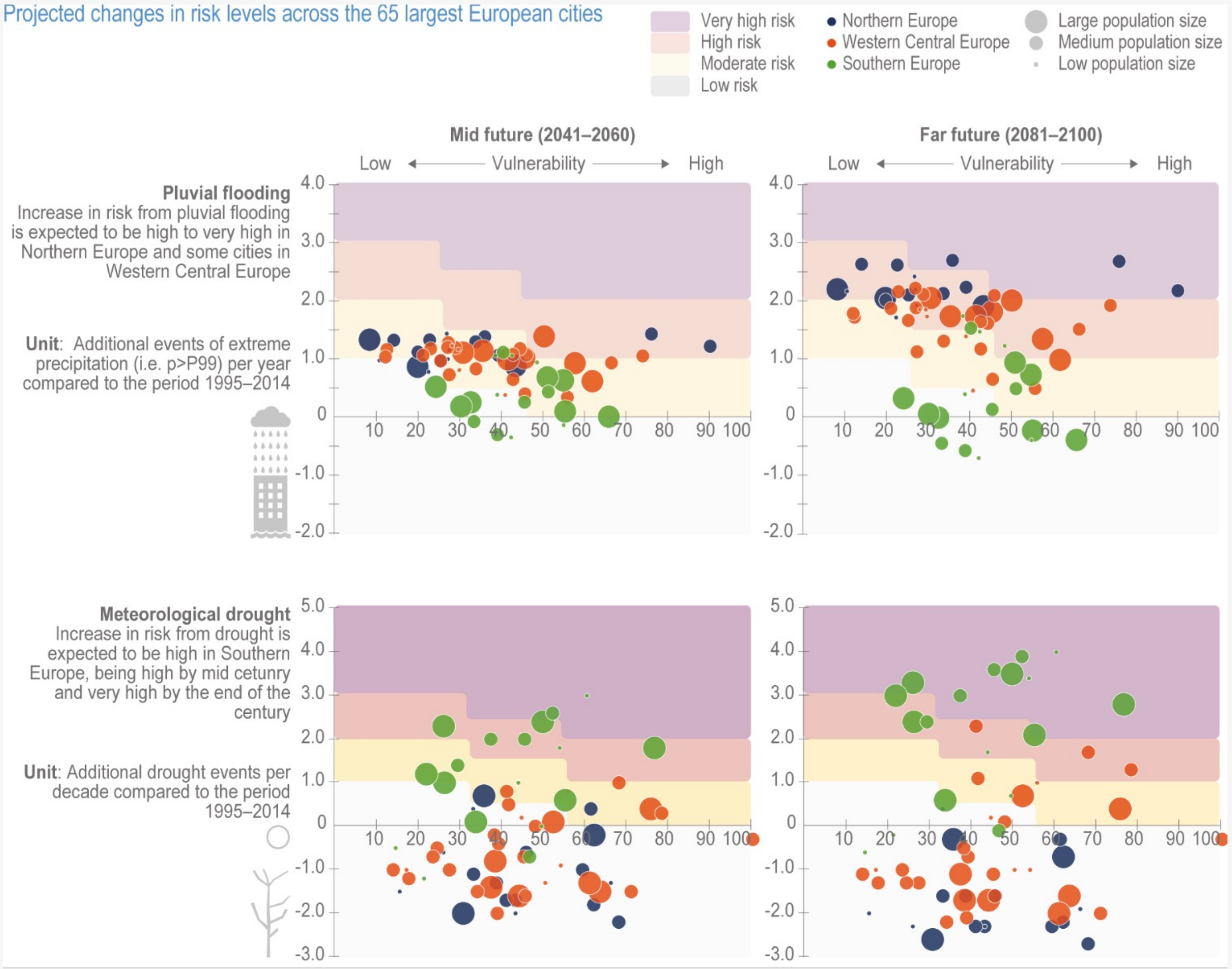
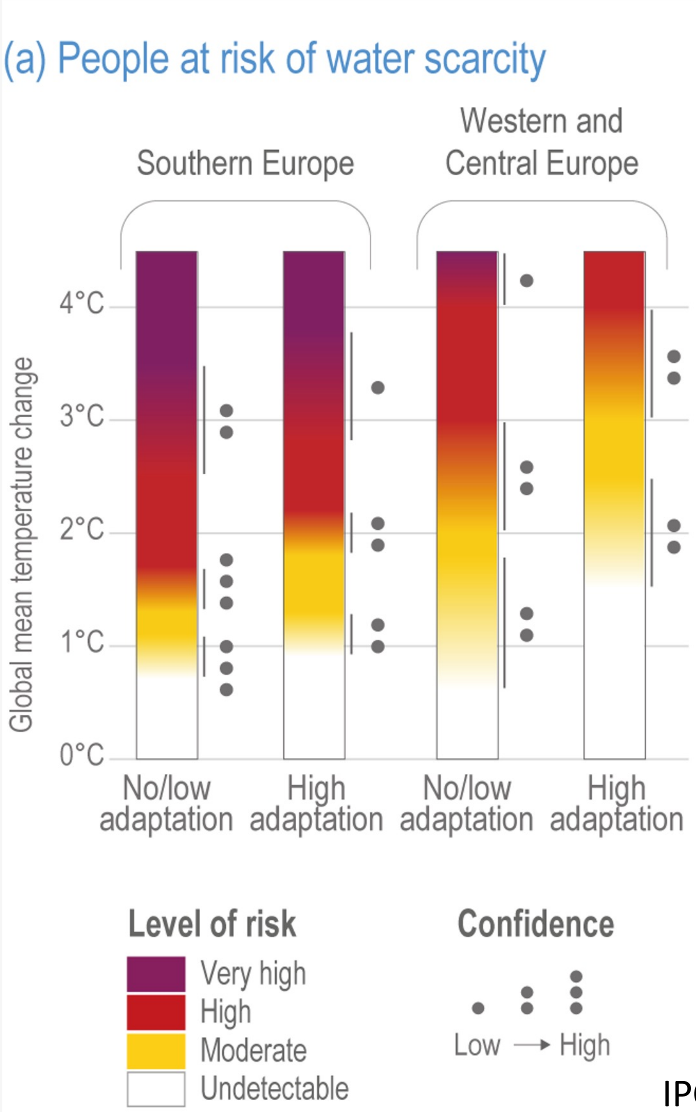
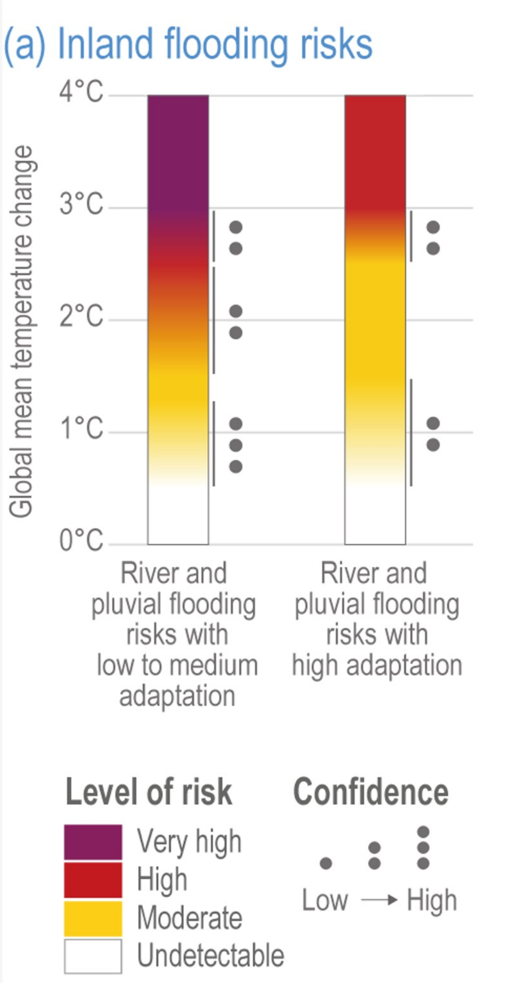


Figure 13.17 WGII AR6

Water related risks without and with adaptation in Europe





IPCC WG2 AR6 Figs. 13.31a-13.32a

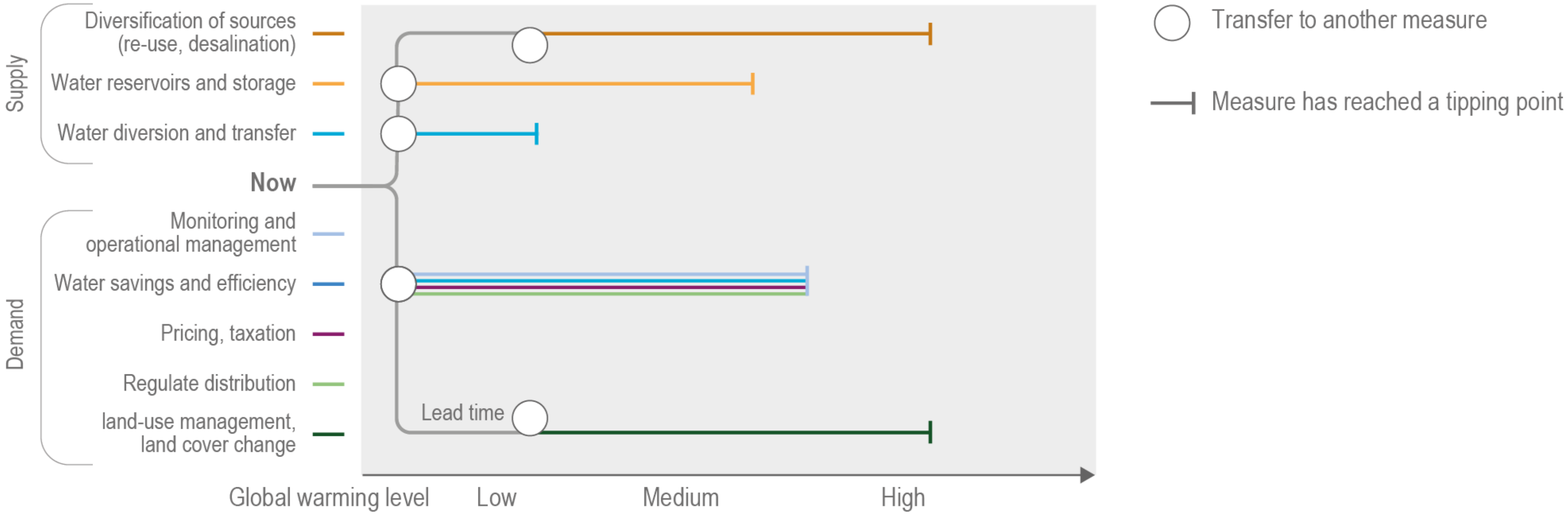
<u>Low adaptation</u>: largely sporadic and consists of small adjustments to Business-As-Usual. Coordination and mainstreaming are limited and fragmented.

<u>Medium adaptation</u>: Adaptation is expanding and increasingly coordinated, including wider implementation and multi-level coordination.

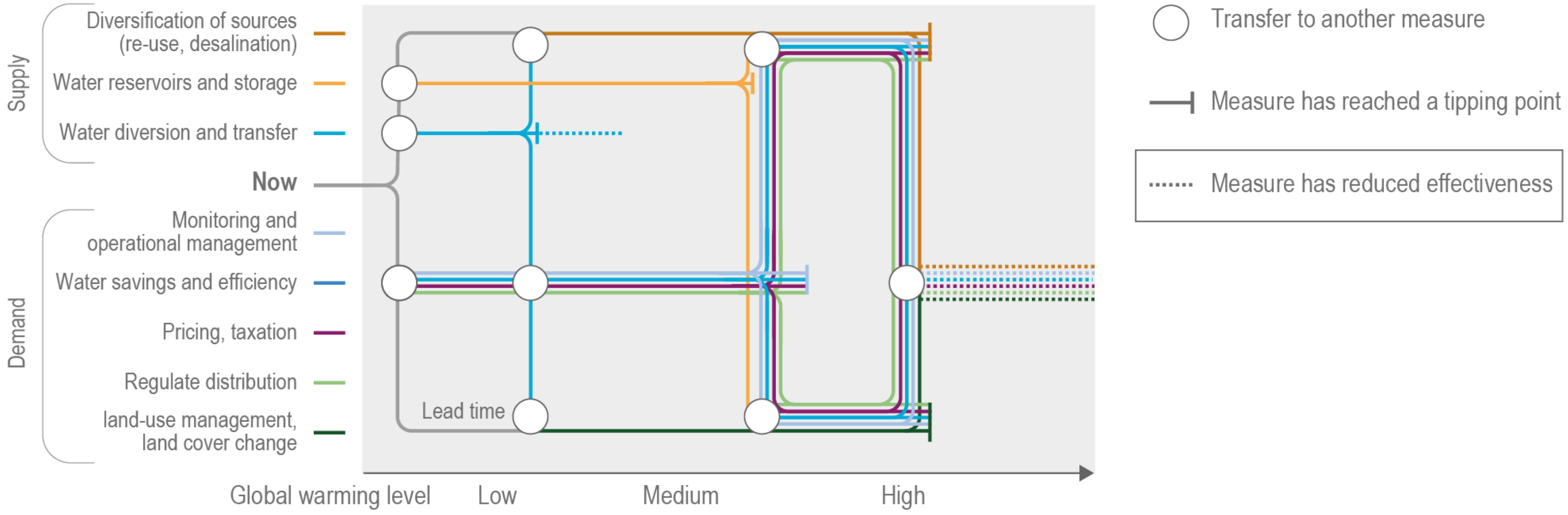
<u>High adaptation</u>: Adaptation is widespread and implemented at or very near its full potential across multiple dimensions.

IPCC WG2 Chapter 16

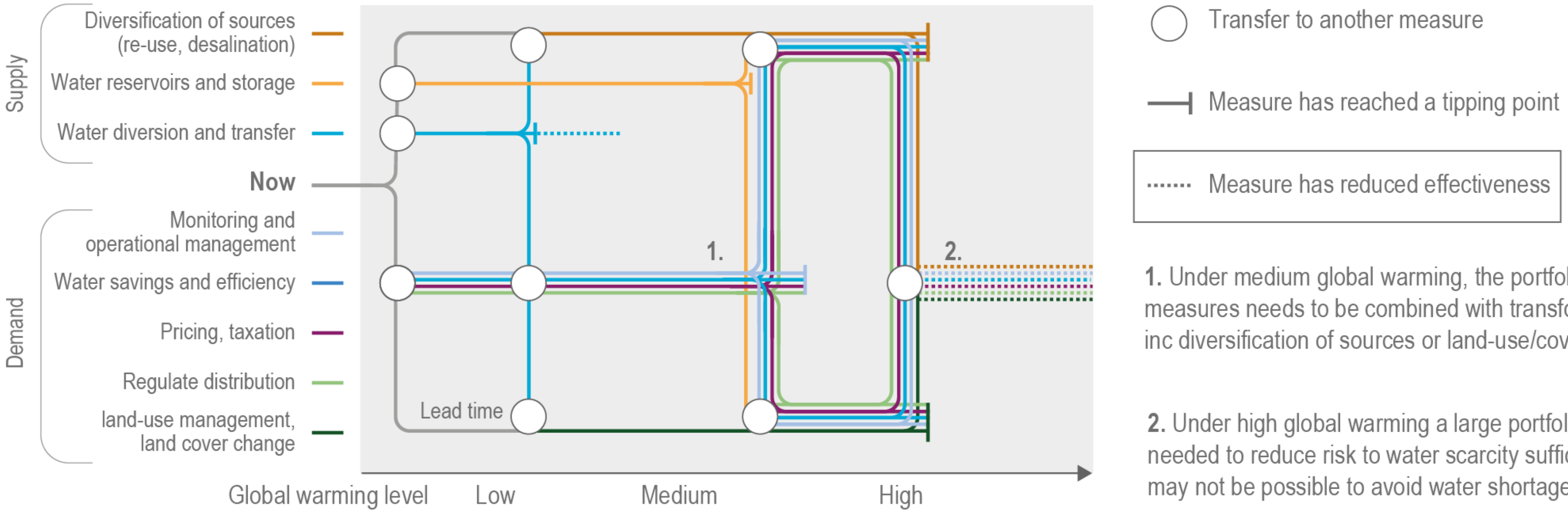
Adaptation pathways water scarcity



Adaptation pathways water scarcity



Adaptation pathways water scarcity



1. Under medium global warming, the portfolio of demand side measures needs to be combined with transformative measures inc diversification of sources or land-use/cover changes.

2. Under high global warming a large portfolio of measures is needed to reduce risk to water scarcity sufficiently, and this may not be possible to avoid water shortage.

Observed and projected hazards in Central and South America

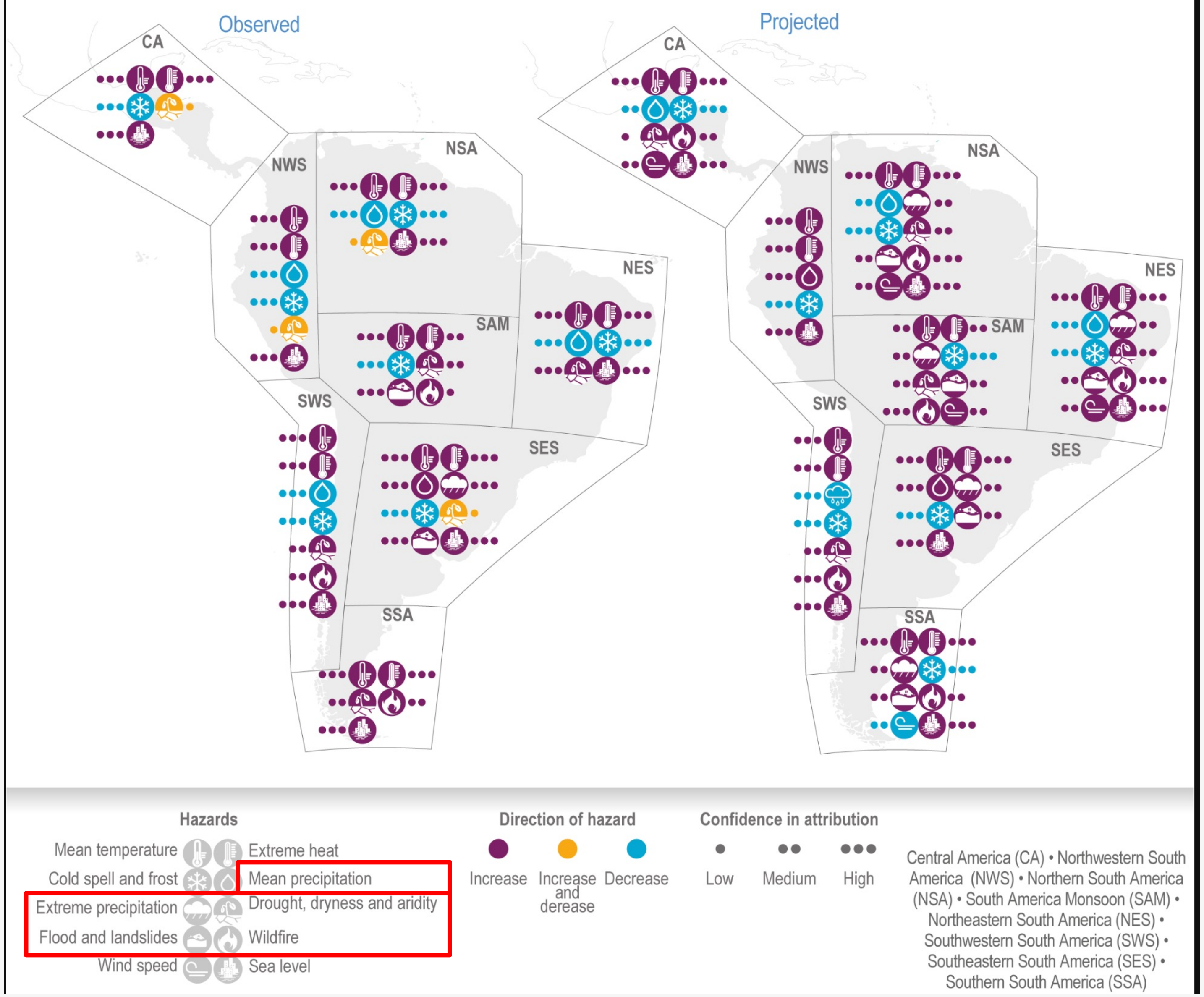


Figure 12.6 WGII AR6

Synthesis of key risks for the CSA region. The base map indicates the mean temperature change between the SSP2 4.5 scenario using CMIP6 model projections for 2081–2100 and a baseline period of 1986–2005 (WGI AR6 Atlas, Gutiérrez et al., 2021).

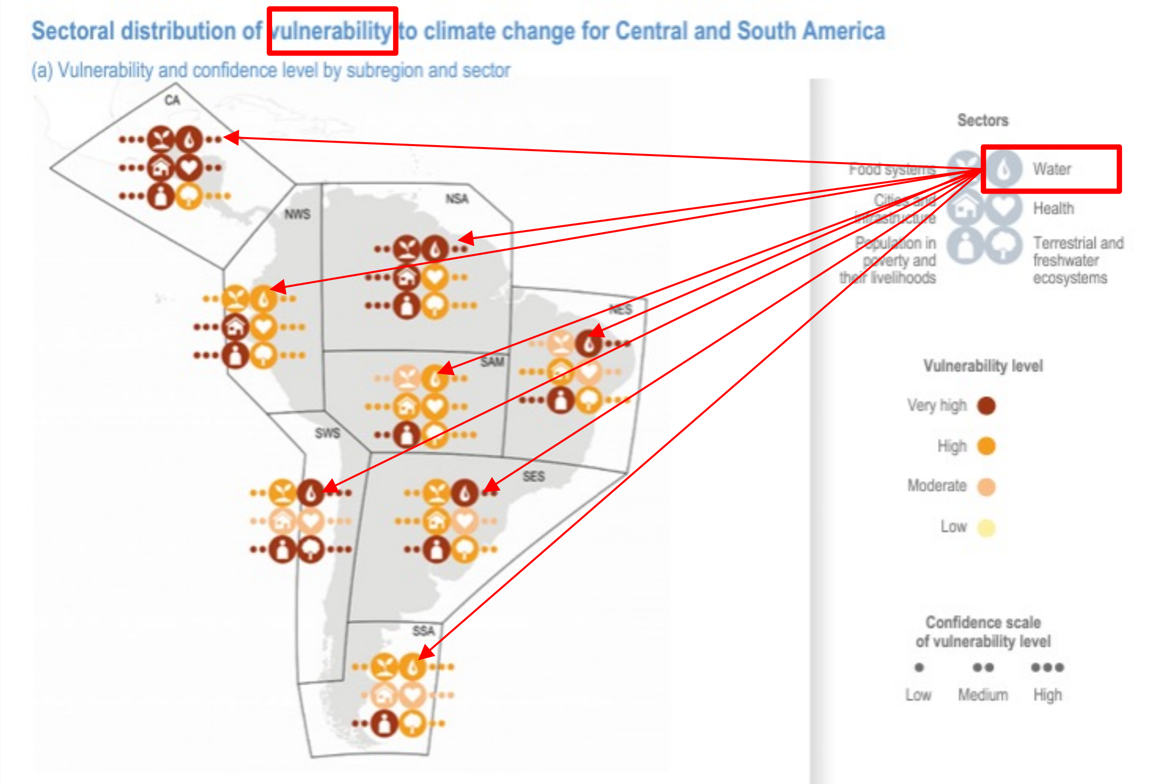


Figure 12.7 WGII AR6

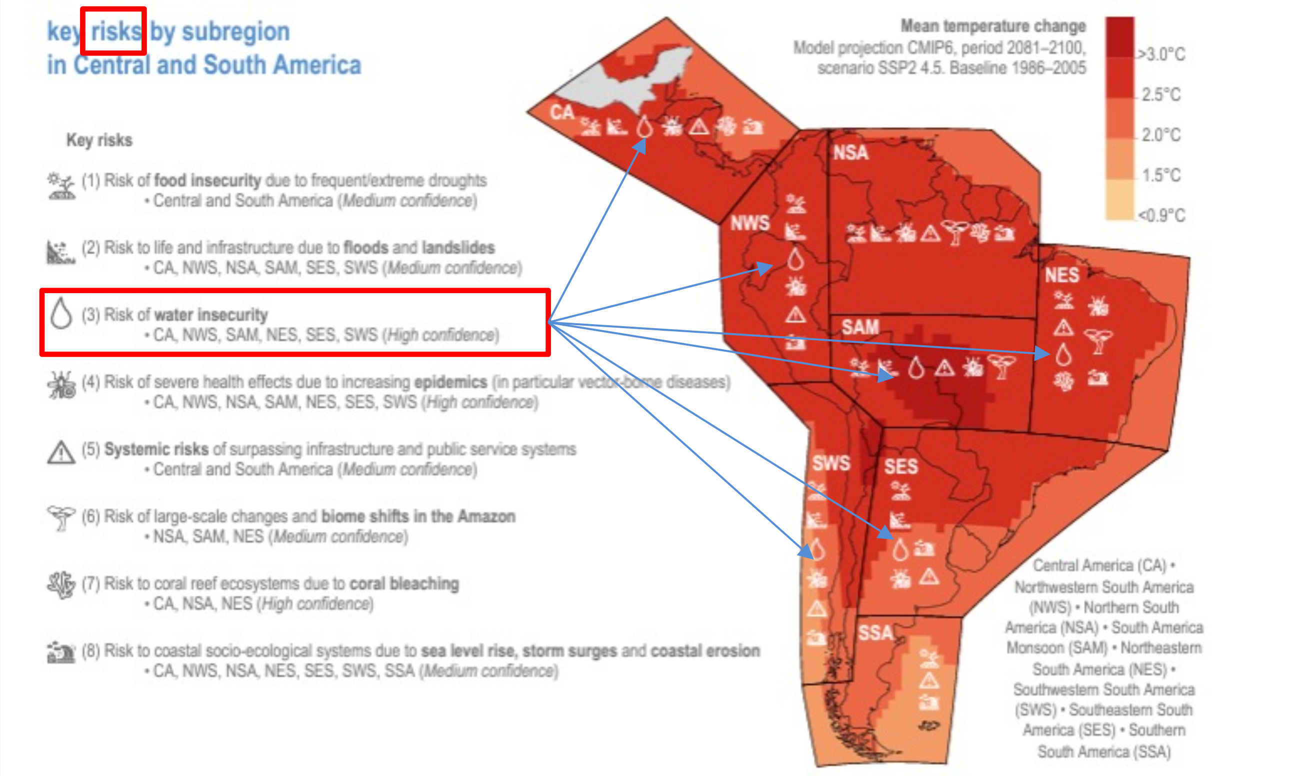
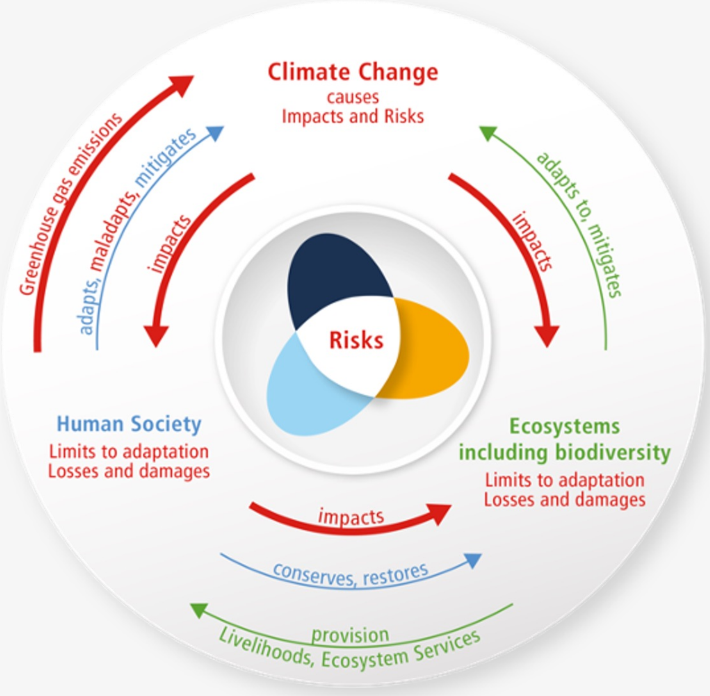


Figure 12.11 WGII AR6

Changes in water: from attributed impacts to projected risks in mountain regions

- Detection and attribution of climate change impacts
- Exposure: mountain areas and mountain people
- Vulnerability in mountains (some data challenges)
- Water related risks



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

Climate hazard(s)

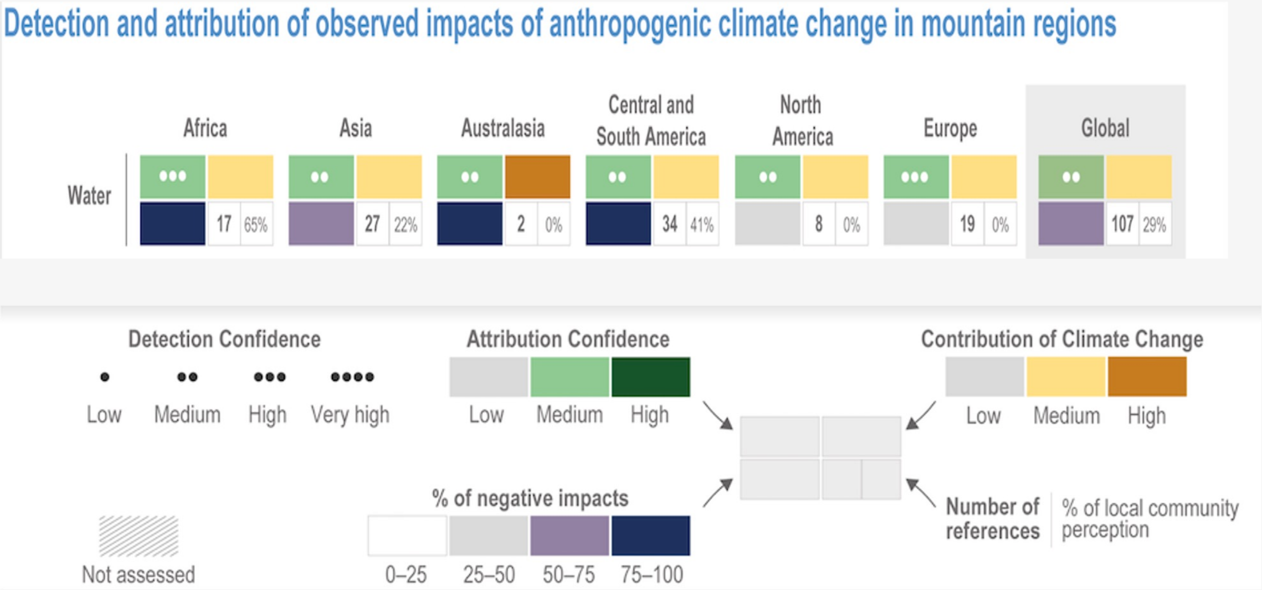
Vulnerability **Exposure**

...of human systems, ecosystems and their biodiversity

Detection and attribution of changes in water availability

Table SMCCP5.5 | Water: River, lake, flood, drought (Code: W). Abbreviations in table: Local Community Perception (LCP), Confidence of detection (Conf. Det.), Contribution of climate change (Contr. C.C.), Confidence of attribution (Conf. Att.) and Negative or no negative impact (Neg / x). Confidences and contributions can be l=*low*, m=*medium*, h=*high* and vh=*very high*.

Code	LCP	IPCC Continental Region	Region	Location/ Country	Conf. Det.	Contr. C.C.	Conf. Att.	Neg / x
W1		Africa	East Africa	Upper Blue Nile	h	l-m	m	X
W2		Africa	East Africa	Tanzania	m	l-m	l-m	Neg
W3		Australasia	Australia	New South Wales, AU	m	h	m	Neg
W4		Asia	South Asia	SW Ghats, India	l	m	l	Neg
W5		Asia	Middle East	Zagros Mountains, Iran	m	h	m	Neg
W6		Europe	Alps	Italy	h	m	m	Neg
W7		Asia	Central Asia	Tarim River, Tien Shan	h	h	m-h	X
W8		Asia	Central Asia	Tarim River, Tien Shan	l-m	m	m	X
W9		Asia	Central Asia	Tarim River, Tien Shan	m	h	m-h	X
W9		Asia	Central Asia	Tarim River, Tien Shan	m	l-m	l	Neg
W10		NA	North America	Rockies, Canada	h	h	h	X
W11		CSA	Andes	Cord. Blanca, Peru	h	m-h	m-h	Neg
W12		Asia	Middle East	Anatolia, Turkey	m-h	h	m-h	X
W13		Europe	Alps	Switzerland	h	h	h	X
W14		Europe	Scandinavia	Arctic Norway	m-h	m-h	m-h	X
W15		NA	North America	Rockies, Canada	m-h	m-h	m-h	Neg
W16		NA	North America	Rockies, Canada	m-h	m	m-h	X
W17		Europe	Alps	Rhone, Po, Danube, Europe	h-vh	m-h	m-h	X
W17		Europe	Alps	Rhone, Po, Danube, Europe	h-vh	l-m	l	Neg
W18		Europe	Alps	Europe	m	m	m	X
W19		Europe	Alps	Austria	m-h	m-h	m-h	X
W20	yes	Asia	Himalaya	Nepal, India	l-m	m	l-m	Neg
W21		CSA	Andes	Argentina	m-h	m	l-m	X
W22		Asia	Himalaya	Nepal	m	m	l	Neg
W23		Asia	Karakoram	Central and Eastern Karakoram	m	m-h	m	X
W24		Asia	Himalaya	India	m	m	l-m	Neg
W25		Asia	Himalaya	Upper Indus	m	h	m	Neg
W26		Asia	Central Asia	Syr Darya, upper reaches	m	m-h	m-h	X
W26		Asia	Central Asia	Syr Darya, lower/middle reaches	m	l	l	Neg
W27		NA	North America	Columbia River, South and Central Canada	m	h	h	Neg
W28		NA	North America	BC, Canada	m	m	m	X



IPCC WG2 AR6, CCP5-SM

IPCC WGI AR6 CH12

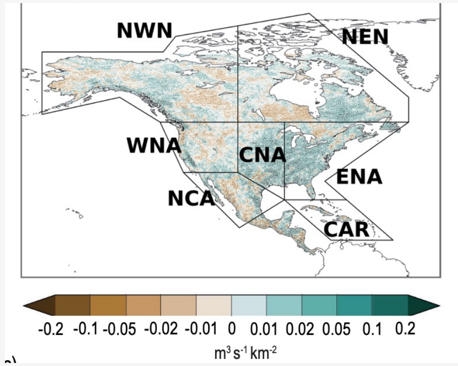


Figure 12.10 | Projected changes in selected climatic impact-driver indices North America.

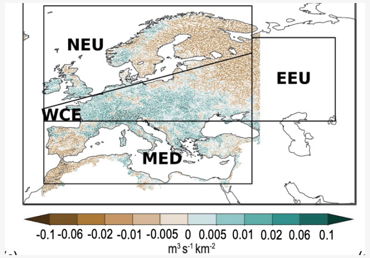


Figure 12.9 | Projected changes in selected climatic impact-driver indices for Europe.

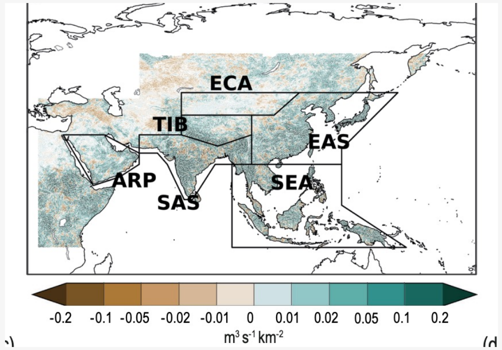


Figure 12.6 | Projected changes in selected climatic impact-driver indices for Asia.

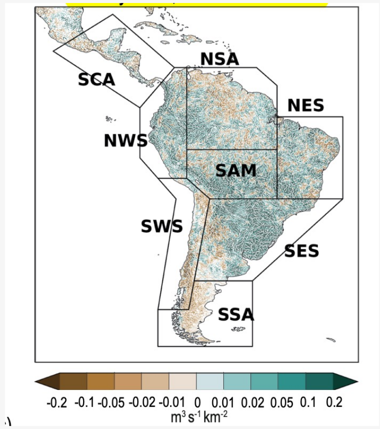


Figure 12.8 | Projected changes in selected climatic impact-driver indices for Central and South America.

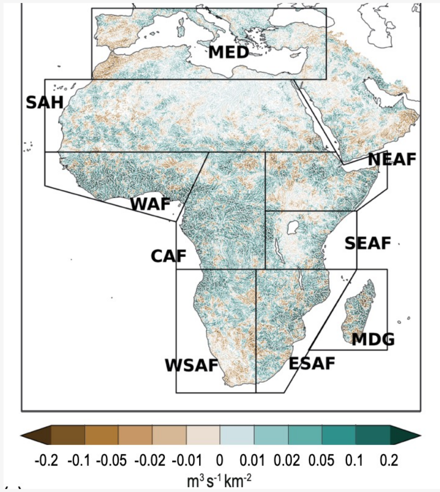


Figure 12.5 | Projected changes in selected climatic impact-driver indices for Africa.

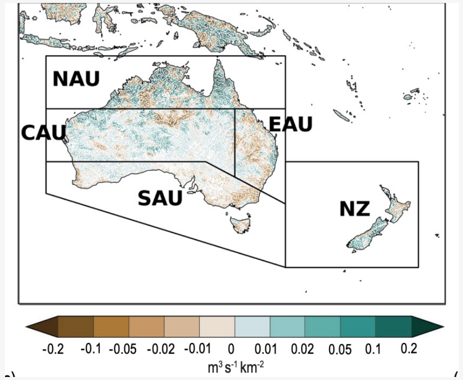


Figure 12.7 | Projected changes in selected climatic impact-driver indices for Australasia

Ranasinghe, R., Ruane, A. C., Vautard, R., Arnell, N., **Coppola**, E., Cruz, F. A., et al. (2021). “Climate Change Information for Regional Impact and for Risk Assessment,” in *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, et al. (Cambridge University Press). Available at: https://www.ipcc.ch./.

Measuring exposure: mountain population and area

Table SMCCP5.2 | Comparison of 2015 population estimates in mountain regions in CCP Mountains, according to various combinations of available population data sets and mountain delineations.

Population Data Source	Global population	Mountain population		
		Kapos et al. (2000) (K1)	Körner et al. (2011) (K2)	Karagulle et al. (2017) (K3)
GPW v4.11	7,329,886,101	1,285,255,489	746,806,057	2,289,068,972
GHS-POP	7,349,323,942	1,019,033,666	344,370,651	2,091,200,860
LandScan	7,284,273,061	1,025,345,709	355,300,352	2,079,259,051
WorldPop	7,330,048,571	1098,621,501	498,107,371	2,150,488,502

Decide on mountain delineation and population dataset

Table SMCCP5.1 | Mountain population estimates for 2015 according to the GPW v4.11 population grids (CIESIN, 2018) and the mountain extent delineations in the CCP Mountains based on Kapos (2000) ('K1'), presented in Figure CCP5.1 a).

IPCC region	Total population	Total mountain population (K1)	Total mountain area (K1) (km²)	Mean mountain population density (K1) (km⁻²)	Proportion of population in mountains (%)
Africa	1,135,725,637	227,804,121	3,851,791	59.1	20.1
Asia	4,329,236,682	720,315,545	15,915,570	45.3	16.6
Australasia	25,332,636	533,142	379,626	1.4	2.1
Central and South America	462,618,762	138,261,907	3,581,164	38.6	29.9
Europe	778,521,501	115,851,128	2,272,365	51.0	14.9
North America	480,613,418	63,751,007	5,418,728	11.8	13.3
Small Islands	70,993,314	16,578,003	321,752	51.5	23.4

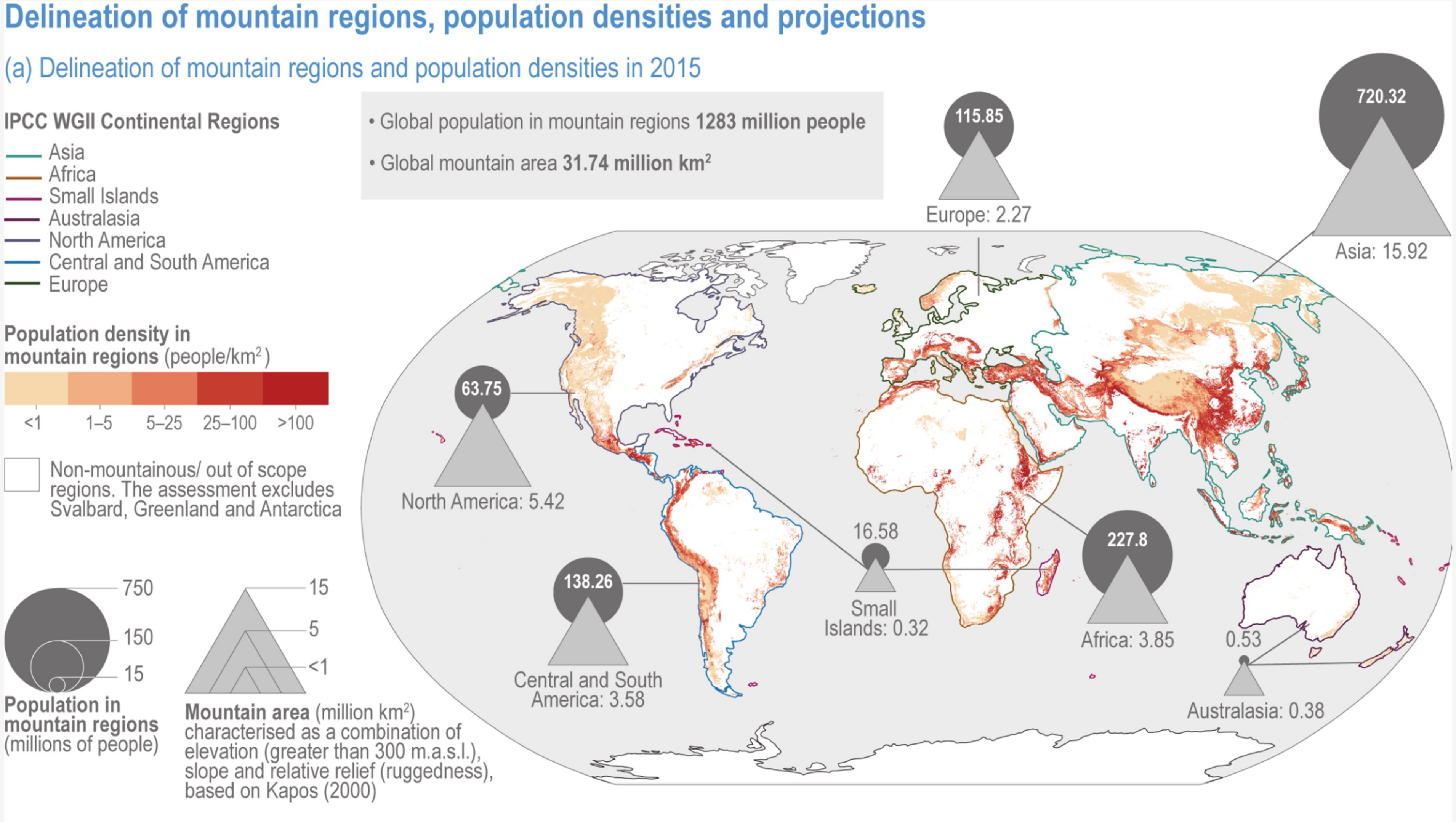
Present mountain population (based on 2015)

Table SMCCP5.3 | Projected changes in population in mountain regions between 2015 and 2100 per IPCC WGII Continental Regions and SSP presented in Figure CCP5.1 c) according to the mountain delineation in CCP Mountains, based on Kapos et al. (2000).

SSP	Africa	Asia	Australasia	Central and South America	Europe	North America	Small Islands
1	107,571,973	–242,813,434	768,769	–27,709,931	–21,864,257	1,481,885	3,442,860
2	247,669,056	–39,672,332	799,800	16,549,341	–3,319,602	18,972,817	14,428,853
3	492,860,214	369,312,026	161,430	116,645,357	18,321,332	44,835,727	34,972,666
4	415,817,525	–34,744,573	527,104	15,551,434	–27,053,252	–3,214,268	26,681,907
5	98,426,392	–247,621,276	1,637,941	–35,651,905	4,058,843	12,336,809	2,074,022

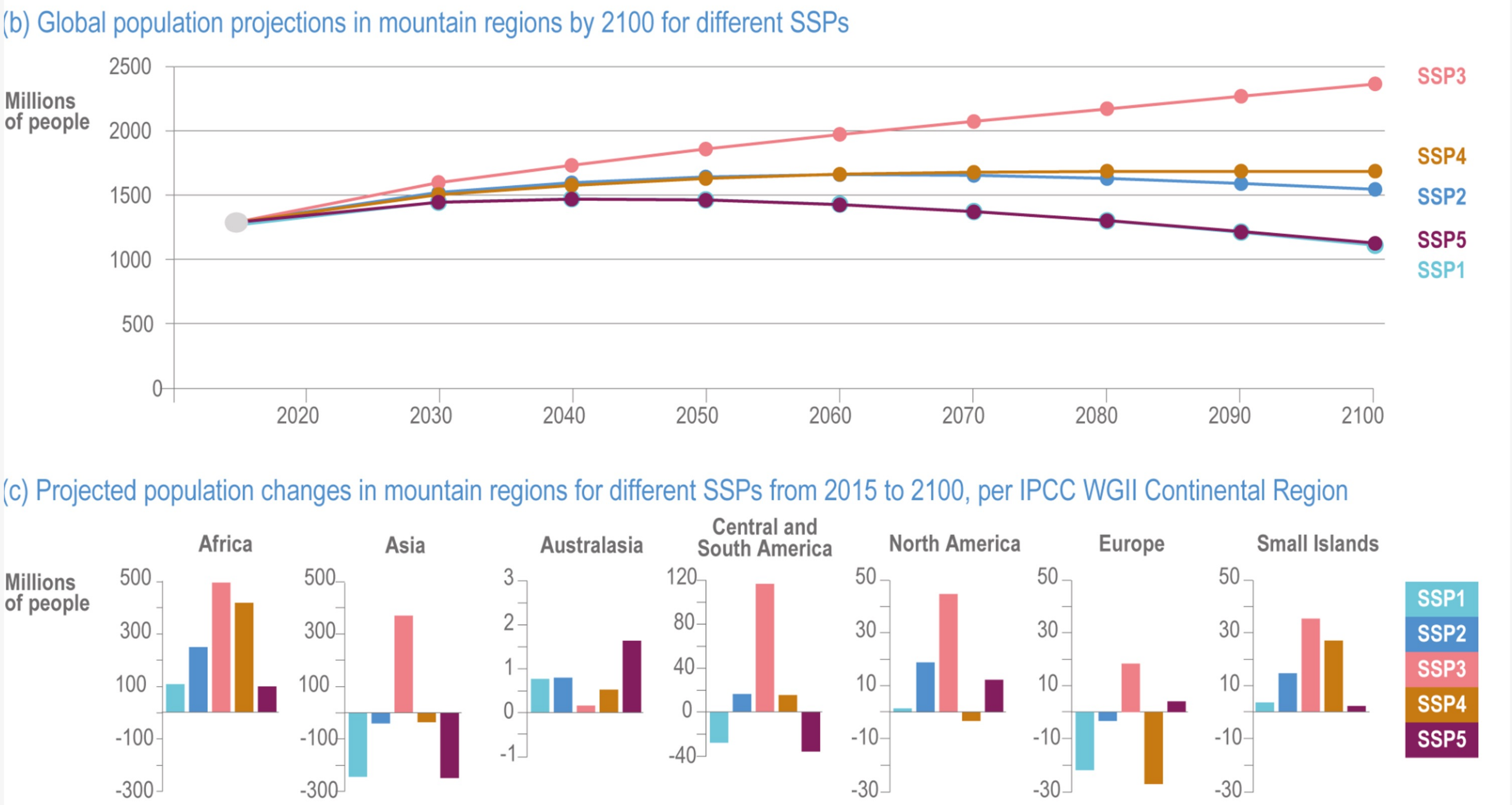
Projections of population for different SSPs

Measuring exposure: mountain population and area



IPCC WG2 AR6, Fig. CCP5.1a

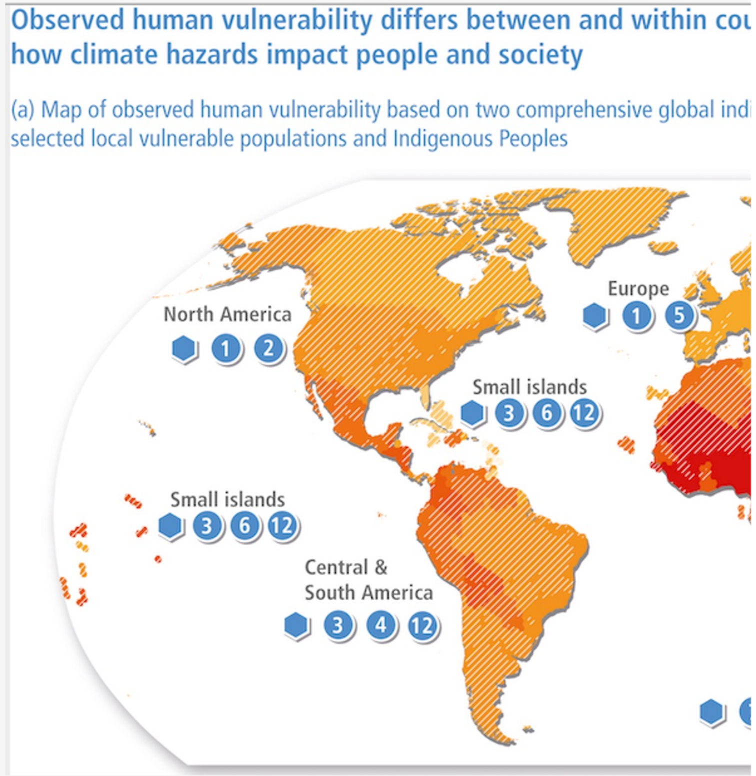
Population projections as proxies of future exposure

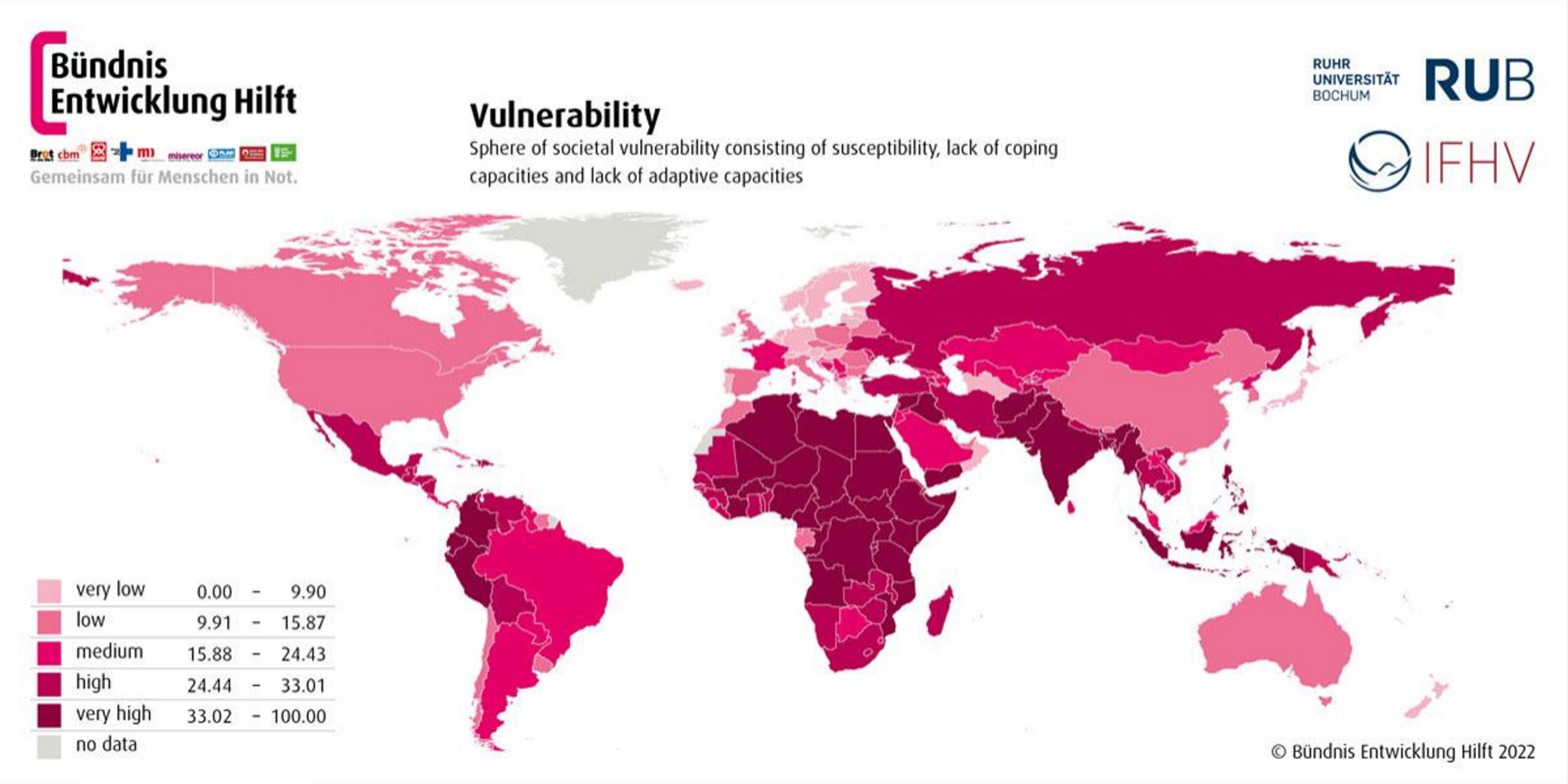


IPCC WG2 AR6, Fig. CCP5.1b

Assessing vulnerability in mountains

- Only qualitative evidence from mountains and in generally very scattered
- Global vulnerability can be a proxy for mountain vulnerability but has obvious shortcomings.

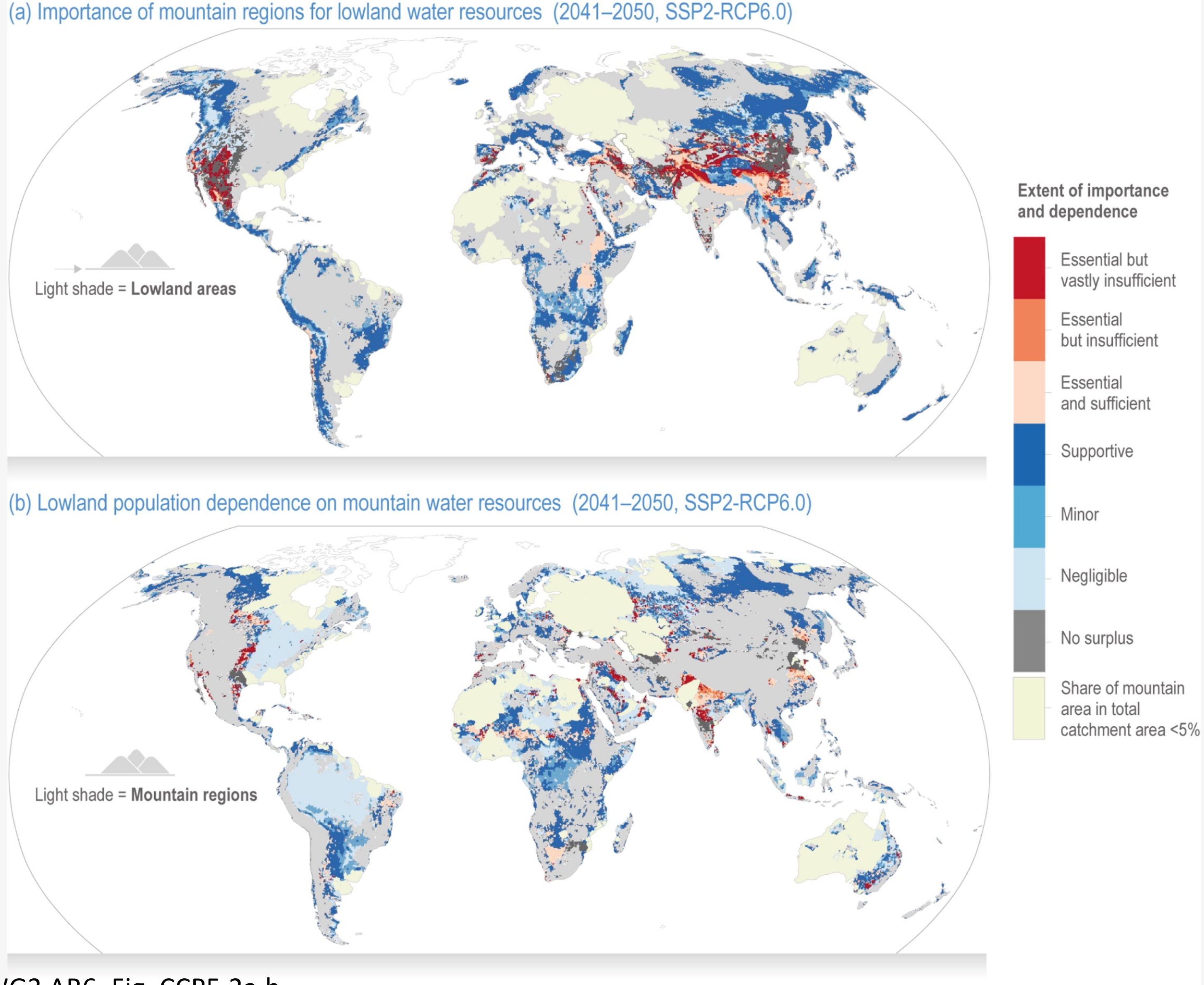




IPCC WG2 AR6, Fig. TS.7

https://weltrisikobericht.de/weltrisikobericht-2022-e/#worldriskindex

Risk interconnections: from mountains to the lowlands

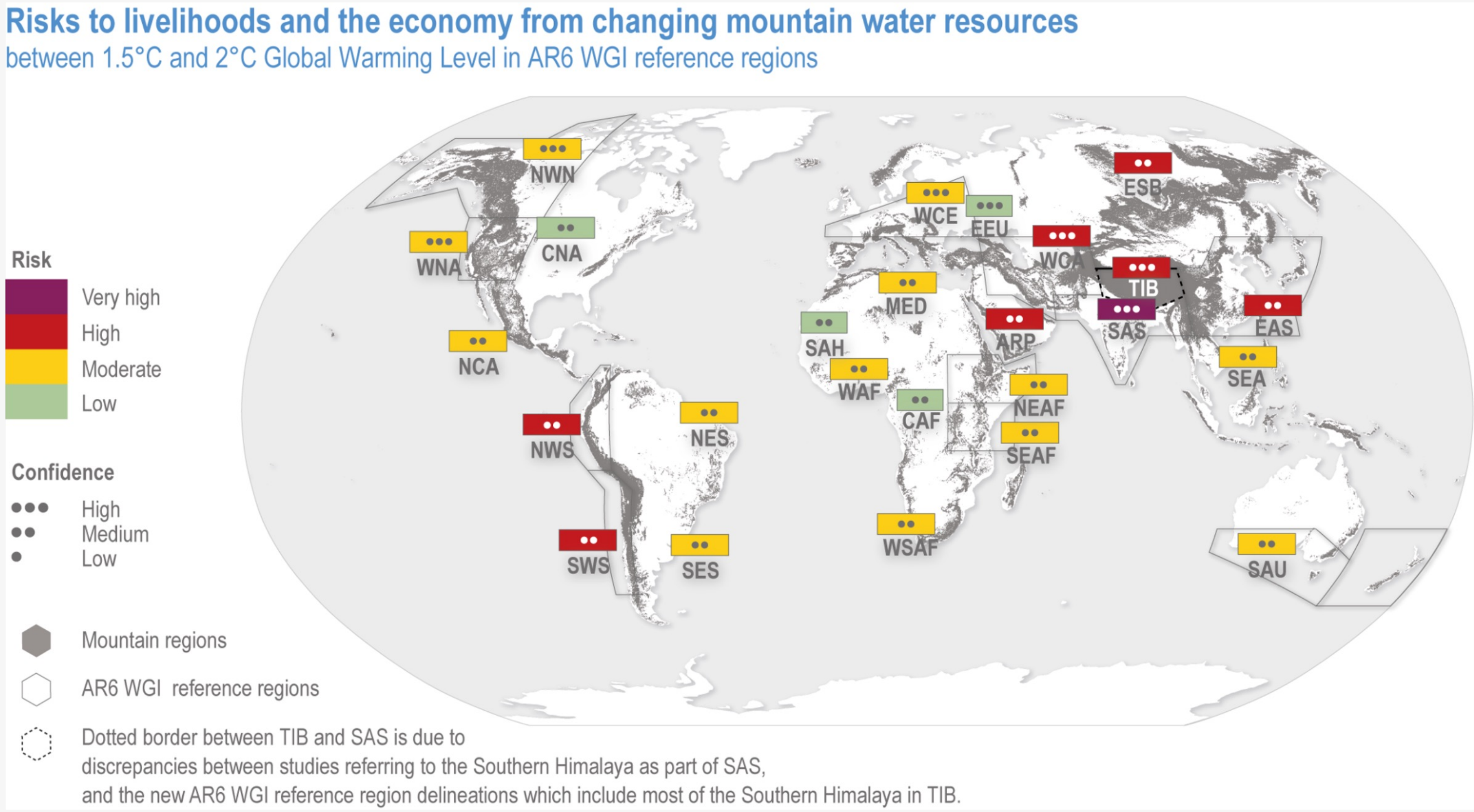


Regions relaying on glacier- and snow-melt for irrigation will face erratic water supply and increased food insecurity (already irreversible).

Damages and losses from water related hazards such as floods and landslides are projected to increase between 1.5°C and 3°C. Globally projected increase in direct flood damages are 2.5-3.9 times higher at 3°C compared to 1.5°C.

IPCC WG2 AR6, Fig. CCP5.2a,b

Bringing all together: risks from changing water resources



The risk levels are calculated by further disaggregating the data and time period and assumptions on hazards (H), exposure (E) and vulnerability (V) level. Risk levels are between 0 and 1 and corresponds to low (0–0.25), medium (0.26–0.50), high (0.51–0.75) and very high (0.76–1). T

IPCC WG2 AR6, Fig. CCP5.6

IPCC WG2 AR6, CCP5-SM

IPCC continental region	IPCC reference region	Risk index	Risk level	Risk level (normal-ised)	Sub-region aver-aged risk level	References
Africa	CAF	2	1	0.25	0.25	
Africa	NEAF	2	1	0.25	0.42	
Africa	NEAF	6	2	0.5	0.42	
Africa	SAH	1	1	0.25	0.25	
Africa	SAH	2	1	0.25	0.25	
Africa	SAH	2	1	0.25	0.25	
Africa	SEAF	2	1	0.25	0.41	
Africa	SEAF	6	2	0.5	0.41	
Africa	WAFS	2	1	0.25	0.41	
Africa	WAFS	6	2	0.5	0.41	
Africa	WAF	2	1	0.25	0.41	
Africa	WAF	6	2	0.5	0.41	
Asia	ARP	8	2	0.5	0.58	
Asia	ARP	12	3	0.75	0.58	Immerzeel et al. (2020) Viviroli et al. (2020) Munia et al. (2020) Strasser et al. (2019) Fuhrer et al. (2014) Drenkhan et al. (2018) Drenkhan et al. (2019) Reyer et al. (2017) Huang et al. (2021)
Asia	EAS	8	2	0.5	0.66	
Asia	EAS	18	4	1	0.66	
Asia	ESB	4	2	0.5	0.58	
Asia	ESB	12	3	0.75	0.58	
Asia	ESB	8	2	0.5	0.58	
Asia	SAE	4	2	0.5	0.50	
Asia	SAE	6	2	0.5	0.50	

Screenshot of a small part of the data table

ipcc
INTERGOVERNMENTAL PANEL ON climate change

Sixth Assessment Report

WORKING GROUP III – MITIGATION OF CLIMATE CHANGE

Many options available now in all sectors are estimated to offer substantial potential to reduce net emissions by 2030. Relative potentials and costs will vary across countries and in the longer term compared to 2030.

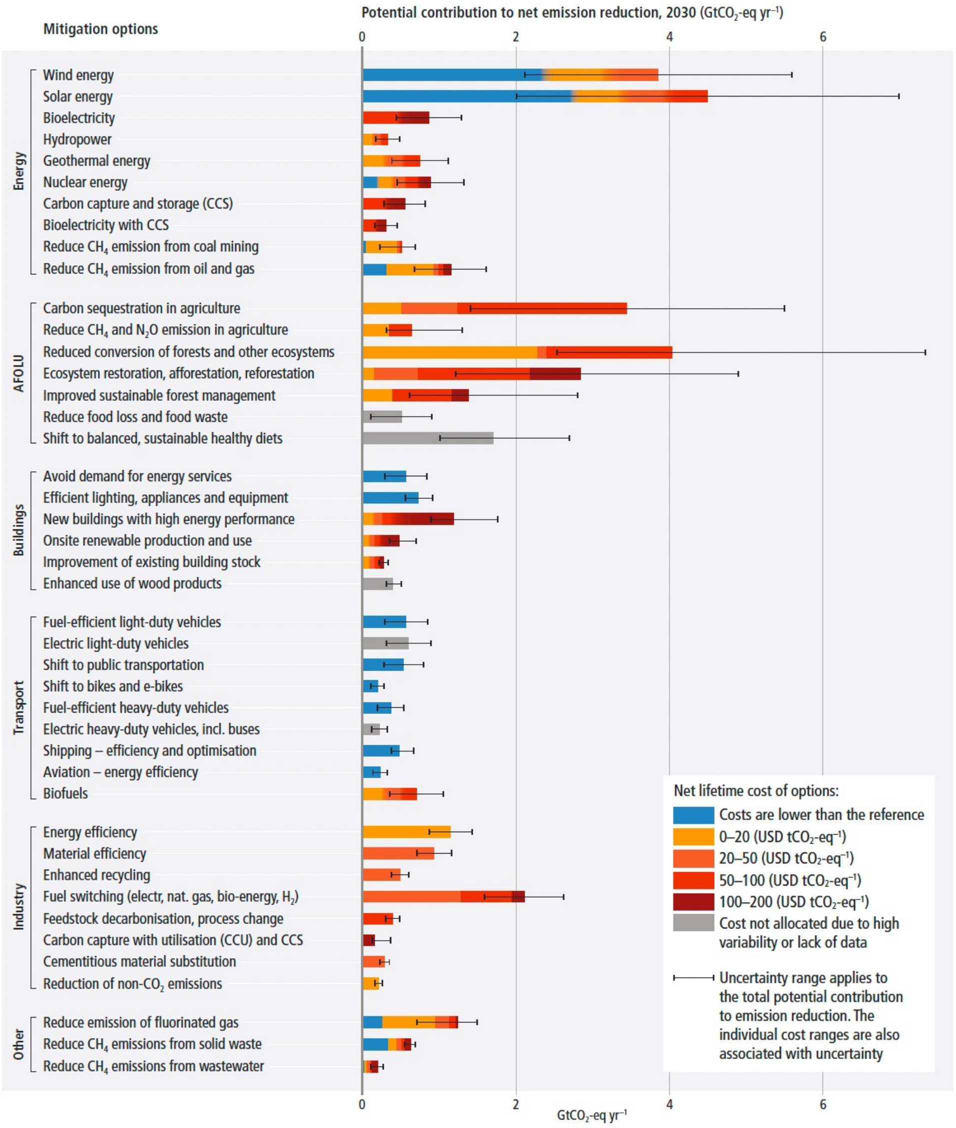


Figure SPM.7 | Overview of mitigation options and their estimated ranges of costs and potentials in 2030.