Vulnerability to climate change, impacts to human systems

Contents

INTRODUCTION

The presentation focuses on a critical and pressing issue – the vulnerability of human systems to the impacts of climate change, as detailed in the latest findings of the Intergovernmental Panel on Climate Change (IPCC) in their AR6 Synthesis Report.

Key areas of concern include:

- **Physical Water availability & Food Production**
- **Health and wellbeing**
- **Cities, settlements and infrastructure**

The presentation will delve into these aspects, exploring how climate change is reshaping the landscape of human vulnerability.

Physical water availability

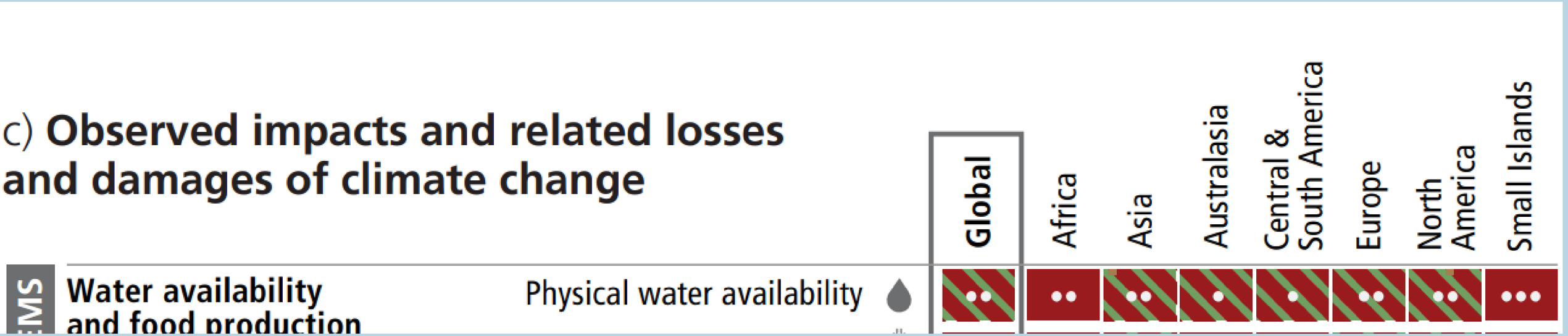
Physical Water Availability - Current Status

Physical water availability includes balance of water available from various sources including ground water, water quality and demand for water

Climate change has reduced affected water security due to warming, changing precipitation patterns, reduction and loss of cryospheric elements, and greater frequency and intensity of climatic extremes

Roughly half of the world's population currently experiences severe water scarcity for at least some part of the year due to a combination of climatic and non-climatic drivers.

Increasing weather and climate extreme events have exposed millions of people to acute food insecurity and reduced water security, with the largest adverse impacts observed in many locations and/or communities in Africa, Asia, Central and South America, LDCs, Small Islands and the Arctic, and globally for Indigenous Peoples, small-scale food producers and low-income households. Between 2010 and 2020, human mortality from floods, droughts and storms was 15 times higher in highly vulnerable regions, compared to regions with very low vulnerability


c) Observed impacts and related losses and damages of climate change
Global
Africa
Asia
Australasia
Central & South America
Europe
North America
Small Islands
EMS
Water availability and food production
Physical water availability
Confidence in attribution to climate change
••• High or very high
•• Medium
• Low
– Evidence limited, insufficient
/ Not assessed
Increased climate impacts
HUMAN SYSTEMS
Adverse impacts
Adverse and positive impacts

Physical Water Availability - Cause

- Warming temperatures are causing rapid shifts between wet and dry conditions, leading to increased floods and droughts.
- Melting glaciers and rising sea levels are leading to the loss of high-mountain water storage and saltwater intrusion into coastal aquifers, affecting freshwater sources for millions.
- Changes in rainfall patterns are stressing agricultural sectors, with warmer temperatures and severe droughts impacting crop yields.
- Human actions are exacerbating these issues. Urban development, deforestation, and nutrient overloading in water bodies are increasing the severity of climate change impacts. For instance, hard surfaces and channelized rivers heighten flood risks, while deforestation in regions like the Amazon destabilizes moisture feedbacks essential for rainforests.

Food production

Food production

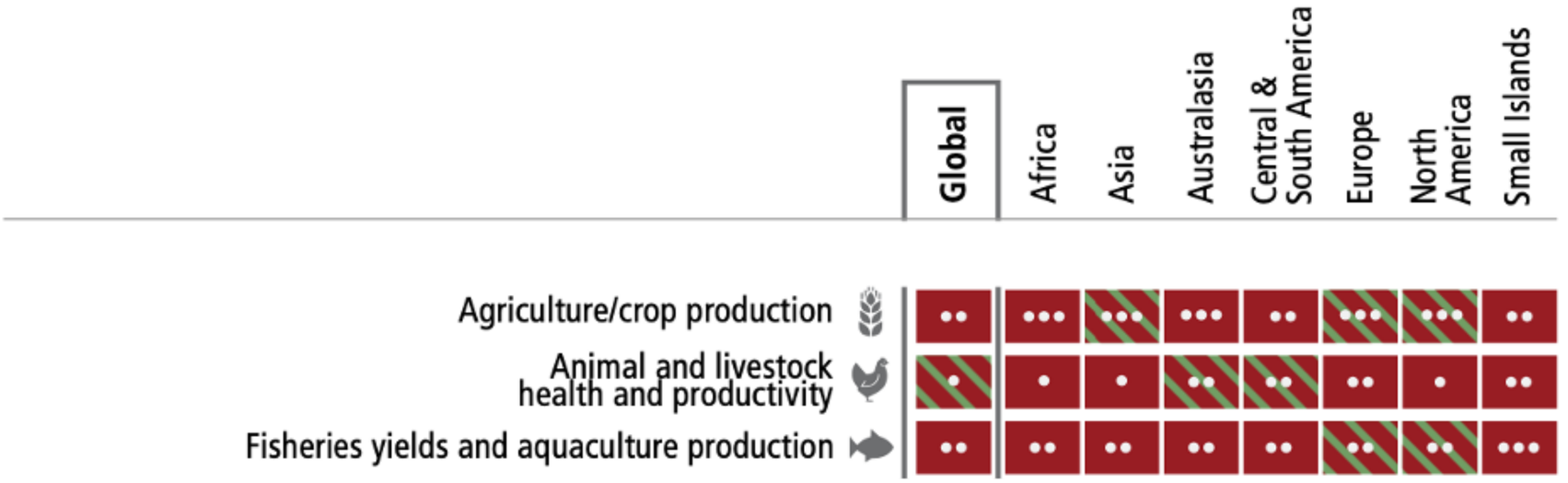
Under researched methodologies for monitoring vulnerability.

The food production system is dynamic.

Vulnerability assessment can be sectoral or regional but involves social and ecological indicators.

- **Agriculture/crop production,**
- **Animal and livestock health and productivity,**
- **Fisheries yields and aquaculture production.**

Observed impacts and related losses and damages of climate change: Human systems - food production.



Dimension of Risk: Impact

Key

Increased climate impacts

HUMAN SYSTEMS

- Adverse impacts
- Adverse and positive impacts

ECOSYSTEMS

- Climate-driven changes observed, no assessment of impact direction

Confidence in attribution to climate change

- ••• *High or very high*
- •• *Medium*
- • *Low*
- – Evidence limited, insufficient
- / Not assessed

Food production - agriculture/crop production

Drought - major risk component in cropping systems globally, with substantial economic loss, livelihood impacts and ultimately hearts risks such as malnutrition. Vulnerability to droughts can be estimated with range of indicators.

- Drought risks could be exacerbated or moderated by regional differences in vulnerability.
- Key vulnerability indicators varies greatly between regions and between farms.

Food production - agriculture/crop production

Impacts on major crops

- recent warming trends have generally shortened the life cycle of major crops,
- climate related hazards that cause crop losses are increasing.

Impacts on other crops (vegetables, fruit, nut and fibre).

Crop stresses:

- soil nutrients,
- pests and diseases,
- heat stress
- aridity
- ozone

Yield Constraint Score for the effect of five crop stresses on global production of soybean and wheat

The yield constraint score integrates the five stress depicted below which provide an indication of where each stress is predicted to be affecting crop yield globally and the magnitude of the effect.

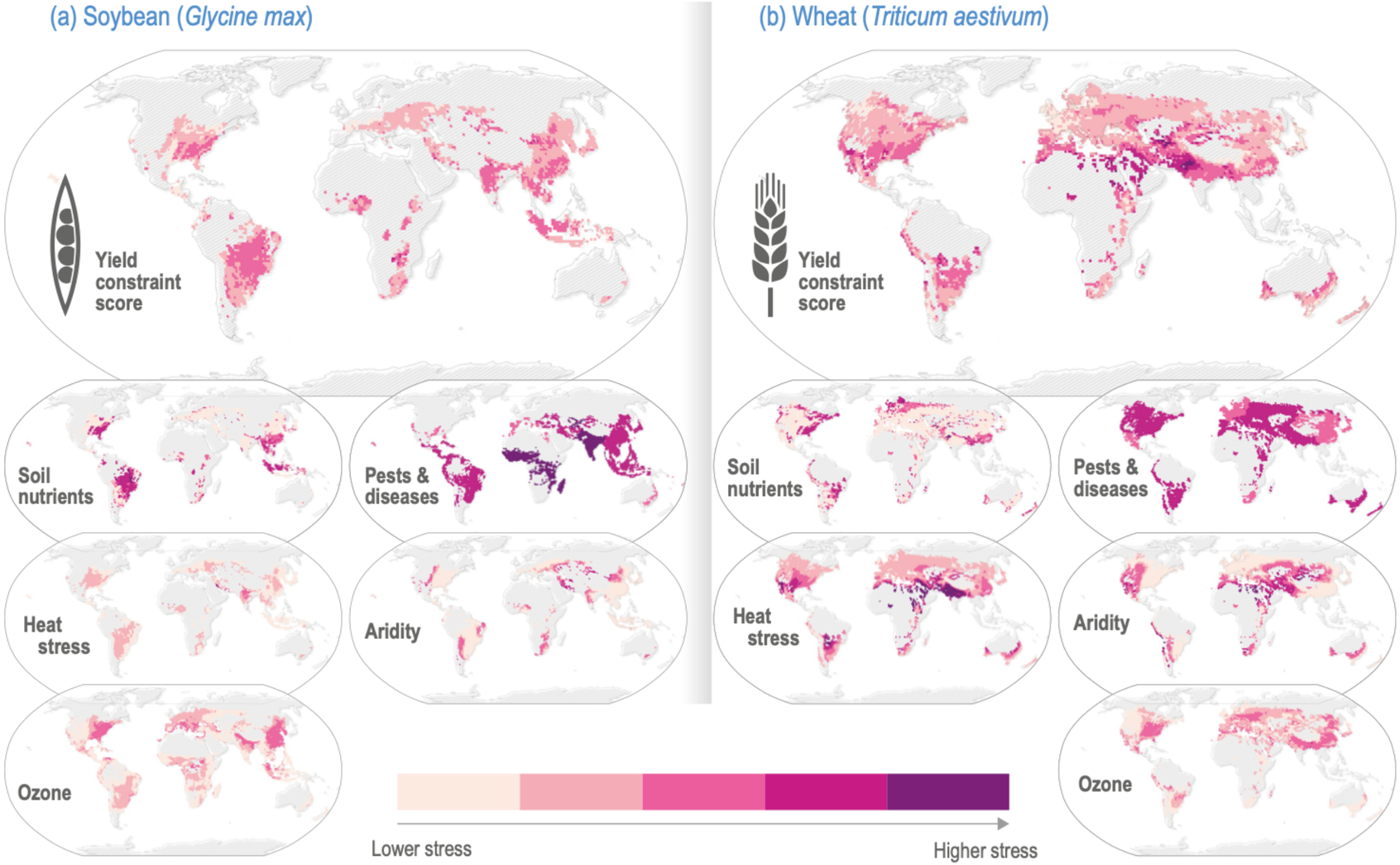
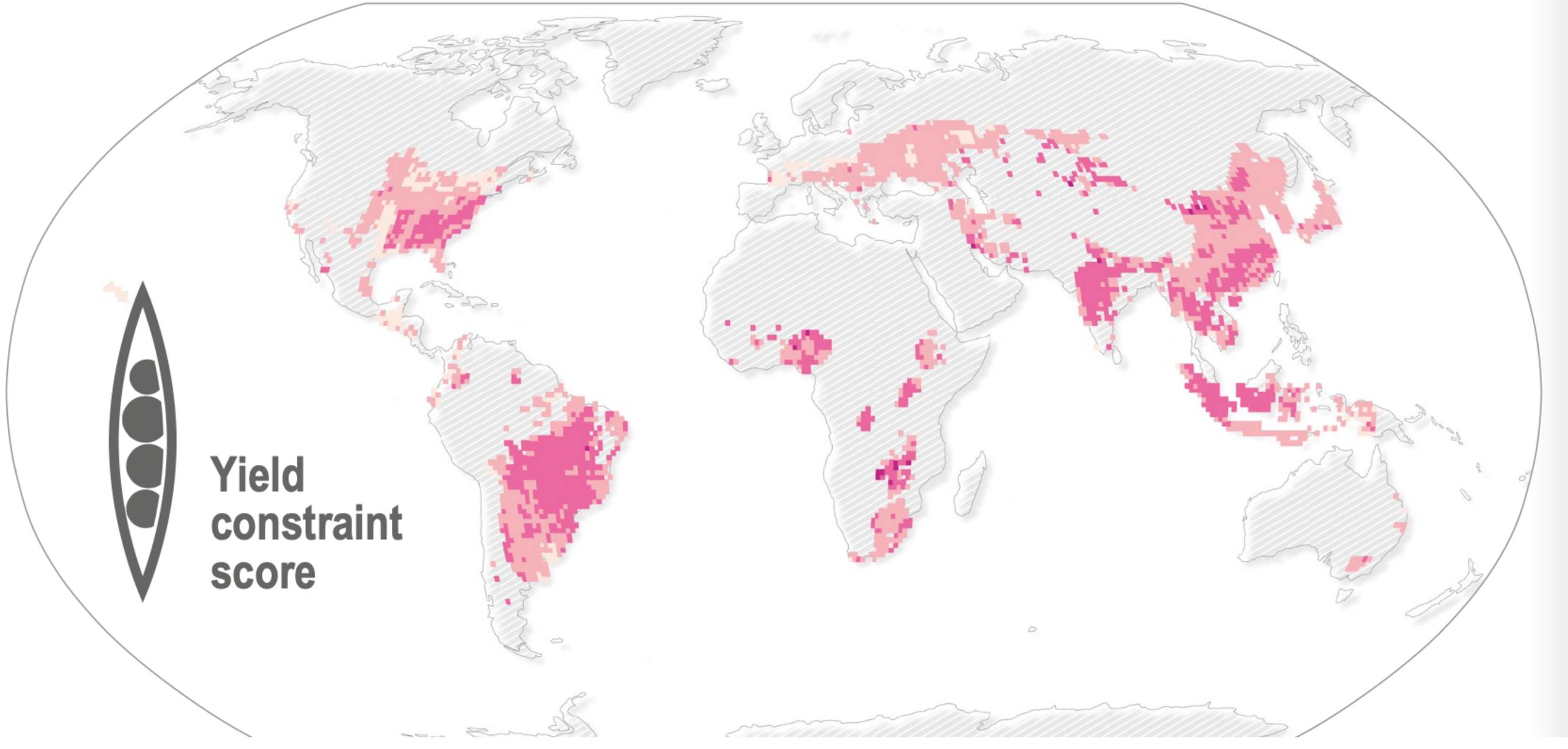
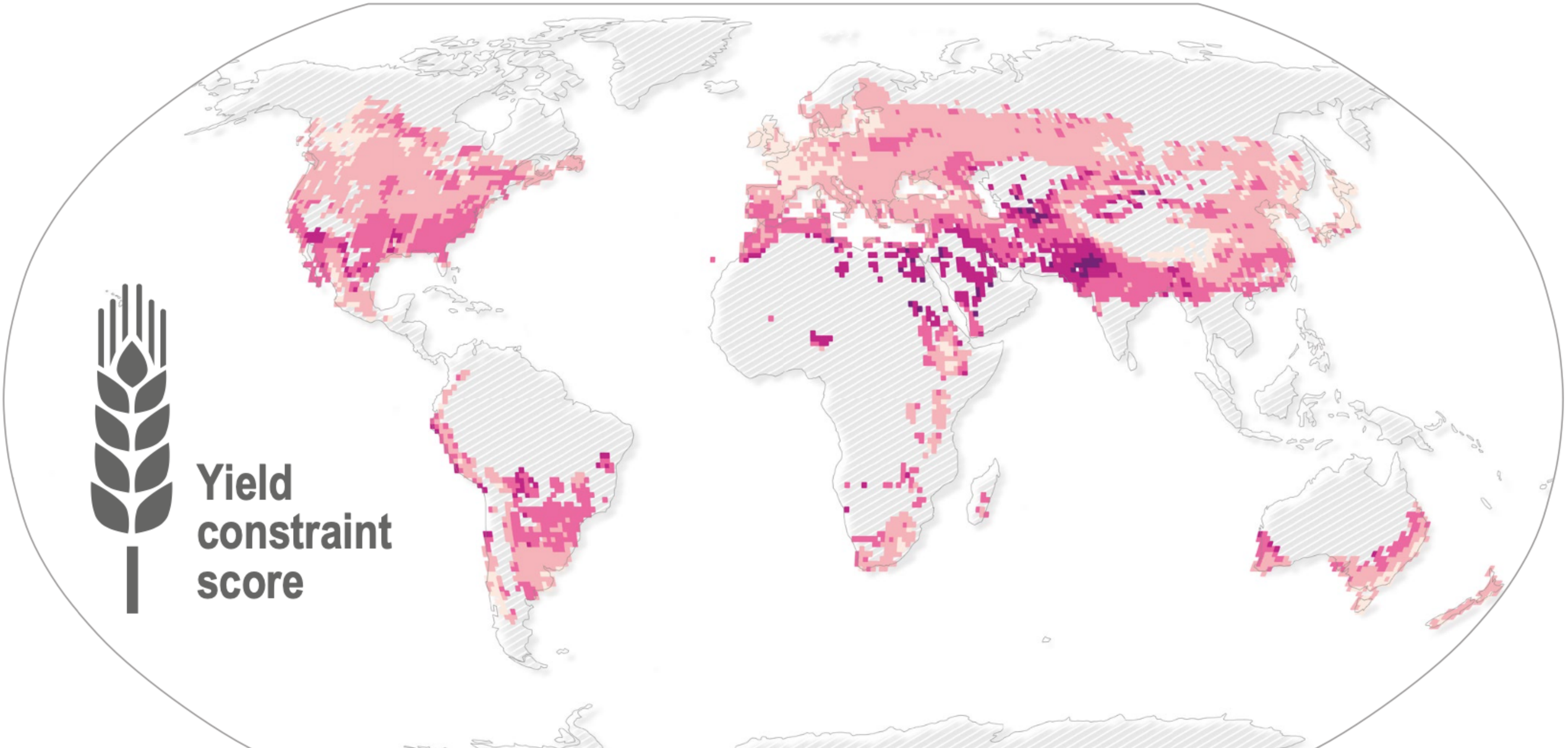


Figure 5.4 | The global effects of five biotic and abiotic stresses on soybean and wheat. All data are presented for the 1 × 1° (latitude and longitude) grid squares where the mean production of soybean or wheat was >500 tonnes (0.0005 Tg). The effect of each stress on yield is presented as a Yield Constraint Score (YCS) on a scale of 1–5, where 5 is the highest level of stress from ozone, pests and diseases, heat stress and aridity (Mills et al., 2018). Data are available at Sharps et al. (2020). See Annex I: Global to Regional Atlas for all four crops.

(a) Soybean (*Glycine max*)



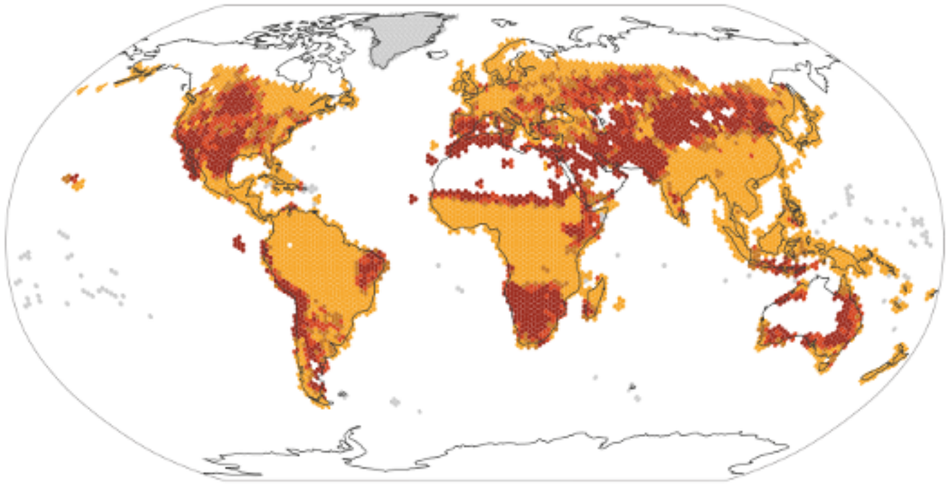
(b) Wheat (*Triticum aestivum*)



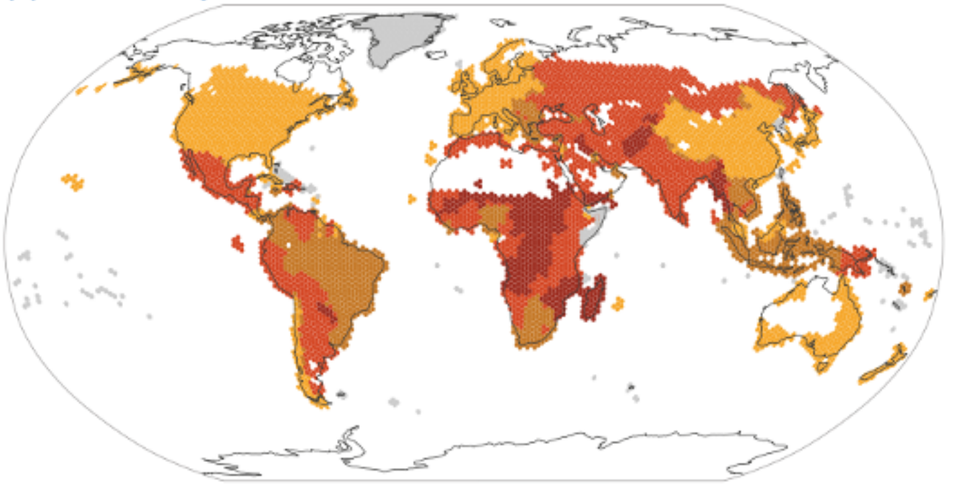
Rainfed agriculture: Drought risks, hazards, exposure and vulnerability indicators

Observed period 1986–2015

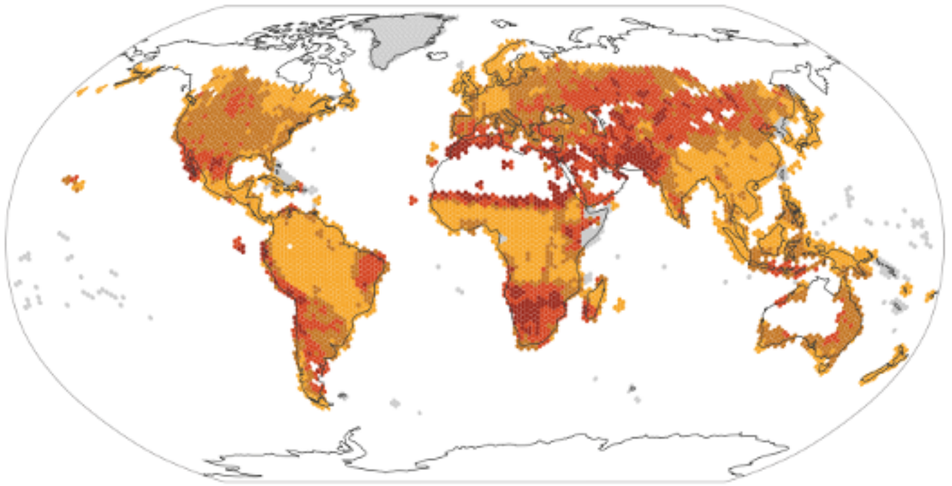
(a) Hazard and exposure indicator score



(b) Vulnerability index



(c) Drought risk index



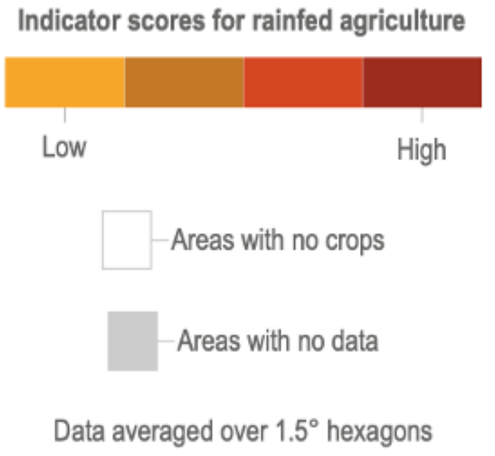
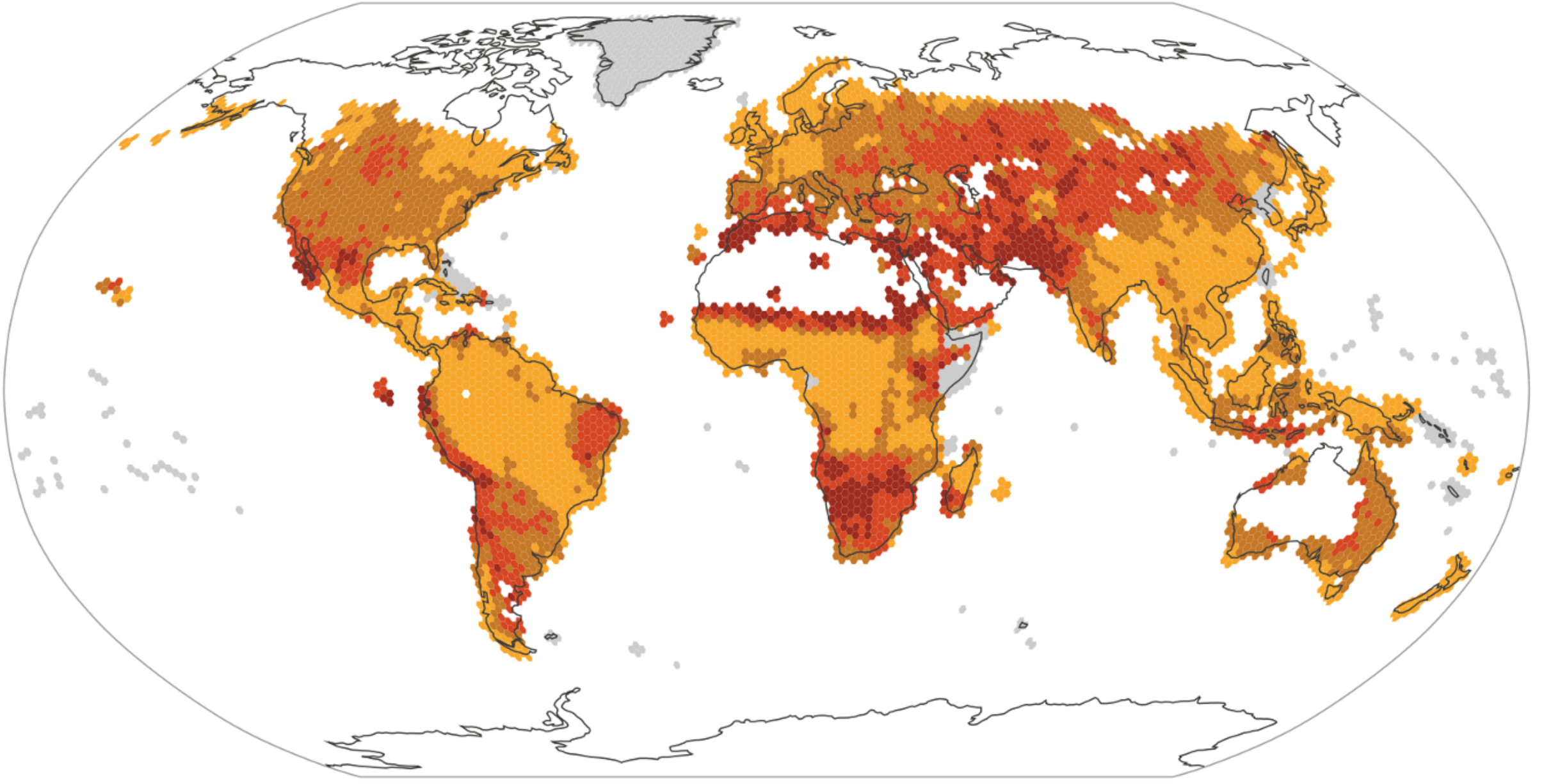


Figure 5.5 | Hazard and exposure indicator score (a), vulnerability index (b) and drought risk index (c), for rainfed agricultural systems between 1986 and 2015. Drought hazard indicator is defined as the ratio of actual crop evapotranspiration to potential crop evapotranspiration, calculated for 24 crops. Vulnerability index is the country-scale weighted average of a total of 64 indicators including social and ecological susceptibility indicators, and coping capacity. Risk index is calculated by multiplying hazard/exposure indicator score and vulnerability index (Meza et al., 2020).

(c) Drought risk index



Food production - agriculture/crop production

There are also social inequities in cropping systems that compound climate change vulnerability.

- Globally, smallholder food producers are more vulnerable than large-scale producers to climate change impacts. Smallholder food producers are more vulnerable in part because of limited policy, infrastructure and institutional support, low credit access, viable markets and limited political voice in policy debates

Case studies:

- Pollinators: Climate change will reduce the effectiveness of pollinator agents as species are lost from certain areas, or the coordination of pollinator activity and flower receptiveness is disrupted in some regions
- Climate change will have significant impacts on soil health indicators such as soil organic matter (SOM). For example, precipitation extremes can reduce soil biological functions, and increase surface flooding, waterlogging, soil erosion and susceptibility to salinisation

Food production – animal and livestock health and productivity

- Rising temperature and heat stress,
- Livestock water needs,
- Rising temperature and livestock disease,
- Effects of climate on the health and vulnerability of livestock keepers,
- Gender and other social inequities.

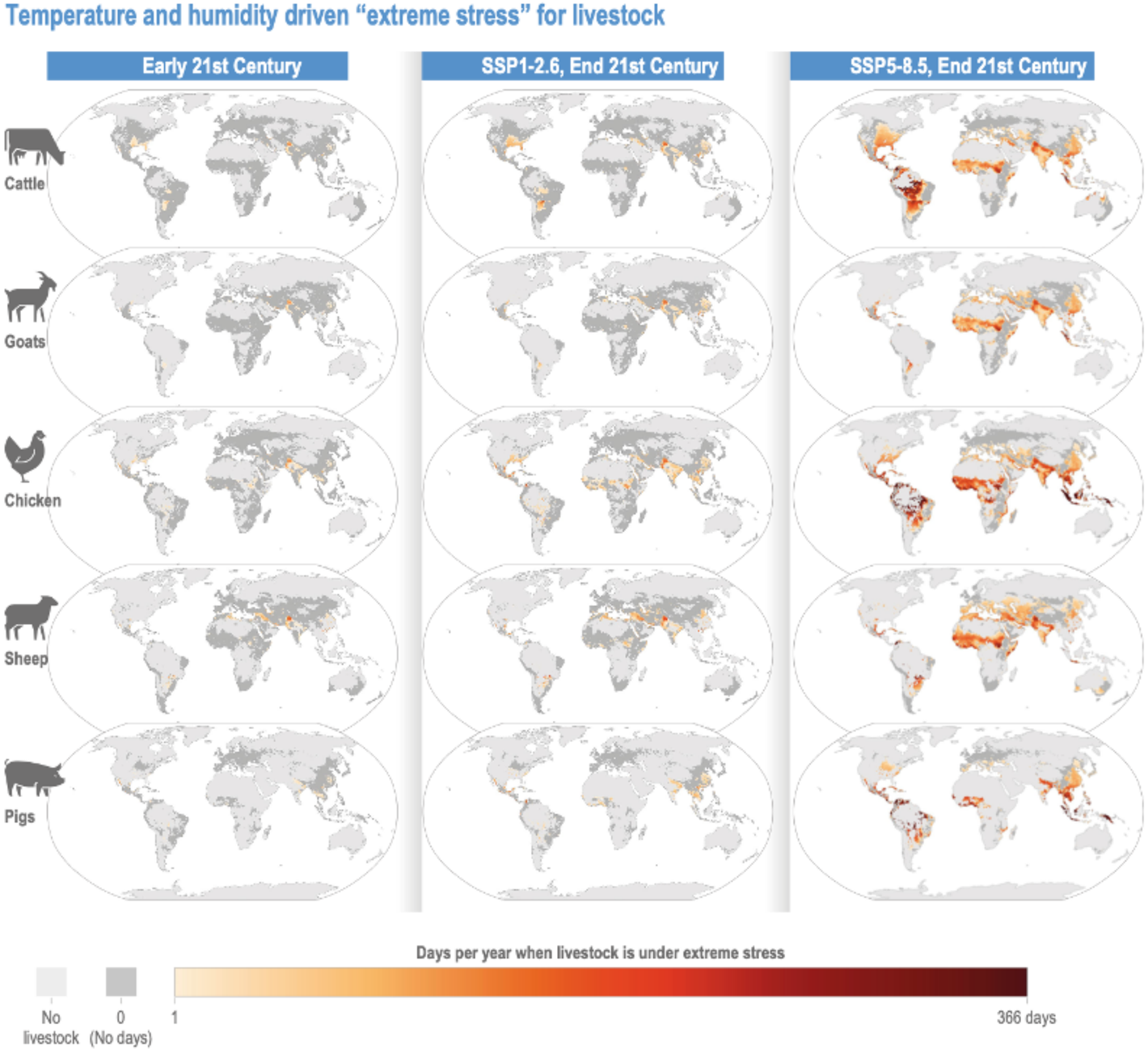
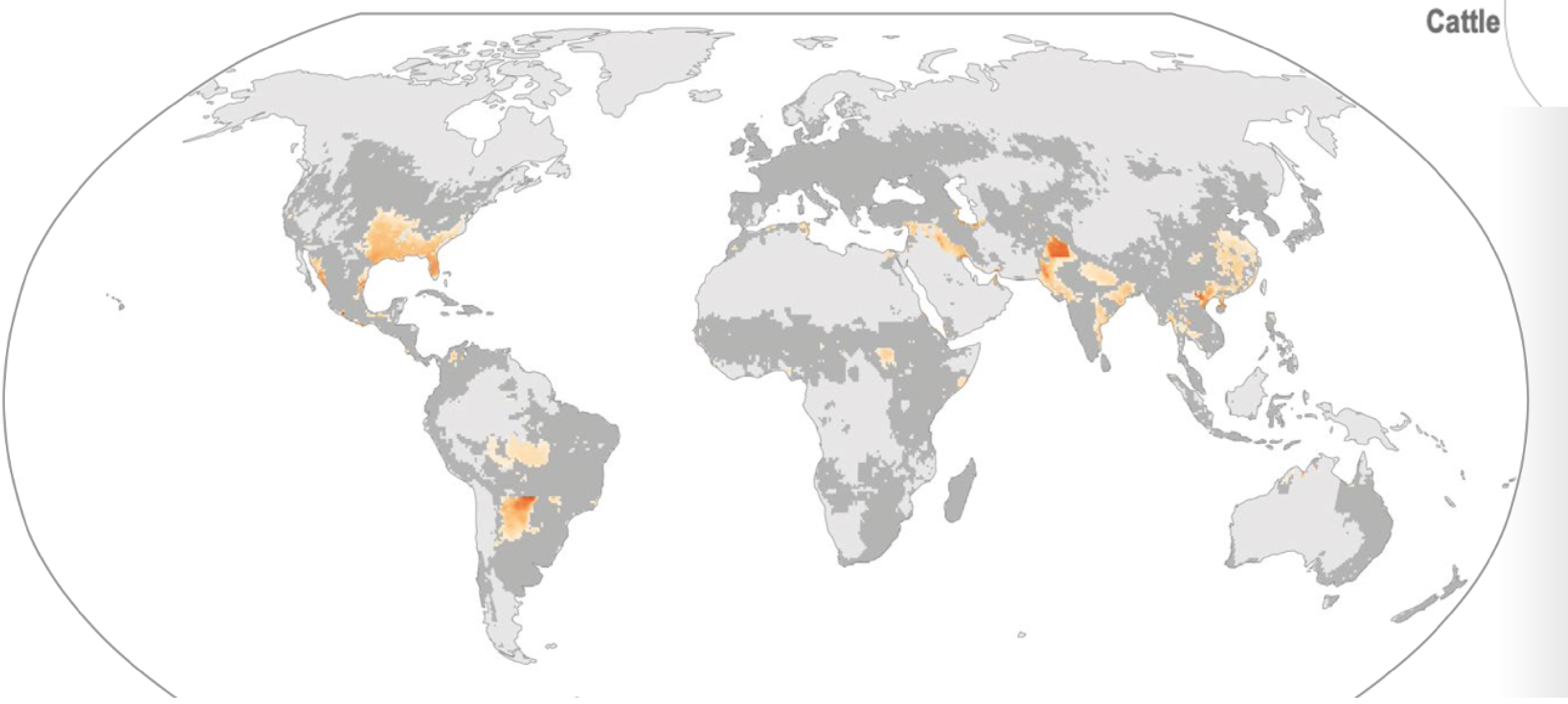


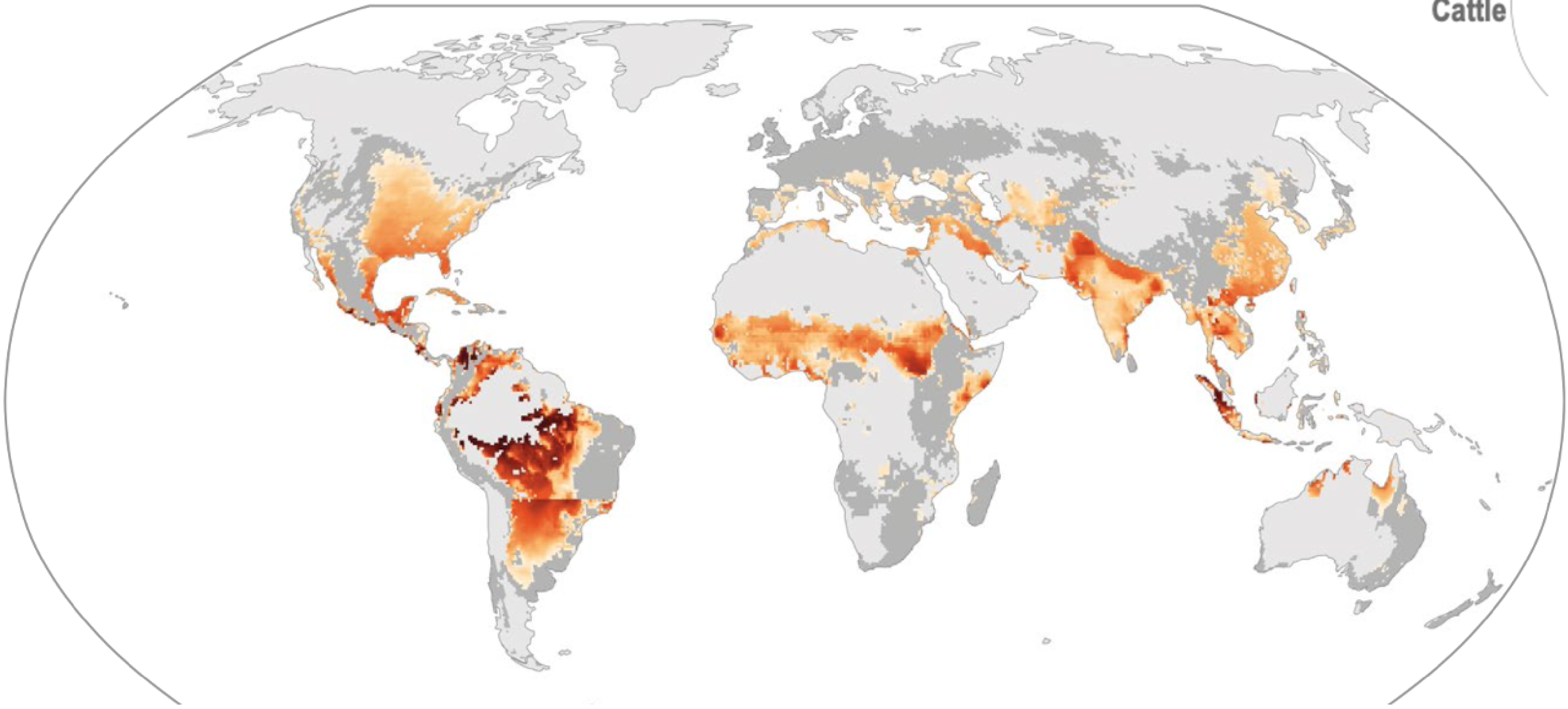
Figure 5.12 | Change in the number of days per year above ‘extreme stress’ values from the early 21st century (1991–2010) to end of century (2081–2100), estimated under SSP1-2.6 and SSP5-8.5 using the Temperature Humidity Index (THI). Mapped for species current global distribution (Gilbert et al., 2018) (grey areas, no change). (Thornton et al., 2021), Also see Annex I: Global to Regional Atlas.

SSP1-2.6, End 21st Century

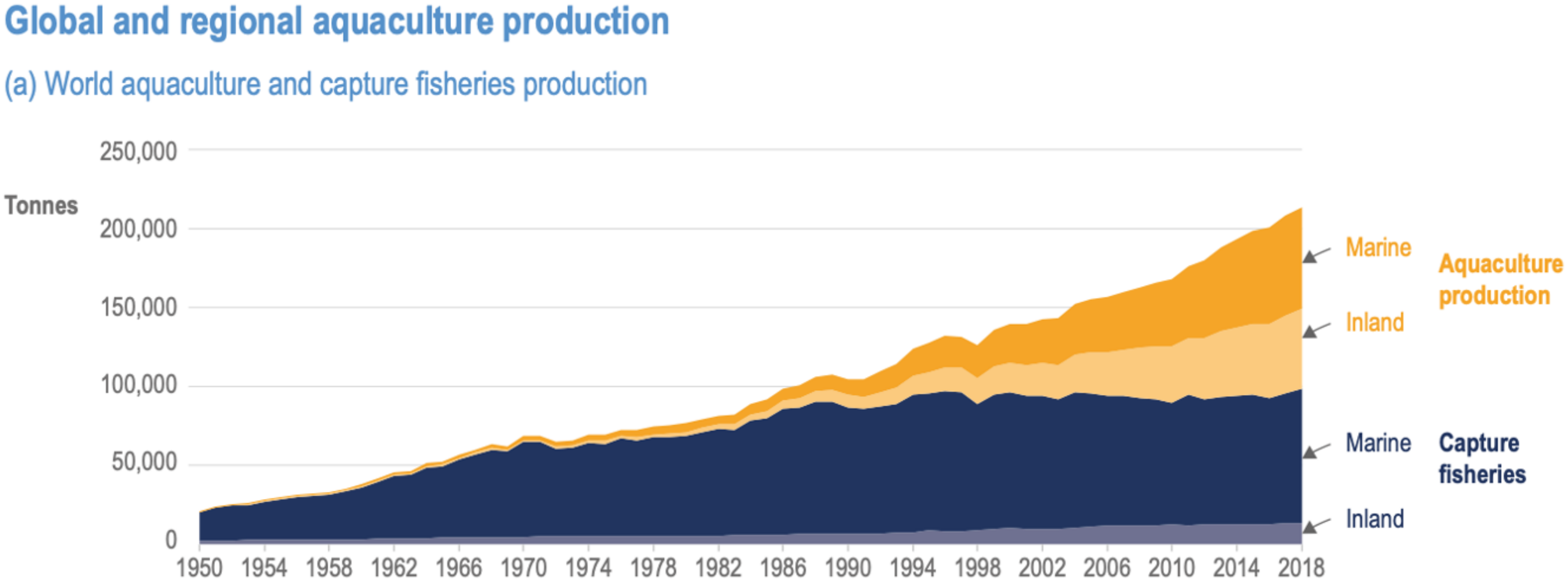


SSP5-8.5, End 21st Century

Cattle



Food production - fisheries yields and aquaculture production



Food production - fisheries yields and aquaculture production

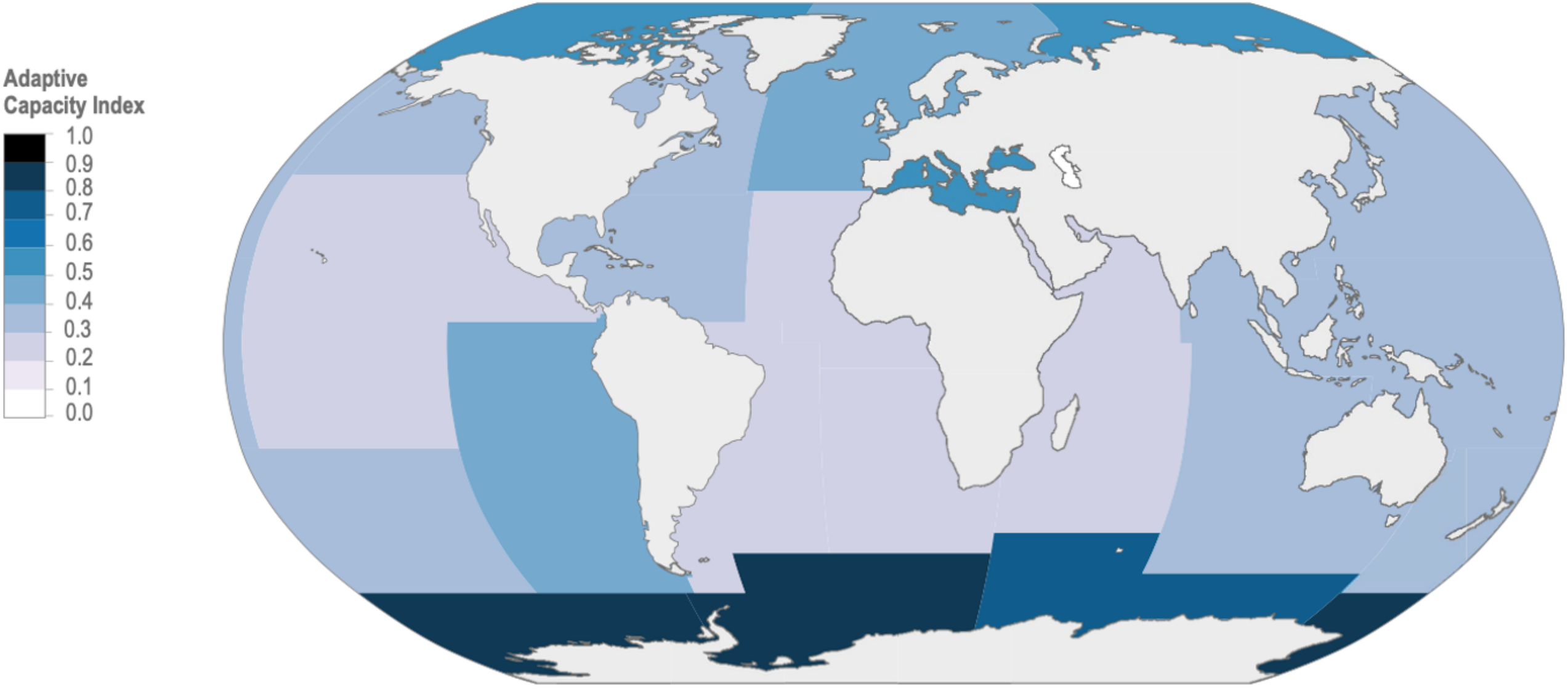
Fisheries yields

- Food security: provision and nutrition
- Social vulnerabilities
- Management, economic and geopolitical vulnerabilities

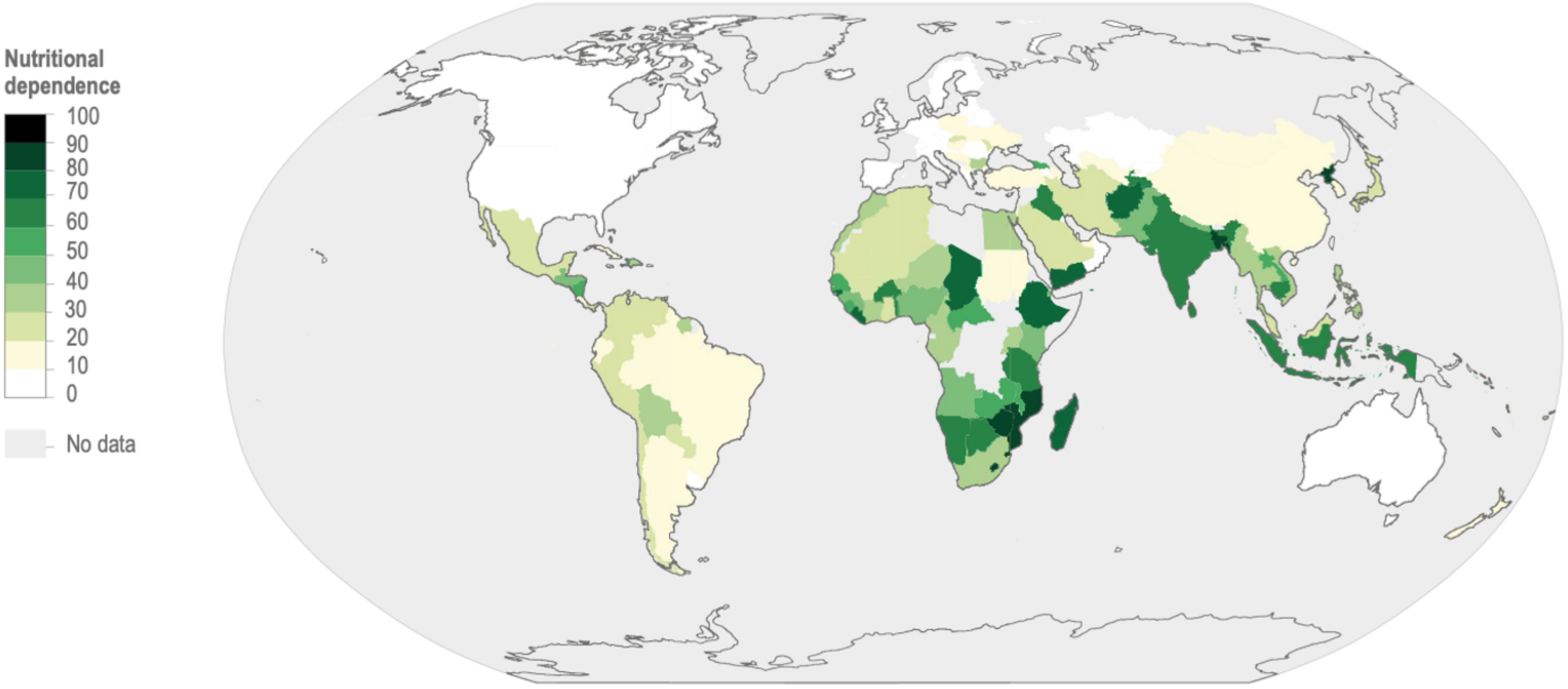
Aquaculture production - Complex

Current fisheries adaptive capacity and regional micronutrient deficiency risks related to seafood-relevant micronutrients in human diets

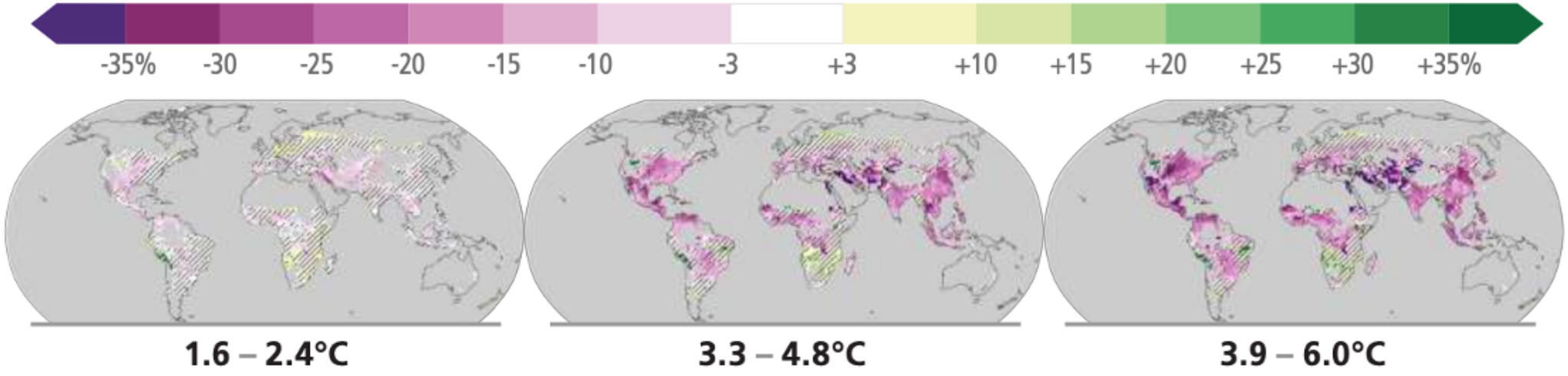
(a) Documented fisheries adaptive capacity to climate change



(b) Regional seafood-relevant micronutrient deficiency risk (Calcium, Iron, Zinc, Vitamin A)



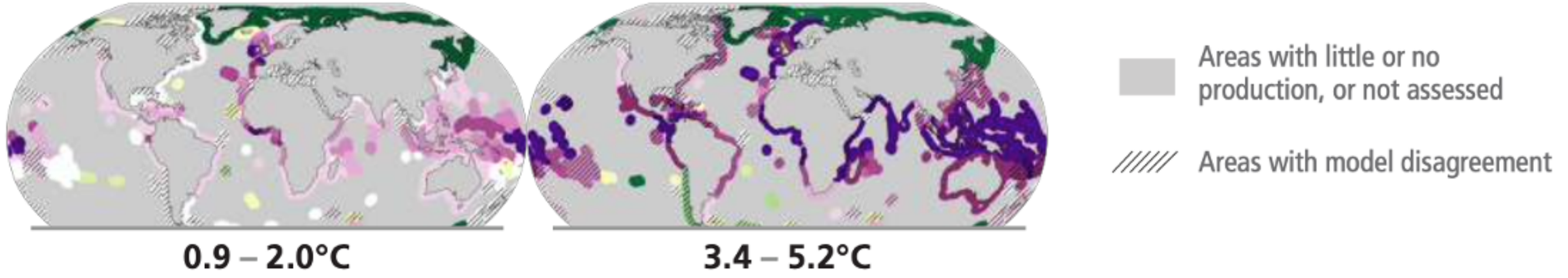
Food production impacts



c1) Maize yield[4]

Changes (%) in yield

[4]Projected regional impacts reflect biophysical responses to changing temperature, precipitation, solar radiation, humidity, wind, and CO_2 enhancement of growth and water retention in currently cultivated areas. Models assume that irrigated areas are not water-limited. Models do not represent pests, diseases, future agro-technological changes and some extreme climate responses.



c2) Fisheries yield[5]

Changes (%) in maximum catch potential

[5]Projected regional impacts reflect fisheries and marine ecosystem responses to ocean physical and biogeochemical conditions such as temperature, oxygen level and net primary production. Models do not represent changes in fishing activities and some extreme climatic conditions. Projected changes in the Arctic regions have low confidence due to uncertainties associated with modelling multiple interacting drivers and ecosystem responses.

Health and wellbeing

“HEALTH OF HUMAN POPULATION IS SENSITIVE TO CLIMATE CHANGE”

“CLIMATE CHANGE IS A THREAT TO HUMAN WELLBEING”

WHAT IS HEALTH AND WELLBEING?

HEALTH

The World Health Organization (WHO):
“A state of complete physical, mental and social wellbeing
and not merely the absence of disease or infirmity”

WELLBEING

There is no consensus definition of wellbeing. It can concern:

- predominance of positive emotions and moods compared with extreme negative emotions,
- satisfaction with life,
- a sense of meaning and positive functioning,
- opportunity for people to achieve their goals in life,
- the ability to take part in society in a meaningful way, and is reflected in personal freedoms, human agency, self-efficacy, ability to selfactualise, dignity and relatedness to others,
- healthy relationship with the natural world

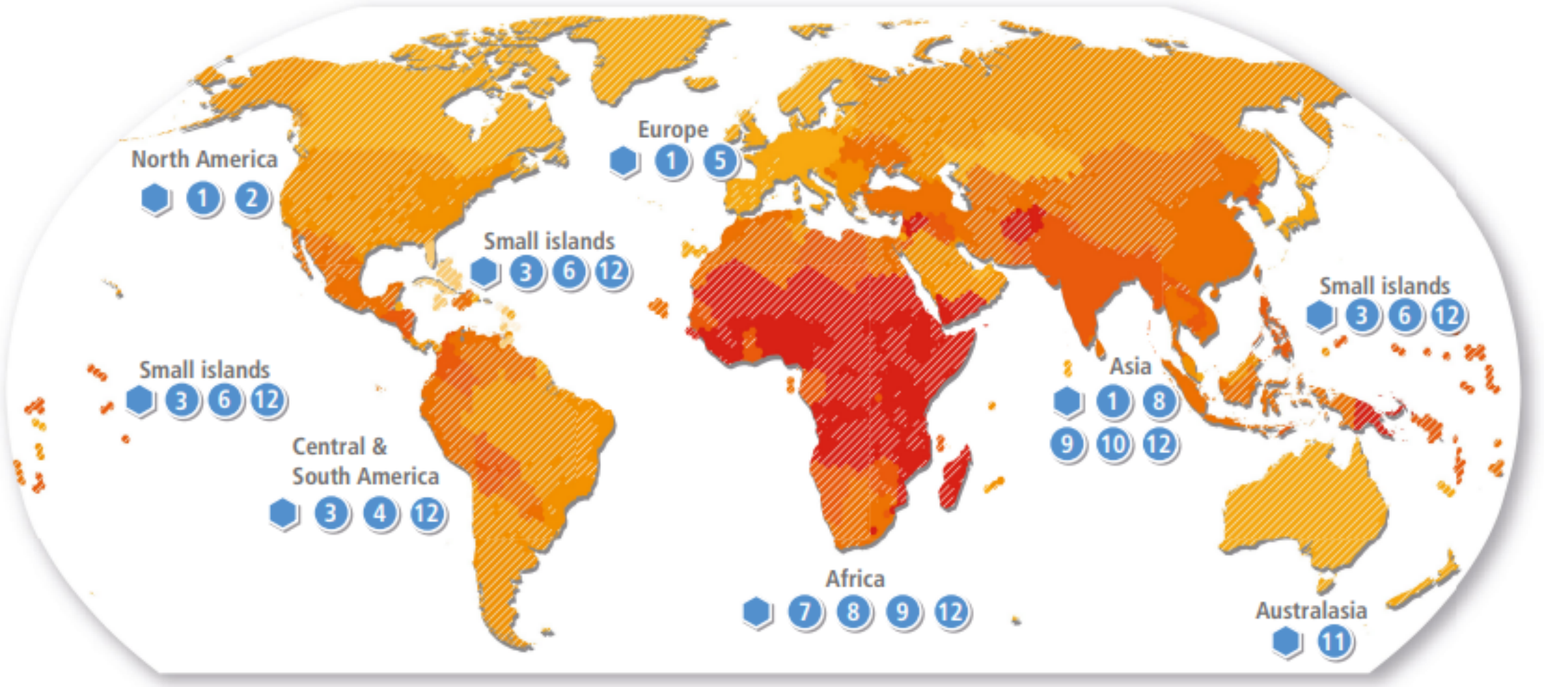
Subjective wellbeing is consistently associated with personal indicators such as higher income, greater economic productivity, better physical health and environmental health, and it is reflected in societal indicators such as social cohesion and equality

GROUPS THAT HAVE HEIGHTENED VULNERABILITY TO CLIMATE-RELATED IMPACTS ON HEALTH AND WELLBEING

- Women and girls
- Children
- Elderly
- Socioeconomically Marginalised Populations and People with Disabilities
- Urban Compared with Rural Populations
- Indigenous Peoples

Observed human vulnerability to climate change is a key risk factor and differs globally

(a) Vulnerability at the national level varies. Vulnerability also greatly differs within countries.
Countries with moderate or low average vulnerability have sub-populations with high vulnerability and vice versa.



Relative vulnerability
- Very high
- High
- Medium
- Low
- Very low

Population density
- High
- Low

Examples of Indigenous Peoples with high vulnerability to climate change and climate change responses (4.3.8, 5.10.2, 5.13.5, Box7.1, 8.2.1, 15.6.4) and the importance of Indigenous Knowledge (Box9.2.1, 11.4, 14.4, Cross-Chapter Box INDIG)

Examples of vulnerable local groups across different contexts include the following:

1 | **Indigenous Peoples of the Arctic** | health inequality, limited access to subsistence resources and culture | CCP 6.2.3, CCP 6.3.1

2 | **Urban ethnic minorities** | structural inequality, marginalisation, exclusion from planning processes | 14.5.9, 14.5.5, 6.3.6

3 | **Smallholder coffee producers** | limited market access & stability, single crop dependency, limited institutional support | 5.4.2

4 | **Indigenous Peoples in the Amazon** | land degradation, deforestation, poverty, lack of support | 8.2.1, Box 8.6

5 | **Older people, especially those poor & socially isolated** | health issues, disability, limited access to support | 8.2.1, 13.7.1, 6.2.3, 7.1.7

6 | **Island communities** | limited land, population growth and coastal ecosystem degradation | 15.3.2

7 | **Children in rural low-income communities** | food insecurity, sensitivity to undernutrition and disease | 5.12.3

8 | **People uprooted by conflict in the Near East and Sahel** | prolonged temporary status, limited mobility | Box 8.1, Box 8.4

9 | **Women & non-binary** | limited access to & control over resources, e.g. water, land, credit | Box 9.1, CCB-GENDER, 4.8.3, 5.4.2, 10.3.3

10 | **Migrants** | informal status, limited access to health services & shelter, exclusion from decision-making processes | 6.3.6, Box 10.2

11 | **Aboriginal and Torres Strait Islander Peoples** | poverty, food & housing insecurity, dislocation from community | 11.4.1

12 | **People living in informal settlements** | poverty, limited basic services & often located in areas with high exposure to climate hazards | 6.2.3, Box 9.1, 9.9, 10.4.6, 12.3.2, 12.3.5, 15.3.4

Figure 7.2 | Global distribution of vulnerable people from two indices, with examples (see also Technical Summary, this report).

Figure 7.6 | Climate change impacts on mental health and key adaptation responses.
PTSD: Post traumatic stress disorder.

1

Hazard

Acute events
(e.g. storms, floods, wildfires, extreme heat)

Chronic changes
(e.g. drought, sea level rise, sea ice loss, changing climate normals)

2

Vulnerability

Pre-existing health conditions
Socio-economic inequities
Gender
Age
Occupation

3

Exposure

Direct exposure(s)

Indirect exposure(s)
(e.g. displacement, food systems disruption, occupational loss)

Vicarious exposure(s)
(e.g. observed experiences of others, media depictions of climate change)

4

Key adaptation responses

Scale of adaptation

Institutional
State and non-state actors:
effective mental health systems, planning and preparedness, informed policies, early intervention
Local governments:
planning, design, green infrastructure

Community
- Supportive social networks, effective information channels

Individuals
- awareness, preparedness, mental health support, nature-based therapy

5

Risks to mental health and wellbeing

Mental illness
[e.g., PTSD, depression, suicide]

Diminished wellbeing
[e.g., stress, climate anxiety, cognitive impairment)

Diminished social relations
[e.g., loss of culture, interpersonal violence)

DISEASES MENTIONED IN IPCC REPORT

- Vector-borne diseases (VBDs) (=mosquito-borne diseases, rodent-borne diseases, and tick-borne diseases)
- Water-borne diseases (WBDs) (=diarrheal diseases, e. g. cholera, shigella, cryptosporidiosis, and typhoid; schistosomiasis, leptospirosis, hepatitis A and E, and poliomyelitis)
- Food-borne diseases (FBDs) (=consuming contaminated food)
- Respiratory tract infections (RTIs) (=pneumonia, influenza)
- Malnutrition, undernutrition, overweight, obesity
- Non-communicable diseases (NCDs), including cardiovascular, neurological (=cancer, diabetes)

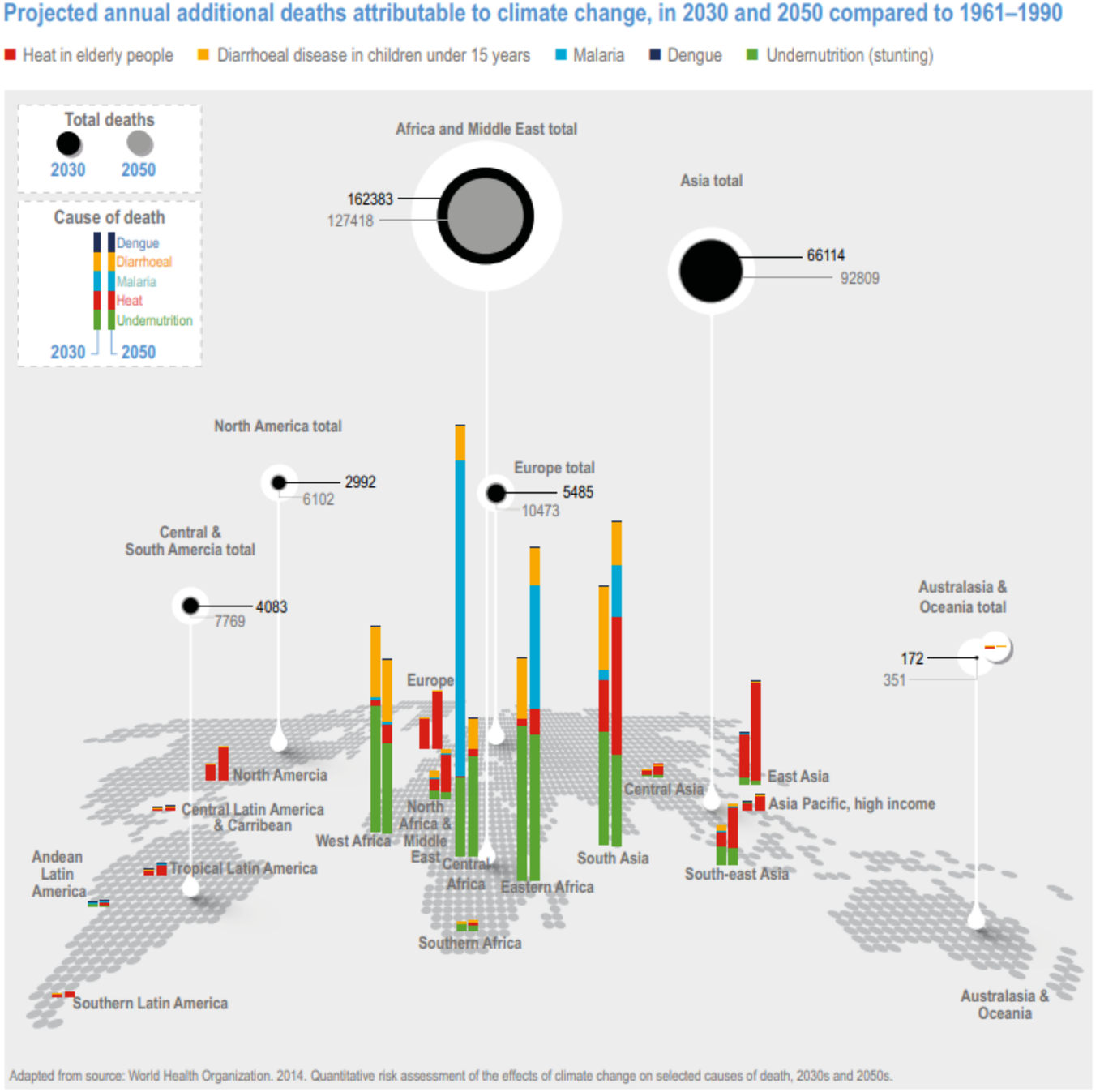


Figure 7.8 | Projected additional annual deaths attributable to climate change in 2030 and 2050 compared to 1961–1990 (WHO, 2014).

HOW CAN CLIMATE CHANGE AFFECT HEALTH AND WELLBEING

- EXTREME HEAT
- INCREASED PRECIPITATION AND HUMIDITY
- LOSS OF ACCESS TO GREEN AND BLUE SPACES
- DECREASED AIR QUALITY
- EXTREME WEATHER EVENTS
- ECONOMIC OR SOCIAL DISRUPTIONS
- CHANGES IN FOOD PRODUCTION

OBSERVED IMPACTS ON HEALTH AND WELLBEING

- Positive correlation between crop failures and suicides by male farmers who could not adapt their livelihoods to rising temperatures
- Drought conditions have been associated with violence due to impacts on income from agriculture and water and food security
- Increases in food prices are associated with civil unrest in urban areas among populations unable to afford or produce their own food and in rural populations due to changes in availability of agricultural employment with shifting commodity pricesdisruption of one's normal pattern of behaviour
- Extreme weather and climate impacts are associated with increased violence against women, girls and vulnerable groups. During and after extreme weather events, women, girls and LGBTQI people are at increased risk of domestic violence, harassment, sexual violence and trafficking
- Women are exposed to increase risk of harassment and sexual assault as scarcity and gender-based roles cause them to walk longer distances to fetch water and fuel
- Within the household, violent backlash or heightened tensions may arise from changing gender norms as men migrate to find work in post-disaster settings and men's use of negative coping mechanisms, such as alcoholism, when unable to meet norms of providing for the household

“Climate change is expected to increase aggression through both direct and indirect mechanisms, with one study predicting a

6% increase in homicides globally for a 1°C temperature increase,

although noting significant variability across countries ”

MIGRATION

can be caused by
weather events and
climate conditions

can act as

direct drivers

indirect drivers

MIGRATION DECISIONS

are influenced by:

- risk,
- social networks,
- wealth,
- age,
- health,
- livelihood choices

“Climate change is expected to significantly increase the health risks resulting from a range of climate-sensitive diseases and conditions, with the scale of impacts depending on emissions and adaptation pathways in coming decades”

Cities, settlements and infrastructure

Cities, settlements and infrastructure

- Urban areas are now home to 4.2 billion people, the majority of the world's population.
- Urbanization processes generate vulnerability and exposure which combine with climate change hazards to drive urban risk and impacts .

$$\text{Risk} = \text{Hazard} \times \text{Exposure} \times \text{Vulnerability}$$

- Cities & settlements
  - Temperature and the urban heat island
  - Urban flooding
  - Urban Water Scarcity and Security
- Key infrastructure

Temperatures & the Urban Heat Island

- **Higher temperatures** associated with climate change (through warmer global average temperatures and regional heatwave episodes) will interact with urban systems in various ways.
- Within cities, **exposure to heat island effects** is **uneven**, with some populations with higher risks (low-income communities, children, the elderly, disabled, and ethnic minorities.)
- The risks to cities, settlements, and infrastructure from heat waves **will worsen.**

Temperatures & the Urban Heat Island

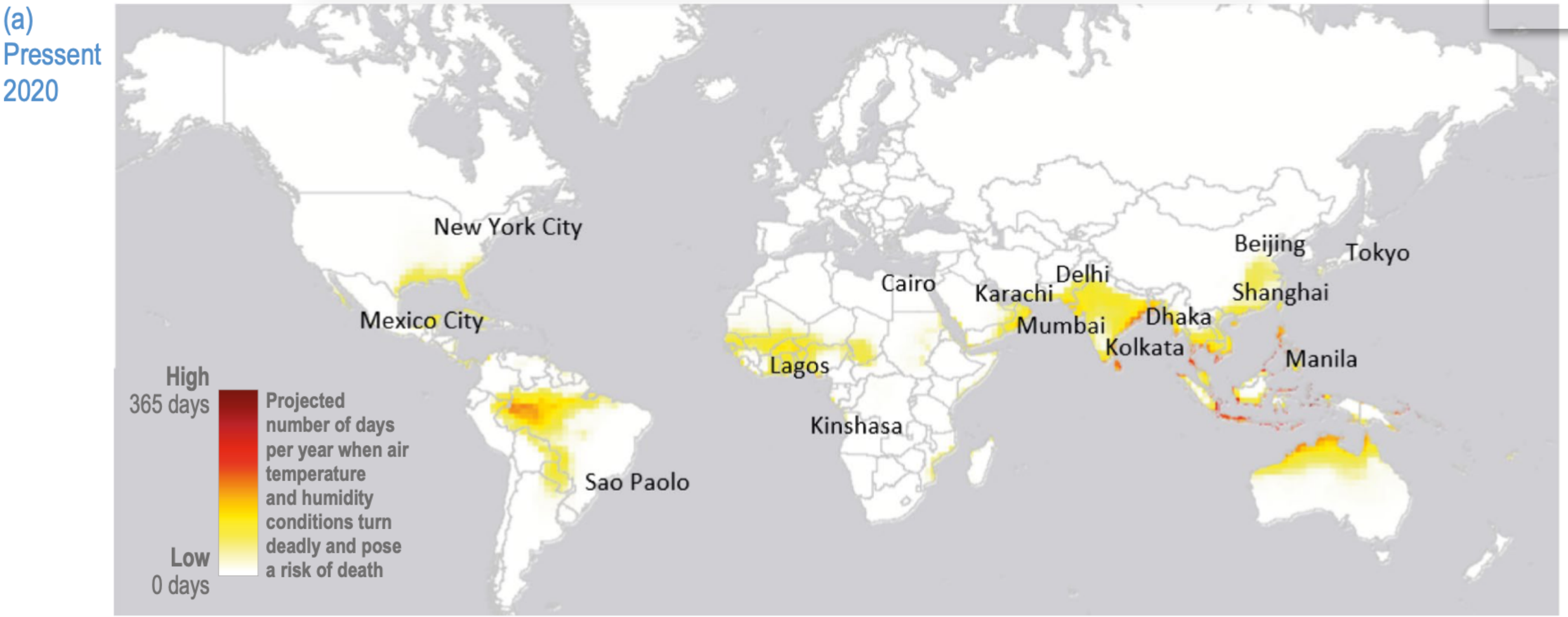


Figure 6.3: Global distribution of population exposed to hyperthermia from extreme heat for (a) the present

Temperatures & the Urban Heat Island

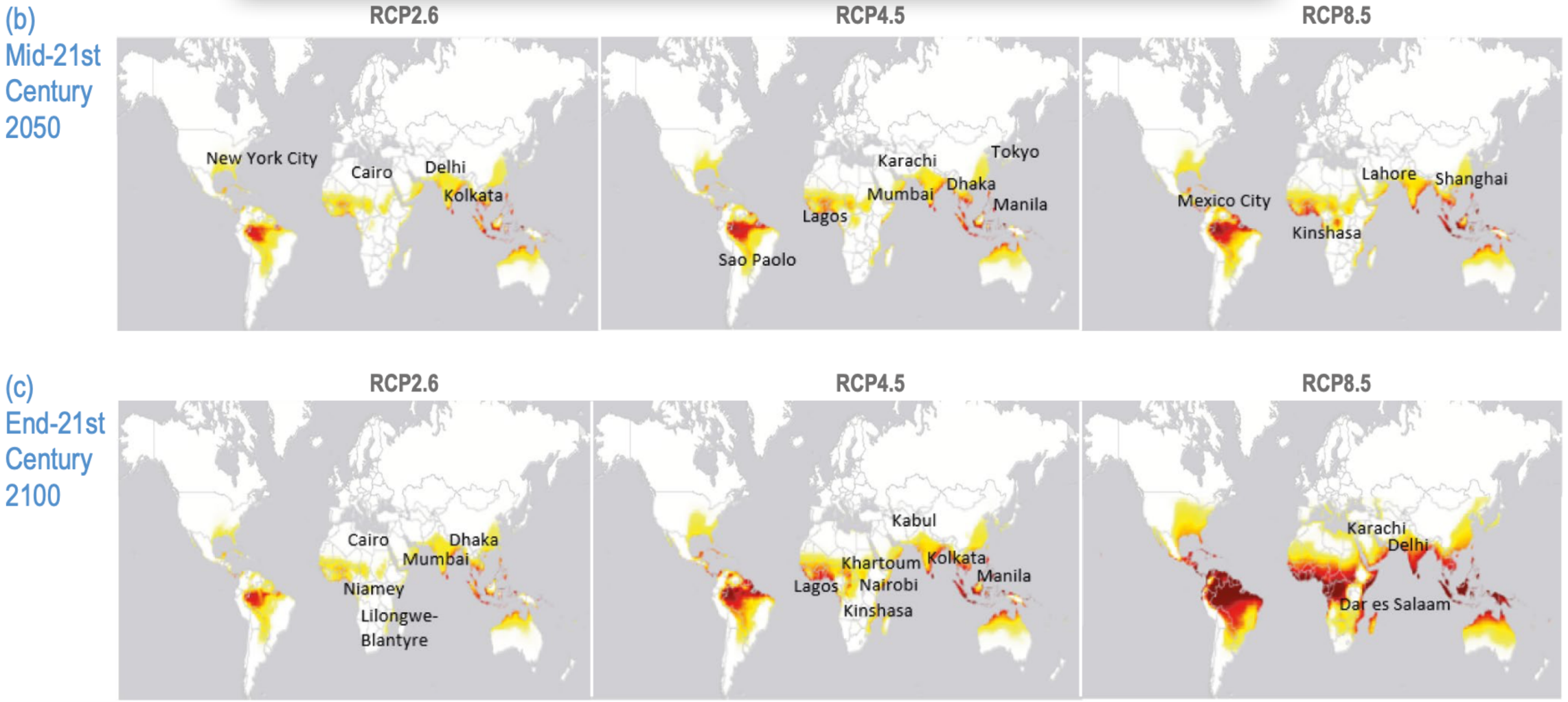
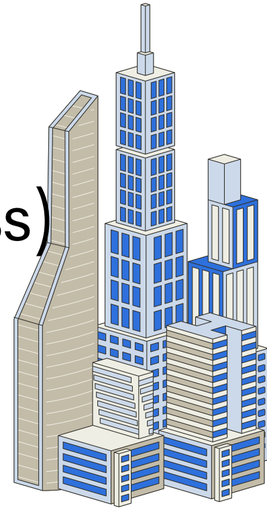


Figure 6.3: Global distribution of population exposed to hyperthermia from extreme heat for (b) the mid-21st century and (c) the end of the 21st century

Temperatures & the Urban Heat Island



- Energy-efficient buildings (high insulation values, high airtightness) are more **vulnerable to overheating** than older buildings (lower insulation levels).
- Heat risk is associated with a range of **health issues** for urban residents.
- Higher urban temperatures result in **lower labour productivity** levels and economic outputs.

- Globally, **urban heat stress** is projected to reduce labour capacity by 20% in hot months by 2050 compared with a current 10% reduction.
- **Thermal inequity** can also be seen as a distributive justice risk .

Urban flooding

- Increase in **frequencies** + **intensities** of **extreme precipitation** from global warming -> expand the global land area affected by **flood hazards.**
- **Urban flooding risks increase: Urban expansion** + **land use & land cover change ->** enlarges impermeable surface areas through soil sealing -> impact drainage of floodwaters with consequent sewer overflows

Urban flooding

- Asian cities are highly exposed to future **flood risks** arising from **urbanization processes**.

2000-2030: Rapid urbanization in Indonesia will elevate flood risks by 76-120% for river and coastal floods

In Can Tho, Vietnam, current urban development patterns put new assets and infrastructure at risk due to sea level rise and river flooding in the Mekong Delta

Urban Water Scarcity and Security

- **Urban water security** requires a **sustainable quantity and quality** of water to meet community and ecosystem needs in a changing climate.
- **Risks arising from urban water scarcity** worldwide are increasing due to climate drivers (e.g., warmer temperatures and droughts) and urbanization processes (e.g., land use changes, migration to cities, and changing patterns of water use including over-extraction of surface and groundwater resources) **affecting supply and demand.**

Urban Water Scarcity and Security

- Projections suggest that 350 million (± 158.8 million) more people living in urban areas will be exposed to water scarcity from severe droughts at 1.5°C warming and 410.7 million (± 213.5 million) at 2°C warming.
- Risks of urban water scarcity and security are compounded by vulnerabilities such as **service availability** and **quality of infrastructure** to supply water for increased urban demand from in-migration to cities.
- Urban interdependencies mean droughts in one region can limit water resources availability in another.

Impacts to key infrastructure

Infrastructure includes:

- Social infrastructure (housing, health, education, livelihoods and social safety nets, security, cultural heritage/institutions, disaster risk management and urban planning)
- Ecological infrastructure (clean air, flood protection, urban agriculture, temperature, green corridors, watercourses and riverways)
- Physical infrastructure (energy, transport, communications [including digital], built form, water and sanitation and solid waste management)

Social infrastructure

- **Housing:** Climate impacts(flooding, heat, fire,...) will likely have detrimental effects on **housing stock** (including physical damage and loss of property value) and on residents exposed to climate risks.
- **Health system:** Healthcare facilities (hospitals, clinics, residential homes) will suffer increasing shocks and stresses related to climate variability and change.

Ecological infrastructure

- Future climate impacts on coastal natural infrastructure, which cause significant **economic losses from property damage** and **decreasing tourism income**, as well as l**oss of natural capital and ecosystem services.**

Physical infrastructure

- **Energy:** Climate change is expected to alter energy demand (e.g, heatwaves increase spot market prices). Climate change can influence **energy consumption** patterns -> energy infrastructure planning under climate change must take into account a greater number of scenarios and investigate impacts on particular energy segments.
- **Transport:** heatwaves will be the most significant risk to EU transport infrastructure in the 2080s, as a result of buckling of roads and railways due to thermal expansion, melting of road asphalt and softening of pavement material. Heavy rain and flooding can also inundate underground transport systems.

Climate Impacts Cascade Through Infrastructure

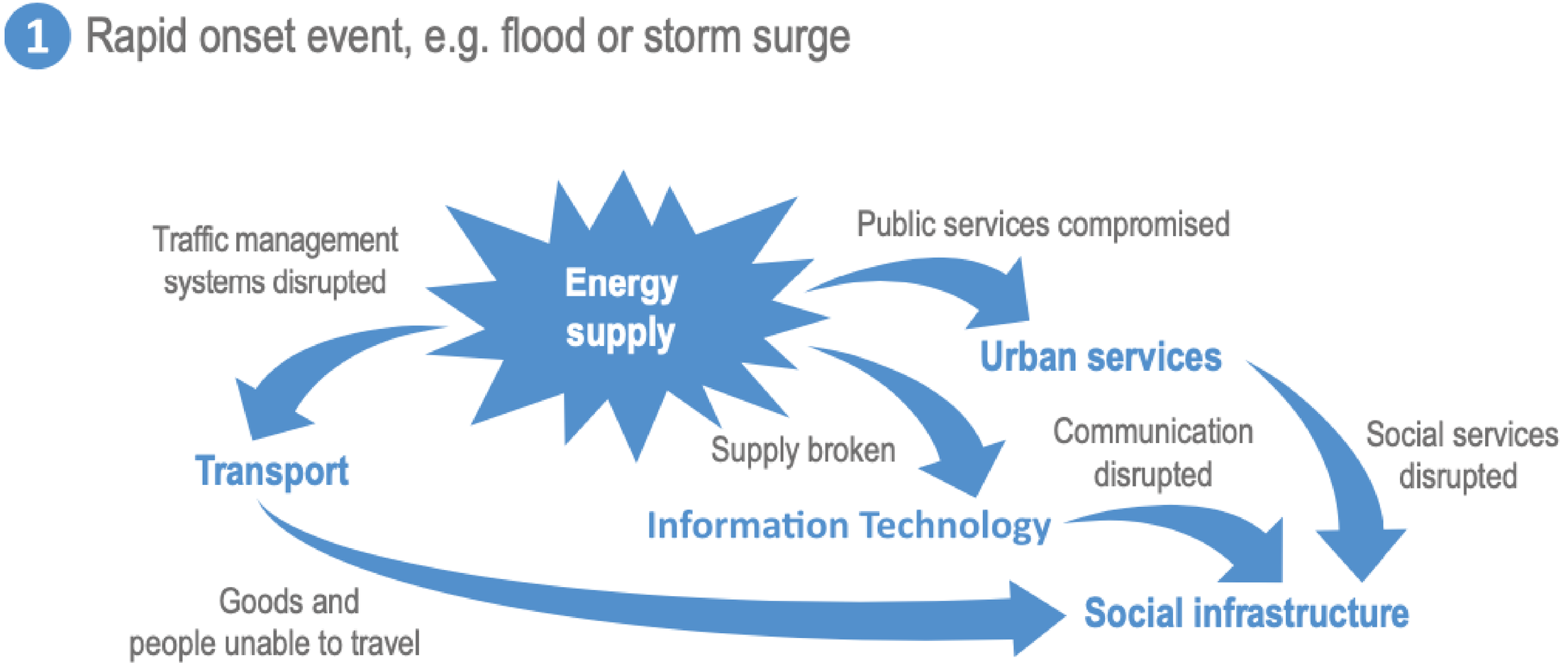


Figure 6.2: The interconnected nature of cities, settlements, and infrastructure

Climate Impacts Cascade Through Infrastructure

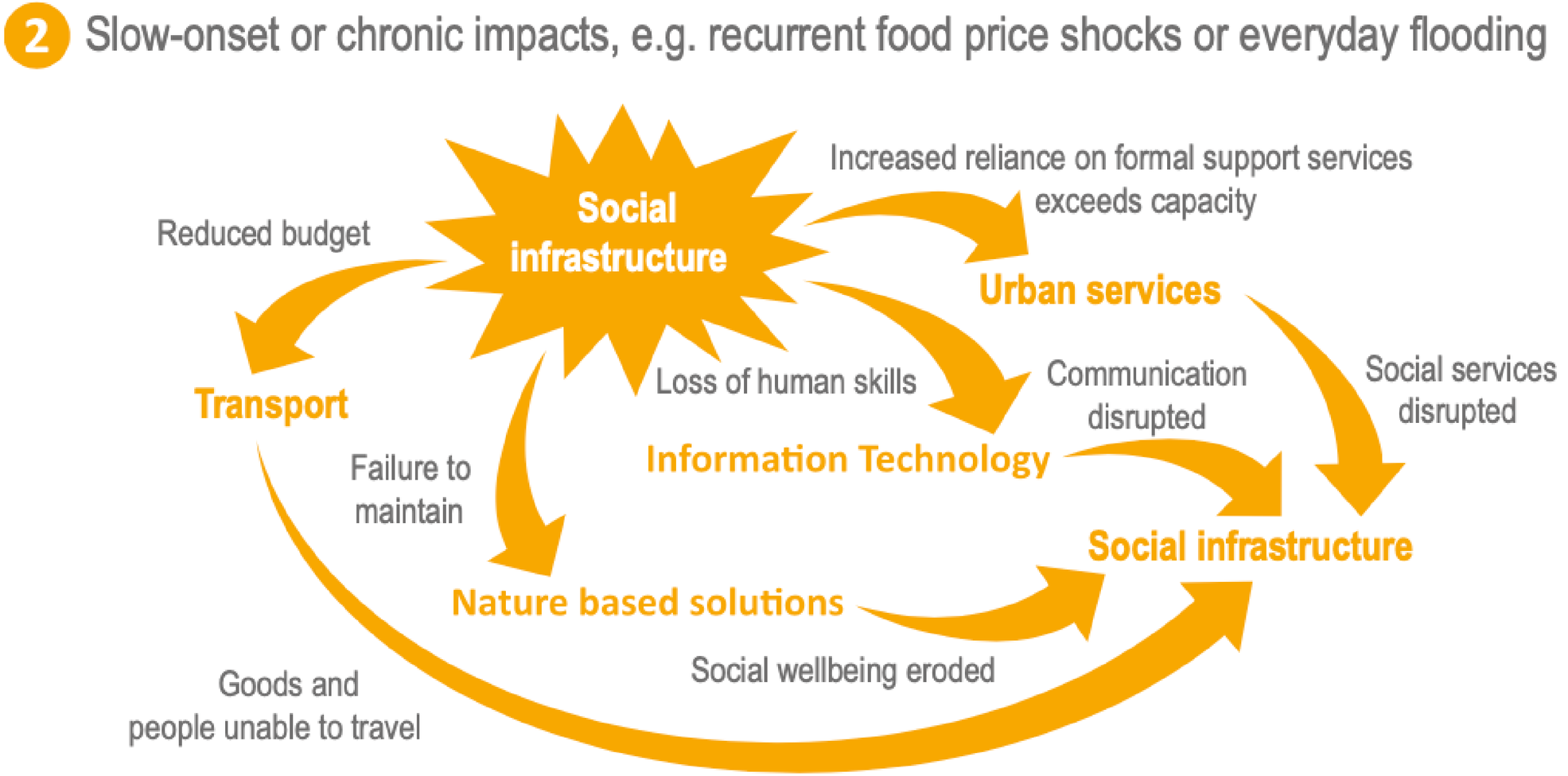


Figure 6.2: The interconnected nature of cities, settlements, and infrastructure

Thanks

Nguyen Thi Quynh Thuong
Dao Thi Nguyet
Natalia Aleksiejuk
Kinga Kopka