Climate change, freshwater and agriculture

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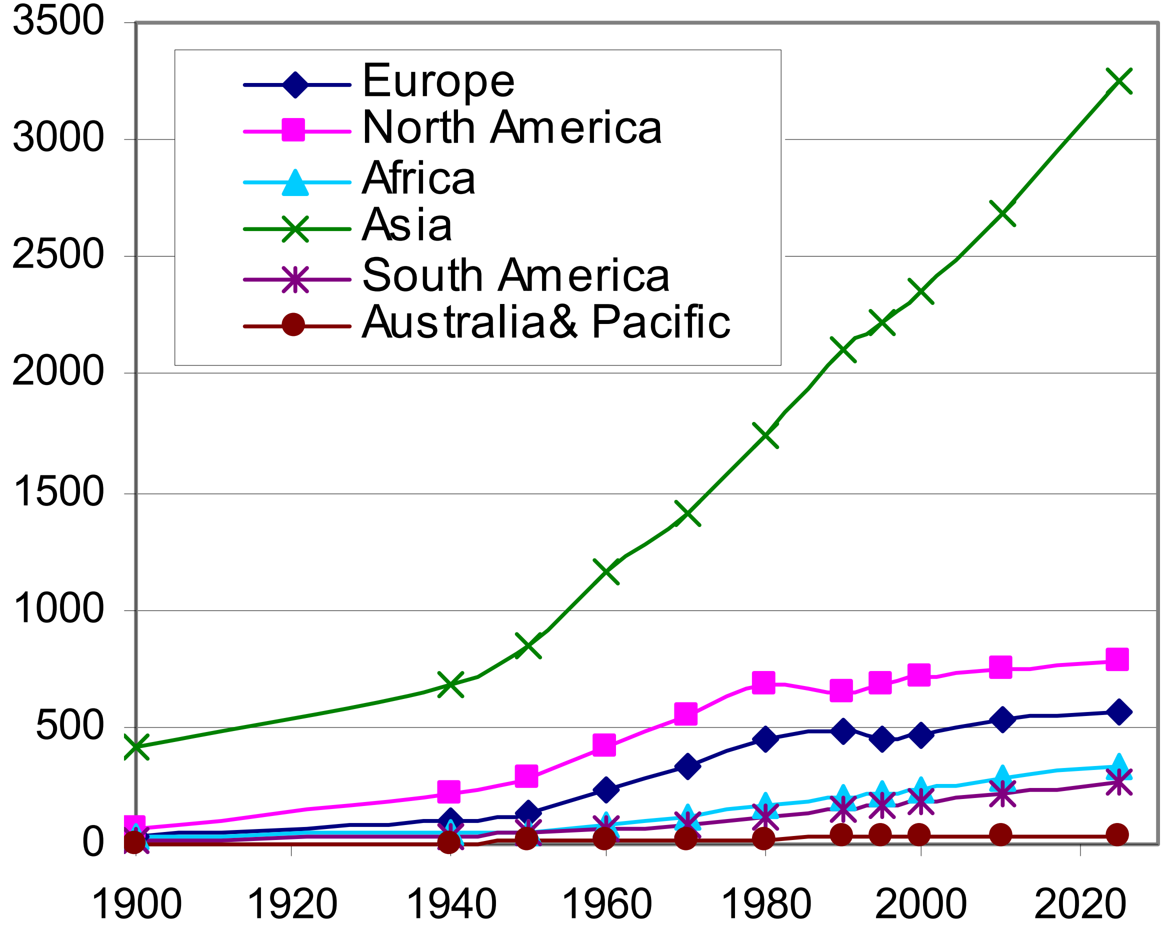
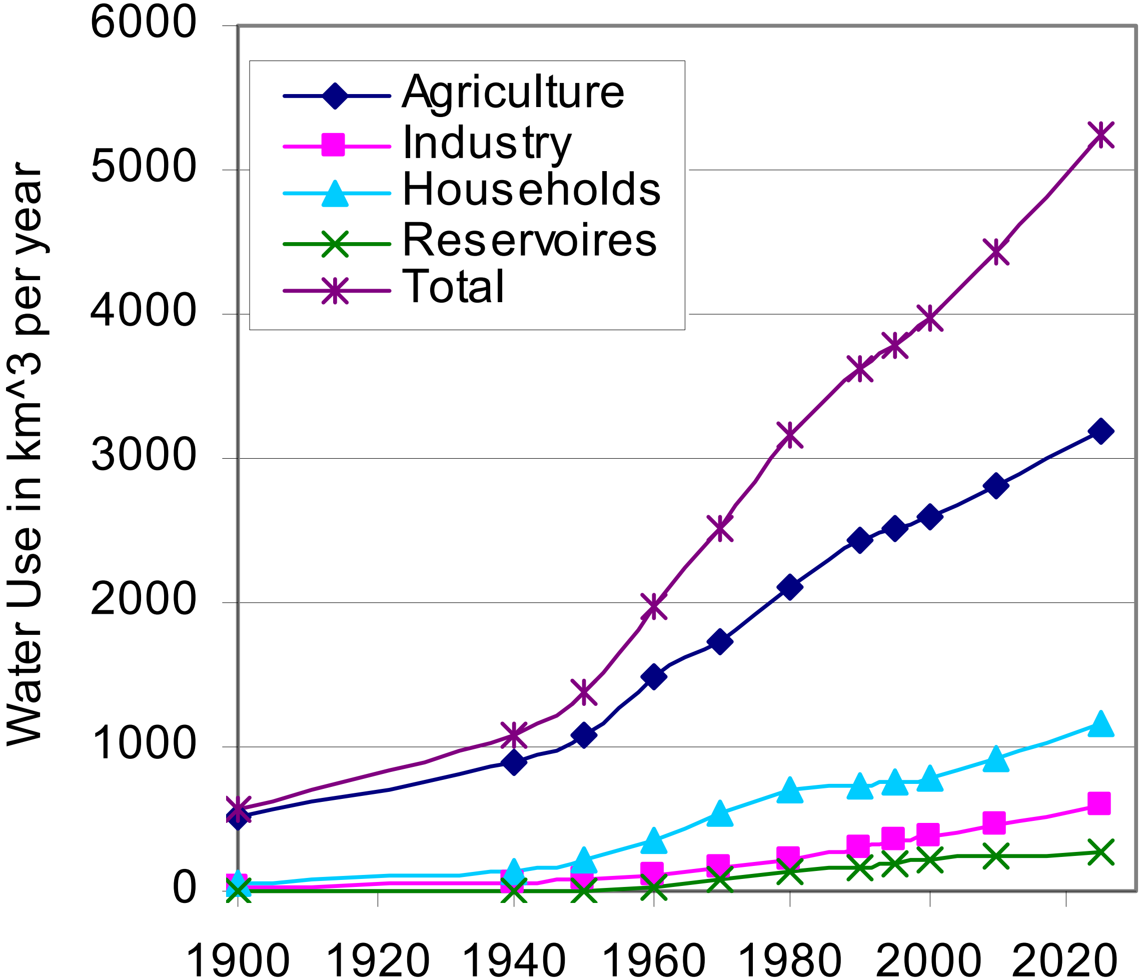
www.klimaatvoorruimte.nl
Intergovernmental Panel on Climate Change (IPCC AR 4)

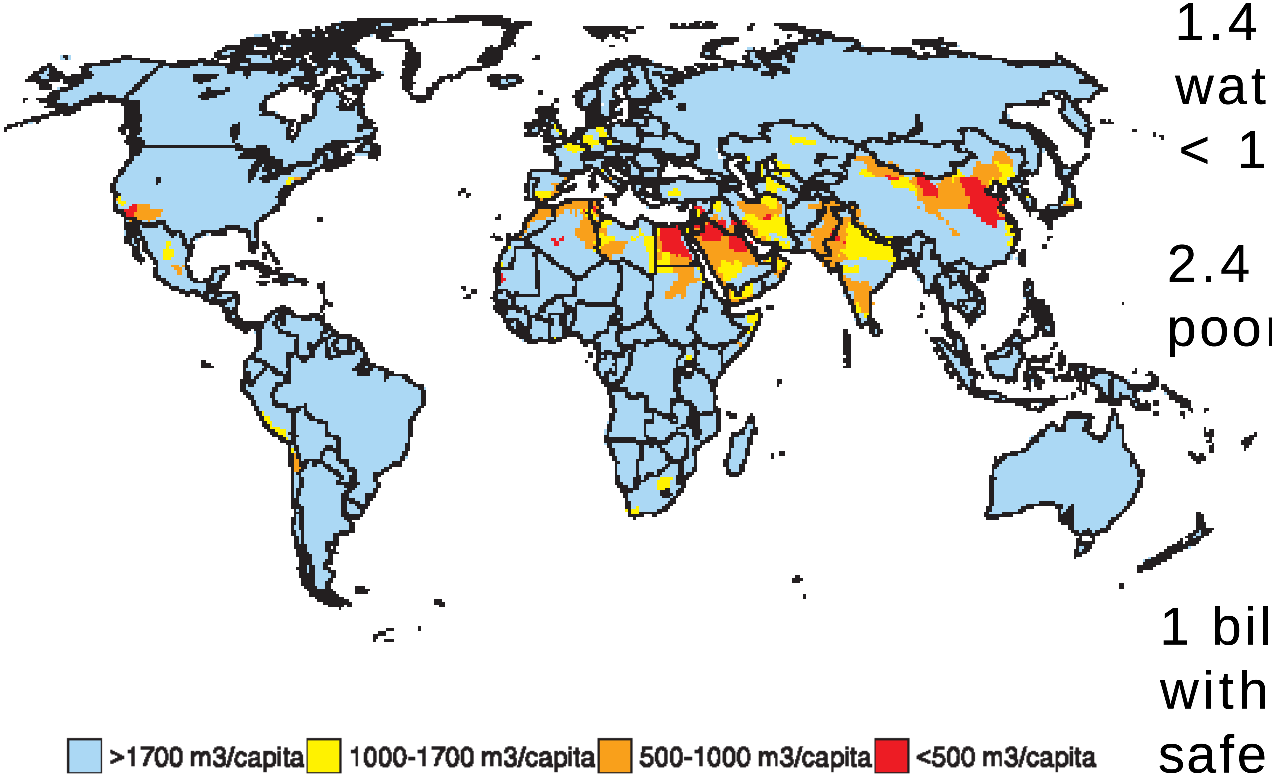
Worldwide Water Use by Region



Worldwide Water Use by Sector



The current situation



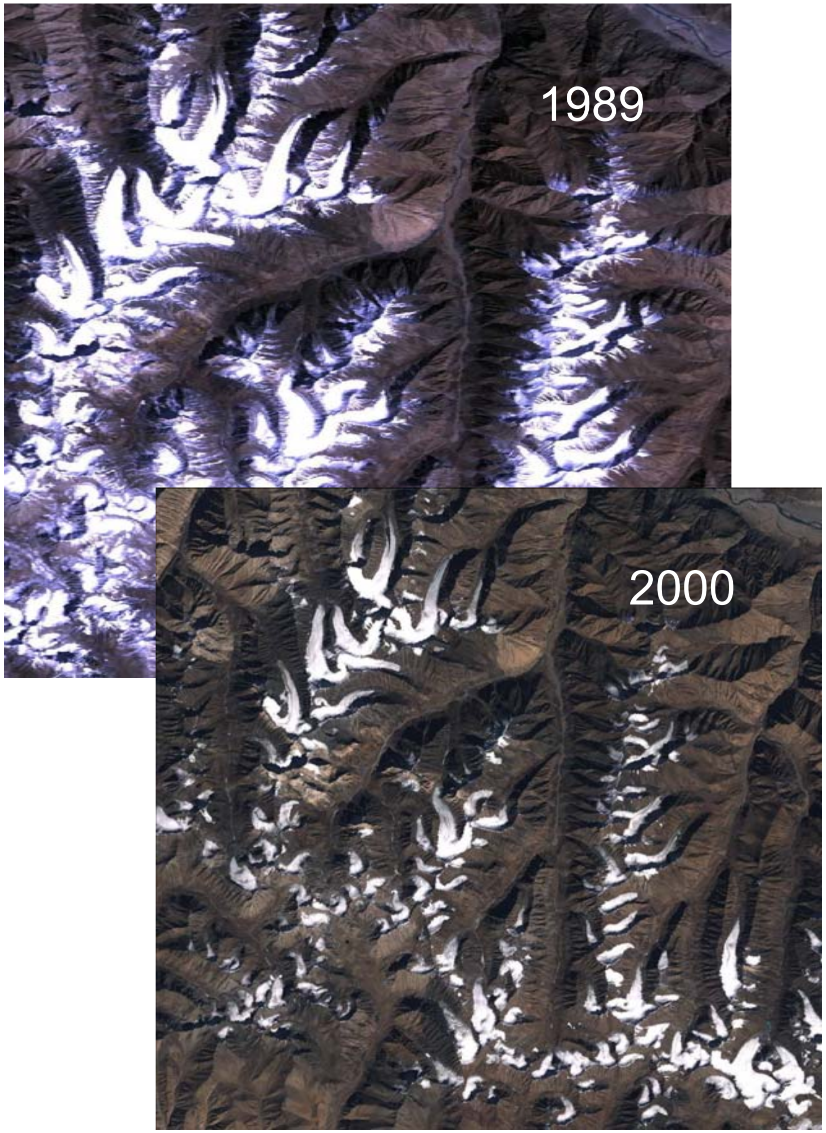
1.4 billion people in watersheds with < $1000 m^3$/capita/year

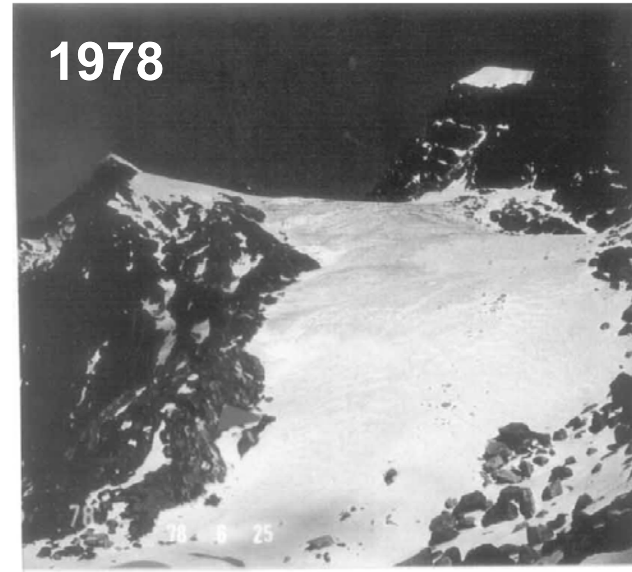
2.4 billion people with poor sanitation

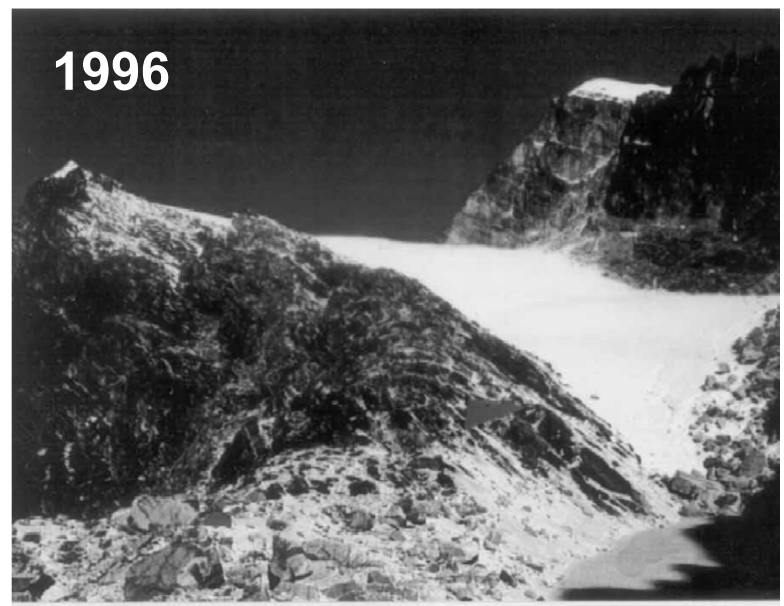
1 billion people without access to safe drinking water

University of Southampton

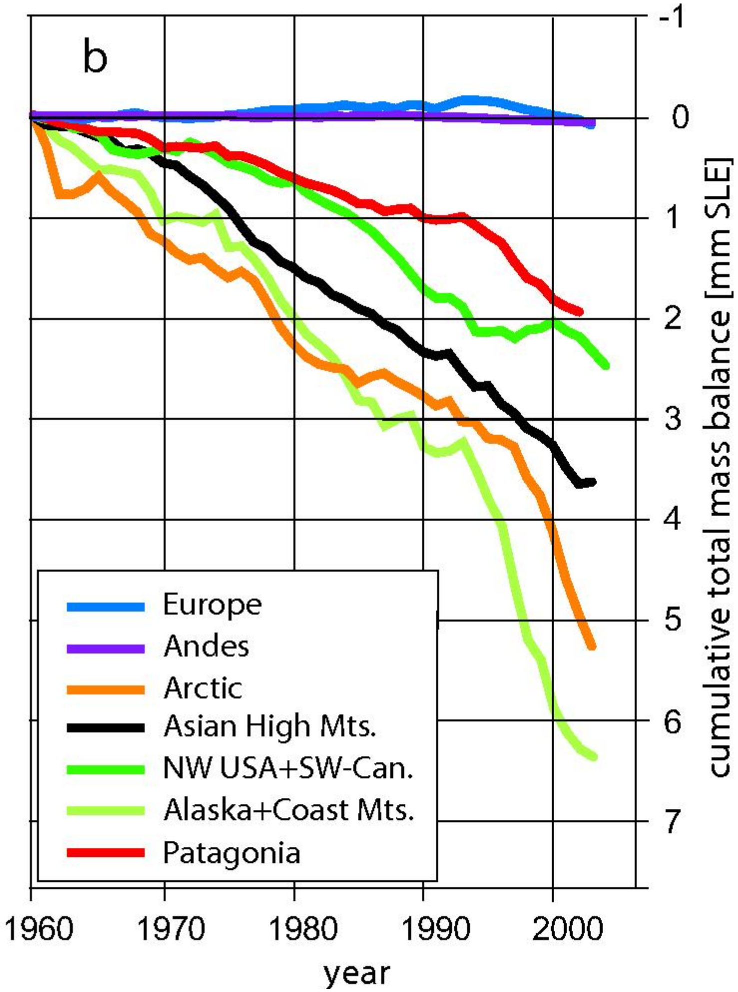
Glacier melt in the Himalayas



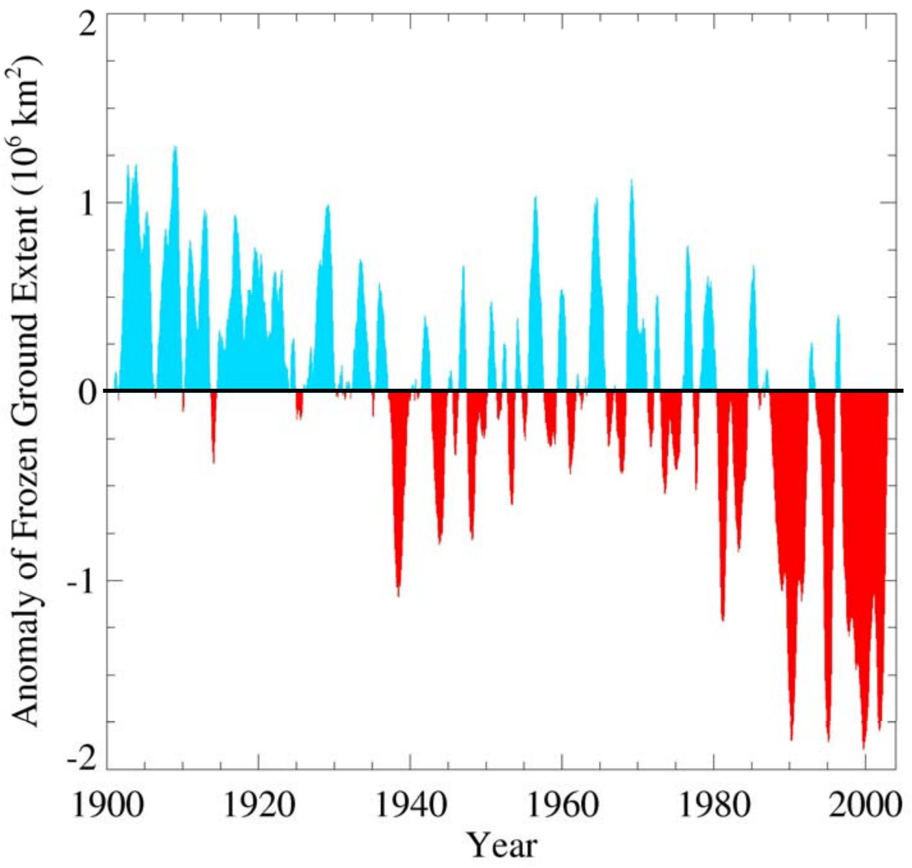




Glaciers and frozen ground are receding



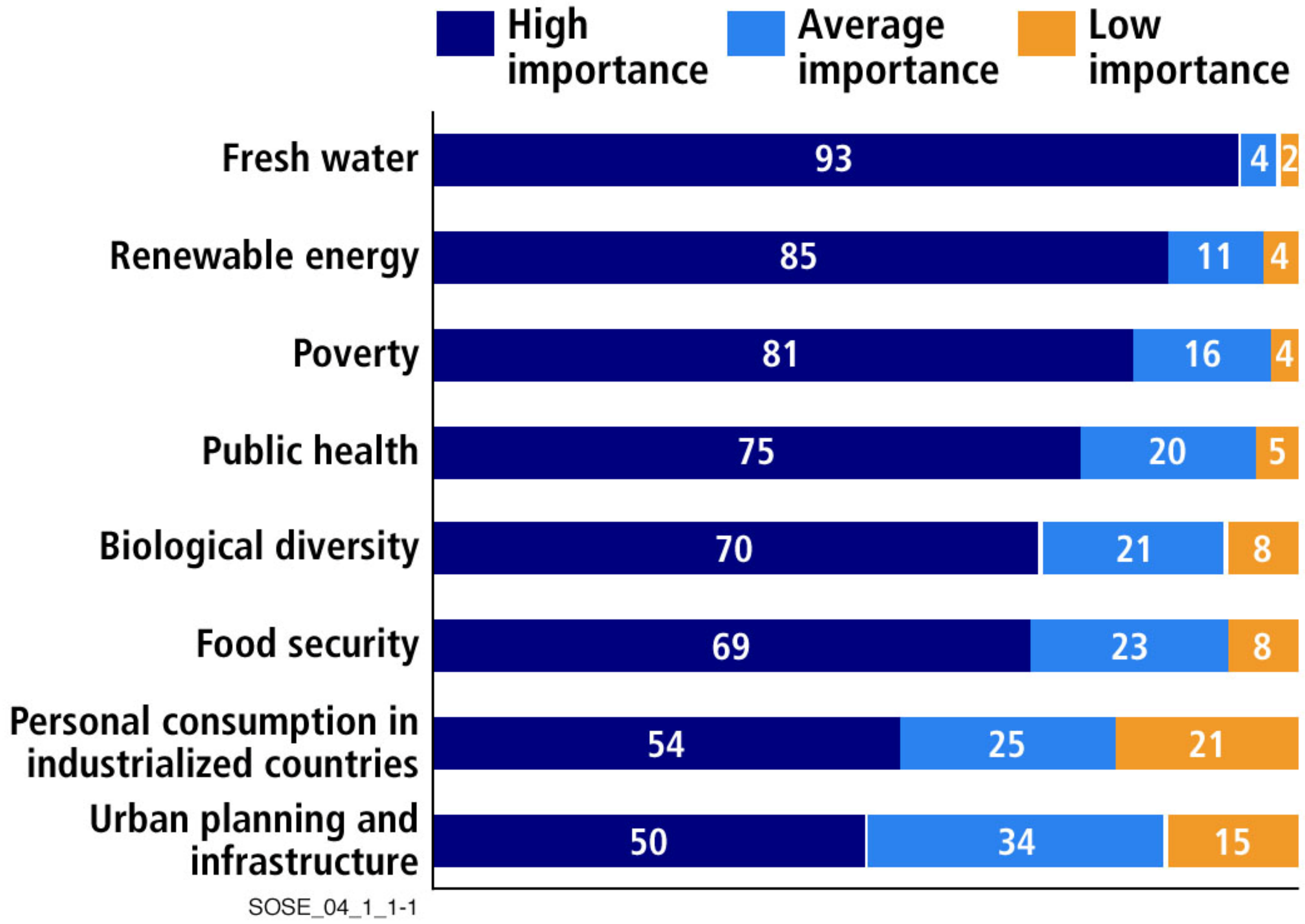
Increased Glacier retreat since the early 1990s



Area of seasonally frozen ground in NH has decreased by 7% from 1901 to 2002

Most Important Focus of World Leaders

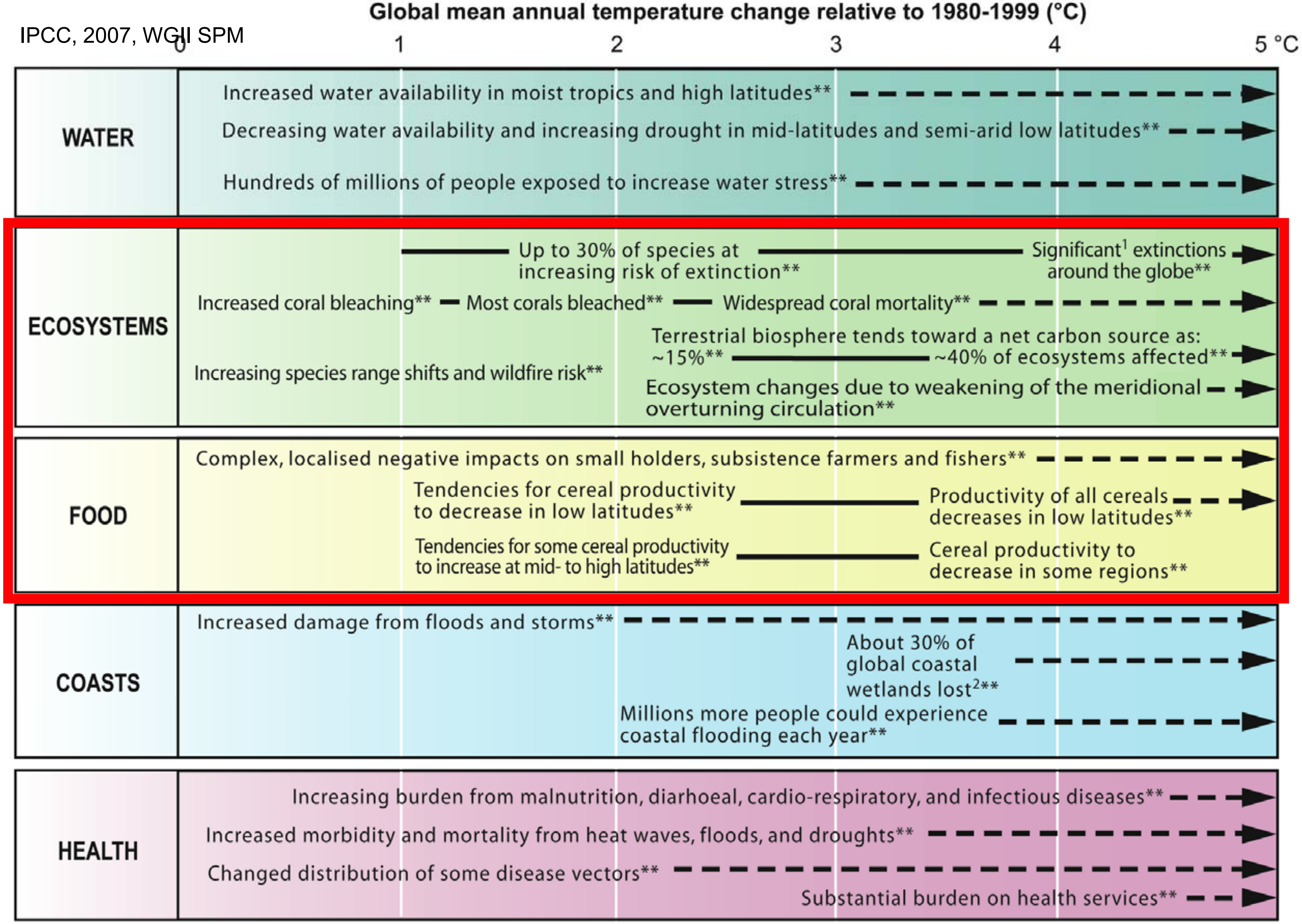
2004



The white space in this chart represents "DK/NA."

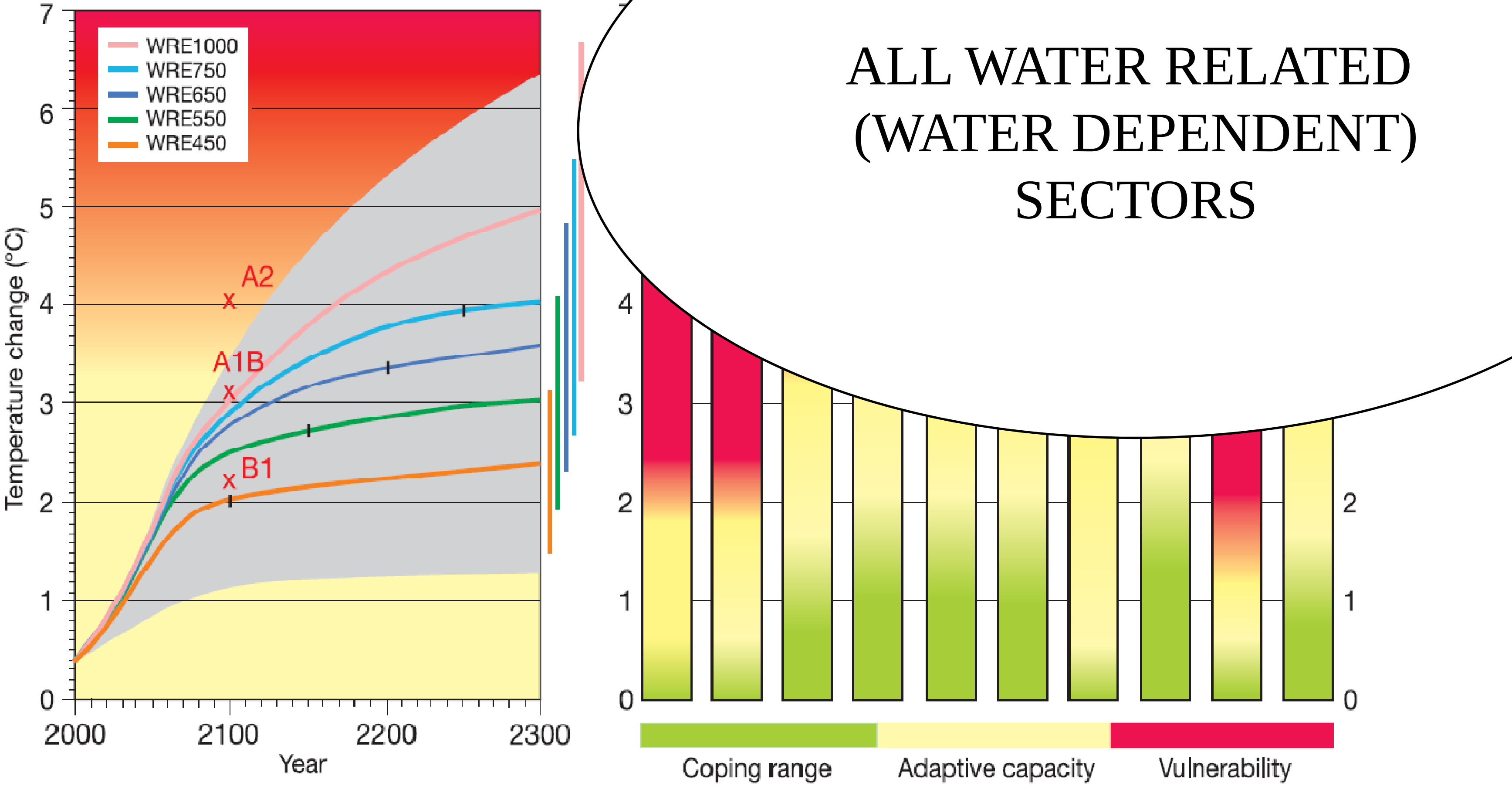
The warmer, the more negative the impacts!

IPCC, 2007, WGII SPM

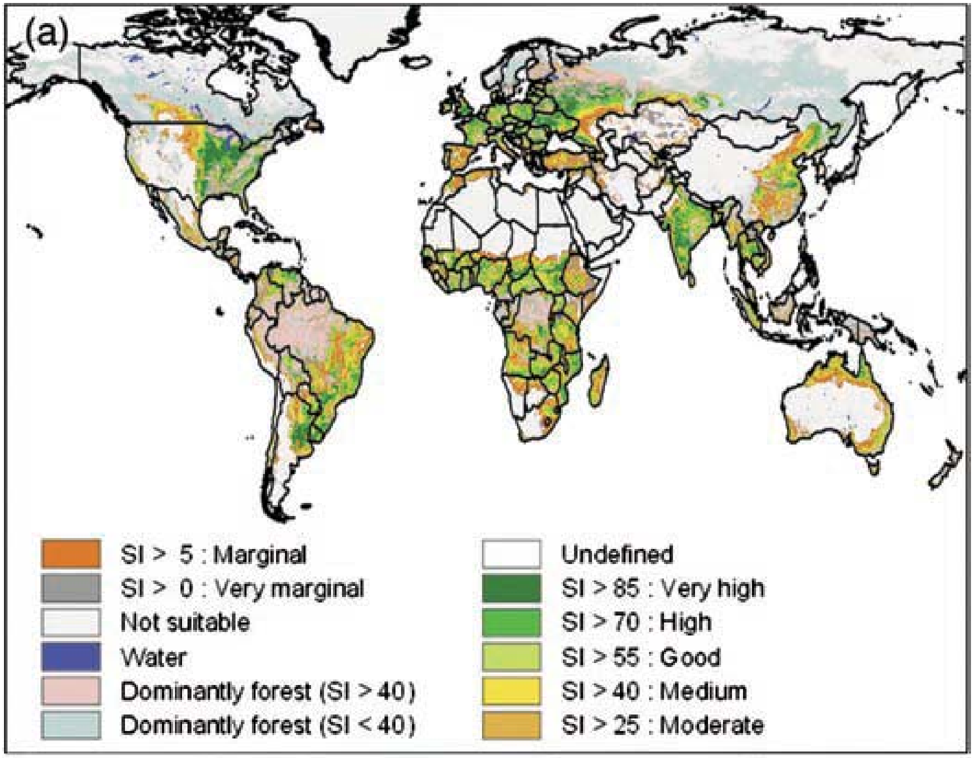


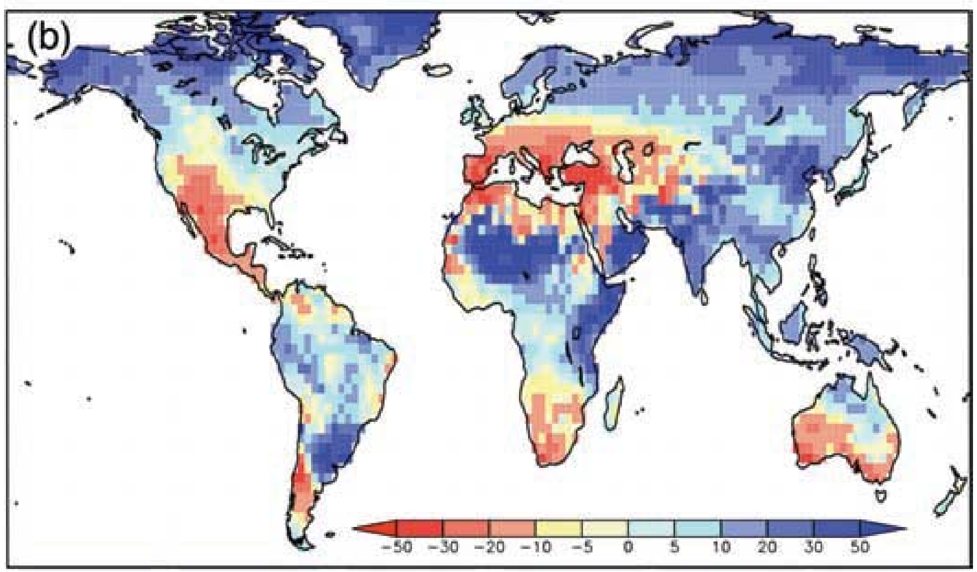
From Figure SPM.2
(IPCC, 2007. Summary for Policy Makers by Working Group II AR4 IPCC)

IPCC 4AR WG II



ALL WATER RELATED (WATER DEPENDENT) SECTORS





Impacts on rain-fed agriculture

a) Suitability index

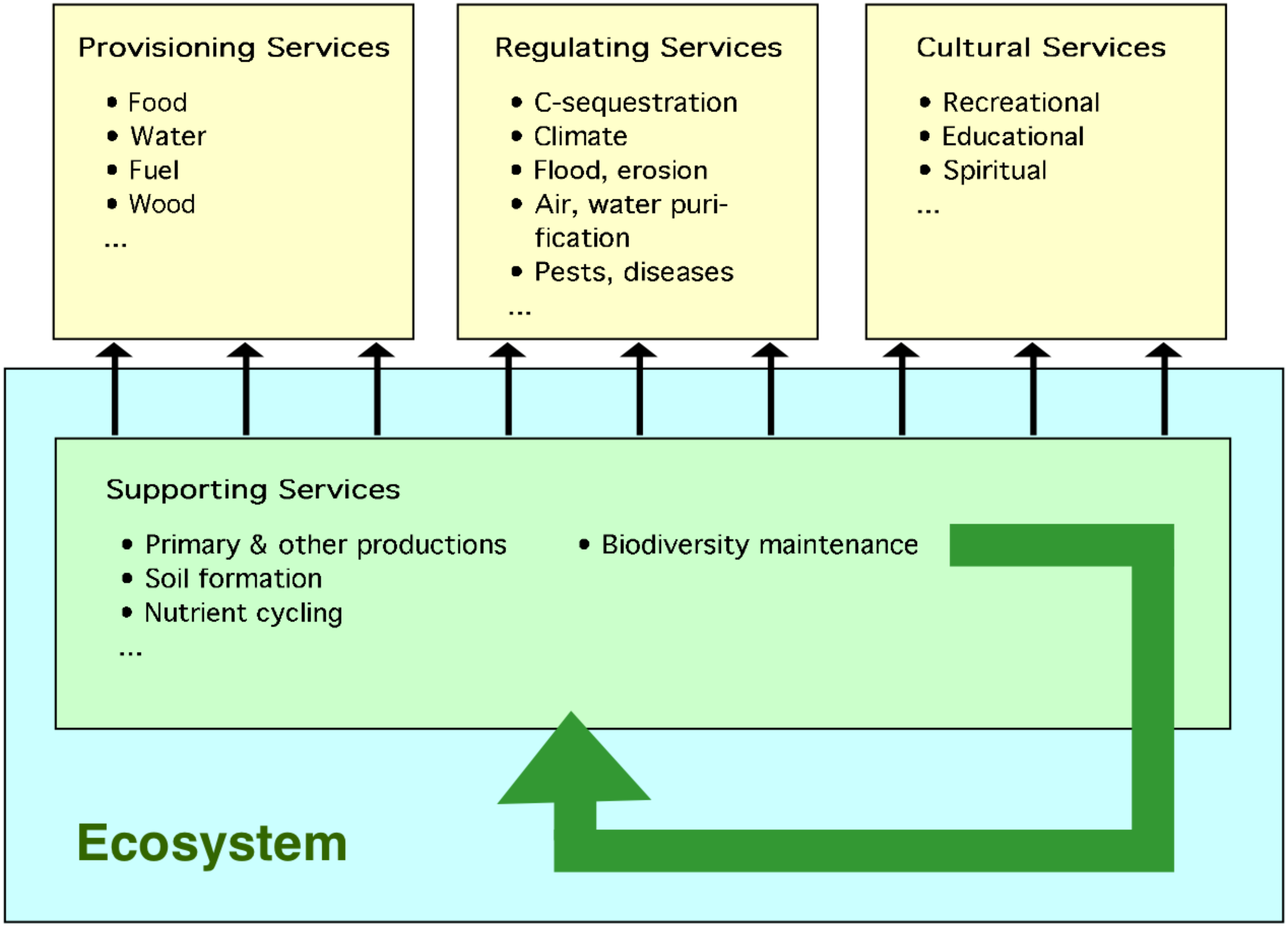
Current Rain-fed Crop Production Potential of the Earth

b) Water run-off change

Current Ensemble mean percentage change of annual runoff between present and 2100

Easterling et al., 2007. Figure 5.1: Suitability of rain fed crops (IPCC, 2007. WGII)

Ecosystems Services



Future Impacts: on a Supporting Service

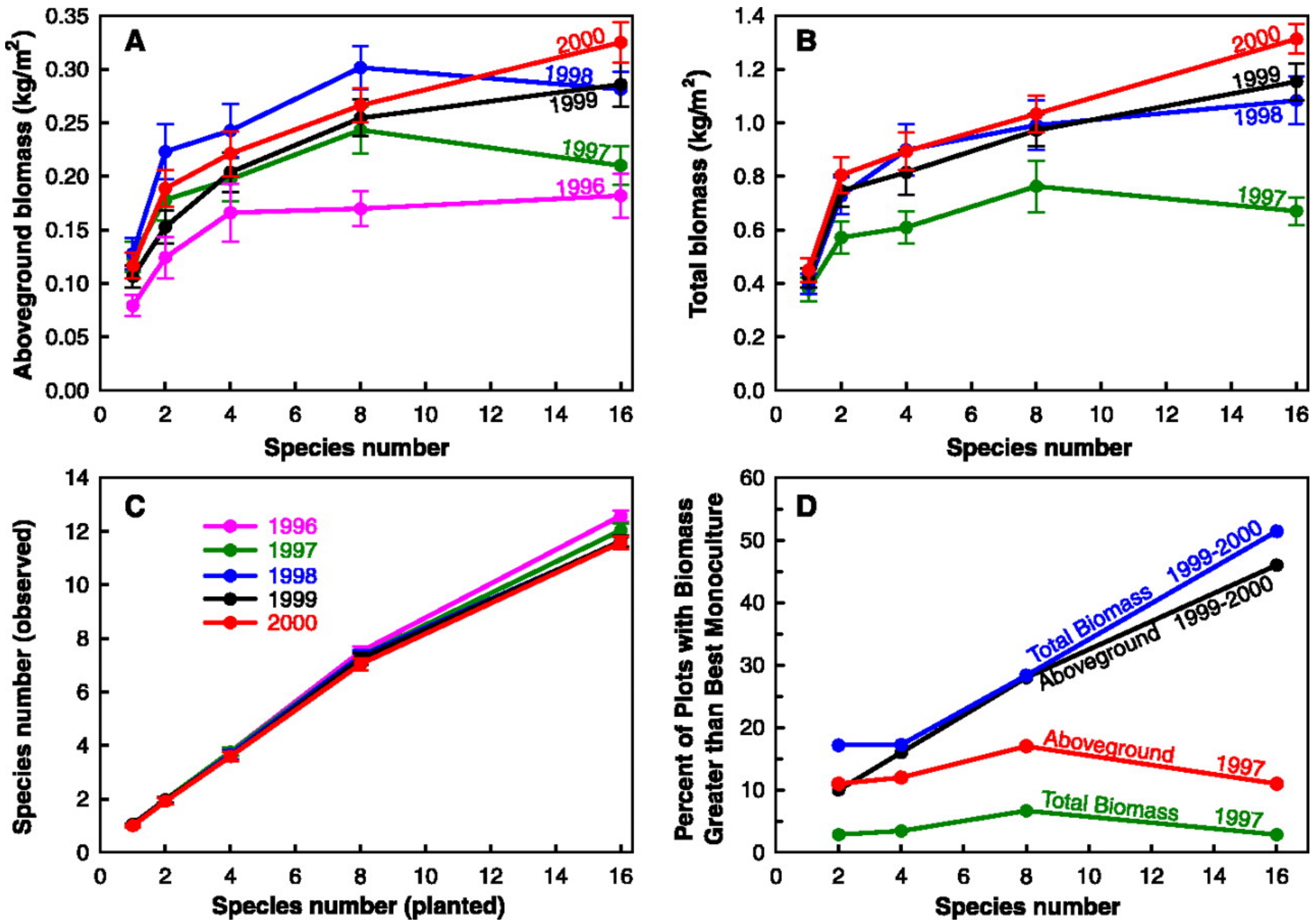
Impacts on Biodiversity

20%-30% of higher plants and animals at high risk of extinction

if ΔT 1.5°C - 2.5°C over present

(medium confidence)

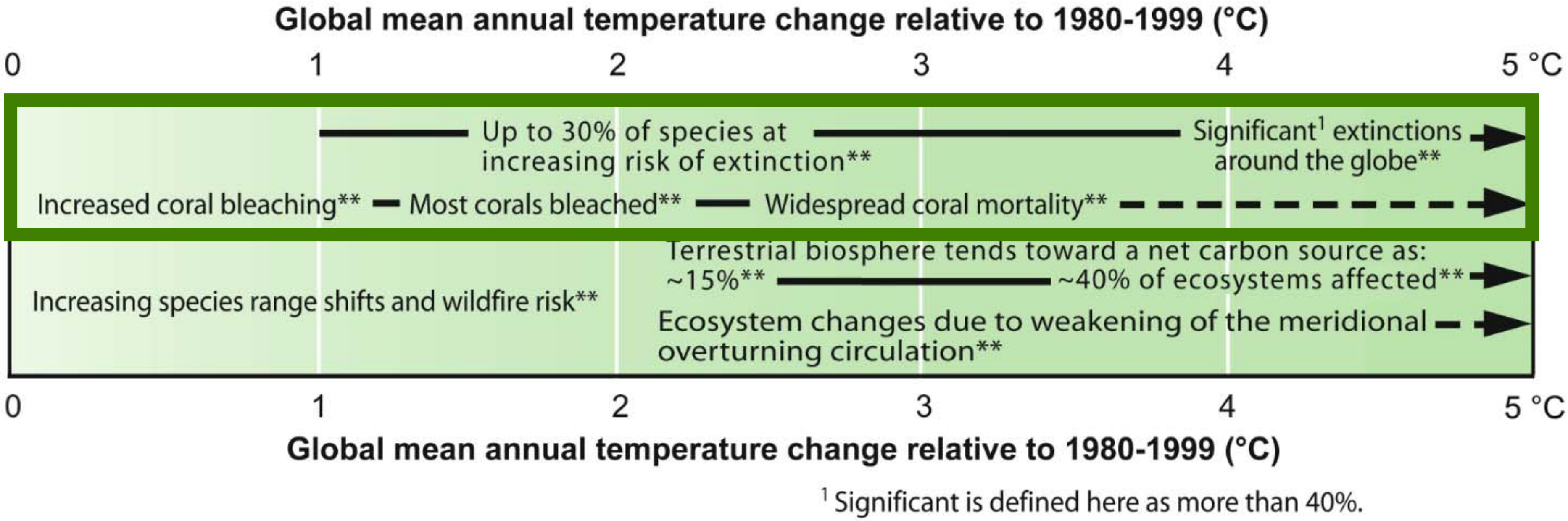
High productivity if diversity high



Tilman et al., 2001. Science, 294: 843 -845

Summary

Impacts on Biodiversity



From Figure SPM.2

(IPCC, 2007. Summary for Policy Makers by Working Group II AR4 IPCC)

Future Impacts: On Provisioning Services

Agricultural Productivity

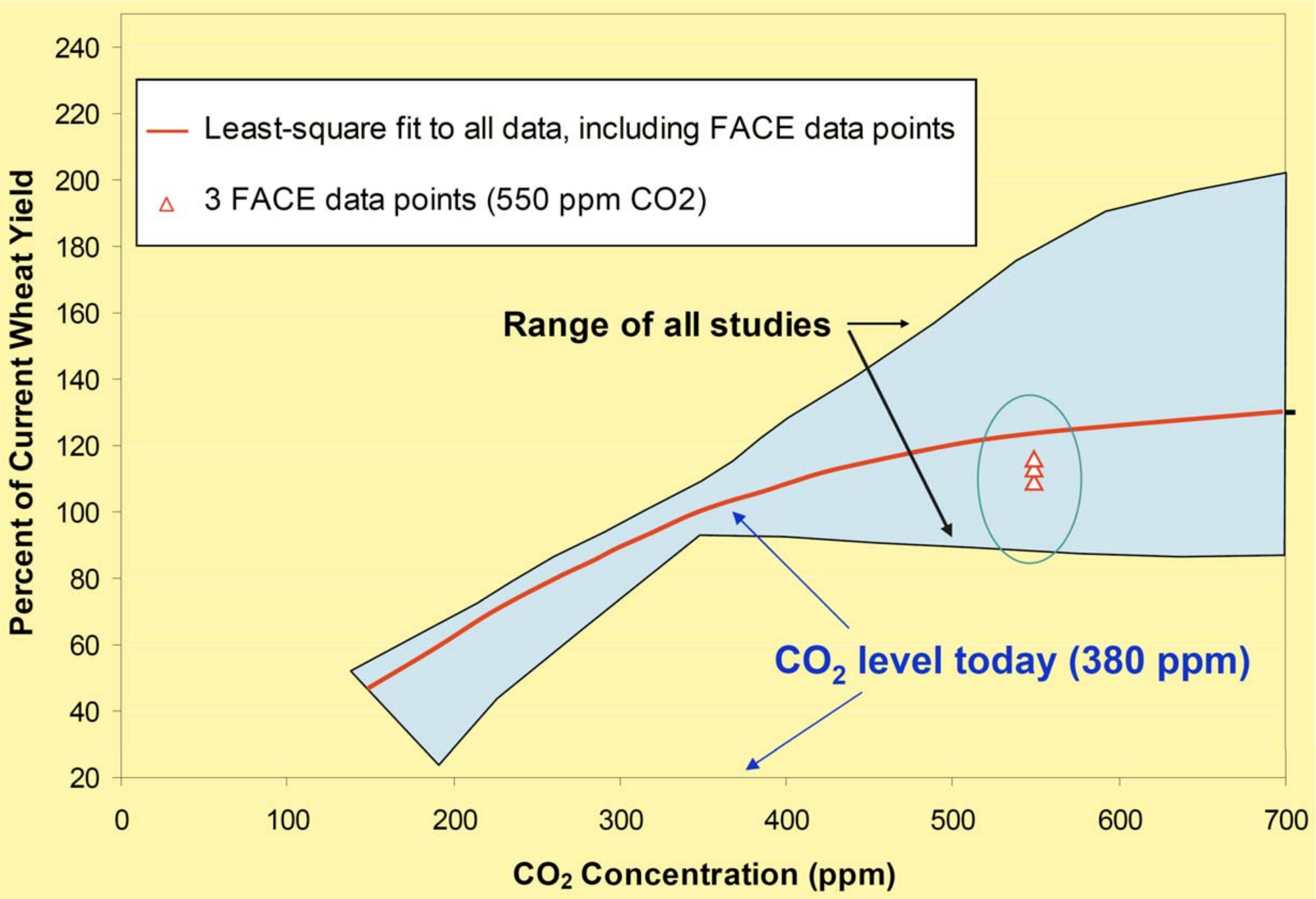
- **Globally**, the potential for food production is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease.
- Crop productivity is projected to increase slightly **at mid- to high latitudes** for local mean temperature increases of up to 1-3°C depending on the crop, and then decrease beyond that in some regions.
- **At lower latitudes**, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1-2°C), which would increase the risk of hunger.

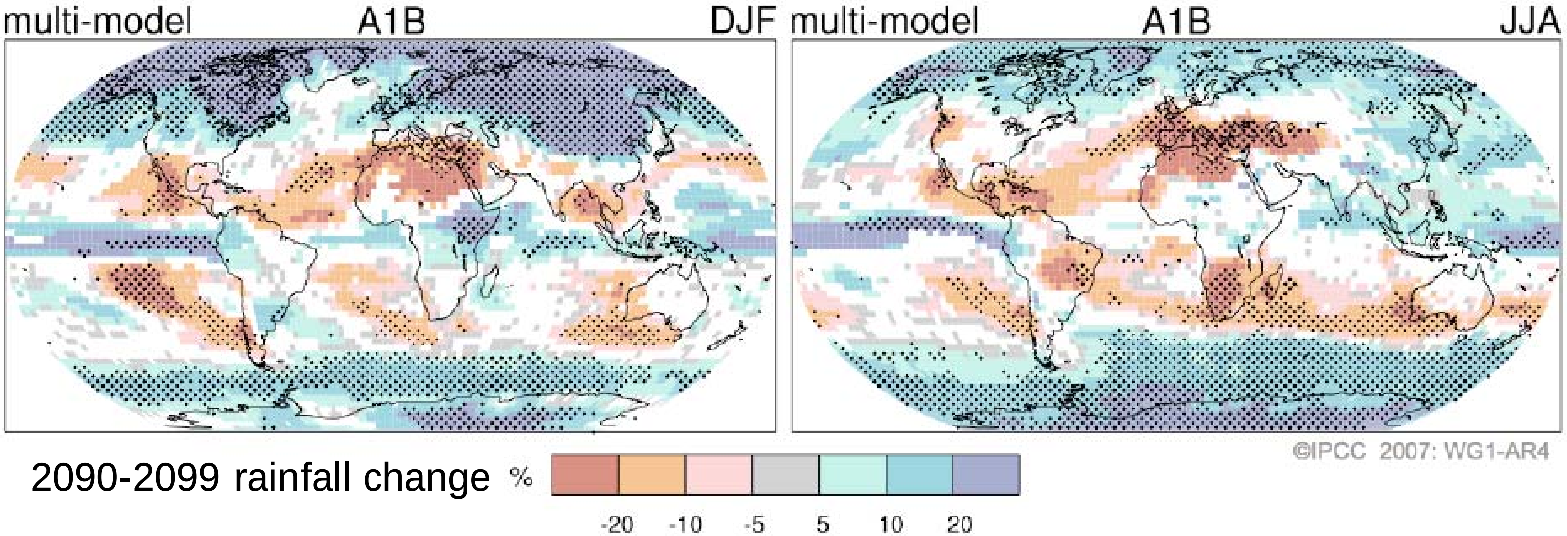
IPCC, 2007. SPM WGII, p.11

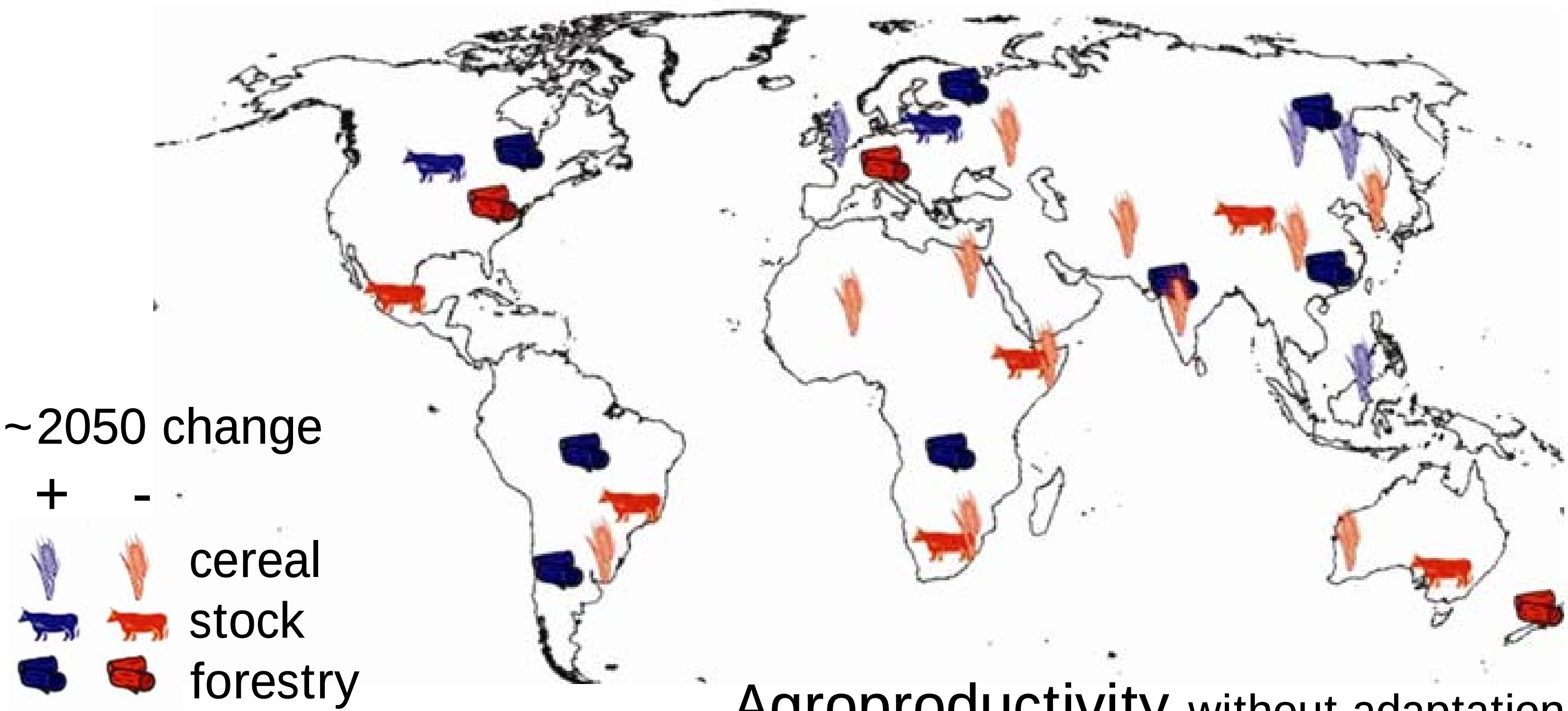
(medium confidence)


Harvests?

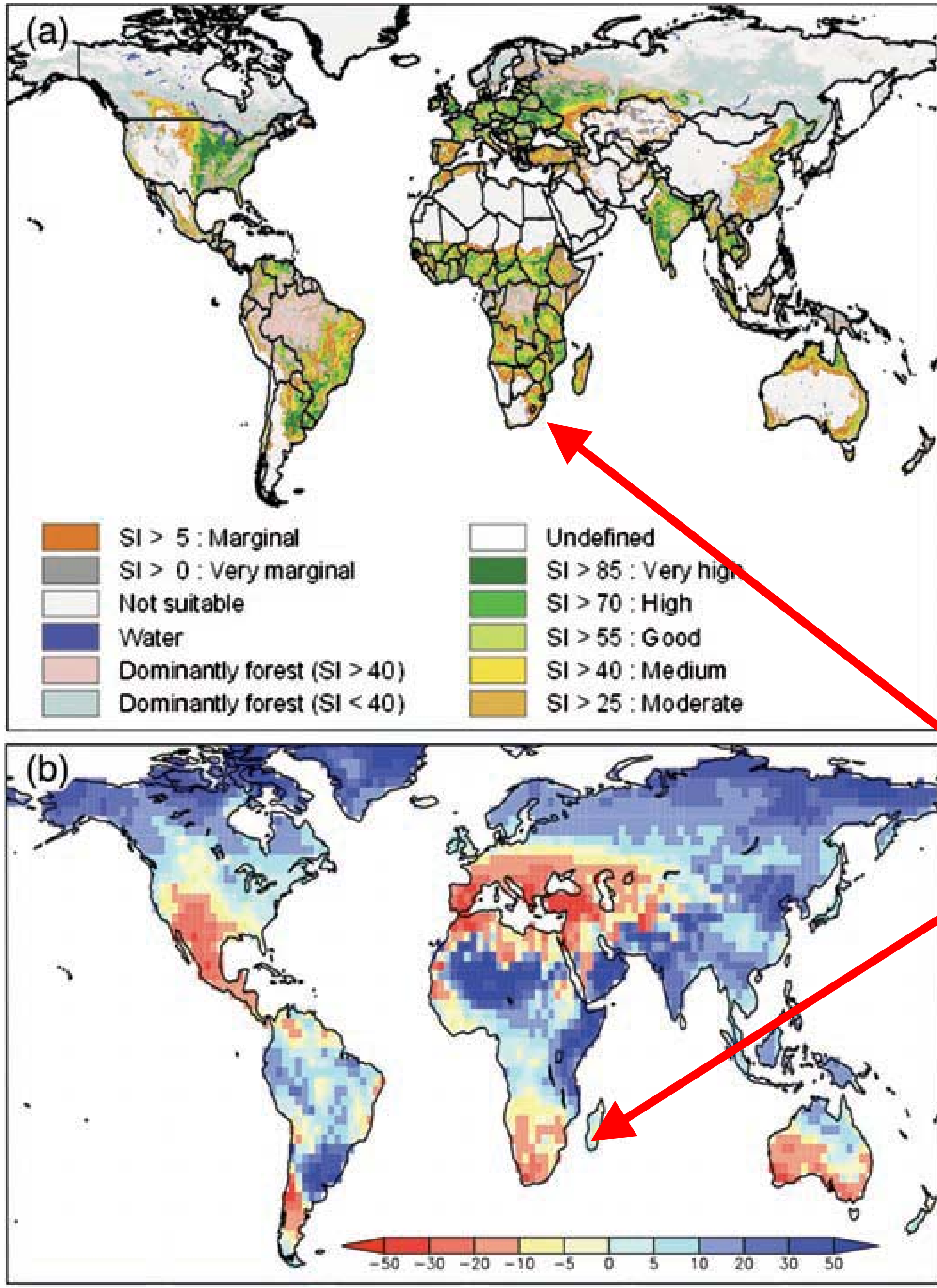
Agricultural Yields and CO_2-fertilisation







Agroproductivity without adaptation



Impacts on rain-fed agriculture

a) Suitability index

Current Rain-fed Crop Production Potential of the Earth

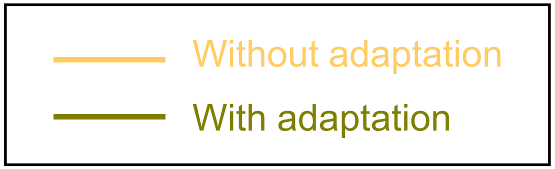
50% reduction in yield by 2020's

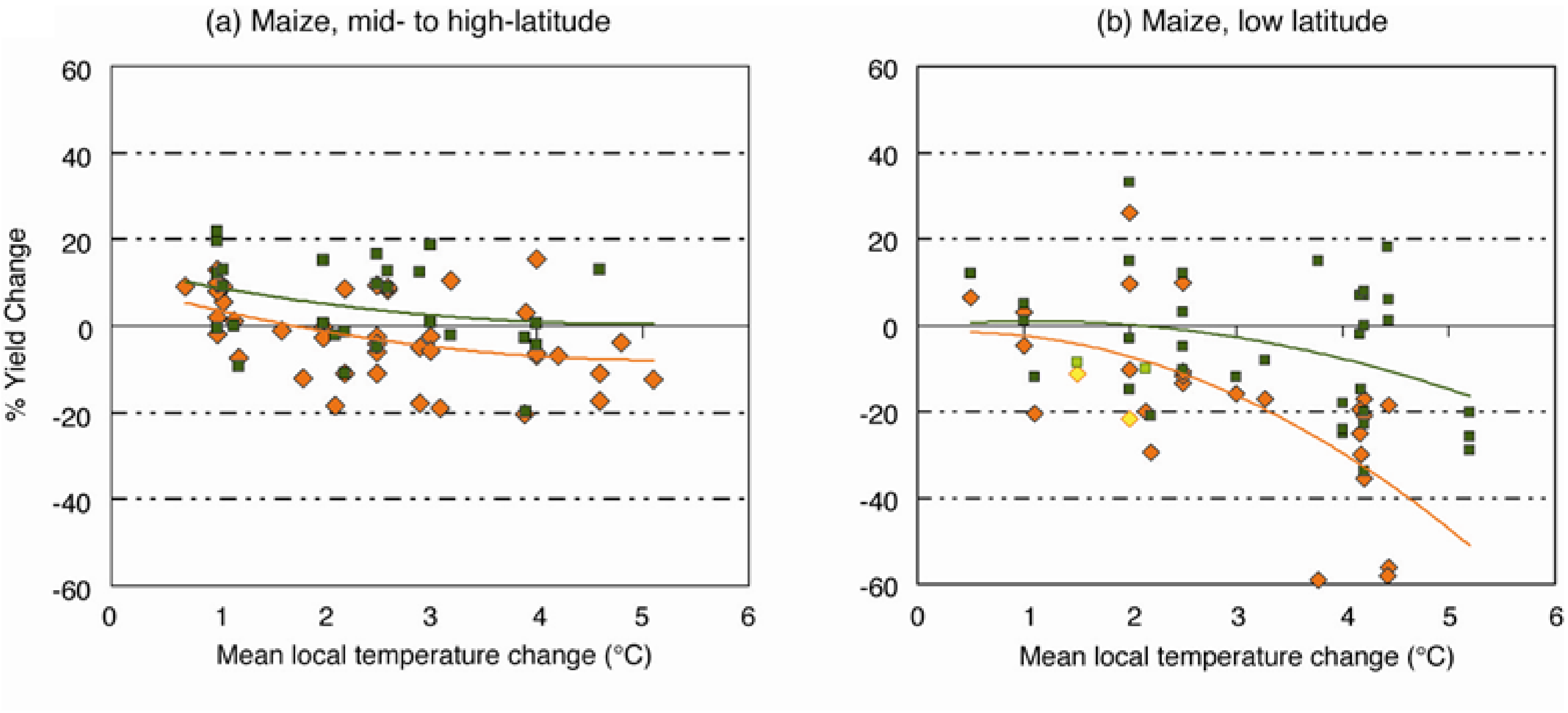
b) Water run-off change

Current Ensemble mean percentage change of annual runoff between present and 2100

Easterling et al., 2007. Figure 5.1: Suitability of rain fed crops (IPCC, 2007. WGII)

Maize

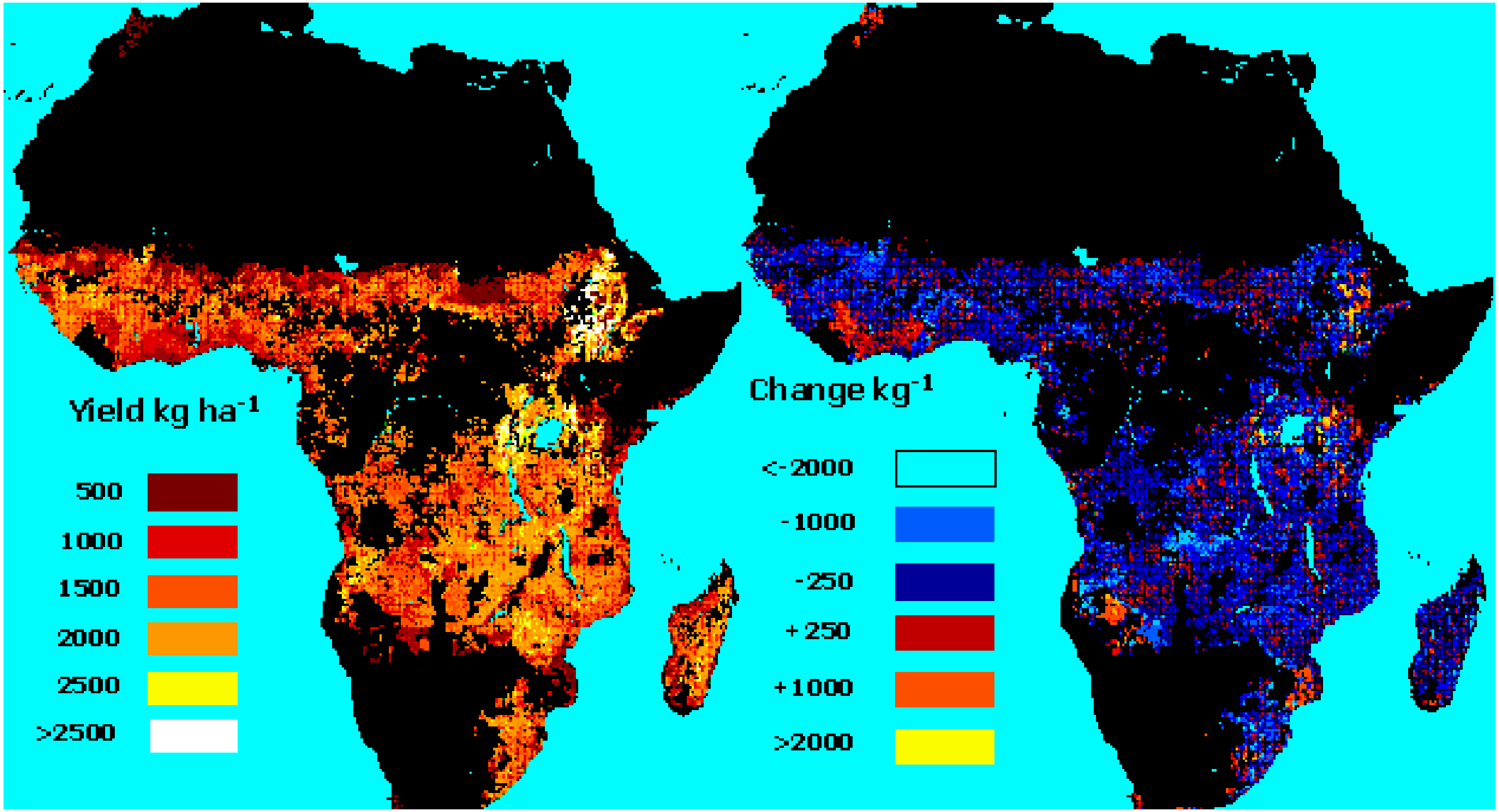




Easterling et al., 2007. Figure 5.2: Yields and warming (IPCC, 2007. WGII)

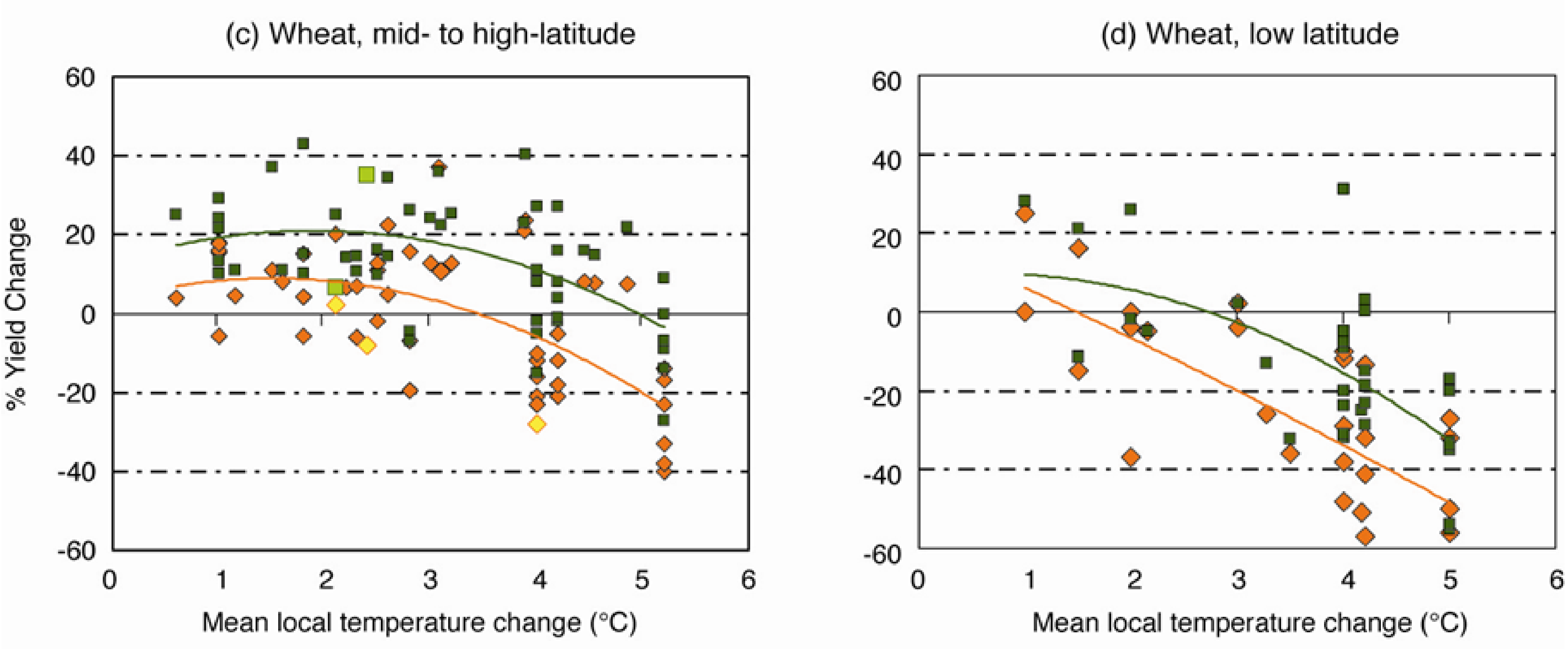
Simulated Corn Yields

today 2055



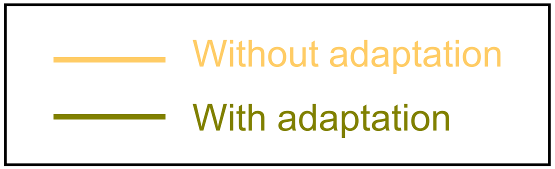
(Jones & Thornton, 2001)

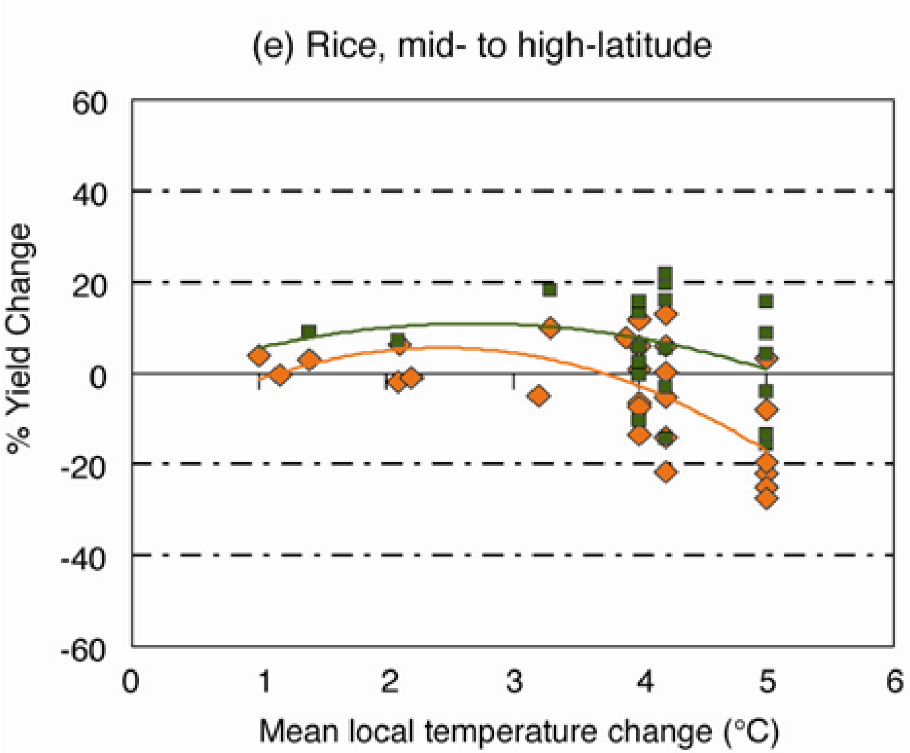
Wheat

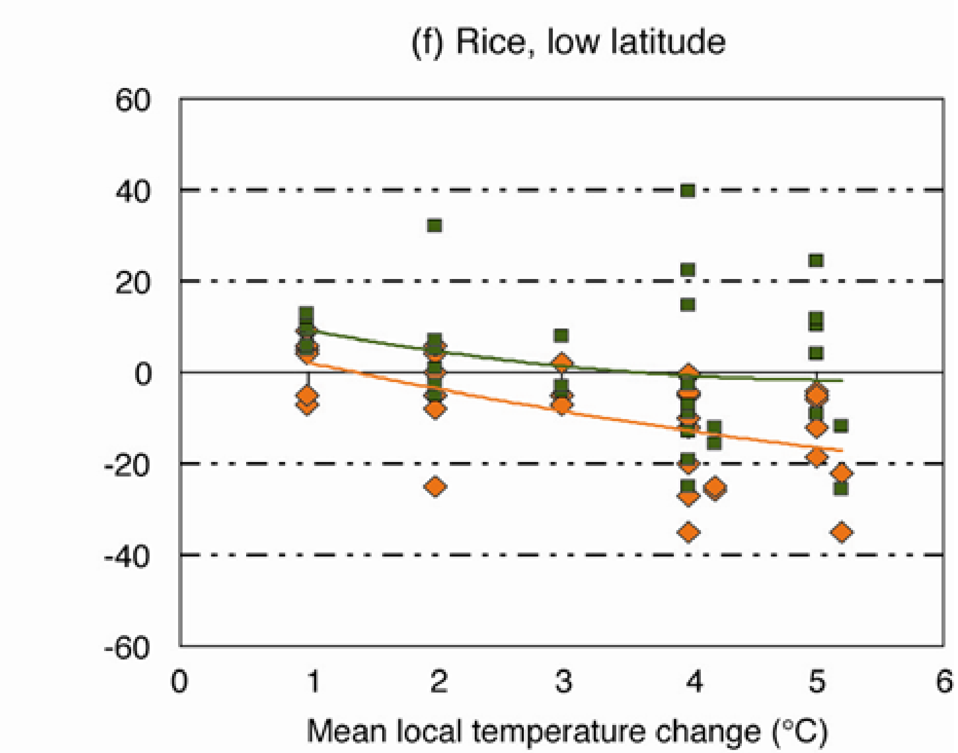


Easterling et al., 2007. Figure 5.2: Yields and warming (IPCC, 2007. WGII)

Rice







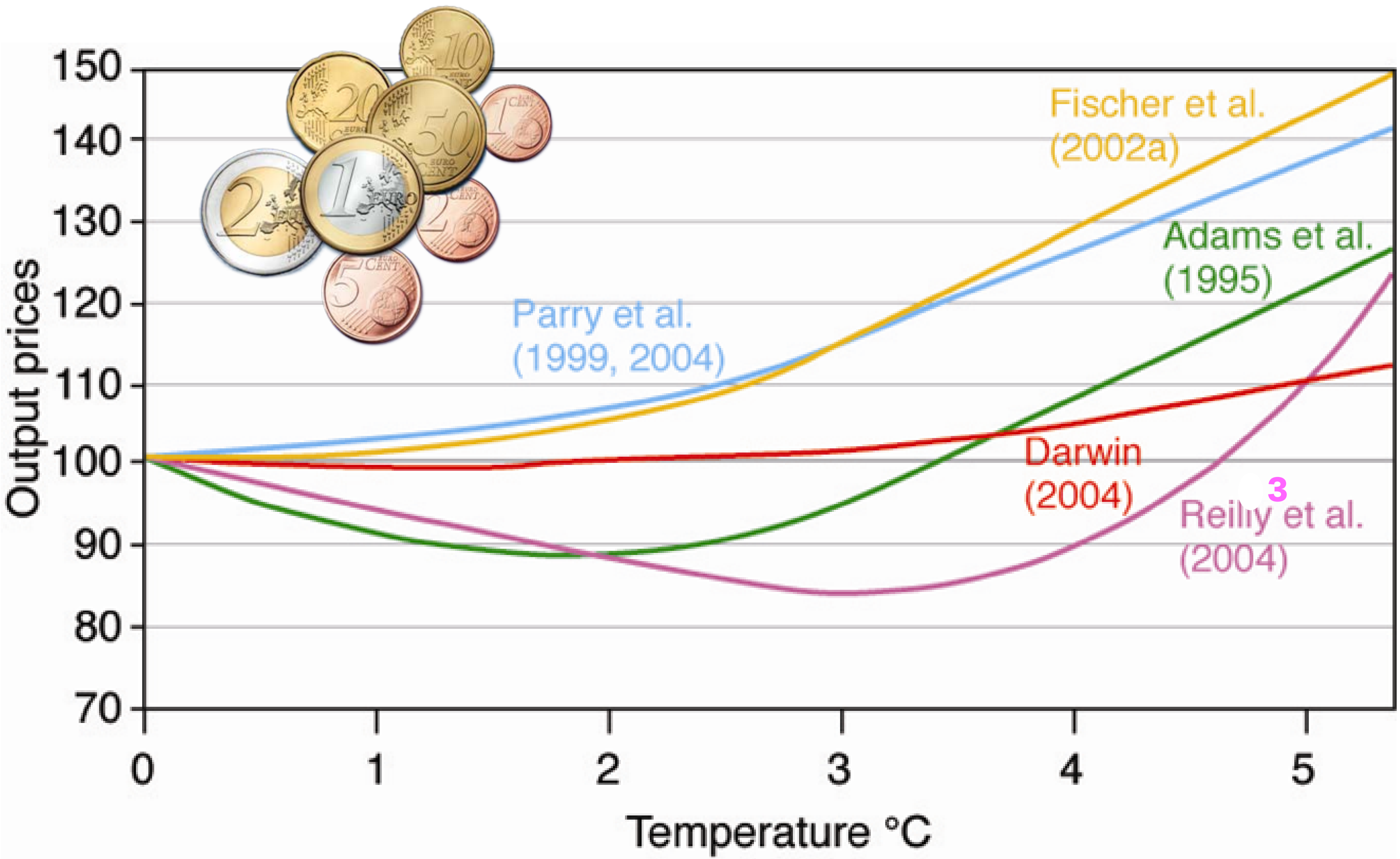
Easterling et al., 2007. Figure 5.2: Yields and warming (IPCC, 2007. WGII)

Diseases

In warmer and wetter weather several are likely to spread

E.g. tan spot (yellow spot) caused by fungus *Pyrenophora tritici-repentis*

Impacts on cereal prices by global temperature increase



Easterling et al., 2007. Figure 5.3: Ecereal prices vs. ΔT (IPCC, 2007. WGII)

Hunger - Malnutrition - Poverty

Reference	2020 Millions at risk AEZ-BLS	2020 Millions at risk DSSAT-BLS	2050 Millions at risk AEZ-BLS	2050 Millions at risk DSSAT-BLS	2080 Millions at risk AEZ-BLS	2080 Millions at risk DSSAT-BLS
A1	663	663	208	208	108	108
A2	782	782	721	721	768	769
B1	749	749	239	240	91	90
B2	630	630	348	348	233	233
CC	**AEZ-BLS**	**DSSAT-BLS**	**AEZ-BLS**	**DSSAT-BLS**	**AEZ-BLS**	**DSSAT-BLS**
A1	666	687	219	210	136	136
A2	777	805	730	722	885	742
B1	739	771	242	242	99	102
B2	640	660	336	358	244	221
CC, no CO_2	**AEZ-BLS**	**DSSAT-BLS**	**AEZ-BLS**	**DSSAT-BLS**	**AEZ-BLS**	**DSSAT-BLS**
A1	NA	726	NA	308	NA	370
A2	794	845	788	933	950	1320
B1	NA	792	NA	275	NA	125
B2	652	685	356	415	257	384

Easterling et al., 2007. Figure 5.6: Climate change, development path, and hunger risks in developing countries (IPCC, 2007. WGII)

Collaboration project:

- Plant Science Group:
  - **Jan Verhagen** (project leader)
  - Pieter Vereijken
  - Frank Ewert
  - Harm Smit
- Social Science Group:
  - Geert Woltjer
  - René Verburg
- Environmental Science Group:
  - **Tia Hermans**
  - Mark Metzger
  - Han Naeff

Content of the project

Scenario	Variant	Crop/prod	Time slices
A1	EU-27	Wheat	05-20-50-*80*
		Potato	05-20-50-*80*
		Milk	05-20-50-*80*
	EU-Ural	Wheat	05-20-50-*80*
		Potato	05-20-50-*80*
		Milk	05-20-50-*80*
B2			

Method

- Step 1: Estimate the achievable supply (tons) of wheat, potato and milk in 2020 and 2050
  - Step 2: Estimate the demand (tons) for wheat, potato and milk in 2020 and 2050
    - Step 3: Adjust the achievable supply to the demand for wheat, potato and milk in 2020 and 2050

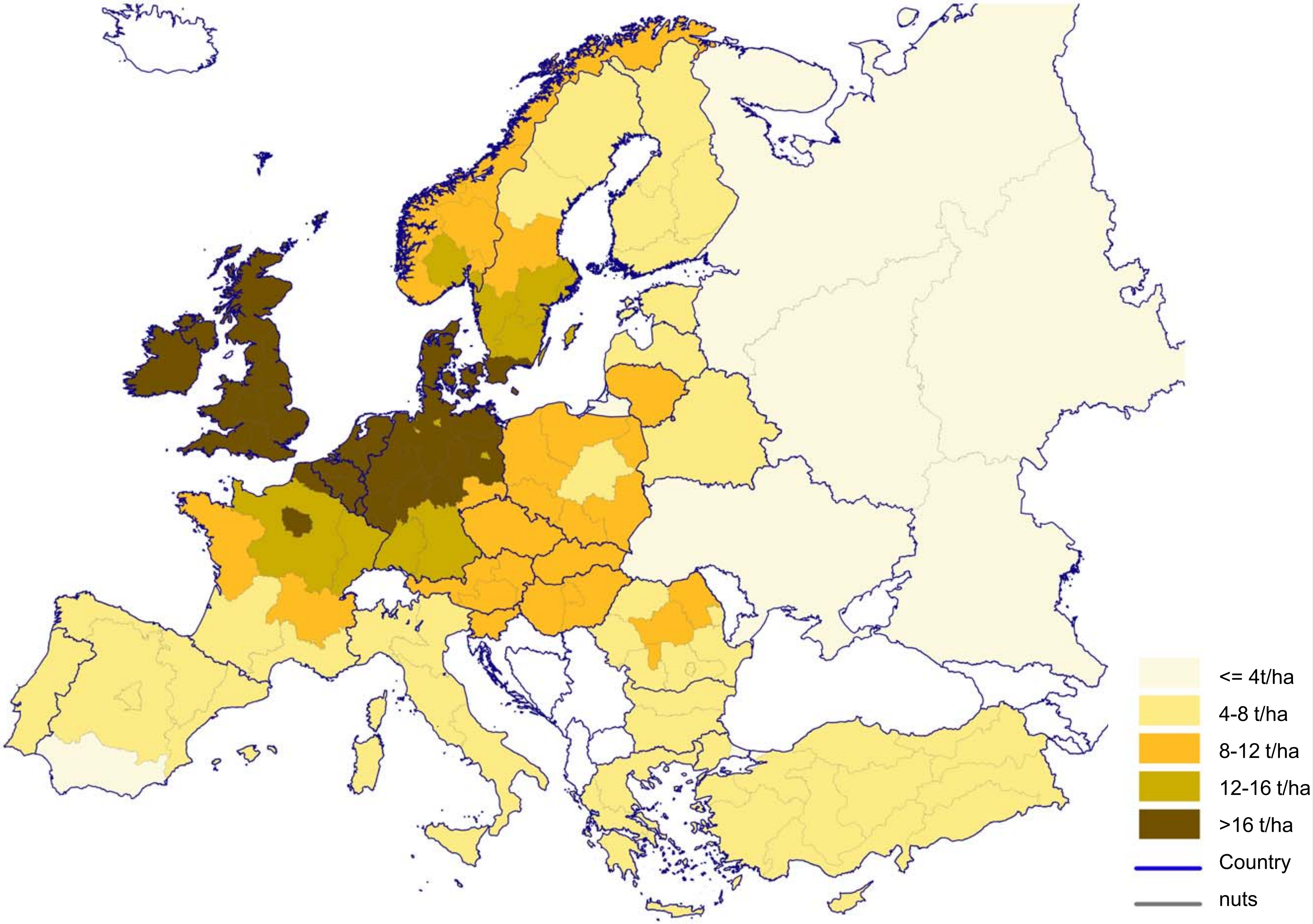
Step 1: A1 wheat achievable supply

2005

2020

2050

2080



Conclusion 1: scenario A1 wheat

- In 2050, as a result of climate changes and technology improvements (related to market) wheat production/ha increases compared to 2005 in all regions (mainly due to technology)
- There are large regional differences in productivity increase (3 to >150%)
- Highest wheat production/ha in 2050 in IE, followed by UK, BE, NL, FR, DK, GE

Step 2: estimate demand

- Elaboration of GTAP (Global Trade Analysis Project) (van Meijl et al, 2006)
- Based on worldwide data on trade and input-output
- Population and economic growth (GDP/capita) are driving variables to estimate growth (%) of commodities

Step 2: A1 wheat demand

Achievable supply (million ton)	**2005**	**2020**	**2050**
EU-27	113,4	160,5	221,5
EU-Urals	176,8	235,3	345,5

Demand (million tons)	**2005**	**2020**	**2050**
EU-27	113,4	121,1	138,4
EU-Urals	176,8	192,8	261,2

Conclusion 2: scenario A1 wheat

- EU-27 demand of wheat in 2050 increases compared to 2005
- Total achievable supply (tons) of EU-27 in 2050 exceeds the demand (tons)
- In scenario B2 the demand exceeds the achievable supply in 2050 for all crops