The Food System, Planetary Boundaries and Global Change




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Food Forum Workshop: Healthy People, Healthy Planet
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AgMIP The Agricultural Model Intercomparison and Improvement Project

Conflict of Interest Disclosures

- Dr. Cynthia Rosenzweig is Senior Research Scientist at the NASA Goddard Institute for Space Studies
- She is Adjunct Senior Research Scientist at the Columbia University Earth Institute, Center for Climate Systems Research
- She is a co-founder of the Agricultural Model Intercomparison and Improvement Project (AgMIP), a global network of over 1,000 food system modelers
- She is part of the Independent Expert Group of the Global Nutrition Report

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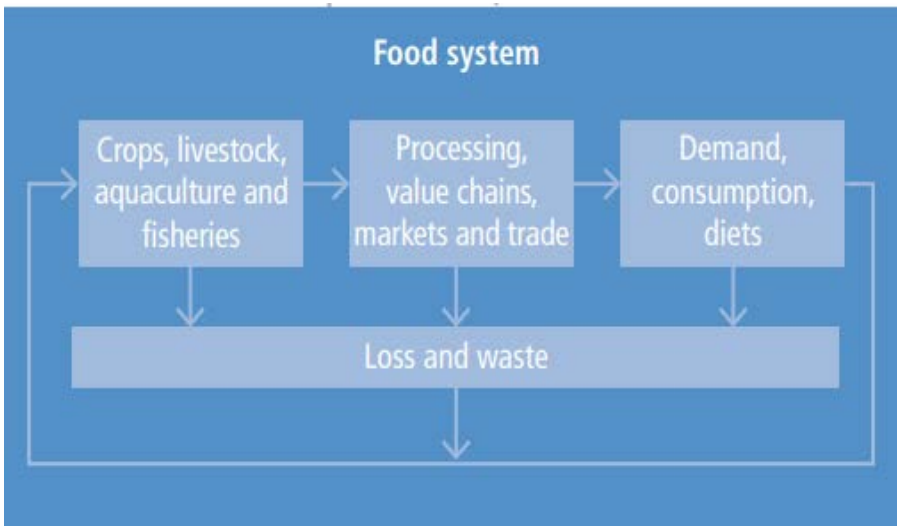
Primary Focus on Agriculture

Crops, livestock, aquaculture and fisheries

Expansion to Food System



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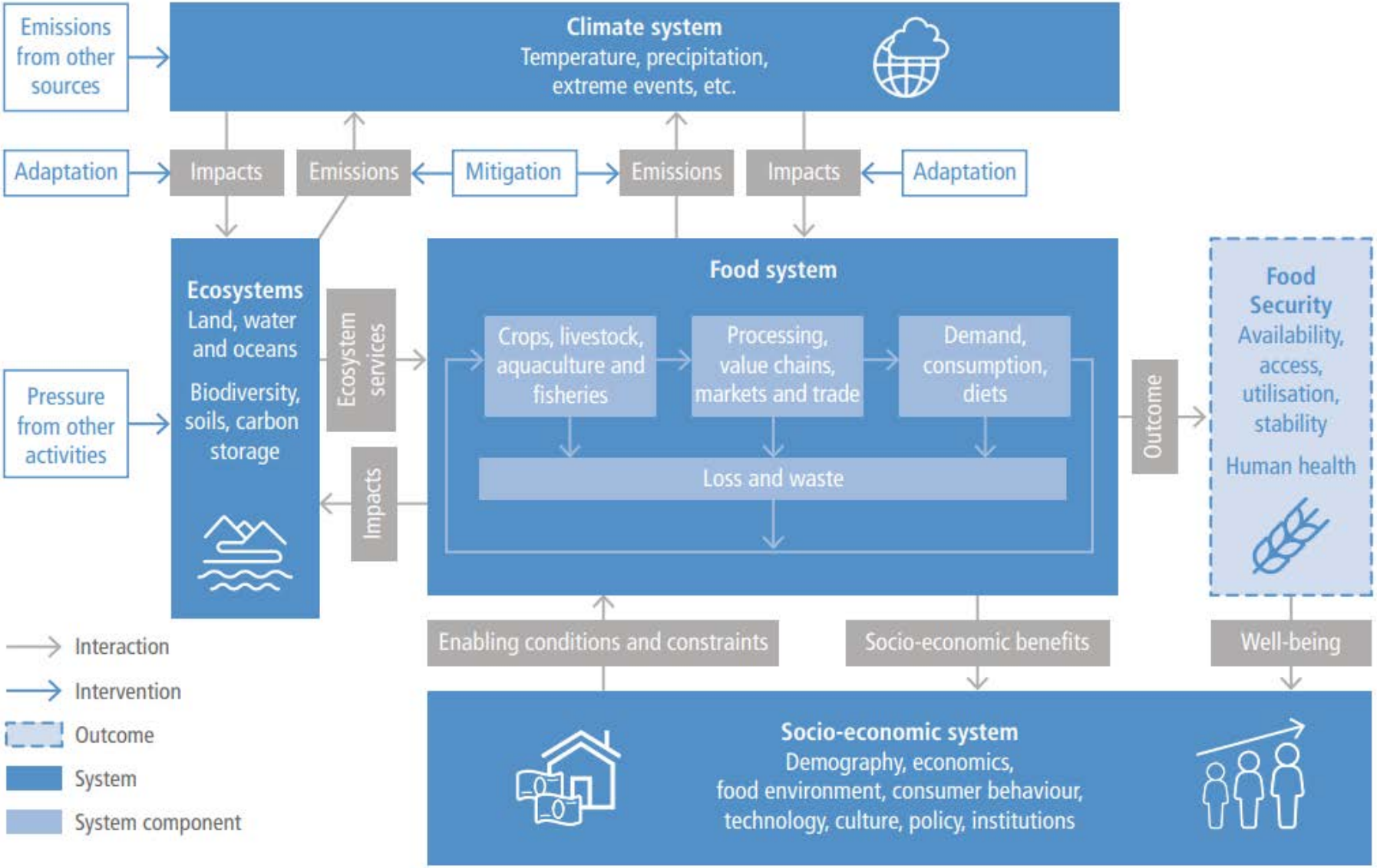
Warp Speed to Planetary Scale



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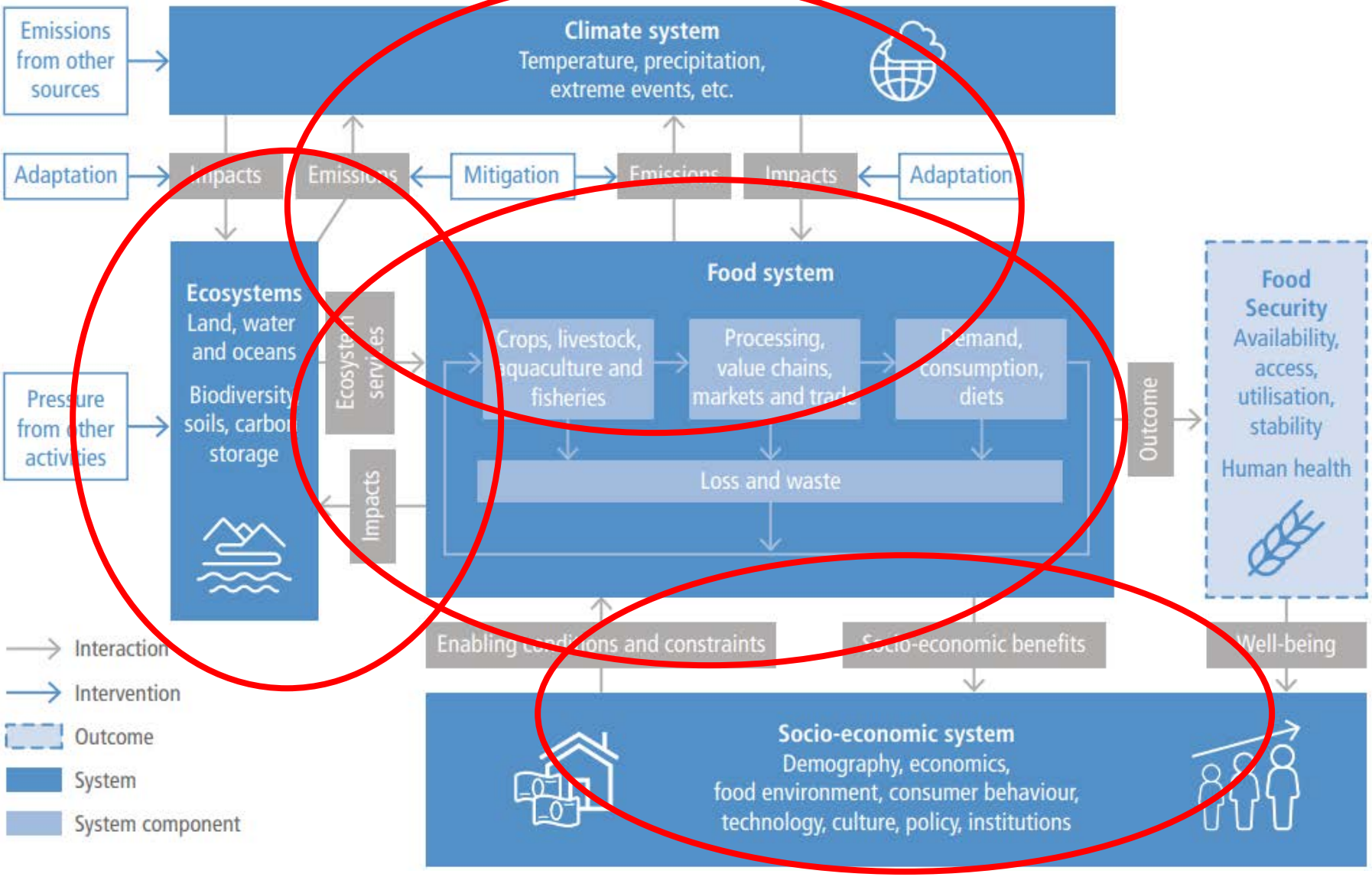
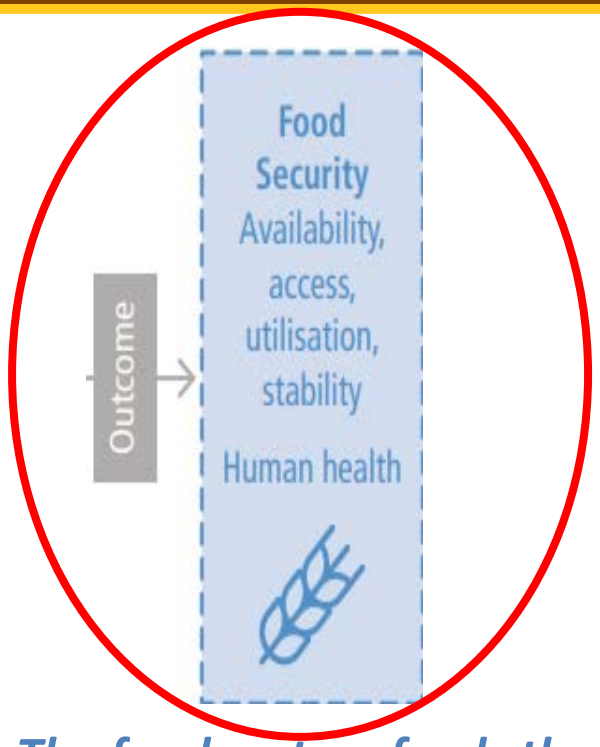
Complexity and Systemic Risks



Expanded Goals → Food Security
Human and Planetary Health



The food system feeds the great majority of world population and supports the livelihoods of over 1 billion people

An estimated 690 million people are currently undernourished and 2 billion adults are overweight or obese

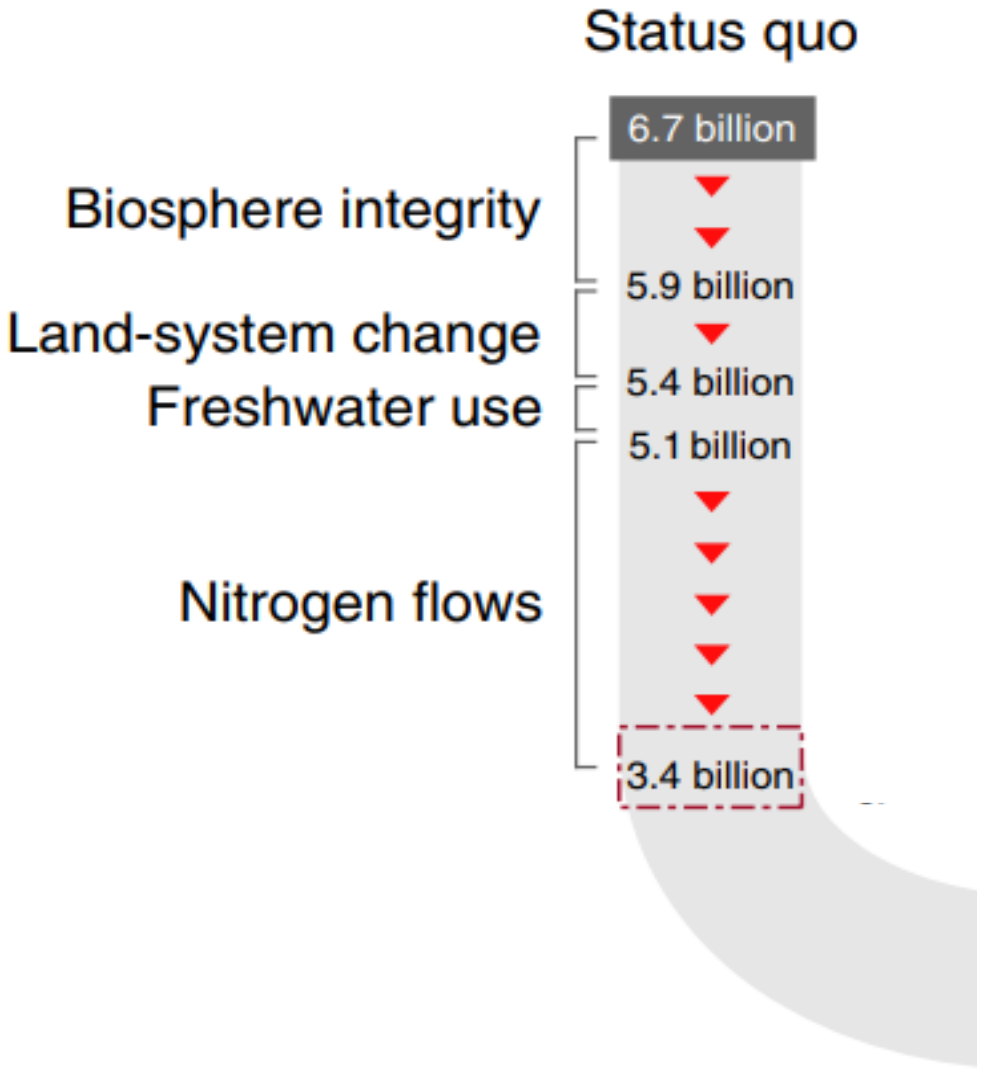
The food system contributes 21-37% of total anthropogenic greenhouse gas emissions

FAO SOFI, 2020
GNR, 2018
IPCC, 2019, Special Report on Land

Current Food System and Planetary Boundaries

Food is on a crash course – Already crossing four planetary boundaries

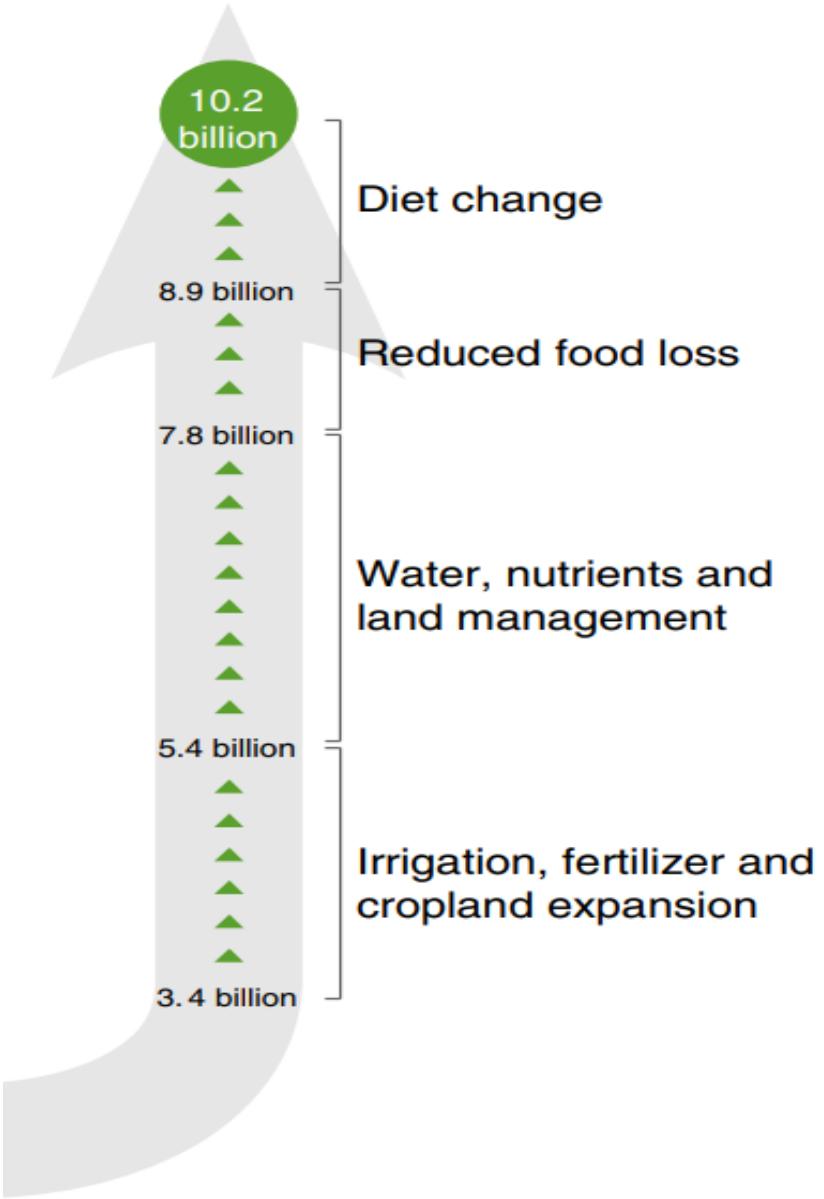
- **Biosphere integrity**
- **Land-use change**
- **Freshwater use**
- **Nitrogen flows**



Gerten et al., 2020

Transformed Food System and Planetary Boundaries

Simulated technological-cultural 'U-turn' towards increasing global food supply within four planetary boundaries



nature sustainability ARTICLES https://doi.org/10.1038/s41893-019-0465-1

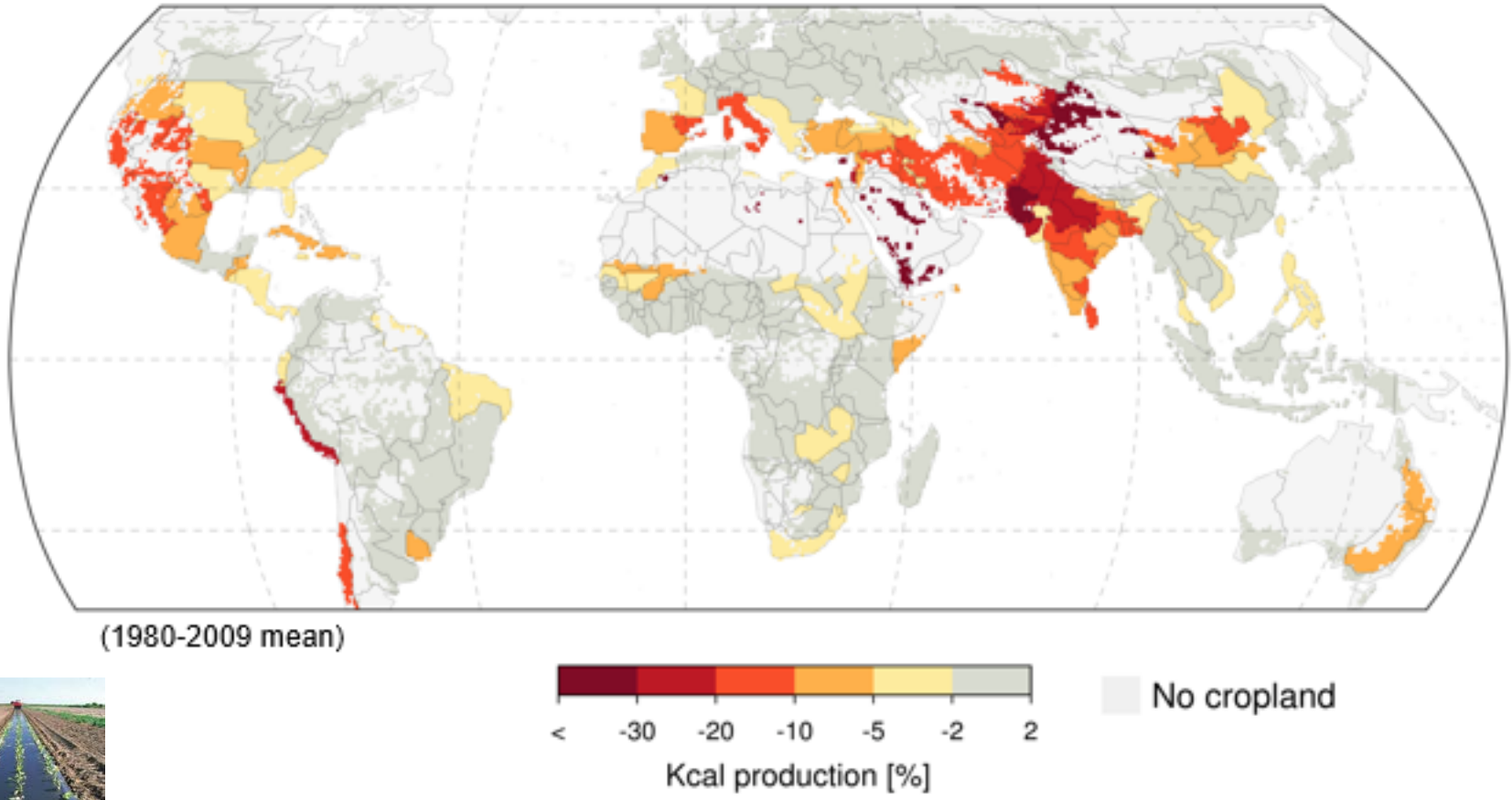
Feeding ten billion people is possible within four terrestrial planetary boundaries

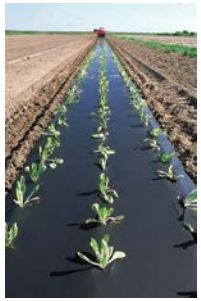
Gerten et al., 2020

Water for Ecosystems vs. Food Production

Half of irrigated cropland faces ≥10% kcal loss

>20% of total production depends on EFRs in hot-spot regions



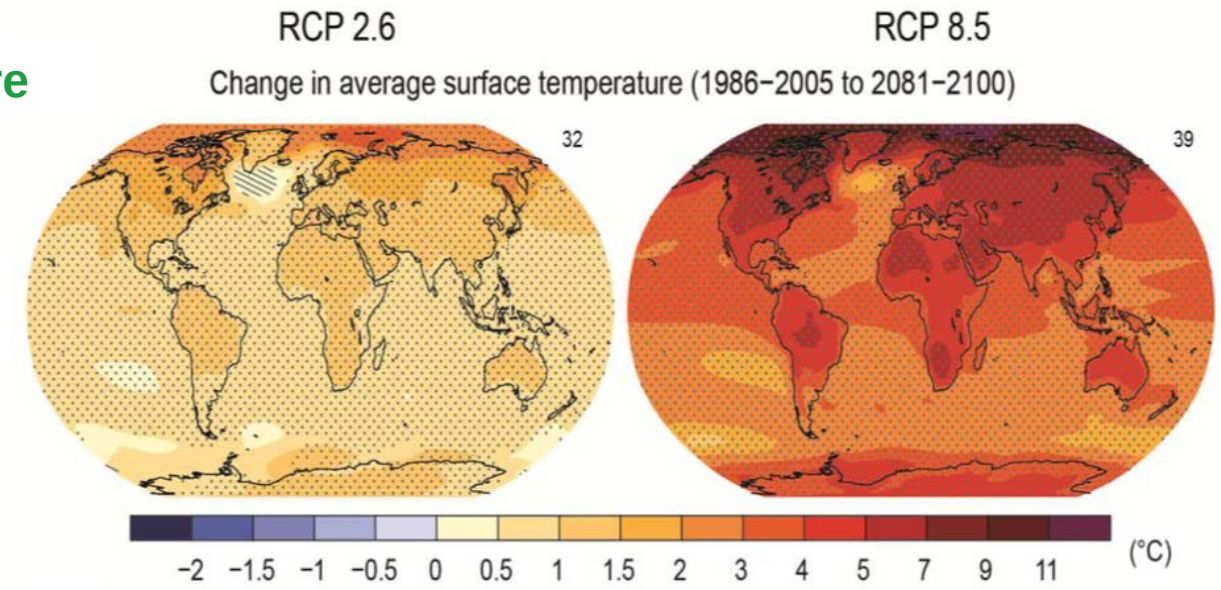


Percent of food production that comes at expense of environmental flow requirements (EFRs)

Jägermeyr et al., 2017

Climate Change

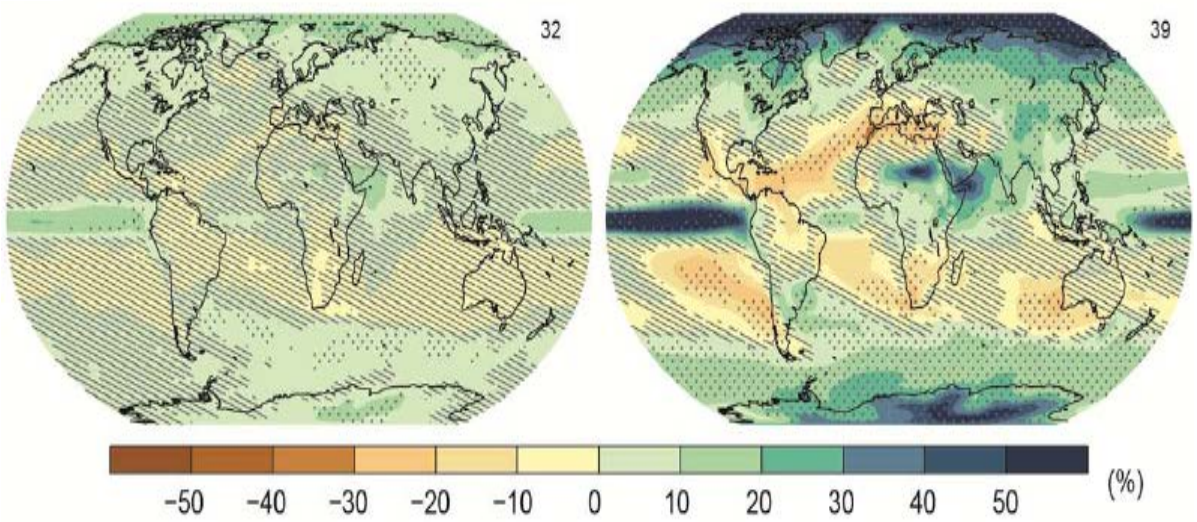
Temperature



Hatching = Signal is small compared to noise

Stippling = Signal is large compared to noise and 90% of models agree

Precipitation



IPCC, 2013, AR5

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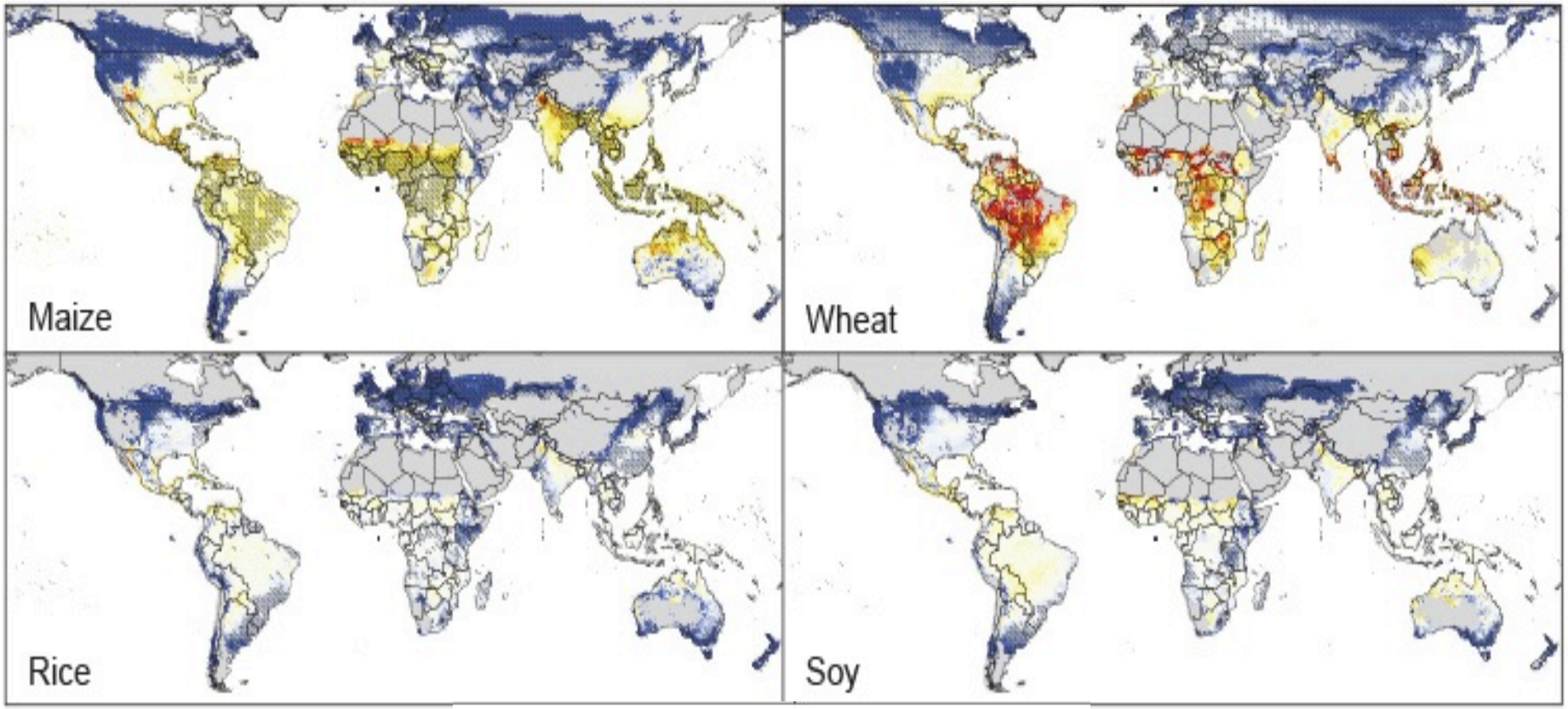
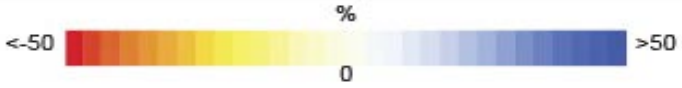
Climate Change Effects on Global Crops



Hatched areas indicate >70% model agreement



Results show yield changes for all agricultural areas, but ultimate viability of future agriculture depends on socioeconomic and biophysical factors

2080s

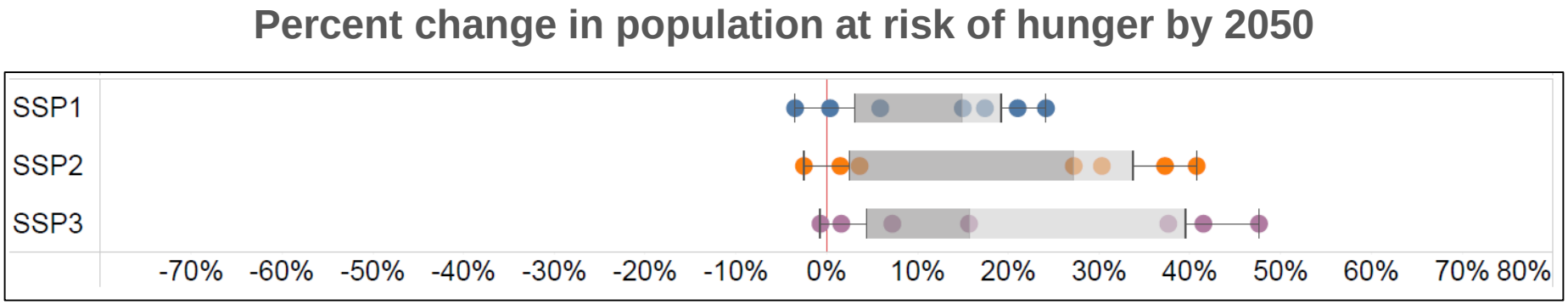
median of 7 GGCMs and 5 GCMs/AgMIP led agricultural contribution to ISIMIP

Lower latitudes are more vulnerable to climate change

Rosenzweig et al., PNAS, 2013

Risk of Hunger

Food security will be increasingly affected by projected future climate change (*high confidence*)

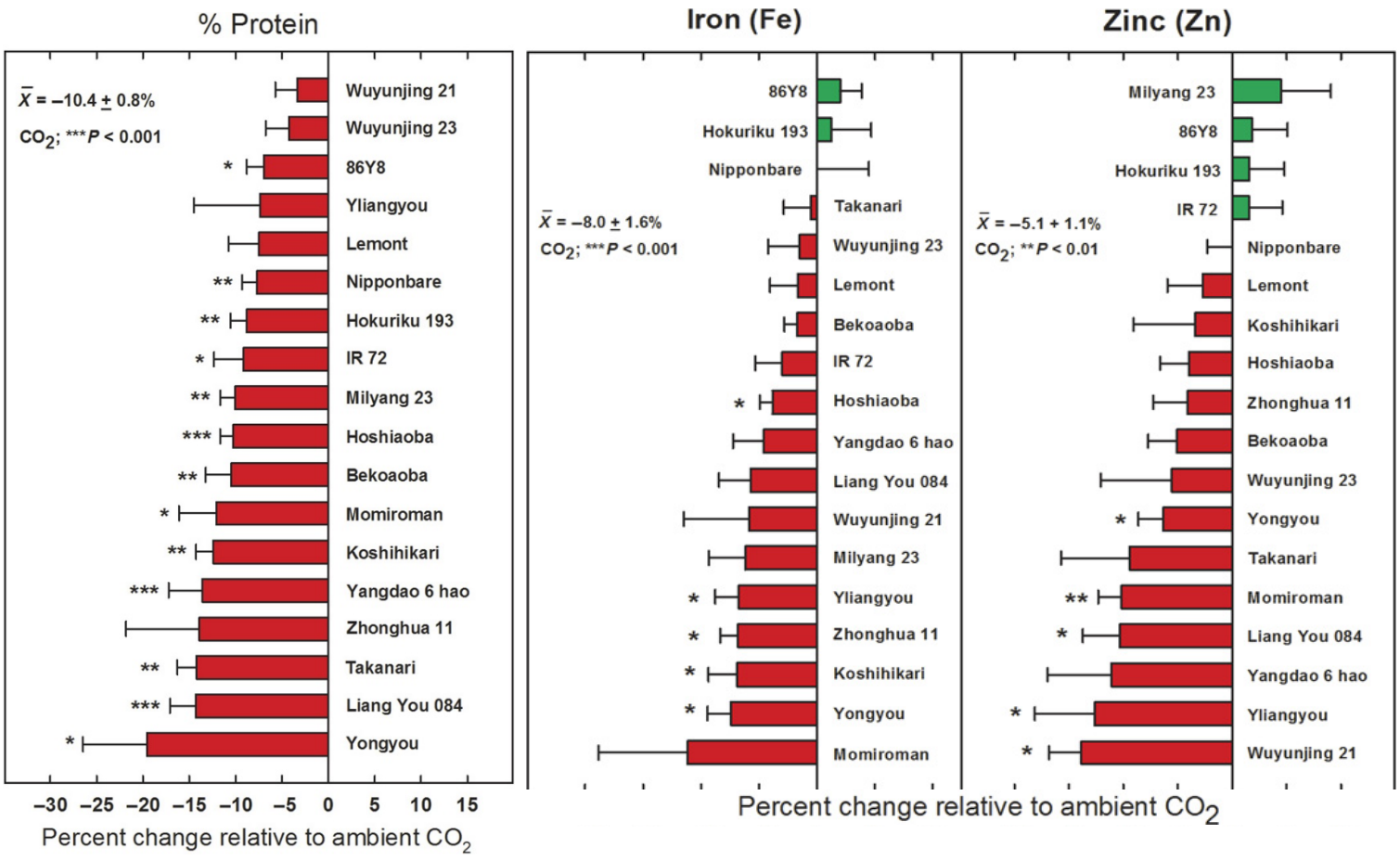


Hasegawa et al. 2018

SSPs = Shared Socio-economic Pathways

1 Green Road; 2 Middle-of-the Road; 3 Rocky Road

CO_2 Effects on Nutrient Quality



Average reduction at elevated (568-590 ppm) relative to ambient [CO_2] for 18 cultivated rice lines

Zhu et al. 2018

While increased CO_2 is projected to be beneficial for crop productivity at lower temperature increases, it is projected to lower nutritional quality (*high confidence*)

IPCC, 2019, Special Report on Land

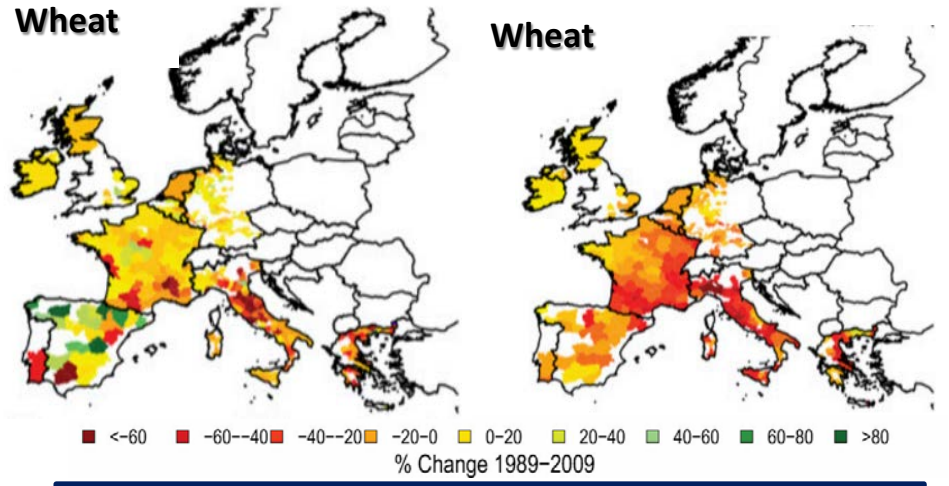
Livestock and Pastoral Systems

- **Temperature affects most critical factors of livestock production: water availability, animal reproduction, and animal health (heat stress)**
- **Livestock diseases are mostly affected by increases in temperature and precipitation variation**
- **Impacts on rangelands and pastures include effects of increasing CO_2 on their biomass and nutritional quality**

Vulnerability of pastoral systems to climate change is very high (*high confidence*)

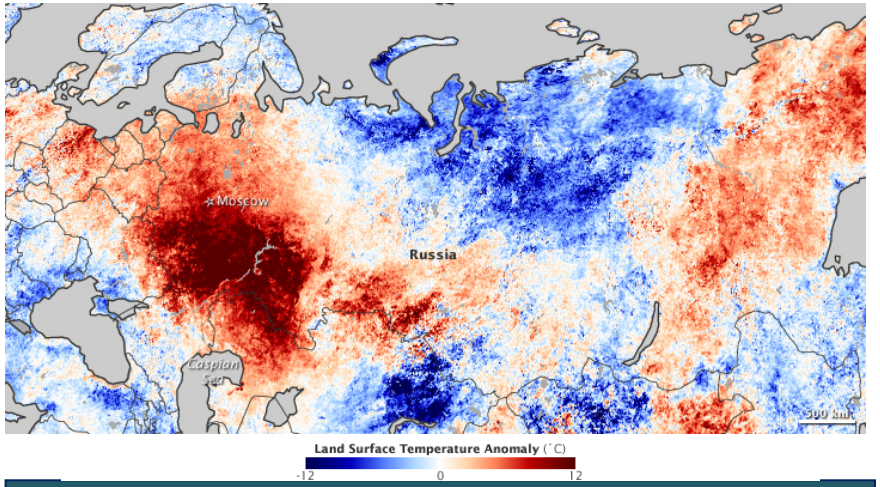
IPCC, 2019, Special Report on Land

Climate Change Food System Impacts are Already Here



Availability – Observed and counterfactual wheat yield changes in Southern Europe

Moore and Lobell, 2015



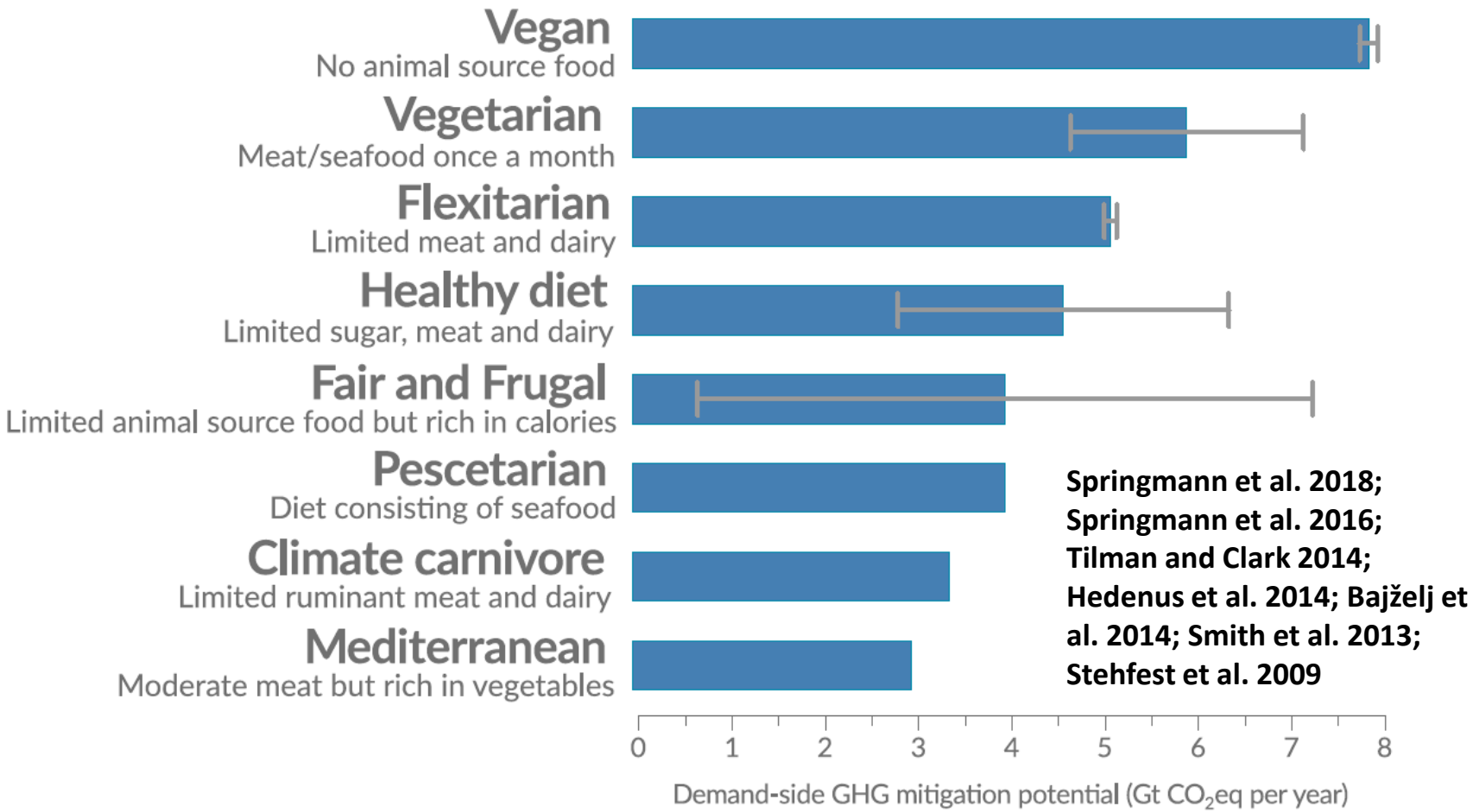
Access – 2010-2011 global food price spike, triggered by heatwave in Eastern Europe/Russia

Hoag 2014,Watanabe et al 2013,Barriopedro et al 2011. Image: NASA

Observed climate change is already affecting food security through increasing temperatures, changing precipitation patterns, and greater frequency of some extreme events (*high confidence*)

IPCC, 2019, Special Report on Land

Climate Change Mitigation
Role of Diets



Springmann et al. 2018; Springmann et al. 2016; Tilman and Clark 2014; Hedenus et al. 2014; Bajželj et al. 2014; Smith et al. 2013; Stehfest et al. 2009

Technical mitigation potential of changing diets by 2050 according to a range of scenarios examined in the literature. Estimates are technical potential only, and include additional effects of carbon sequestration from land-sparing. Data without error bars are from one study only.

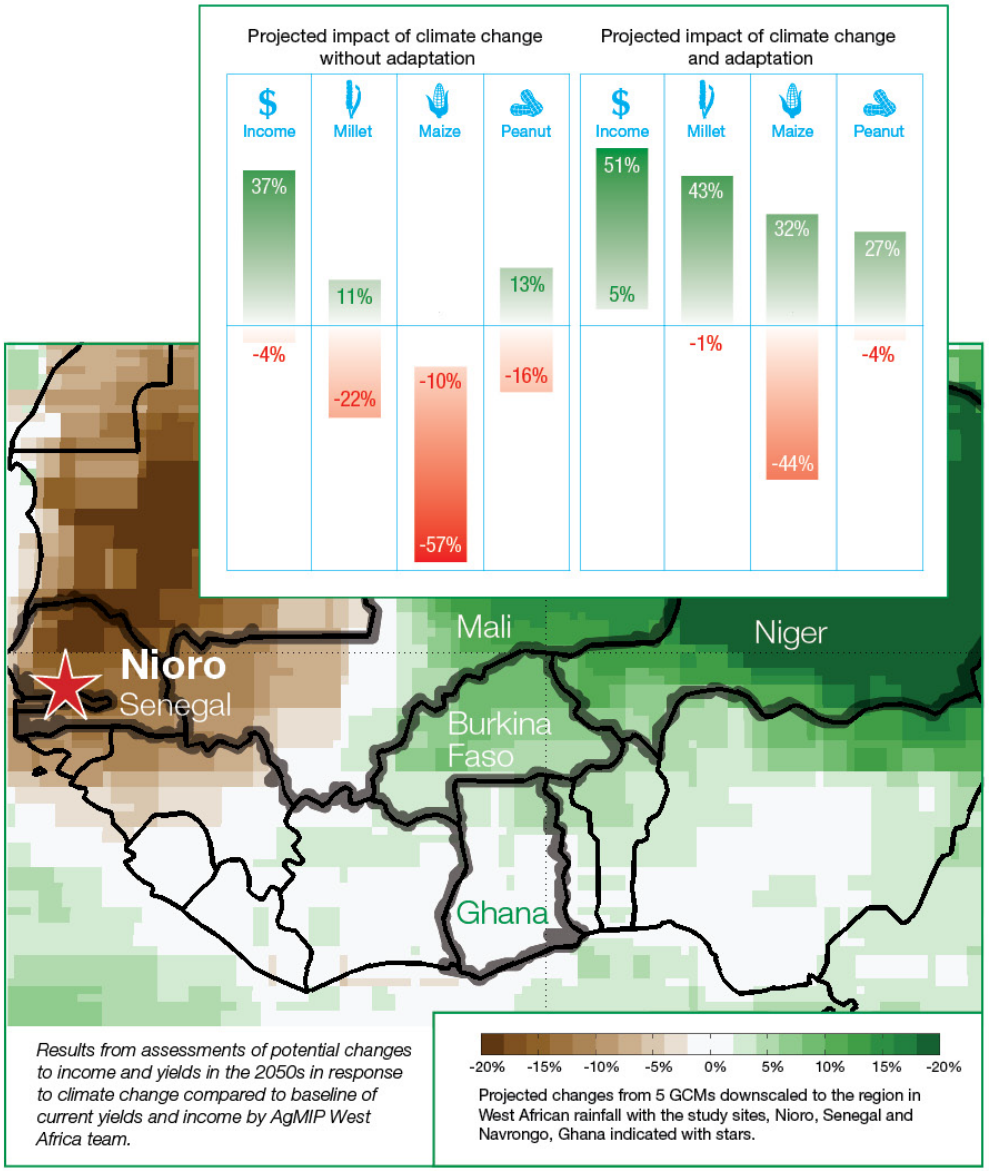
Economic mitigation potential is estimated as 1.8-3.4 $GtCO_2eq\ yr^{-1}$ by 2050 at prices ranging from 20-100 USD/tCO_2

IPCC, 2019, Special Report on Land

Don't Forget Adaptation!

Adaptation packages can raise incomes and lower poverty rates,

but do not always compensate crop yield losses completely



AgMIP West Africa Regional Integrated Assessment
Adiku et al., 2015

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Cascading Risks
COVID-19, Climate Change, and Food

- **COVID-19 and climate change are both global systemic threats**
- **Both affect the poor, minorities and refugees disproportionately**
- **COVID-19 is concatenating disruption to all parts of the food system, already stressed by increasing climate extremes**
- **On the production side, farm labor has been unable to work**
- **On the consumption side, accessibility has been diminished and prices have increased**
- **Integrated governance of COVID-19 and climate change is essential as we move forward**

AgMIP8

Food Systems, Shocks, and Actions

SAVE THE DATES

Virtual Webshop
October 13 – 15, 2020
AgMIP Team Sessions, October 12, 2020

Global Workshop
Columbia University, New York
June 8 – 10, 2021
AgMIP Team Sessions, June 7 & 11, 2021

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