POTSDAM-INSTITUT FÜR KLIMAFOLGENFORSCHUNG

Agricultural research challenges in the context of climate change and Planetary Boundaries

DAFA - Konferenz Agrarforschung zum Klimawandel
11.03.2024

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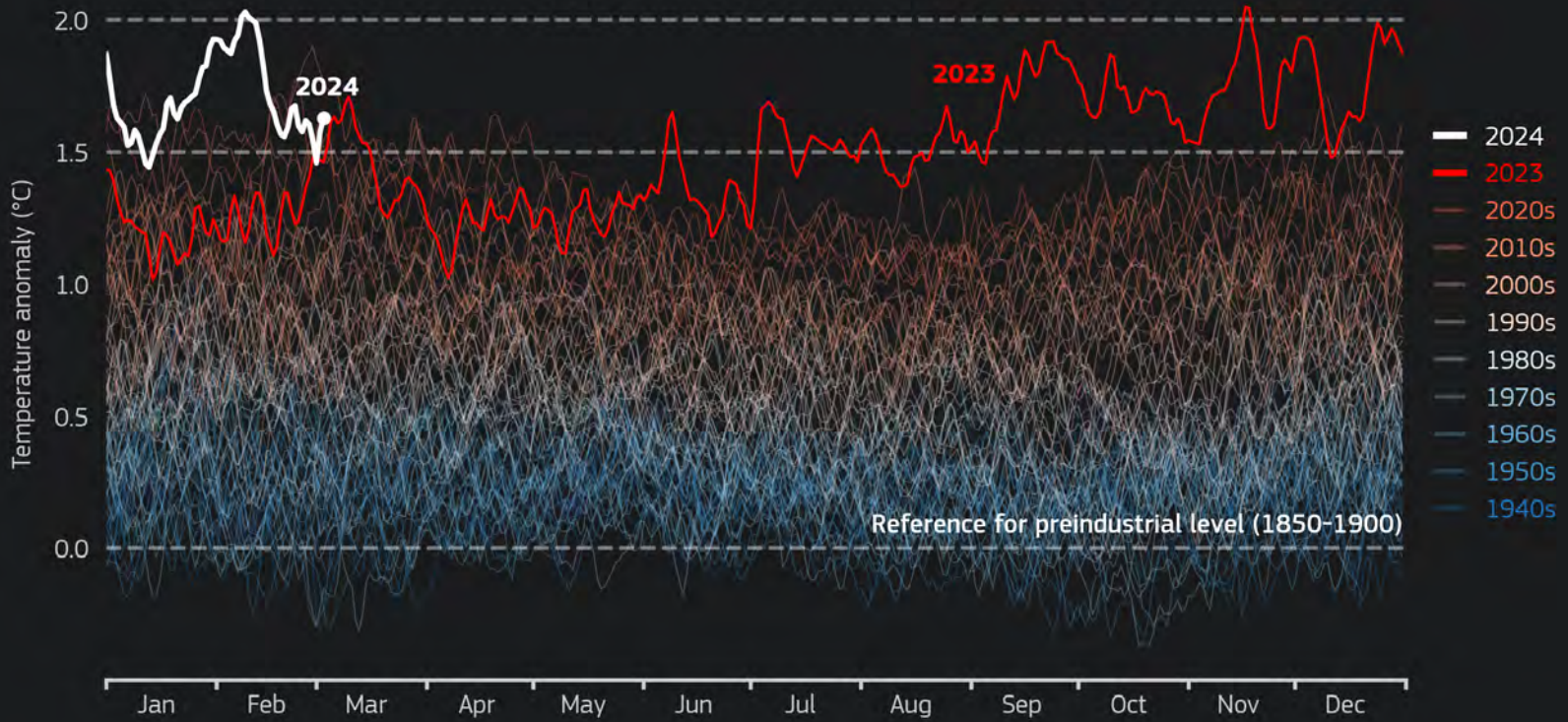
A biosphere shaped by humans

Anthropocene

Scale, Speed, Inter-connections

Daily global surface air temperature anomalies

Data: ERA5 1940–2024 • Reference period: 1850-1900 • Credit: C3S/ECMWF



PROGRAMME OF THE EUROPEAN UNION

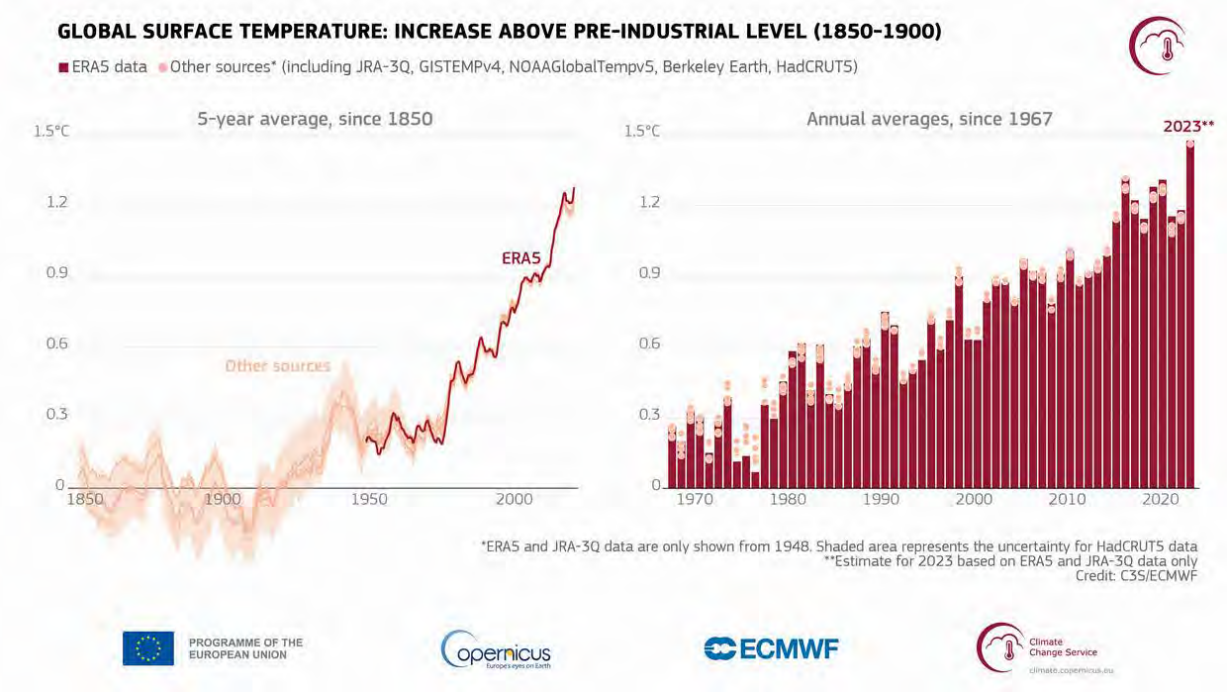
Copernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

Climate Change Service

climate.copernicus.eu

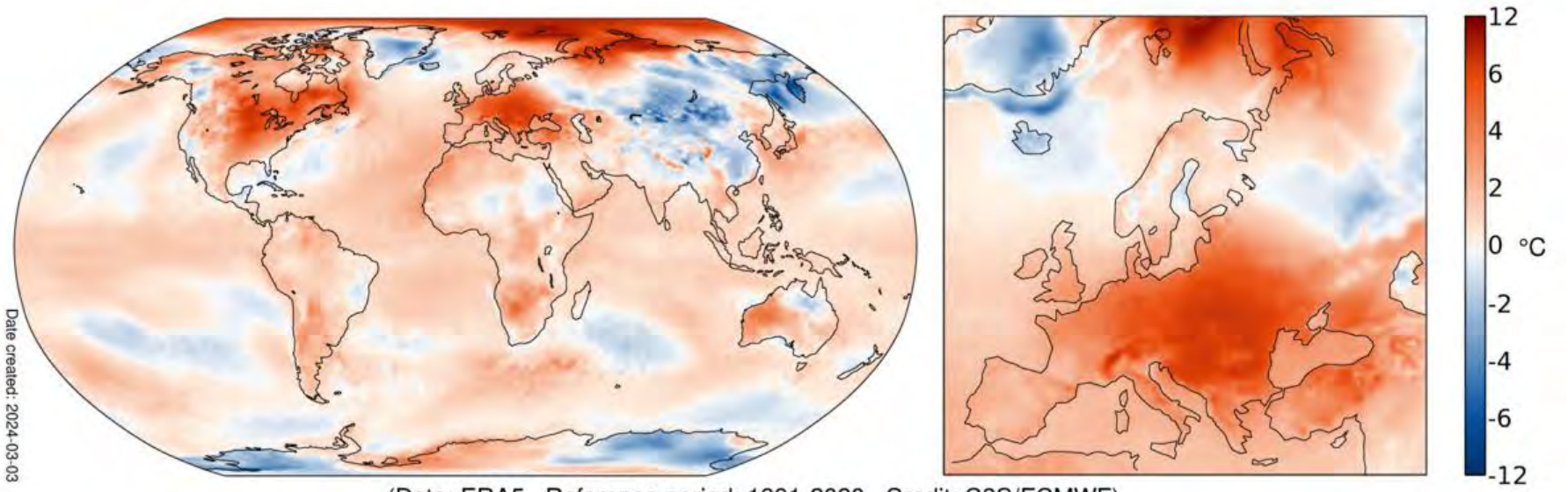
2023 is the hottest year on record – Global temperatures close to the 1.5°C limit



- **2023 was 0.60°C warmer than the 1991-2020 average**
- **1.48°C warmer than the 1850-1900 pre-industrial level**

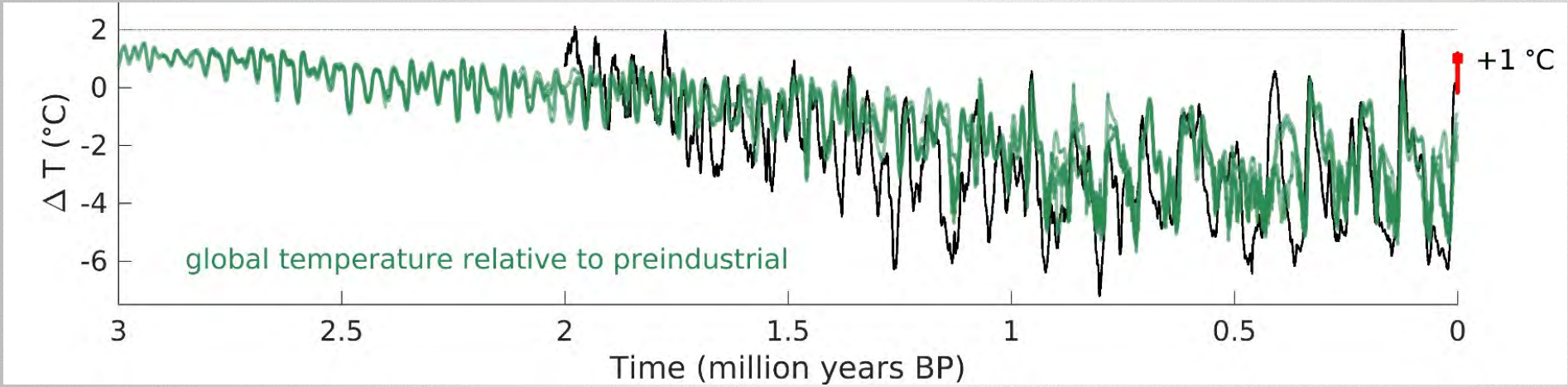
Source: climate.copernicus.eu

Surface air temperature anomaly for February 2024



- February 2024 was the warmest February on record: globally 0.81°C above the 1991-2020 average for February and 0.12°C above the temperature of the previous warmest February, in 2016.
- February 2024 was 1.77°C warmer than an estimate of the February average for 1850-1900, the designated pre-industrial reference period.

We have never exceeded 2 degree C in the last Three Million Years

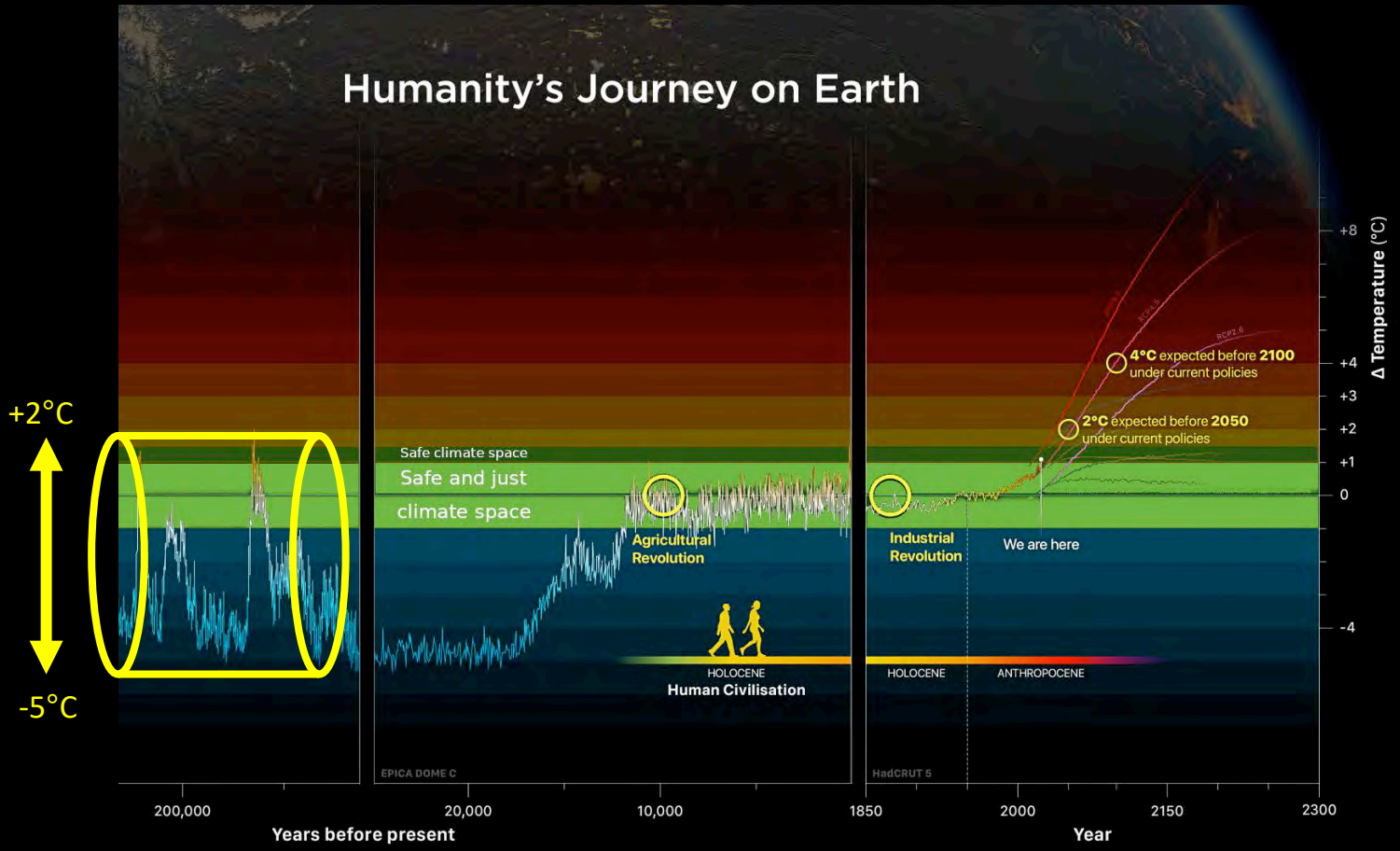


Observations shown in black, results of model simulations in colour.

Source: Willeit et al., Science Advances 2019

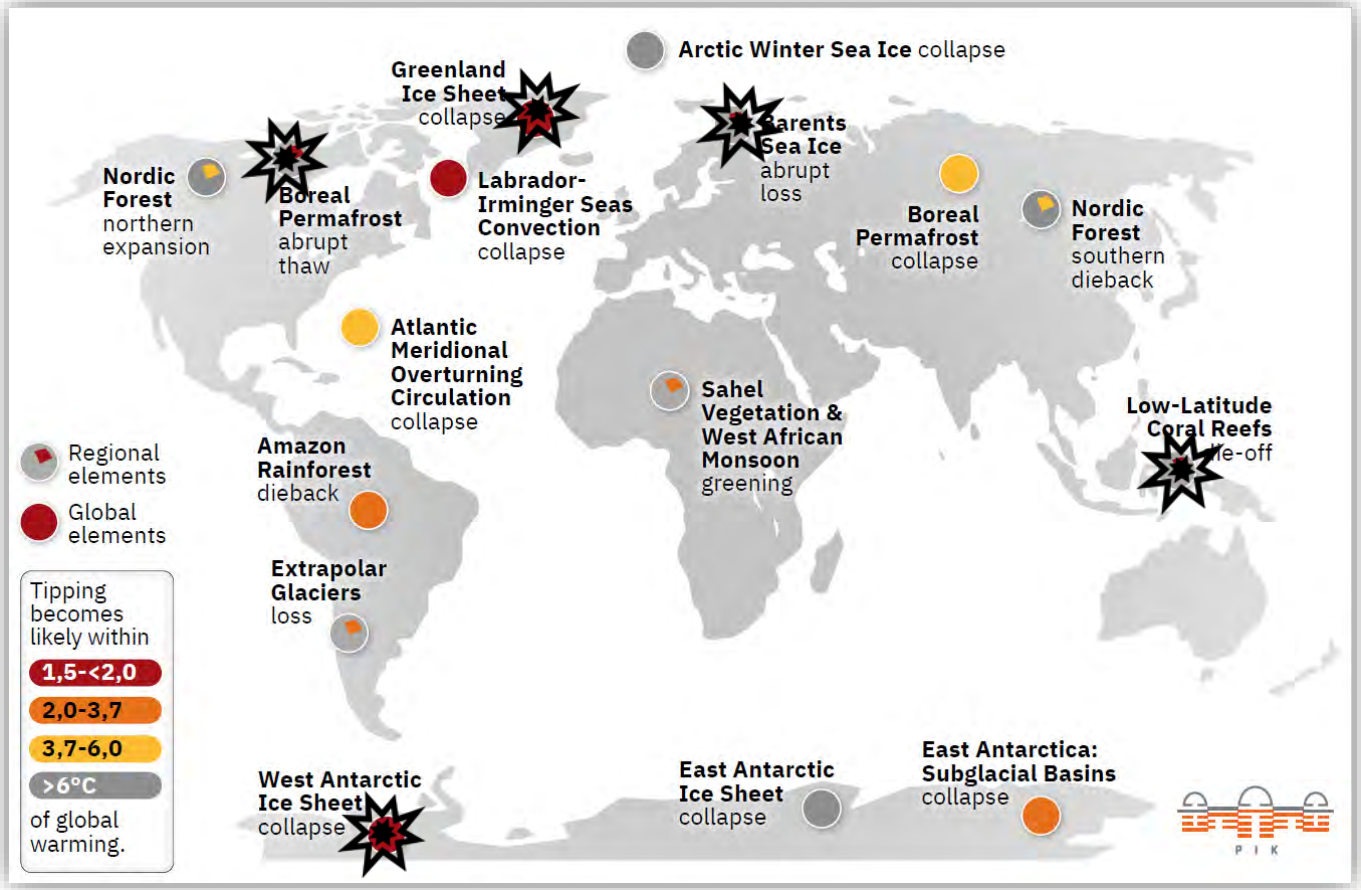
Holocene Our Garden of Eden

Image: GLOBAIA



Visualization: GLOBAIA

Tipping Elements in the Earth System

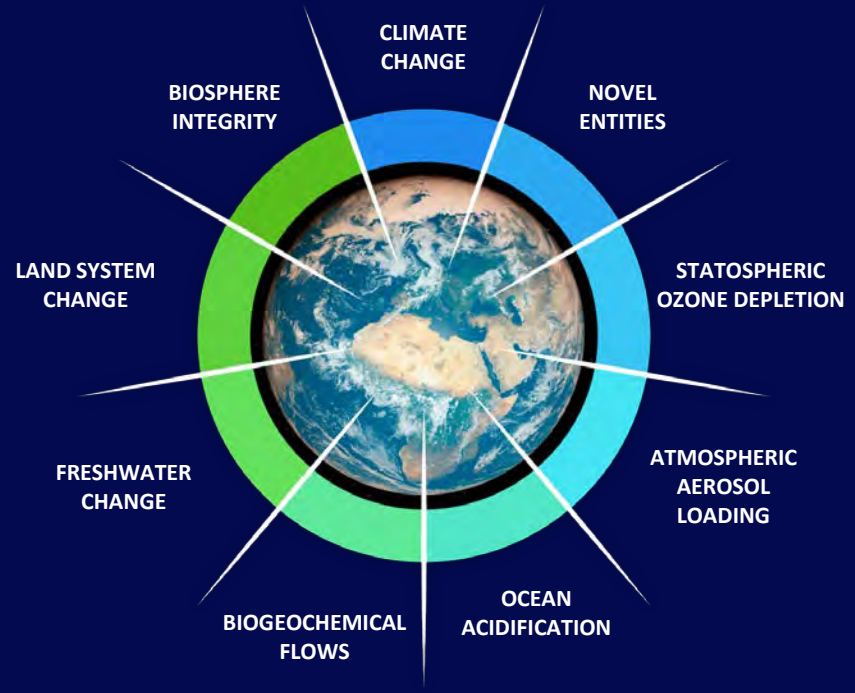


Based on: Armstrong McKay et al., Science (2022)

Tipping Points are real, making 1.5°C a physical limit:

A Planetary Boundary

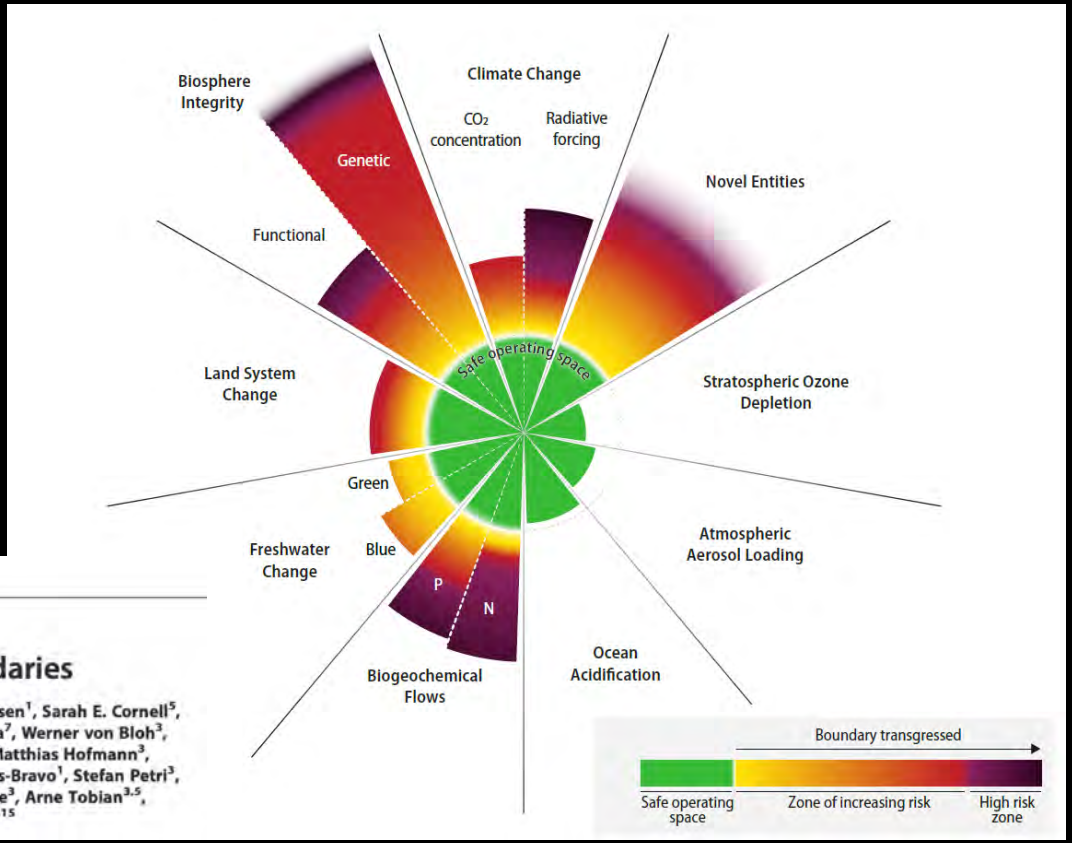
Humanity is entirely dependent on the balance of 9 Planetary Boundaries…



…but today we are over-exploiting many of them…

Source: Stockholm Resilience Centre, Sept 2022

Planetary Boundaries 3.0



SCIENCE ADVANCES | RESEARCH ARTICLE 2023

ENVIRONMENTAL STUDIES

Earth beyond six of nine planetary boundaries

Katherine Richardson[1]*, Will Steffen[2]†, Wolfgang Lucht[3,4], Jørgen Bendtsen[1], Sarah E. Cornell[5], Jonathan F. Donges[3,5], Markus Drüke[3], Ingo Fetzer[5,6], Govindasamy Bala[7], Werner von Bloh[3], Georg Feulner[3], Stephanie Fiedler[8], Dieter Gerten[3,4], Tom Gleeson[9,10], Matthias Hofmann[3], Willem Huiskamp[3], Matti Kummu[11], Chinchu Mohan[8,12,13], David Nogués-Bravo[1], Stefan Petri[3], Miina Porkka[11], Stefan Rahmstorf[3,14], Sibyll Schaphoff[3], Kirsten Thonicke[3], Arne Tobian[3,5], Vili Virkki[11], Lan Wang-Erlandsson[3,5,6], Lisa Weber[8], Johan Rockström[3,5,15]

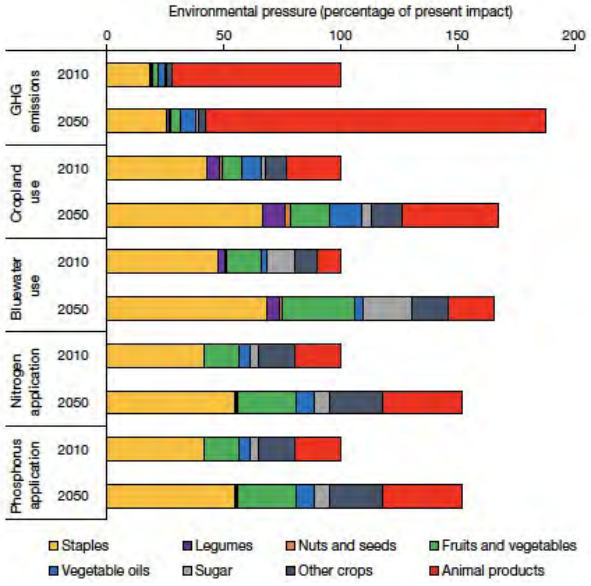
Feeding Humanity within Planetary Boundaries:
EAT-Lancet ”Planetary Health Diet”

ARTICLE
https://doi.org/10.1038/s41586-018-0594-0

Options for keeping the food system within environmental limits

Marco Springmann[1,2*], Michael Clark[3], Daniel Mason-D'Croz[4,5], Keith Wiebe[1], Benjamin Leon Bodirsky[6], Luis Lassaletta[7], Wim de Vries[8], Sonja J. Vermeulen[9,10], Mario Herrero[5], Kimberly M. Carlson[11], Malin Jonell[12], Max Troell[12,13], Fabrice DeClerck[14,15], Line J. Gordon[12], Rami Zurayk[16], Peter Scarborough[2], Mike Rayner[2], Brent Loken[14], Jess Fanzo[17,18], H. Charles J. Godfray[3,19], David Tilman[20,21], Johan Rockström[12] & Walter Willett[22]

Diet scenario	Tech scenario	Waste scenario	GHG emissions			Cropland use			Bluewater use			Nitrogen application			Phosphorus application		
			SSP2	SSP1	SSP3	SSP2	SSP1	SSP3	SSP2	SSP1	SSP3	SSP2	SSP1	SSP3	SSP2	SSP1	SSP3
BMK	BMK	BMK	4	4	4	4	4	4	3	3	3	4	4	4	4	4	4
		Waste/2	4	4	4	4	4	4	3	3	3	4	4	4	4	4	4
		Waste/4	4	4	4	4	4	4	3	3	3	4	4	4	4	4	4
	Tech	BMK	4	4	4	4	4	4	3	3	3	4	4	4	4	4	4
		Waste/2	4	4	4	3	3	3	2	2	2	4	4	4	4	4	4
		Waste/4	4	4	4	2	2	2	2	2	2	4	4	4	4	4	4
	Tech+	BMK	4	4	4	3	3	3	3	3	3	3	3	3	2	2	2
		Waste/2	4	4	4	2	2	2	2	2	2	3	3	3	2	2	2
		Waste/4	4	4	4	1	1	1	2	2	2	3	3	3	2	2	2
HGD	BMK	BMK	4	4	4	4	4	4	3	3	3	4	4	4	4	4	4
		Waste/2	4	4	4	4	4	4	3	3	3	4	4	4	4	4	4
		Waste/4	4	4	4	4	3	4	3	3	3	3	3	3	4	4	4
	Tech	BMK	4	4	4	3	3	3	3	2	3	4	4	4	4	4	4
		Waste/2	4	4	4	2	2	2	2	2	2	4	3	4	4	4	4
		Waste/4	4	4	4	2	1	2	2	2	2	3	3	3	4	3	4
	Tech+	BMK	4	4	4	2	2	2	3	2	3	3	3	3	2	2	2
		Waste/2	4	4	4	1	1	1	2	2	2	3	3	3	2	2	2
		Waste/4	4	3	4	1	1	1	2	2	2	3	3	3	2	2	2
FLX	BMK	BMK	3	2	3	4	4	4	3	3	3	4	4	4	4	4	4
		Waste/2	1	1	2	4	4	4	3	3	3	3	3	3	4	4	4
		Waste/4	1	1	1	4	3	4	3	2	3	3	3	3	3	3	3
	Tech	BMK	2	1	2	3	3	3	2	2	3	4	4	4	4	4	4
		Waste/2	1	1	1	2	2	2	2	2	2	3	3	3	4	4	4
		Waste/4	1	1	1	1	1	2	2	2	2	3	3	3	3	2	3
	Tech+	BMK	1	1	2	2	2	2	2	2	3	3	3	3	2	2	2
		Waste/2	1	1	1	1	1	1	2	2	2	3	2	3	2	2	2
		Waste/4	1	1	1	1	1	1	2	2	2	2	2	2	2	1	2

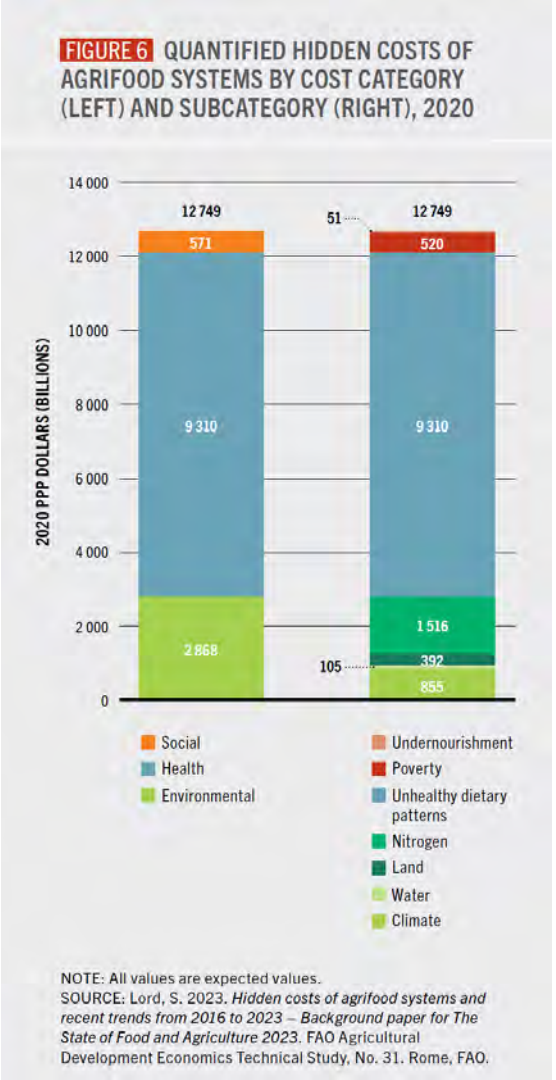


Springmann et al. 2018; Willett et al. 2019

Die “versteckten” (oder externen) Kosten des globalen Agrar- und Ernährungssystems:

> 10 Billionen USD pro Jahr!

(> 10% der globalen Wirtschaftsleistung)



FAO, SOFA 2023

Food System Economics *Commission* (2020 - 2024)















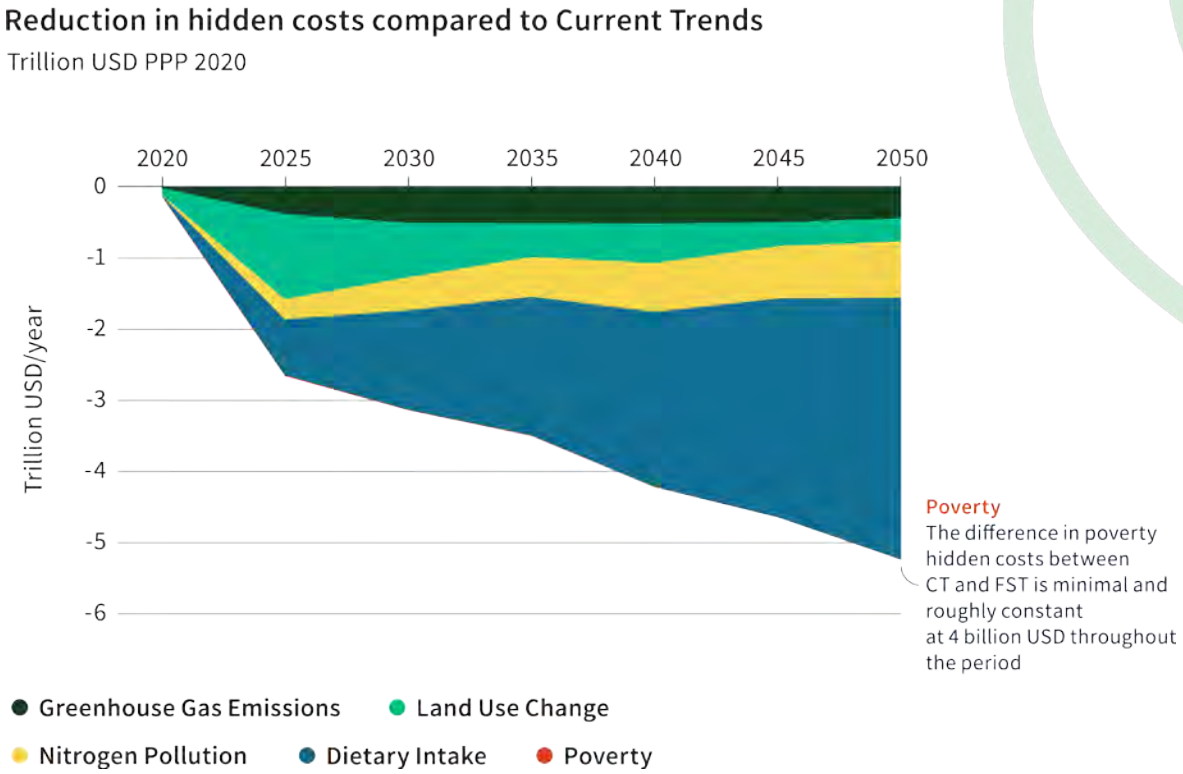



foodsystemeconomics.org

FSEC

Eine nachhaltige Agrar- und Ernährungstransformation ist *notwendig für die Einhaltung der Planetaren Grenzen, möglich* und *gesamtwirtschaftlich sehr vorteilhaft*, aber *nicht leicht umzusetzen.*

Eine Reduktion der globalen externen Kosten um *5-10 Billionen USD* bis 2050 ist möglich



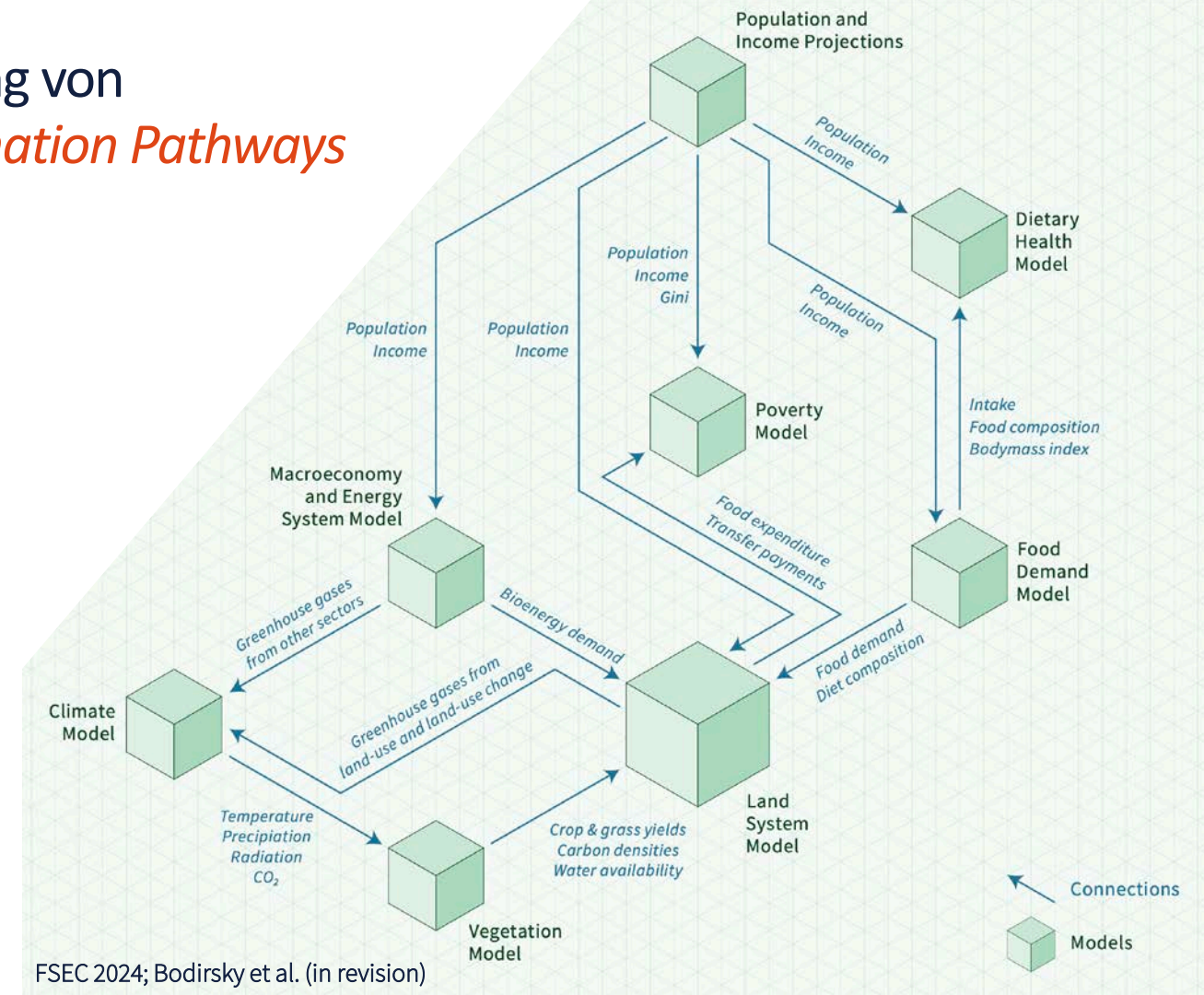
Integrierte Modellierung von *Food System Transformation Pathways*

- MAgPIE (land system)
- LPJmL (vegetation)
- REMIND (energy system)
- MAGICC (climate)
- Food Demand Model

  (Bodirsky et al. 2020)
- Poverty Model

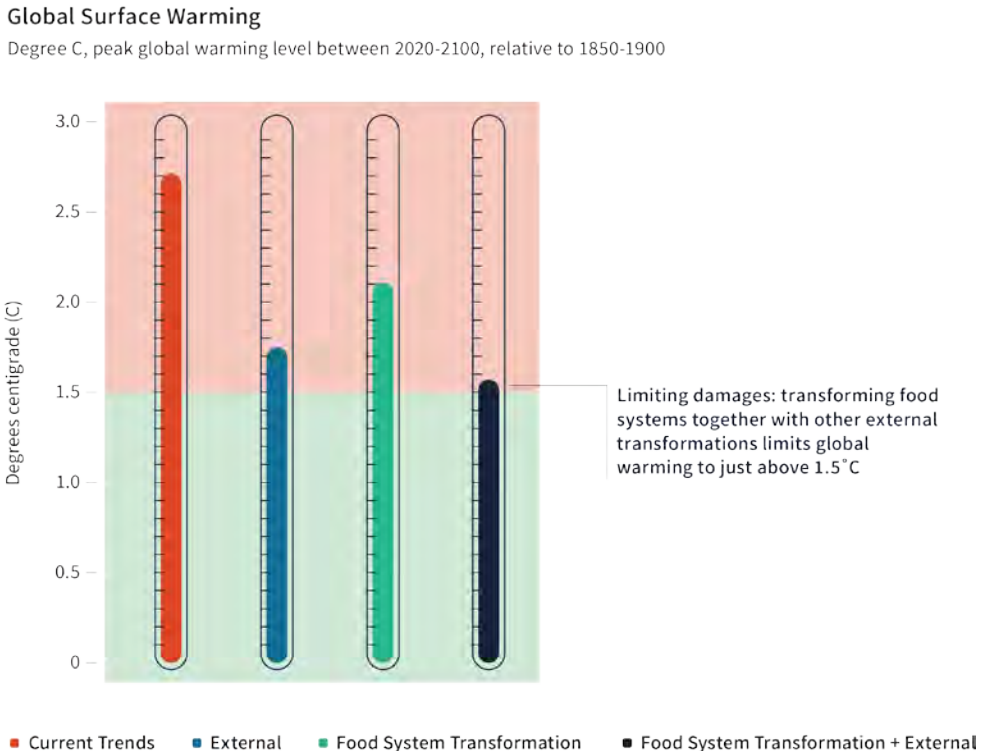
  (Sörgel et al. 2021)
- Dietary Health Model

  (Springmann et al. 2018)

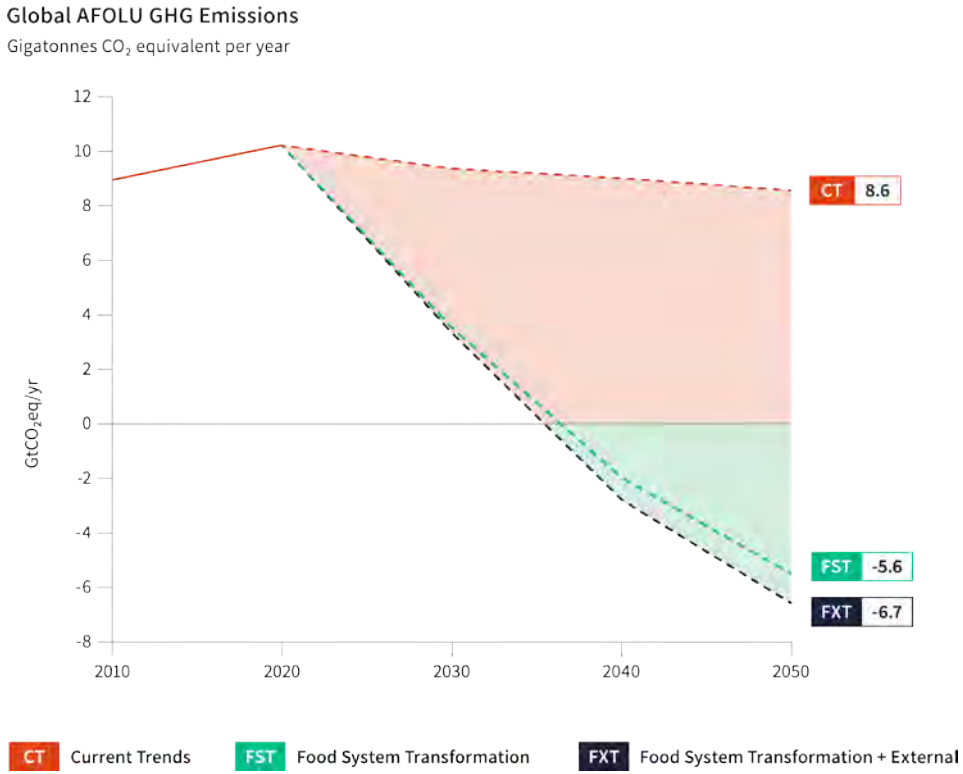


FSEC 2024; Bodirsky et al. (in revision)

Eine Agrar- und Ernährungstransformation ist *notwendig* für die *Einhaltung des 1.5-Grad-Ziels*

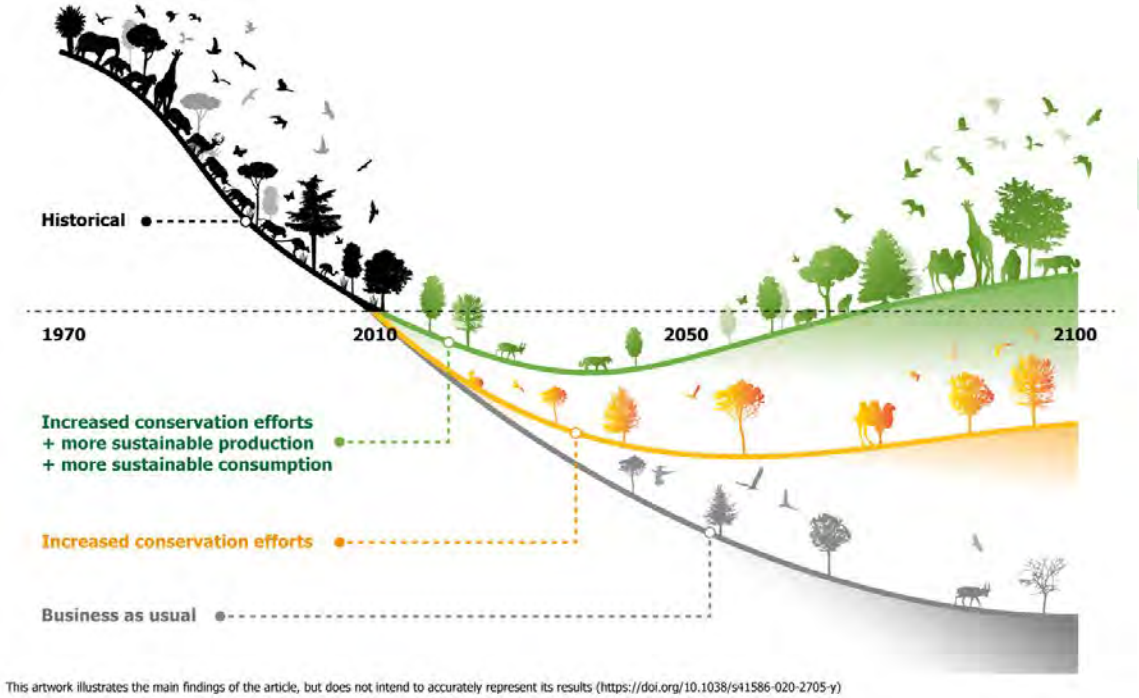


Der Agrar- und Ernährungssektor kann zu einer *Netto-C-Senke* werden



Der Biodiversitätsverlust kann gestoppt werden:

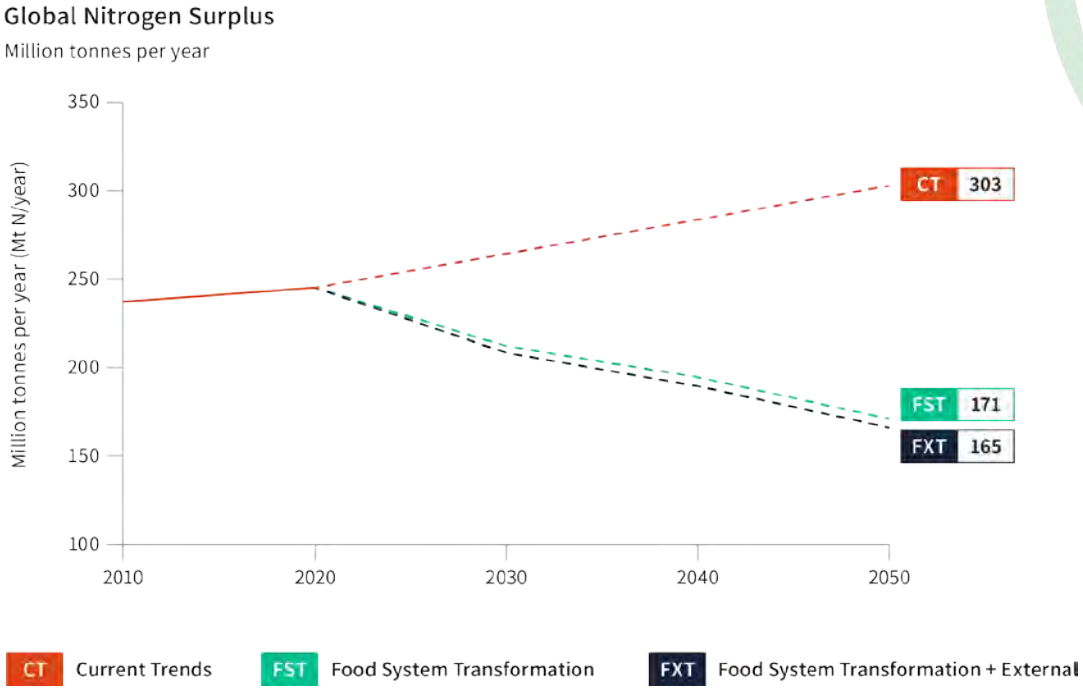
„*Bending the curve*“



Leclere, Lotze-Campen et al., Nature 2020

FSEC

Eine Agrar- und Ernährungstransformation kann die *N-Überschüsse halbieren*



Maßnahmen zur Umsetzung der Agrar- und Ernährungstransformation

FSEC 2024; Bodirsky et al. (in revision)

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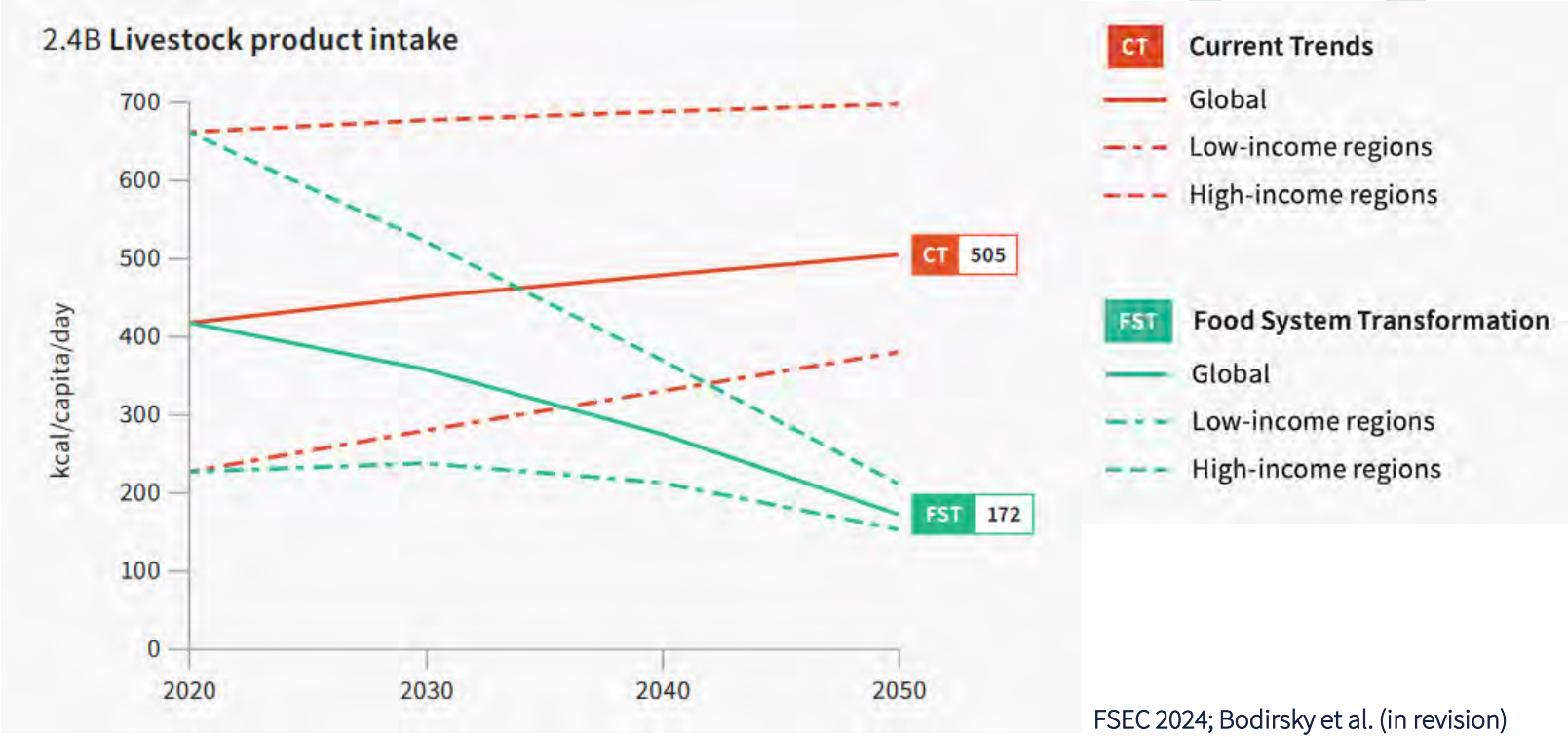
Eine stark pflanzenbasierte Ernährung entsprechend der *EAT-Lancet Planetary Healt Diet* ist entscheidend für die Agrar- und Ernährungstransformation



FSEC 2024; Bodirsky et al. (in revision)

FSEC

Eine Agrar- und Ernährungstransformation
ist *notwendig*
für die Einhaltung der Planetaren Grenzen...
...aber nicht leicht umzusetzen.

Fünf wichtige Politikbereiche

1. Veränderung der Ernährungsumgebungen
2. Neuausrichtung bestehender Agrarsubventionen
3. Neue Lenkungsinstrumente (zB THG-Bepreisung, N-Überschussabgabe)
4. Investitionen in Forschung und Technologieentwicklung
5. Kompensationszahlungen und Verbesserung sozialer Sicherungssysteme

Forschungsbedarf zur Umsetzung der Agrar- und Ernährungstransformation:

skalenübergreifend,

regional – national – global

FSEC 2024; Bodirsky et al. (in revision)

FSEC

POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Vielen Dank!

Member of Leibniz Association

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