



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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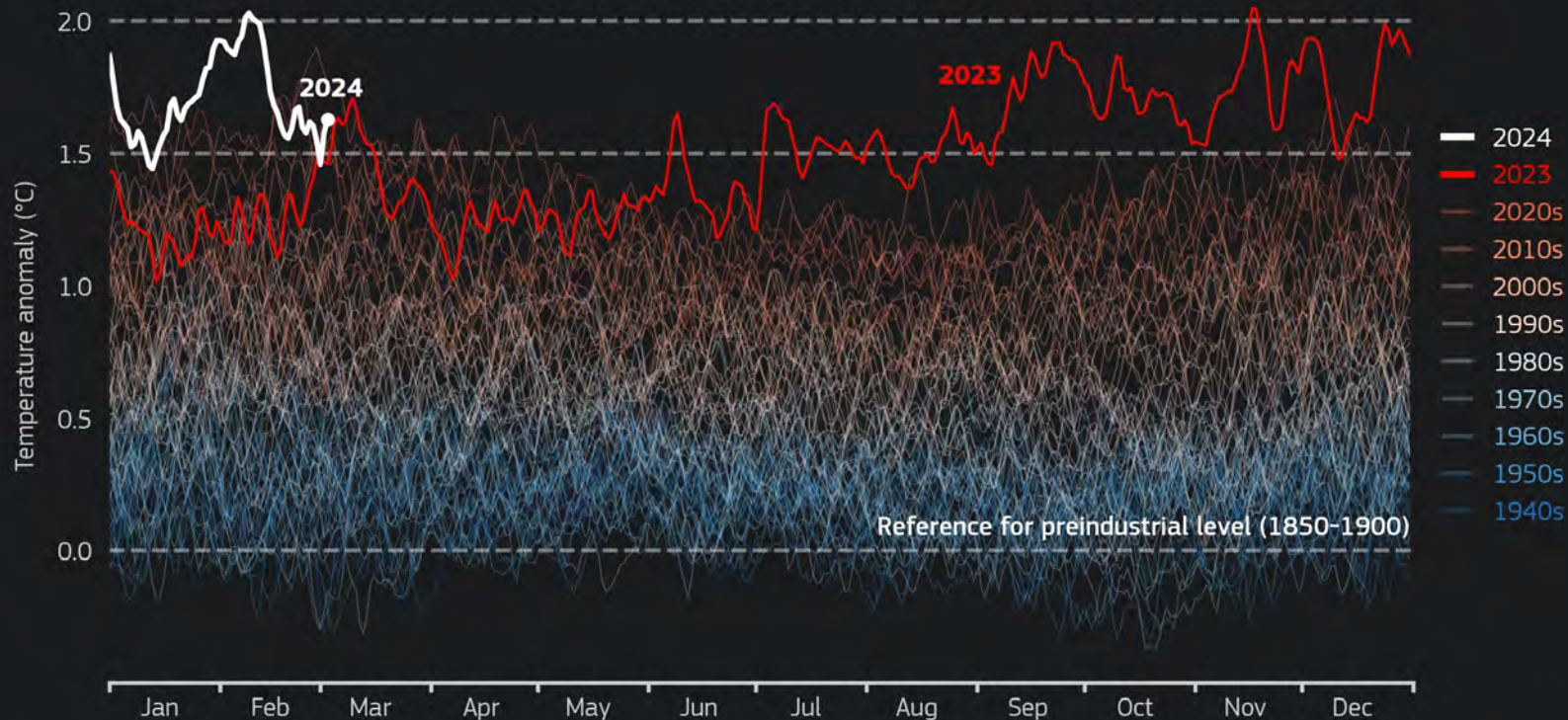
A biosphere shaped by humans

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



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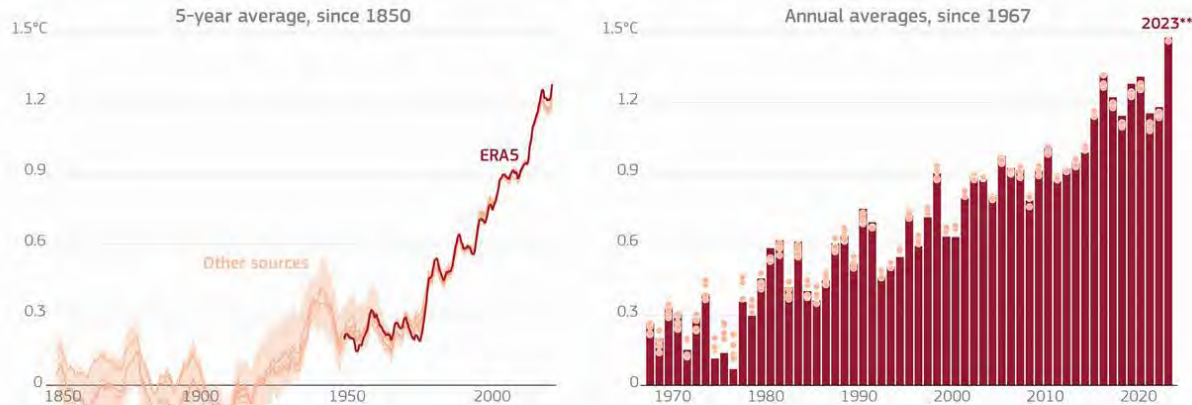


Climate
Change Service
climate.copernicus.eu

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

GLOBAL SURFACE TEMPERATURE: INCREASE ABOVE PRE-INDUSTRIAL LEVEL (1850–1900)

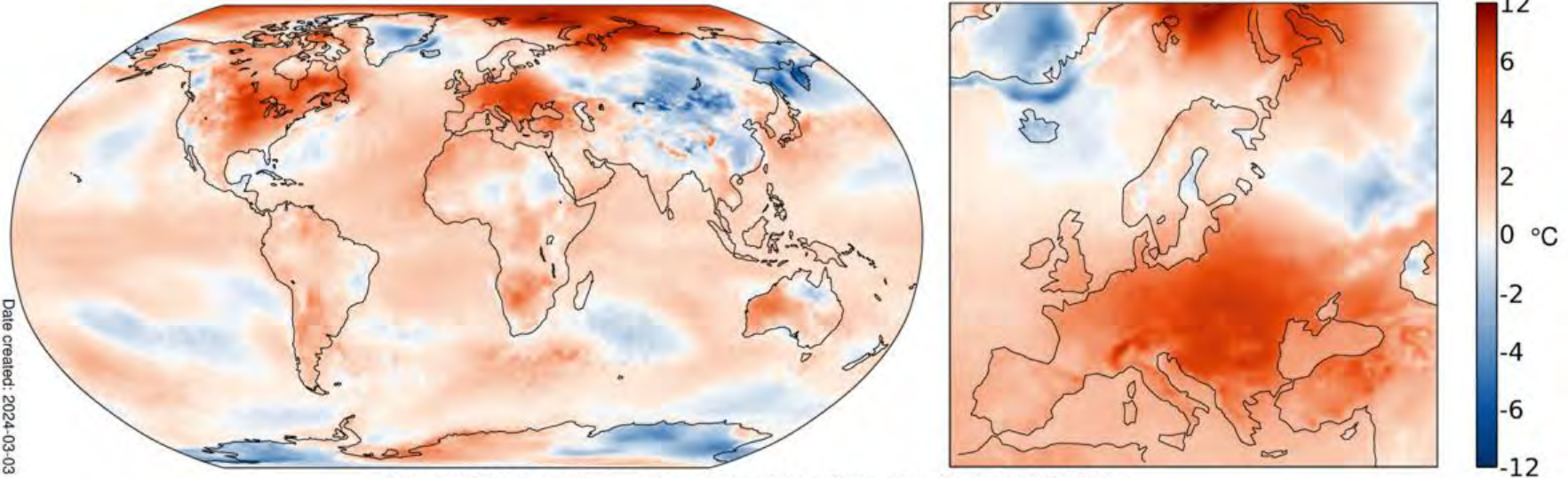
■ ERA5 data ■ Other sources* (including JRA-3Q, GISTEMPv4, NOAA GlobalTempv5, Berkeley Earth, HadCRUT5)



*ERA5 and JRA-3Q data are only shown from 1948. Shaded area represents the uncertainty for HadCRUT5 data
**Estimate for 2023 based on ERA5 and JRA-3Q data only
Credit: C3S/ECMWF

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

Surface air temperature anomaly for February 2024



(Data: ERA5. Reference period: 1991-2020. Credit: C3S/ECMWF)



PROGRAMME OF
THE EUROPEAN UNION



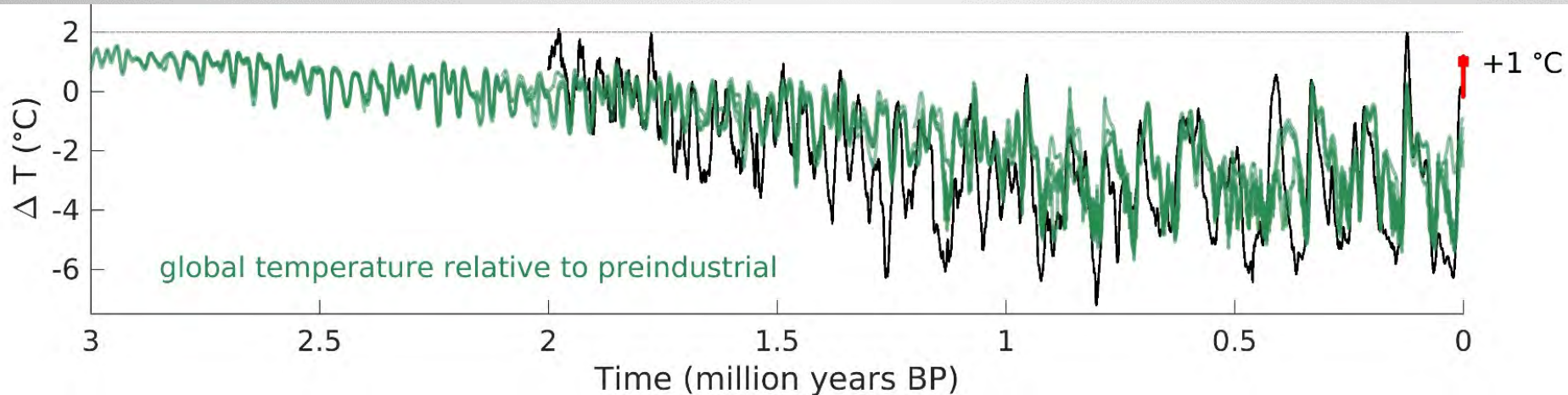
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Climate
Change Service

- 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.

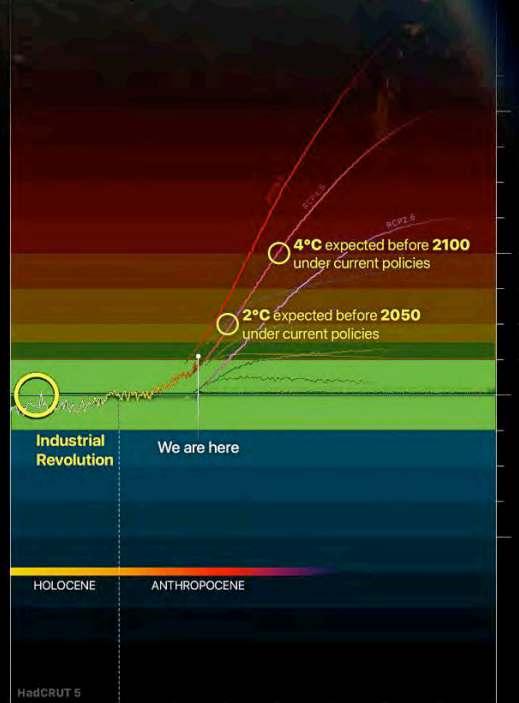
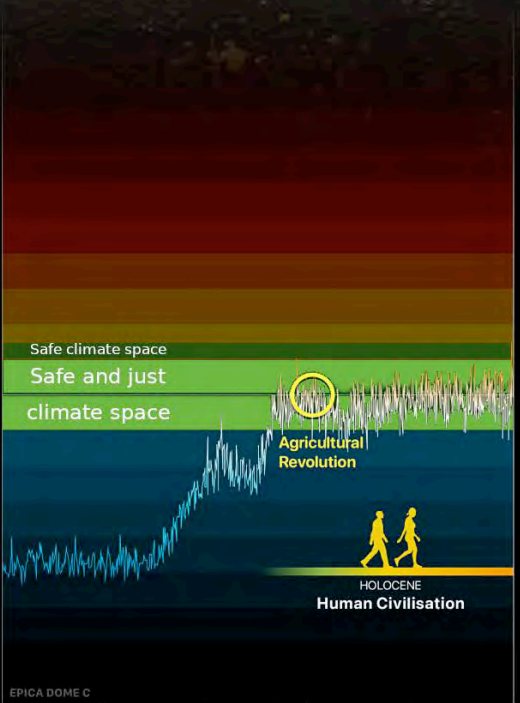
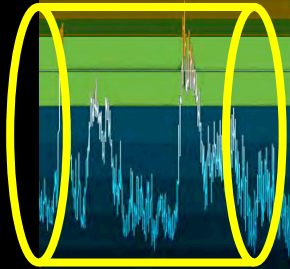
Source: Willeit et al., Science Advances 2019



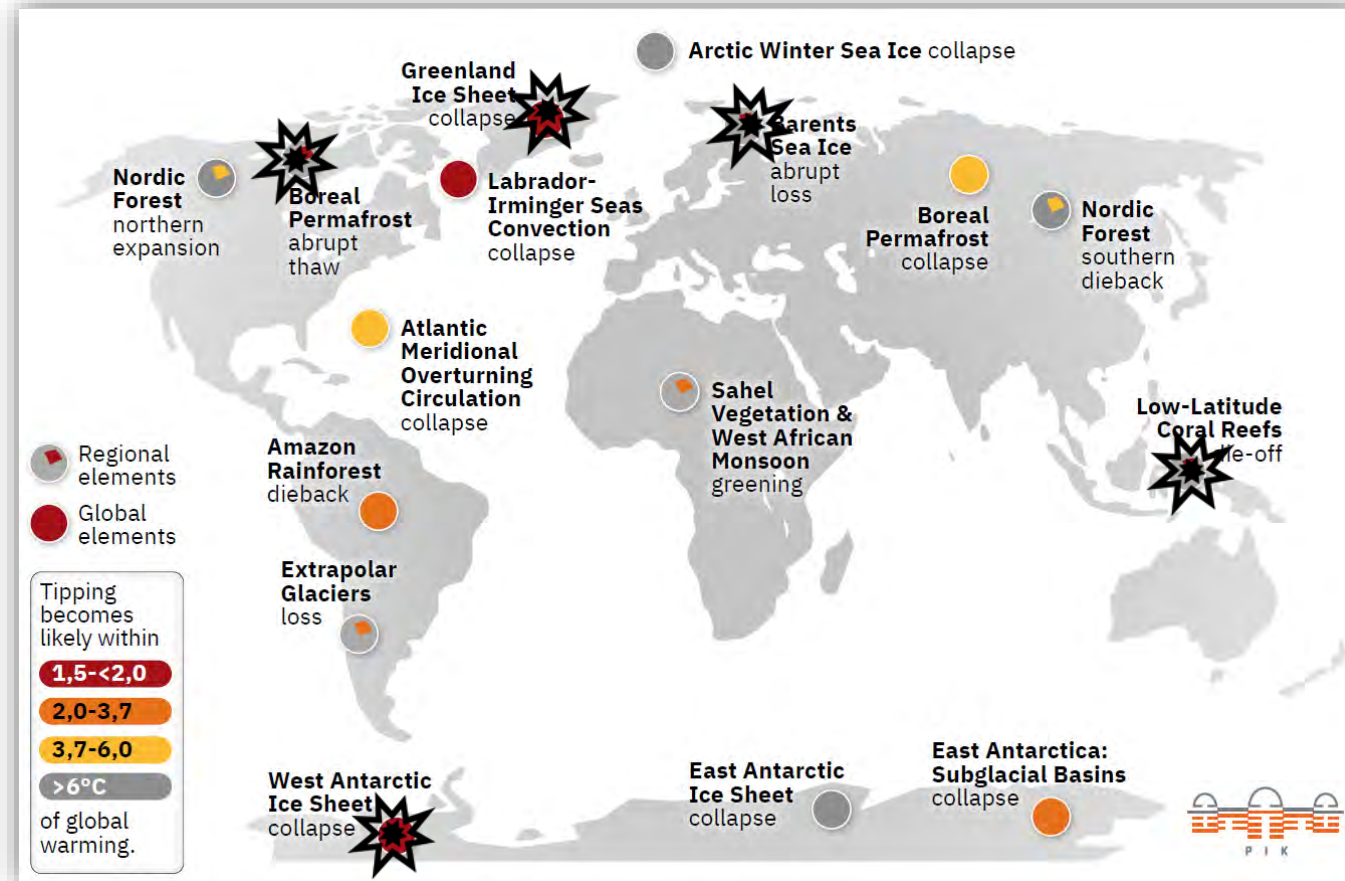
Holocene Our **Garden of Eden**

Humanity's Journey on Earth

+2°C
↑
↓
-5°C

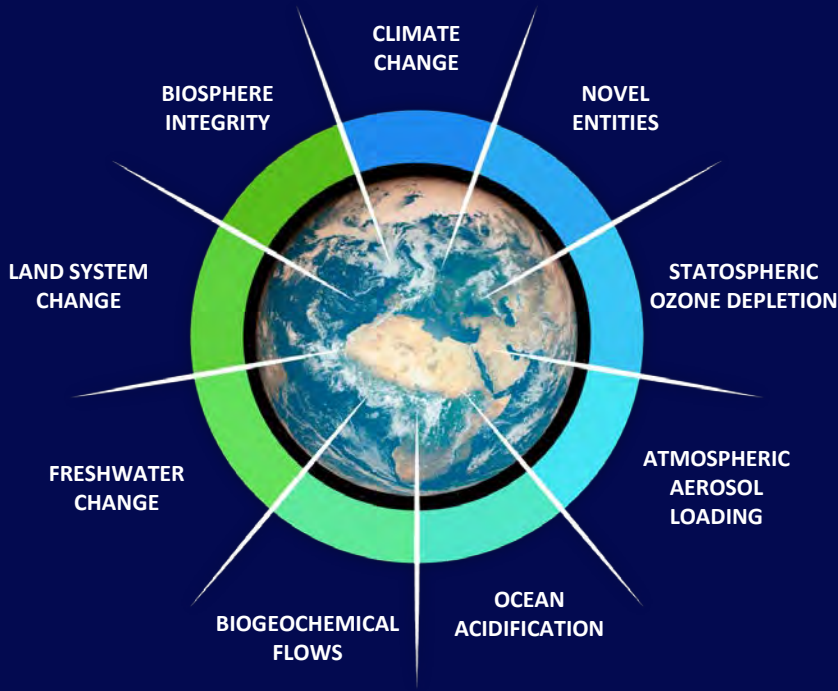


Tipping Elements in the Earth System



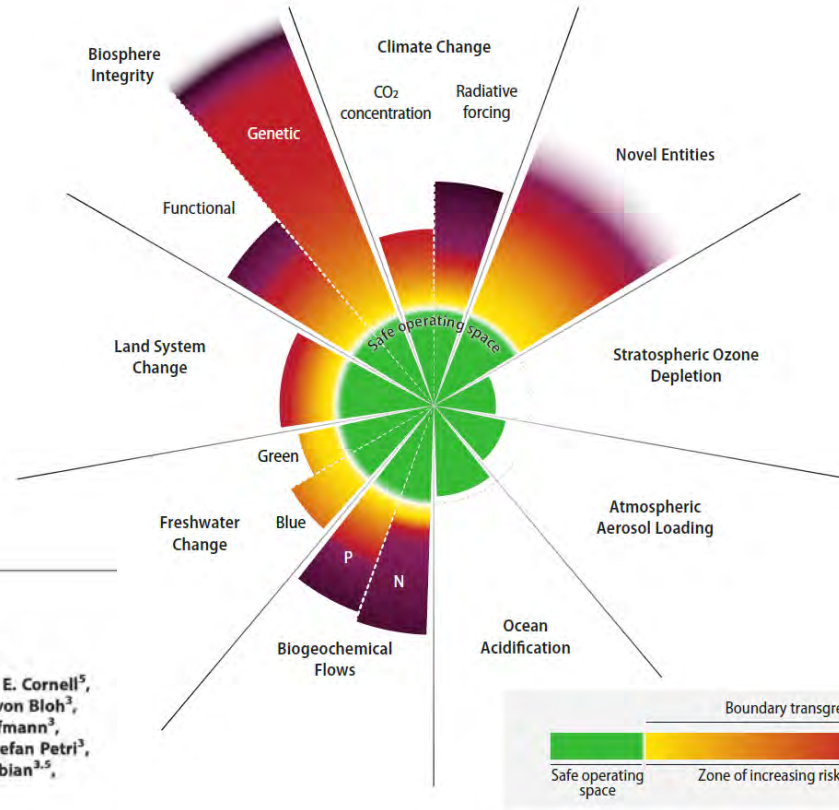
Tipping Points are real,
making 1.5°C a physical limit:
A Planetary Boundary

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



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

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 Bendtsen¹, Sarah E. Cornell⁵, Jonathan F. Donges^{3,5}, Markus Drüke³, Ingo Fetzer^{5,6}, Govindasamy Bala⁷, Werner von Bloh³, Georg Feulner³, Stephanie Fiedler⁸, Dieter Gerten^{3,4}, Tom Gleeson^{9,10}, Matthias Hofmann³, Willem Huiskamp⁷, Matti Kummu¹¹, Chinchu Mohan^{8,12,13}, David Nogués-Bravo¹, Stefan Petri³, Miina Porkka¹¹, Stefan Rahmstorf^{3,14}, Sibyll Schaphoff³, Kirsten Thonicke³, Arne Tobian^{3,5}, Vili Virkki¹¹, Lan Wang-Erlandsson^{3,5,6}, Lisa Weber⁸, Johan Rockström^{3,5,15}

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

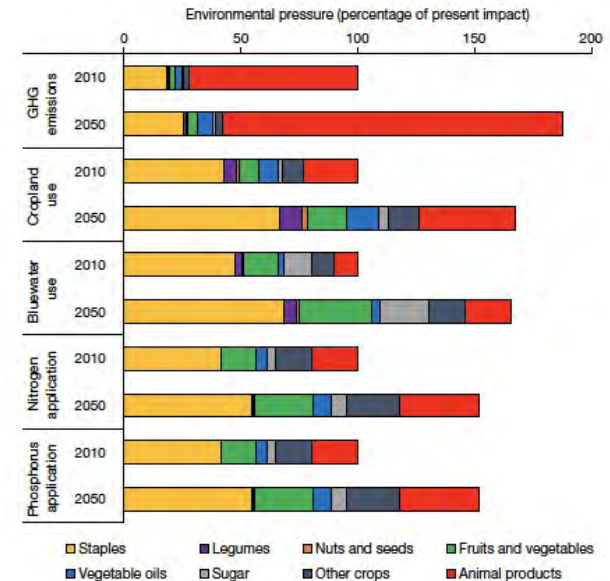
ARTICLE

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

Options for keeping the food system within environmental limits

Marco Springmann^{1,2*}, Michael Clark³, Daniel Mason-D'Croz^{4,5}, Keith Wiebe¹, Benjamin Leon Bodirsky⁶, Luis Lassalerra⁷, Wim de Vries⁸, Sonja J. Vermeulen^{9,10}, Mario Herrero⁹, Kimberly M. Carlson¹¹, Malin Jonell¹², Max Troell^{2,13}, Fabrice DeClerck^{14,15}, Line J. Gordon¹², Rami Zurayk¹⁶, Peter Scarborough¹⁷, Mike Rayner², Brent Loken¹⁴, Jess Fanzo^{17,18}, H. Charles J. Godfray^{1,19}, David Tilman^{20,21}, Johan Rockström¹² & Walter Willett²²

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
			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
		BMK	4	4	4	4	4	4	3	3	3	4	4	4	4	4	4
	Tech	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
		BMK	4	4	4	3	3	3	3	3	3	3	3	2	2	2	2
		Waste/2	4	4	4	2	2	2	2	2	2	3	3	3	2	2	2
	Tech+	Waste/4	4	4	4	1	1	1	2	2	2	3	3	3	2	2	2
		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	3	4	3	3	3	3	3	3	4	4	4	4
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	4	4	4	4
		BMK	4	4	4	3	3	3	3	2	3	4	4	4	4	4	4
	Tech	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
		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
	Tech+	Waste/4	4	3	4	1	1	1	2	2	2	3	3	3	2	2	2
		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
FLX	BMK	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	3	3	3	4	4	4	4
		Waste/4	1	1	1	1	1	2	2	2	2	3	3	3	2	2	3
		BMK	1	1	2	2	2	2	2	2	3	3	3	3	2	2	2
	Tech+	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



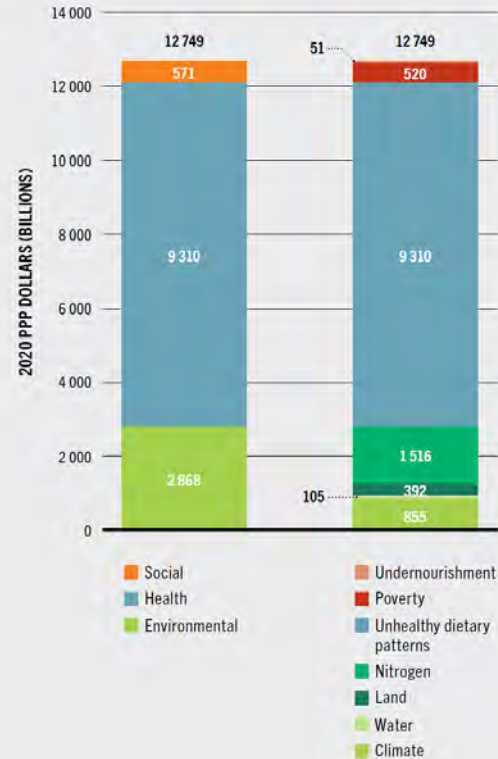
Die “versteckten” (oder externen) Kosten des globalen Agrar- und Ernährungssystems:

> 10 Billionen USD pro Jahr!

(> 10% der globalen Wirtschaftsleistung)

FAO, SOFA 2023

FIGURE 6 QUANTIFIED HIDDEN COSTS OF AGRIFOOD SYSTEMS BY COST CATEGORY (LEFT) AND SUBCATEGORY (RIGHT), 2020



NOTE: All values are expected values.

SOURCE: Lord, S. 2023. *Hidden costs of agrifood systems and recent trends from 2016 to 2023 – Background paper for The State of Food and Agriculture 2023*. FAO Agricultural Development Economics Technical Study, No. 31. Rome, FAO.



Food System Economics Commission

(2020 - 2024)

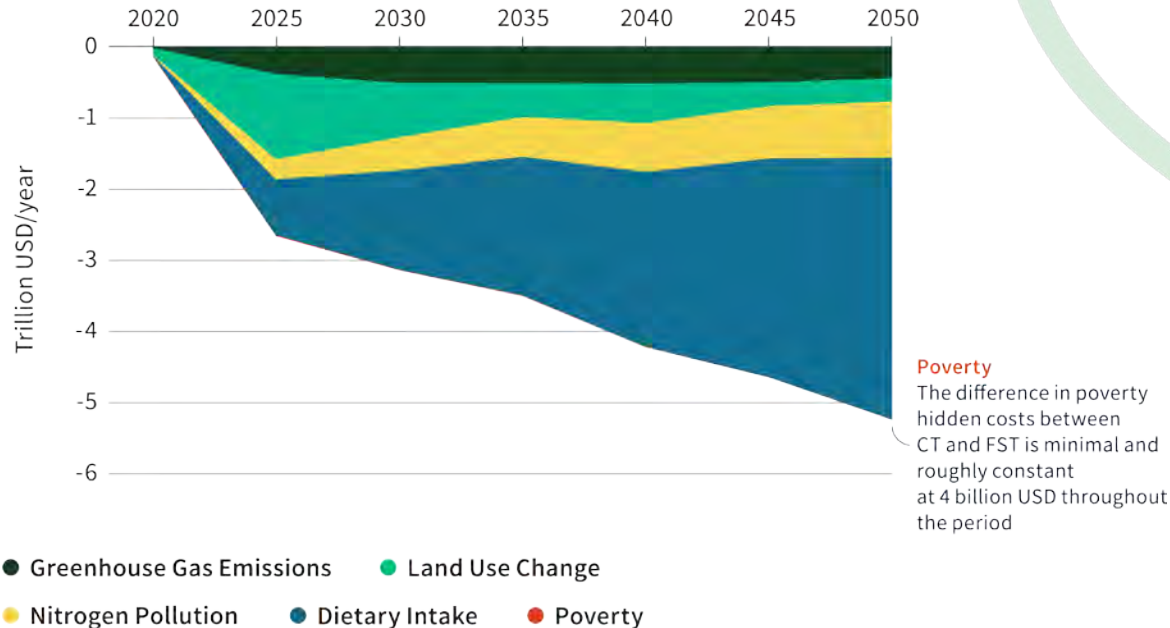


Eine nachhaltige Agrar- und Ernährungstransformation
ist *notwendig für die Einhaltung der Planetaren Grenzen,*
möglich und *gesamtwirtschaftlich sehr vorteilhaft,*
aber *nicht leicht umzusetzen.*

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

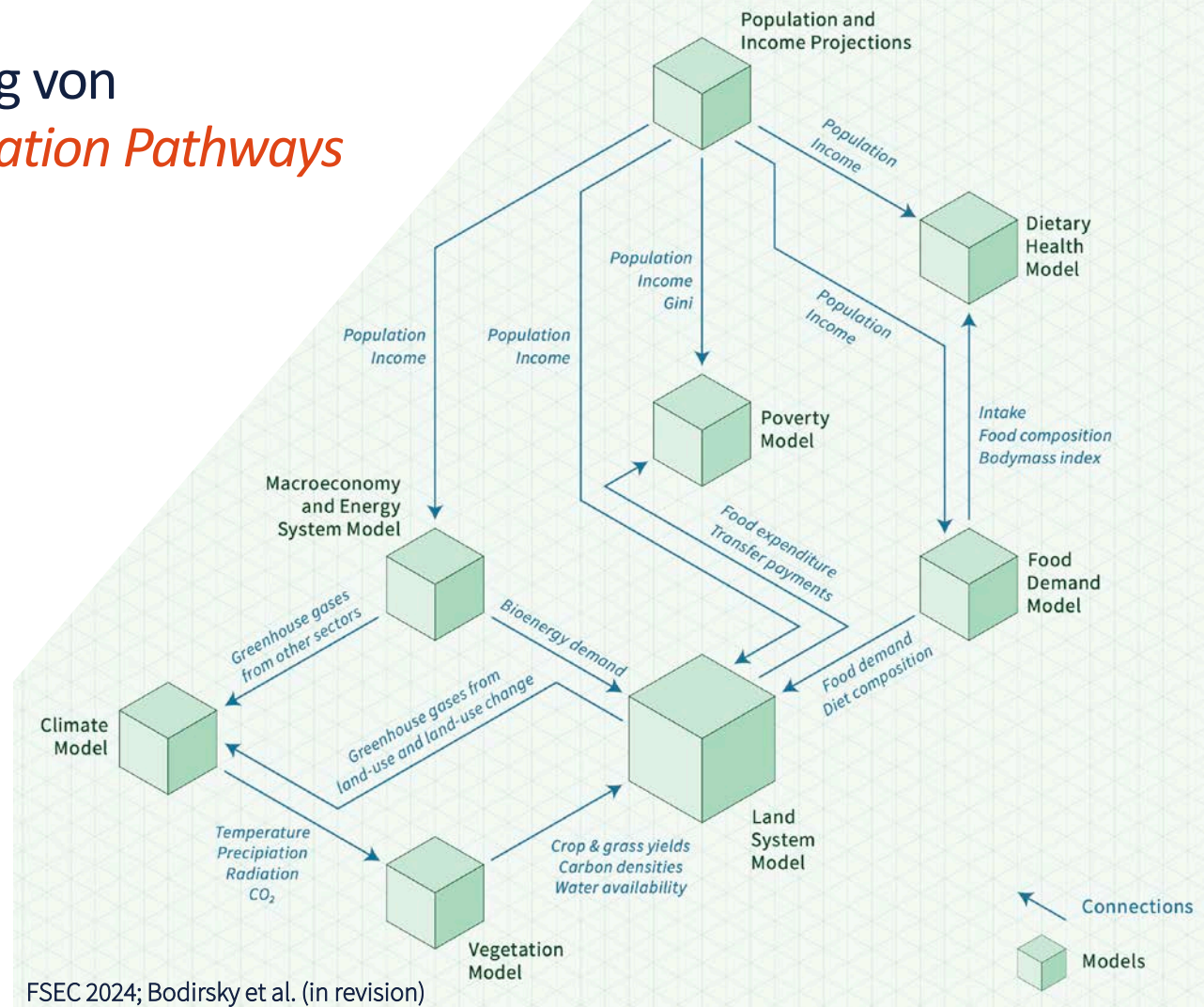
Reduction in hidden costs compared to Current Trends

Trillion USD PPP 2020



Integrierte Modellierung von *Food System Transformation Pathways*

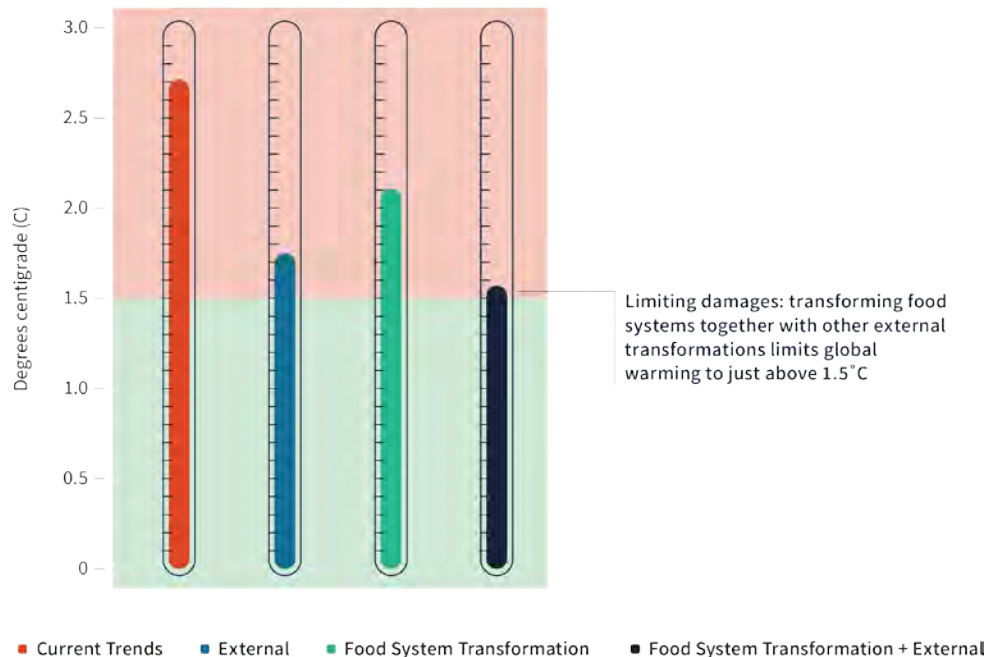
- MAgPIE (land system)
- LPJmL (vegetation)
- REMIND (energy system)
- MAGICC (climate)
- Food Demand Model
(Bodirsky et al. 2020)
- Poverty Model
(Sörgel et al. 2021)
- Dietary Health Model
(Springmann et al. 2018)



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

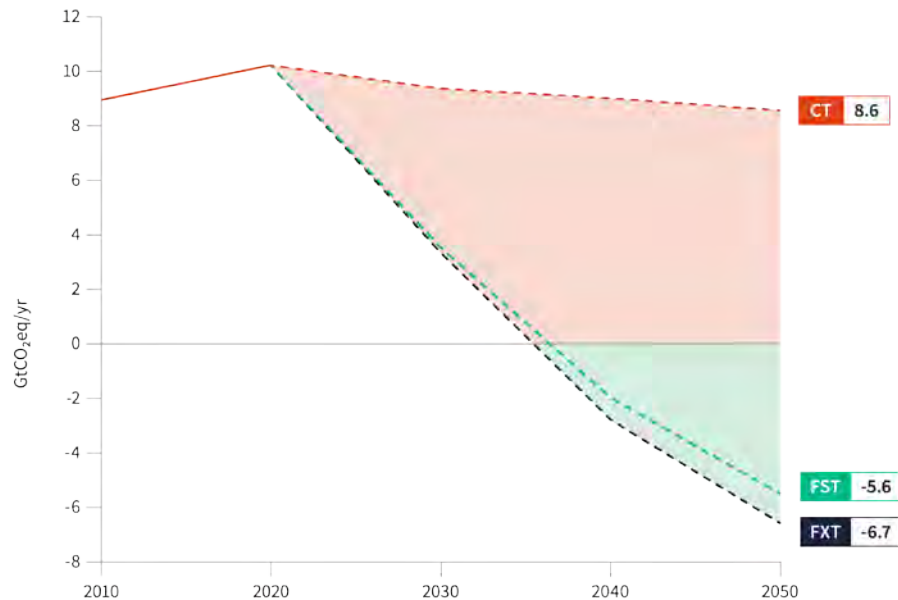
Global Surface Warming

Degree C, peak global warming level between 2020-2100, relative to 1850-1900



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

Global AFOLU GHG Emissions
Gigatonnes CO₂ equivalent per year



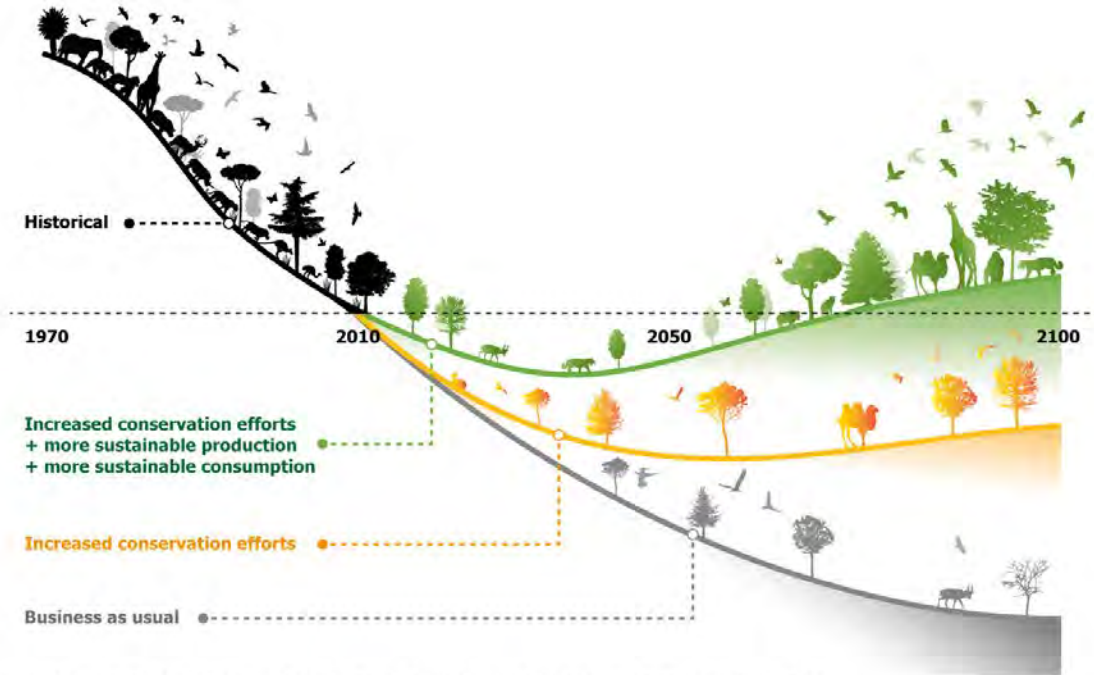
CT Current Trends

FST Food System Transformation

FXT Food System Transformation + External

Der Biodiversitätsverlust kann gestoppt werden:

„*Bending the curve*“

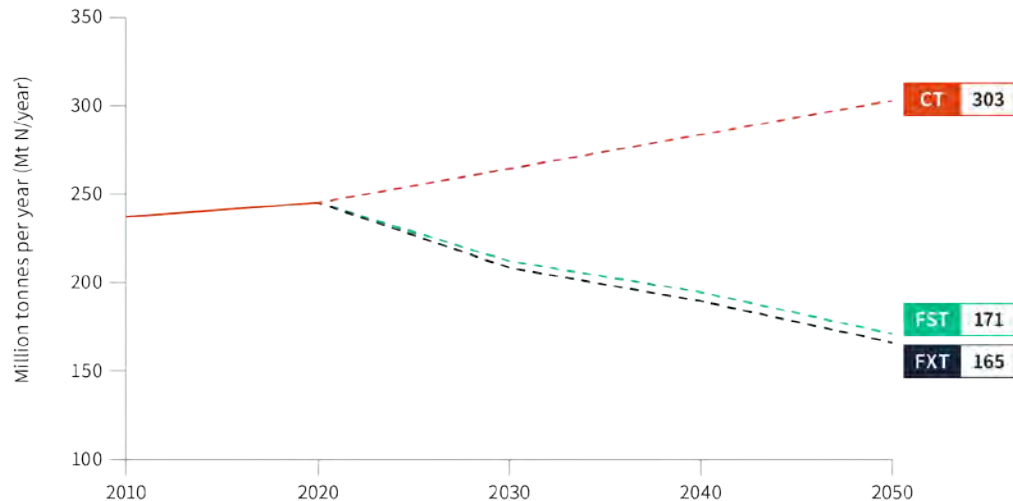


This artwork illustrates the main findings of the article, but does not intend to accurately represent its results (<https://doi.org/10.1038/s41586-020-2705-y>)

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

Global Nitrogen Surplus




Million tonnes per year




CT Current Trends

FST Food System Transformation

FXT Food System Transformation + External

Operational Goal	Food system measures
 <p>Diets Consumption of healthy diets by all</p>	<ul style="list-style-type: none"> • Eradication of undernutrition • Stabilization of obesity • Convergence towards healthy diets • Halving food waste
 <p>Livelihoods Strong livelihoods throughout the food system</p>	<ul style="list-style-type: none"> • Trade liberalization • Wage increases in agriculture • Capital substitution
 <p>Biosphere Protection of intact land and restoration of degraded land</p>	<ul style="list-style-type: none"> • Reducing emissions from deforestation and forest degradation (REDD+) • Land conservation • Peatland rewetting • Water conservation • Biodiversity offset
 <p>Production Environmentally sustainable production throughout the food system</p>	<ul style="list-style-type: none"> • Nitrogen efficiency • Longer crop rotations • More landscape habitats • Emission mitigation from rice cultivation • Livestock management • Manure management • Soil carbon management

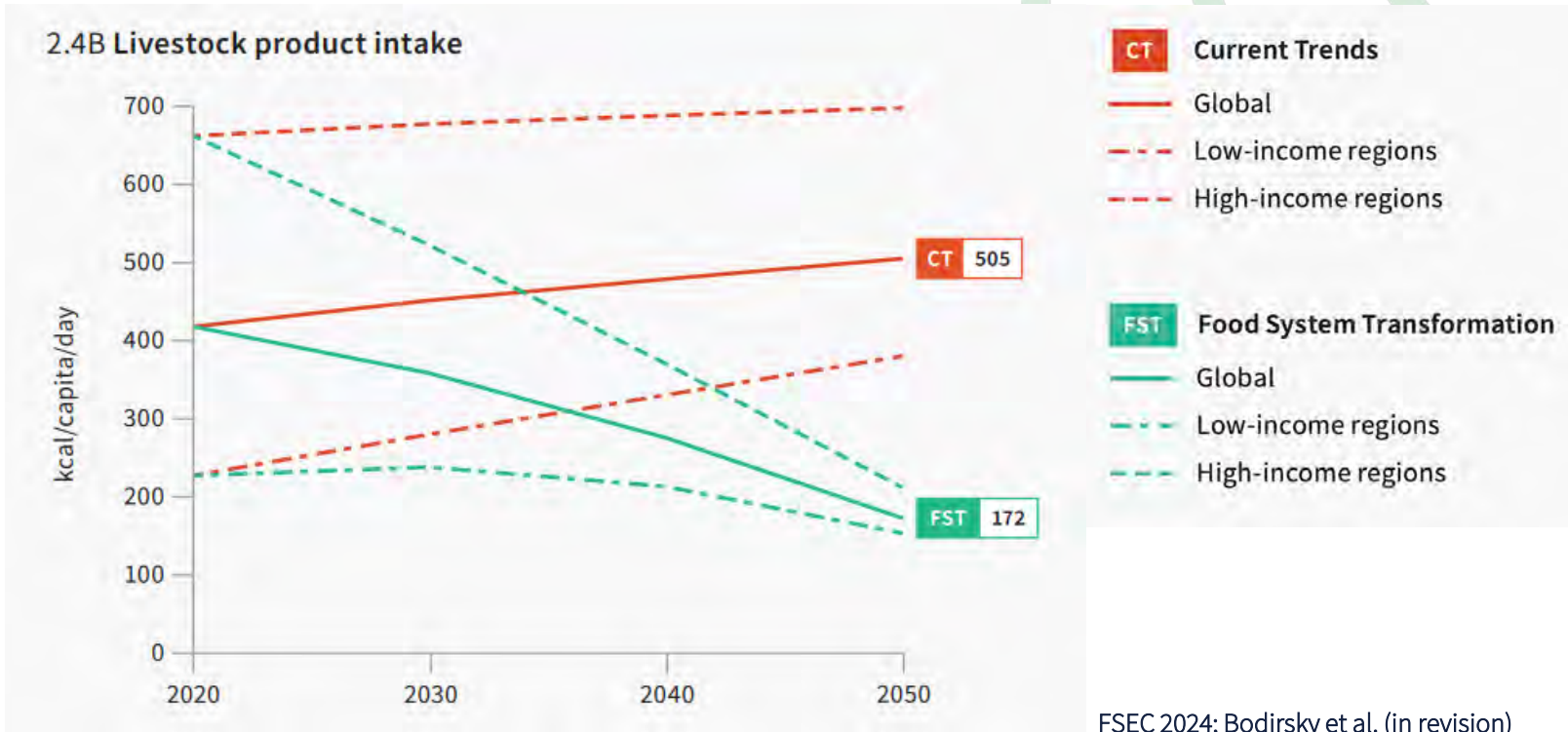


External
Sustainable transformations external to the food system

- Slower population growth
- Equitable human development
- Sustainable energy transition
- Increase in bioplastics
- More timber construction

Maßnahmen zur Umsetzung der Agrar- und Ernährungstransformation

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




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

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Forschungsbedarf zur Umsetzung der Agrar- und Ernährungstransformation: skalenübergreifend, regional – national – global



POTSDAM INSTITUTE FOR
CLIMATE IMPACT RESEARCH

Vielen Dank!

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