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# Food systems transformation for climate change mitigation and sustainable development

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Integrated Research on Energy, Environment and Society (IREES)

13.02.24



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# Have you ever tried to grow/raise plants/animals?

What do plants and animals need to grow/raise, where do they come from, and what plants/animals give in return?

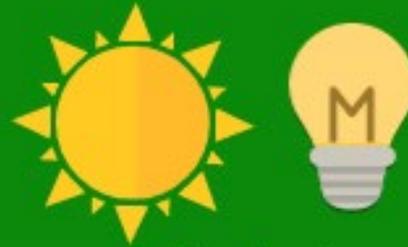


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# Things Plants Need



Water



Light



Air



Space to grow



Nutrients



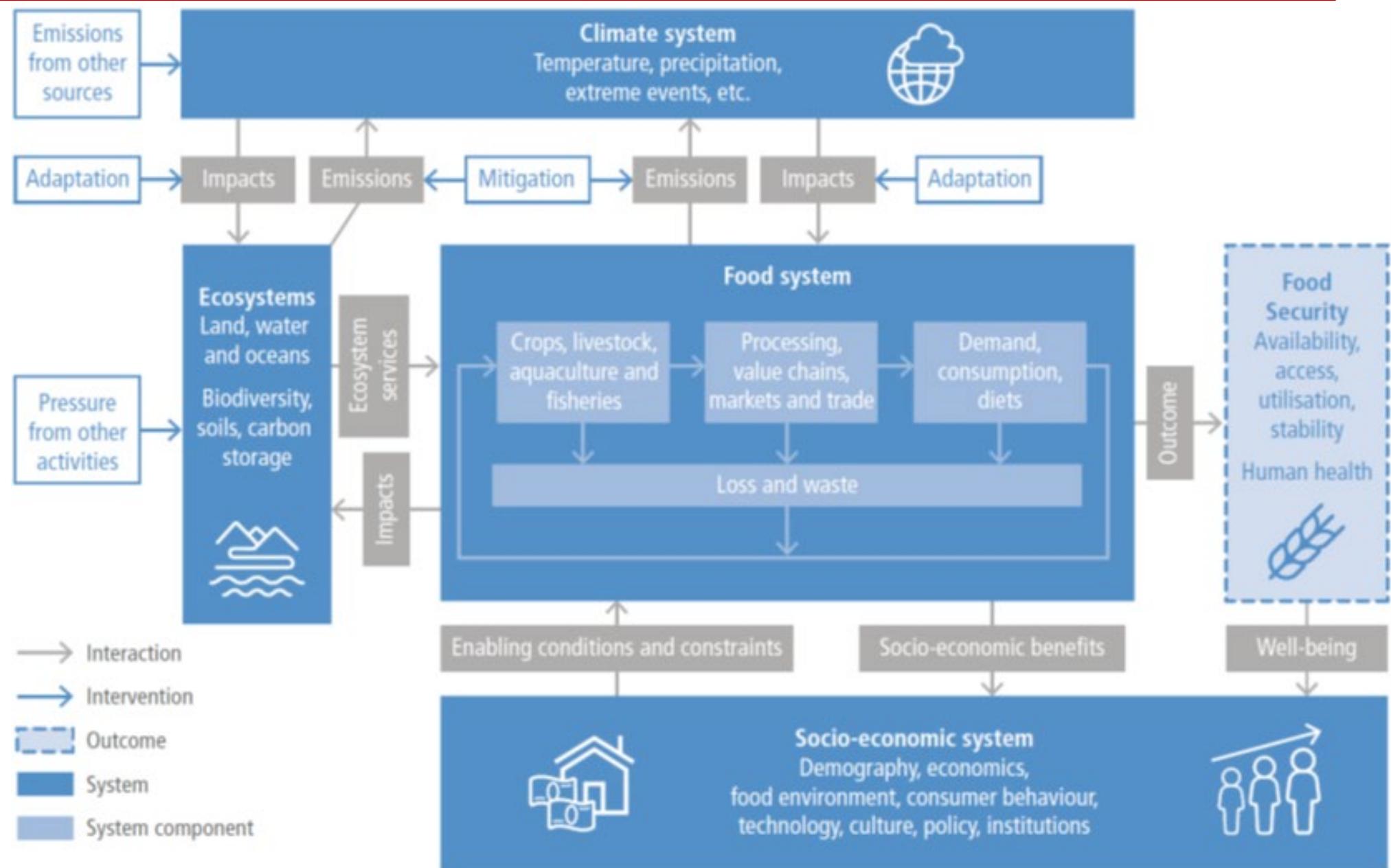
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# What is food system?

Describe in around a minute what comes in your mind when you think about a food system.



## Why is the food system broken?

MARCO ANTONIO REZENDE/BRAZIL PHOTOS/LIGHTROCKET/GETTY



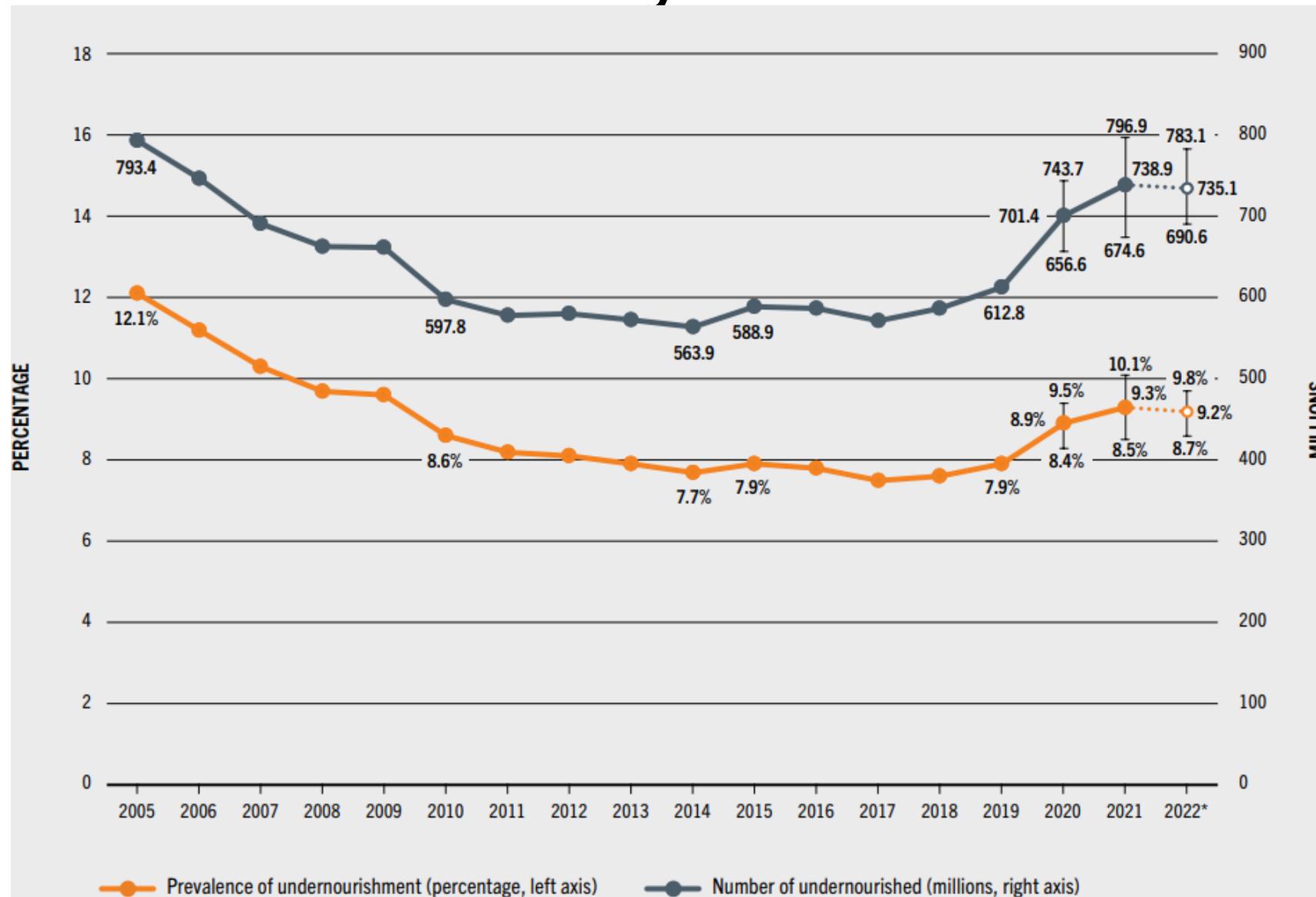
A cattle rancher in Brazil, where pressures to produce more meat collide with the need to reduce deforestation and greenhouse-gas emissions.

# Fix the broken food system in three steps

Schmidt-Traub et al. 2019 (Nature)

Map, model and manage agriculture, biodiversity, trade and nutrition – and build a global network, urge Guido Schmidt-Traub, Michael Obersteiner and Aline Mosnier.

# State of Food Security and Nutrition 2023

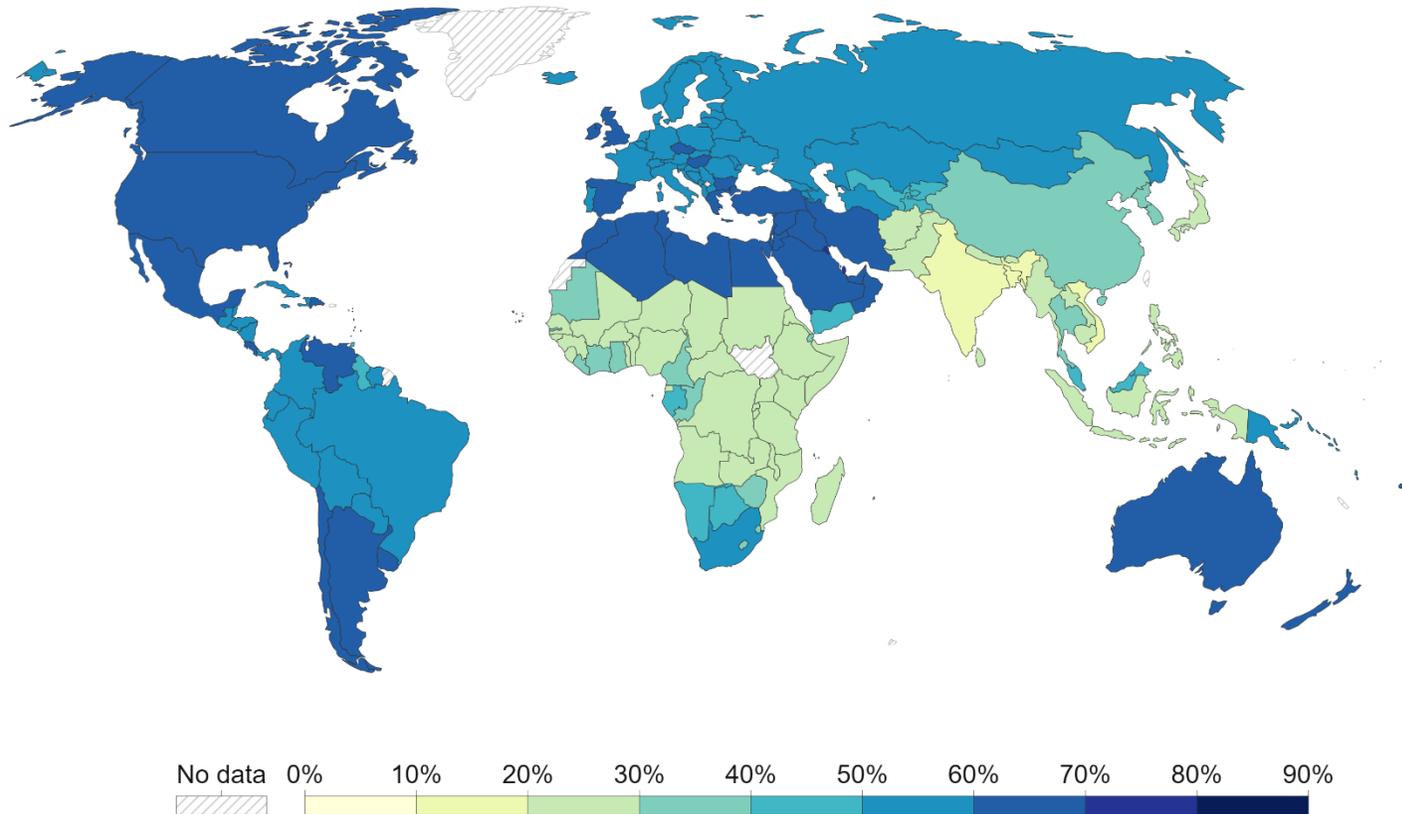


# The triple burden of malnutrition

## Share of adults who are overweight or obese, 2016

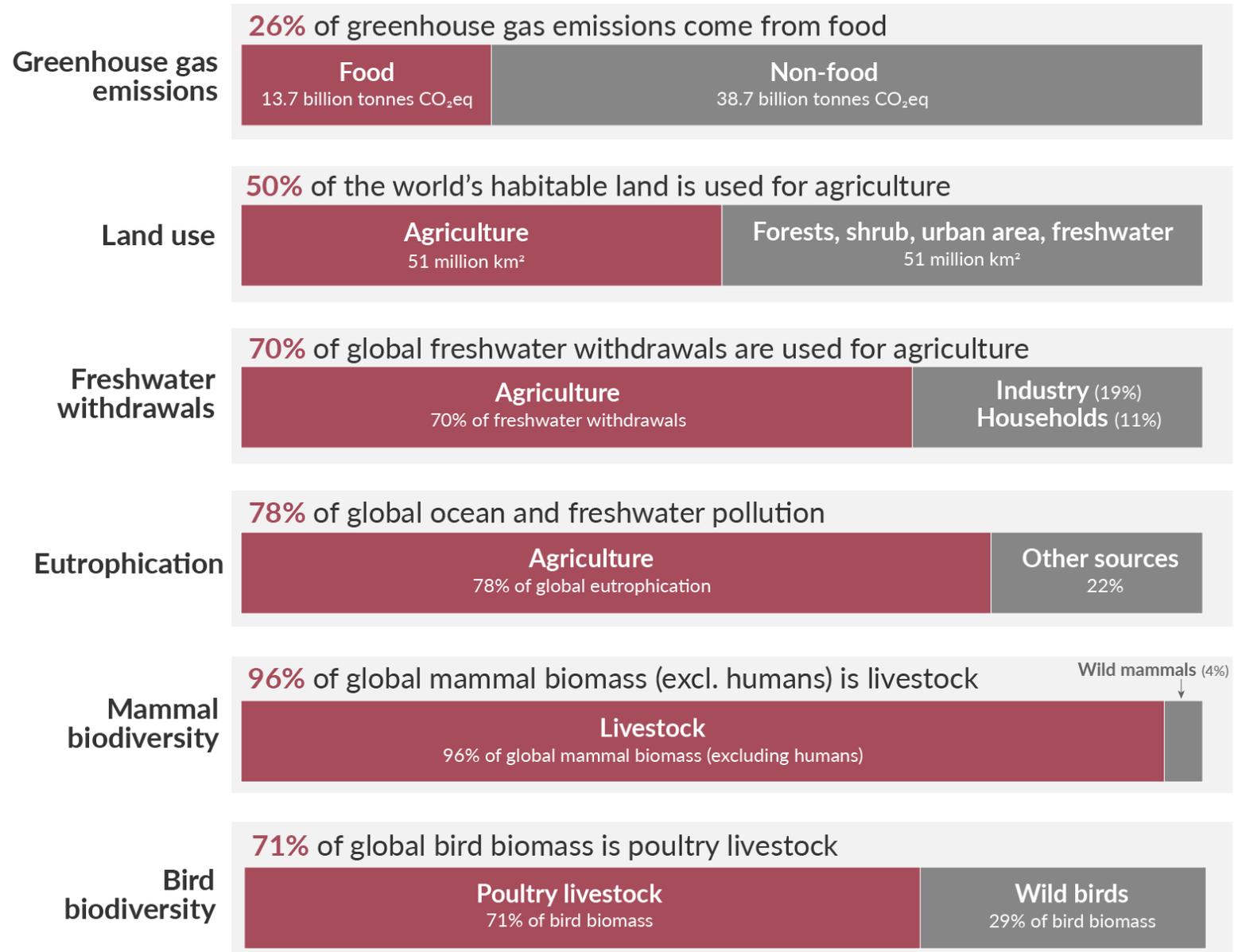
Our World  
in Data

"Overweight" is defined here as having a body mass index (BMI) equal to or greater than 25. BMI is a person's weight in kilograms divided by their height in meters squared.



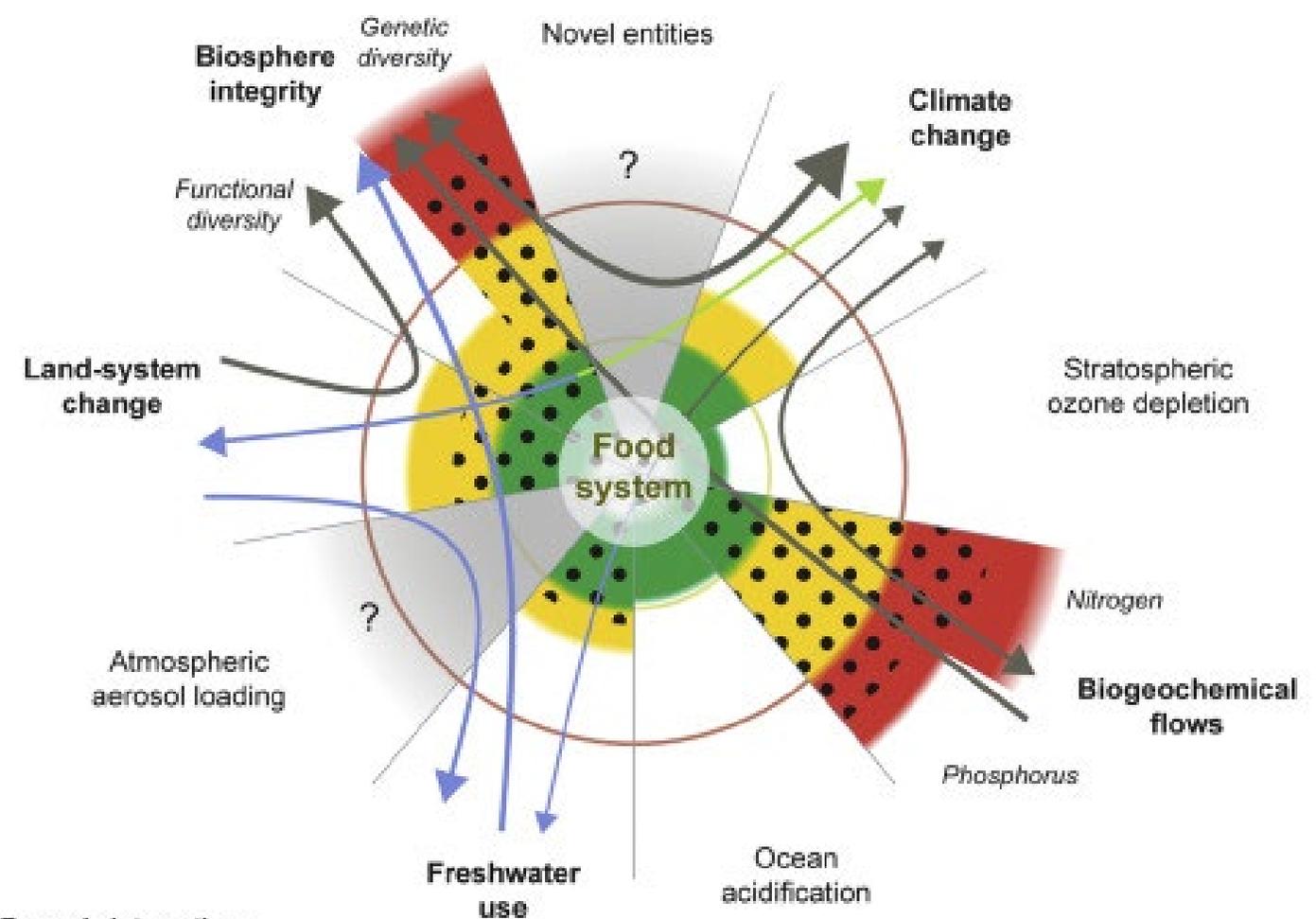
# Environmental implications

Our food systems have a huge environmental impacts in terms of land, water, energy, biodiversity, and ecosystems.



# Environmental implications

Food systems contribute in transgressing several planetary boundaries.



**Example interactions:**

- Climate change → Freshwater use → Biosphere integrity: Climate change impacts freshwater directly and through land-system change, and changes in freshwater availability again on Biosphere integrity (Aquatic biodiversity) --> this impacts on the food system by e.g. reducing irrigation water availability
- Land-system change → Climate change: Changes in land-system have direct impacts on climate change --> e.g. reduced forest cover leads to warming and reduces precipitation, which again have impacts on food production, for example

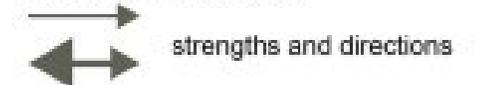
**Planetary boundary status**

- Beyond zone of uncertainty (high risk)
- In zone of uncertainty (increasing risk)
- Below boundary (safe)
- Boundary not yet quantified

**Role of agriculture**



**Boundary interactions**





# FOOD SYSTEM AND CLIMATE CHANGE

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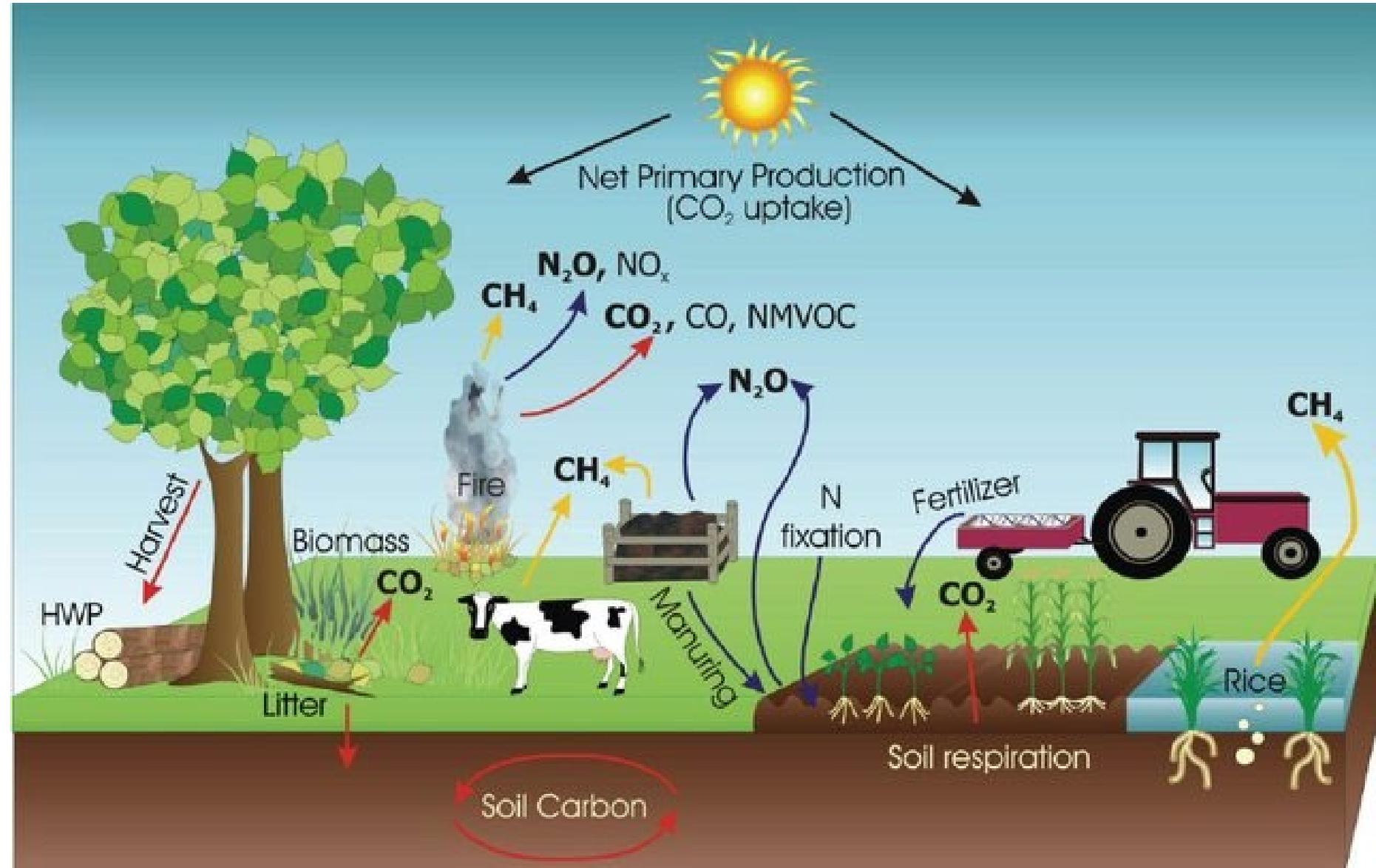
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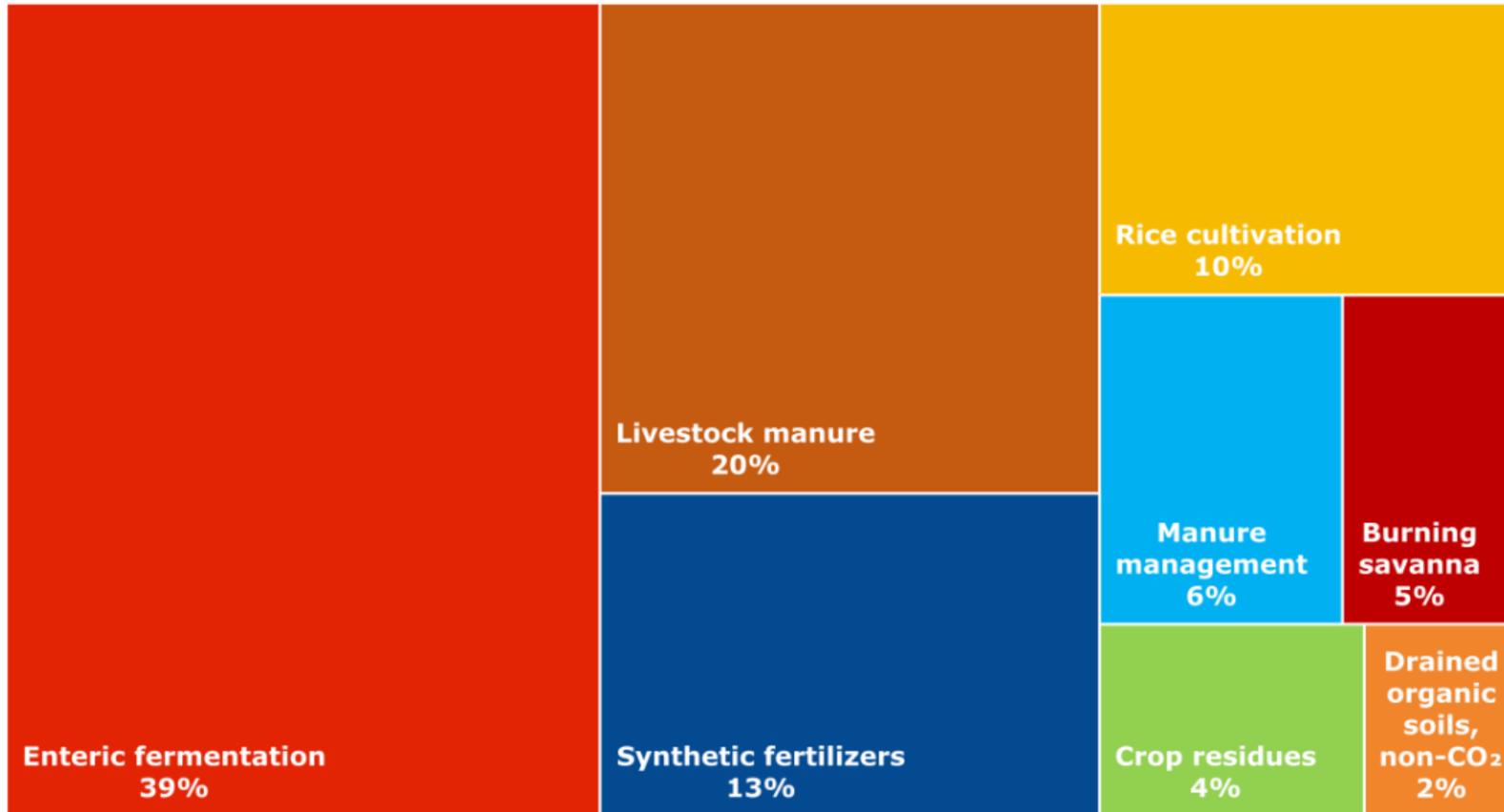
# What are the sources of greenhouse gas emissions in food system?

Which are the main GHG gases the food system emits?

# Food system emissions



# Food system emissions



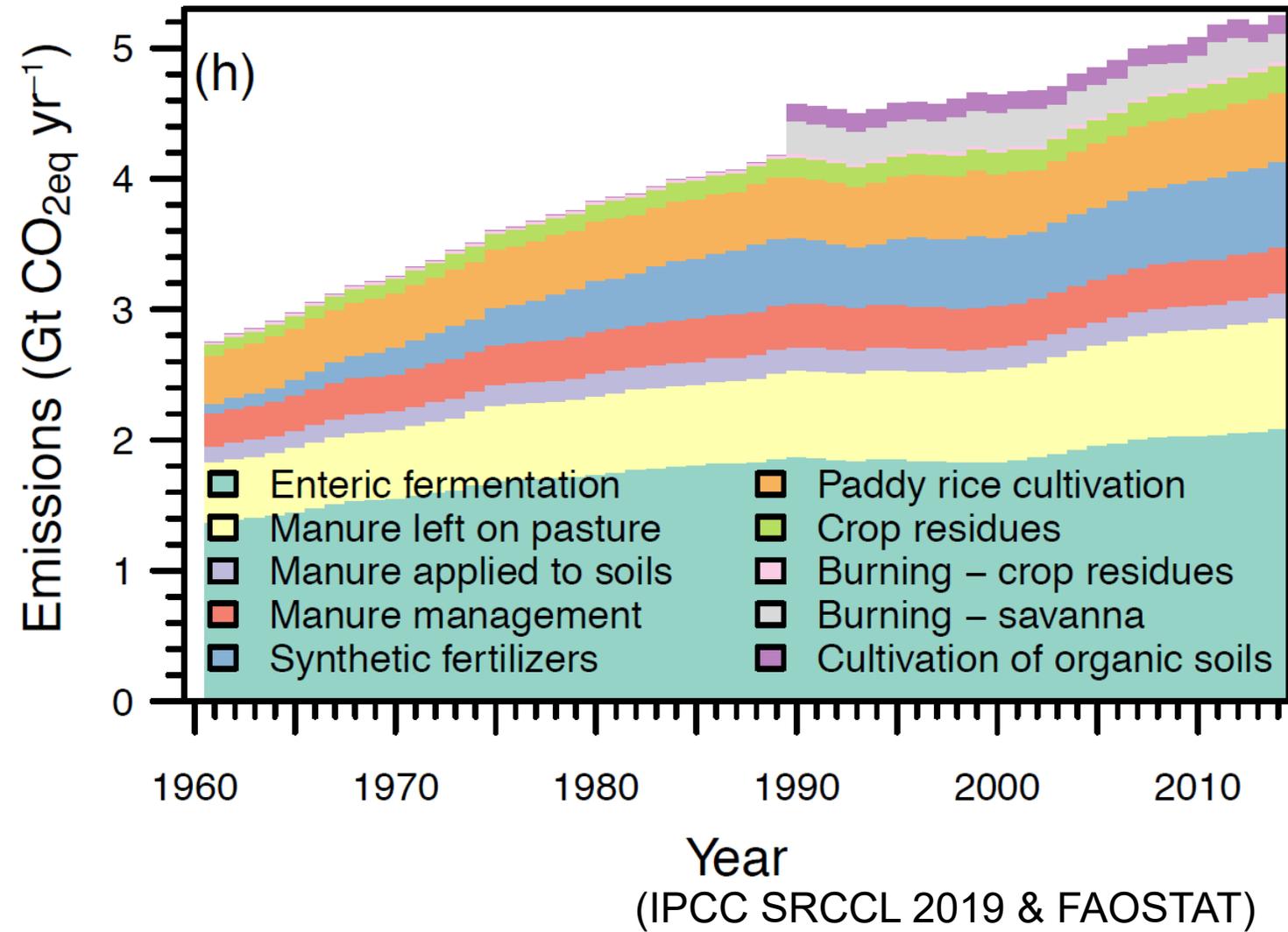
Source: FAOSTAT 2020.



**Crippa et al. (2021)**

17.9 billion tonnes CO<sub>2</sub>e from food\*  
 That's 34% of global GHG emissions  
 (\*some non-food agricultural products included)

NGHGI Sector	Activity	GHG Emitted			FAO		
		CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub>			
AFOLU	LULUCF	Forest Conversion to Other Land Uses and Burning Biomass	x	x	x	LAND USE CHANGE	
		Peat Fires	x		x		
		Drained Organic Soils	x		x		
	AGRICULTURE	FARM GATE	Burning - Crop residues	x	x	AGRICULTURAL LAND	
			Burning - Savanna	x	x		
			Crop Residues		x		
			Drained Organic Soils		x		
			Enteric Fermentation	x			
			Manure Management	x	x		
			Manure Applied to Soils		x		
			Manure Left on Pasture		x		
			Rice Cultivation	x			
			Synthetic Fertilizers		x		
ENERGY AND IPPU	PRE AND POST PRODUCTION	On-farm Energy Use	x	x	x		
		Food Transport	x	x	x		
		Processing	x	x	x		
		Packaging	x	x	x		
		Refrigeration	x	x	x		
		Retail	x	x	x		
		Cooking	x	x	x		
WASTE	PRE AND POST PRODUCTION	Fertilizer manufacturing and other pre-production	x	x	x		
		Solid Food Waste	x				
		Incineration			x		
		Industrial Wastewater	x	x			
	Domestic Wastewater	x	x				



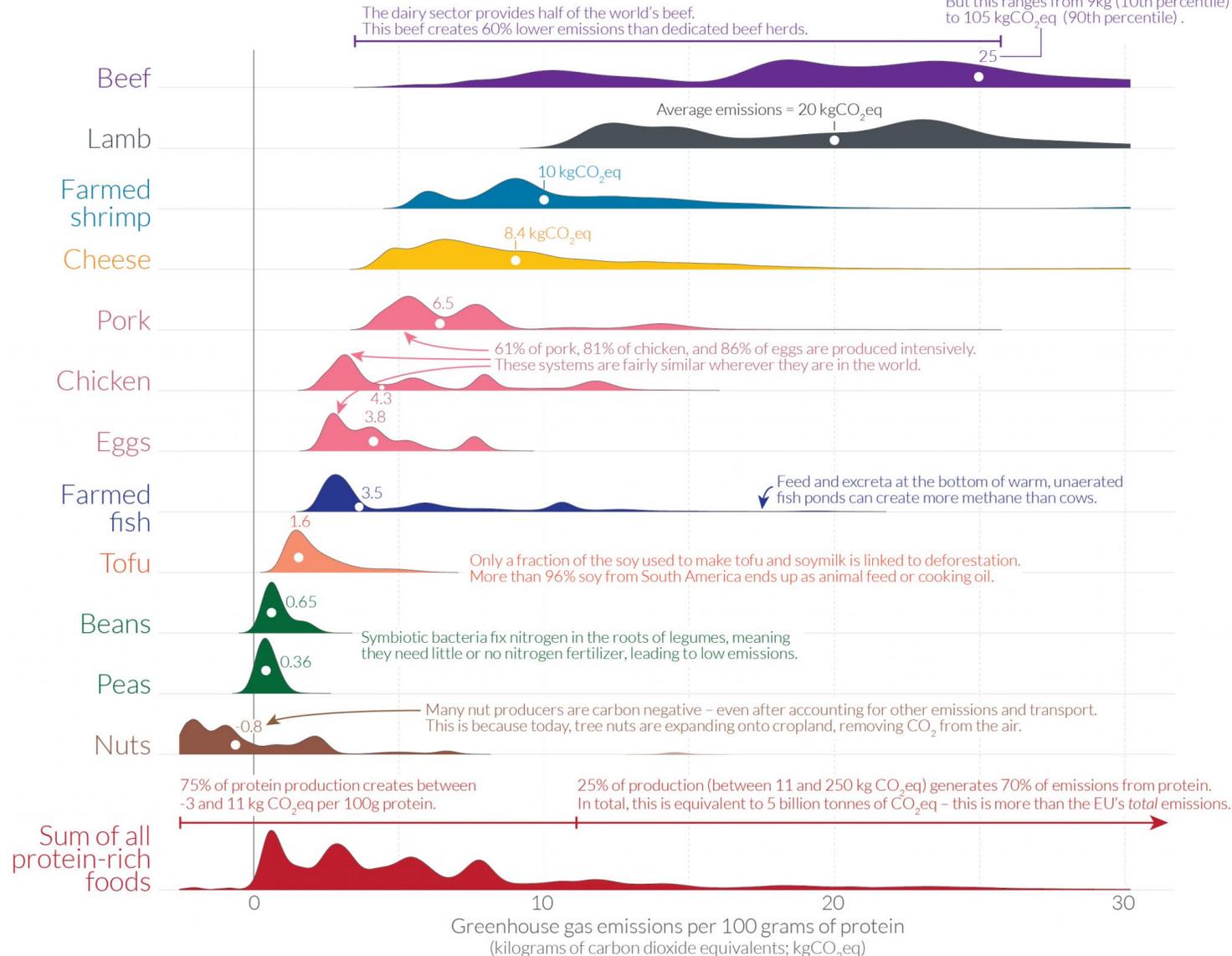
Agriculture, forestry and other land uses (AFOLU)  
National GHG inventory (NGHGI)  
land use, land use change and forestry (LULUCF)  
Industrial Processes and Product Use (IPPU)  
(Tubiello et al. 2021, ERL)

# How does the carbon footprint of protein-rich foods compare?

Greenhouse gas emissions from protein-rich foods are shown per 100 grams of protein across a global sample of 38,700 commercially viable farms in 119 countries. The height of the curve represents the amount of production globally with that specific footprint. The white dot marks the median greenhouse gas emissions for each food product.

Producing 100 grams of protein from beef emits 25 kilograms of CO<sub>2</sub>eq, on average. But this ranges from 9kg (10th percentile) to 105 kgCO<sub>2</sub>eq (90th percentile).

Animal-source foods emits more greenhouse gas than plant-based foods.



Note: Data refers to the greenhouse gas emissions of food products across a global sample of 38,700 commercially viable farms in 119 countries. Emissions are measured across the full supply-chain, from land use change through to the retailer and includes on-farm, processing, transport, packaging and retail emissions. Data source: Joseph Poore and Thomas Nemecek (2018). Reducing food's environmental impacts through producers and consumers. *Science*. OurWorldinData.org – Research and data to make progress against the world's largest problems. Licensed under CC-BY by the authors Joseph Poore & Hannah Ritchie.



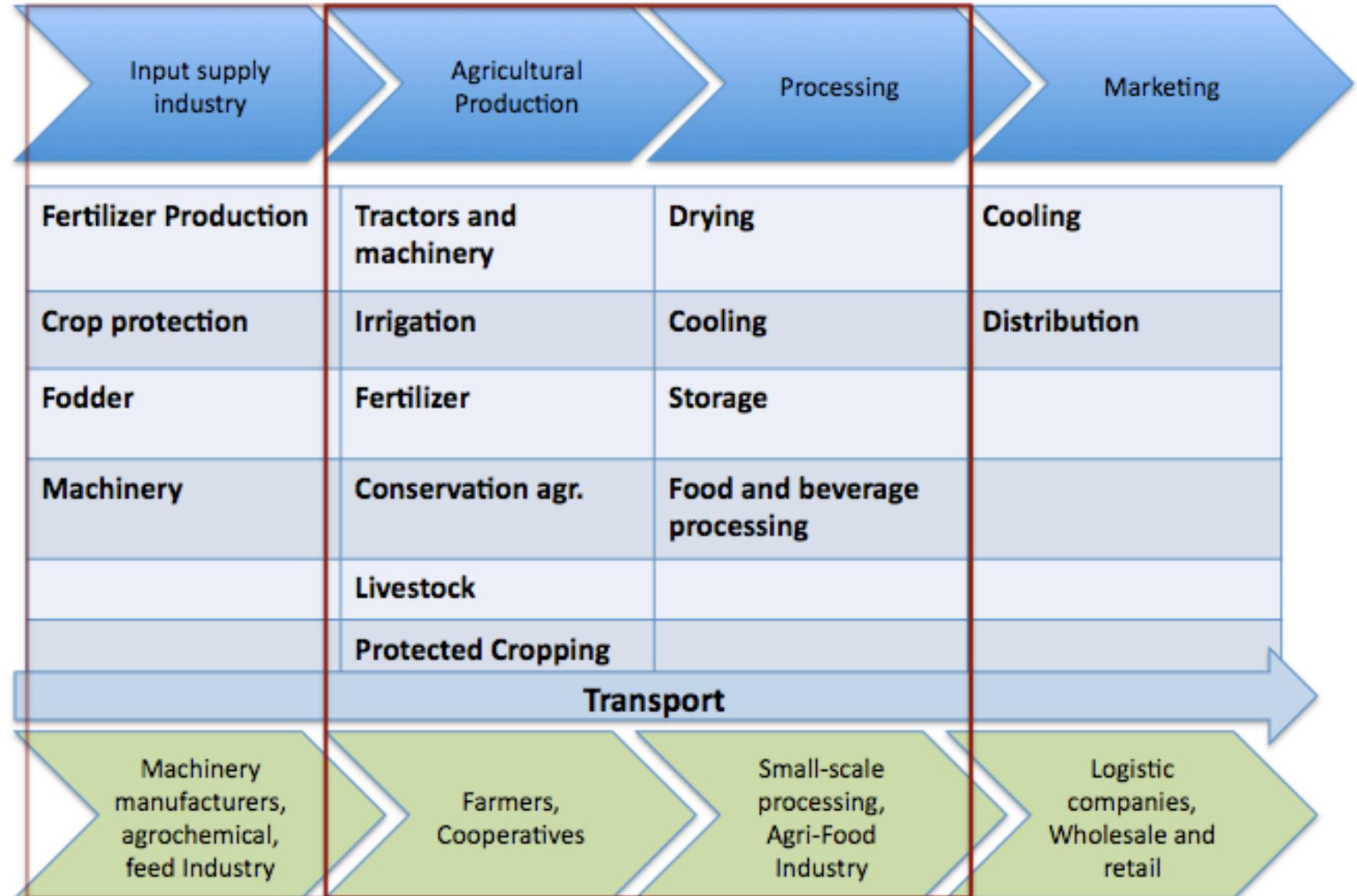
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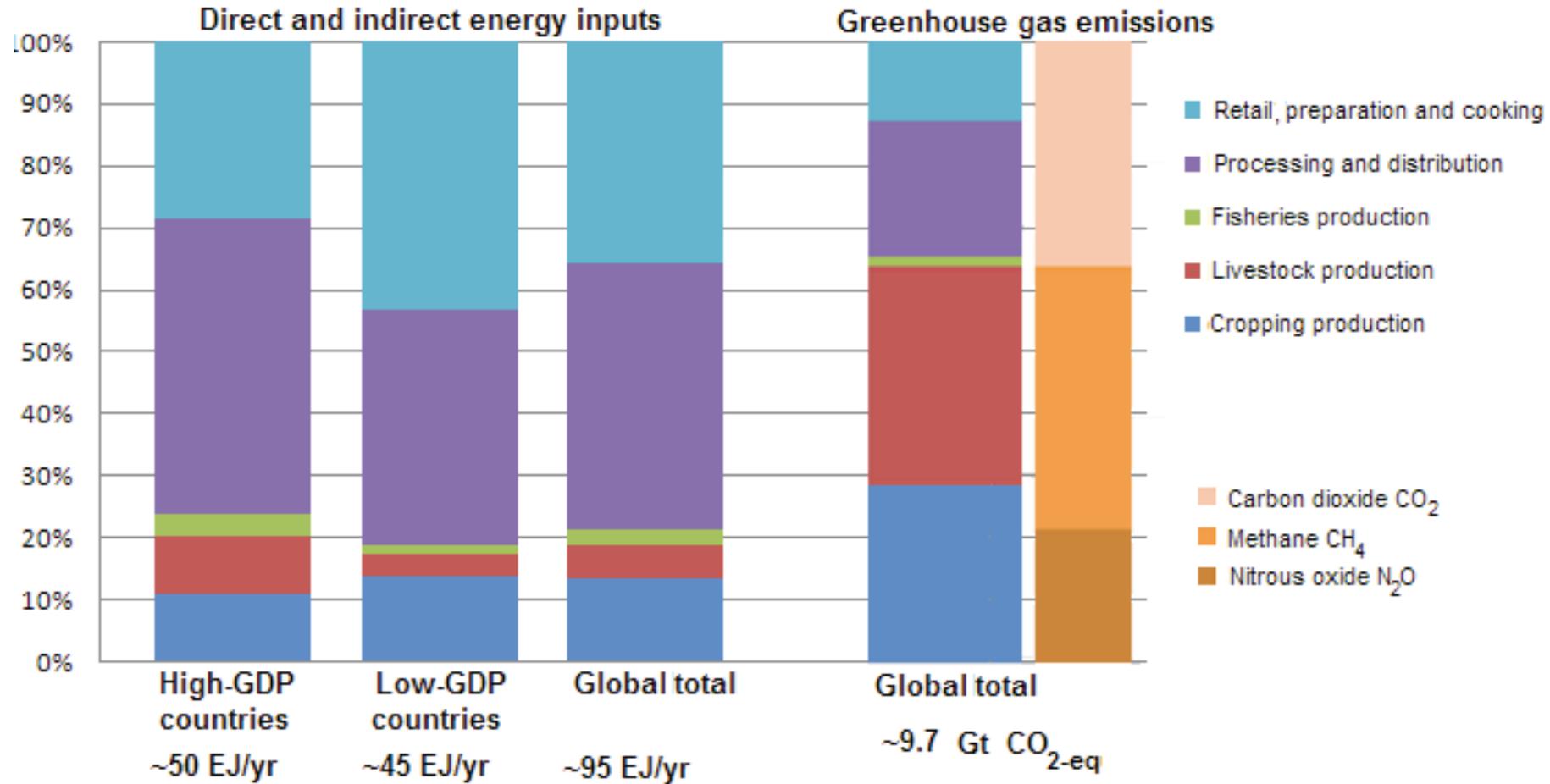
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# Energy for food

# Energy consumption within food supply chain

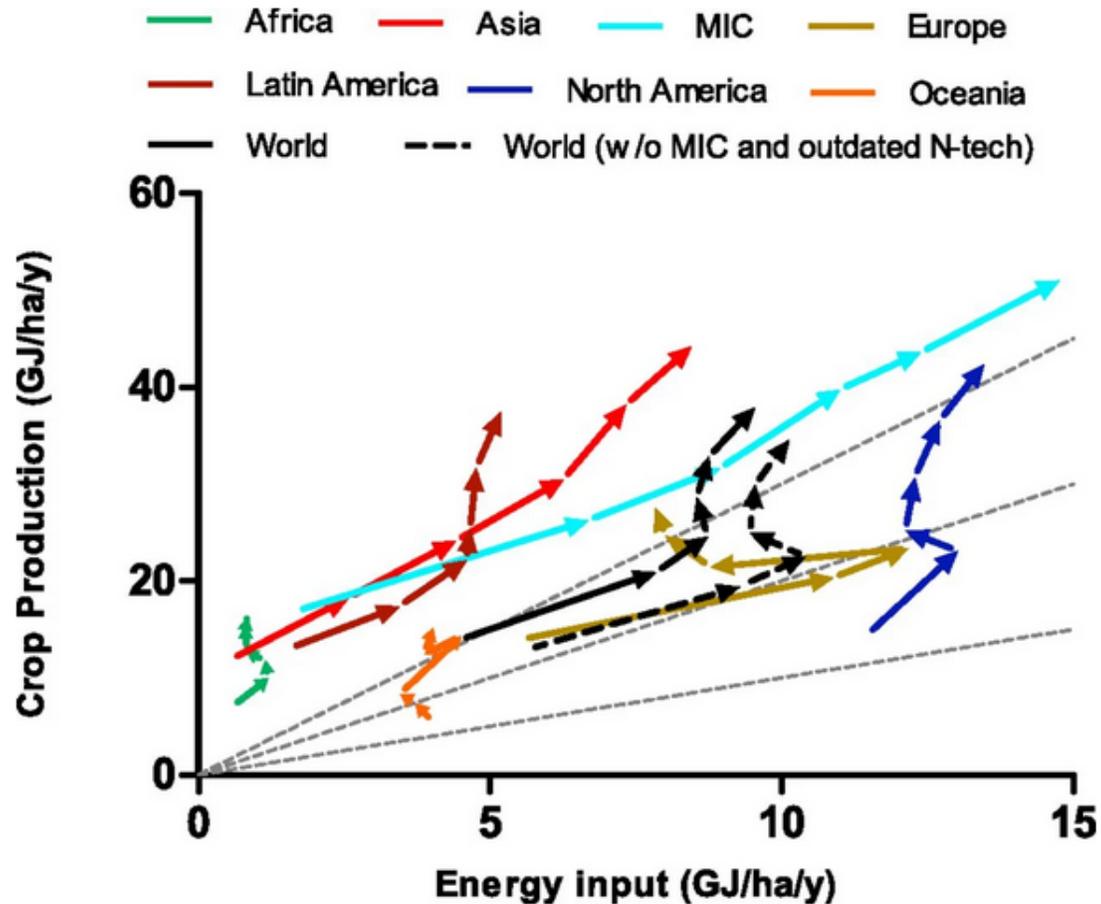


Food consumes about 30% of global energy



FAO, 2011: “Energy-smart” food for people and climate – Issue Paper: <http://www.fao.org/docrep/014/i2454e/i2454e00.pdf>

# Energy use for food varies



(Pellegrini and Fernández 2018, PNAS)

**Total primary energy use (PEU) per tonne of food products produced and imported to UK**  
(Webb et al. 2013)

PEU<sup>a</sup> GJ/t

UK    non-UK

Tomatoes (loose classic), Spain		
Pre-farm gate total	34.1	4.4
Transport to the UK	NA	3.6
Total	36.2	9.6

Strawberries, Spain		
Pre-farm gate total	12.9	8.3
Transport to the UK	NA	3.0
Total	14.6	13.3

Early potatoes, Israel		
Pre-farm gate total	1.5	1.9
Transport to the UK	NA	8.6
Total	2.8	10.5

Apples, New Zealand		
Pre-farm gate total	2.1	1.2
Transport to the UK	NA	7.5
Total	5.1	11.2

Lamb, New Zealand		
Pre-farm gate total	17.9	12.2
Transport to the UK	NA	7.5
Total	30.7	37.0

Poultry, Brazil		
Pre-farm gate total	15.9	12.2
Transport to the UK	NA	4.1
Total	21.1	24.7

Beef, Brazil		
Pre-farm gate total	41.3	7.8
Transport to the UK	NA	4.0
Total	44.4	17.1



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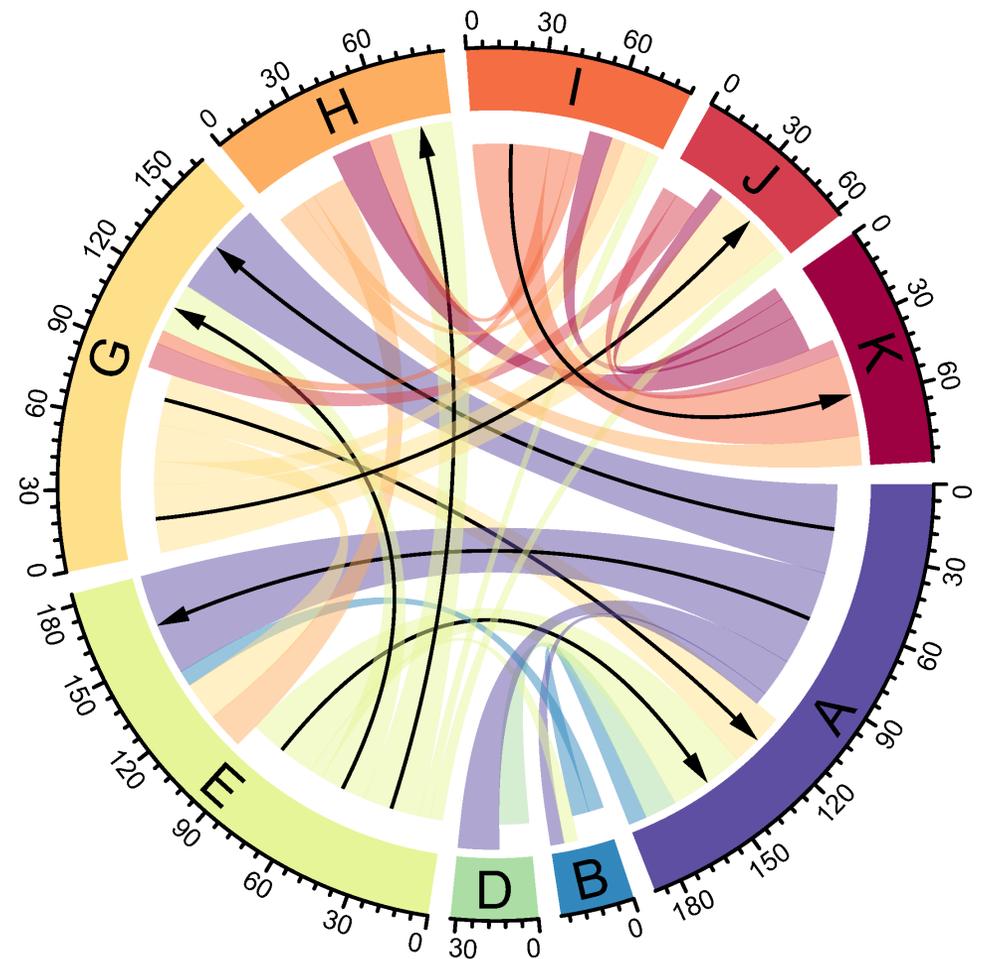
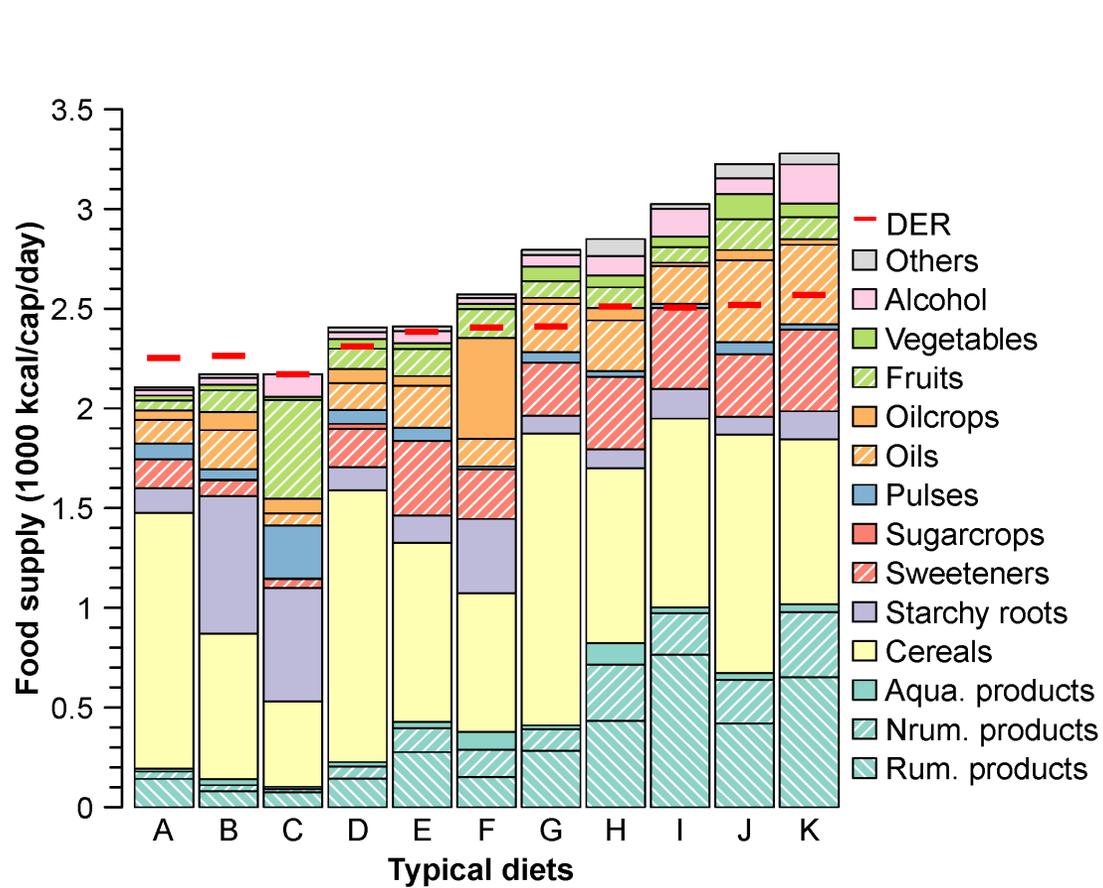
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# How have our diets changed in last decades?

Reflect on the food you have during childhood and now.

# Dietary changes



(Pradhan and Kropp 2020, Sustainability)



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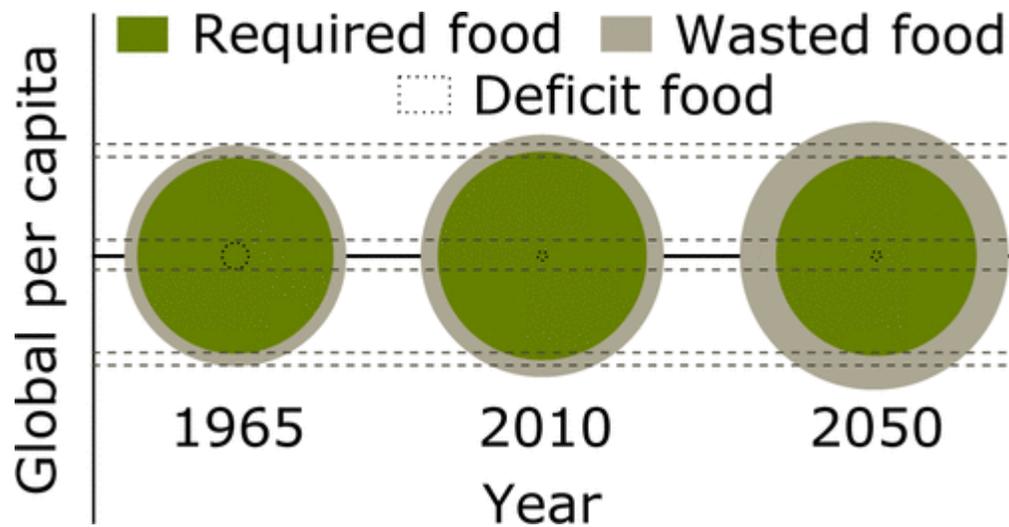
# Was there food left today after your lunch?

Reflect on how much food do we waste or loss.

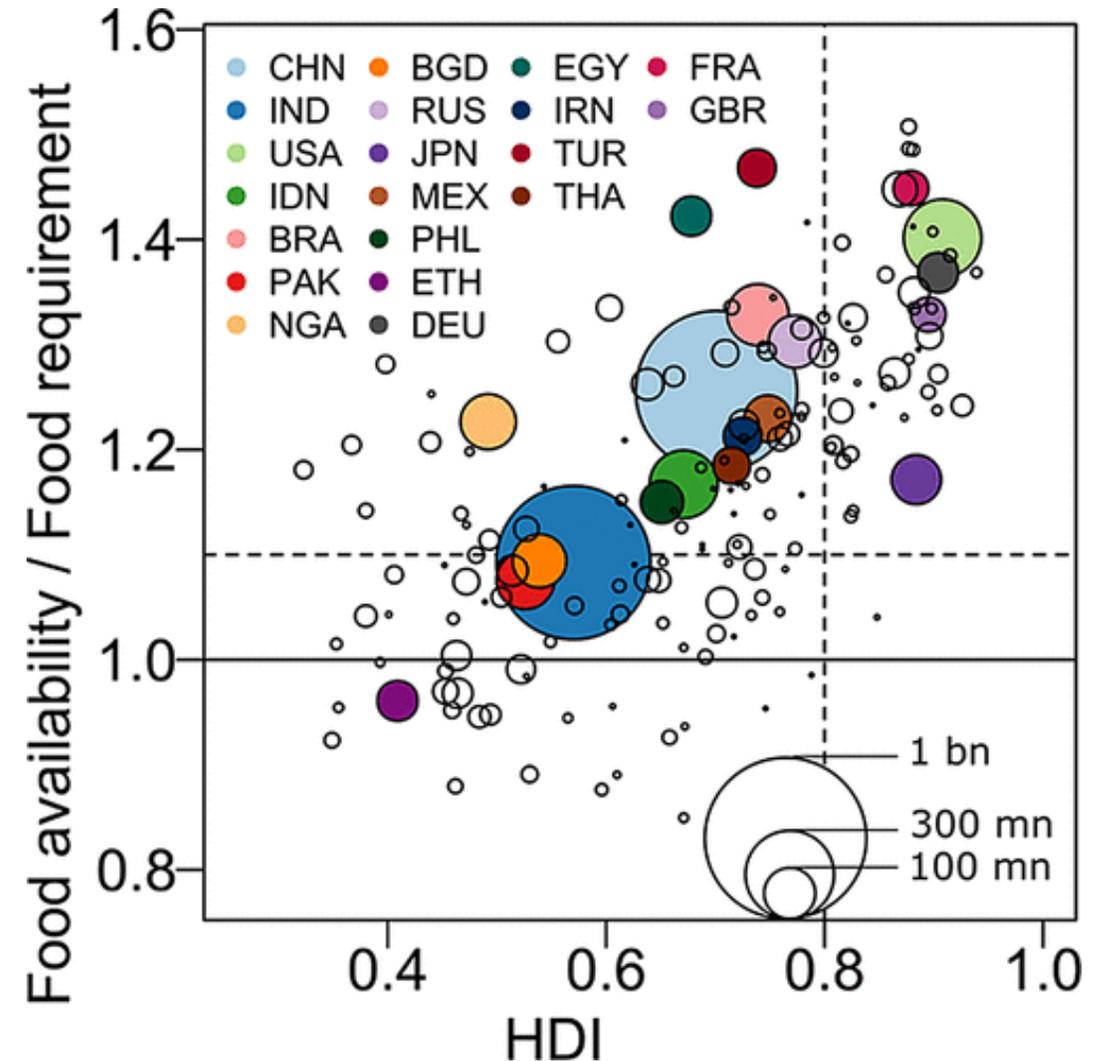
# Food loss and waste

- › 30%- 40% of food is lost and wasted in both developing and developed countries (Godfray et al. 2010)
- › food is lost and wasted across various stages of the food supply chain (FAO 2011)
- › food loss is food decreased during production, post-harvest, and processing
- › food waste is food discarded at the consumer level

# Food waste and human development index (HDI)



(Hic et al. 2016, ES&T)





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# How can we transform our food systems?

# Food systems response options

Multiple options are available to transform food systems with mitigation, adaptation and other co-benefits.

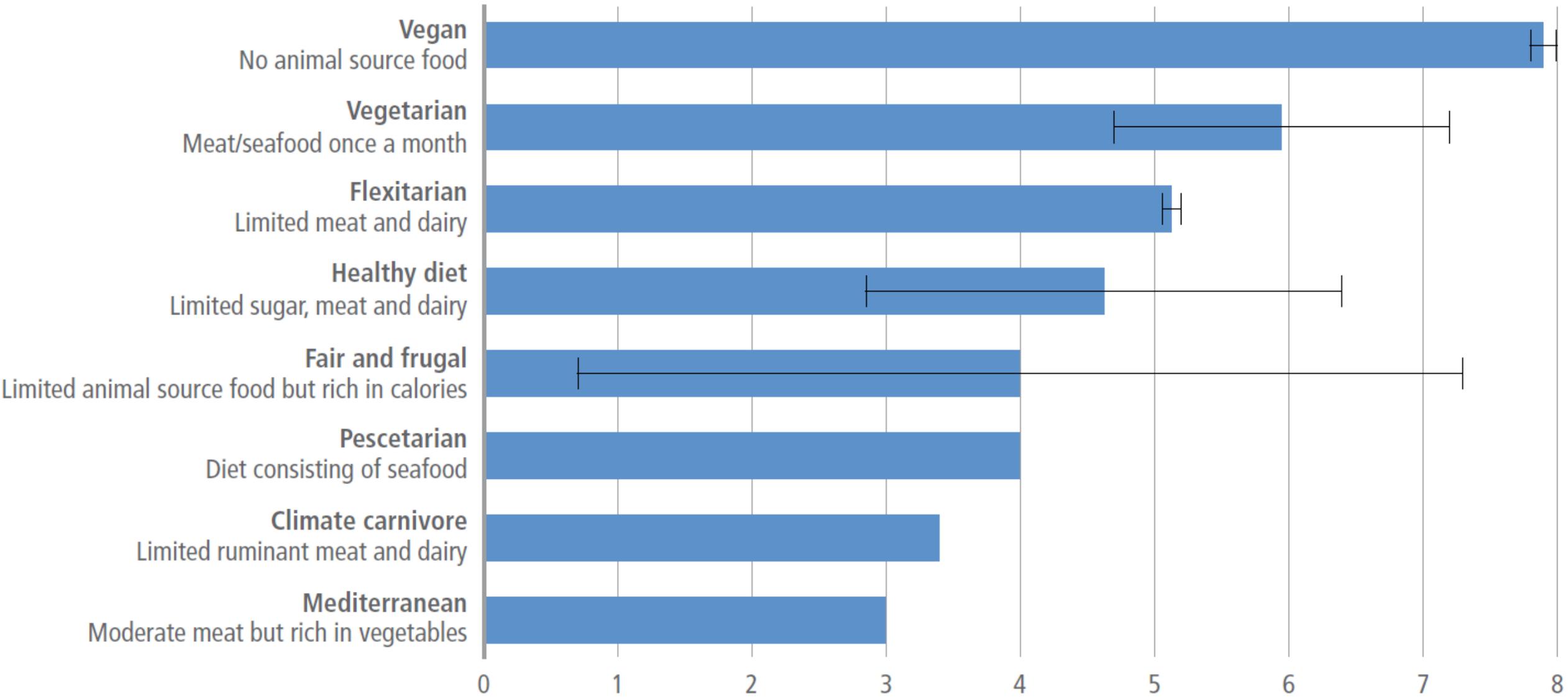
(Rosenzweig et al. 2020, Nature Food)



Mitigation and adaptation potential: None (Grey), Limited (Light Green), High (Medium Green), Very high (Dark Green)

# Demand-side mitigation

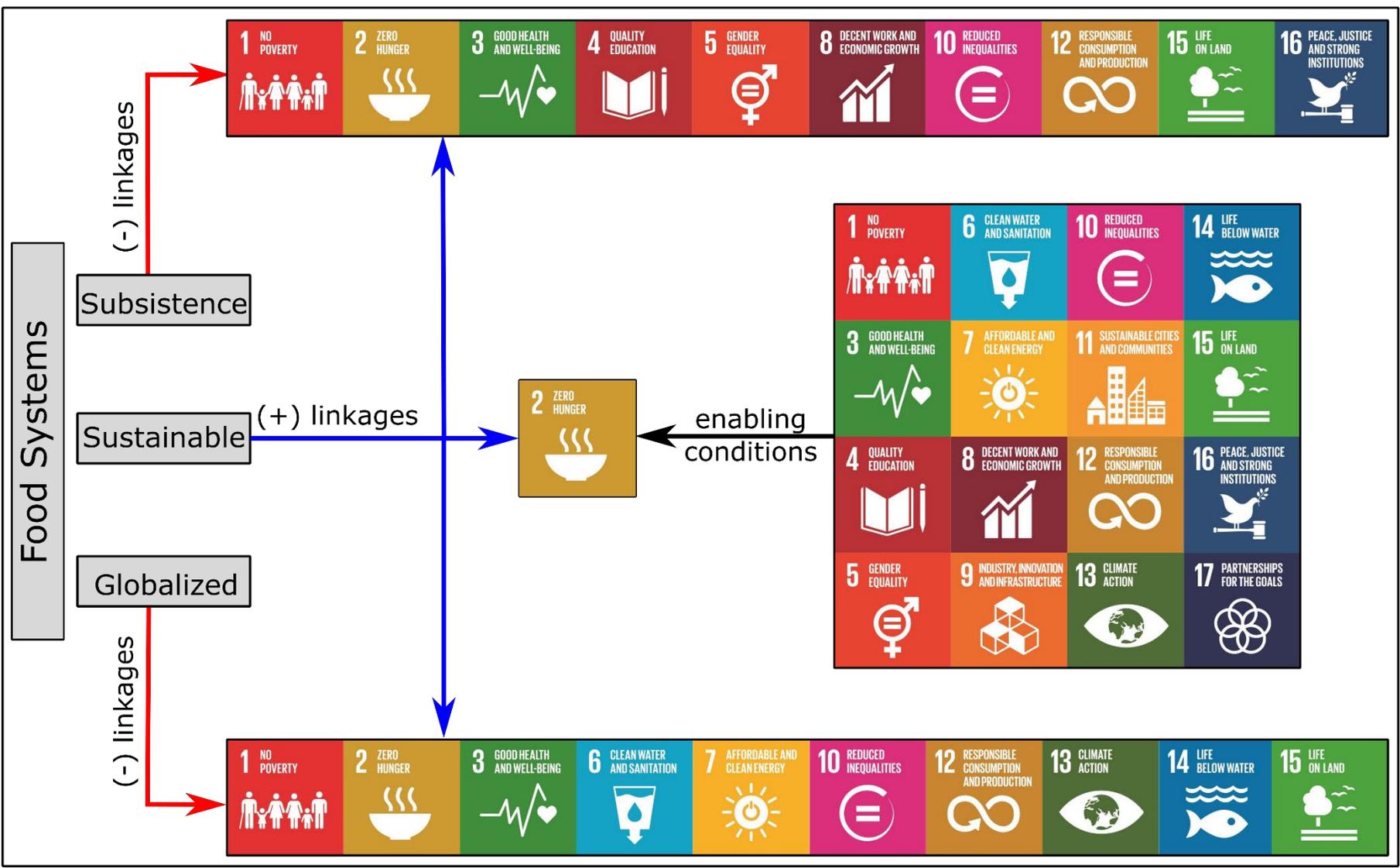
## GHG mitigation potential of different diets



(IPCC 2019, SRCCL)

Demand-side GHG mitigation potential (GtCO<sub>2</sub>-eq yr<sup>-1</sup>)

# Sustainable food systems and SDGs



# Recap

- › Concept of food system
- › Environmental impacts from the food system
- › Greenhouse gas emissions from the food system
- › Response options for the food system transformation

**ED82.9013 Selected Topic: Sustainability  
– Introduction, Analysis, and Practices**