FOOD SYSTEMS & GLOBAL CHANGE

Healthy diet transitions, alternative proteins and GHG policy

Mario Herrero and Daniel Mason-D'Croz

Cornell CALS
College of Agriculture and Life Sciences

The key issues

Malnutrition

More than 200 million children under five still face a life adversely affected by early years of undernutrition.[3]

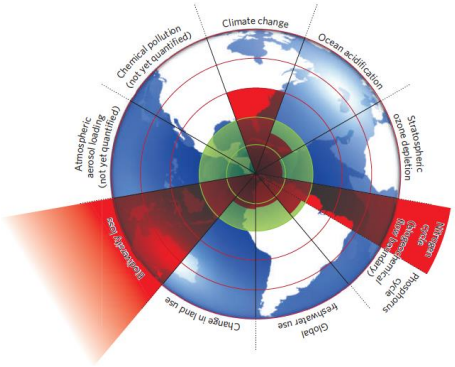
NCDs and their costs

The burden of diet-related disease is highest in LMICs; for diabetes alone, by 2030 (assuming present trends) the annual economic impact for East Asia and the Pacific region is expected to reach almost US$800 billion, and US$52 billion in sub-Saharan Africa.[4]

Climate change

A low-income country with an annual average temperature today of 25°C could see a fall in national economic growth (Gross Domestic Product or GDP) of 1.2% for each 1°C increase in temperature.[8]

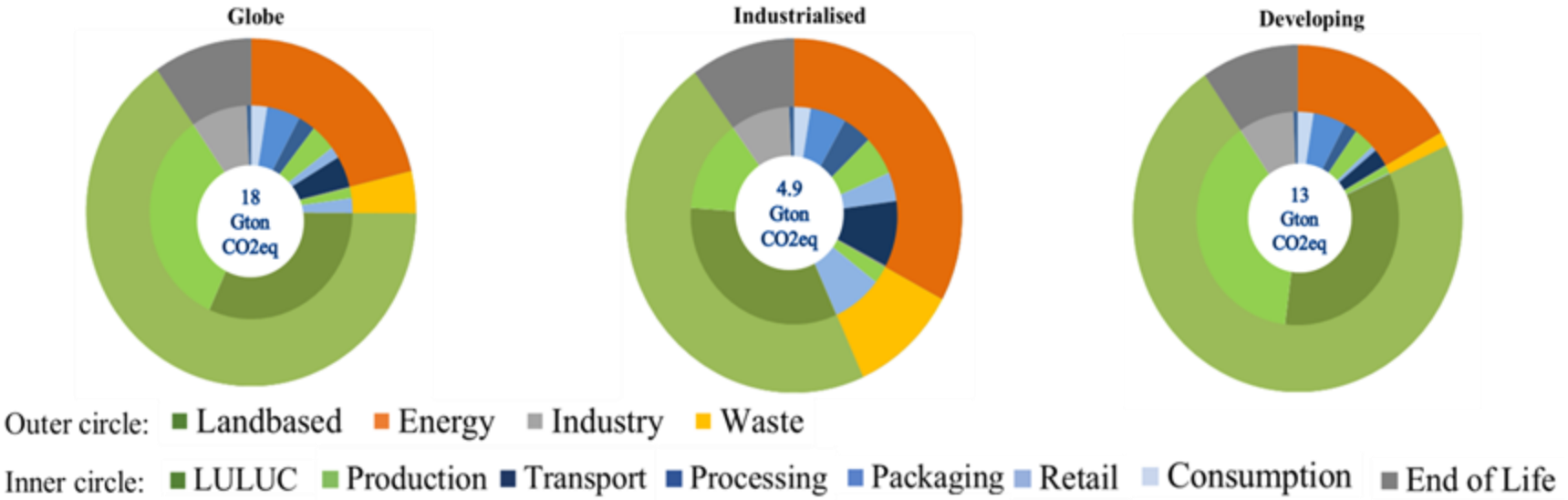
Environmental degradation



+ power asymmetries and policy distortions!

Rockstrom et al 2009, Rosenzweig et al. 2020, GLOPAN 2020

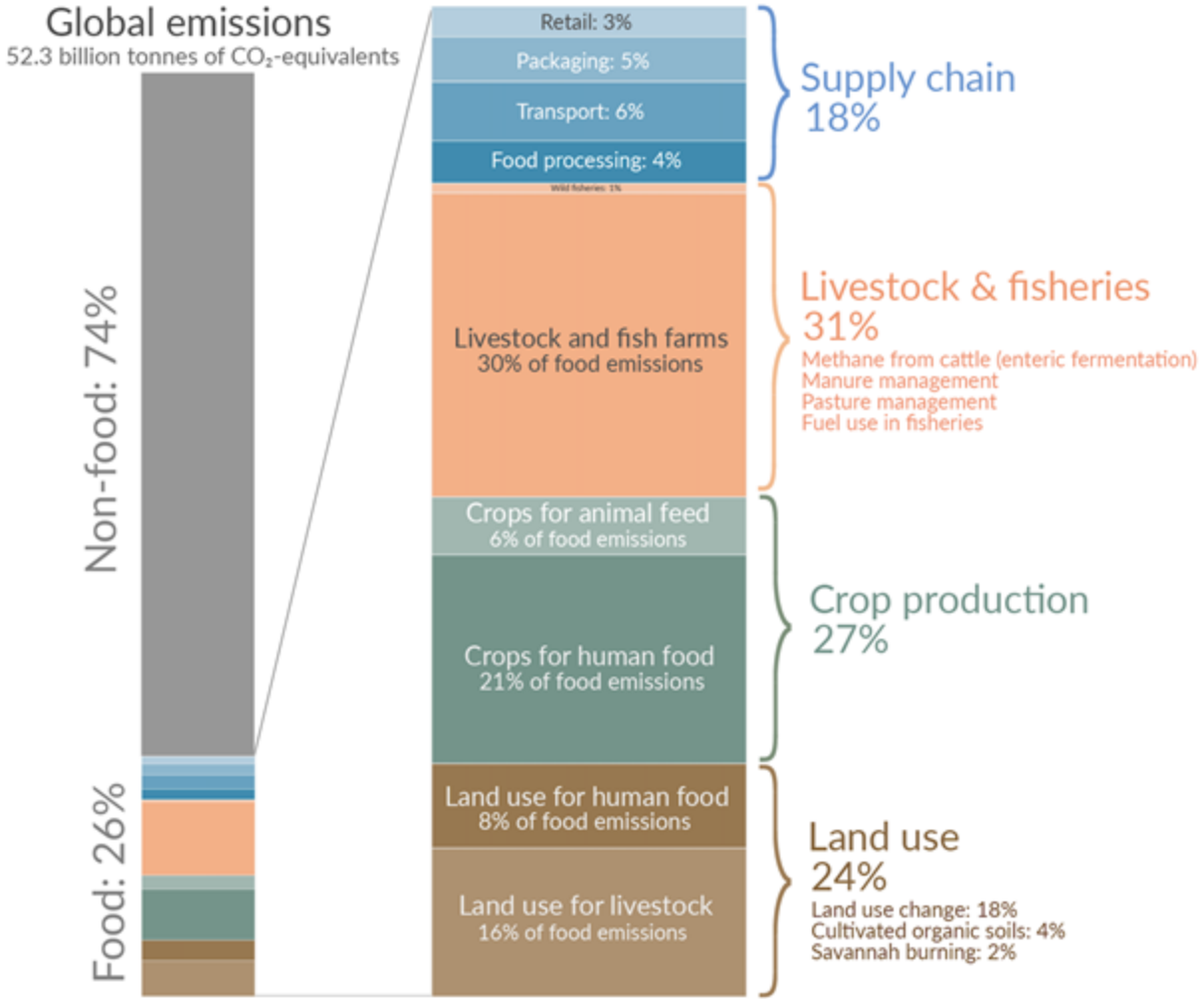
Food systems emit 1/3 of global anthropogenic GHG



Source:
Crippa et al. 2021

Breaking it down

global GHG from food production



source:
Poore & Nemecek 2018

Source: Tilman and Clark, Nature 2014

what we eat

impacts the environment & our health

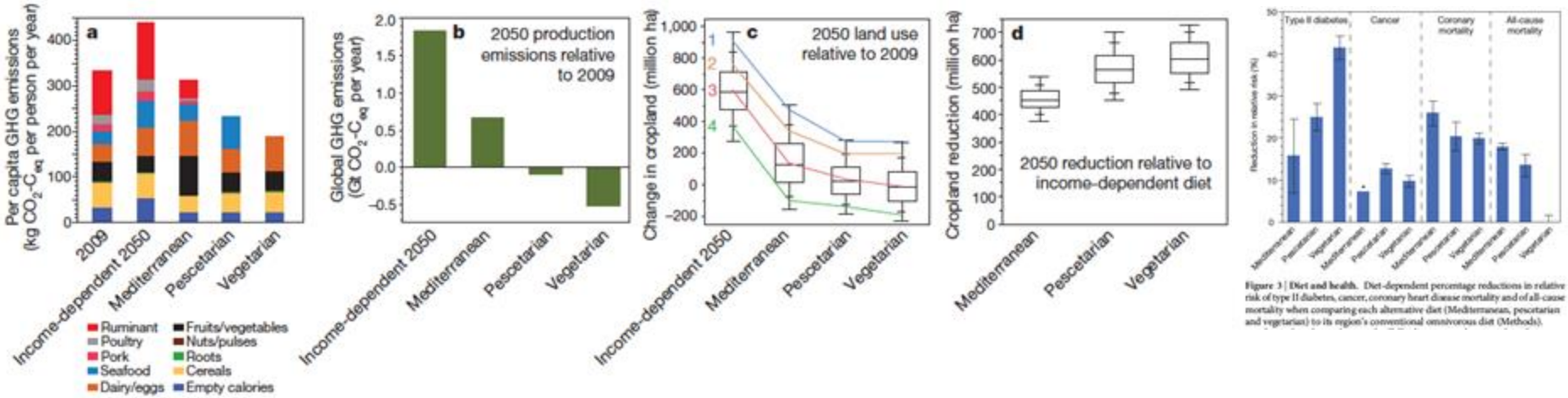
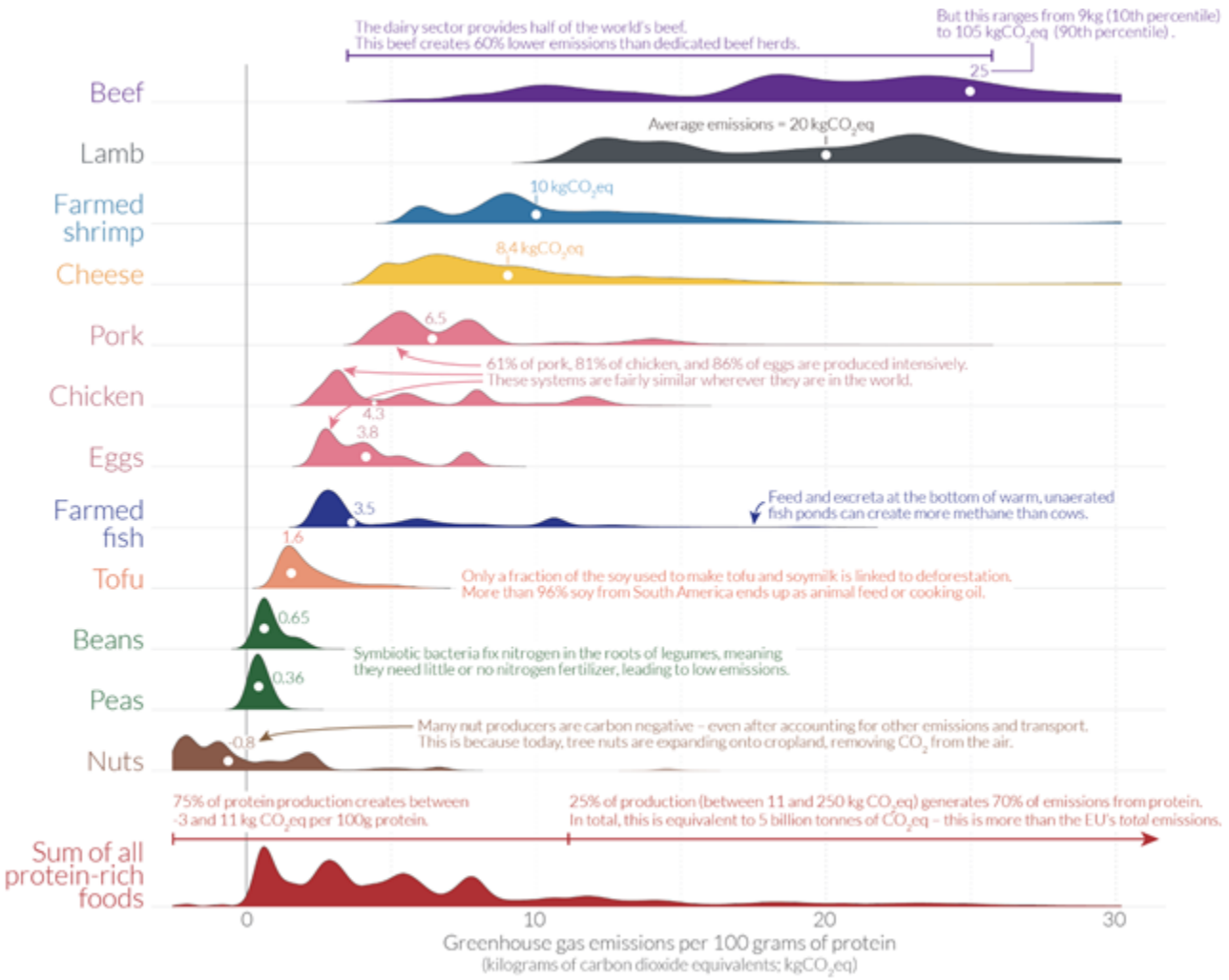


Figure 3 | Diet and health. Diet-dependent percentage reductions in relative risk of type II diabetes, cancer, coronary heart disease mortality and of all-cause mortality when comparing each alternative diet (Mediterranean, pescetarian and vegetarian) to its region's conventional omnivorous diet (Methods).

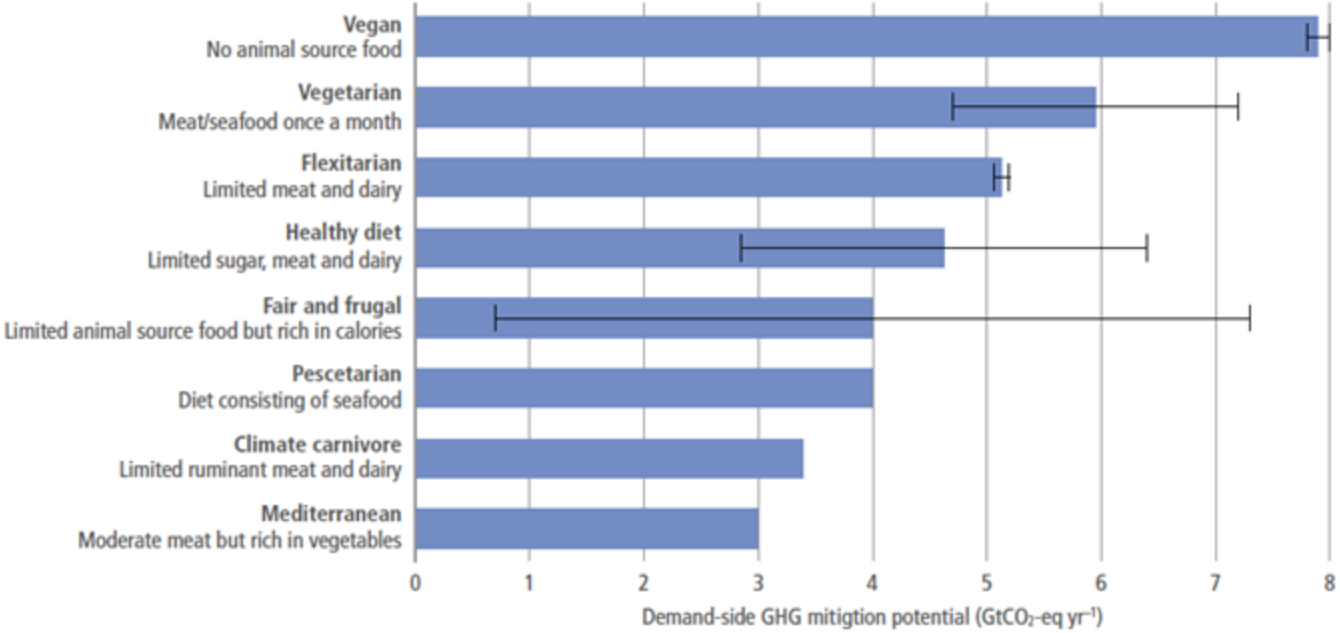
… but large differences in the carbon footprint of the same foods

source:
Poore & Nemecek 2018



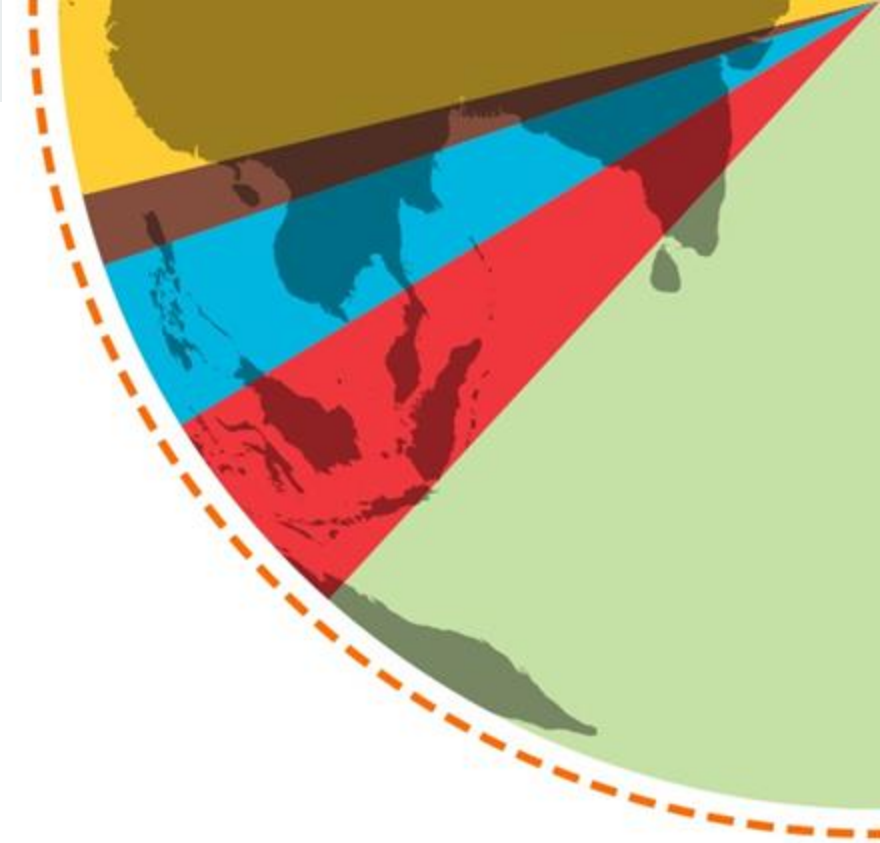
Source: Mbow et al. IPCC SRCCL 2019, Herrero et al 2016

technical mitigation potential of **changing diets**



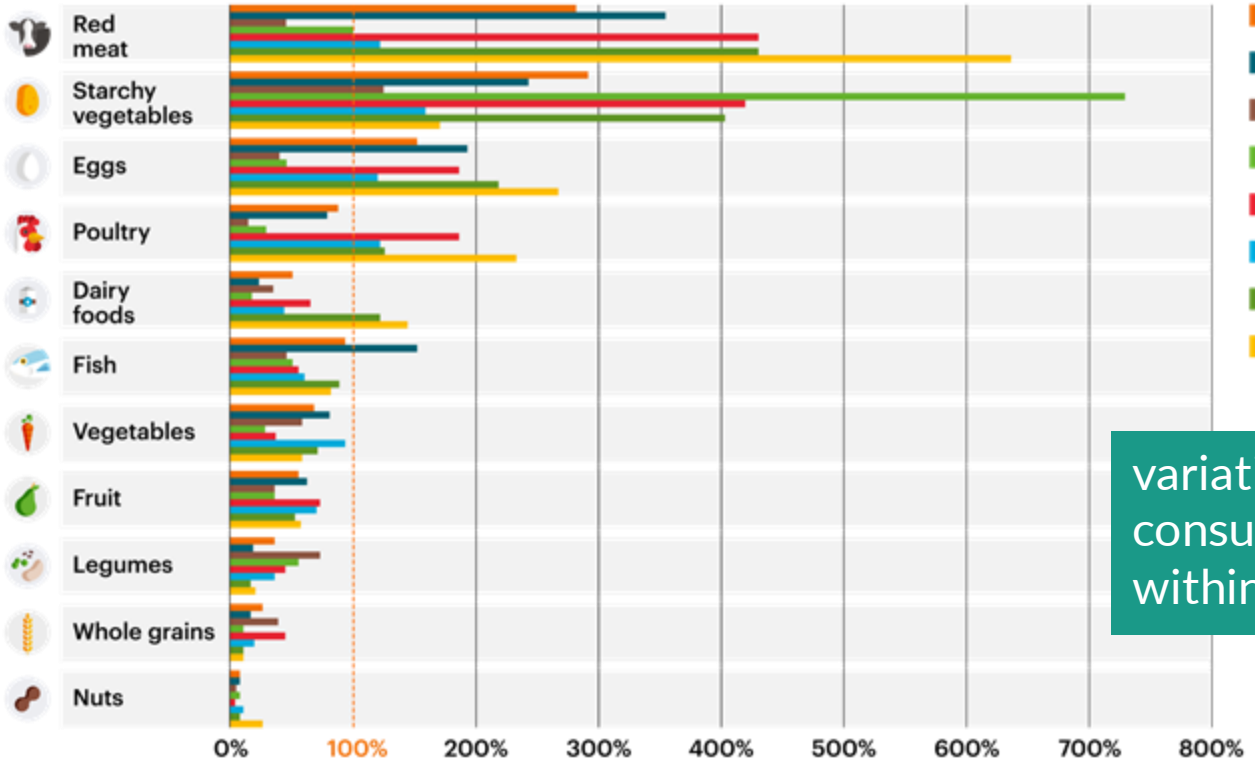
EAT-Lancet Commission
on Healthy Diets From
Sustainable Food Systems

Food Planet Health



source: Willett et al 2019, The Lancet

current intakes vs planetary health diet



variation in under- / over-consumption of products within & between regions

EAT-Lancet **scenarios**

			GHG emissions	Cropland use	Water use	Nitrogen application	Phosphorus application	Biodiversity loss
Food production boundary			5.0 (4.7–5.4)	13 (11.0–15.0)	2.5 (1.0–4.0)	90 (65.0–140.0)	8 (6.0–16.0)	10 (1–80)
Baseline in 2010			5.2	12.6	1.8	131.8	17.9	100–1000
Production (2050)	Waste (2050)	Diet (2050)						
BAU	Full waste	BAU	9.8	21.1	3.0	199.5	27.5	1,043
BAU	Full waste	Dietary shift	5.0	21.1	3.0	191.4	25.5	1,270
BAU	Halve waste	BAU	9.2	18.2	2.6	171.0	23.2	684
BAU	Halve waste	Dietary shift	4.5	18.1	2.6	162.6	21.2	885
PROD	Full waste	BAU	8.9	14.8	2.2	187.3	25.5	206
PROD	Full waste	Dietary shift	4.5	14.8	2.2	179.5	24.1	351
PROD	Halve waste	BAU	8.3	12.7	1.9	160.1	21.5	50
PROD	Halve waste	Dietary shift	4.1	12.7	1.9	151.7	20.0	102
PROD+	Full waste	BAU	8.7	13.1	2.2	147.6	16.5	37
PROD+	Full waste	Dietary shift	4.4	12.8	2.1	140.8	15.4	34
PROD+	Halve waste	BAU	8.1	11.3	1.9	128.2	14.2	21
PROD+	Halve waste	Dietary shift	4.0	11.0	1.9	121.3	13.1	19

not only about diets — increases in **productivity** + **waste reduction** essential for achieving targets

‘90% of the $4.3 trillion annual costs of healthcare in the US is due to non-communicable diseases for which diet is a key risk factor’

Volpp et al. 2023 Circulation

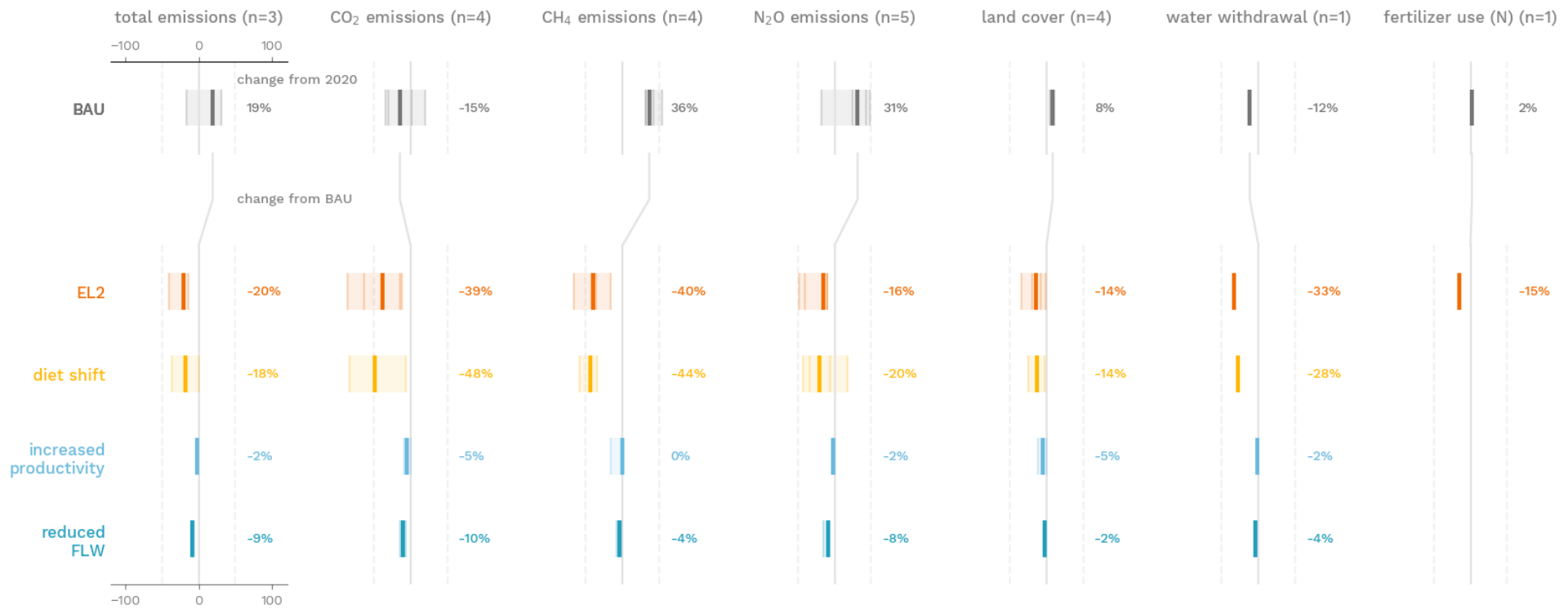
Willett et al. 2019

Eat-Lancet 2.0

- Broader
- Includes socio-economics and justice elements explicitly: jobs, wages, affordability of diets
- Diets and planetary boundaries revised
- Multi-model ensembles
- Case studies (circularity, trade, mitigation, micronutrients and others)

Preliminary multi-model ensemble environmental results for agriculture, 2050

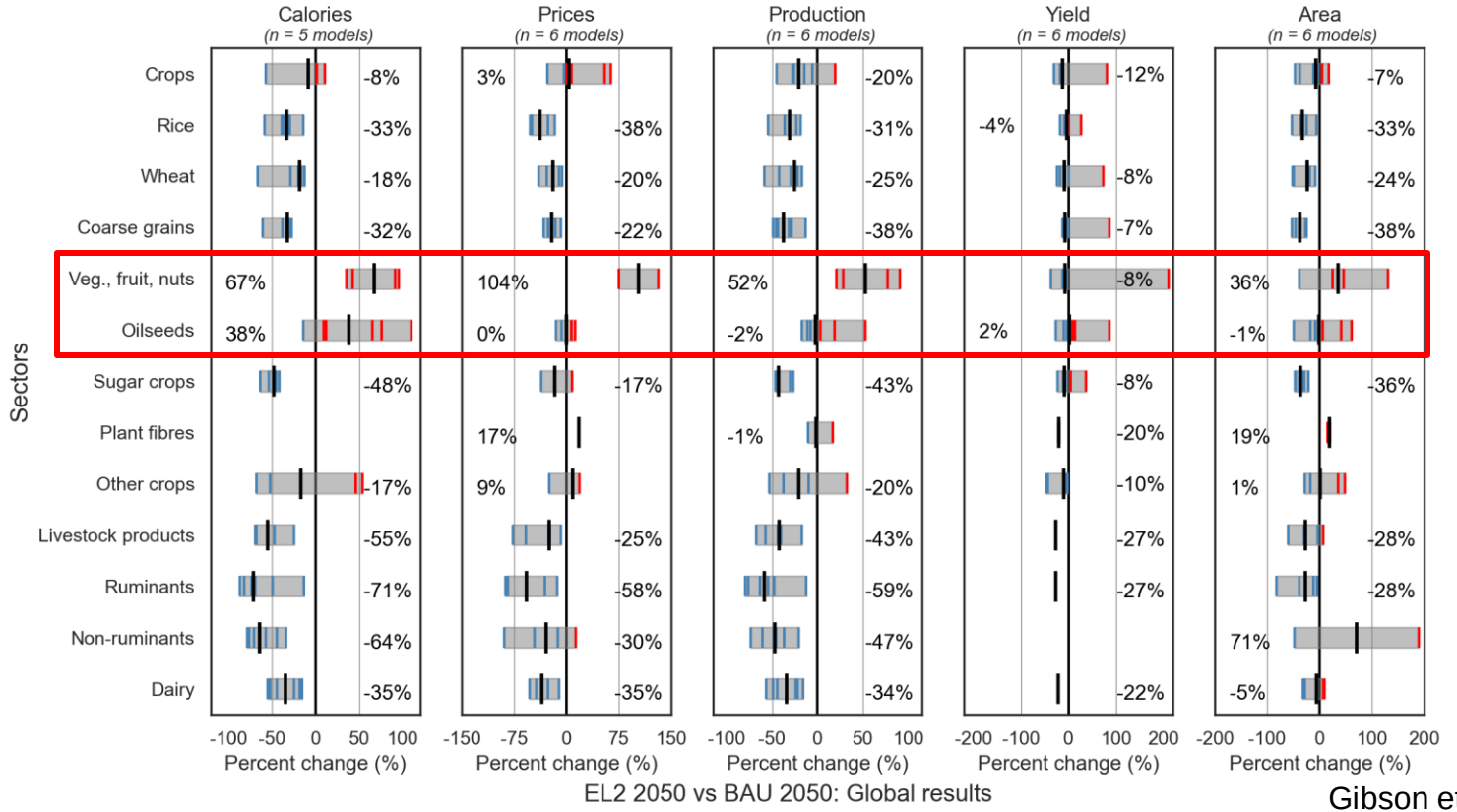
Percentage change for scenarios vs BAU 2050



Sundiang et al. *in prep*

Preliminary multi-model ensemble results

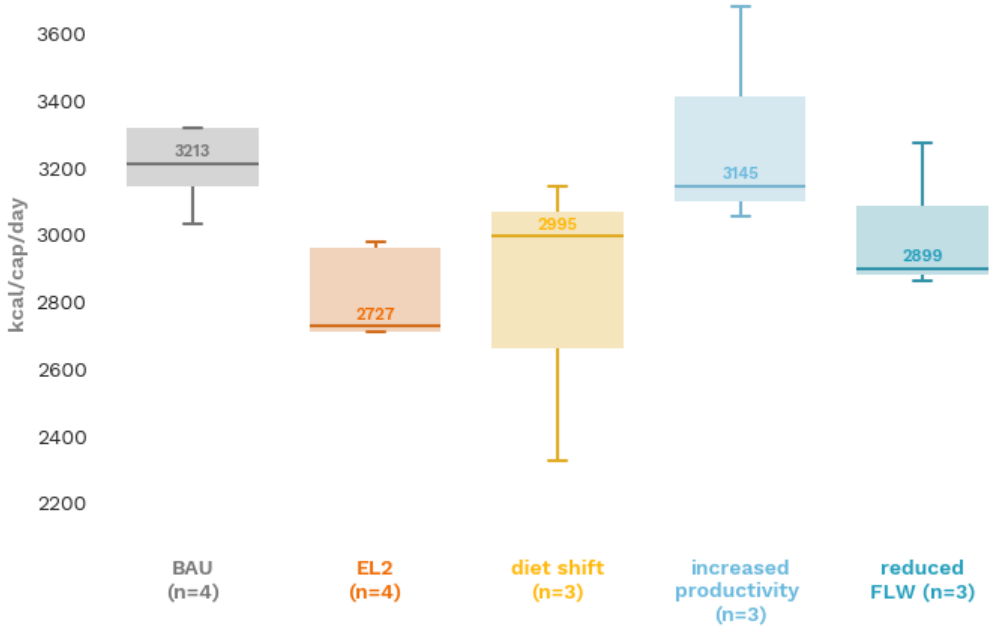
Percentage change for EL2 2050 vs Business-as-usual (BAU) 2050: Food sectors, global



Gibson et al. *in prep*

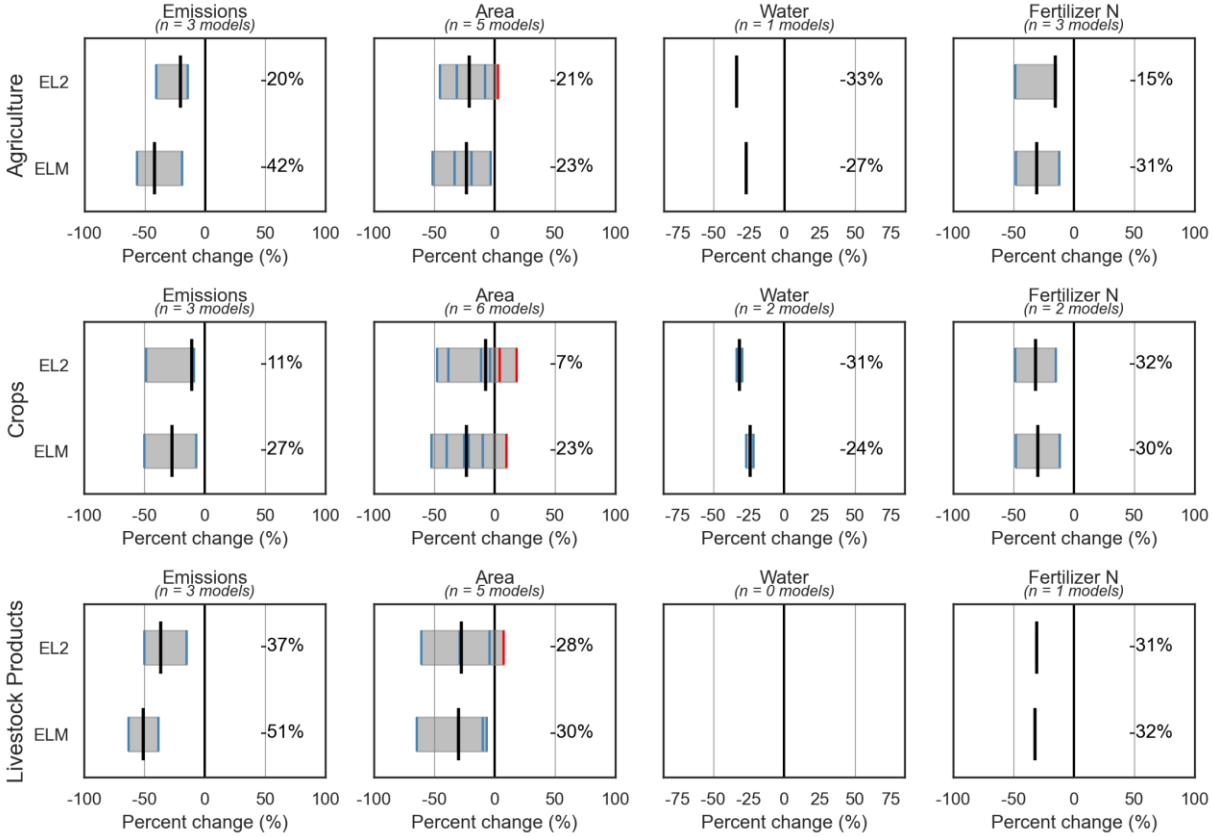
Preliminary multi-model ensemble results

Calorie availability per capita in 2050 under different scenarios



Gibson et al. *in prep*

EL2 2050 vs BAU 2050: Global results

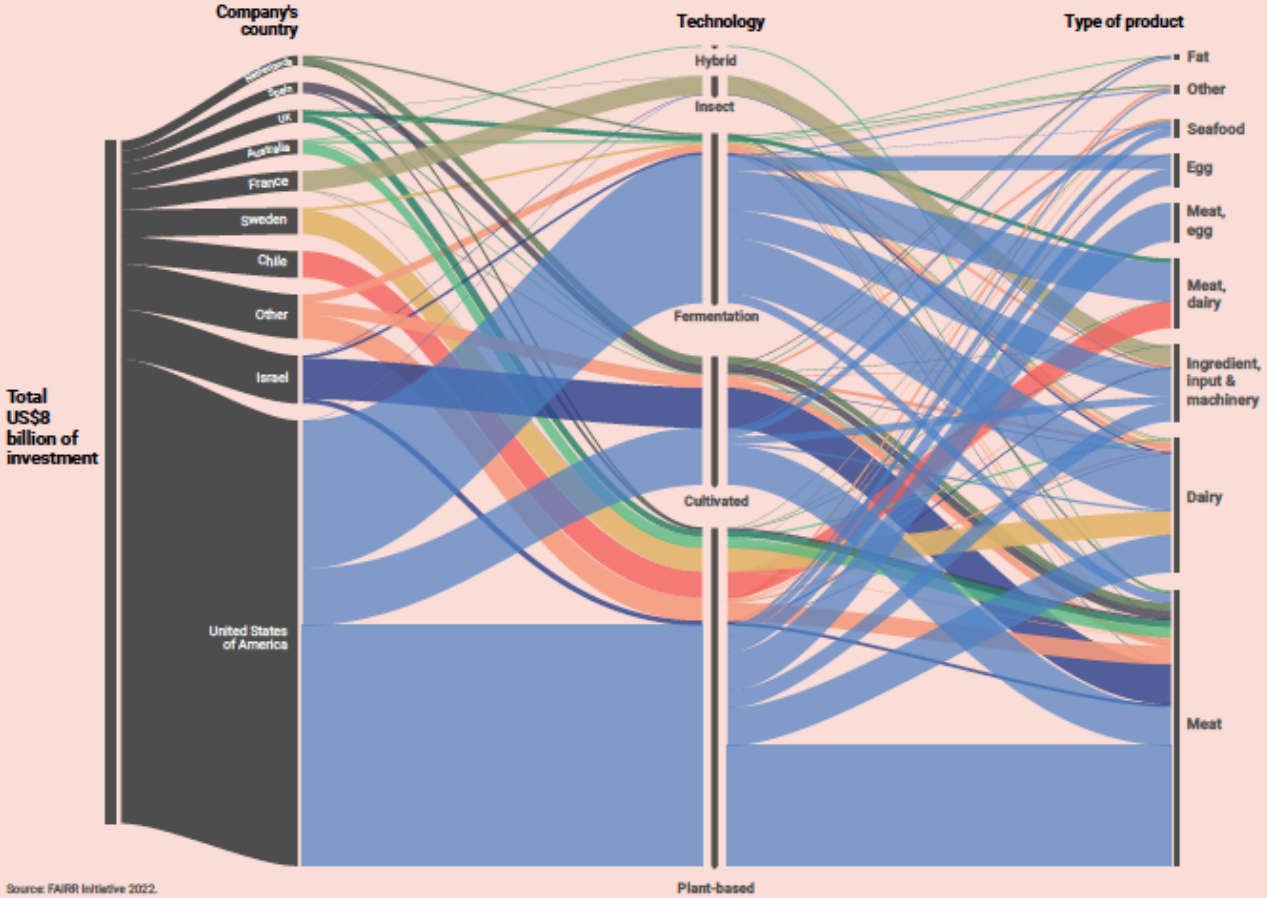


Sundiang et al. *in prep*

Plant-based alternatives and fermentation products dominate the alt prot market

UNEP 2023

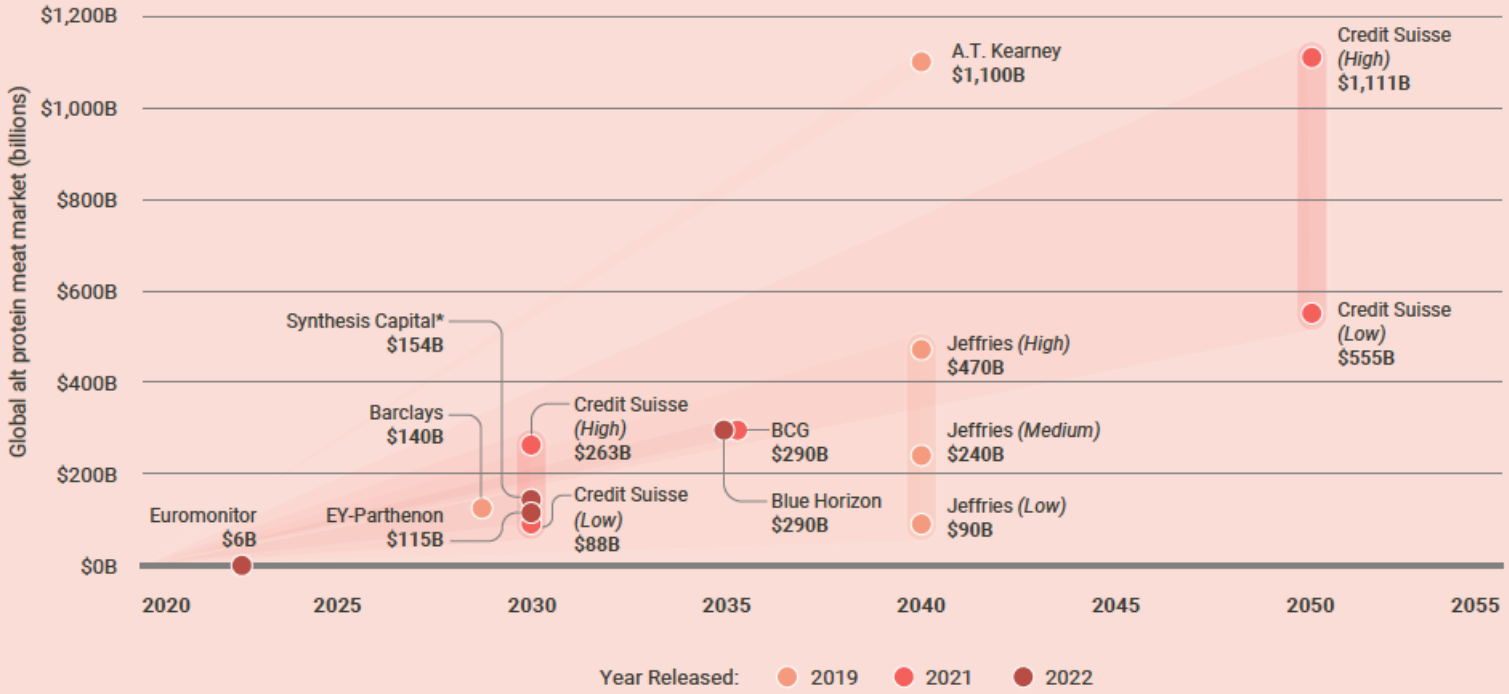
Breakdown of venture investments by company's country, technology type and type of product



Source: FAIRR Initiative 2022.
Note: The data refers to deals for the period 2020-2021.

Figure 3.4

Global alternatives to conventional meat industry forecasts by year



UNEP 2023, adapted from GFI 2023

A-ASF
through the lens of…
NUTRITION

Ultra-
processed

Minimally
processed

Beef vs Plant Alternatives: Nutritionally Interchangeable?

Ground Beef

Nutrition Facts

Serving size	(113g)
Amount Per Serving	
Calories	**220**
	% Daily Value*
Total Fat 14g	**18%**
Saturated Fat 5g	**25%**
Trans Fat 0g	
Cholesterol 60mg	**20%**
Sodium 70mg	**3%**
Total Carbohydrate 0g	**0%**
Dietary Fiber 0g	**0%**
Total Sugars 0g	
Includes 0g Added Sugars	**0%**
Protein 23g	**46%**
Vitamin D 0.1mcg	0%
Calcium 12mg	0%
Iron 2mg	10%
Potassium 289mg	6%
Thiamin 0.05mg	4%
Riboflavin 0.2mg	15%
Niacin 4.8mg	30%
Vitamin B6 0.4mg	25%
Folate 6mcg	2%
Vitamin B12 2mcg	80%
Phosphorus 175mg	15%
Zinc 4.6mg	40%

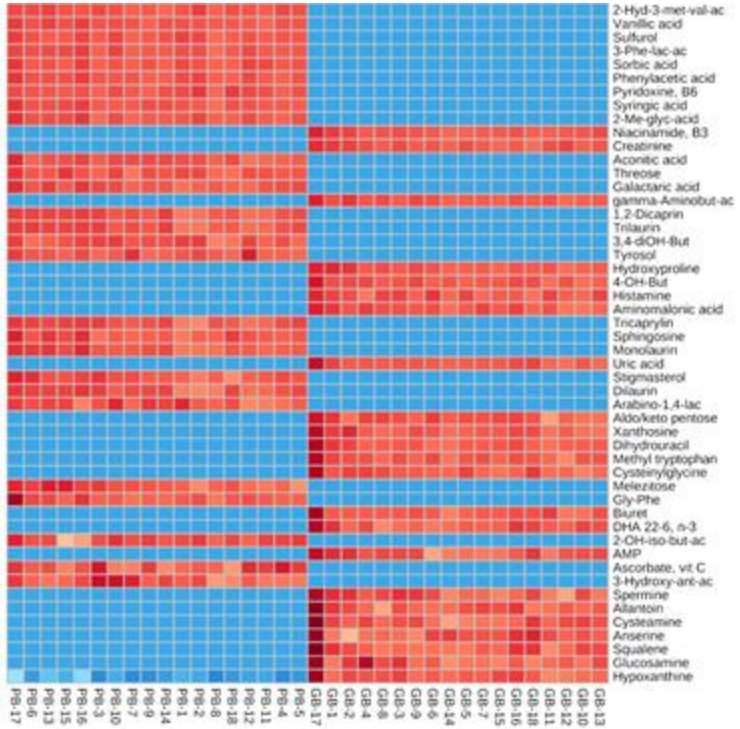
*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Plant Alternative

Nutrition Facts

Serving size	(113g)
Amount Per Serving	
Calories	**250**
	% Daily Value*
Total Fat 14g	**18%**
Saturated Fat 8g	**40%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 370mg	**16%**
Total Carbohydrate 9g	**3%**
Dietary Fiber 3g	**11%**
Total Sugars 0g	
Includes 0g Added Sugars	**0%**
Protein 19g	**38%**
Vitamin D 0mcg	0%
Calcium 180mg	15%
Iron 4.2mg	25%
Potassium 610mg	15%
Thiamin 28.2mg	2350%
Riboflavin 0.4mg	30%
Niacin 4.8mg	30%
Vitamin B6 0.4mg	25%
Folate 115mcg	30%
Vitamin B12 3mcg	120%
Phosphorus 180mg	15%
Zinc 5.5mg	50%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

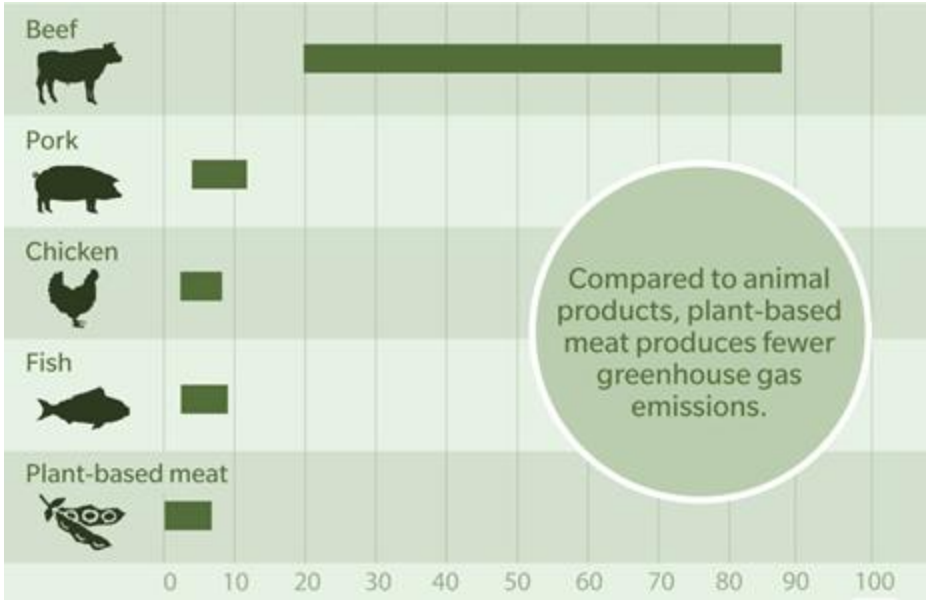


similar **Nutrition Facts** panels, but **90% difference** in metabolite abundances

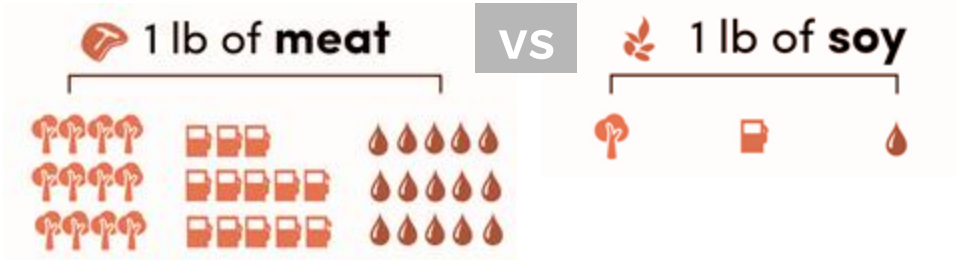
A-ASF

through the lens of…

ENVIRONMENTAL IMPACT



Source: Santo et al. (2020)



Source: Reijnders & Soret (2003)

A-ASF
through the lens of...
LIVELIHOODS

Current livestock sector supports the livelihoods of **1.1B low-income people** (70% of whom are women)

Adoption of A-ASF can **adversely impact** livelihoods but also offers **new opportunities**. Seizing them depends on:

- Land Access
- Location
- Skills & Education
- Job Quality

16–20 OCTOBER 2023

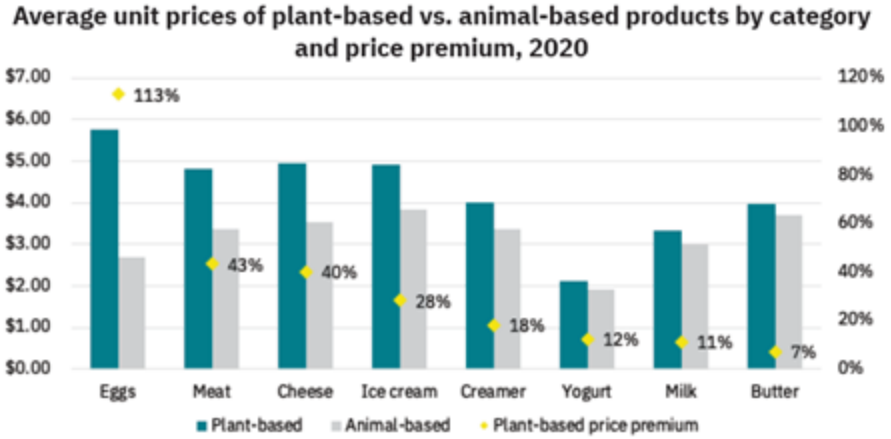
FAO | WORLD FOOD FORUM | SCIENCE & INNOVATION

SCIENCE AND INNOVATION FOR CLIMATE ACTION

A-ASF
through the lens of…
AFFORDABILITY

→ Affordability may look very different when considered on a **'per nutrient'** basis, as opposed to **'per serving/unit weight'** basis

Affordability of A-ASF **depends on what you compare:**



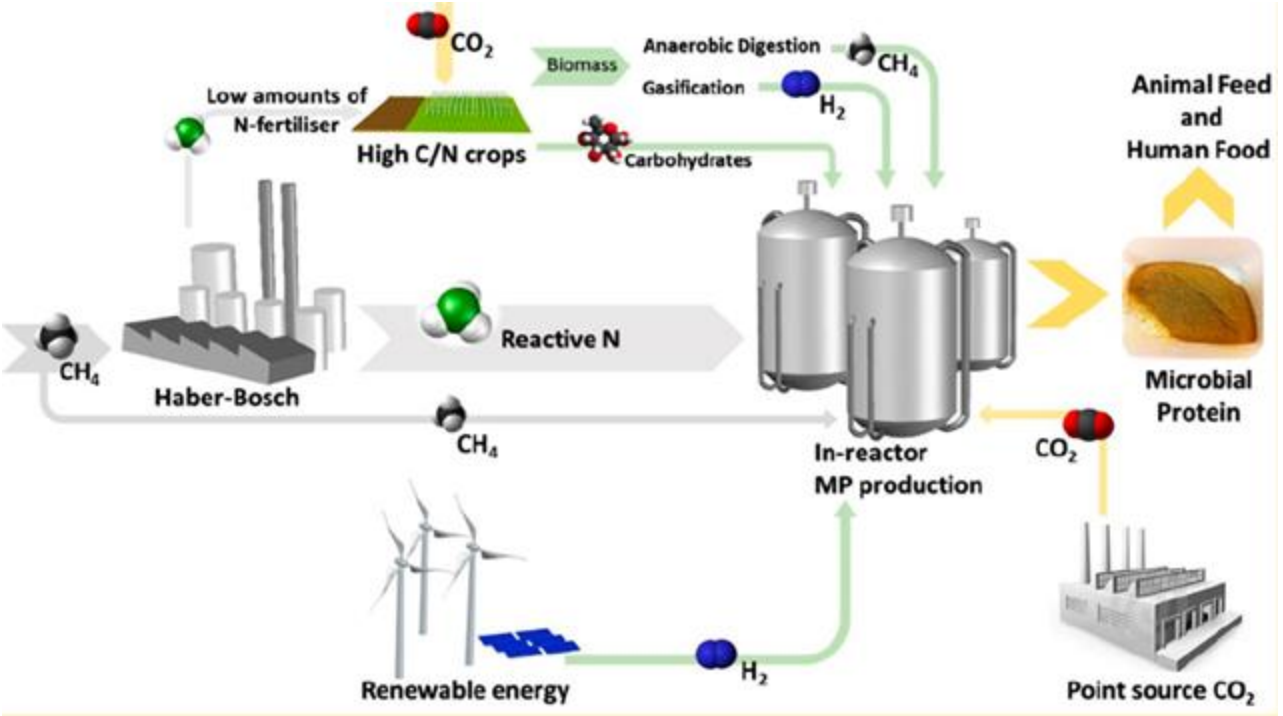
'Modern' A-ASF like **processed burgers** are disproportionately consumed by richer consumers, with high relative prices being a barrier to consumption

…yet **legumes**, for example, are highly affordable—less than USD 0.50 per serving

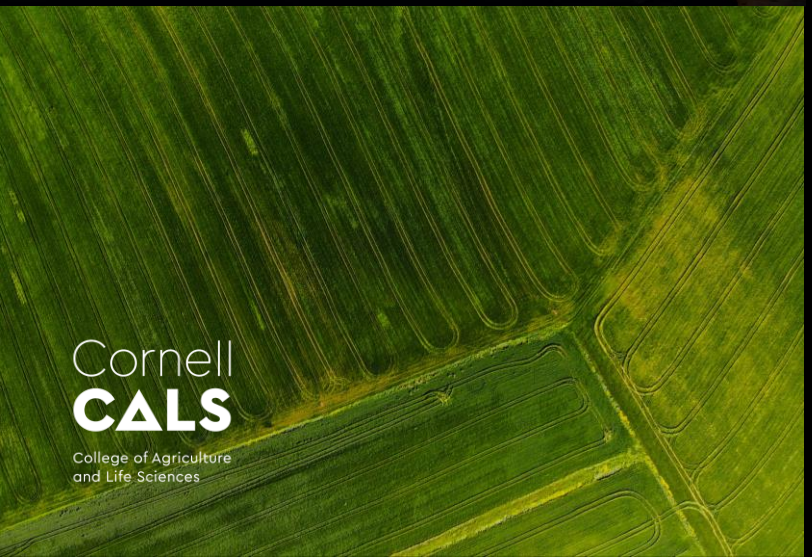
Adoption of A-ASF | Some modelling results

SOURCE	LAND USE	BLUEWATER USE	FERTILIZER USE	GHG EMISSIONS
(Eshel et al. 2018)	Reallocates 32 million ha (25% cropland) from feed production for beef	• 10% if replaced by buckwheat • 80% if replaced by tofu	• 10% if replaced by snap bean • 60% if replaced by soybeans	• 5% if replaced by pork • 90% if replaced by legumes
(White and Hall 2017)	NA	NA	NA	• With food imports: -33% reduction • No food imports: -31% reduction
(Goldstein et al. 2017)	• Vegetarian: -70% reduction • Vegan: -79% reduction • 10% Shift: -2% reduction • 25% shift: -6% reduction • 50% shift: -12% reduction	• Vegetarian: -70% reduction • Vegan: -75% reduction • 10% Shift: -2% reduction • 25% shift: -5% reduction • 50% shift: -10% reduction	NA	• Vegetarian: -32% • Vegan: -67% • 10% Shift: -1% (9 Mt CO2eq) • 25% shift: -3% (23 Mt CO2eq) • 50% shift: -6% (45 Mt CO2eq)
(Harwatt et al. 2017)	42% sparing of cropland for other uses (70 million ha)	NA	NA	206-209 Mt CO2eq reduction
Mason-D'Croz et al. 2022	Reallocated from Beef • TAX*: 6% to 18% • Pref[2]: 6% to 10% • ALTP*: 6% to 38%	• TAX*: < ±1% • Pref: <±1% • ALTP*: +1% to +7%	• TAX*: < ±1% • Pref: < ±1% • ALTP*: +1% to +7%	• TAX*: -3% to -8% (9-27 Mt CO2eq) • Pref: -2% to -4% (9-14 Mt CO2eq) • ALTP*: -2% to -14% (8-47 Mt CO2eq)

alt-protein sources **can reduce 8% of GHG** from crop production



Source: Pikaar et al. 2017 Env Sci Tech



FOOD SYSTEMS & GLOBAL CHANGE

THANK YOU

mario.herrero@cornell.edu

115 Bruckner Hall, Cornell University, Ithaca, NY

cals.cornell.edu/food-systems-global-change

@GlobalFoodTeam