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climate change

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The environmental impacts of food

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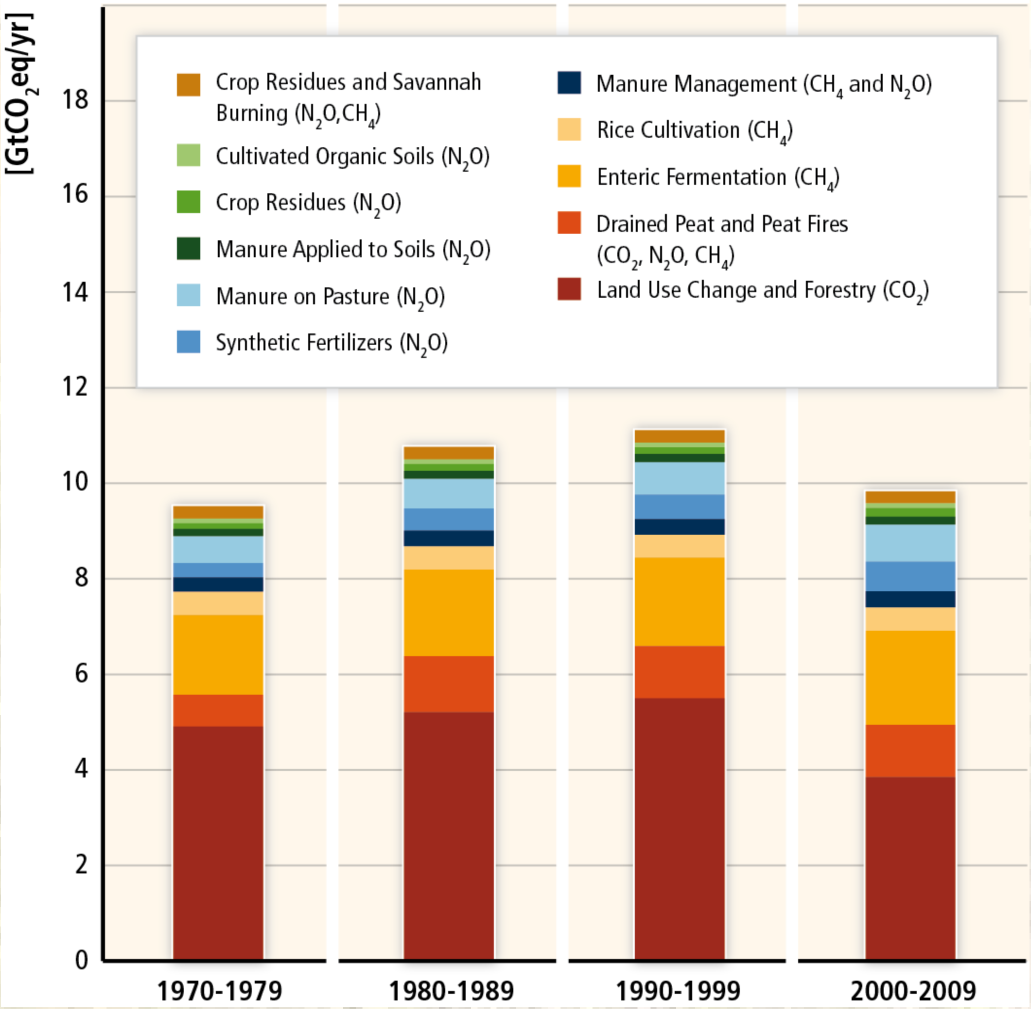
The impact of food on climate change

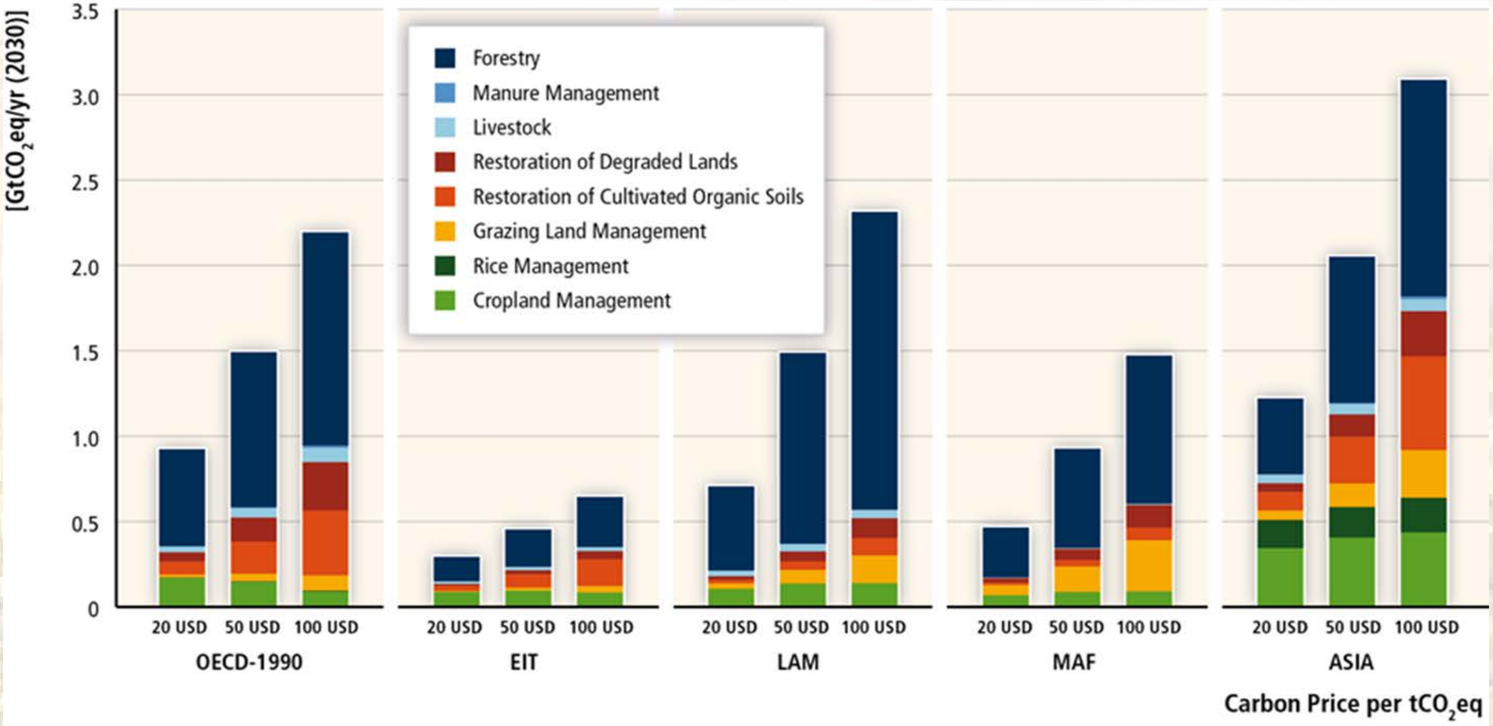

Agricultural emissions are increasing, but *net* forestry CO_2 emissions have fallen recently



- AFOLU accounts for 24% of total anthropogenic GHG emissions
- AFOLU is the only sector where net emissions fell in the most recent decade
- Whilst agricultural non-CO_2 GHG emissions increased, *net* CO_2 emissions fell, mainly due to decreasing deforestation, and increased afforestation rates

Smith *et al.* (2014) – IPCC WGIII AR5

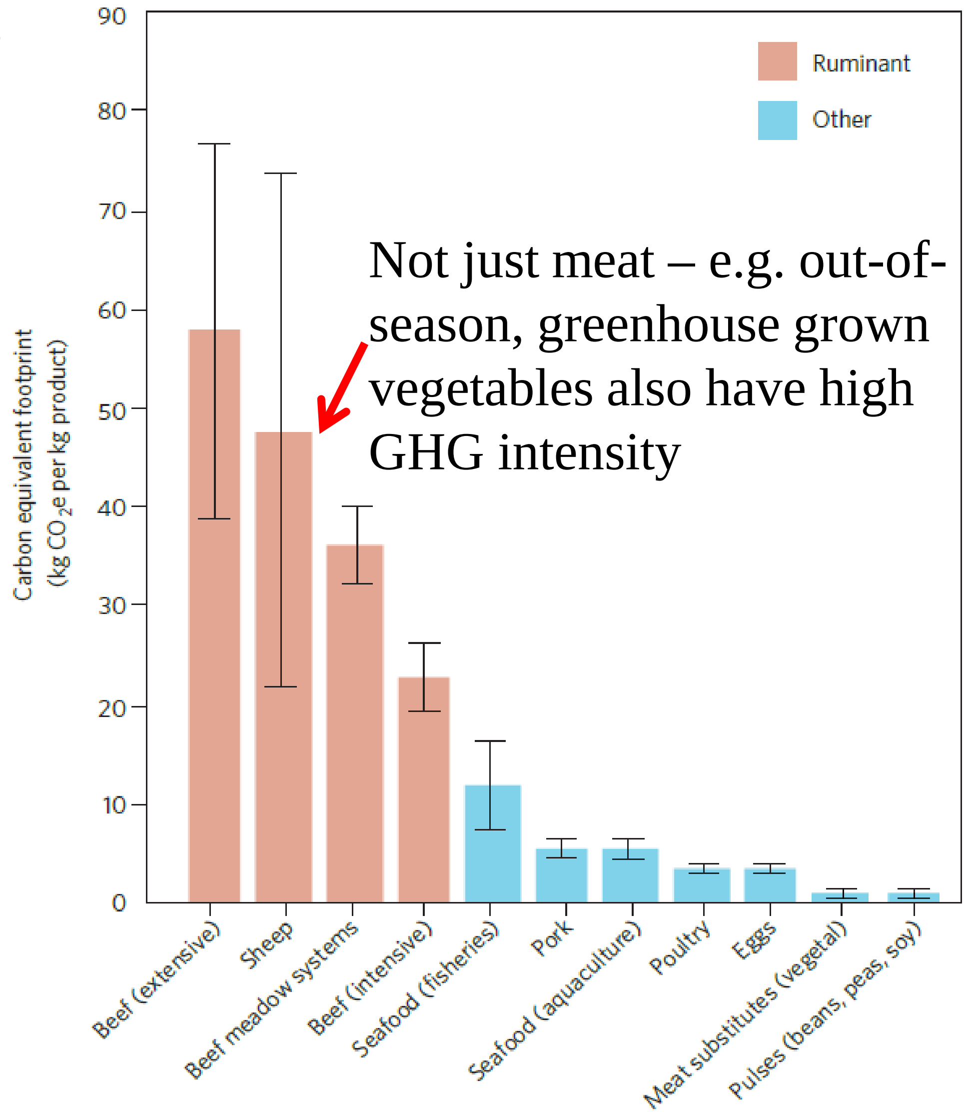
What is the potential of the mitigation options for reducing GHG emissions in the AFOLU Sector?



- Global economic mitigation potentials in agriculture in 2050 are estimated to be 0.5—10.6 $GtCO_2eq/yr$.
- Reducing food losses & waste: GHG emission savings of 0.6—6.0 $GtCO_2eq/yr$.
- Changes in diet: GHG emission savings of 0.7—7.3 $GtCO_2eq/yr$.
- Forestry mitigation options are estimated to contribute 0.2—13.8 $GtCO_2/yr$.

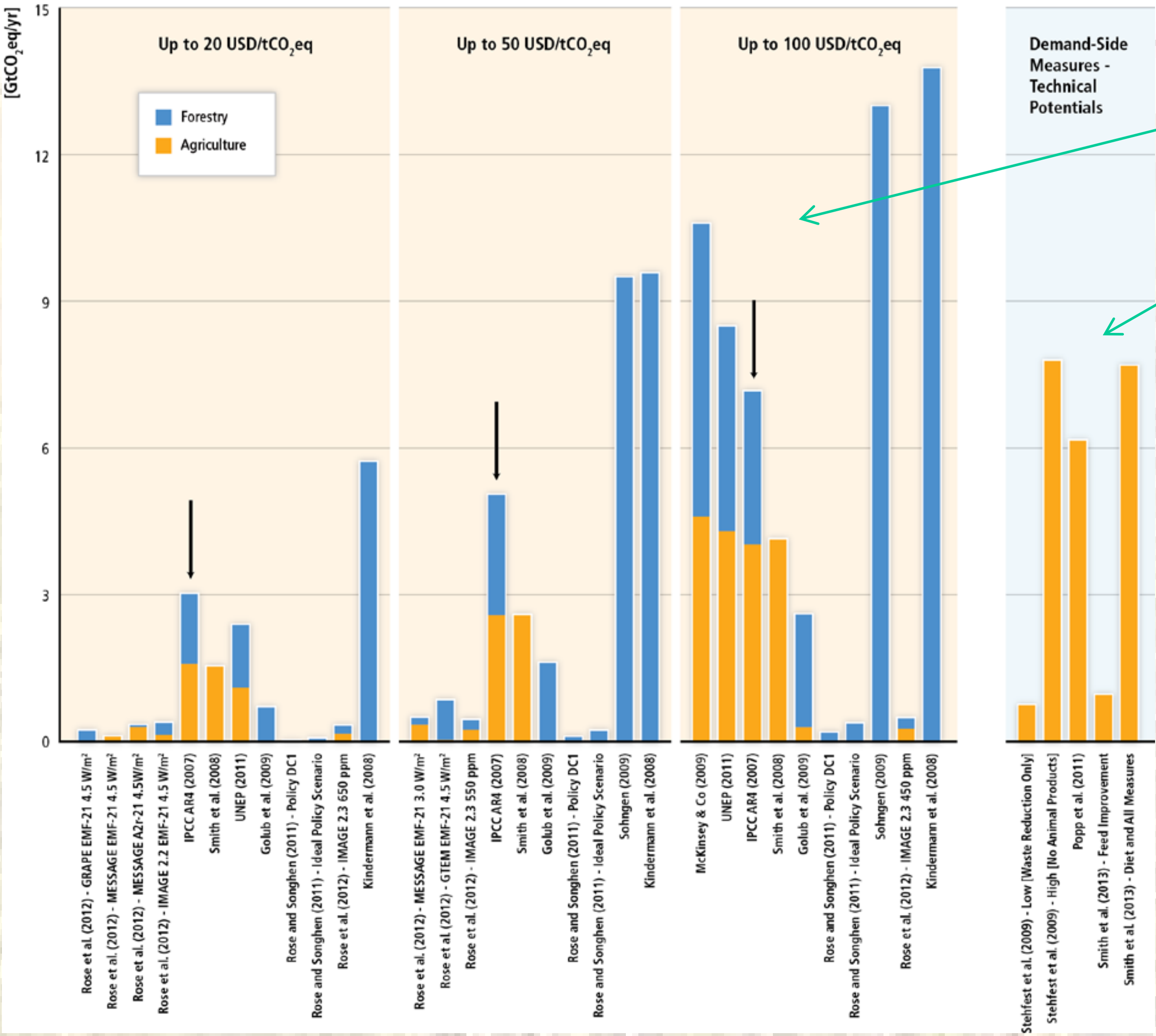
Smith *et al.* (2014) – IPCC WGIII AR5

Big differences in the GHG intensity of different foods



Ripple *et al.*(2014)

Demand- and supply-side measures need to be considered



- Supply-side measures in the AFOLU sector are large & cost-competitive
- Demand-side measures such as dietary change and waste reduction also have large, but uncertain, mitigation
- Demand-side measures may be difficult to implement, but are worthy of further research
- Other options in the AFOLU sector include bioenergy

Smith *et al.* (2014) – IPCC WGIII AR5

Changed consumption patterns

Table 3 Description of the reference scenario and the four dietary variants

Variant	Description
Reference	Agricultural production for 2000–2030 (Bruinsma 2003) and 2030–2050 (FAO 2006). The 2000–2030 projections are country-scale and aggregated to the 24 world regions of the IMAGE model. The projections for 2030–2050 have a continental scale
No Ruminant Meat (NoRM)	As reference, but with complete substitution of proteins from ruminant meat (cattle, buffaloes, sheep and goats) by plant-proteins, starting in 2010 and completed by 2030. By-products such as wool and leather are also assumed to be substituted by other materials
No Meat (NoM)	As NoRM, with additional substitution of white meat (pork, poultry) by plant proteins, starting in 2010 and completed by 2030
No Animal Products (NoAP)	As NoM, with additional substitution of milk and eggs by plant proteins, starting in 2010 and completed by 2030
Healthy Diet (HDiet)	"Healthy Eating" recommendations from the Harvard Medical School (Willett 2001) implemented globally for meat and eggs, starting in 2010 and completed by 2030. See also Table 4

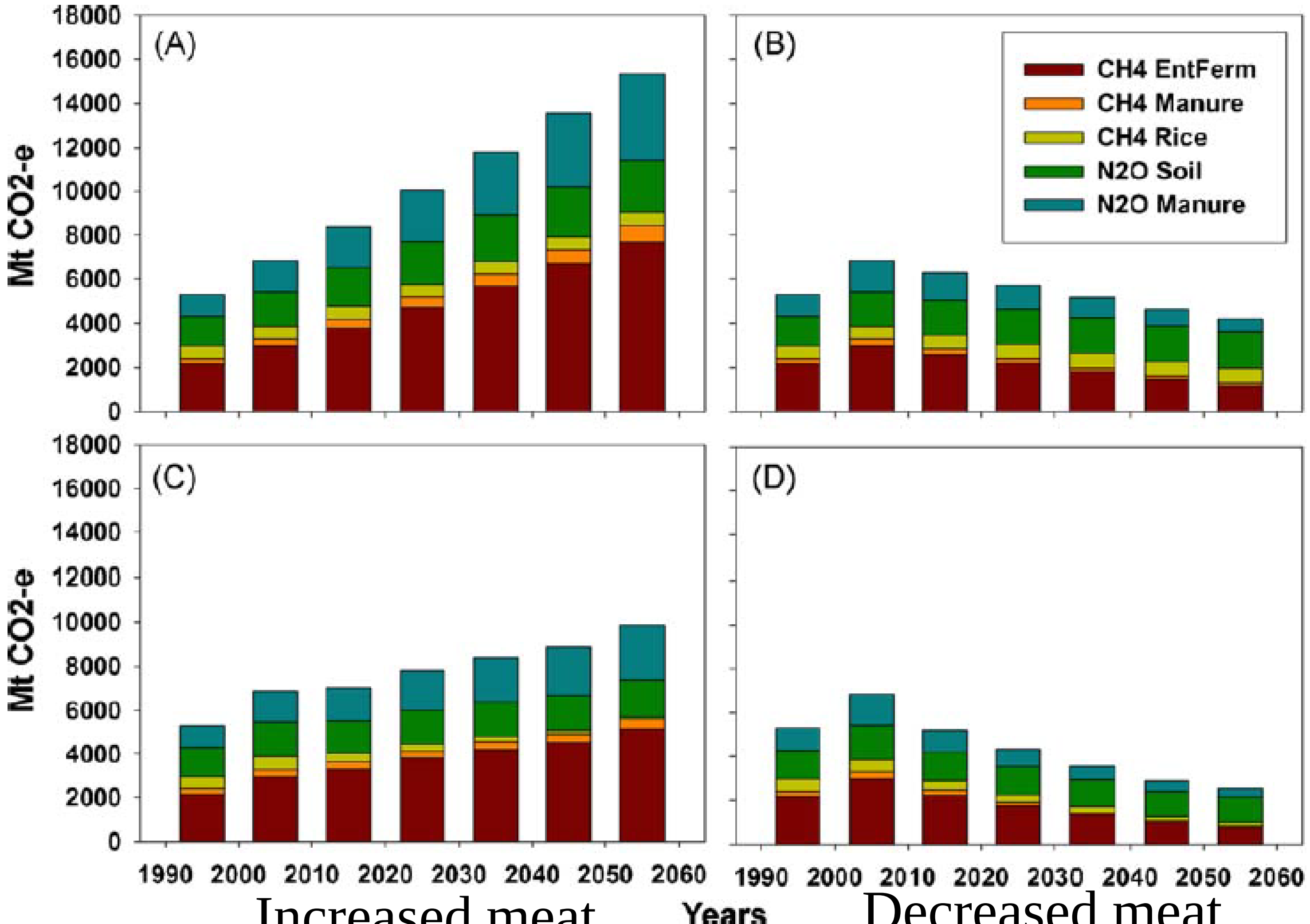
Fewer animal products in global diet allows everyone to be fed, and land is available for energy and nature conservation

Land based GHG emissions:

	GtC eq.
2000	3.0
2050-Reference	3.3
2050-NoRM	1.7
2050-NoM	1.5
2050-NoAP	1.1
2050-HDiet	2.1

Stehfest *et al.* (2009)

Reducing GHG emissions – dietary change *vs*. technical mitigation



Without technical mitigation

With technical mitigation

Increased meat

Decreased meat

Popp *et al*. (2011)

Food demand must be managed because sustainable intensification alone will not suffice

Scenarios	Yields		Demand side reduction measures:	
	Current trends in yields	Yield gap closures (sustainable intensification)	50% Food waste reduction	Healthy diets
CT1	x			
CT2	x		x	
CT3	x		x	x
YG1		x		
YG2		x	x	
YG3		x	x	x

Bajželj *et al.* (2014) Nature CC

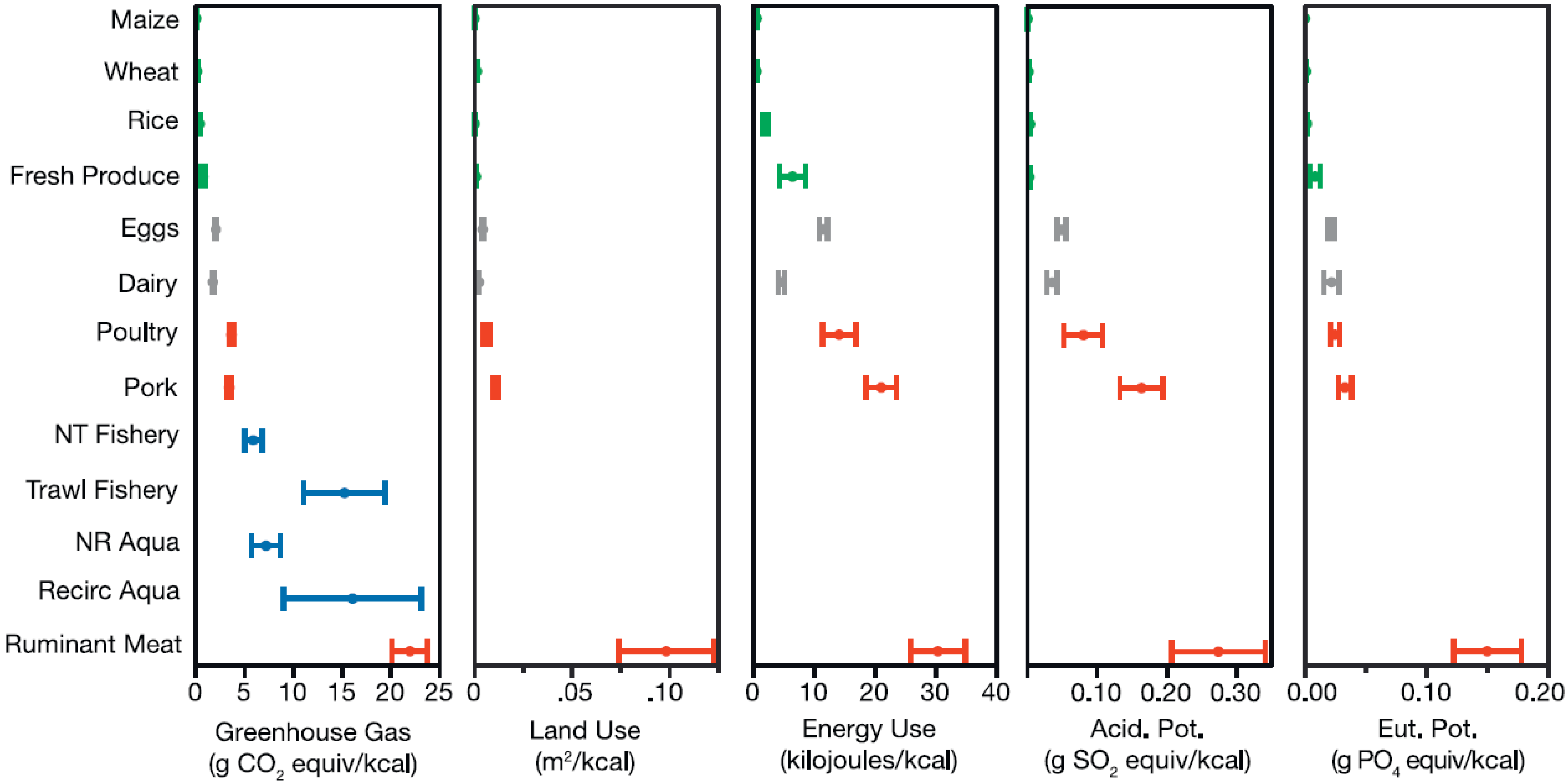
Food demand must be managed because sustainable intensification alone will not suffice

Current yield trend | Yield gap closure only | Yield gap closure + demand options

	units	2009*	CT1		CT2		CT3		YG1		YG2		YG3	
Cropland	Mkm^2	15.6	22.5	(+44%)	18.7	(+20%)	17.6	(+12%)	18.2	(+16%)	16.0	(+2%)	14.6	(-6%)
Pasture	Mkm^2	32.8	35.2	(+7%)	32.6	(-1%)	26.8	(-18%)	36.0	(+10%)	33.1	(+1%)	27.1	(-17%)
Net Forest cover	Mkm^2	26.1	23.1	(-12%)	24.7	(-6%)	26.1	(+0%)	24.2	(-7%)	25.6	(-2%)	27.1	(+4%)
Tropical Pristine Forests	Mkm^2	7.9	7.2	(-9%)	7.4	(-7%)	7.4	(-6%)	7.4	(-6%)	7.6	(-4%)	7.6	(-4%)
Total GHG emissions	$GtCO_2$/y	13.5	22.2	(+64%)	16.1	(+20%)	11.7	(-13%)	19.2	(+42%)	15.0	(+11%)	10.2	(-25%)
Carbon sink potential	$GtCO_2$/y	14.7	14.5	(-1%)	14.6	(-0%)	14.8	(+0%)	14.6	(-1%)	14.7	(+0%)	14.7	(+0%)
Fertiliser use	Mt/y	103	166	(+61%)	136	(+32%)	125	(+22%)	226	(+120%)	196	(+90%)	175	(+70%)
Irrigation water use	km^3/y	2889	6496	(+125%)	5328	(+84%)	5075	(+76%)	5051	(+75%)	4413	(+53%)	4157	(+44%)

Bajželj *et al.* (2014) Nature CC

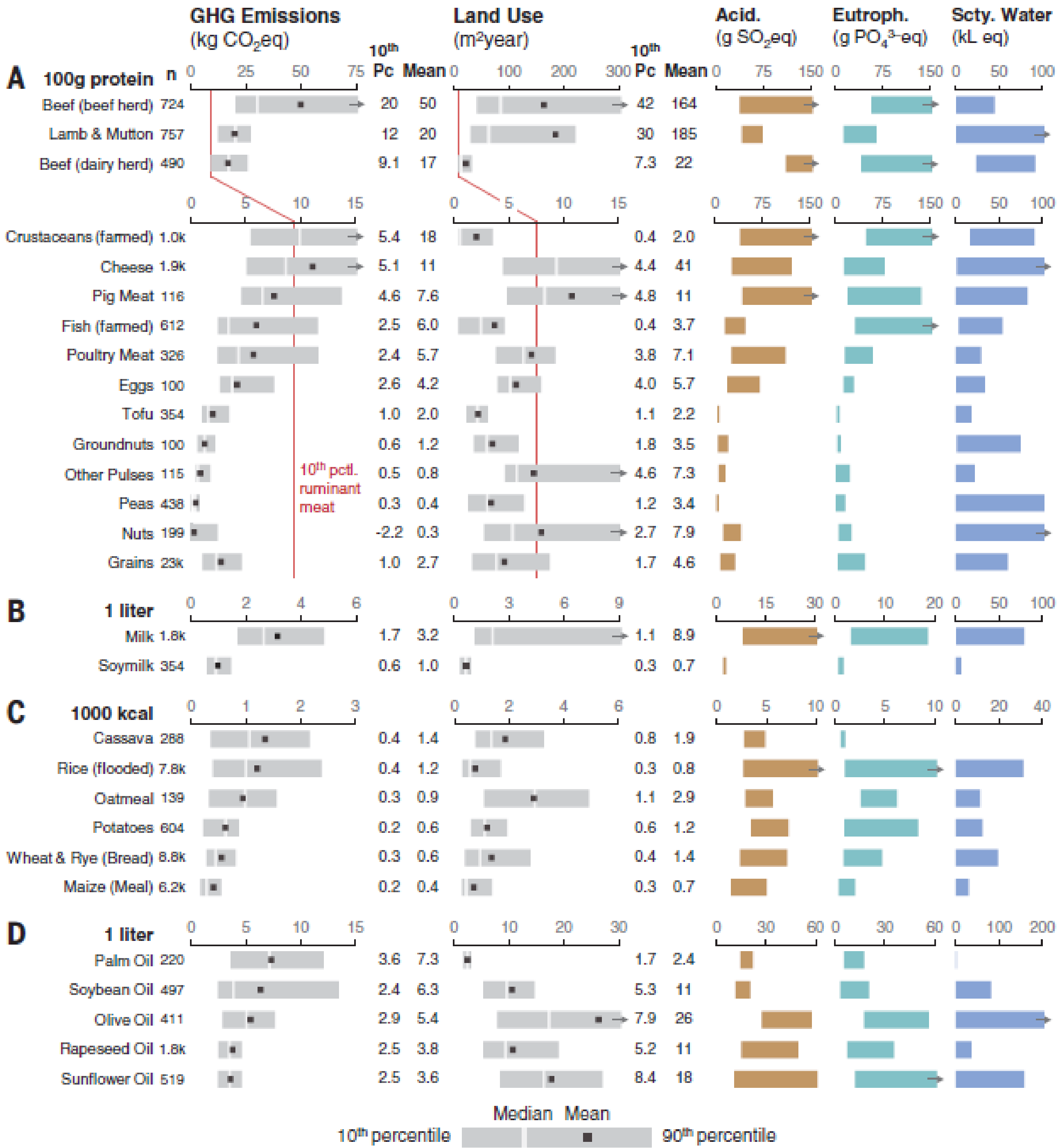
The impact of food on land, water and other indicators



Environmental impacts of broad groups of foods per kilocalorie

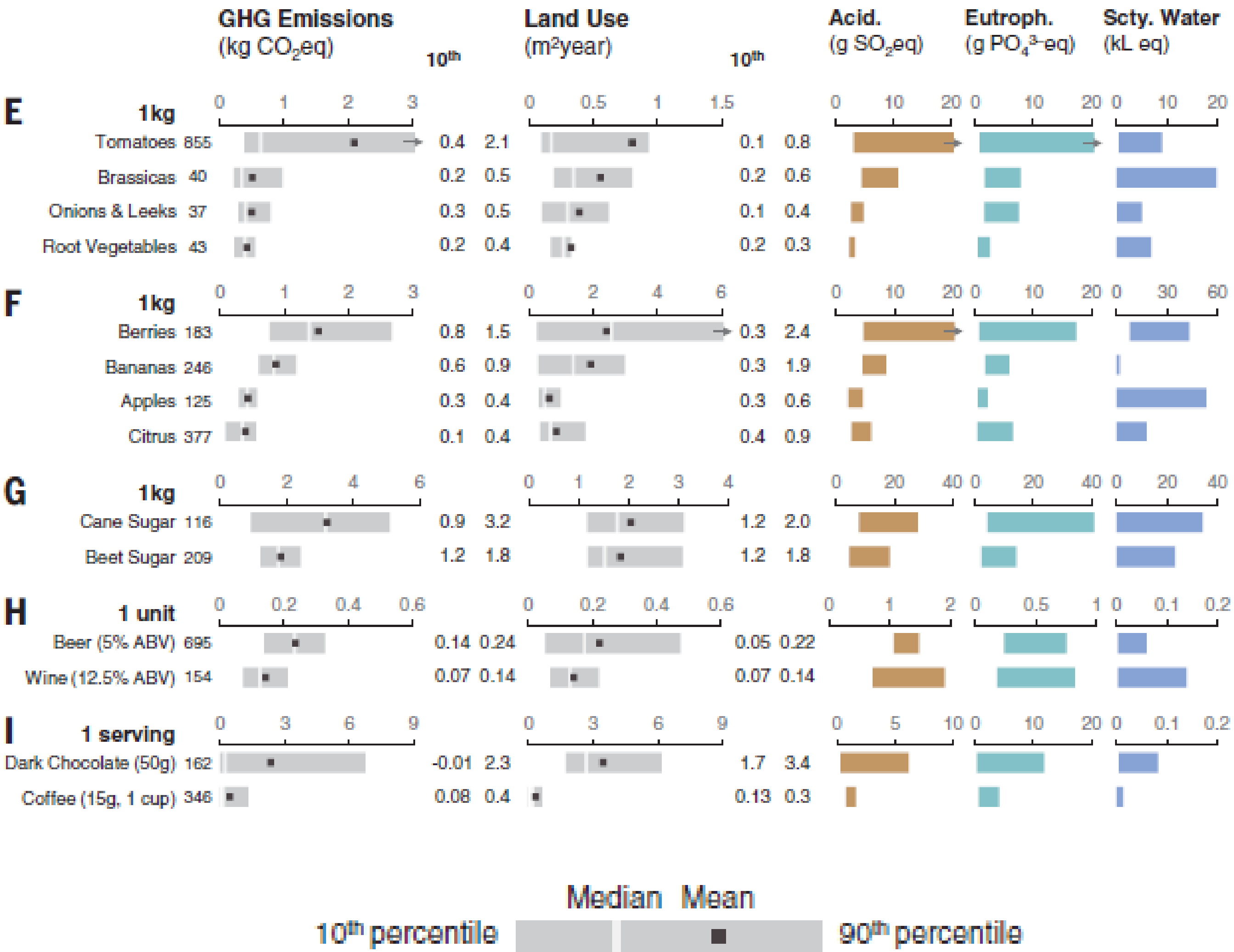
"***For all environmental indicators and nutritional units examined***, *plant-based foods have the lowest environmental impacts; eggs, dairy, pork, poultry, non-trawling fisheries, and non-recirculating aquaculture have intermediate impacts; and* ***ruminant meat has impacts ~100 times those of plant-based foods***"

Clark & Tilman (2017)



Estimated global variation in GHG emissions, land use, terrestrial acidification, eutrophication, and scarcity-weighted freshwater withdrawals, within and between 40 major foods. (A) Protein-rich products. Grains are also shown here given that they contribute 41% of global protein intake, despite lower protein content. (B) Milks. (C) Starch-rich products. (D) Oils.

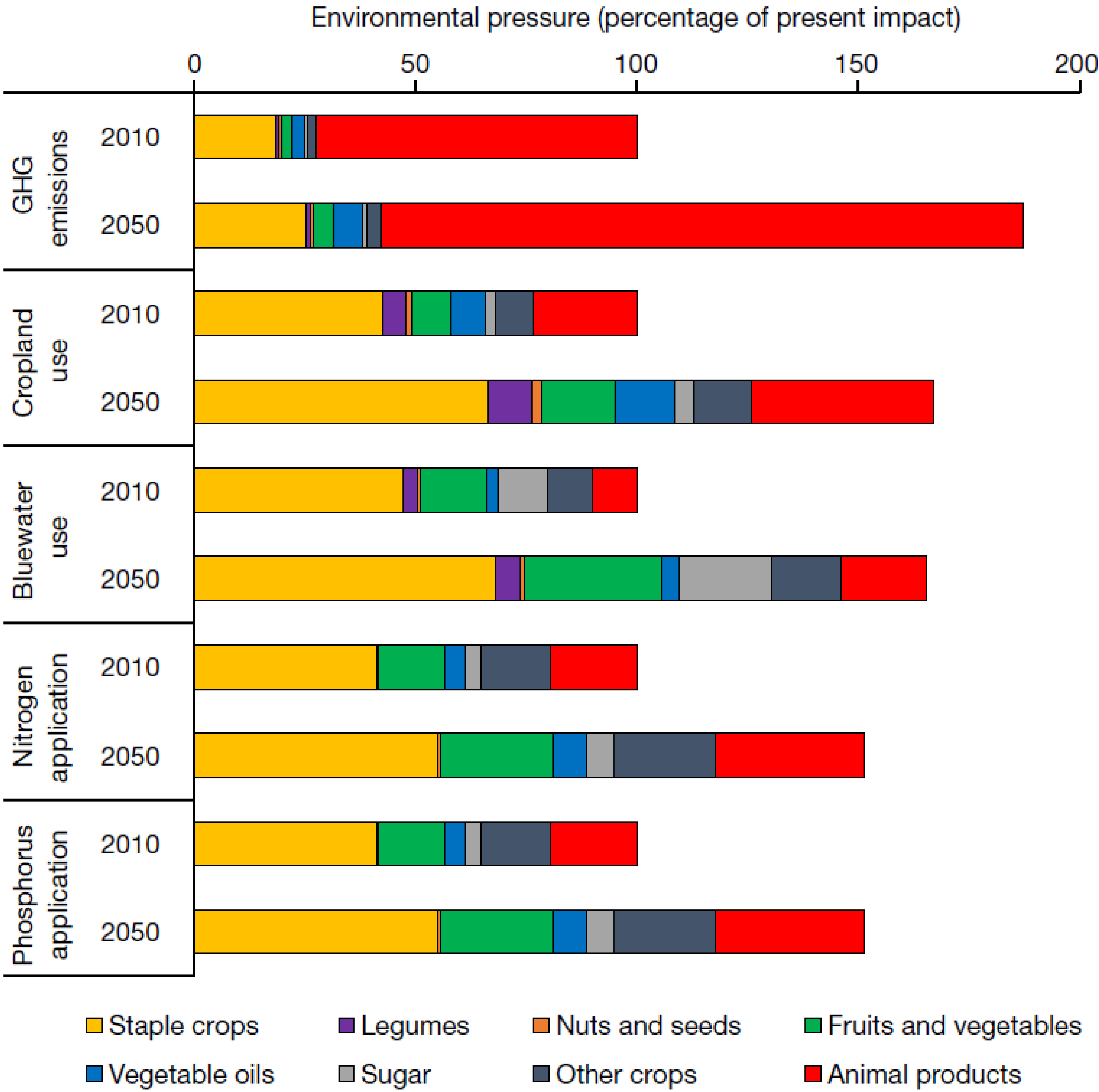
Poore & Nemececk (2018)



Estimated global variation in GHG emissions, land use, terrestrial acidification, eutrophication, and scarcity-weighted freshwater withdrawals, within and between 40 major foods. (E) Vegetables. (F) Fruits. (G) Sugars. (H) Alcoholic beverages (1 unit = 10 ml of alcohol; ABV, alcohol by volume). (I) Stimulants. n = farm or regional inventories. Pc and pctl., percentile; scty., scarcity.

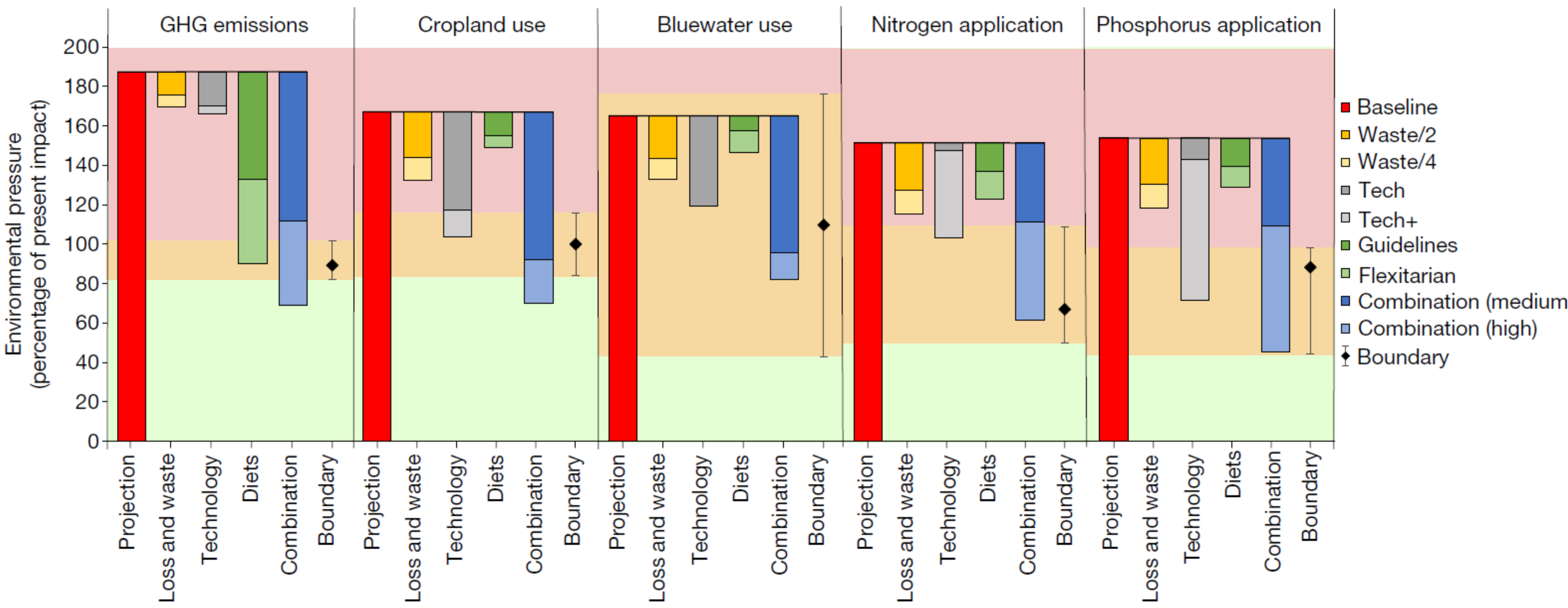
Poore & Nemececk (2018)

Present (2010) and projected (2050) environmental pressures on five environmental domains divided by food group



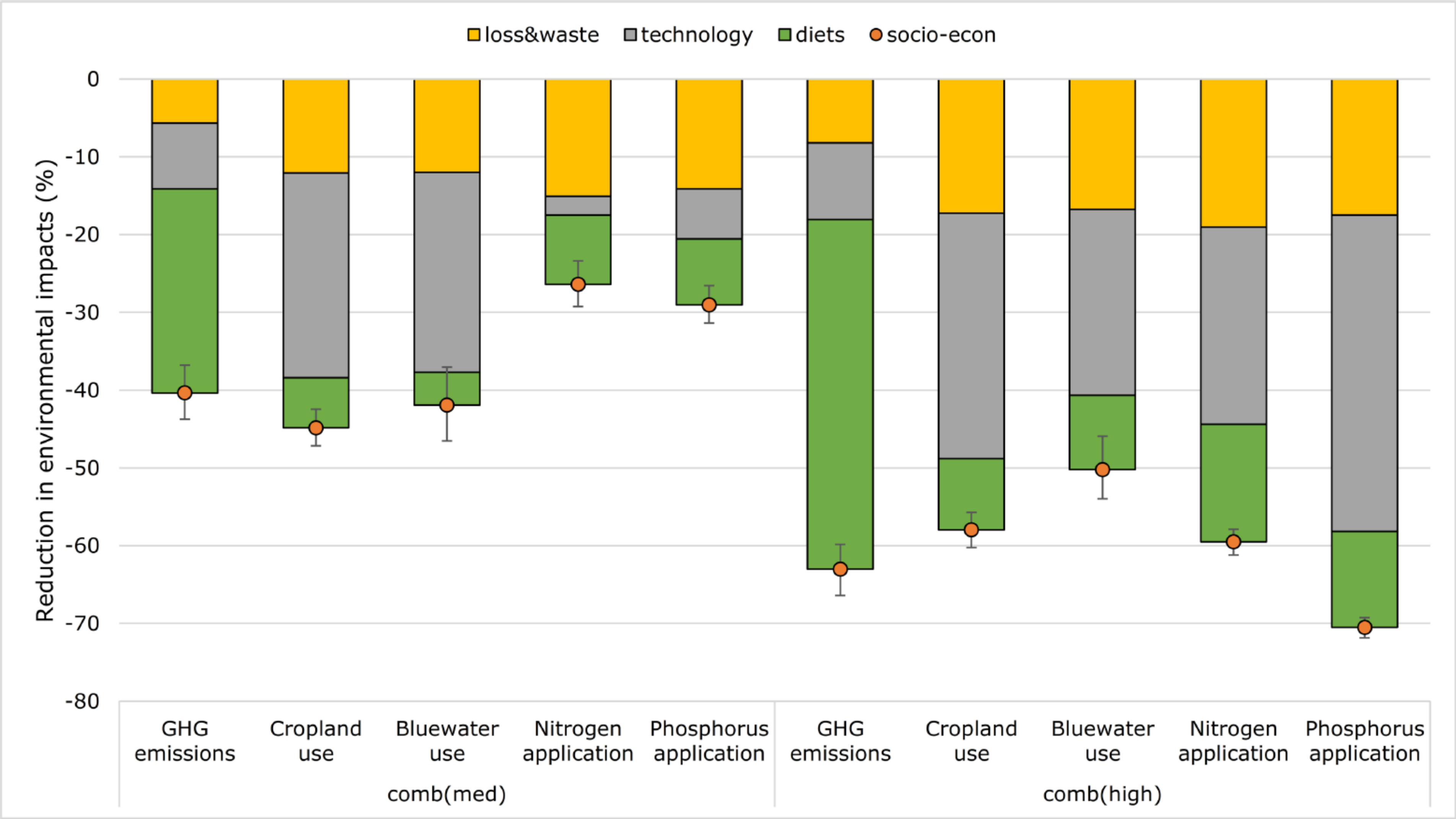
Springmann et al. (2018)

Impacts of reductions in food loss and waste, technological change, and dietary changes on global environmental pressures in 2050



Springmann et al. (2018)

Reduction in environmental impacts when measures are combined

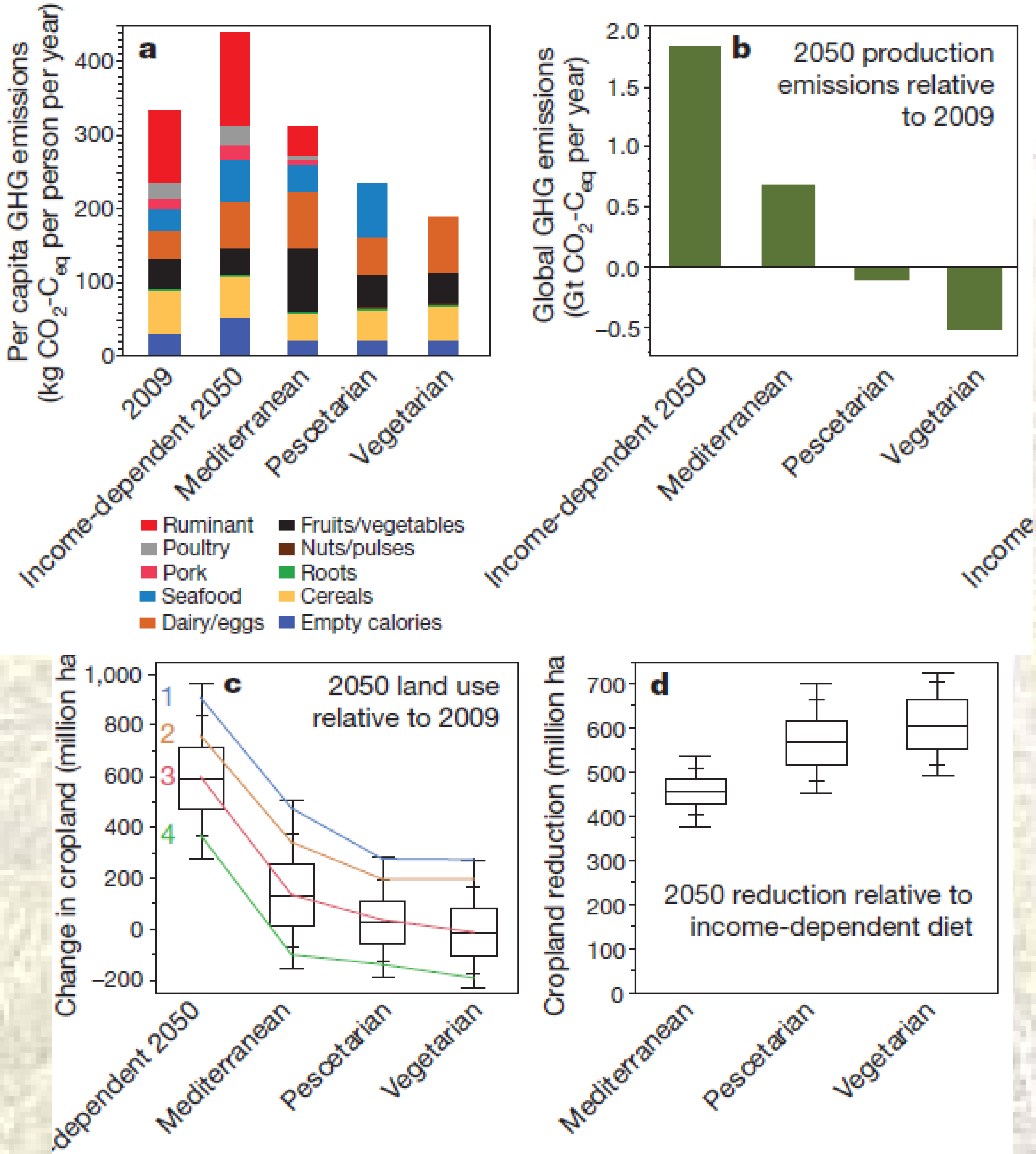


Springmann et al. (2018)

Planetary option space

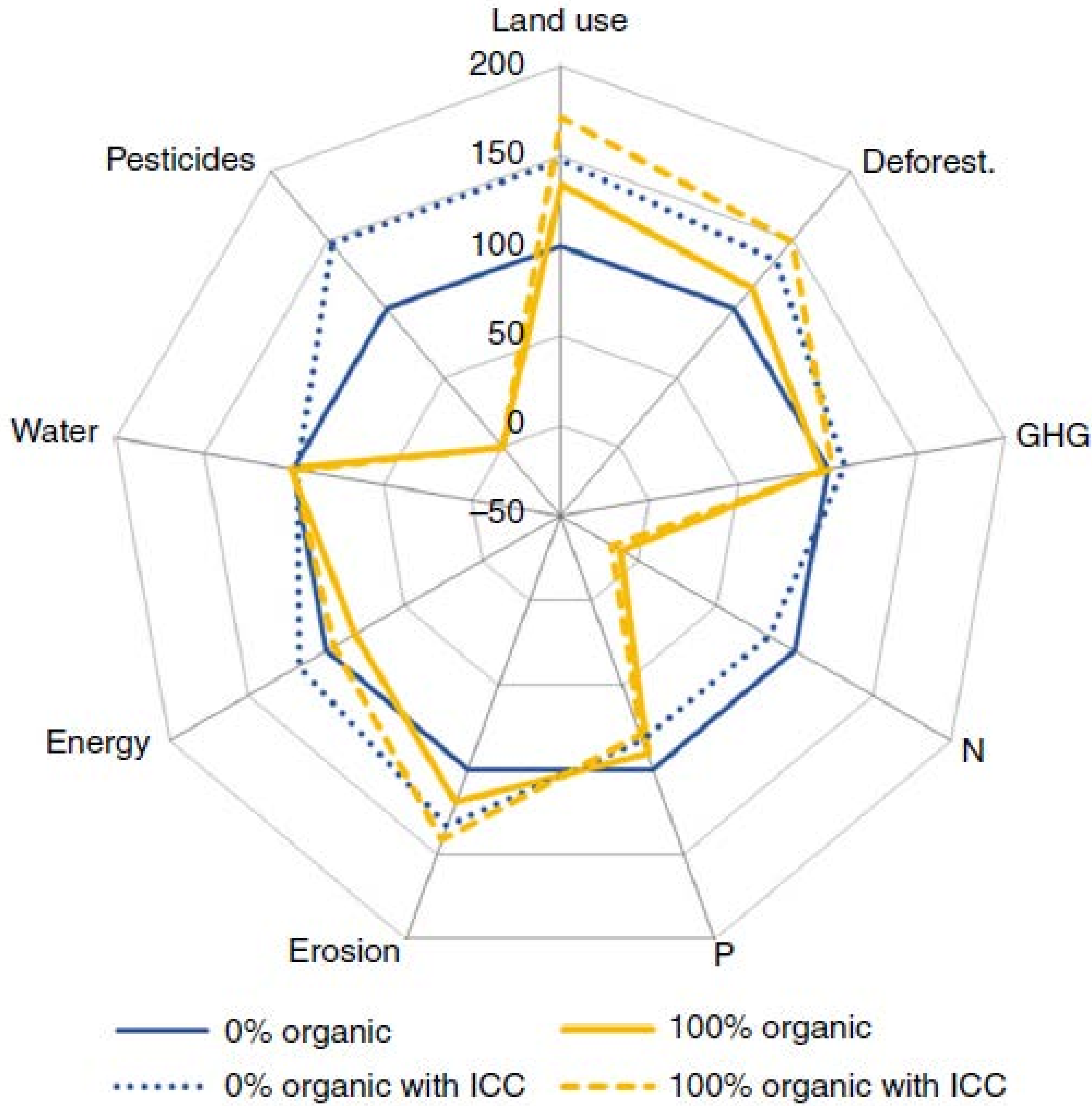
Diet scenario	Tech scenario	Loss and waste scenario	GHG emissions			Cropland use			Bluewater use			Nitrogen application			Phosphorus application		
			SSP2	SSP1	SSP3	SSP2	SSP1	SSP3	SSP2	SSP1	SSP3	SSP2	SSP1	SSP3	SSP2	SSP1	SSP3
Baseline	Baseline	Baseline	4	4	4	4	4	4	3	3	3	4	4	4	4	4	4
		Waste/2	4	4	4	4	4	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	Baseline	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+	Baseline	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
Guidelines	Baseline	Baseline	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	Baseline	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+	Baseline	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
Flexitarian	Baseline	Baseline	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	Baseline	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+	Baseline	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)



Effect of diets on GHG emissions and cropland. a, Per capita food production GHG emissions for five diets b, c, Forecasted 2009 to 2050 changes (2009 value set to 0) in global food emissions (b), and cropland for each diet (Methods; alternative scenarios, such as lines 1-4, have fairly parallel trends) (c). d, 2050 global cropland reductions from alternative diets relative to income-dependent diet.

Tilman & Clark (2014)



Reducing animal product consumption creates the headspace for less intensive forms of agriculture. The highest levels of organic share can only be achieved by reduction in animal product consumption and elimination of animal feeds that could be fed to humans

Muller *et al.* (2017)


Other benefits of dietary change


Other papers arriving at similar conclusions……

ARTICLE

doi:10.1038/nature13959

Global diets link environmental sustainability and human health

David Tilman[1,2] & Michael Clark[1]

Diets link environmental and human health. Rising incomes and urbanization are driving a global dietary transition in which traditional diets are replaced by diets higher in refined sugars, refined fats, oils and meats. By 2050 these dietary trends, if unchecked, would be a major contributor to an estimated 80 per cent increase in global agricultural greenhouse gas emissions from food production and to global land clearing. Moreover, these dietary shifts are greatly increasing the incidence of type II diabetes, coronary heart disease and other chronic non-communicable diseases that lower global life expectancies. Alternative diets that offer substantial health benefits could, if widely adopted, reduce global agricultural greenhouse gas emissions, reduce land clearing and resultant species extinctions, and help prevent such diet-related chronic non-communicable diseases. The implementation of dietary solutions to the tightly linked diet–environment–health trilemma is a global challenge, and opportunity, of great environmental and public health importance.

Tilman & Clark Nature (2014)

Cancer risk increases with higher consumptions of red and processed meats…

Carcinogenicity of consumption of red and processed meat

In October, 2015, 22 scientists from ten countries met at the International Agency for Research on Cancer (IARC) in Lyon, France, to evaluate the carcinogenicity of the consumption of red meat and processed meat. These assessments will be published in volume 114 of the IARC Monographs.[1]

Red meat refers to unprocessed mammalian muscle meat—for example, beef, veal, pork, lamb, mutton, horse, or goat meat—including minced or frozen meat; it is usually consumed cooked. Processed meat refers to meat that has been transformed through salting, more than 200 g per person per day.[4] Less information is available on the consumption of processed meat.

The Working Group assessed more than 800 epidemiological studies that investigated the association of cancer with consumption of red meat or processed meat in many countries, from several continents, with diverse ethnicities and diets. For the evaluation, the greatest weight was given to prospective cohort studies done in the general population. High quality population-based case-control studies provided additional evidence. For both day of red meat and an 18% increase (95% CI 1·10–1·28) per 50 g per day of processed meat.[12]

Data were also available for more than 15 other types of cancer. Positive associations were seen in cohort studies and population-based case-control studies between consumption of red meat and cancers of the pancreas and the prostate (mainly advanced prostate cancer), and between consumption of processed meat and cancer of the stomach.

On the basis of the large amount of data and the consistent associations

Lancet Oncol 2015

Published Online October 26, 2015 http://dx.doi.org/10.1016/S1470-2045(15)00444-1

For more on the **IARC Monographs** see http://monographs.iarc.fr/

18% increase in risk of colorectal cancer = increase of 1/100 people

Food, health, climate change…

Analysis and valuation of the health and climate change cobenefits of dietary change

Marco Springmann[a,b,1], H. Charles J. Godfray[a,c], Mike Rayner[a,b], and Peter Scarborough[a,b]

[a]Oxford Martin Programme on the Future of Food, Department of Zoology, University of Oxford, Oxford OX1 3PS, United Kingdom; [b]British Heart Foundation Centre on Population Approaches for Non-Communicable Disease Prevention, Nuffield Department of Population Health, University of Oxford, Headington, Oxford OX3 7LF, United Kingdom; and [c]Department of Zoology, University of Oxford, Oxford OX1 3PS, United Kingdom

Edited by David Tilman, University of Minnesota, St. Paul, MN, and approved February 9, 2016 (received for review November 22, 2015)

What we eat greatly influences our personal health and the environment we all share. Recent analyses have highlighted the likely dual health and environmental benefits of reducing the fraction of animal-sourced foods in our diets. Here, we couple for the first time, to our knowledge, a region-specific global health model based on dietary and weight-related risk factors with emissions accounting and economic valuation modules to quantify the linked health and environmental consequences of dietary changes. We find that the impacts of dietary changes toward less meat and more plant-based diets vary greatly

The diets investigated in these studies include diets with a pro rata reduction in animal products (ruminant meat, total meat, dairy) (11, 13, 14), specific dietary patterns that include reduced or no meat (such as Mediterranean, "pescatarian," and vegetarian diets) (11, 12), and diets based on recommendations about healthy eating (7, 11). The health consequences of adopting these diets have not been explicitly modeled or quantitatively analyzed, but instead inferences have been drawn from information available in the epidemiological literature (16). In the most comprehensive study to date, Tilman and Clark (12) analyzed the GHG emissions


How to incentivise dietary change


Taxes on food by GHG emissions?

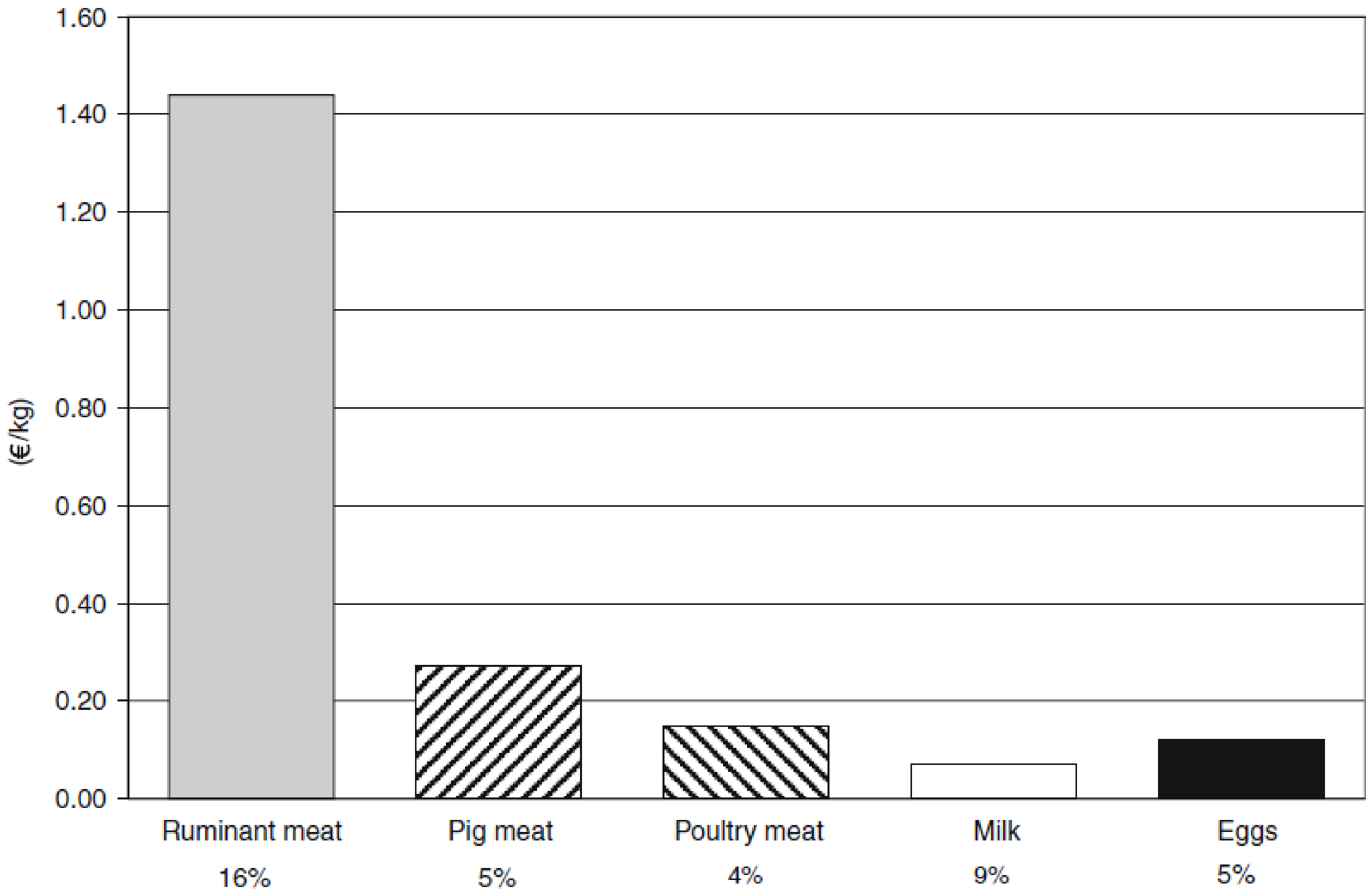
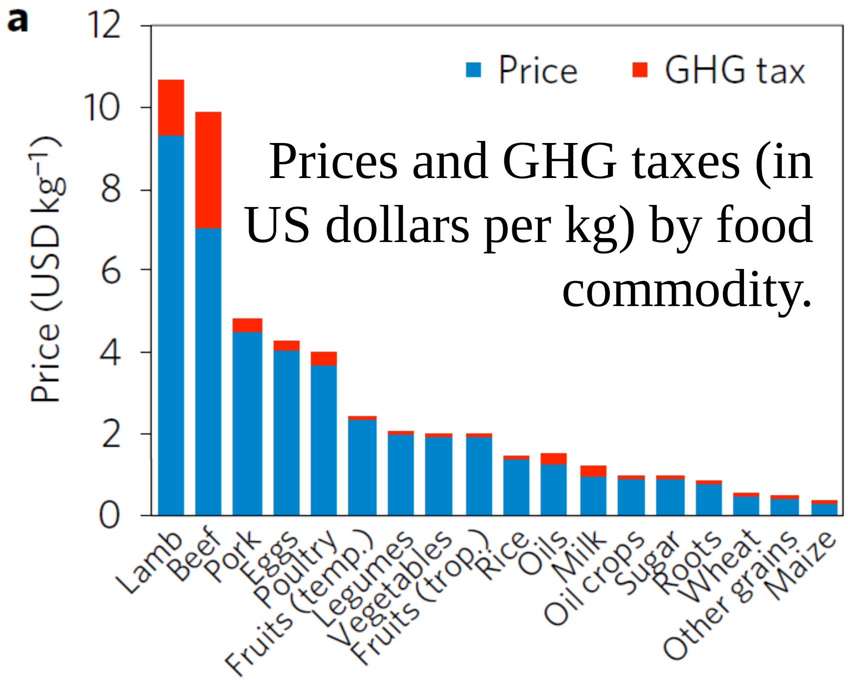
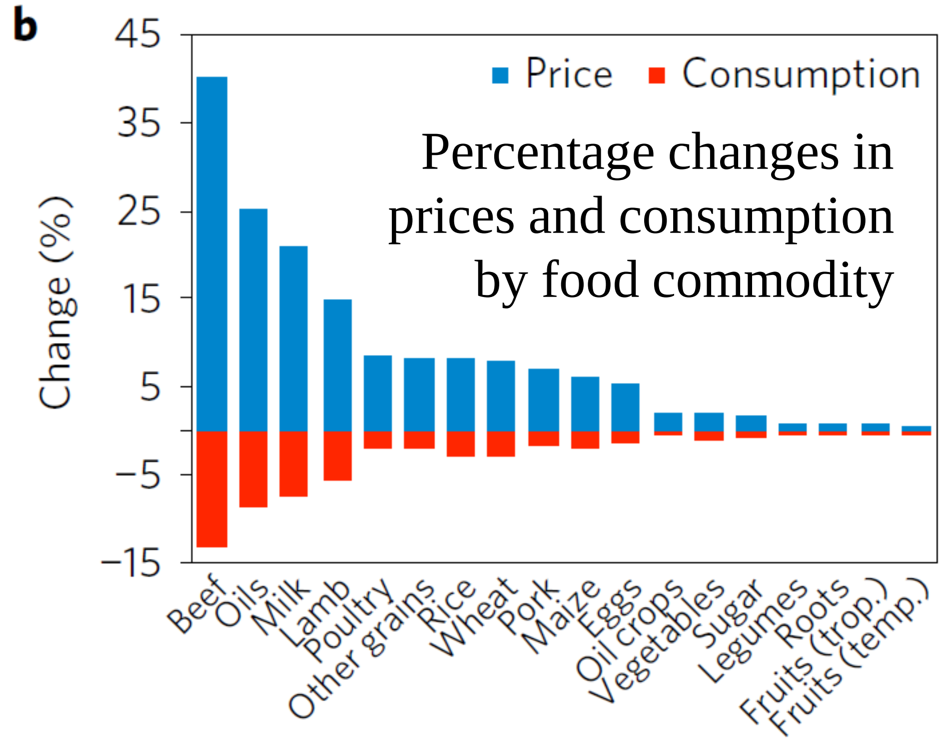


Fig. 9 Taxes per kg (fresh weight) food product for GHG weighted consumption taxes on animal food equivalent to €60 per ton CO_2-eq. *Percentages on top of bars* show the corresponding relative increase in consumer price

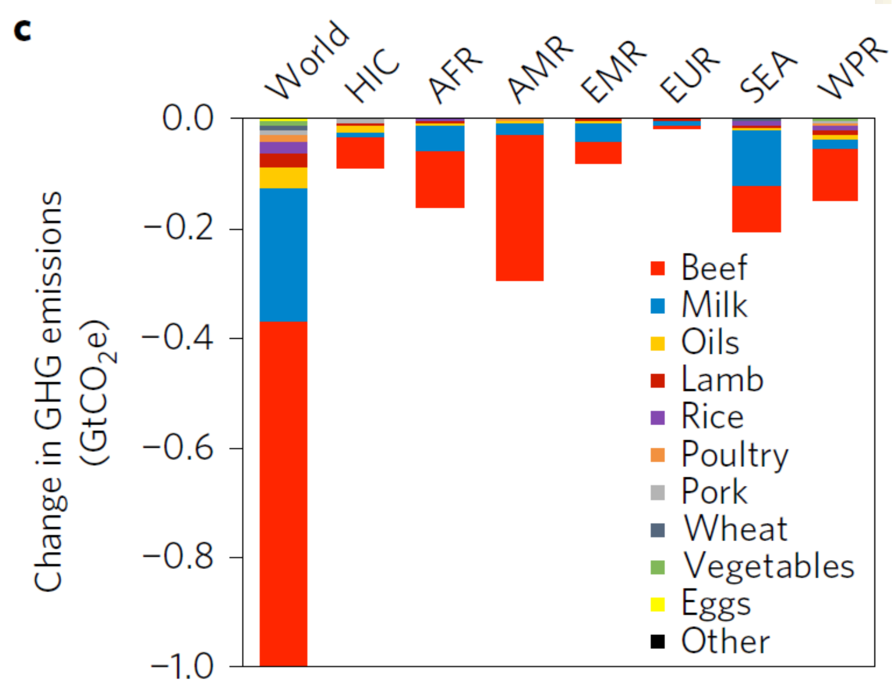
Wirsenius *et al.* (2011)



Prices and GHG taxes (in US dollars per kg) by food commodity.

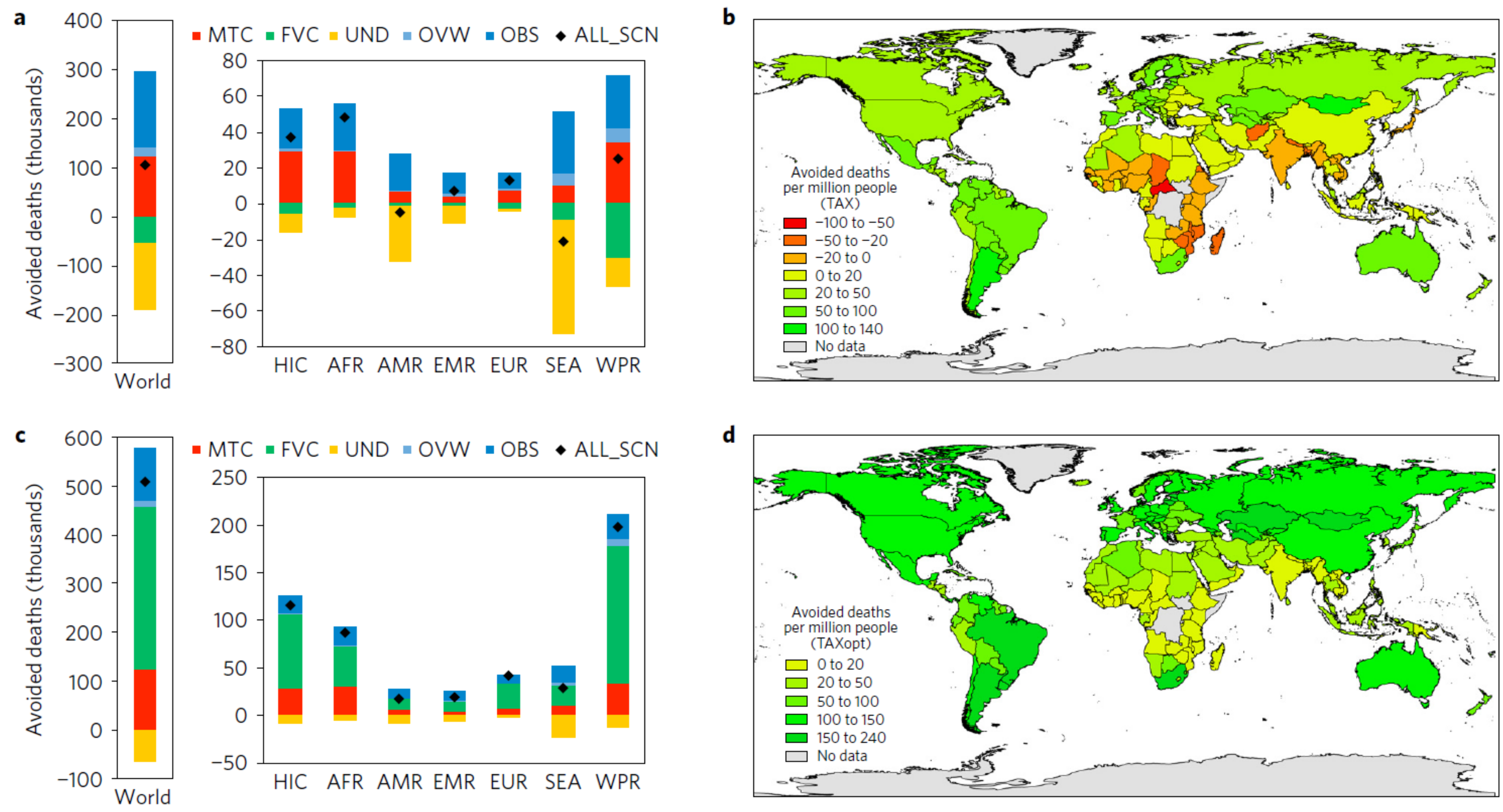


Percentage changes in prices and consumption by food commodity



Change in GHG emissions (in $GtCO_2e$) by food commodity and region

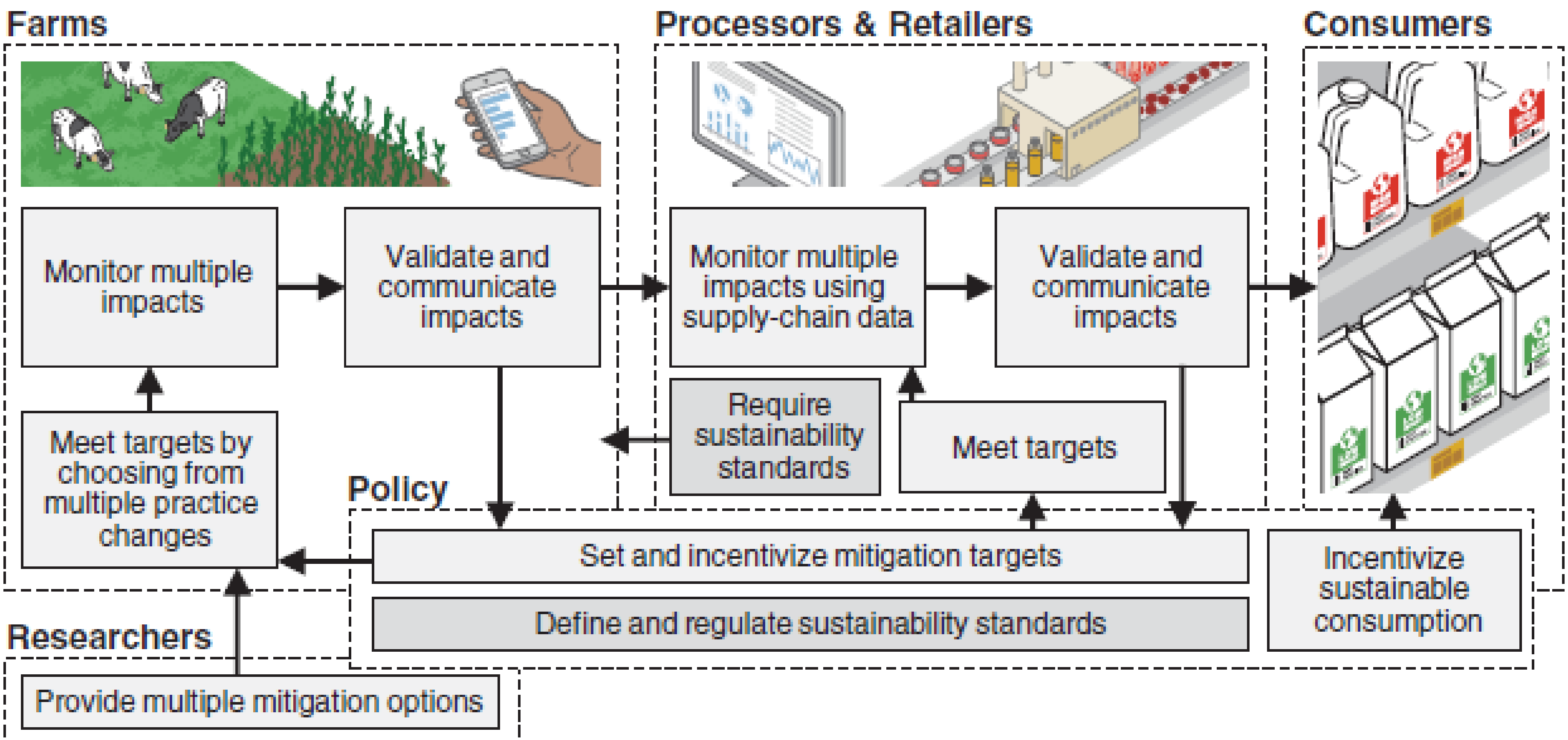
Springmann *et al.* (2017)



Avoided deaths in thousands (**a**,**c**) and per million people (**b**,**d**) in a scenario that covers all food commodities. Risk factors (**a**,**c**) include increases in red meat consumption (MTC), decreases in fruit and vegetable consumption (FVC), increases in the prevalence of underweight (UND) and overweight (OVW) people, and increases in obesity (OBS)

Springmann *et al.*, (2017)

Graphical representation of the mitigation framework



Poore & Nemececk (2018)

Conclusions (I)

- There are up to 2 orders of magnitude (100x) difference in the environmental impact of different foods
- The differences in environmental impact holds for a range of environmental indicators including:
  - greenhouse gas emissions,
  - land requirement,
  - water footprint,
  - atmospheric acidification, and
  - eutrophication of water

Smith (2014a)

Conclusions (II)

- Demand-side measures such as ***dietary change*** and ***food waste reduction*** are effective measures to reduce the environmental footprint of food
- Policy to incentivise change will be challenging, but might include taxes – though social justice and equity issues need to be considered
- There are a range of health co-benefits associated with dietary change
- Dietary change provides a multiple-win solution for climate change, food security, human health and environmental sustainability

Smith (2014)


Thank you for your attention