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UNIVERSITY OF ABERDEEN

Greenhouse gas emissions from the food system

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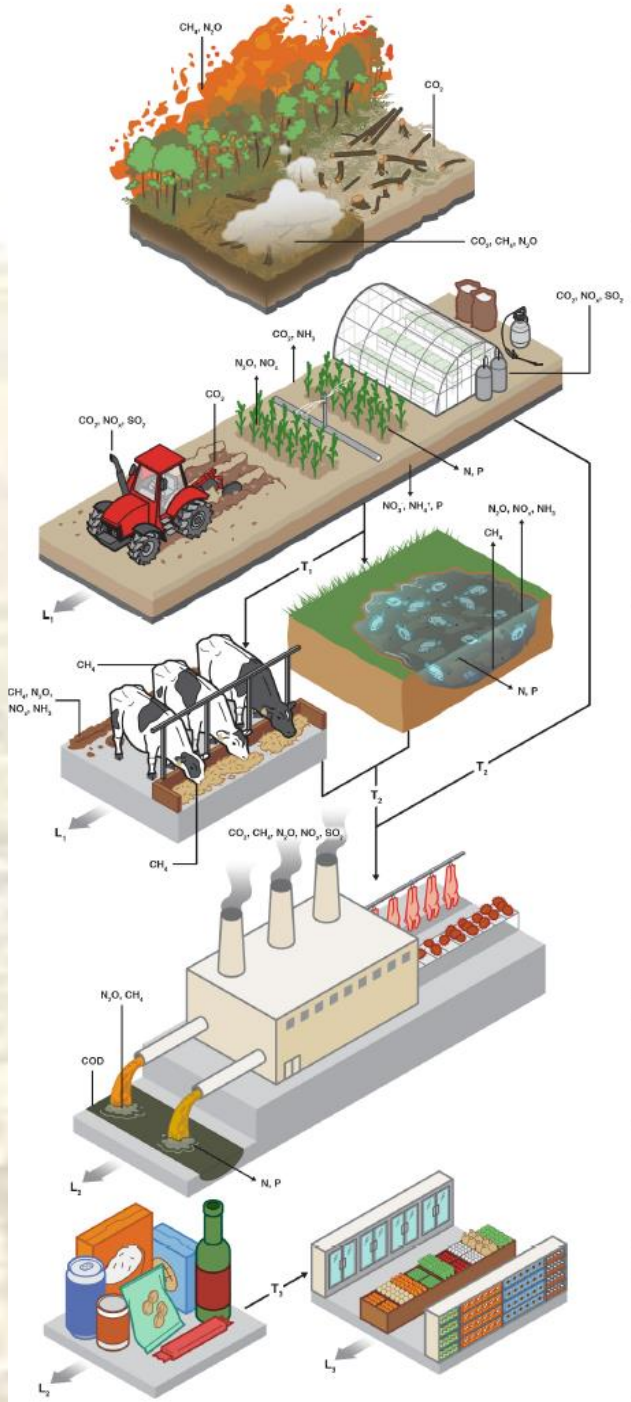
ICA Rectors and Deans Forum: "*The Role of Life Science Universities in Transitioning to Climate Neutrality and Open Science*" 21st October 2021



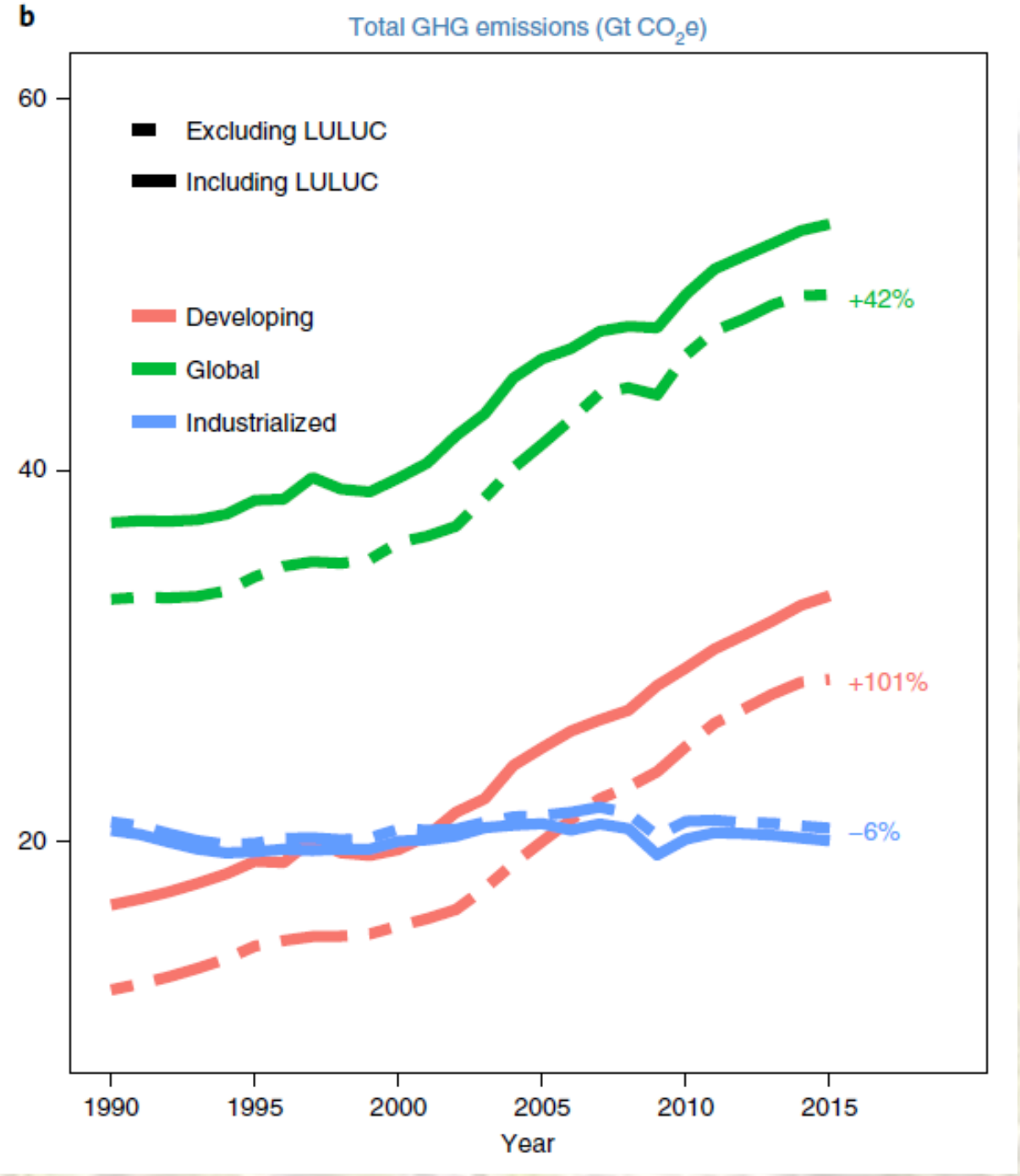
Included	Excluded
Land Use Change	
• Above ground C stock change (CO_2) • Below ground C stock change (CO_2) • Forest burning (CH_4, N_2O) • Organic soil burning (CO_2, CH_4, N_2O)	• Leaching, runoff and induced non-CO_2 emissions
Crop Production	
• Seed & nursery • Inputs production • Machinery • Greenhouse & trellis infrastructure • Electricity & fuel • Fertilizer & retained crop residue (N_2O, NH_3, NO_x, NO_3^-, NH_4^+, P, N) • Urea & lime (CO_2) • Flooded rice (CH_4) • Residue burning (CH_4, N_2O, NH_3, NO_x) • Cultivation of drained organic soils (CO_2, N_2O) • Drying / grading • Irrigation water consumption — Land use: seed; fallow; arable and permanent crops	• Soil emissions (CH_4) • Organic fertilizer application (CH_4) • N fixation emissions • C sequestration in crop residue • Runoff (N) • Residue burning indirect emissions (N_2O) • Human labour
Livestock/Aquaculture	
• Pasture management (same as for food/feed) • Feed processing • Housing energy use • Enteric fermentation (CH_4) • Manure management (N_2O, NO_x, NH_3, CH_4) • Aquaculture ponds (N, P, N_2O, NO_x, NH_3, CH_4) • Drinking & service water — Land use: permanent pasture; temporary pasture; aquaculture ponds	• Infrastructure • Pasture residue (emissions or burning) • Pasture N fixation emissions • Pasture runoff (N) • Manure management (P) • Human labour
Processing	
• Energy (CO_2, NO_x, SO_2) • Wood burning (CH_4, N_2O, NO_x, SO_2) • Wastewater (CH_4, N_2O, P, N, COD) • Incineration (CH_4, N_2O, NO_x, SO_2) • Processing water consumption	• Miscellaneous inputs • Human labour • Infrastructure • Land use
Packaging	
• Materials • Material transport • End of life disposal	• Human labour • Infrastructure • Land & water use
Retail	
• Energy use	• Human labour • Infrastructure • Land & water use
Losses	**Transport (CO_2, NO_x, SO_2)**
L_1 - Storage and transport L_2 - Processing and packaging L_3 - Wholesale and retail	T_1 - Feed T_2 - Food T_3 - Processed food

Emissions and resource uses included or excluded by supply chain stage by Poore & Nemecek (2018)

- Land use change
- Crop production
- Livestock / aquaculture
- Processing
- Packaging
- Retail
- Losses
- Transport

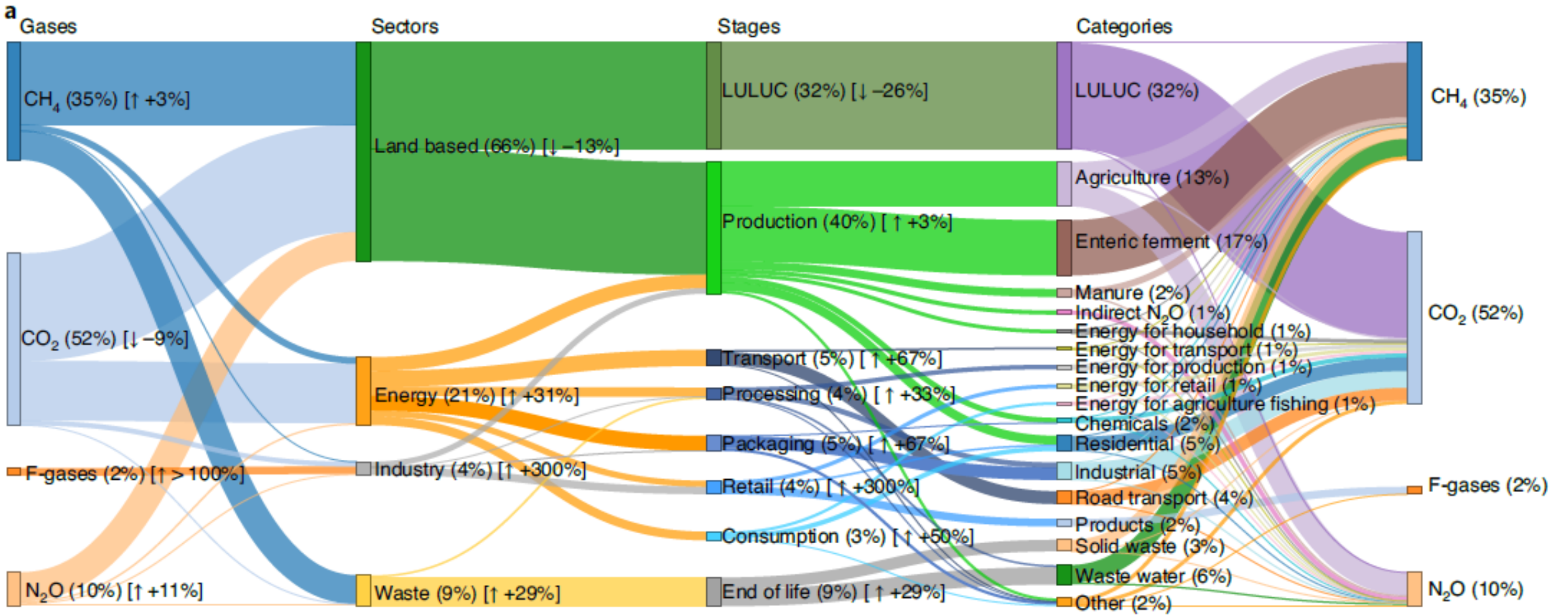
Total GHG emissions from the global food system

- Emissions have increased by 42% since 1990, globally
- Emissions have increased by 101% since 1990, in developing countries
- Emissions have decreased by 6% since 1990, in industrialised countries



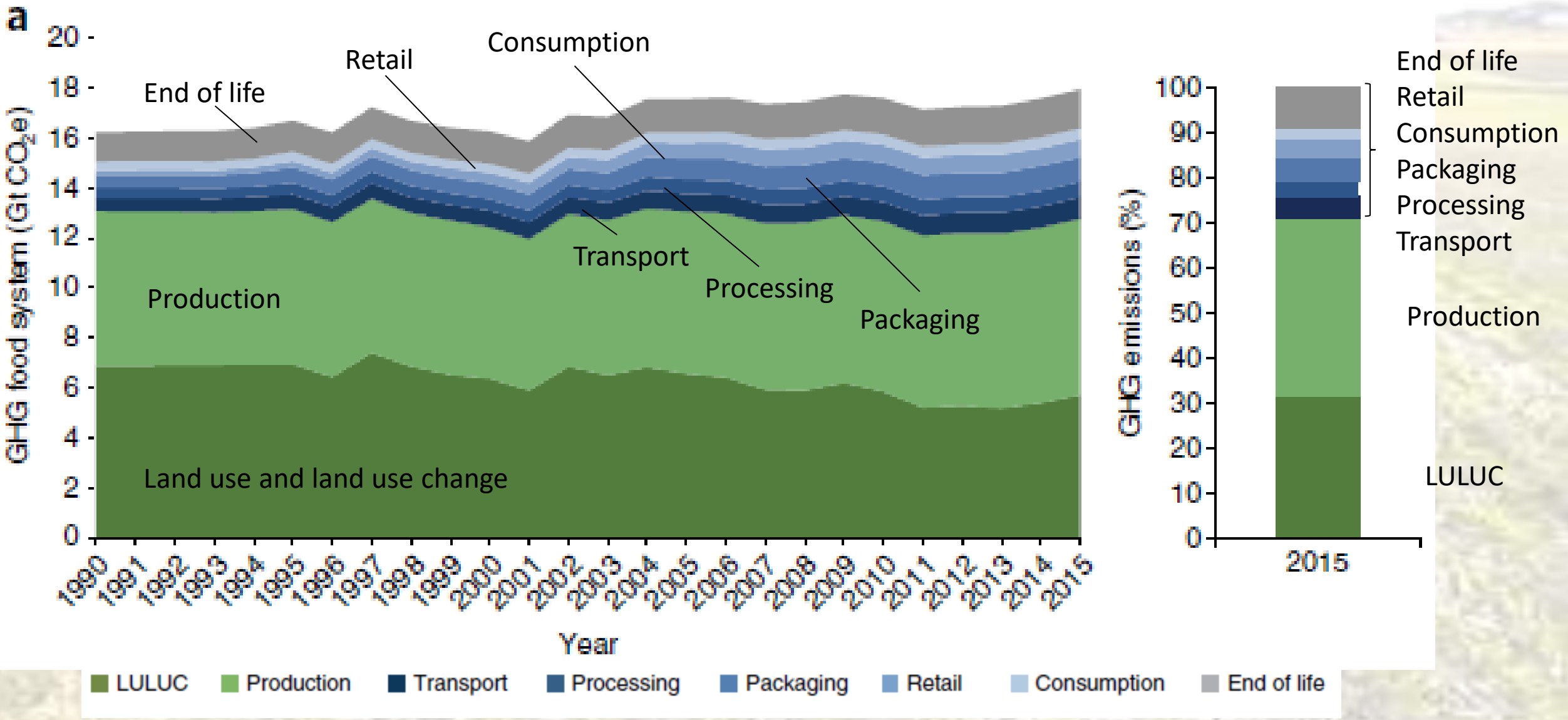
Crippa *et al.* (2021) Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food*.

GHG emissions from the global food system in 2015



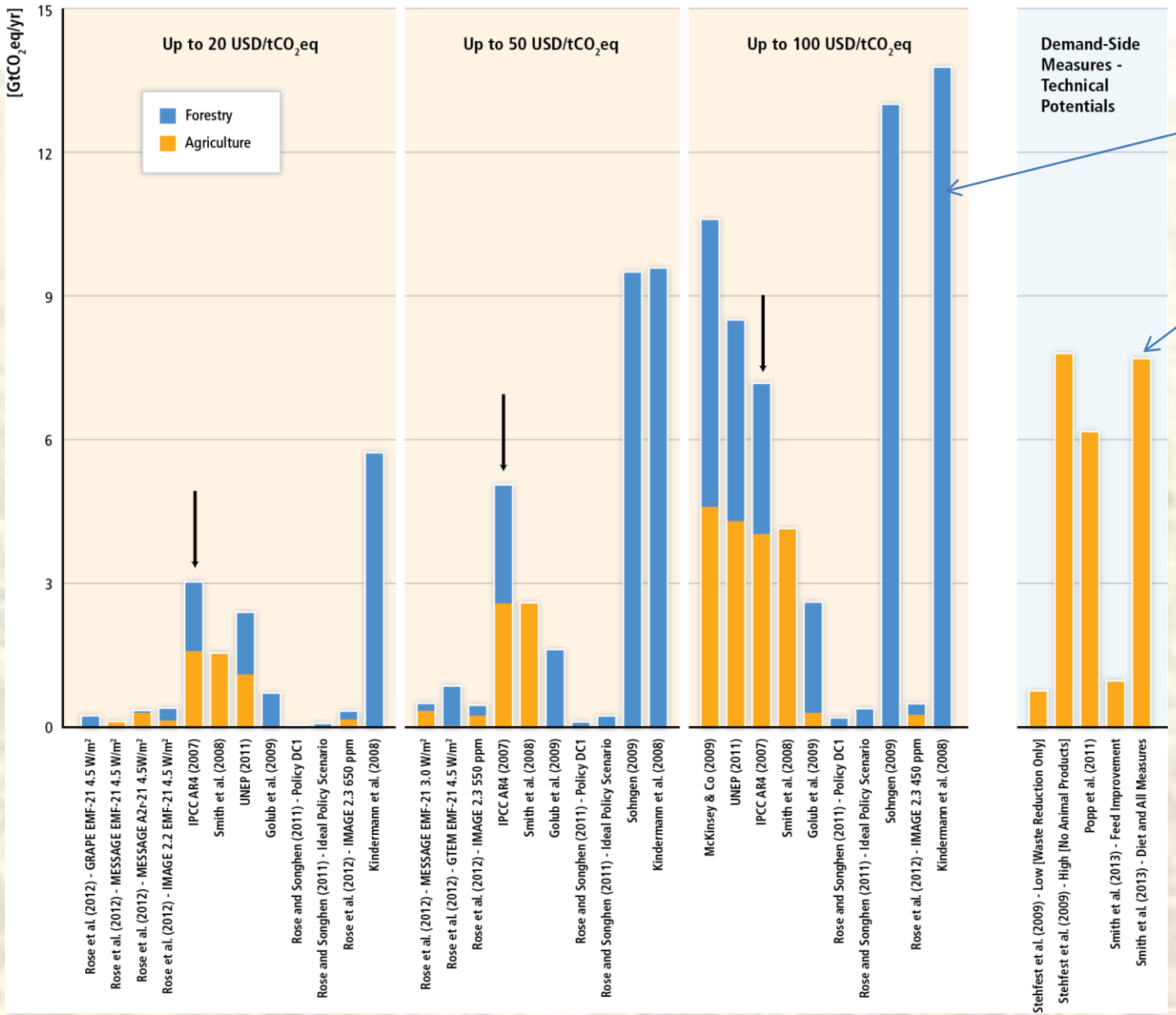
Crippa *et al.* (2021) Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food*.

Global GHG emissions trends of the food system by sector



Crippa *et al.* (2021) Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food*.

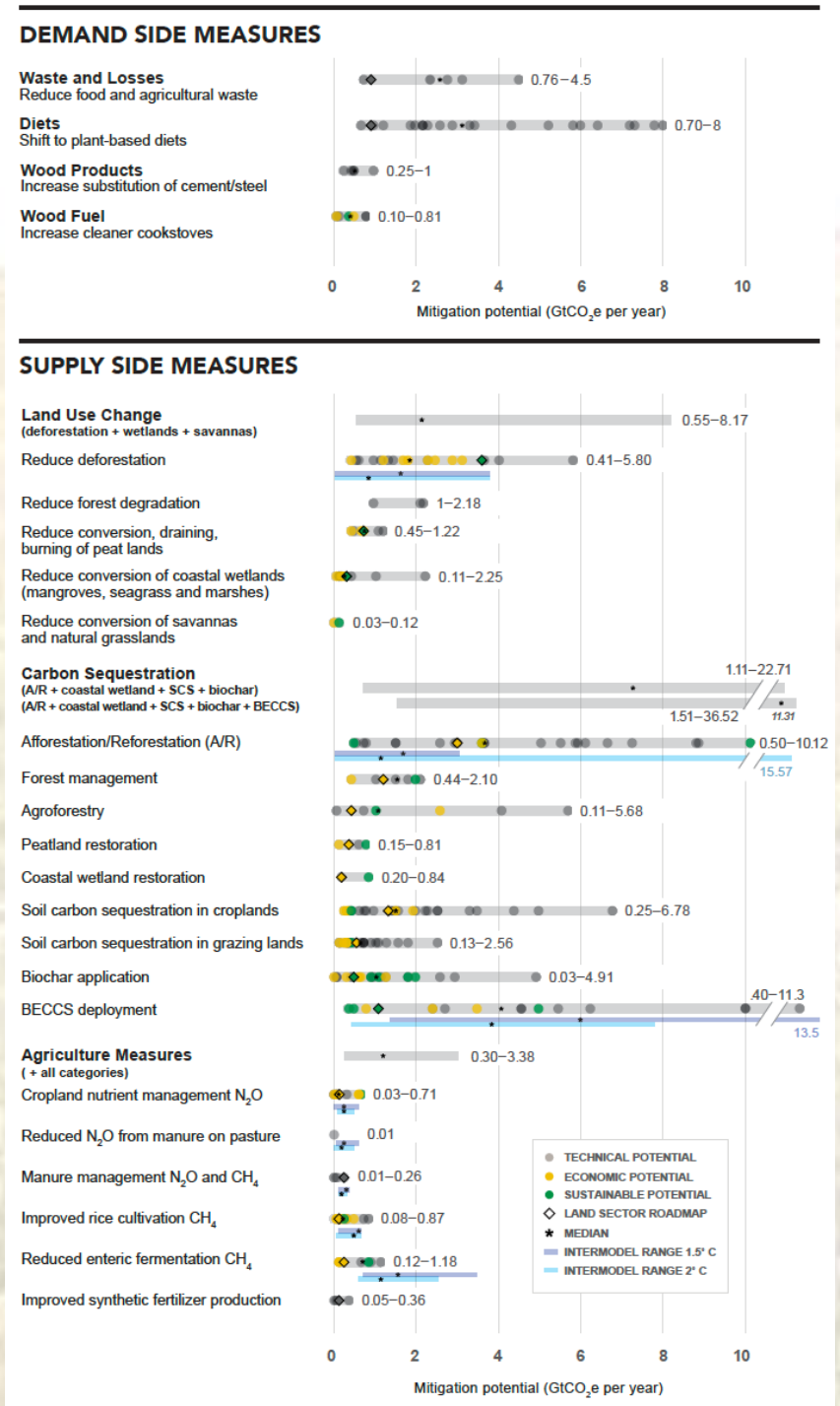
Demand- and supply-side measures need to be considered

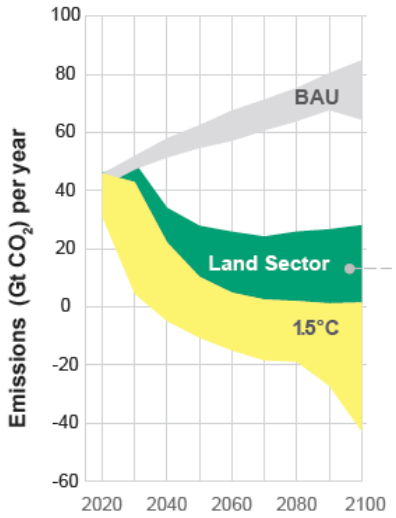


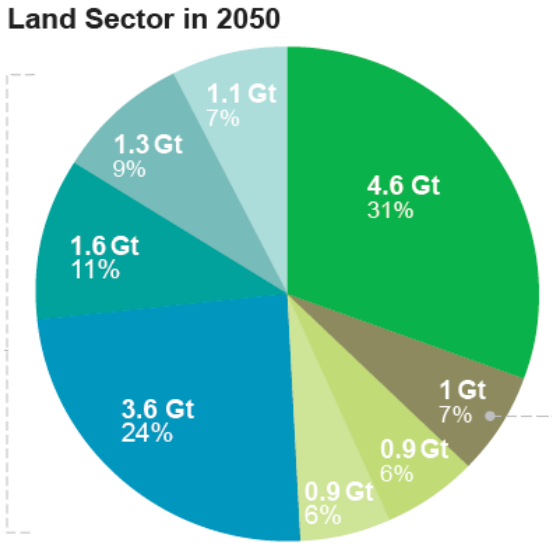
- Supply-side measures in the AFOLU sector are large & cost-competitive
- Demand-side measures such as dietary change and waste reduction also have large, but uncertain, mitigation
- Demand-side measures may be difficult to implement, but are worthy of further research
- Other options in the AFOLU sector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

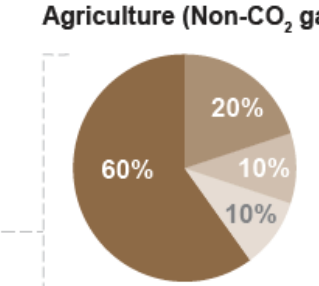
Smith *et al.* (2014) – IPCC WGIII AR5

Contribution of the land sector to a 1.5°C World









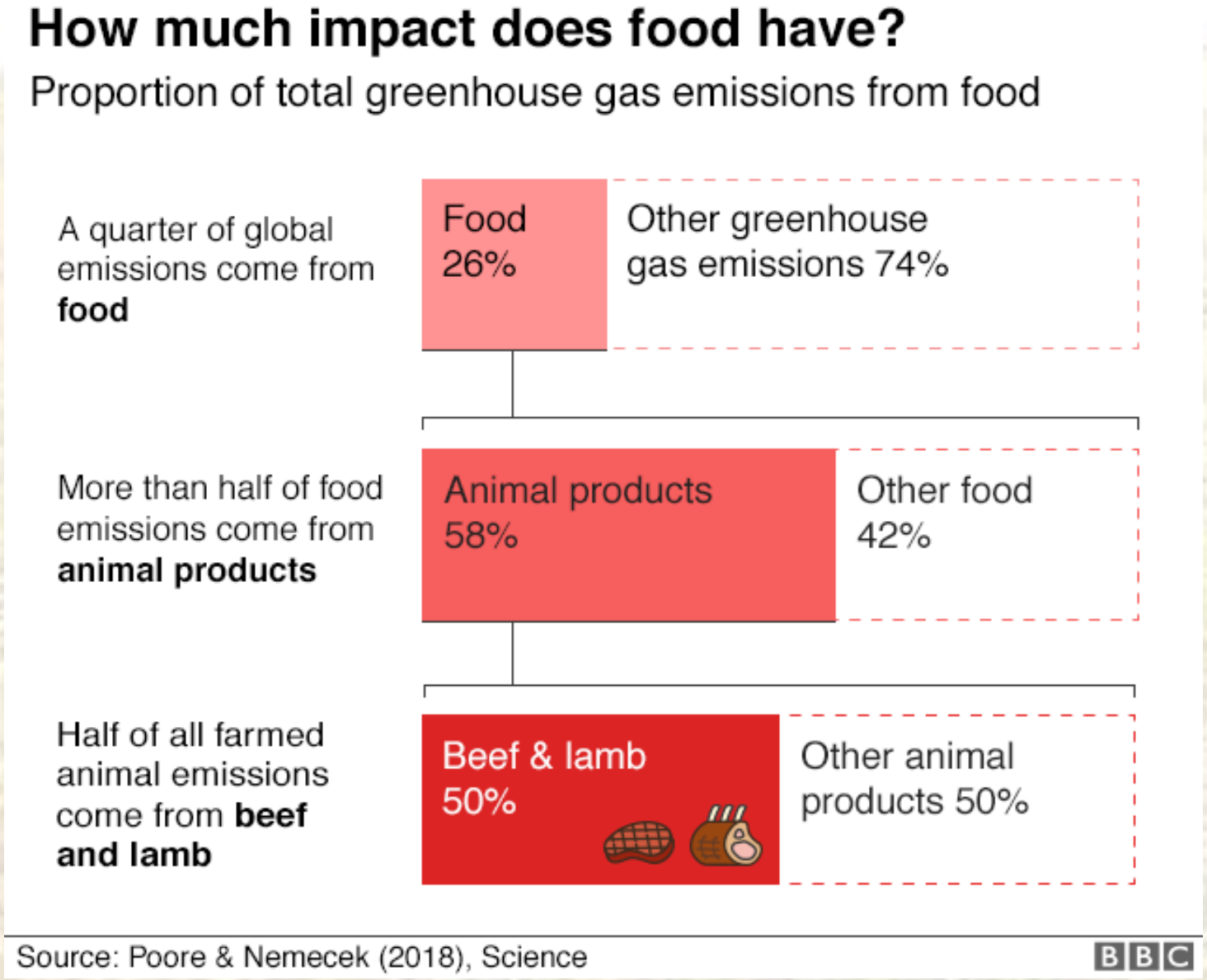
- Reduce deforestation and degradation, conversion of mangroves, and peatland burning
- Reduce emissions from agriculture
- Shift to plant-based diets
- Reduce food waste
- Restore forests, mangroves and drained peatlands
- Improve forest management and agroforestry
- Enhance soil carbon in agriculture and biochar
- R&D, investment and deployment of BECCS

Reduce emissions from:

- Livestock emissions (enteric fermentation and manure management)
- Rice cultivation
- Cropland nutrient management
- Synthetic fertilizer production

Roe *et al. Nature Climate Change* (2019)

Greenhouse gas emissions from meat and dairy

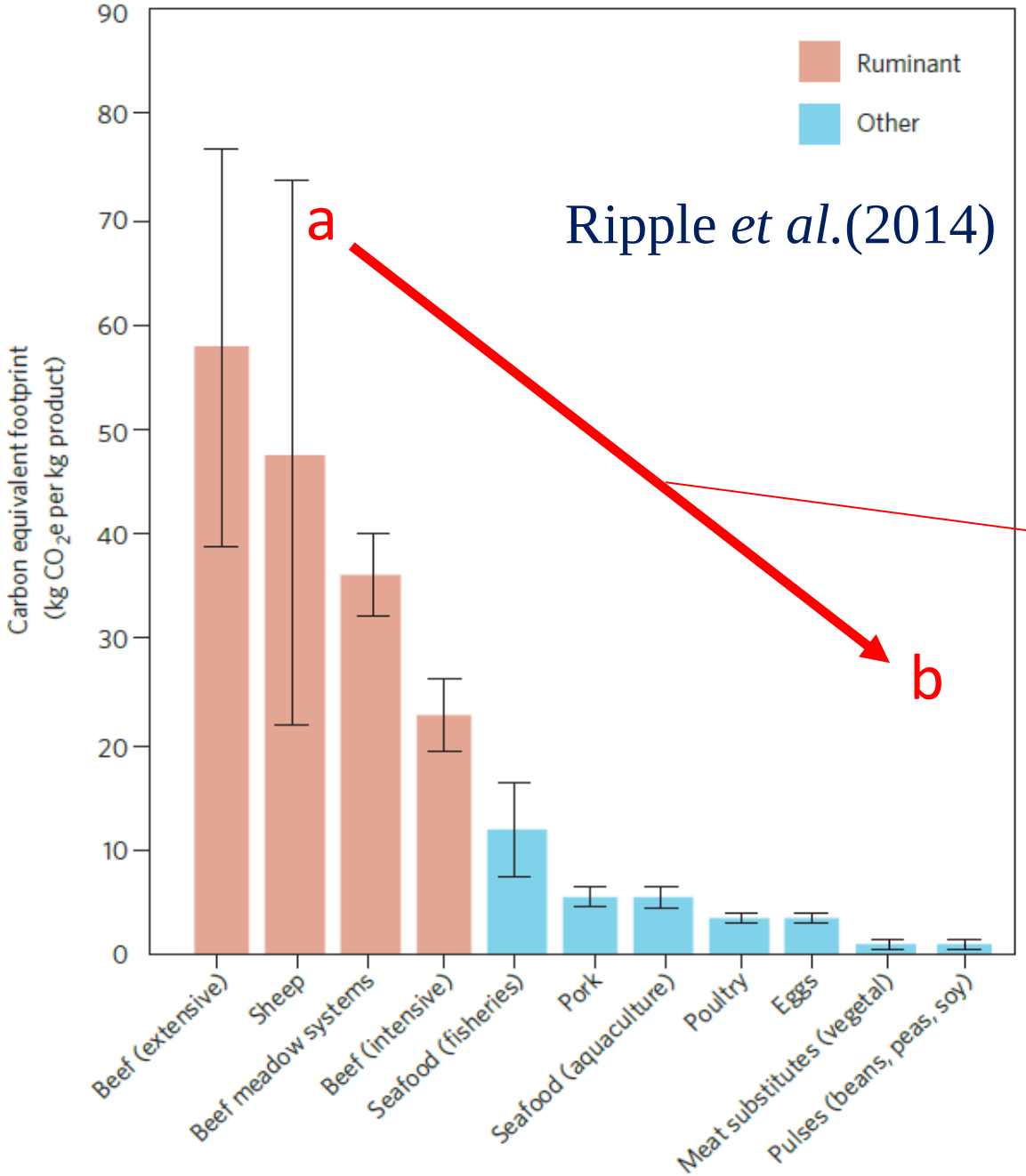


https://www.bbc.co.uk/news/science-environment-51210622

The UK Committee on Climate Change says we need to cut meat and dairy consumption by at least 20% (and reduce waste by 20%)

CCC chief executive Chris Stark told BBC News: “We can't meet the government's 2050 Net Zero target without major changes in the way we use the land, the way we farm, and what we eat.”

Big differences in the climate impact of different foods



Ruminant meat (cattle, sheep etc.) has a climate impact **10 to 100 times greater** than that plant-based foods (Poore & Nemecek, 2018)

Shift diets from foods in shown in a to more foods in b, will greatly reduce the climate impact of the diet

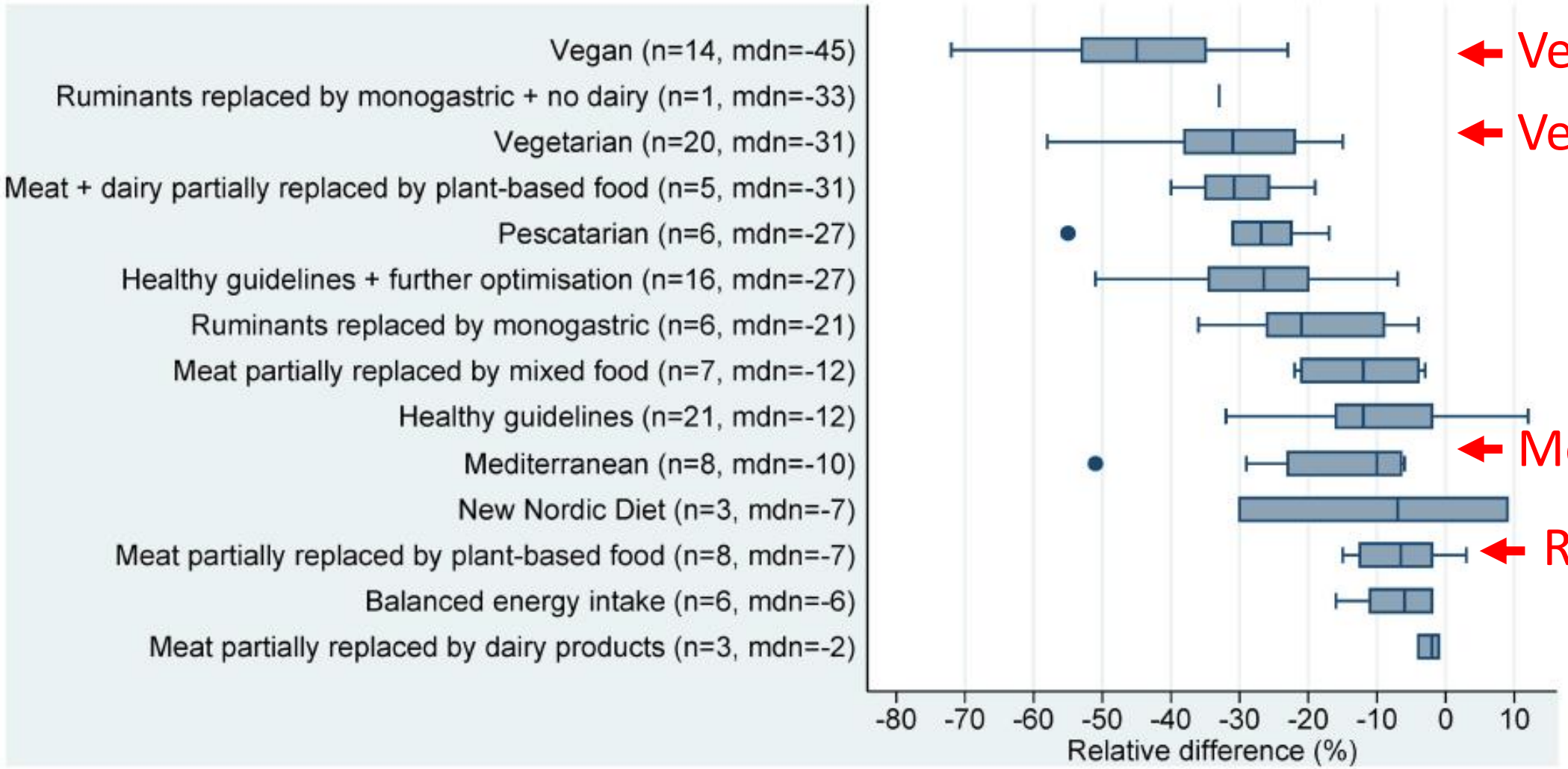


Fig 2. Relative differences in GHG emissions (kg CO_2eq/capita/year) between current average diets and sustainable dietary patterns. Note: n = number of studies, mdn = median.

doi:10.1371/journal.pone.0165797.g002

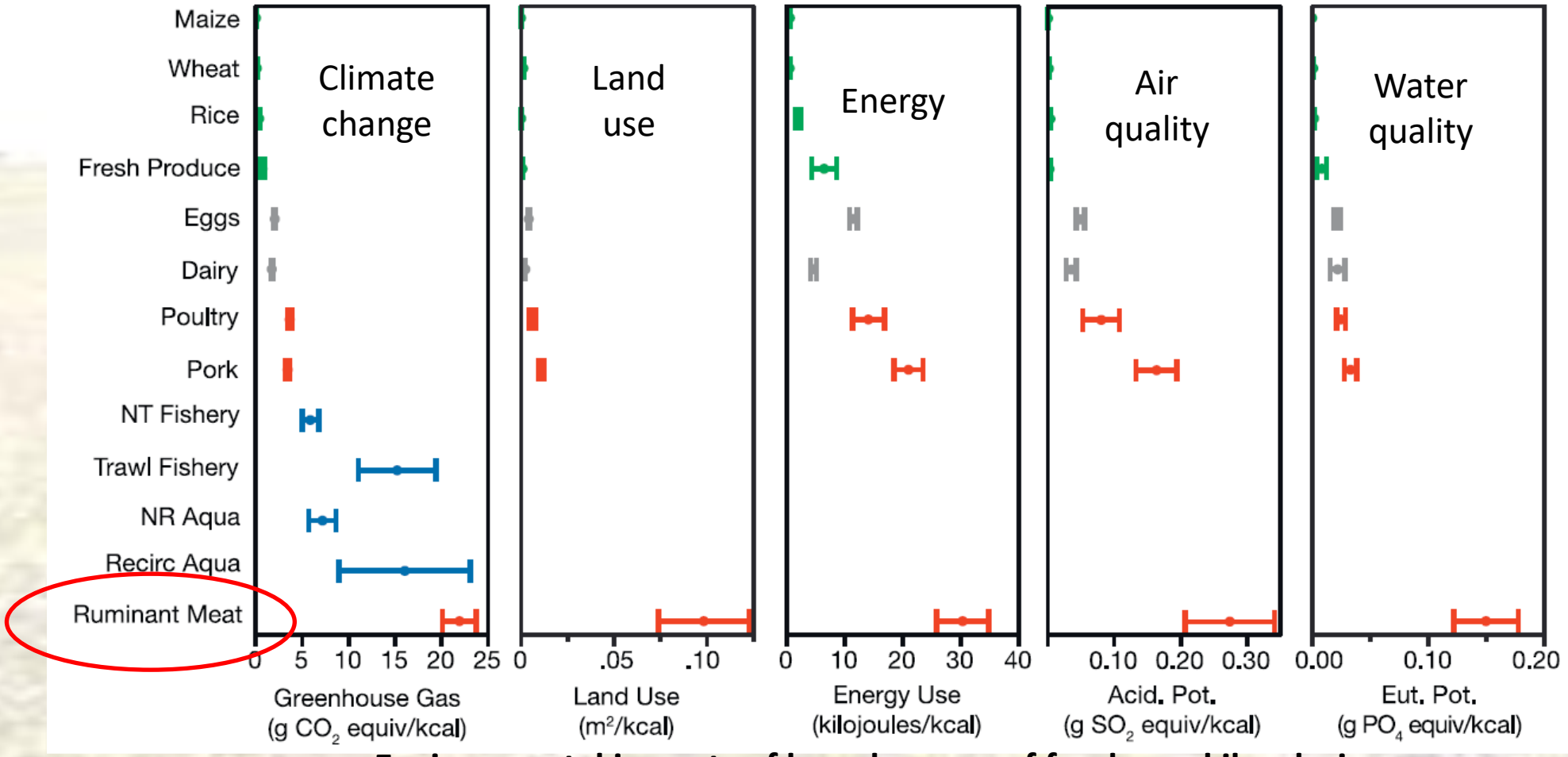
Vegan diets have lowest climate impact, then vegetarian diets – but *all reductions in meat and dairy* deliver climate benefits

Aleksandrowicz et al., 2016

Greenhouse gas emissions from individual diets

A heavy meat diet ALONE exceeds the worldwide per-person emissions target to combat climate change

Calculated using the Carbon Footprint Calculator (https://www.carbonfootprint.com/calculator.aspx)



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)

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

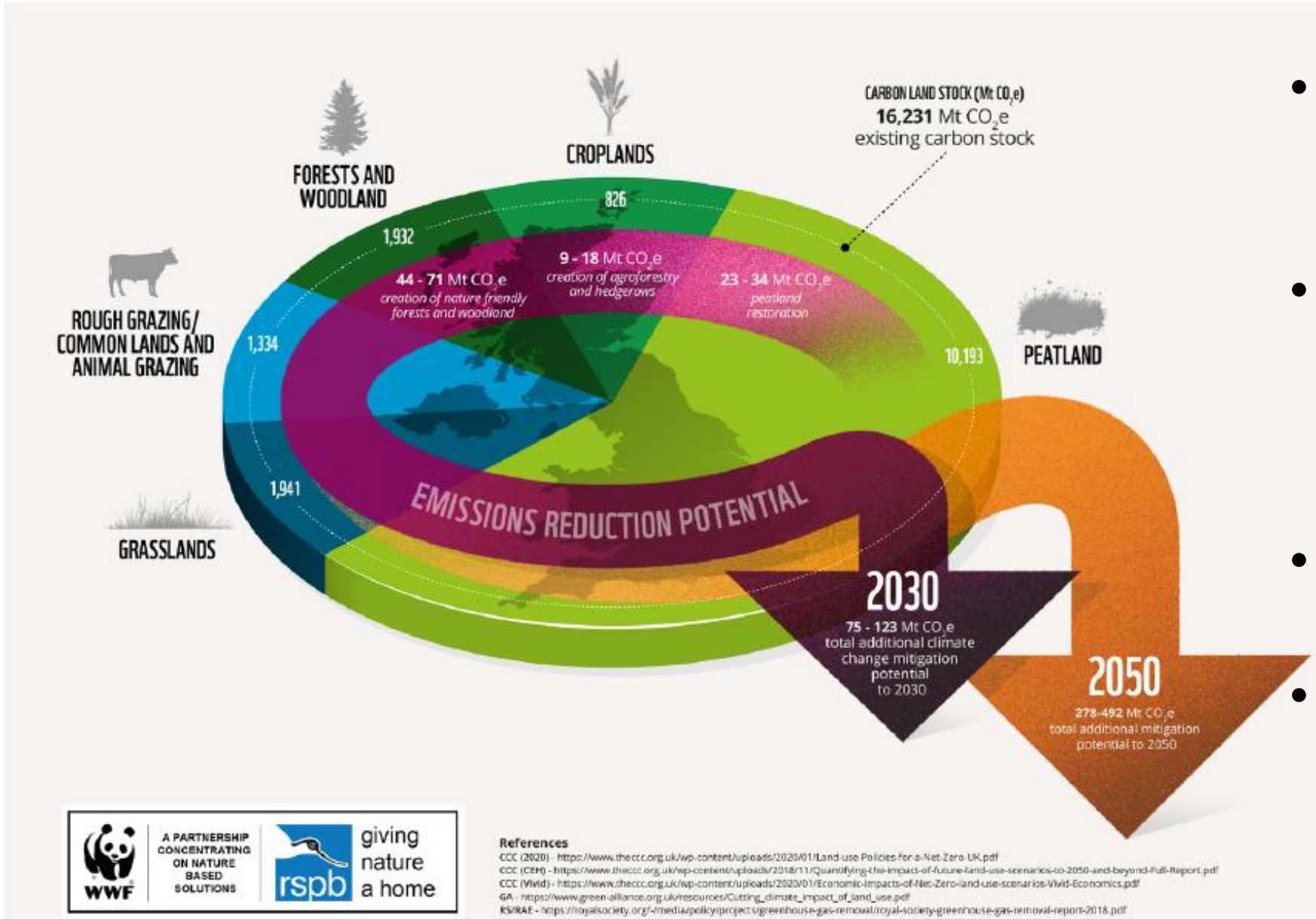
Using the land to tackle climate change

- Over 30% of crops grown on the planet are fed to livestock rather than humans
- ***Eating less meat and dairy*** would ***free-up land*** to use for other things, like protecting biodiversity, or ***tackling climate change***
- When plants grow, they remove carbon dioxide (the most important greenhouse gas) for the atmosphere
- The ***land can*** therefore be used to remove carbon dioxide from the atmosphere to ***help tackle climate change***
- ***Nature-based solutions*** (like protecting peatlands and woodland, restoring degraded peatlands and woodland, better managing woodlands and soils and creating new native woodland) can ***help biodiversity*** and help to address ***climate change***

Using the land to tackle climate change – some words of caution

- ***The land can't do it all***! There is not enough land to soak up emissions from other sectors, like transport, energy generation aviation etc.
- ***Immediate and aggressive action*** is needed across all sectors of the economy in we are to meet net zero targets
- Not all land-based solutions are necessarily good for biodiversity - so they need to be chosen and implemented carefully to get the multiple benefits
- Implemented carefully though, ***nature-based solutions*** are good for ***biodiversity***, good for ***people*** and good for both climate change ***adaptation*** and ***mitigation***

Nature-based solutions in the UK – Scotland has a big role



- **Protect** peatlands, woodland and permanent grassland
- **Restore** degraded peatlands, forest and coastal / marine systems (blue carbon)
- **Manage** woodlands and soils better
- **Create** new woodland with native trees

A PARTNERSHIP CONCENTRATING ON NATURE BASED SOLUTIONS

WWF

rspb giving nature a home

References

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CCC (CEH) - https://www.theccc.org.uk/wp-content/uploads/2018/11/Quantifying-the-Impact-of-future-land-use-scenarios-to-2050-and-beyond-Full-Report.pdf

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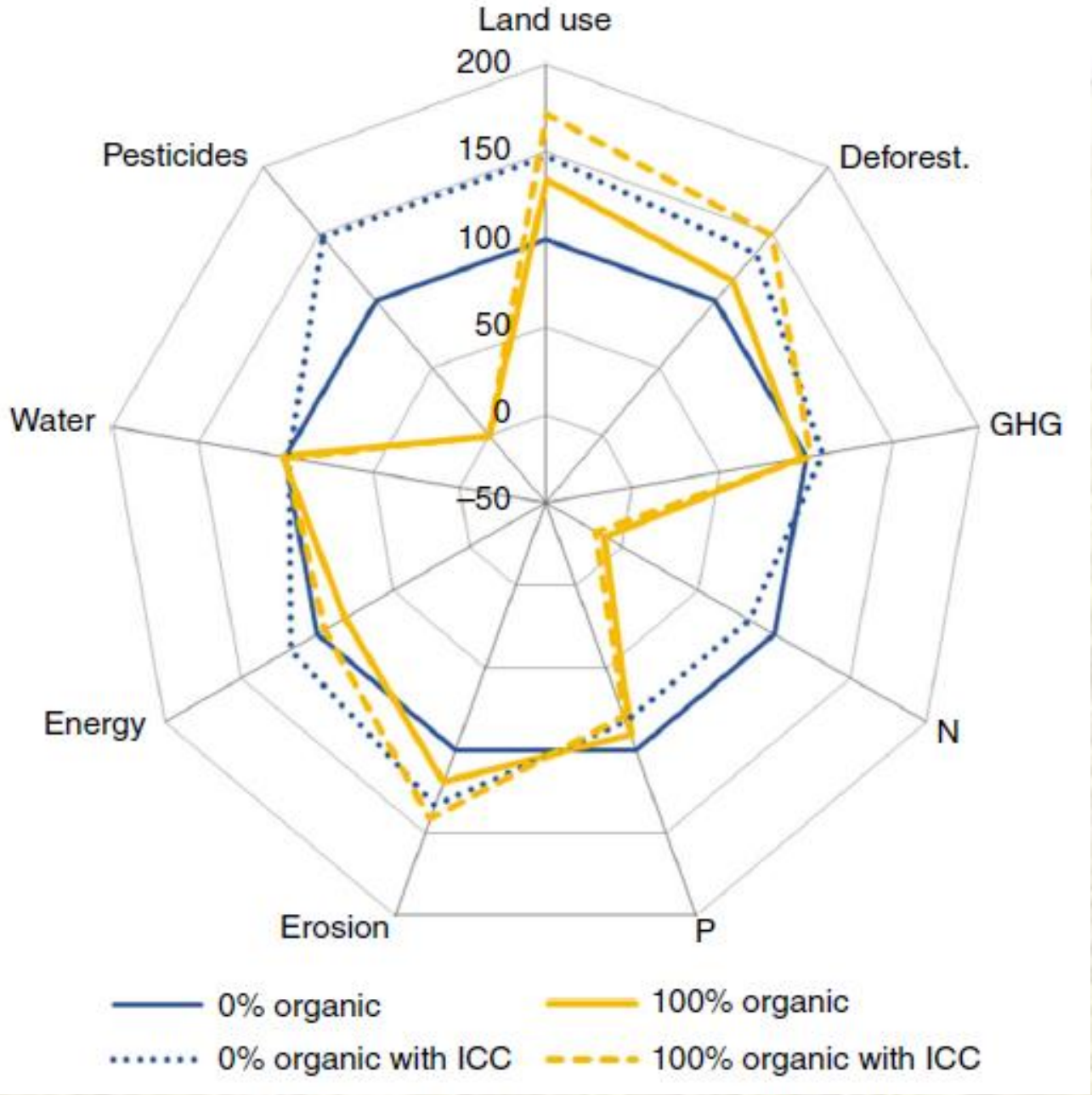

Reducing animal product consumption also creates the headspace for less intensive forms of agriculture. The highest levels of organic share can only be achieved by reduction in animal product consumption and elimination of animal feeds that could be fed to humans

Muller *et al.* (2017)

Conclusions

- Food production and distribution contributes up to a third of global greenhouse gases emitted by human activity
- Livestock production is responsible for 58% of all emissions from agriculture, and half of these emissions come from ruminants, such as cattle
- Ruminant meat has a 10-100 times worse impact on the climate than plant-based foods, as well as 10-100 times worse impact on land use, water use, air pollution and water pollution
- We need to redesign the food system to produce food that is healthy and sustainable – this will mean lower meat consumption and halving food loss and waste, as well as improving efficiency of production
- Agricultural and life science universities need to: a) embrace the whole food system, b) engage with demand-side changes needed in the food system to address societal challenges, c) engage more with social scientists and nutritionists and d) reduce YOUR emissions by 65-70% by 2030 (compared to 1990 emissions)