

How our food choices affect the climate

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Lini Wollenberg

Alliance of Bioversity International and CIAT
(CGIAR), and
Gund Institute, University of Vermont

Alliance





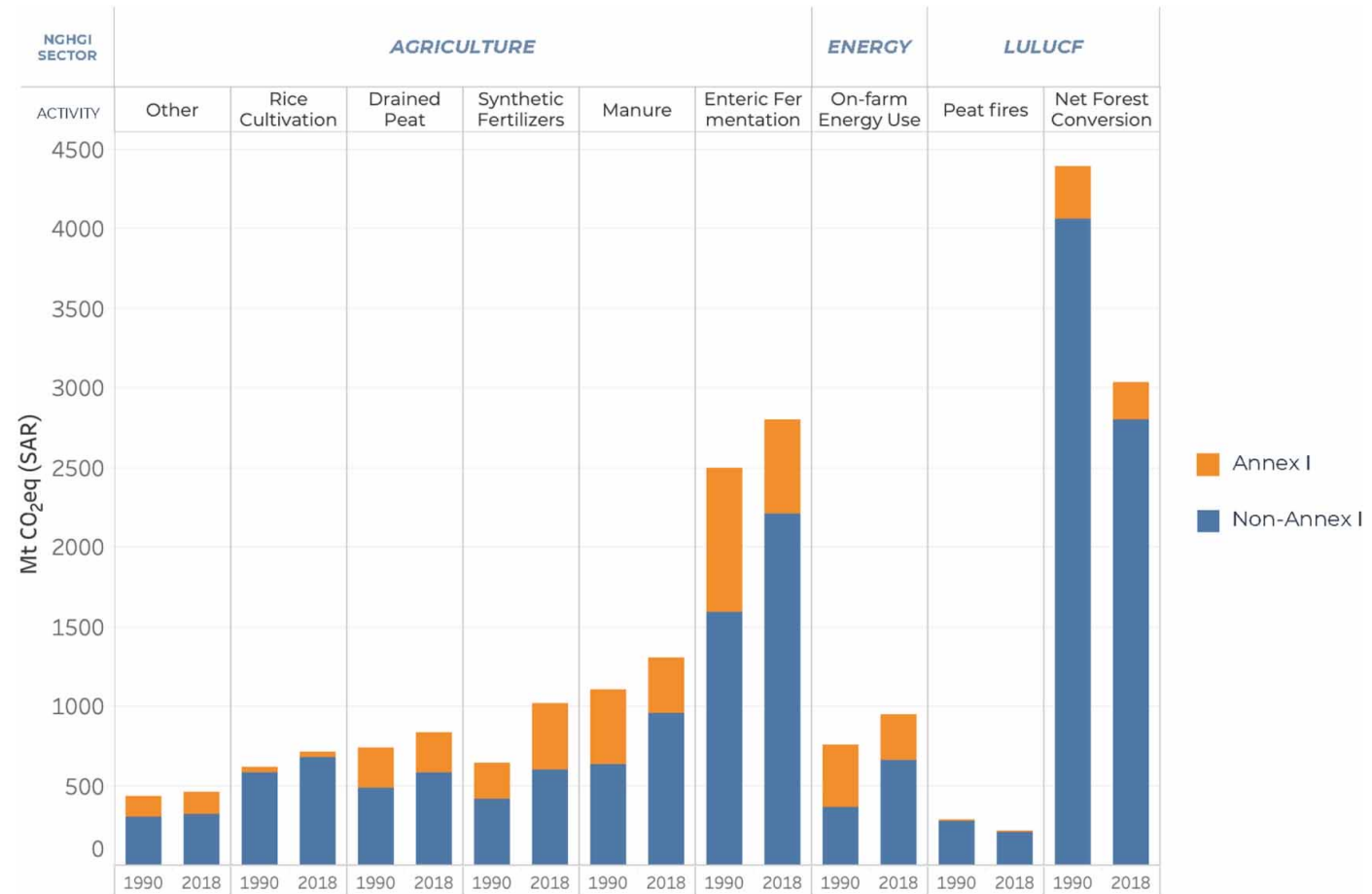
RESEARCH PROGRAM ON
**Climate Change,
Agriculture and
Food Security**



We review over 4000 countries, companies, and subnational governments, which together make up the preponderance of global emissions. We find 769 of these entities have net zero targets, but only 152 meet minimum criteria for robustness, including timing, status, coverage, use of offsets, and governance. Though net zero is now widespread as a concept, its operationalization is still in its infancy. Making net zero targets robust should now be a priority for policymakers in order to deliver Paris-consistent action, as well as securing more ambitious targets.

Food system emissions contribute to 1/3 of global emission (1990-2018) Tubiello et al. 2021

- Significant source of emissions: 16 billion tCO₂e/year
- Reducing food system emissions is necessary to meet global climate targets.



Mitigation options in food systems

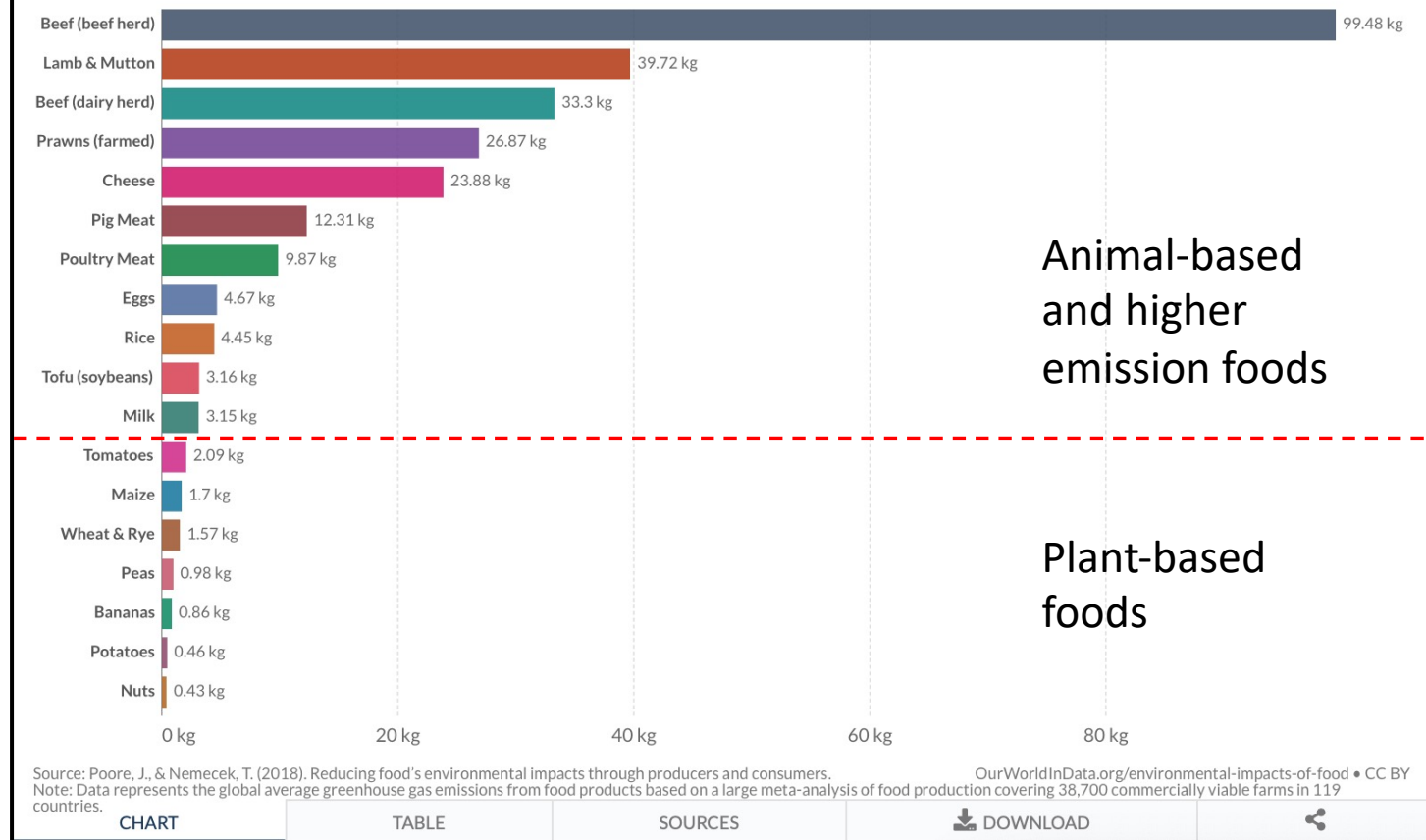
- **Paddy rice** - alternate wetting and drying
- **Livestock systems** - improving feeding, animal and herd management; pasture management
- **Cereal crops**- building soil organic matter, e.g. through integrated soil fertility management; nutrient efficiency through technologies such as urea deep placement; BNI in crops
- **Perennial crops**- transitioning from annual crops or degraded land to agroforestry, forestry or grassland
- **Avoided conversion of high carbon landscapes** (forests, peatlands, mangroves, grasslands)
- **Reduced food loss and waste**- storage, packaging, waste recycling
- **Supply chain energy use** – fertilizer production, cooling, transportation
- **Dietary shifts**- shift to low-emissions food products, e.g. beef to chicken, meat substitutes

Intergovernmental Panel on Climate Change (IPCC) concluded that **food consumption changes are necessary to meet global climate targets.**

EAT-Lancet's 2019 Planetary Health Diet is an example of a climate-friendly diet.



Greenhouse gas (GHG) emissions per kilogram food product (CO₂e)



Food emissions vary!

- Beef has the highest emissions, nuts lowest.
- Poultry and pork are ~1/10 the emissions of beef.
- Plant-based products are 20-to 200X lower than beef
- Rice has highest plant-based emissions
- Foods linked to deforestation have higher emissions (beef, soy)

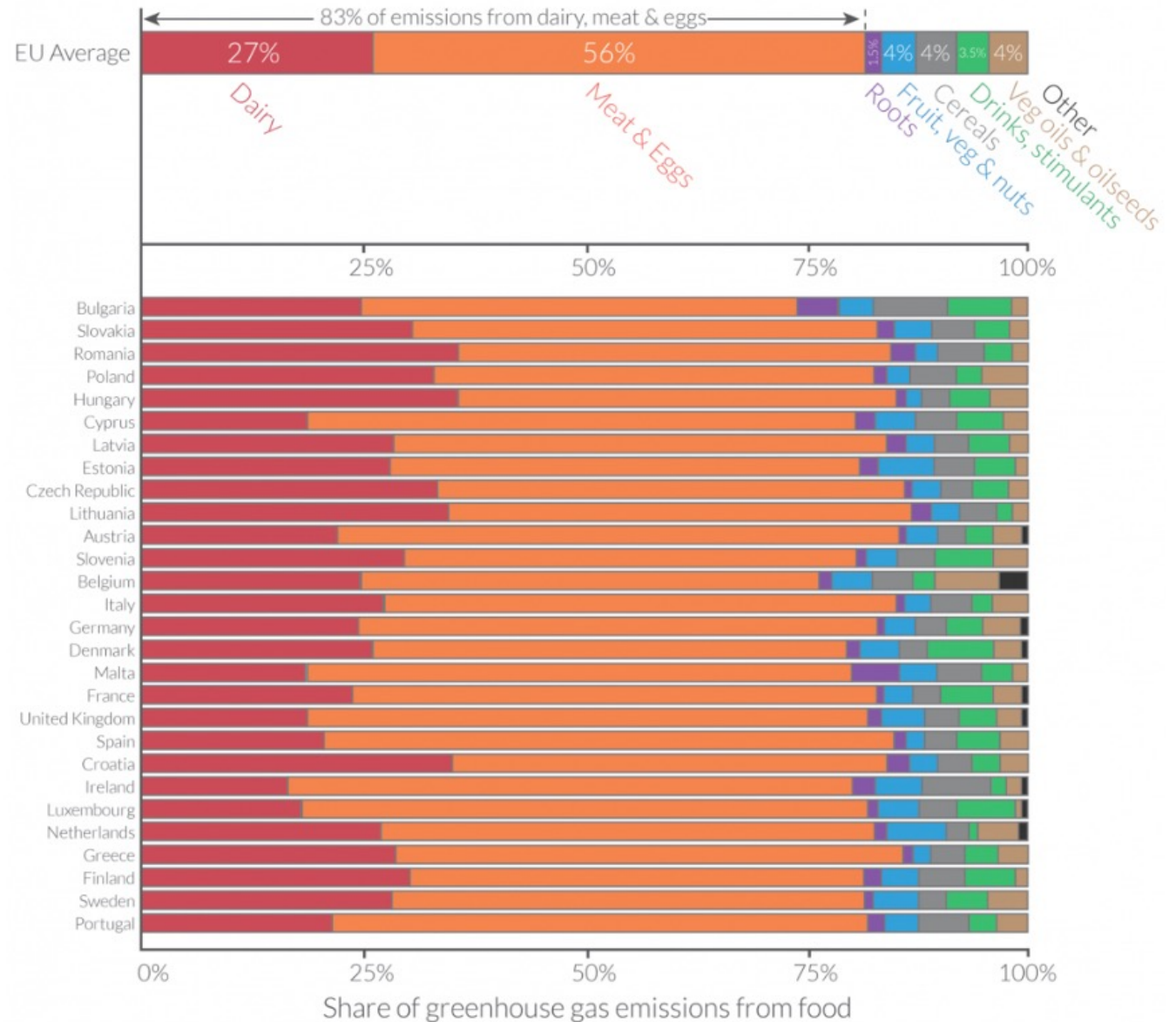
Meat, eggs and dairy contribute 83% of emissions on average in the EU.

Only 17% of dietary emissions from plant-based foods.

Sandström et al. 2018

Carbon footprint of diets across the European Union: which foods are responsible for greenhouse gas emissions?

Our World
in Data



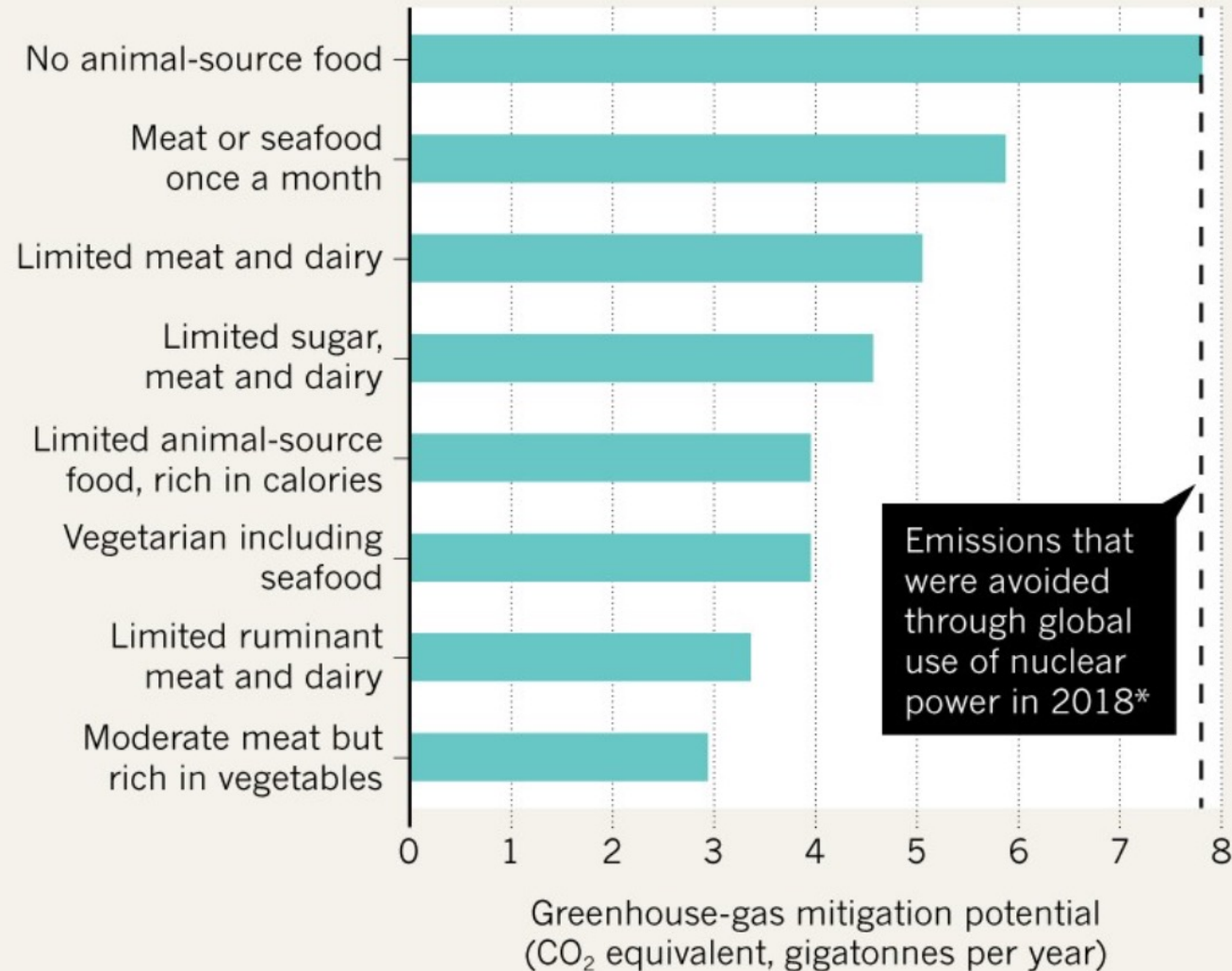
Data source: Sandström et al. (2018). The role of trade in the greenhouse gas footprints of EU diets.
OurWorldinData.org – Research and data to make progress against the world's largest problems.

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By 2050, dietary change could reduce emissions by 3 - 8 billion tCO₂e/yr.

WHAT IF PEOPLE ATE LESS MEAT?

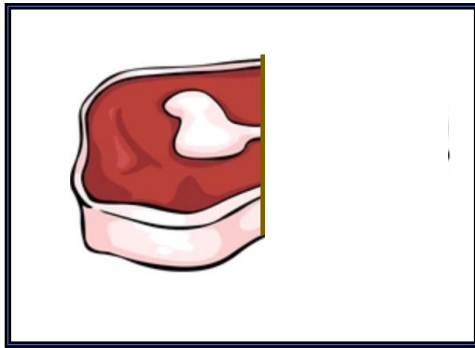
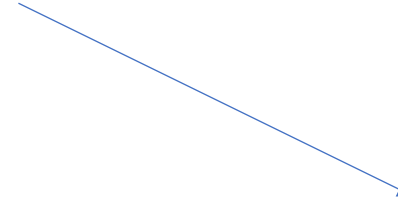
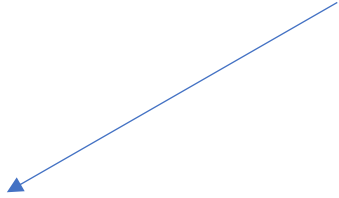
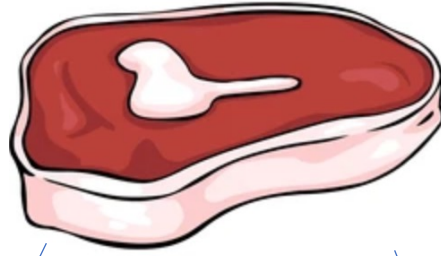
The Intergovernmental Panel on Climate Change examined the estimated impact on greenhouse-gas emissions of the world's population adopting a variety of diets.



*Assumes nuclear power plants replaced fossil fuels; data from the World Nuclear Association.

©nature

Data from 2019 IPCC Special Report on Land



Continue to eat
meat, but at
reduced levels

Meatless Mondays



Shift to lower-
emission meats

Health campaigns,
animal feed
additives (e.g.,
Bovaer)



Substitute with plant, cell-
based and mycoprotein
meat analogs

Beyond Meat, Impossible
Foods

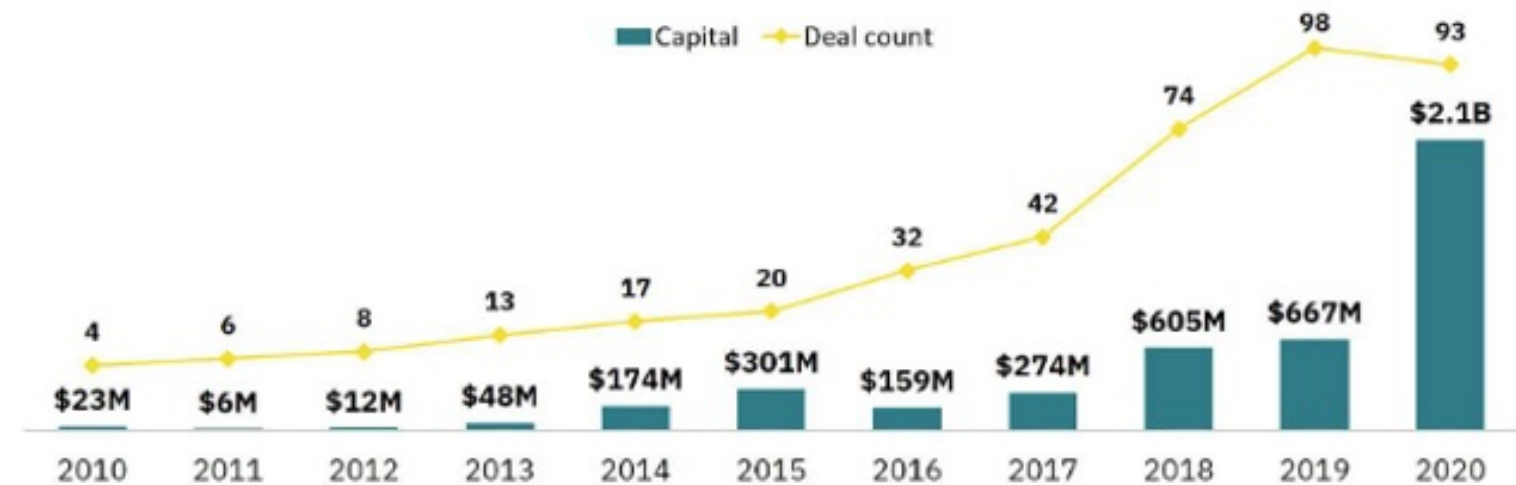


Eliminate meat: vegan,
vegetarianism

Grassroots advocacy,
People for the Ethical
Treatment of Animals
(PETA)

Rapid growth of plant-based meat industry

Figure 15: Annual investment in plant-based companies (2010–2020) (U.S. and global)



Source: GFI analysis of PitchBook data.
Note: Data has not been reviewed by PitchBook analysts.

Table 9.2. Comparison of investment and market status for different types of alternative meats (meat analogs).

Technology	Invested capital 2010-2020 and market
Plant-based	US\$ 4.4 Billion <ul style="list-style-type: none">PBM and dairy products are available for consumers around the world in supermarkets and restaurantsStartups can be found globally.
Cultivated	US\$ 0.49 Billion <ul style="list-style-type: none">Products are not on the shelf, but the first consumer testing has begunThe technology is rapidly advancing and starting to get more investment
Fermented mycoproteins	US\$ 1 Billion <ul style="list-style-type: none">Fermented products are mainly marketed as additives for plant-based productsImpossible Foods uses a fermentation process to create heme proteins



Indonesia's first homegrown plant-based meat firm Green Butcher is banking on its localised flavours and spices focus to pique the interest of the nation's consumers. ©Green Butcher

Scaling up PBM in low and middle-income countries

Veggie Victory, Nigeria

Global investors from the US and Europe are [backing Nigeria's first plant-based meat start up](#), VeggieVictory.

Africa is increasingly seen as a new frontier for plant-based protein investment with a rapidly growing economy and population that is seeking more dairy and meat.

VeggieVictory plans to [expand into other African countries and become a trailblazer for plant-based diets in Africa](#) and beyond. The company is already expanding to neighboring West African countries.

Plant-based meat: What is it?

Designed to mimic meat experience and nutrition. Edible protein is converted into meat-like textures.

- **Proteins:** soy, pea, potato, rice, mung bean, wheat, or fungus
- **Fats:** canola, coconut, soybean, cocoa, or sunflower oil,
- **Vitamins:** B1, B2, B6, B12, zinc and iron
- **Other:** Binding, nutrition, sensory experience or food safety ingredients.

Nutritionally comparable to beef and pork, although lower in total fat and vitamins (Rubio et al. 2020).

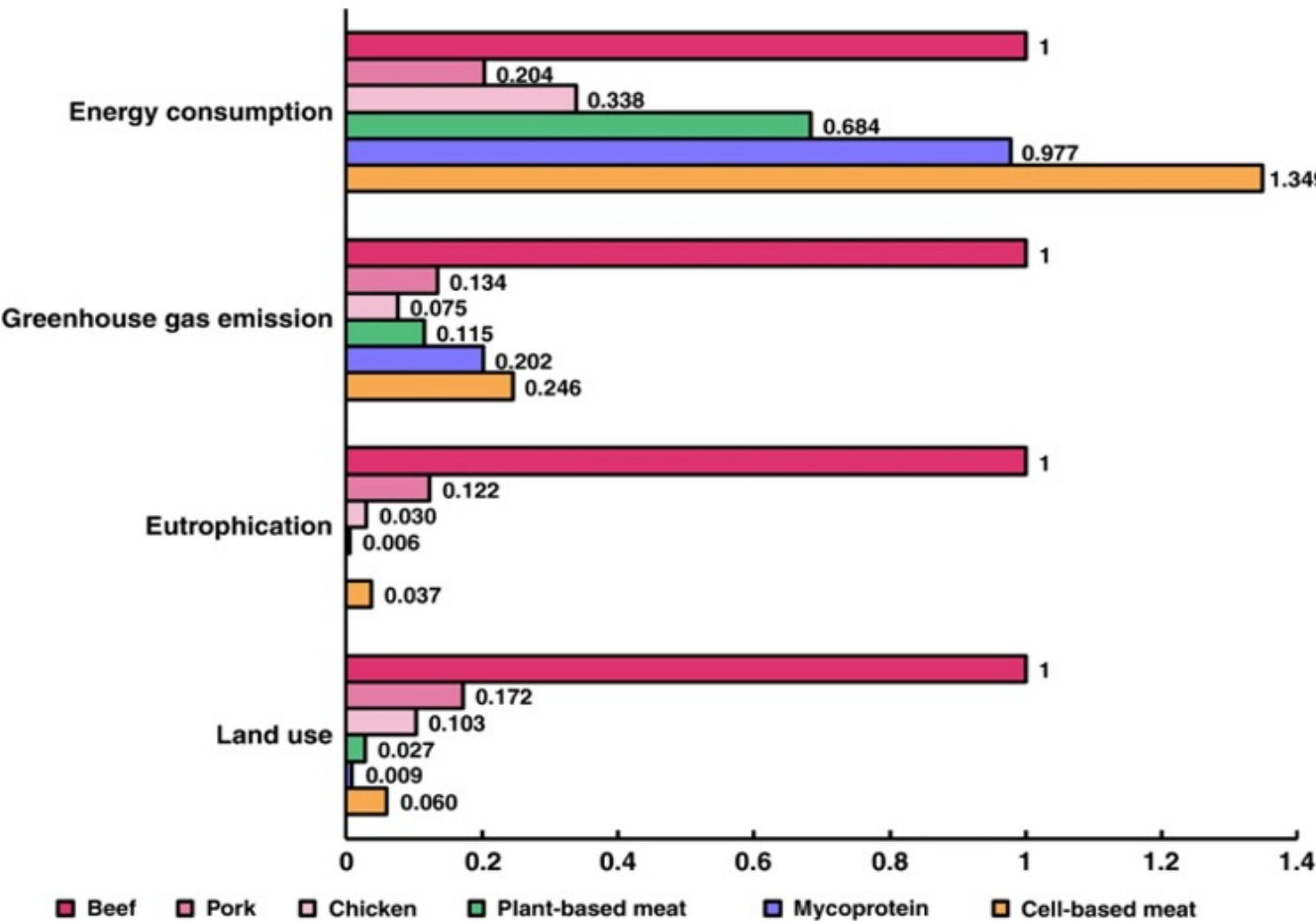
But 90% of 190 metabolites in grass-fed beef and high-quality PBM differ (Van Vliet et al. 2021).

PBM is also a highly processed food and can have high salt content.



Environmental impact of meat and meat analogs

From: [Plant-based and cell-based approaches to meat production](#)



Data are normalized to the impact of beef production. Eutrophication does not include data for mycoprotein. Land, emissions and energy data for mycoprotein were adapted from a 2015 LCA⁷². Data for beef, pork, chicken and CBM were adapted from a 2015 life cycle assessment⁷⁵. Data for PBM were adapted from an Impossible™ Beef LCA (land, eutrophication, emissions) and a Beyond Meat® life cycle assessment (energy use)^{70,71}.

- Beef
- Pork
- Chicken
- Plant-based meat
- Cell-based meat

Emissions and energy used for plant-based meat were higher than chicken meat (Rubio et al. 2020). All products had significantly lower impacts than beef, however, with the exception of cell-based meat, due to its high energy use

Source: Rubio et al. 2020

Production inputs strongly affect PBM's greenhouse gas footprint

Most PBM emissions are from:

- primary protein ingredient (e.g., whether ingredient involves deforestation)
- packaging
- energy used for processing

Heller and Keoleian 2018

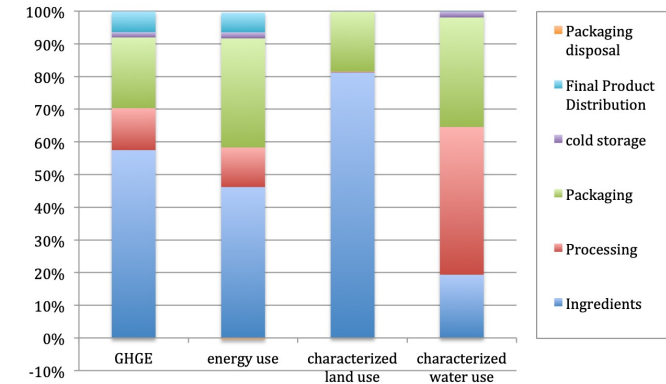
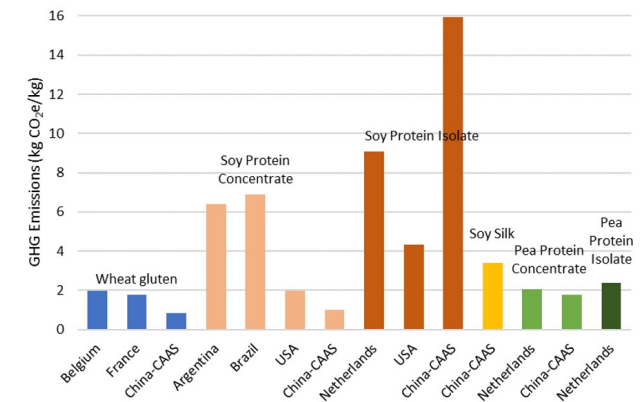


Figure ES1. Distribution of impacts across life cycle stages for the Beyond Burger.

PBM's emissions are lower where

- primary protein ingredients minimize emissions and are deforestation-free
- processing technology is energy efficient
- energy is renewable
- minimal packaging is used, and
- by-products and waste are used

Sha et al. 2021



Plant-based meat (PBM) in low and middle-income countries

- Collaboration of IIASA, Limestone Analytics, CCAFS, Impossible Foods, and USAID
 - Investigated expansion of plant-based meat (PBM) and dairy and their impacts on climate, land use, and food security
 - Used GLOBIOM model, exploring scenarios of animal product substitution using hypothetical plant-based meat "recipes" that are nutritionally equivalent and realistic for global production
 - Explored business cases in four countries: Brazil, China, Nigeria and Vietnam



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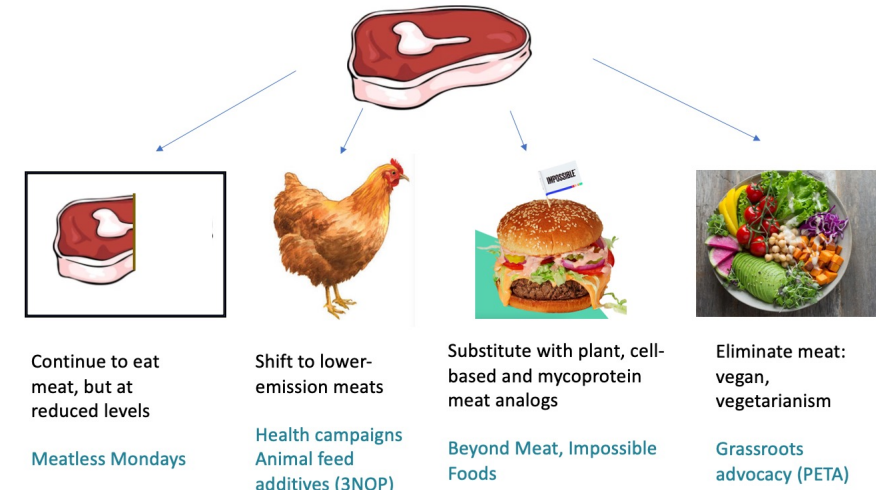
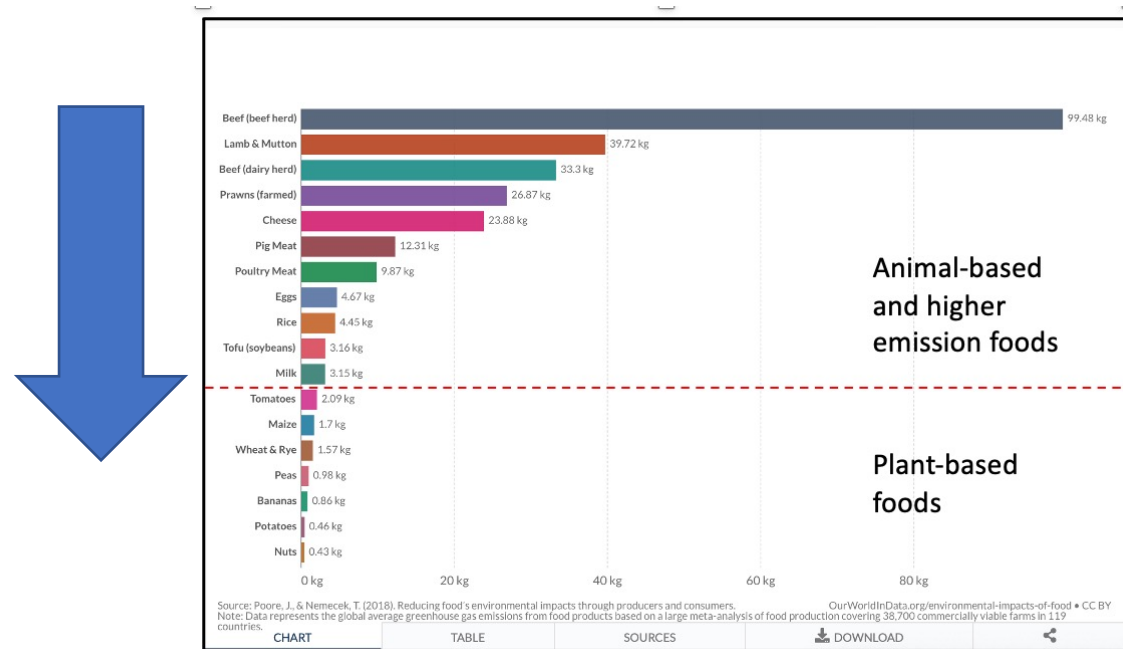
Slide courtesy of Miroslav Batka

Global PBM Scenarios (IIASA) Kozicka, Batka, Havlik et al., forthcoming

- PBM has substantial mitigation outcomes
 - A 25% substitution rate of PBM for its respective meat led to a 1 GtCO₂e/yr reduction in 2050.
- PBM substitution of beef has the highest impacts, compared to other meats.
- If the land released from beef production is used as forest, the mitigation impact of PBM is doubled.
- The potential for biodiversity co-benefits is significant due to the reduced area of cultivated land and lower pressure for expansion in forests.

What can consumers do?

- 1) Aim to reduce food emissions by 20%
- 2) Eat lower emissions foods



- 3) Avoid products associated with deforestation (oil palm, soy from Brazil)
- 4) Reduce food waste

Local does *not* necessarily mean low emissions (Ritchie and Roser 2021)

Transport accounts for only ~5% of food emissions.

For beef, transport is less than 1% of emissions



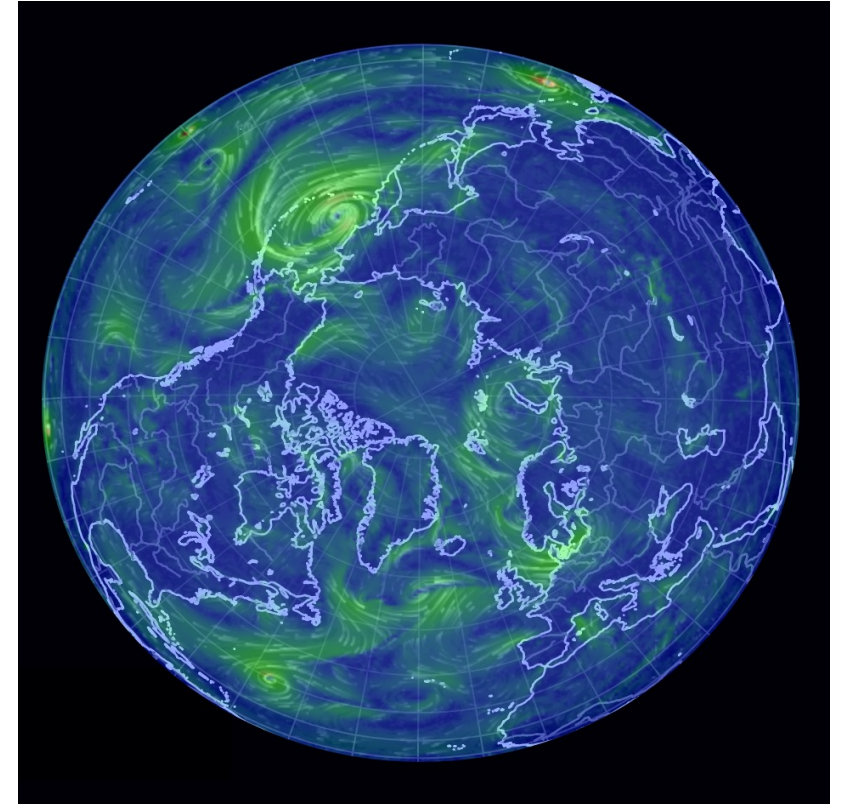
Local can mean *higher* emissions if a product is out of season.

Greenhouse tomatoes in Sweden used 10X more energy than imported in-season tomatoes from Southern Europe (Hospido et al. 2009).

Exception: airfreight for highly perishable foods such as asparagus, berries produces high emissions. But airfreight is only 0.16% of food.

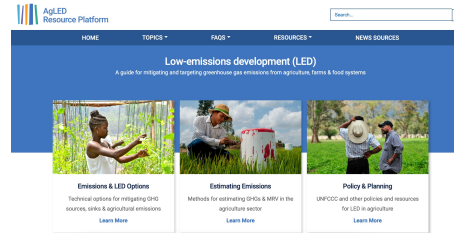
5. Take individual action to drive large-scale, systemic impacts

- Promote policy targets and actions for reduced meat diets in high- and middle-income countries (e.g. C40 cities)
- Support labeling and certification of meat
- Advance affordable meat alternatives
- Support consumption of lower-emission foods
 - Increase the ease and visibility of buying plant-based foods in menus, canteens and supermarkets.
 - Promote awareness campaigns and social movements for consumer behavior change, link to health.



Some resources

1. CCAFS AgLED website

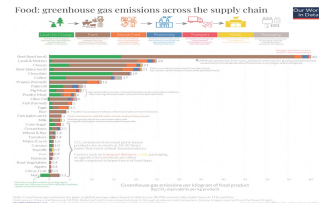


<https://agledx.ccafs.cgiar.org>

2. Agrochain emissions Calculator (ACE)

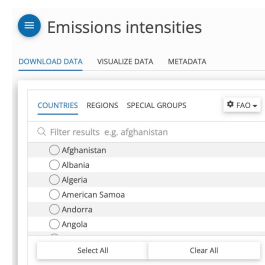
<https://cgspace.cgiar.org/handle/10568/106161>

3. Our World in Data



<https://ourworldindata.org/food-choice-vs-eating-local>

4. FAO emission intensity and food systems data



<https://www.fao.org/faostat/en/#data/EI>

<https://iopscience.iop.org/article/10.1088/1748-9326/ac018e>

Thank you!

Lini.Wollenberg@uvm.edu



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