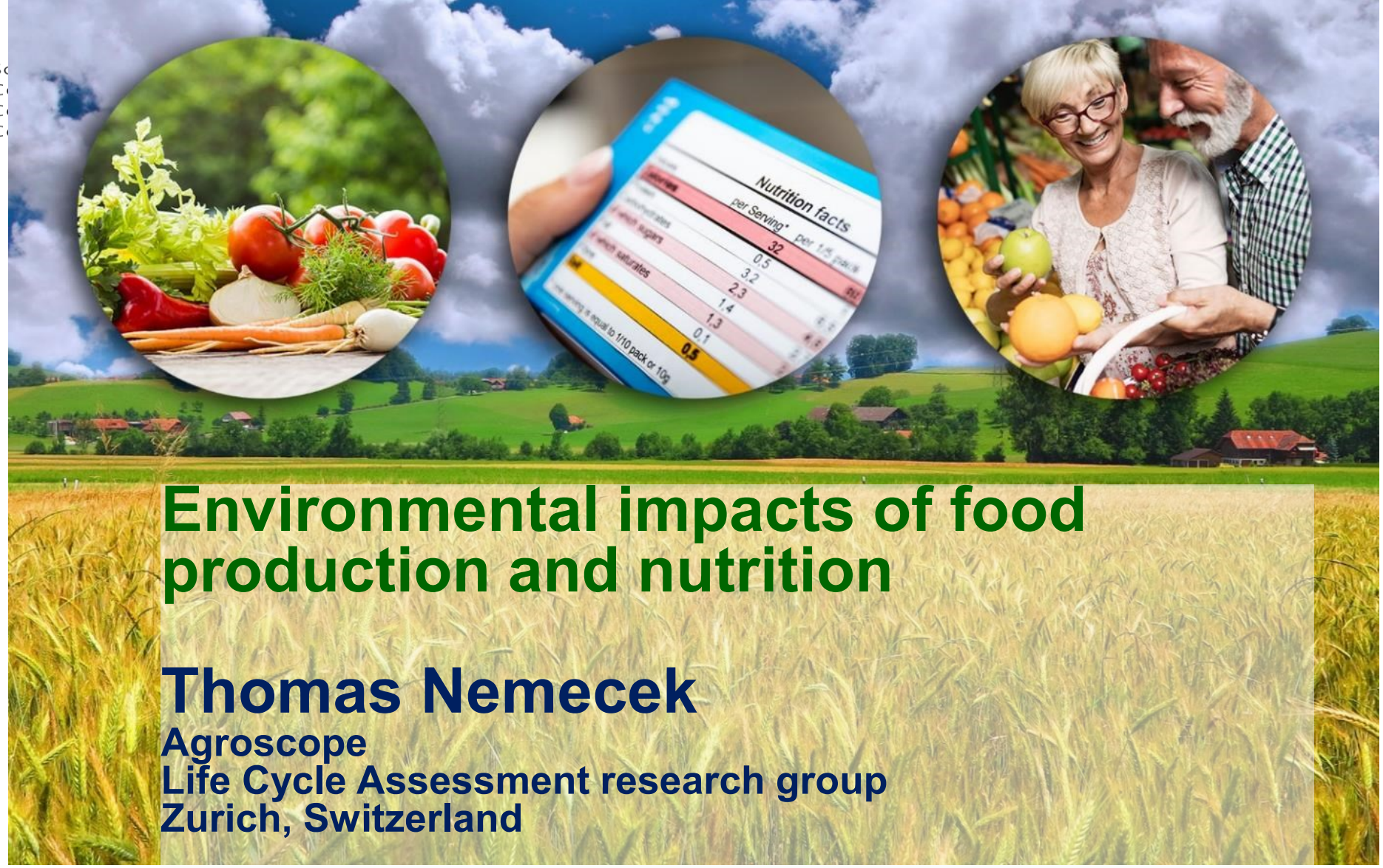

Environmental impacts of food production and nutrition

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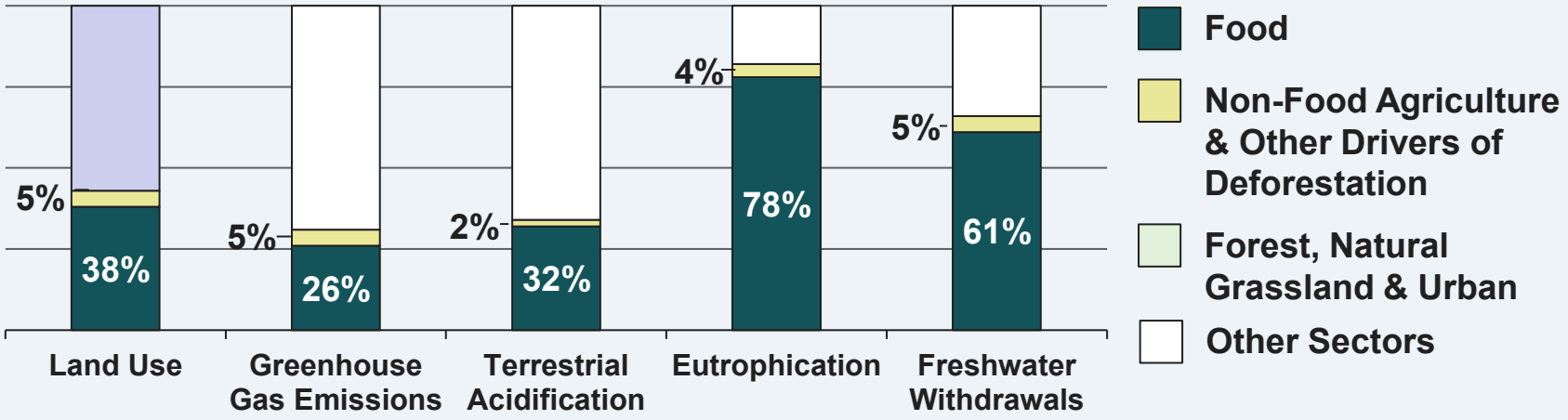
21 October 2024

Today's Menu

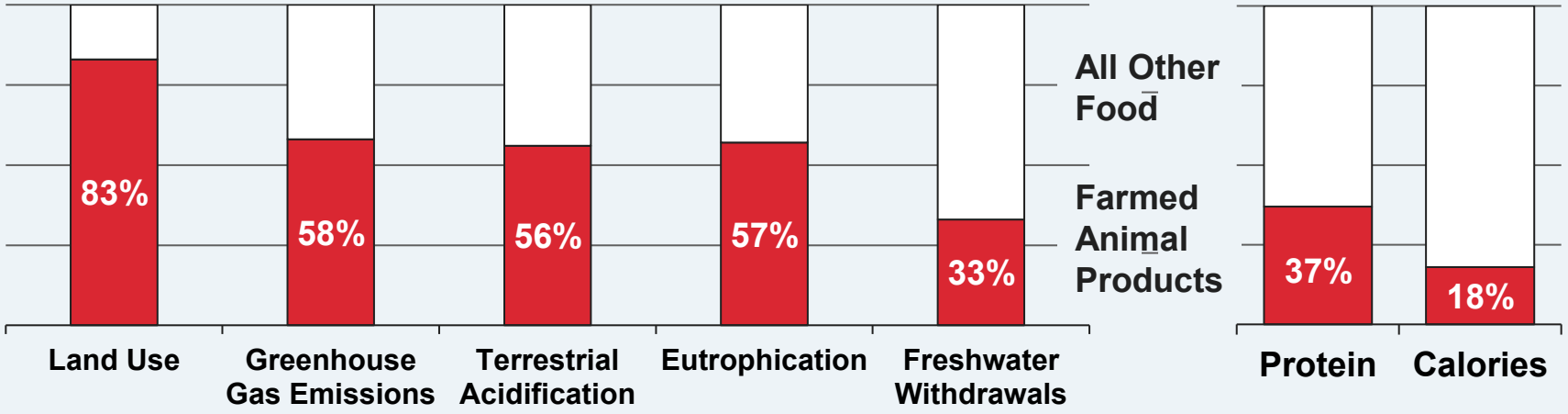
- Environmental impacts of the food sector
- Life Cycle Assessment
- Food production:
  - Variability offers mitigation options
  - Animal vs. plant proteins, meat production
- Supply chains phases
- Meat and milk alternatives
- Diets and food system
  - Changing diets: global, Swiss
- Concluding remarks

The importance of the food sector and animal-based foods

Share of the **food sector** on global environmental impacts



Share of **animal products** on global environmental impacts of food



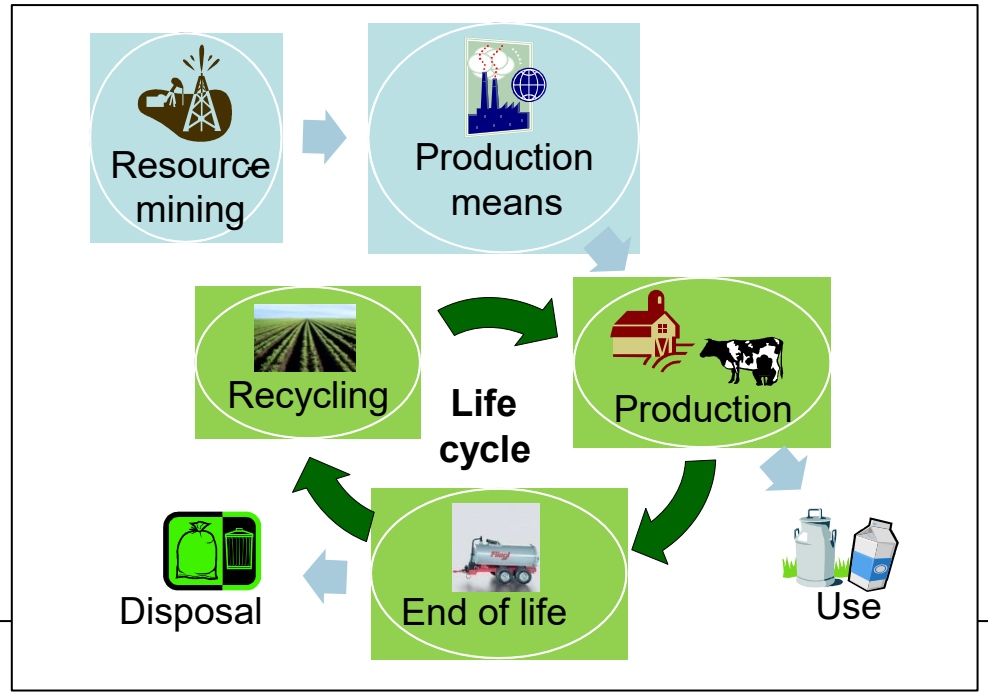
J. Poore, and T. Nemecek Science 2018;360:987-992

What is environmental life cycle assessment? (LCA)

- Environmental impacts of products or processes
- Optimisation of production (hotspot analysis)
- Comparing alternatives (comparative LCA)
- Environmental impacts calculated by models
- Decision support → environmental management

There key characteristics:

1. **Life cycle:**
   → From cradle to grave
2. **Comprehensive analysis** of all relevant environmental impacts
3. Relate env. impact to a **functional unit**

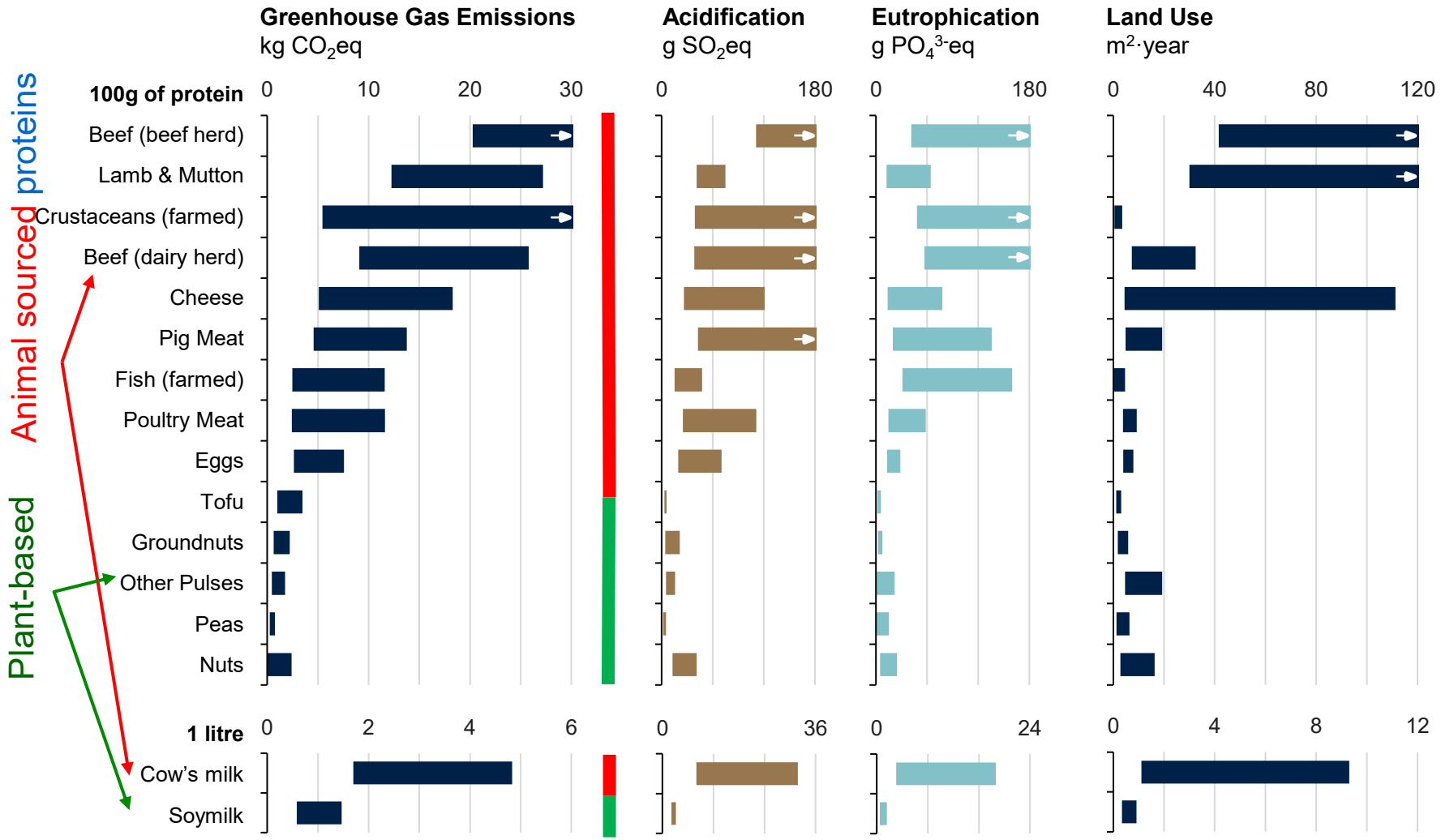


Life Cycle Assessment (LCA)-based meta-analysis for 40 food groups

- Comprehensive meta-analysis:
  - 1500 LCA studies analysed
  - 570 studies included with feedbacks of 140 authors
- Harmonisation, consolidation and filling data gaps
- Randomisation and re-sampling
- Weighting by country and production system
- Systematic quantification of variability
- 5 environmental indicators:
  1. Climate change (greenhouse gas emissions)
  2. Terrestrial acidification
  3. Eutrophication (N & P)
  4. Land use (land occupation)
  5. Water scarcity

Poore J. & Nemecek T., 2018. Reducing food's environmental impacts through producers and consumers. Science 360, 987-998.

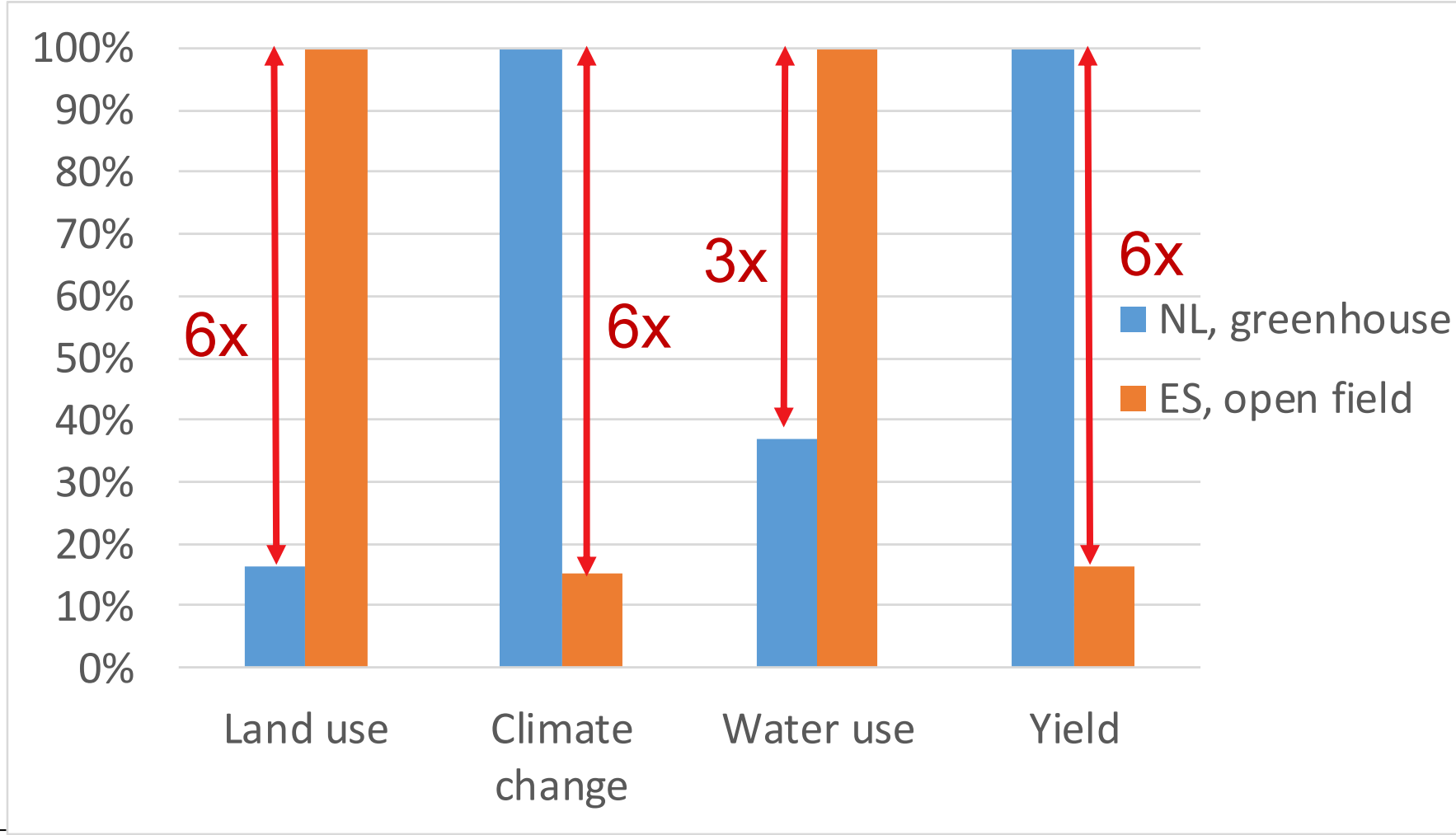
➢ The variability between supply chains is huge
➢ Plant-based protein-rich foods have much lower impacts than animal-based foods



Low impact producers 10th percentile — **High impact producers** 90th percentile

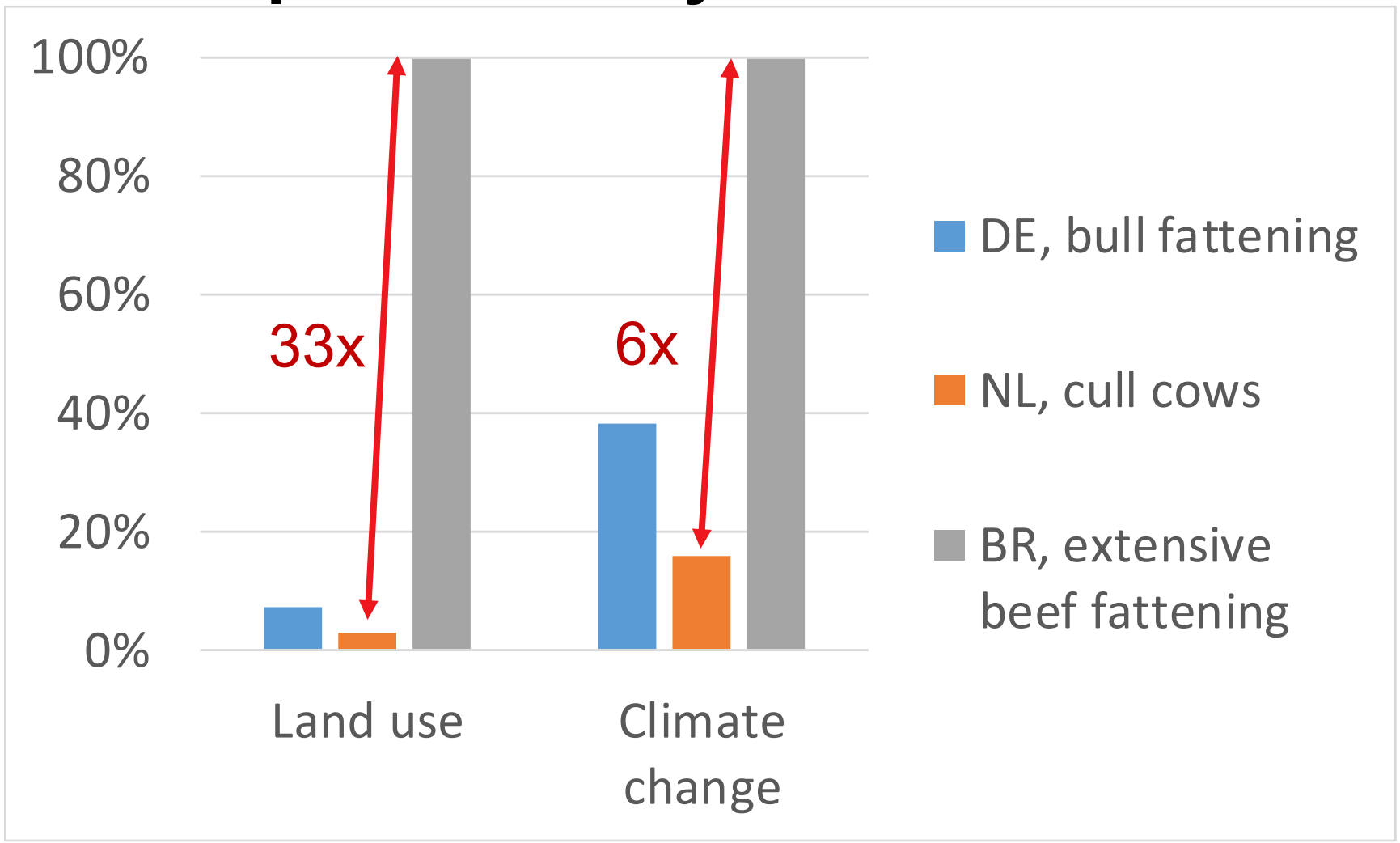
J. Poore, and T. Nemecek, Science 2018;360:987-992

Variability of impacts: greenhouse vs. open field tomatoes



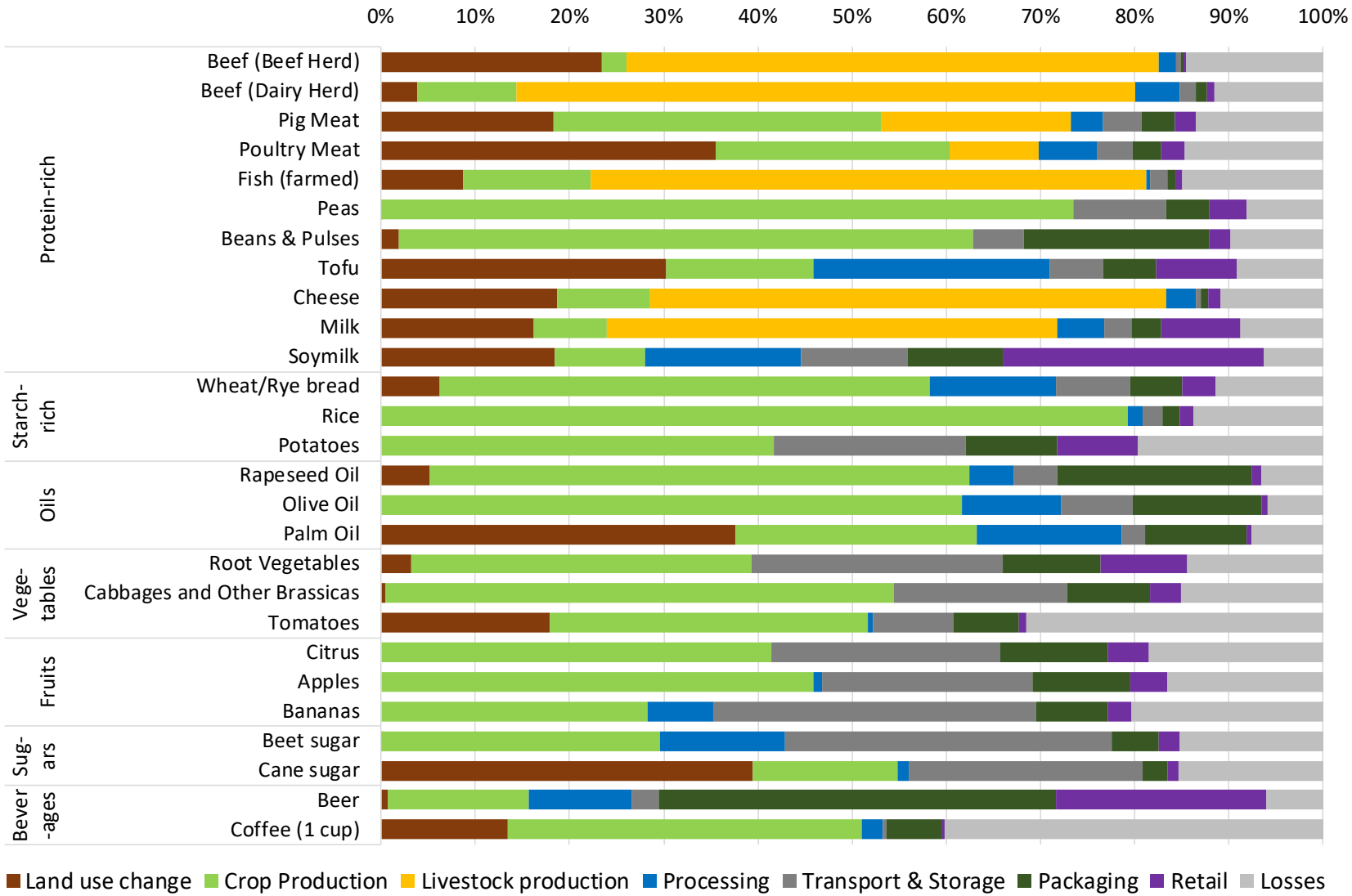
J. Poore, and T. Nemecek Science 2018;360:987-992

Variability of impacts: Beef production systems



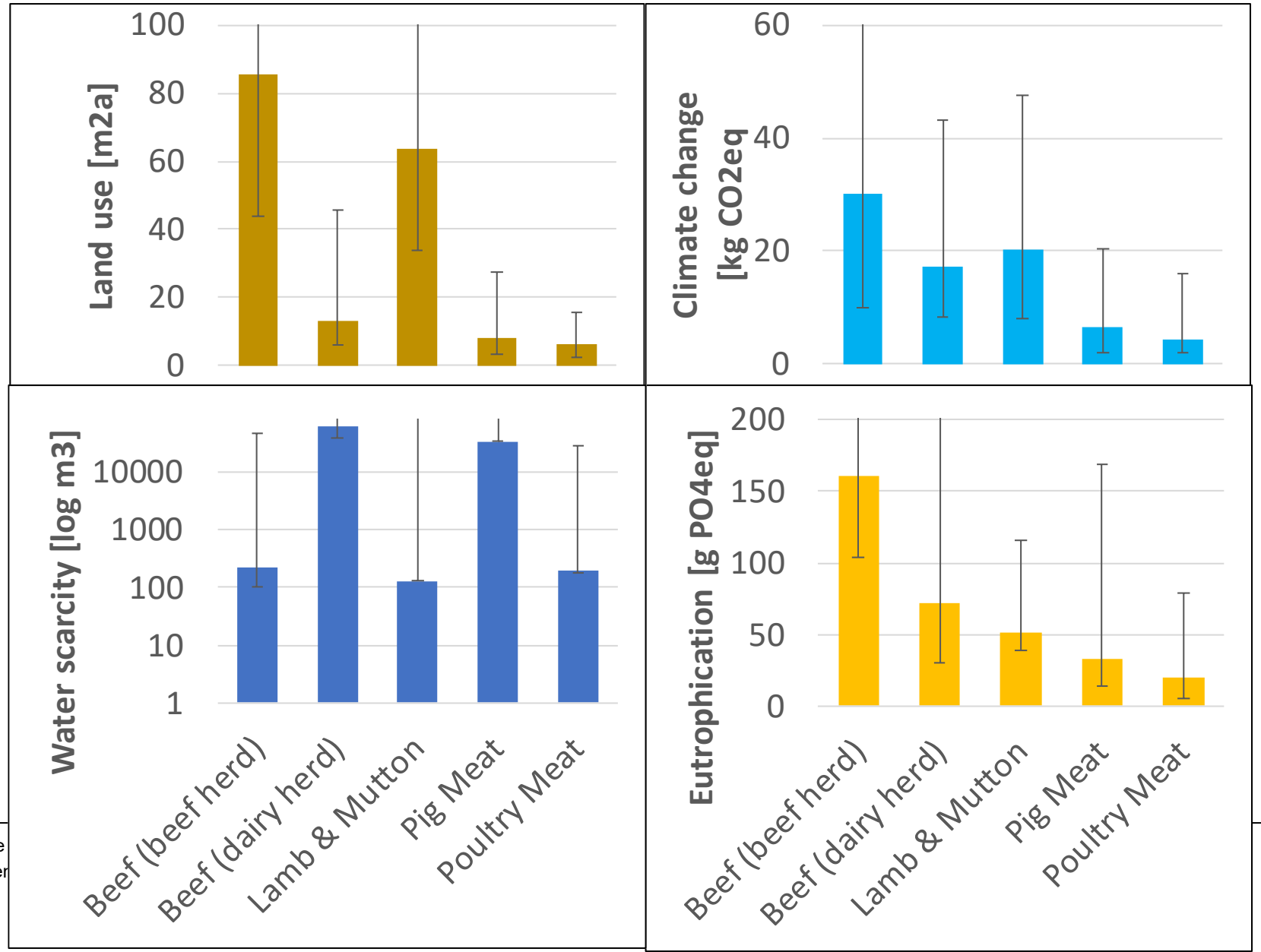
Source: Poore & Nemecek (2018), Science 360 (6392), 987-992.

Contribution of phases to the climate change impacts of food



J. Poore, and T. Nemecek Science 2018;360:987-992

Large differences between meat categories (per 100g protein)

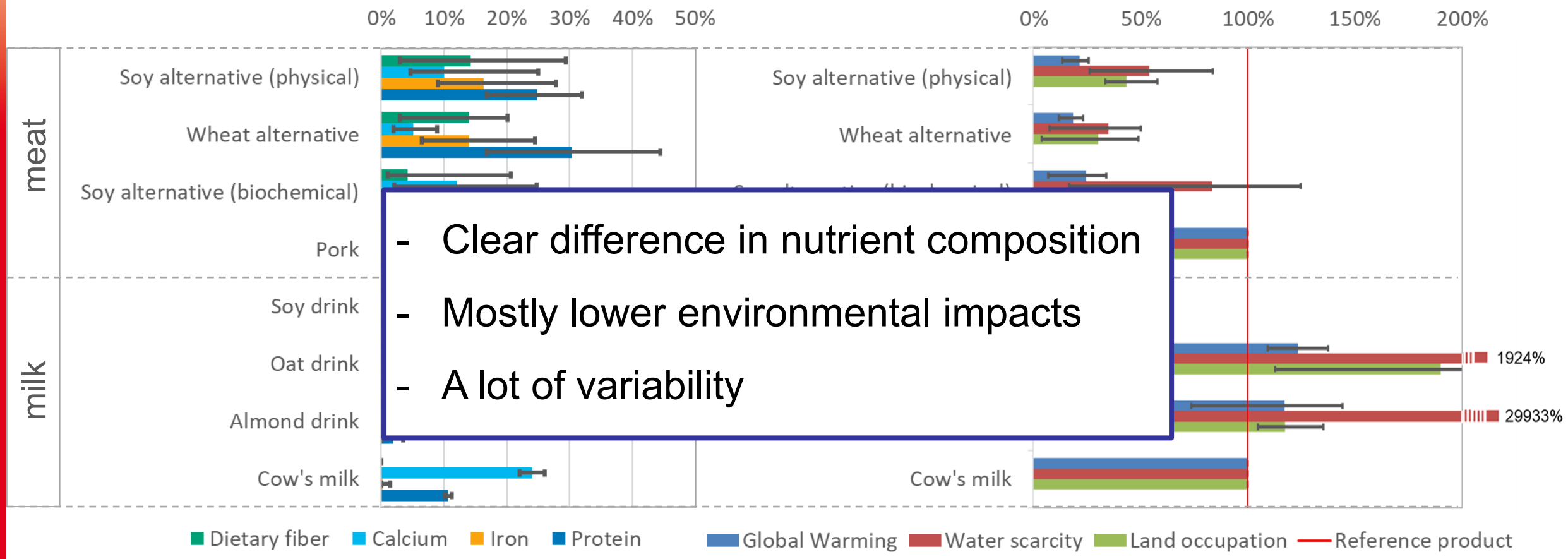


Source: Poore & Nemecek (2018), Science 360 (6392), 987-992.

Meat and milk substitutes

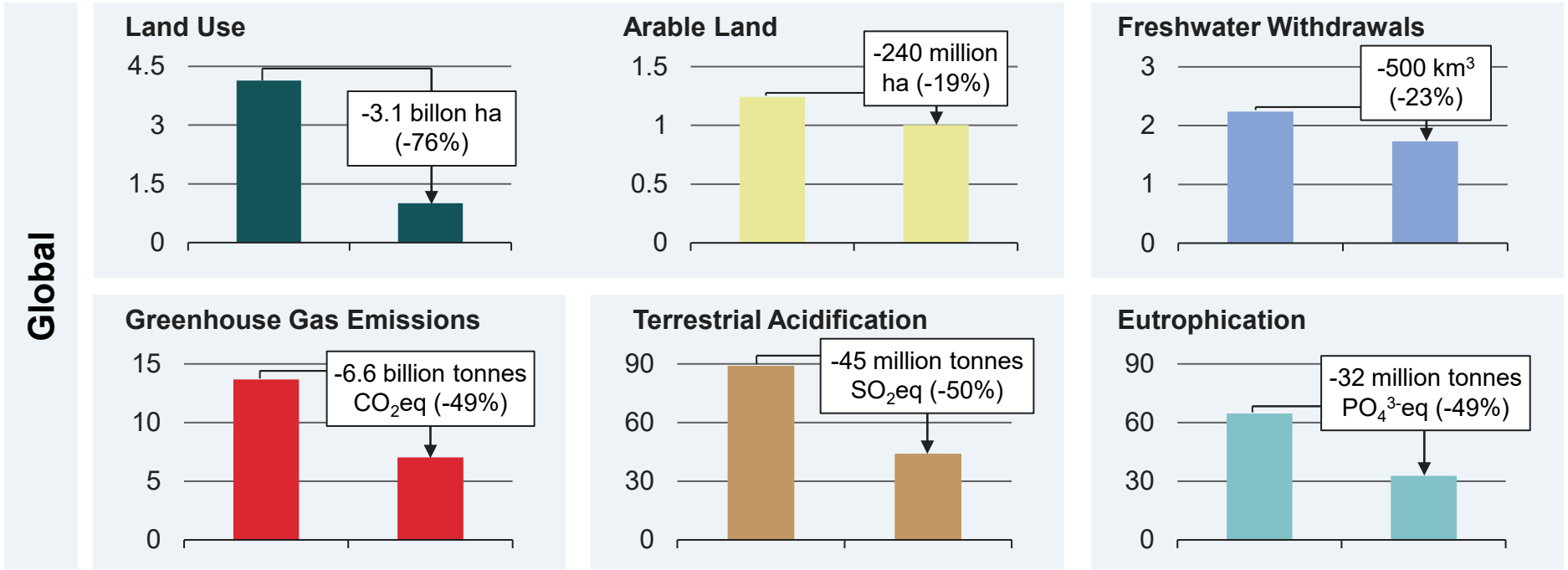
Nutrient content per portion in relation to the dietary reference intake

Comparison between product and reference environmental impact per kg protein



Changing global diets

- **Animal-product free diets** could reduce most environmental impacts by ½

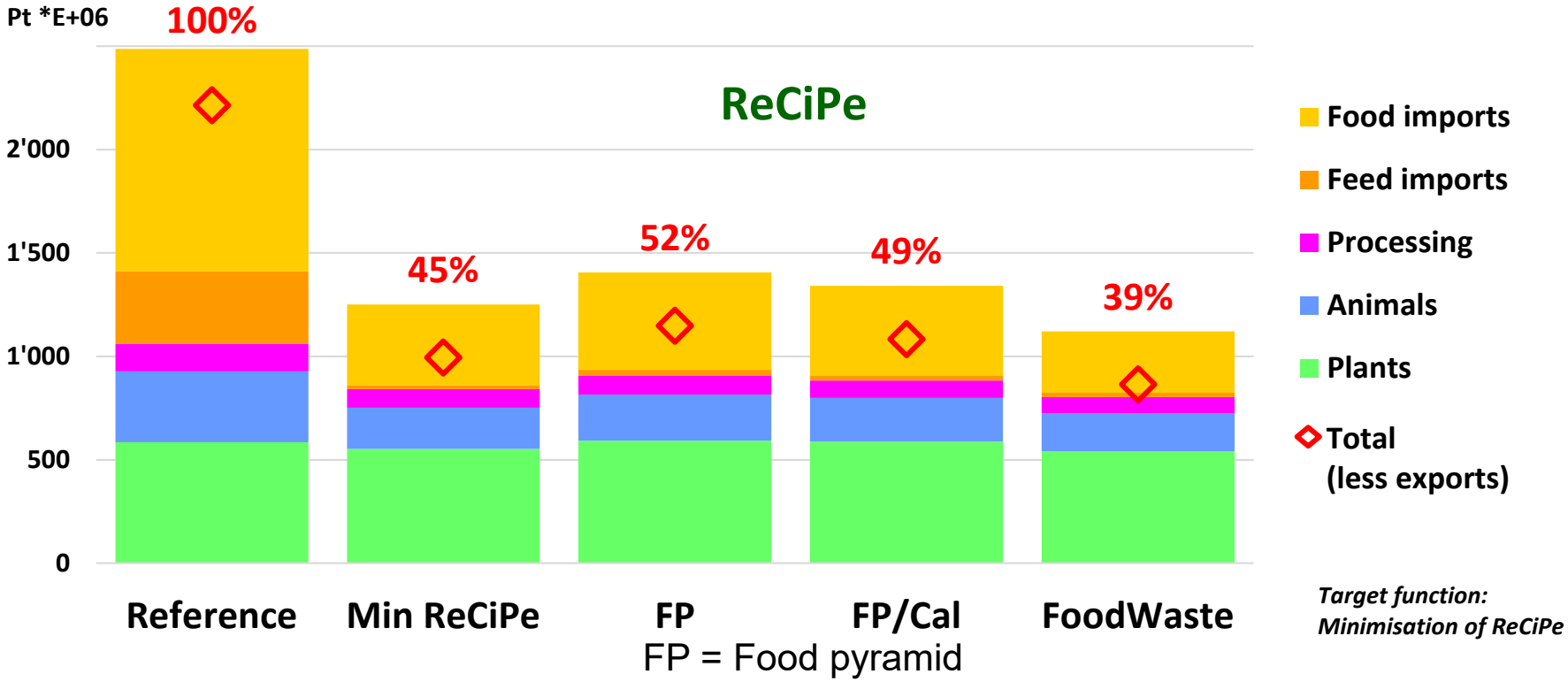


- Halving consumption of animal-based products by avoiding the high-impact producers reduce most environmental impacts by ⅓ → synergistic effects:
  - Climate change -36%
  - Land use -51%
  - Acidification -32%
  - Eutrophication -27%

} Synergistic effects of improved production and changed consumption

Source: Poore & Nemecek (2018), Science 360 (6392), 987-992.

Environmental impacts of Swiss diets can be reduced over 50%

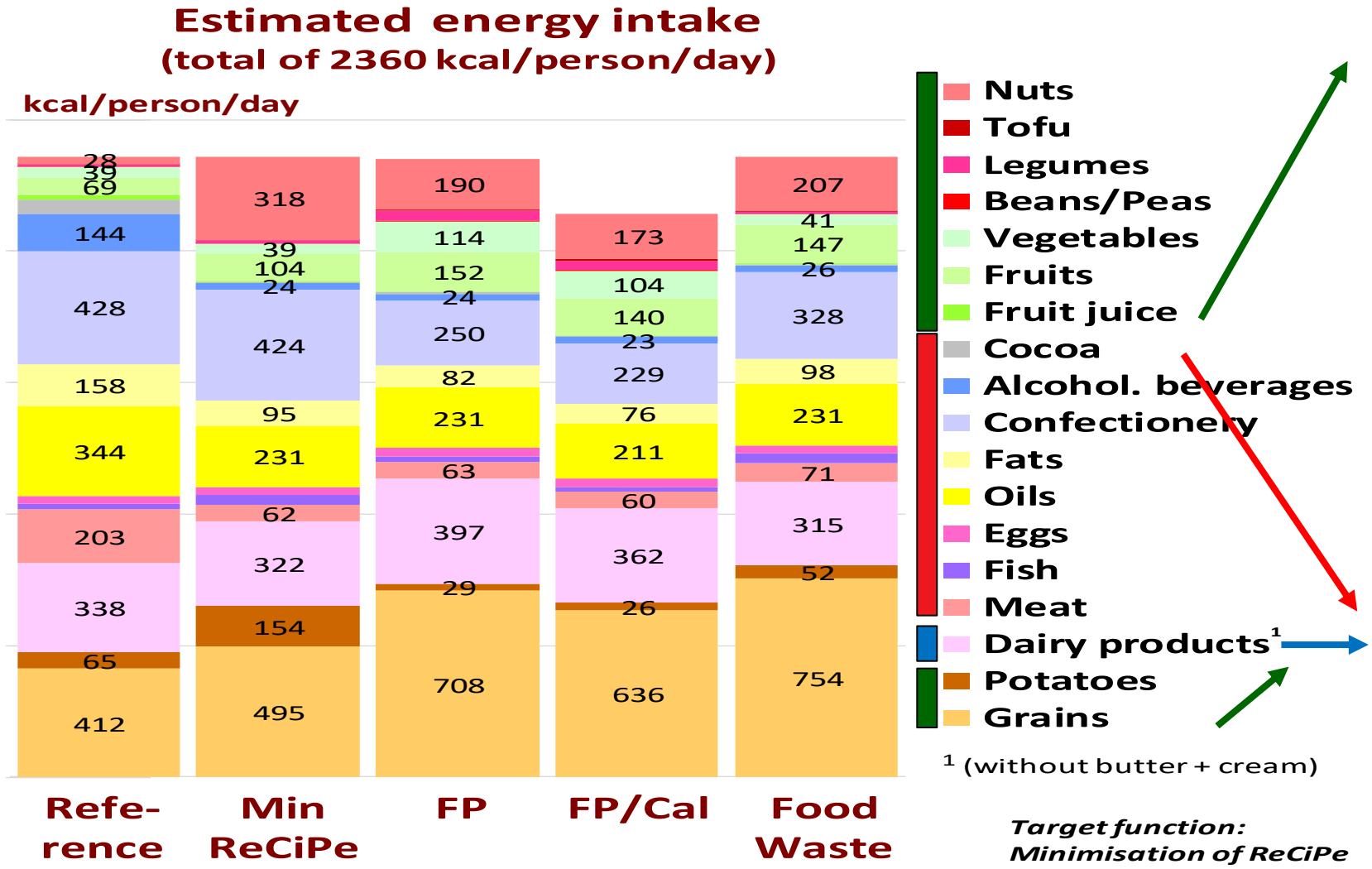


FP = Food pyramid

Mainly achieved by reducing food impacts, feed imports and animal herds. Further reductions through reduced calorie intake and avoided food waste.

Source: Zimmermann et al. (2017), Agroscope Science 55.
von Ow et al. (2020)
https://doi.org/10.1016/j.jclepro.2019.119241

Optimised diets differ significantly



– Less meat, alcohol, vegetable oils

○ Constant consumption of dairy products

+ More cereals, potatoes, fruits, vegetables, legumes

Source: Zimmermann et al. (2017), Agroscope Science 55.
von Ow et al. (2020)
https://doi.org/10.1016/j.jclepro.2019.119241

Concluding remarks

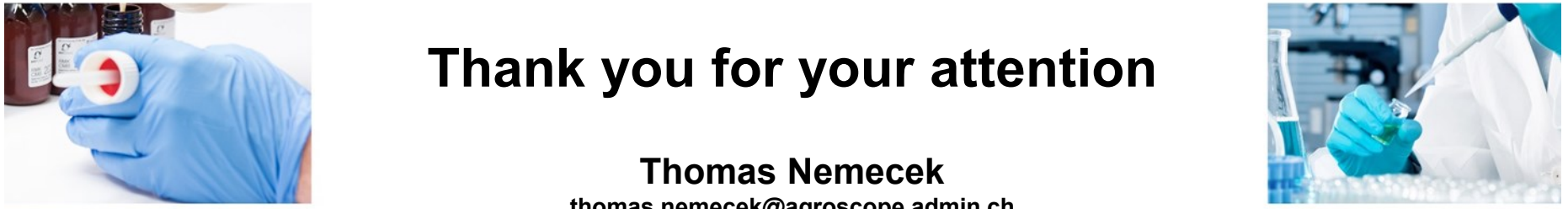
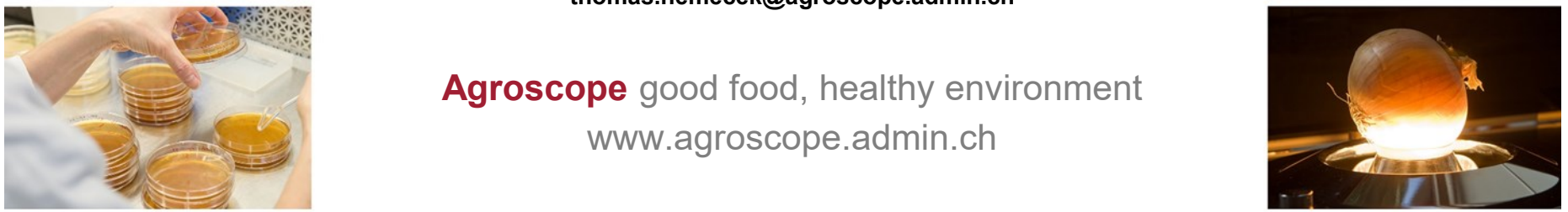
- Large variability between food products → big mitigation potential
- Information on environmental impacts must be made available and communicated throughout the supply chain
- Reducing meat consumption and food waste are crucial for sustainable food systems
- Substituting meat by plant-based protein sources can substantially reduce environmental impacts, but the nutritional quality has to be considered
- Optimised diet would be closer to nutritional recommendations

What can we do as consumers?

- Follow dietary recommendations
- Reduce consumption of animal-based foods, mainly meat
- Reduce food waste
- Prefer local and seasonal production, notably for vegetables
- Avoid food transported by air or from heated greenhouses
- Prefer less processed food
- Choose products with low environmental impacts → needs adequate information on environmental impacts
- Avoid/reduce shopping by car

Enjoy!



Thank you for your attention

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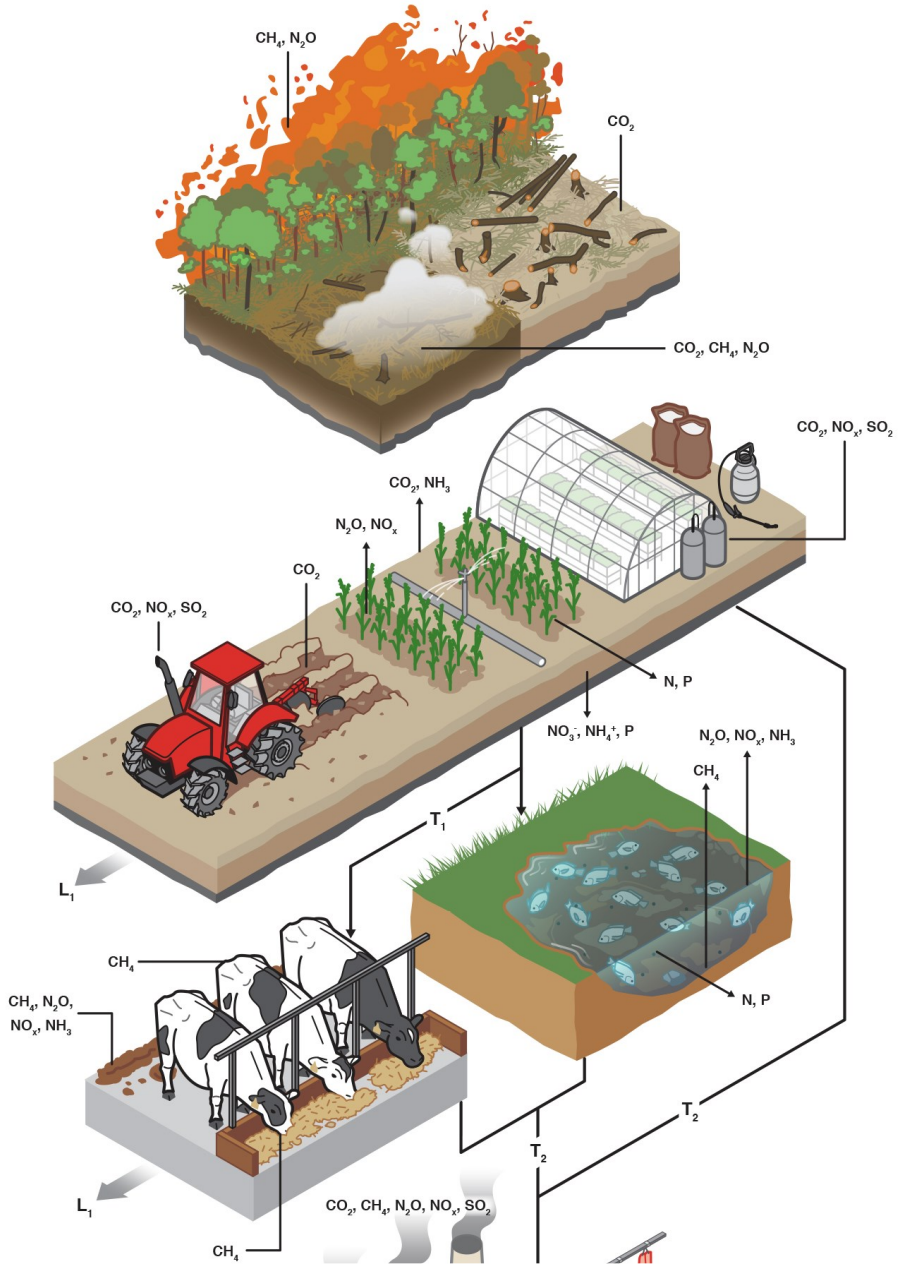
Agroscope good food, healthy environment
www.agroscope.admin.ch

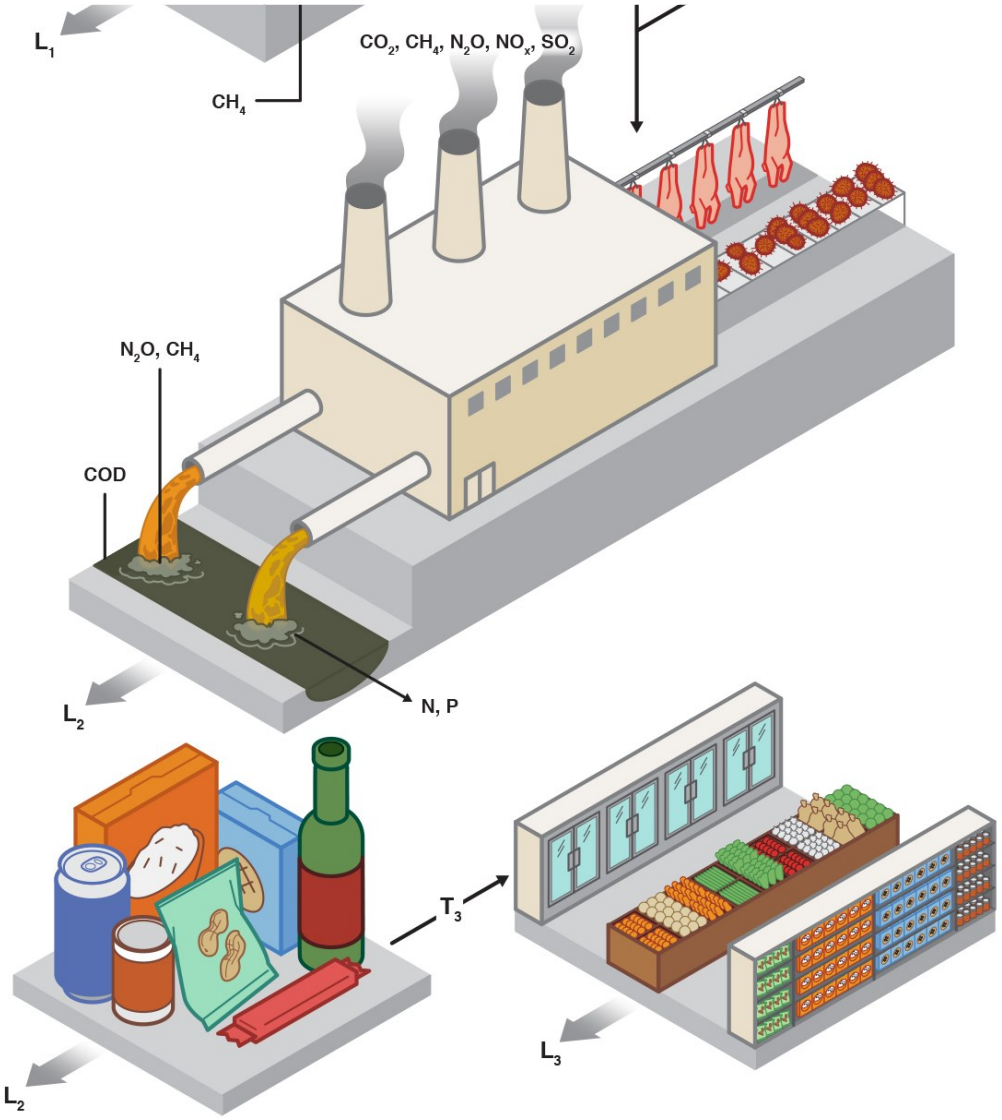
Processes considered: agriculture



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

J. Poore, and T. Nemecek Science 2018;360:987-992

Processes considered: food sector



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

L_1 - Storage and transport
L_2 - Processing and packaging
L_3 - Wholesale and retail

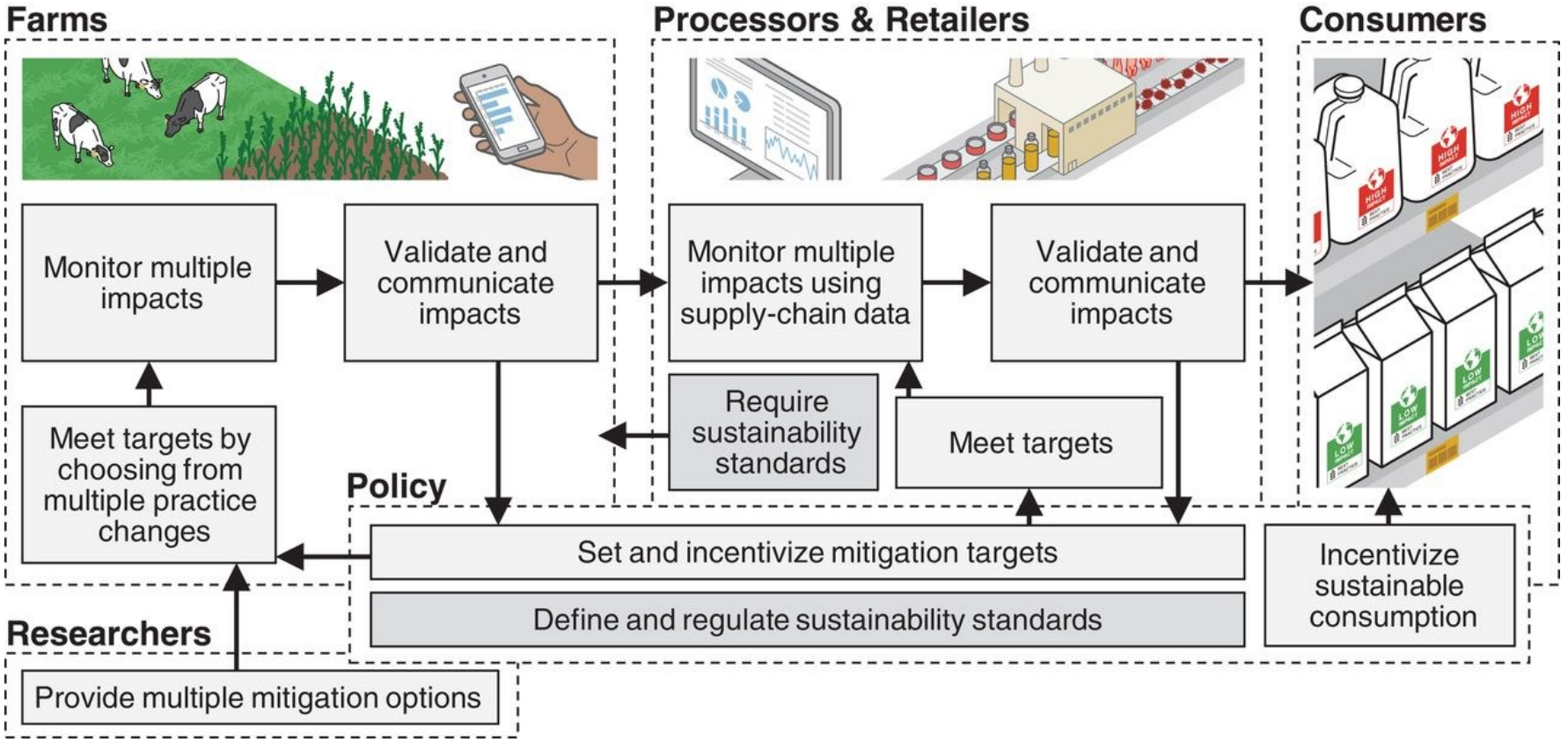
Transport (CO_2, NO_x, SO_2)

T_1 - Feed
T_2 - Food
T_3 - Processed food

J. Poore, and T. Nemecek Science 2018;360:987-992

Environmental management of food supply chains, environmental product declaration and changed consumer behaviour

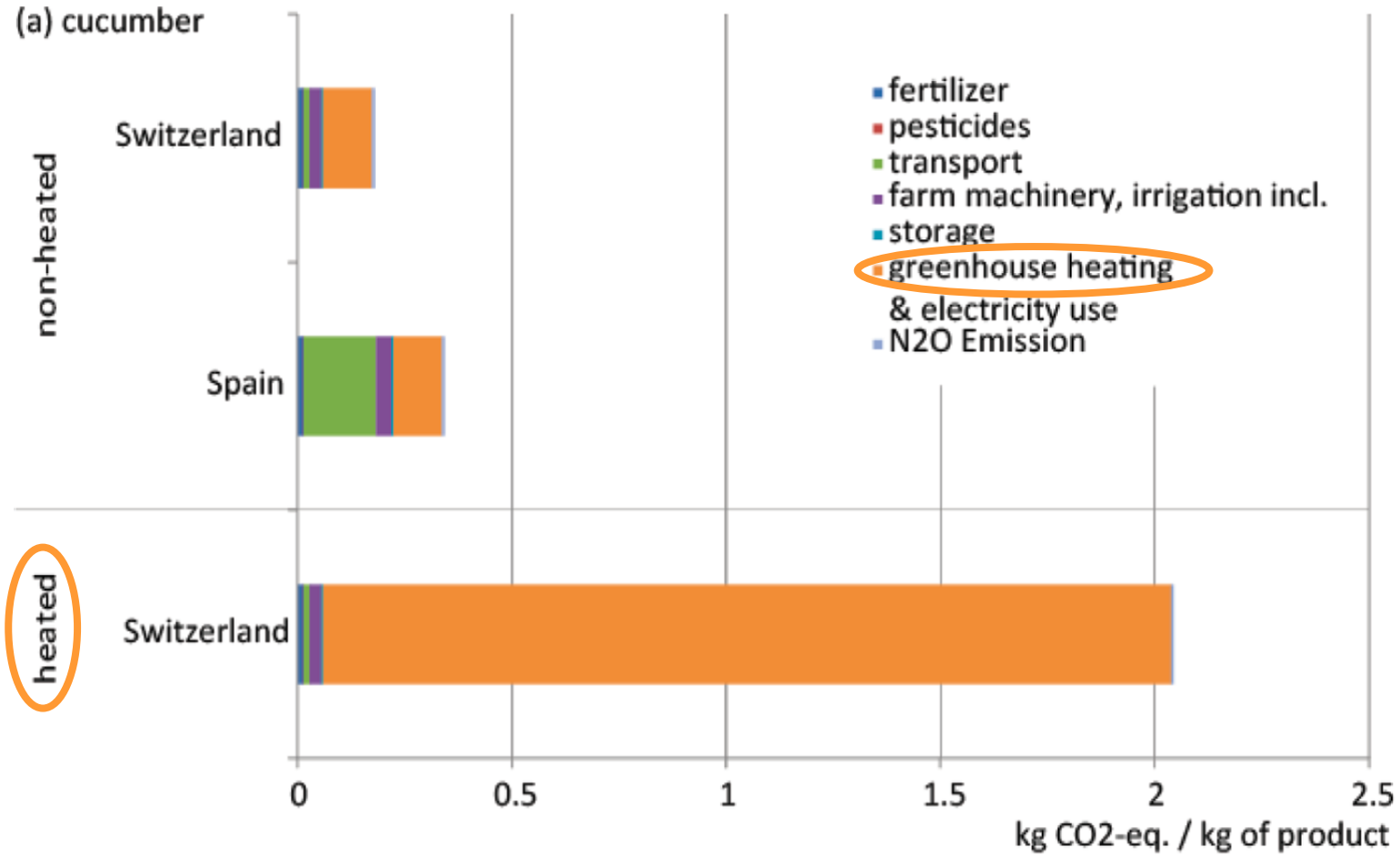
Fig. 4 Graphical representation of the mitigation framework.



J. Poore, and T. Nemecek Science 2018;360:987-992

Seasonal production: cucumber

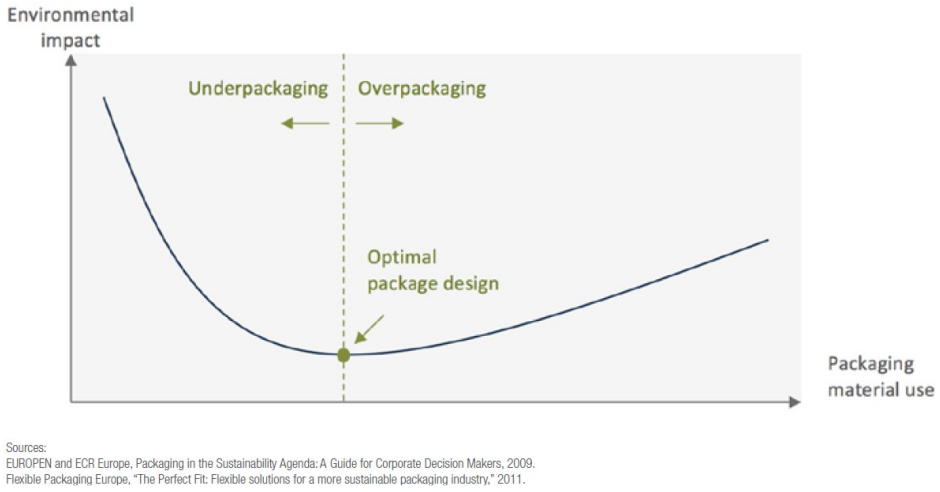
Impact of heated greenhouses



Source: Stössel *et al.* (2012) Env Sci Techn, 46: 3253-3262.

Role of food packaging

- Plays a minor role for most food categories (exceptions: e.g. beverages)
- Packaging should be avoided if not needed to protect the product …
- … but a reduction should not be at the expense of increasing losses
- The higher the environmental impacts per unit of food product, the better should the packaging protect (e.g. cheese or meat)



Sources:
EUROPEN and ECR Europe, Packaging in the Sustainability Agenda: A Guide for Corporate Decision Makers, 2009.
Flexible Packaging Europe, "The Perfect Fit: Flexible solutions for a more sustainable packaging industry," 2011.

Ratio of environmental impacts of 1 kg product / environmental impacts of packaging per kg product					
	Ketchup	Bread	Milk	Cheese	Beef
Energy demand	1.9	10	7.2	58	15
Global warming potential	3.0	22	15	193	93
Eutrophication potential	22	100	120	1200	610
Acidification potential	50	15	76	450	180

Source: Williams *et al.* (2011) Journal of Cleaner Production, 19: 43-48

Food loss and waste

Manufacturing

By-products, such as carcasses & bones from meat production

Misshapen products

Damaged products

Overproduction

Wholesale and retail

Temperature changes

Aesthetic standards

Packaging defects

Overstocking

Households

Buying too much

Bad storage

Confusion over labels

Discarding parts of food, such as apple skins or bread crusts

Making portions that are too big

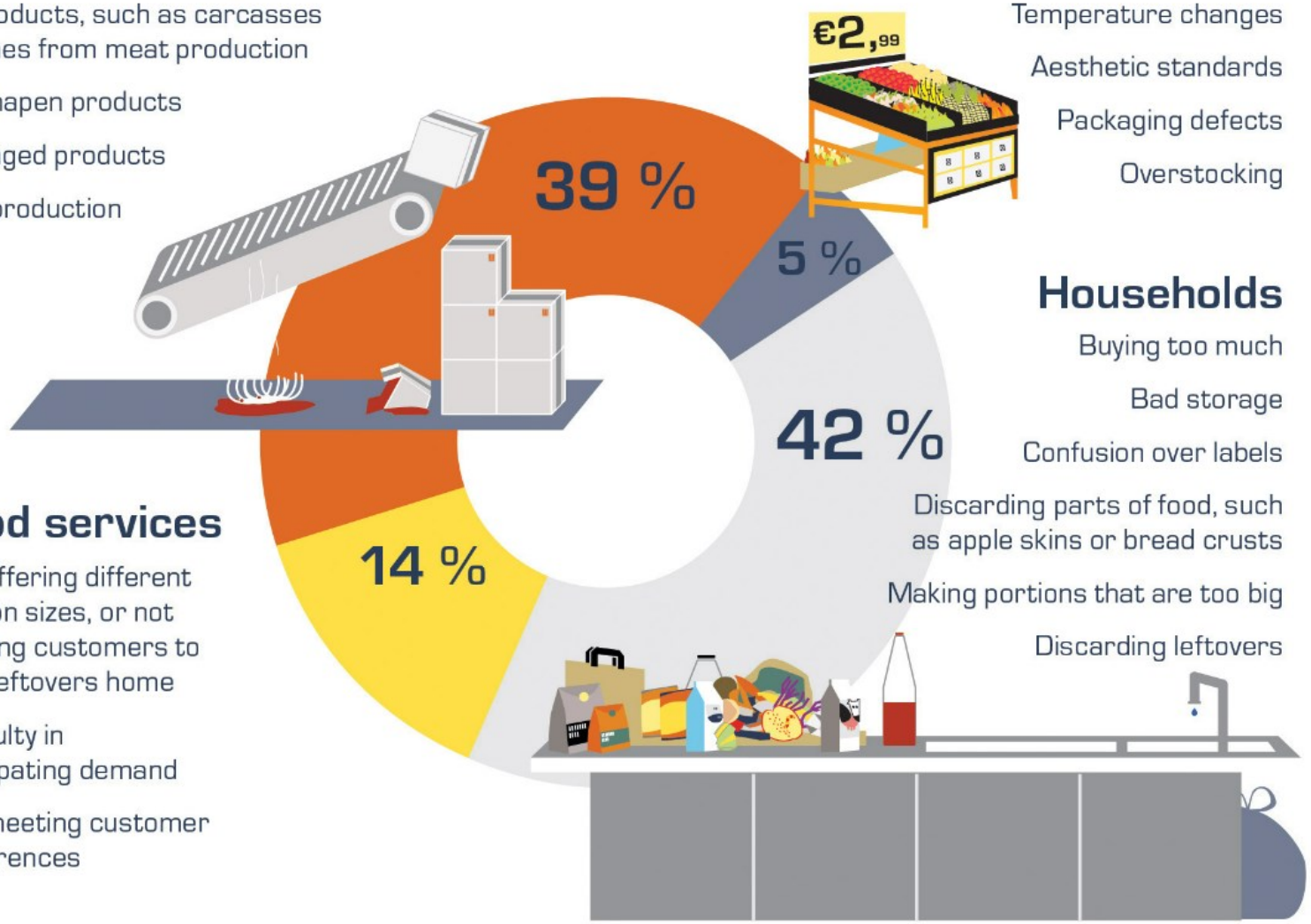
Discarding leftovers

Food services

Not offering different portion sizes, or not allowing customers to take leftovers home

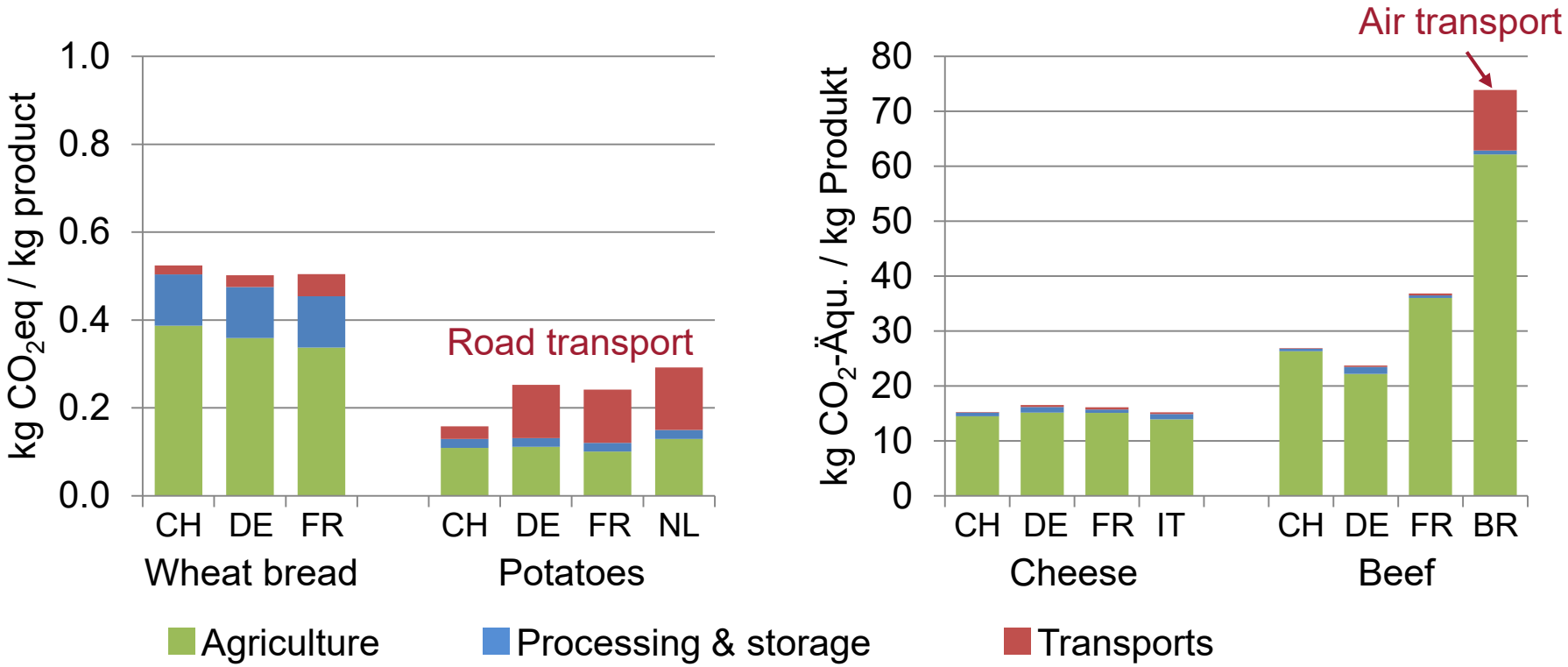
Difficulty in anticipating demand

Not meeting customer preferences



Source: https://www.eea.europa.eu/media/infographics/wasting-food-1

Climate change impacts of domestic and imported food

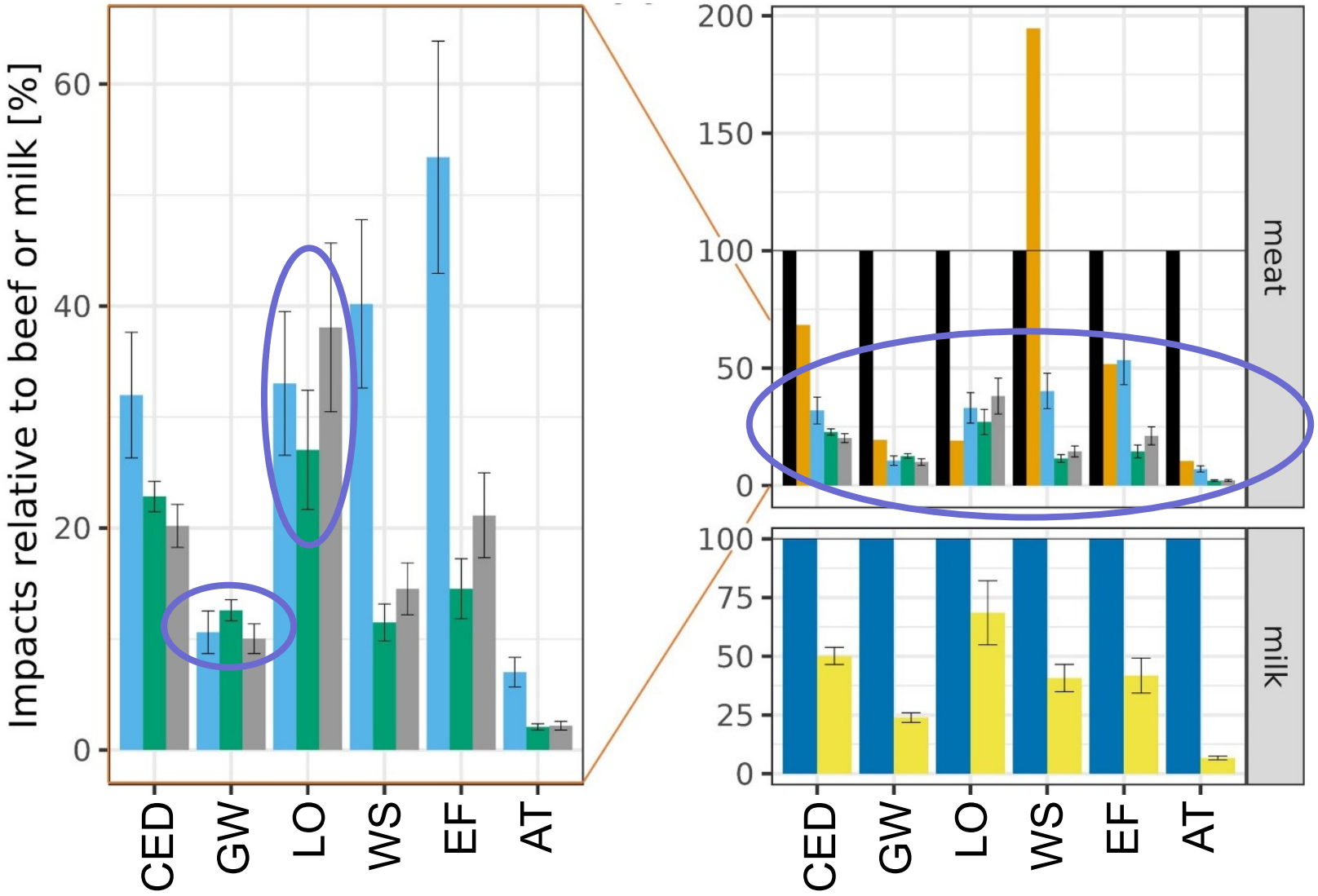


Source: Bystricky *et al.* (2014) Agroscope Science 2

Some observations on the environmental impacts of food supply chains

- The agricultural phase dominates for most products
- Seasonality matters: heated greenhouses and irrigation
- Food loss or waste occur at all stages and have high and increasing impacts
- Packaging is less relevant, but the protection of the food products must be ensured
- Transports relevant for fruit and vegetables and transport by aircraft
- Domestic/regional products are not necessarily better

Results



Comparison between alternative and reference products per **[g qc-protein]**. Range bars represent the sensitivity analysis.

- Beef (CH), minced
- Chicken (CH) meat
- SBMA
- Tofu, plain
- Soybeans, cooked
- Cow milk (CH), UHT
- Soydrink, UHT

Herrmann et al. (2024) doi.org/10.3389/fsufs.2024.1413802

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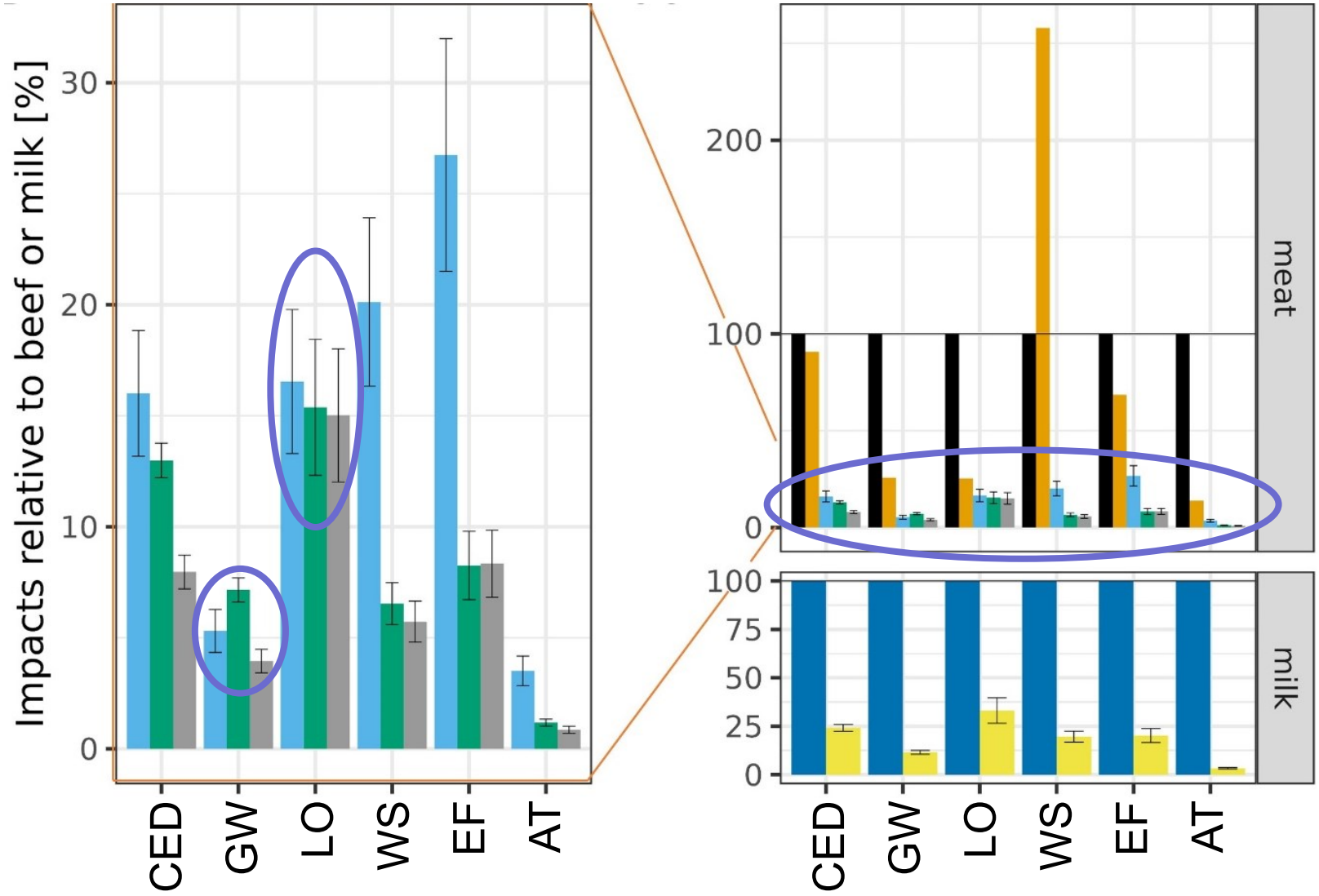
Results



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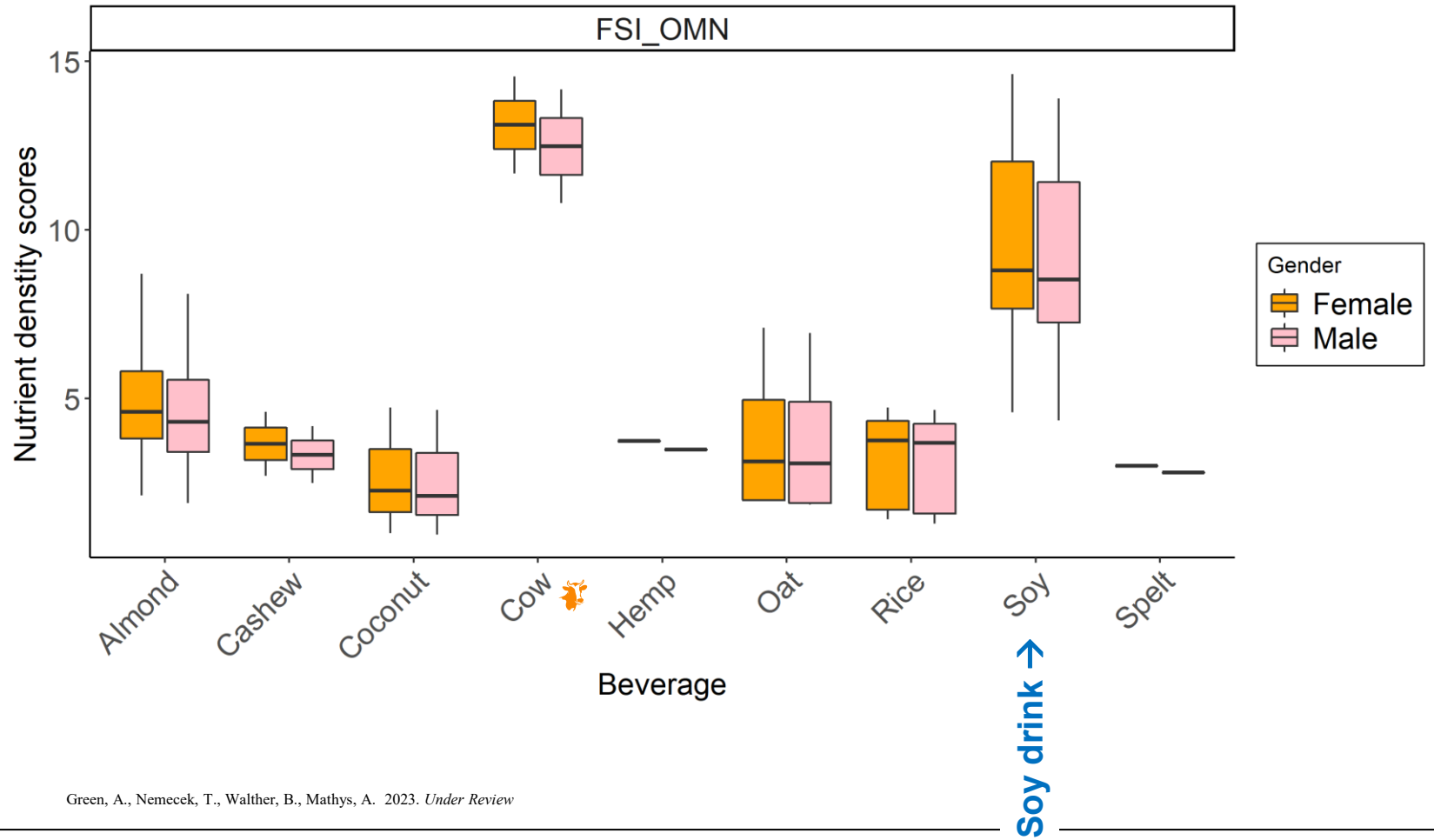
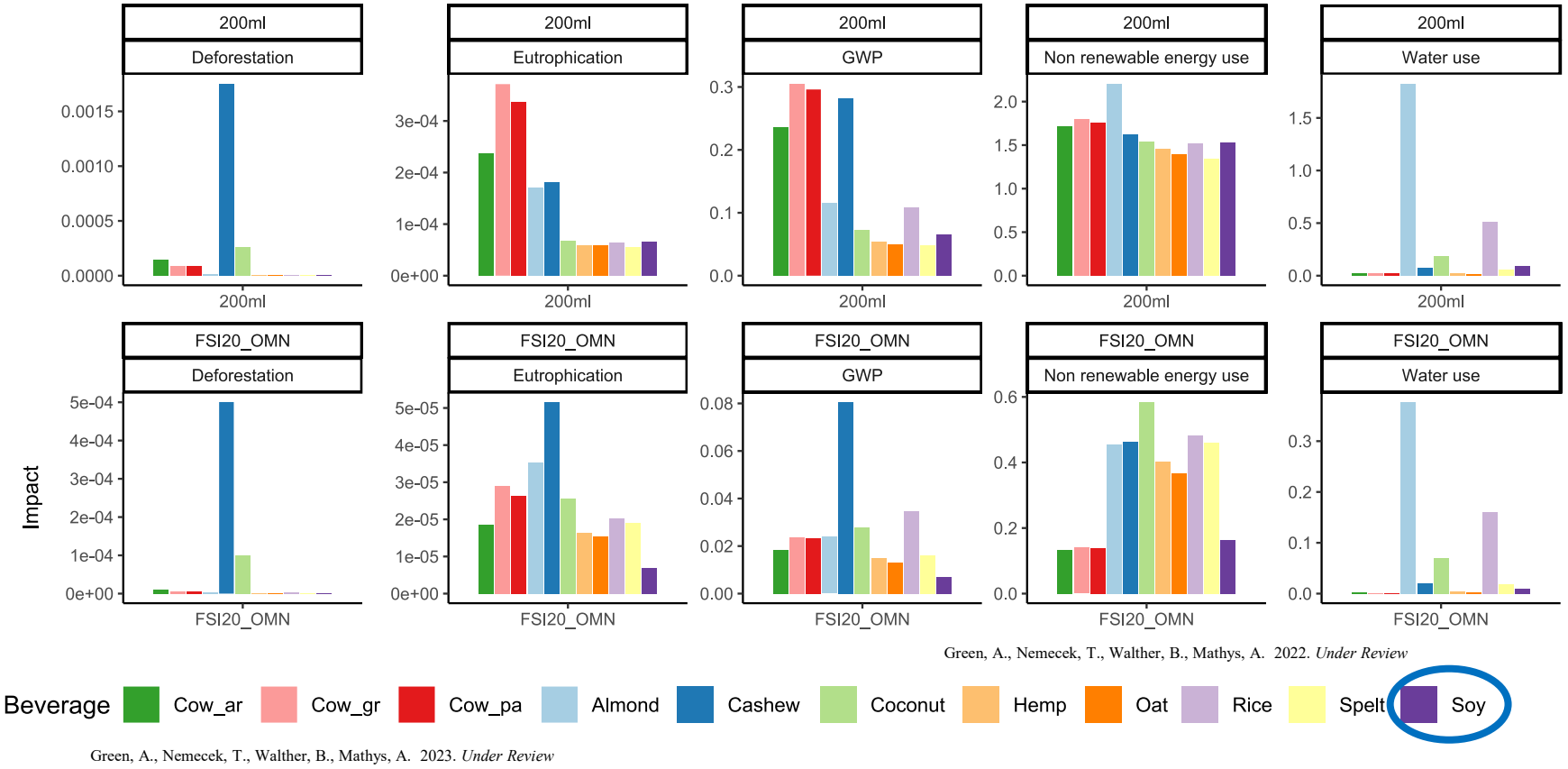
Herrmann et al. (2024) doi.org/10.3389/fsufs.2024.1413802

Plant based milk alternatives
Large differences in nutritional value



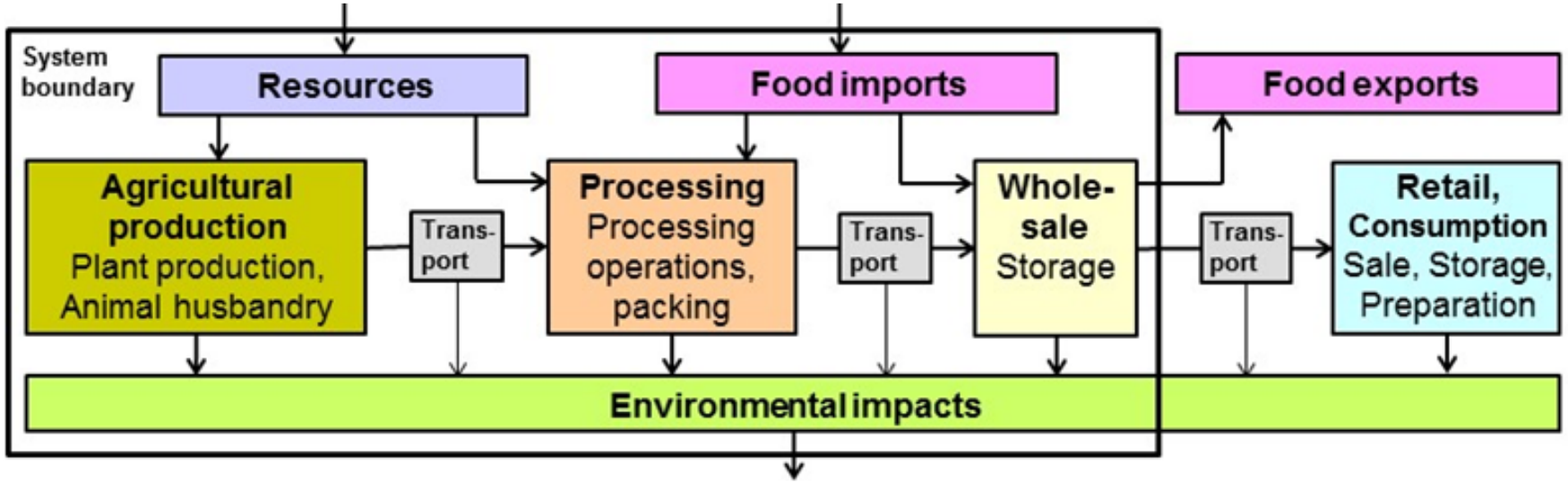
Green, A., Nemecek, T., Walther, B., Mathys, A. 2023. *Under Review*

Plant based milk alternatives
Nutritionally-invested environmental impacts



Environmentally optimised Swiss diets

- **Functional unit**: Nutrition of the Swiss population
- **System boundary**: Food supply
  - \+ Including upstream processes
  - \+ Including environmental impacts abroad through feed and food imports to Switzerland
  - – Excluding environmental imports from exports
  - – Excluding retail, food preparation and consumption



Source: Zimmermann et al. (2017), Agroscope Science 55.