

Variation in Greenhouse Gas Emission Estimates Across Dairy Farm Models Using Danish Farm Accountancy Data

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Plan

1. Three farm-level greenhouse gas emission models
2. Danish Farm Accountancy Data
3. Categorization in eight typical Danish dairy farms types
4. Model comparison
5. Policy Implications



Research Question

How do greenhouse gas emission estimates vary across commonly used dairy farm models when applied to harmonized Danish farm data?

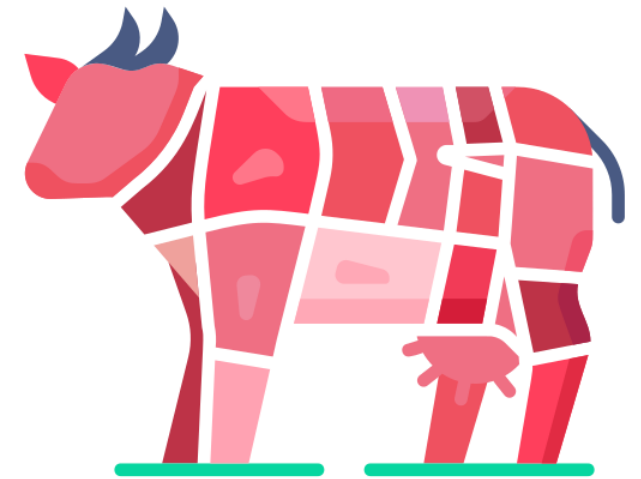
Key aspects examined:



Emission magnitude



Farm ranking



Allocation sensitivity

Balancing food security and emission reduction

Food security
Economic viability

Emission reduction
Climate targets

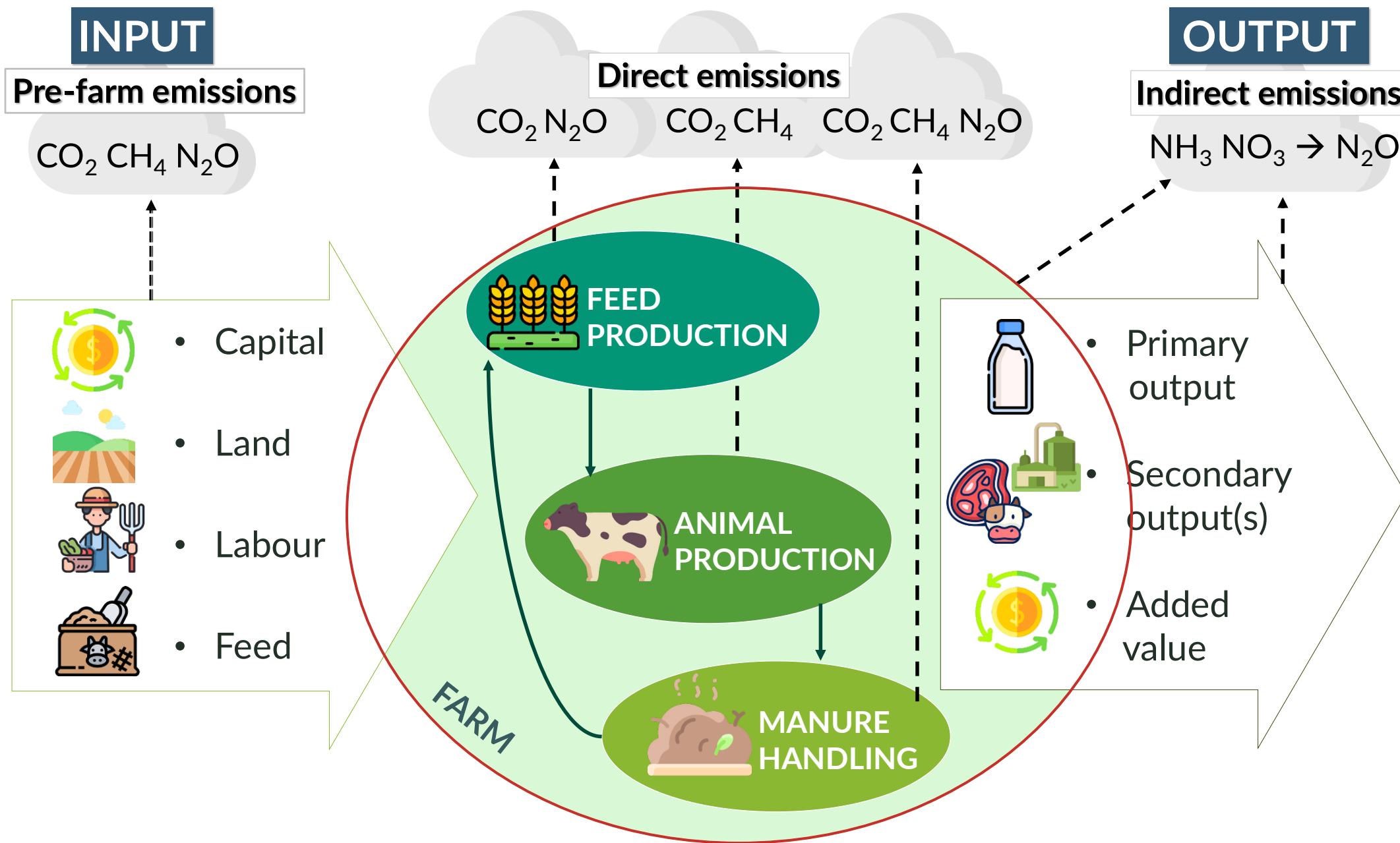


Dairy:

- 20% of protein in diet
- ~ 30% agricultural workforce
- 15B DKK (2B €) to agricultural GDP₁

Agriculture:

- ~ 30% of total GHG emissions
 - 60% Land-Use
 - 1L milk = 600-1000 L water eq.
- Overall goal: -70% emissions by 2030



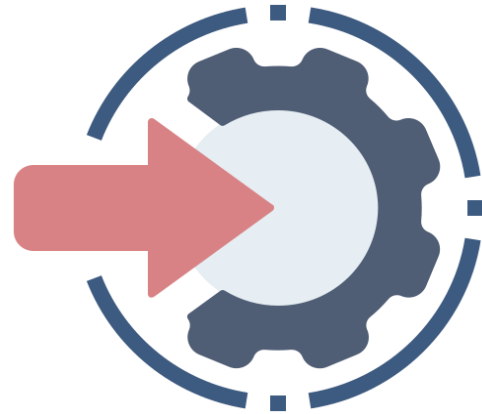
Harmonized Danish farm data for consistent model comparison

Data Source



- **2023 Danish Farm Accountancy Data**
- Production variables
- Economic variables
- Farm-level records

Harmonization



- Same herd structure
- Same feed and manure assumptions

Farm Representation



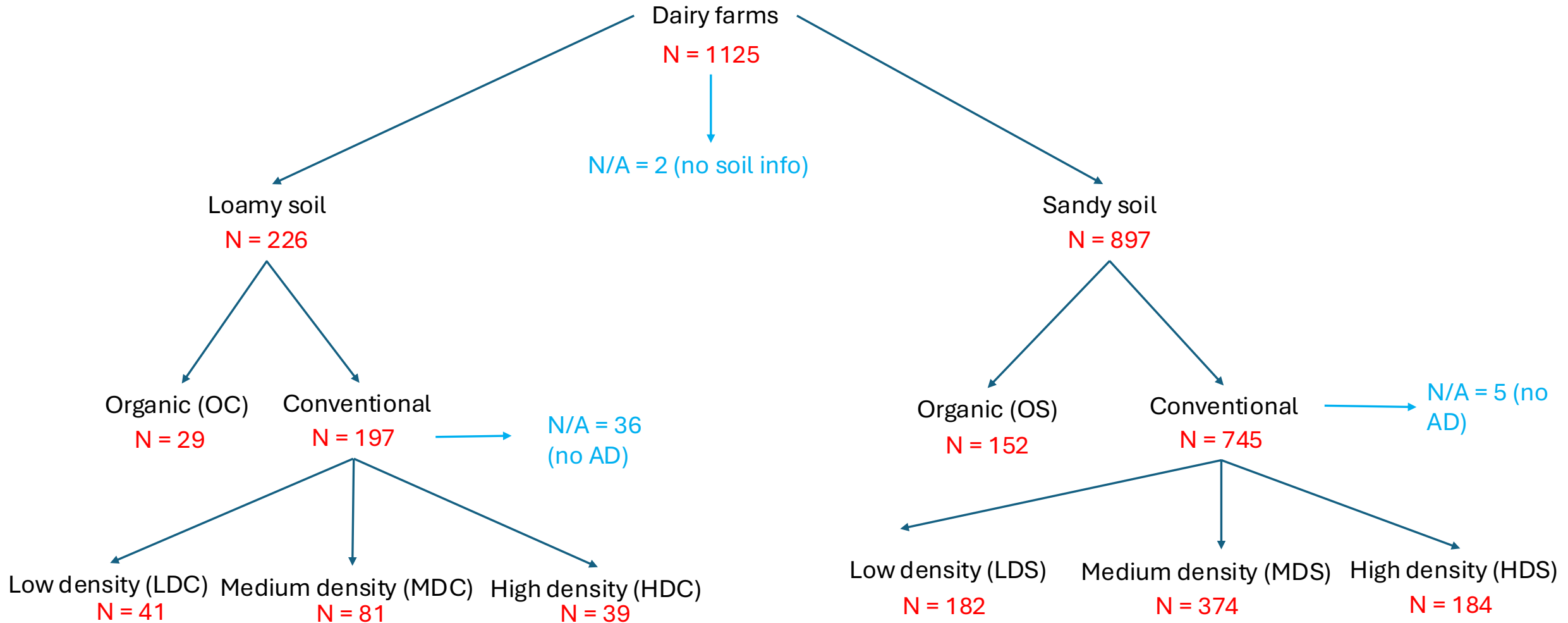
- **8 Representative Dairy Farm Categories**
- Organic vs Conventional
- Small , Medium, Large systems

Emission indicators



- **Total emissions** (t CO₂e / farm-year)
- **Milk emission intensity** (kg CO₂e / kg FPCM)
- **Land-based intensity** (t CO₂e / hectare)

Overview of eight representative dairy farm types



Different model structures → different emission estimates and ranking outcomes

	Denmark-specific Tier-2 (Farra 2026) ¹	Cool Farm Tool (Hillier 2011) ²	Dairy GHG (Rotz 2018) ³
Model	Danish National Inventory Methodology	Empirical emission factors	Process-based, nonlinear (energy partition model)
Enteric Fermentation	Gross Energy Intake	Dry Matter Intake or Gross Energy Intake	Metabolizable Energy Intake
Feed dependence	Based on methane conversion factor (% of Gross Energy converted to CH ₄)	Based on default CH ₄ factors (18–22 g CH ₄ /kg DMI)	Based on diet energy density, digestibility, and efficiency
Context	Danish-specific emission factors	Global, farmer-oriented footprinting tool	U.S.-specific, research-grade simulation

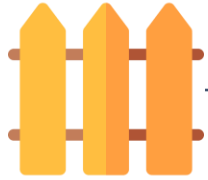
1. Farra et al. (2026). Variation in Greenhouse Gas Emission Estimates Across Dairy Farm Models Using Danish Farm Accountancy Data (submission pending).

2. Hillier, J. et al. (2011). Cool Farm Tool: Modelling Greenhouse Gas Emissions from Agricultural Production Worldwide. *Computers and Electronics in Agriculture*, 86, 156–163.

3. Rotz et al. (2018). Modeling greenhouse gas emissions from dairy farms. *Journal of Dairy Science*, 101(7), 6675–6690.

Do modelling choices matter? How much?

Boundaries



- What is included / excluded

Formulas



- Even if same source is included, can be calculated differently (Tiers, emission factors)



Data availability



- Inconsistency across countries
- 100s variables required

Functional units



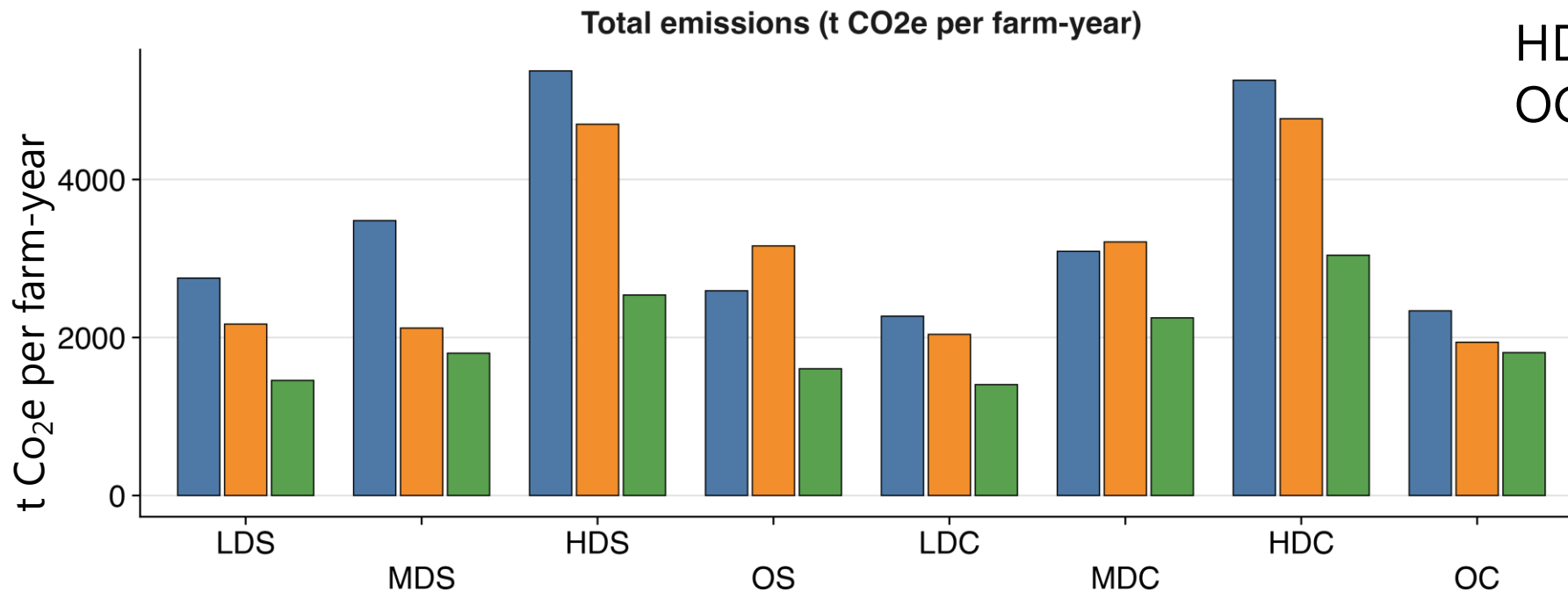
- Units used to express the output (per farm, per cow, per L milk)

The problem: Same farms, but different emissions

Emission estimates can differ significantly for the same farm, depending on the model

LDS: Low Density Sandy
MDS: Medium Density Sandy
HDS: High Density Sandy
OS: Organic Sandy
LDC: Low Density Clay
MDC: Medium Density Clay
HDC: High Density Clay
OC: Organic Clay

Tier2 CFT DairyGHG



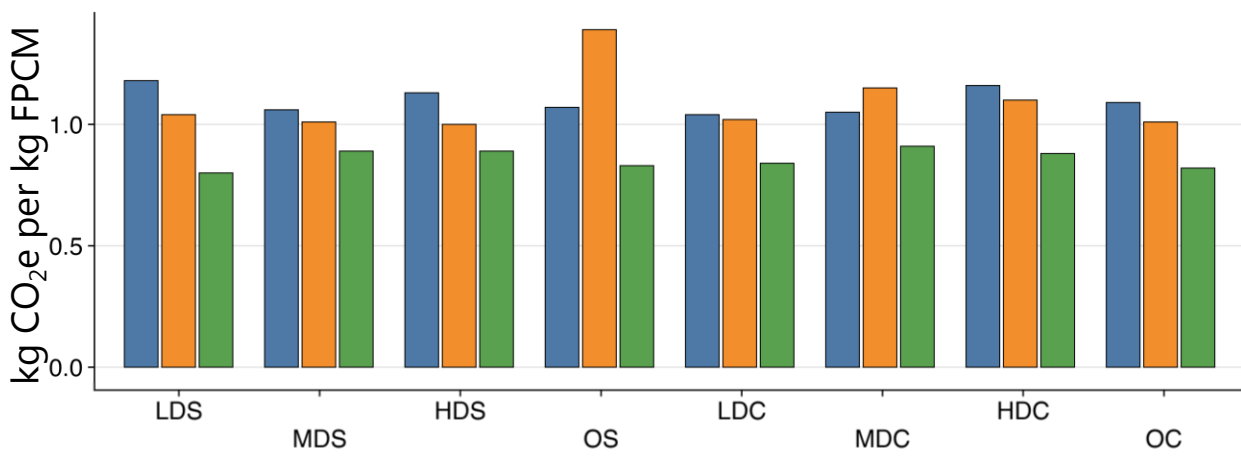
Functional unit affects ranking

CFT, DairyGHG, and Tier 2 across three functional units

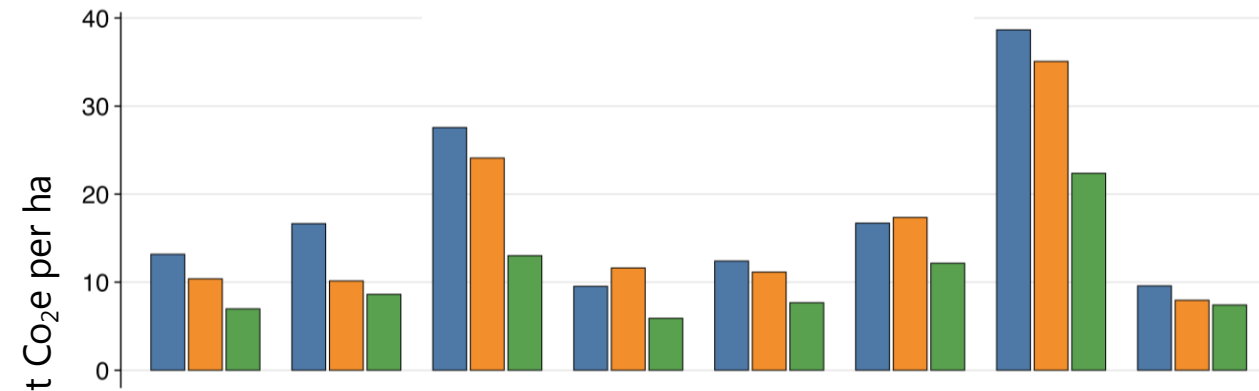
■ Tier2
 ■ CFT
 ■ DairyGHG

LDS: Low Density Sandy, MDS: Medium Density Sandy, HDS: High Density Sandy, OS: Organic Sandy, LDC: Low Density Clay, MDC: Medium Density Clay, HDC: High Density Clay, OC: Organic Clay

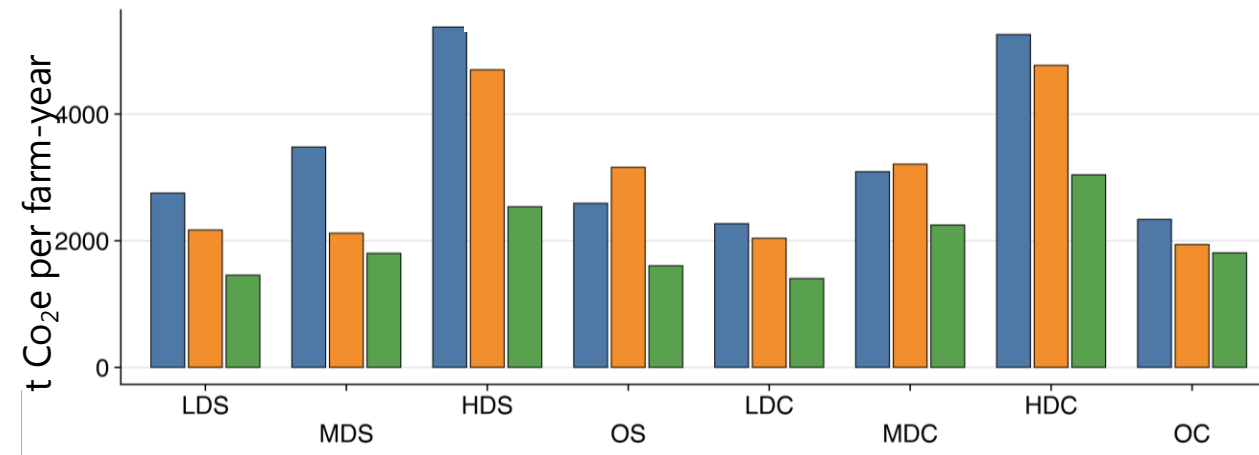
Emission intensity



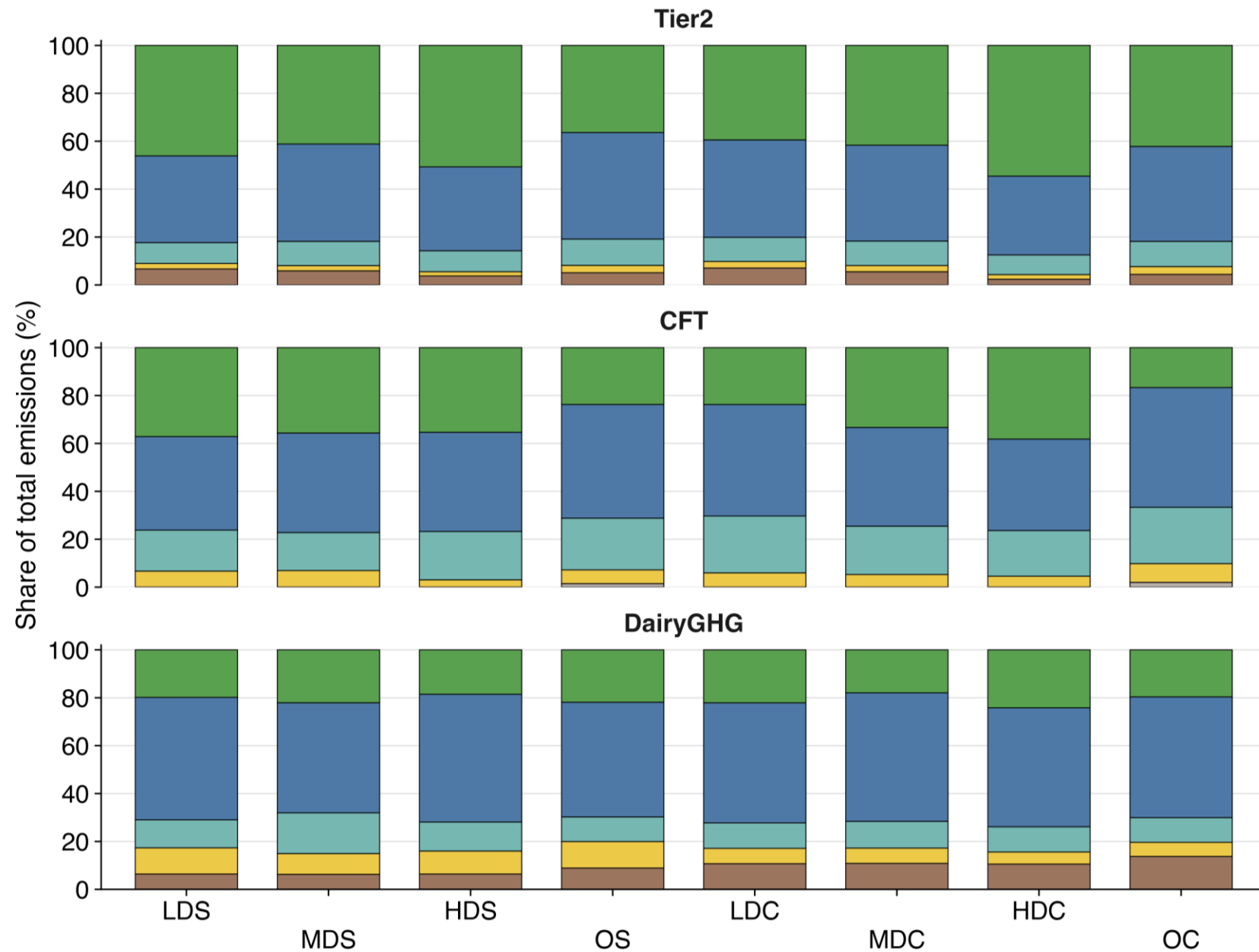
Emissions per hectare



Total emissions



Emission-Source per model & Unit



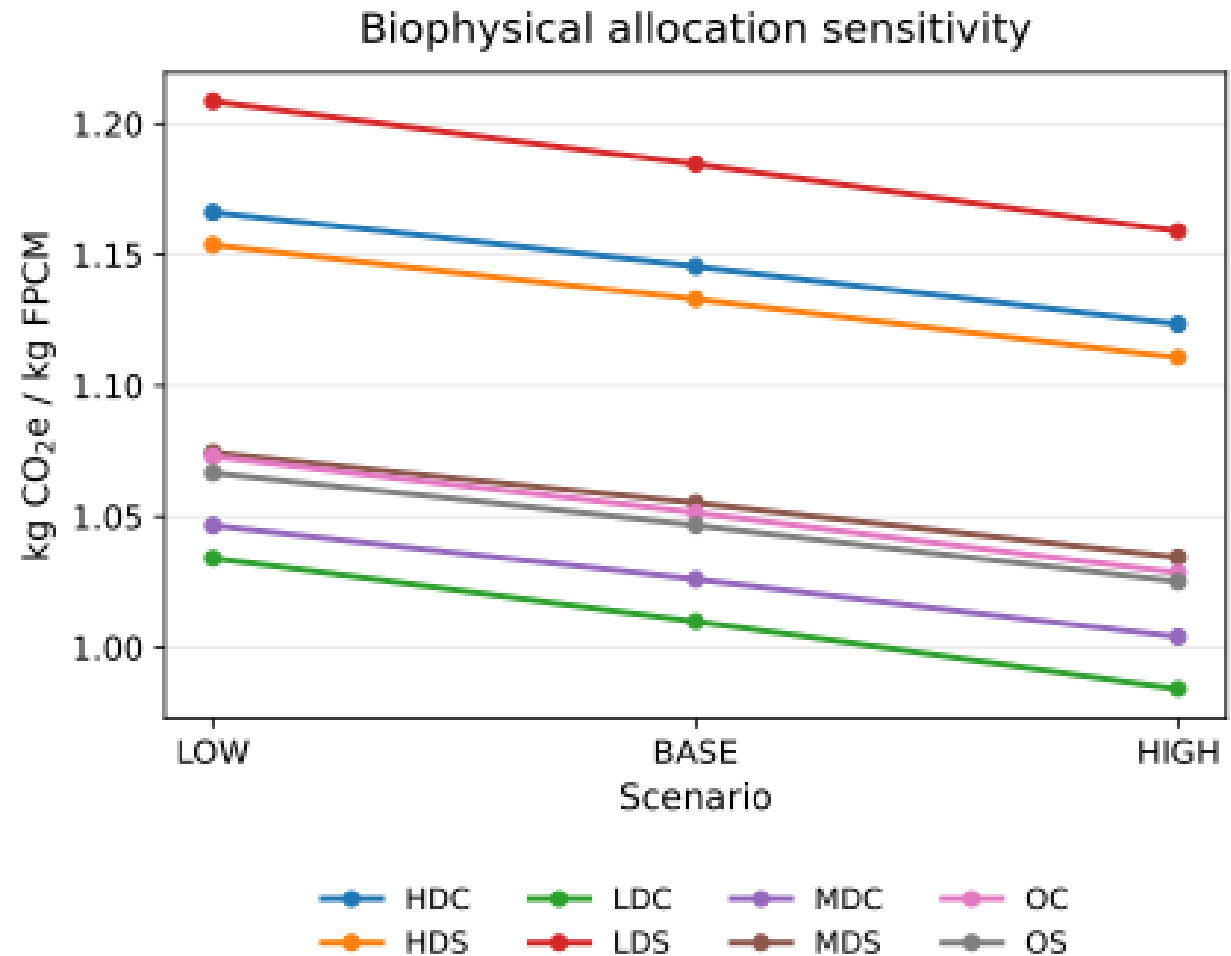
Conclusions

Stable findings:

- Farm ranking largely stable
- Tier-2 and CFT show similar ordering
- Allocation sensitivity analysis stable

Observed differences:

- Emission magnitude varies
- US Model significantly differs from others
- Milk-based intensity diverges more
- Allocation affects intensity results



Further reading: Two manuscripts (submission pending)



Farm-Level Greenhouse Gas Assessment in Dairy Systems: A Review of Drivers of Variability

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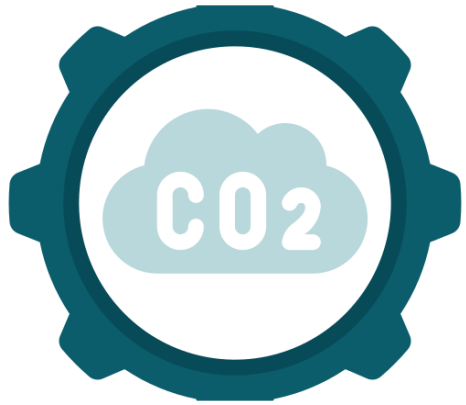
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Why do model comparison matters?



Carbon Taxation



Farm profitability



Policy incentives



Food affordability

Reliable models are essential for fair and effective climate action

Thank you for your attention!

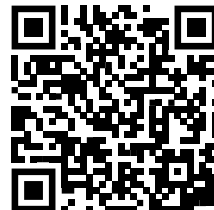


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