UNIVERSITÀ DEGLI STUDI DI PADOVA

DAFNAE
Department of Agronomy Food Natural resources Animals Environment

TOPVALUE
Mehrwert von Bergerzeugnissen
Il valore aggiunto del Prodotto di Montagna

Indicators of efficiency and environmental footprint for Eastern Alps mountain dairy systems

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Introduction

Traditional mountain livestock farms are largely based on the use of meadows and pastures:

- Medium/low production; strong link with PDO and other quality products
- Several non-market services (water regulation, landscape maintenance,…)

- How to define and evaluate the efficiency?

Project TOP VALUE, Interreg ITA-AUT

- The TOP VALUE project aims to support mountain food chains using the policy instruments provided by the optional quality term “mountain product”(EU Reg. 1151/12 and 665/14).
  - in particular, Alps mountain dairy farming systems

- The innovative approach consists in empowering the “mountain product” by identifying and quantifying ecosystem services linked to the natural and cultural assets of the Alpine area.

Aim

- This contribute presents preliminary results from TOP VALUE project regarding the environmental footprint and production efficiency of the Eastern Alps dairy farming system.

  - → analyzing the synergies and trade-offs between production efficiency (gross energy conversion ratio) and environmental footprint (Life Cycle Assessment) indicators.

Study area and sampled farms

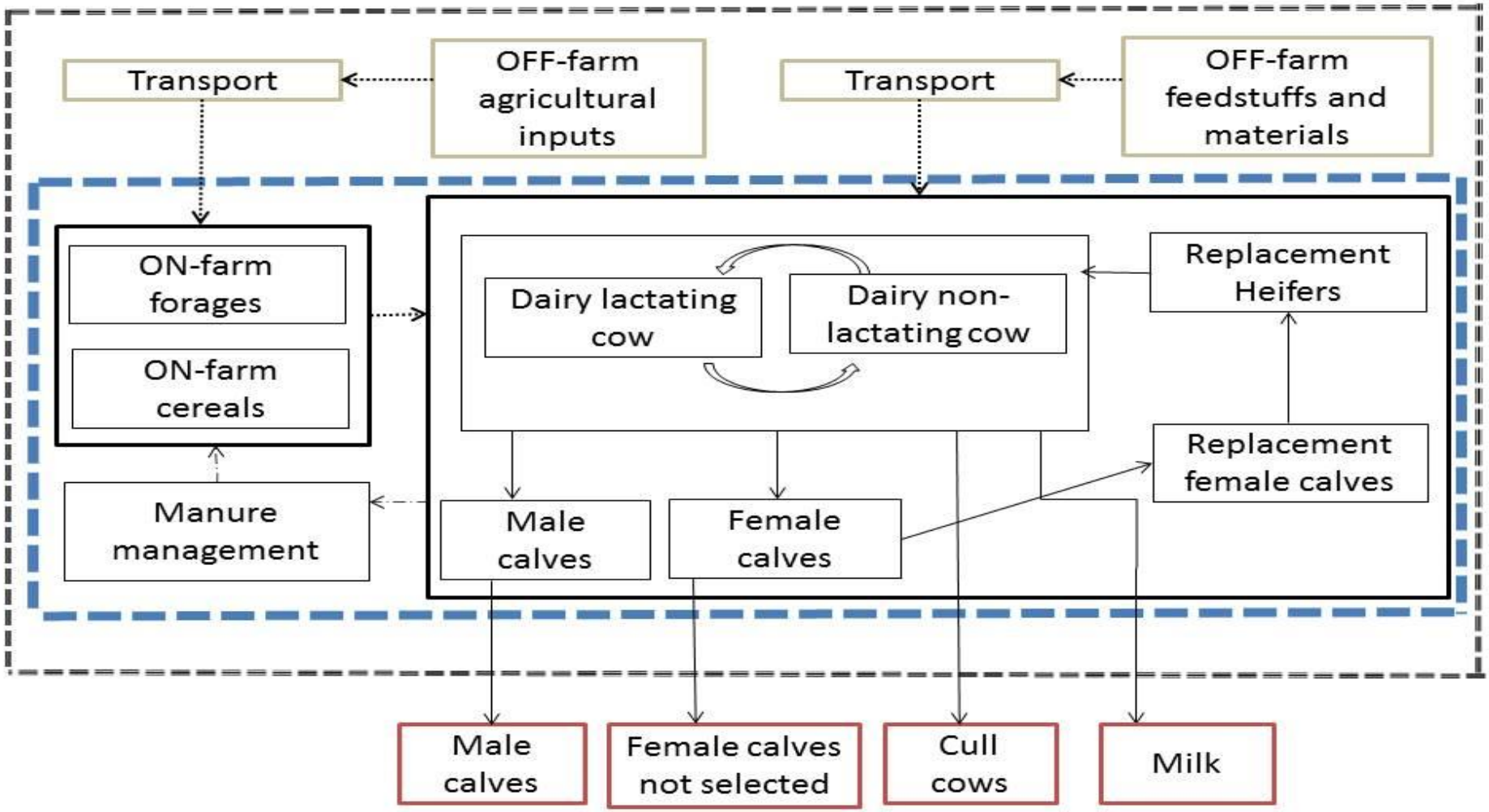
- North-eastern Alps (Veneto and Friuli Venezia Giulia in Italy and Kärtner in Austria)
- 38 dairy farms
  - Members of 6 cooperative dairies producing local cheeses

Life Cycle Assessment

- Method to evaluate the overall environmental footprint of one unit of product (standard ISO 14040-14044) through its life cycle (production, use, disposal).

- Goal and scope definition:
  - Reference unit: dairy farm
  - Functional units: 1 kg fat and protein corrected milk, 1 m^2 of farm agricultural area
  - Categories: climate change (kg CO_2-eq), eutrophication potential (g PO_4-eq), cumulative energy demand (MJ), land occupation (m^2/year)
  - Allocation of the impact between milk and meat: IDF (2010) method

Production stages and system boundaries



Life Cycle Inventory

- Collection of general data on farm facilities and management

- Recording of specific data:
  - Animal: at herd level, collection of data on productive performances, diet composition and administration
  - Crop: production inputs (fuel, mineral and organic fertilizers, pesticides, seeds), extension of land use and yields were recorded for each crop destined to on-farm feed
  - Off-farm feedstuffs and materials consumed on farm

  - Background data: Ecoinvent and Agri-footprint databases

Gross energy conversion ratio

- Efficiency in feedstuffs-to-milk energy conversion has been established as powerful indicator of production efficiency.

- From the diet composition and milk production data collected for LCA, we computed:
  - Gross energy conversion ratio: Gross energy in the feedstuffs (allocated to milk) / Gross energy in fat and protein corrected milk
  - Potentially human-edible conversion ratio: Gross energy in the human-edible feedstuffs (allocated to milk) / Gross energy in fat and protein corrected milk

- Gross energy of feedstuffs: INRA (2007)
- Human-edible portion per feedstuff: Wilkinson (2011)
- Gross energy of milk: IDF (2010)

Statistical analysis

- Synergies and trade-offs were analysed though Pearson's r correlation between:
  - Impact categories per 1 kg Fat and Protein Corrected Milk
  - Impact categories per 1 m^2 farm agricultural area
  - Gross energy conversion ratios (whole diet and potentially human-edible portion)

Descriptive statistics

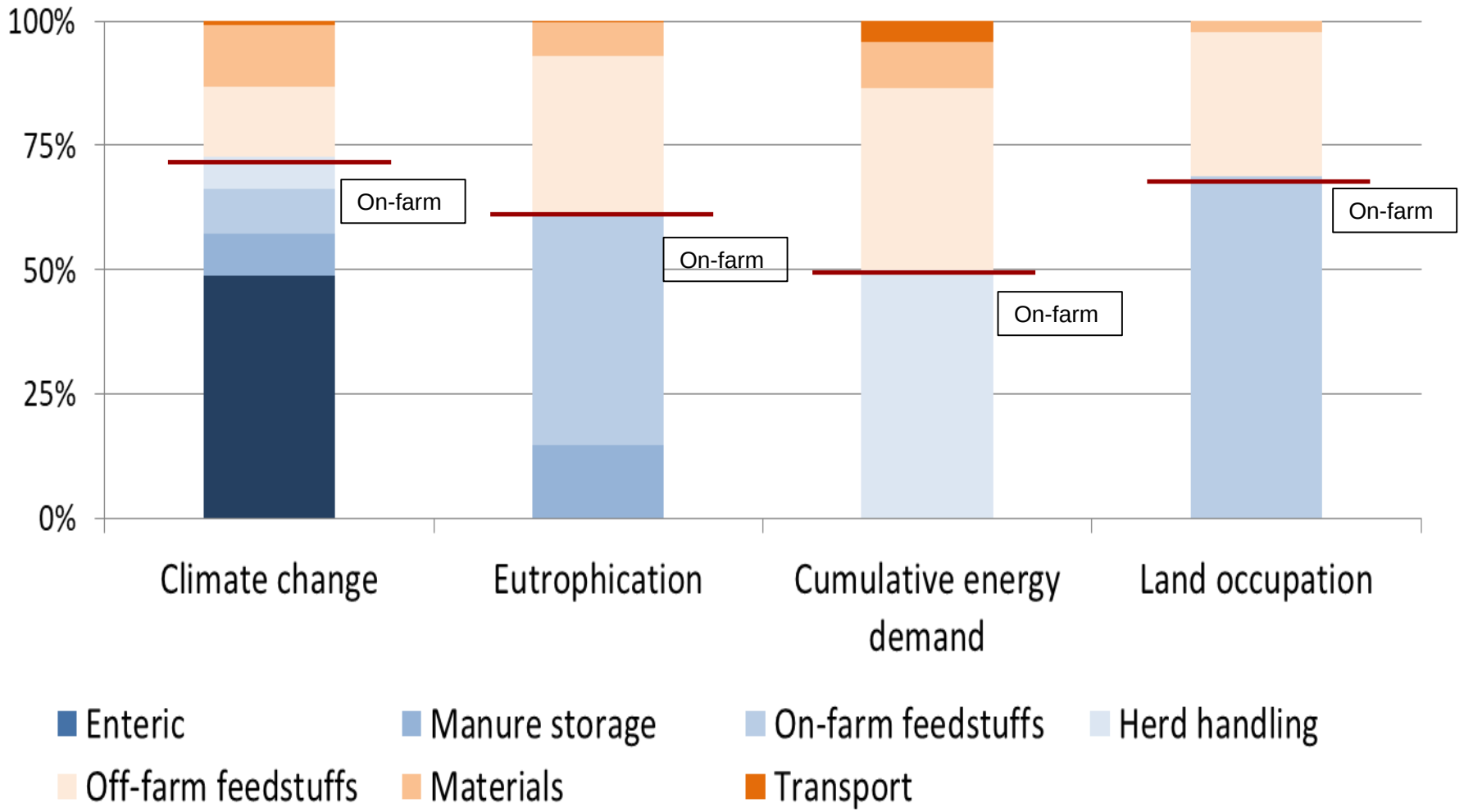
Variable	Unit	Mean	C.V.
Lactating cows/farm	n	30	67%
Herd size (Livestock Unit)	n	45	58%
Agricultural surface	ha	30	80%
Grassland on total surface	%	94	10%
Stocking rate	LU/ha	1.6	41%
Milk production	kg FPCM/cow/d	20.6	24%

38 dairy farms

Efficiency indicators results

Variable	Unit	FU	Mean	C.V
Climate change	kg CO_2-eq	1 kg fat and protein corrected milk	1.2	21%
Eutrophication potential	g PO_4-eq		6.6	31 %
Cum. Energy Demand	MJ		3.1	49 %
Land occupation	m^2/y		1.8	42 %
Climate change	kg CO_2-eq	1 m^2 farm agricultural area	0.6	26 %
Eutrophication potential	g PO_4-eq		2.7	31 %
Cum. Energy Demand	MJ		1.8	43 %
Feed/Milk (gross energy, whole diet)	MJ/MJ		7.6	18 %
Feed/Milk (gross energy, potentially human-edible portion)	MJ edible/MJ		0.8	84 %

Contribution to the impact categories (milk)



Statistical analysis results (Pearson's correlation factors)

	Dairy cows	Stock rate	Milk prod.	Clim. Chang /Milk	Eutro. Pot. /Milk	Cum. Energy Dem. /Milk	Land Occ. /Milk	Clim. Chang /m^2	Eutro. pot. /m^2	Cum. Energy Dem. /m^2	GE conv. ratio
Stock rate	n.s.										
Milk prod.	n.s.	n.s.									
Clim. Chang. /Milk	n.s.	n.s.	-0.69								
Eutro. pot. /Milk	n.s.	n.s.	-0.55	0.75							
Cum.EnergyDem. /Milk	n.s.	n.s.	n.s.	0.54	0.51						
Land Occ. /Milk	n.s.	-0.38	-0.40	0.62	0.51	0.42					
Clim. Chang. /m^2	n.s.	0.52	n.s.	n.s.	n.s.	n.s.	-0.78				
Eutro. pot. /m^2	n.s.	0.56	n.s.	n.s.	n.s.	n.s.	-0.54	0.83			
Cum.EnergyDem. /m^2	n.s.	0.38	n.s.	n.s.	n.s.	0.35	-0.36	0.56	0.62		
GE conv. ratio	n.s.	n.s.	-0.64	0.75	0.56	n.s.	0.57	-0.38	-0.34	-0.51	
Human-edible GE conv. ratio	0.42	n.s.	n.s.	n.s.	n.s.	0.54	0.37	n.s.	n.s.	0.49	n.s.

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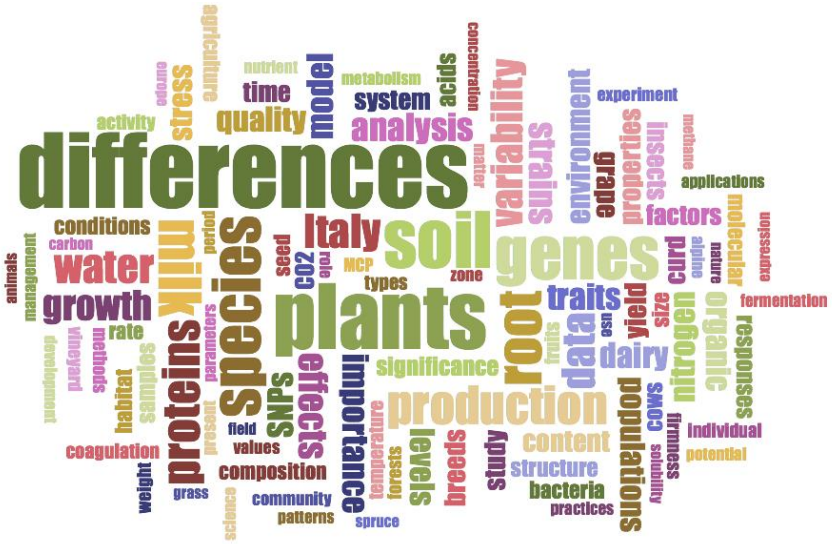
Conclusions

- The production of 1 kg FPCM caused the emissions of 1.2 kg CO_2-eq and 6.6 g PO_4-eq on average, using 3.1 MJ and 1.8 m^2 of agricultural land.
- The occupation of 1 m^2 of agricultural land for milk production in the Eastern Alps is related to 0.6 kg CO_2-eq, 2.7 g PO_4-eq, and 1.8 MJ of energy.
- Within the same functional unit, impact categories were strongly and positive correlated, whereas no univocal trend was found between categories per FPCM and per m^2.
- The differences in the correlation between impact categories and efficiency indicators of gross energy conversion, as well as the notable variability in farms characteristics, shows room for improvement in the environmental footprint of mountain dairy farming systems.

Perspectives

- Widening this analysis in order to include:
  - the whole farms sample (80 farms) involved into the TOP VALUE project,
  - other impact categories (e.g. acidification potential),
  - N and P efficiency use,
  - the cheese-making phase (preliminary results: from 9.7 to 14.4 kg CO_2-eq, from fresh to ripened ones)
- Studying how environmental and efficiency results are connected with the other main issues of the TOP VALUE project (Ecosystem services approach).



Thank you for your attention

Computation of impacts and efficiency

Variable	Production stage	Reference
Enteric CH_4	Animal	Ramin et al. (2013)
CH_4, N-compounds loss	Manure storage	IPCC (2006)
N-compounds loss	Fertilizers spreading on farm agricultural area	
Phosphorous loss	Fertilizers spreading on farm agricultural area	Nemecek and Kägi (2007)
Emissions, energy and land occupation	Agricultural inputs production	Ecoinvent 3.0, Agri-footprint 1.0 databases (Simapro software)
	Off-farm feedstuffs production	
	Off-farm materials production	

Variability between States