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

Environmental footprint and efficiency of mountain dairy farms

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Introduction

Traditional mountain livestock farms:

- 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 evaluate the environmental footprint and 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

- The aim of this study is to analyze the environmental footprint and production efficiency (gross energy and potentially human-edible gross energy conversion ratios, ECR and HeECR respectively) of the eastern Alps dairy farming system,

    - testing how farm management affects the environmental footprint and production efficiency.

Study area and sampled farms

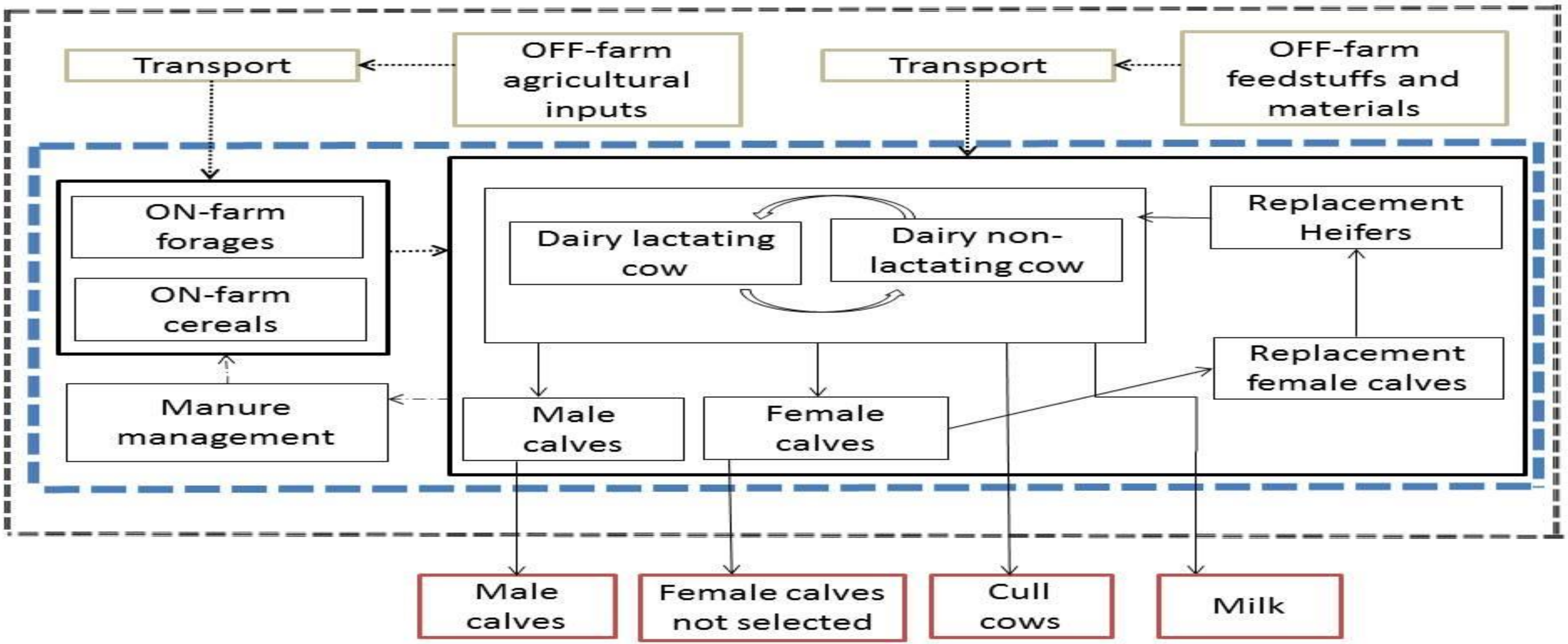
- North-eastern Alps (Veneto, Friuli Venezia Giulia and Sud Tirol in Italy and Kärtner in Austria)
- 75 dairy farms
  - Members of 9 cooperative dairies producing local cheeses

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: global warming potential (kg CO_2-eq), cumulative energy demand (MJ), land occupation (m^2/year)
  - Allocation of the impact between milk and meat: IDF (2015) 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)
- Potentially human-edible portion per feedstuff: Wilkinson (2011)
- Gross energy of milk: IDF (2015)

Statistical analysis

- Principal Component Analysis to analyse the relation between:
  - Herd size
  - Farm agricultural area
  - Farm characteristics (stalls, type of rations, use of silages, use of pasture for lactating cows, diet self-sufficiency)
  - 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

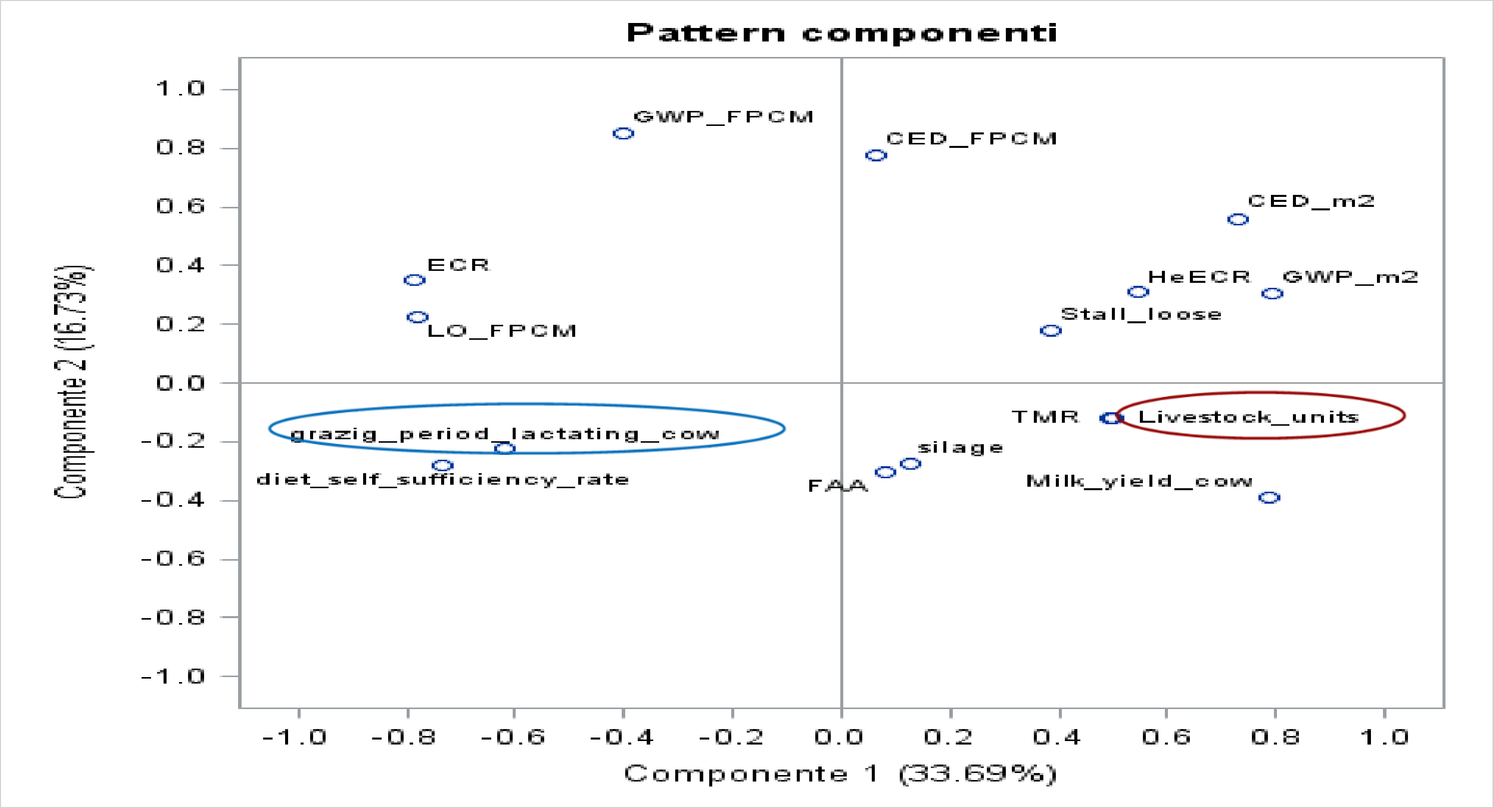
Variable	Mean	CV (%)
Farm agricultural area , ha	34	69
Crop area, % farm agricultural area	5	202
Dairy cows, Livestock units (LU)	28	66
Lactating cows	23	65
Heifers, LU	10	74
Milk productivity, kg FPCM[1] / lactating cow / y	7643	26
Feed concentrates, kg DM / lactating cow / y	920	120
Diet self-sufficiency rate, %	70	30
Nitrogen fertilization (organic), kg N/LU/year	74	24
Nitrogen fertilization (mineral), kg N/LU/year	4	268

[1] FPCM: Fat- and protein-corrected milk

Impact and efficiency indicators results

Variable	Mean	CV (%)
Global warming potential, kg CO_2-eq / kg FPCM	1.18	17
Cumulative energy demand, MJ / kg FPCM	3.34	47
Land occupation, m^2/y / kg FPCM	2.25	45
Global warming potential, kg CO_2-eq / m^2	0.49	34
Cumulative energy demand, MJ / m^2	1.38	52
Gross energy conversion ratio, MJ_{feed} / MJ_{milk}	6.53	13
Potentially human-edible gross energy conversion ratio, MJ_{feed} / MJ_{milk}	0.48	78

Statistical analysis results (PCA)



a) Under farmer's control
b) Possible change for mitigation

Statistical analysis

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  - 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)

- GLM model testing the effect of herd size (3 classes, x<25, 25<x<50, x>50 Livestock Unit – LU), of the presence of a grazing period for lactating cows (2 levels) and their interaction

Statistical analysis results (GLM model)

Variable		Per 1 kg Fat-, protein-corrected milk GWP (kg CO_2-eq)	Per 1 kg Fat-, protein-corrected milk CED (MJ)	Per 1 kg Fat-, protein-corrected milk LO (m^2/y)	Per 1 m^2 agricultural land GWP (kg CO_2-eq)	Per 1 m^2 agricultural land CED (MJ)	ECR (MJ/MJ)	HeECR (MJ/MJ)
R^2		0.12	0.20	0.30	0.51	0.33	0.18	0.53
RMSE		0.20	1.50	0.91	0.13	0.63	0.83	0.27
Herd size	Small	1.18	2.86	2.42	0.42	0.98	6.89	0.34
	Medium	1.16	3.37	2.32	0.46	1.29	6.53	0.40
	Large	1.16	3.40	2.24	0.43	1.22	6.28	0.52
Grazing period for lactating cows	Absence	1.15	3.33	1.74 [a]	0.60 [b]	1.70 [b]	6.23 [a]	0.63 [b]
	Presence	1.20	3.18	2.39 [b]	0.43 [a]	1.12 [a]	6.73 [b]	0.37 [a]

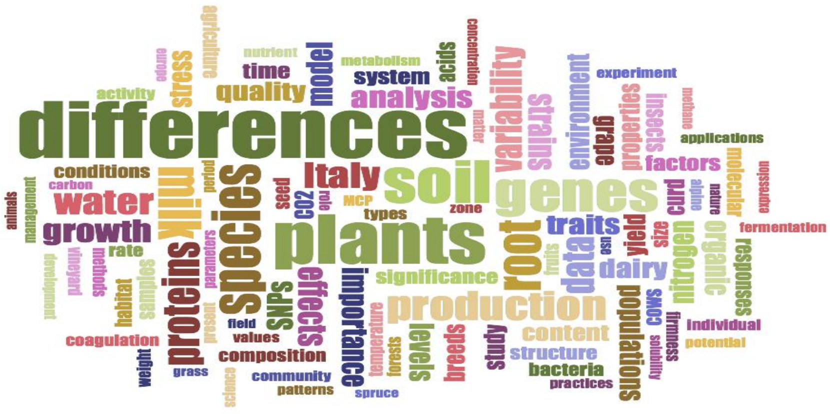
Conclusions

- The results evidenced that the alpine dairy system is characterized by a large variability in terms of farm size and management.

- Moreover, the study evidenced that the traditional managing options in the mountain dairy farming system (small-scale farms using pasture for lactating cows) generally do not worsen the environmental footprint indicators but enhance the decoupling of milk production from crop production intended for direct human consumption.

- On the other hand, farms with cows at pasture showed a lower milk productivity than farms with confined cows. As milk is the first revenue for dairy farms, the economic sustainability of the mountain dairy farming system has to be considered.

- In perspective, study 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	
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	