UNIVERSITÀ DEGLI STUDI DI PADOVA

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Multi-indicators approach for the evaluation of efficiency of mountain dairy farms

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Introduction

Traditional mountain livestock systems are largely based on the use of meadows and pastures, providing several market and non-market services:

- Dairy products (and meat)
- Conservation of local breeds
- Biodiversity and landscape maintenance
- Risk prevention
- Recreation and ecotourism
- Cultural heritage

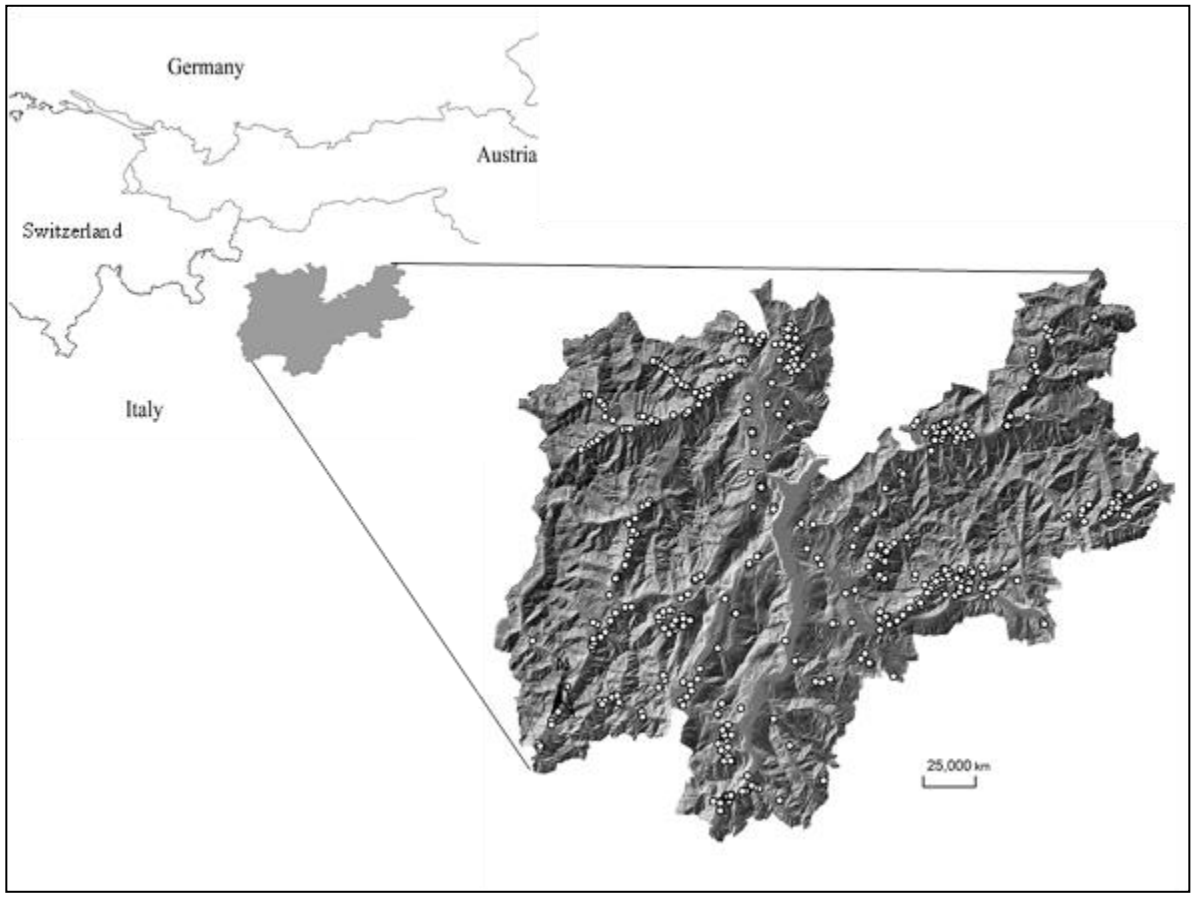
Aim

1) to assess the sustainability of dairy farms in mountainous areas by using a multi-indicators approach:

- environmental impact categories computed according to Life Cycle Assessment approach
- competition with human-edible feedstuffs for the production of energy into human-edible livestock products

2) to analyse synergies and trade-offs among different indicators

Study area and sampled farms



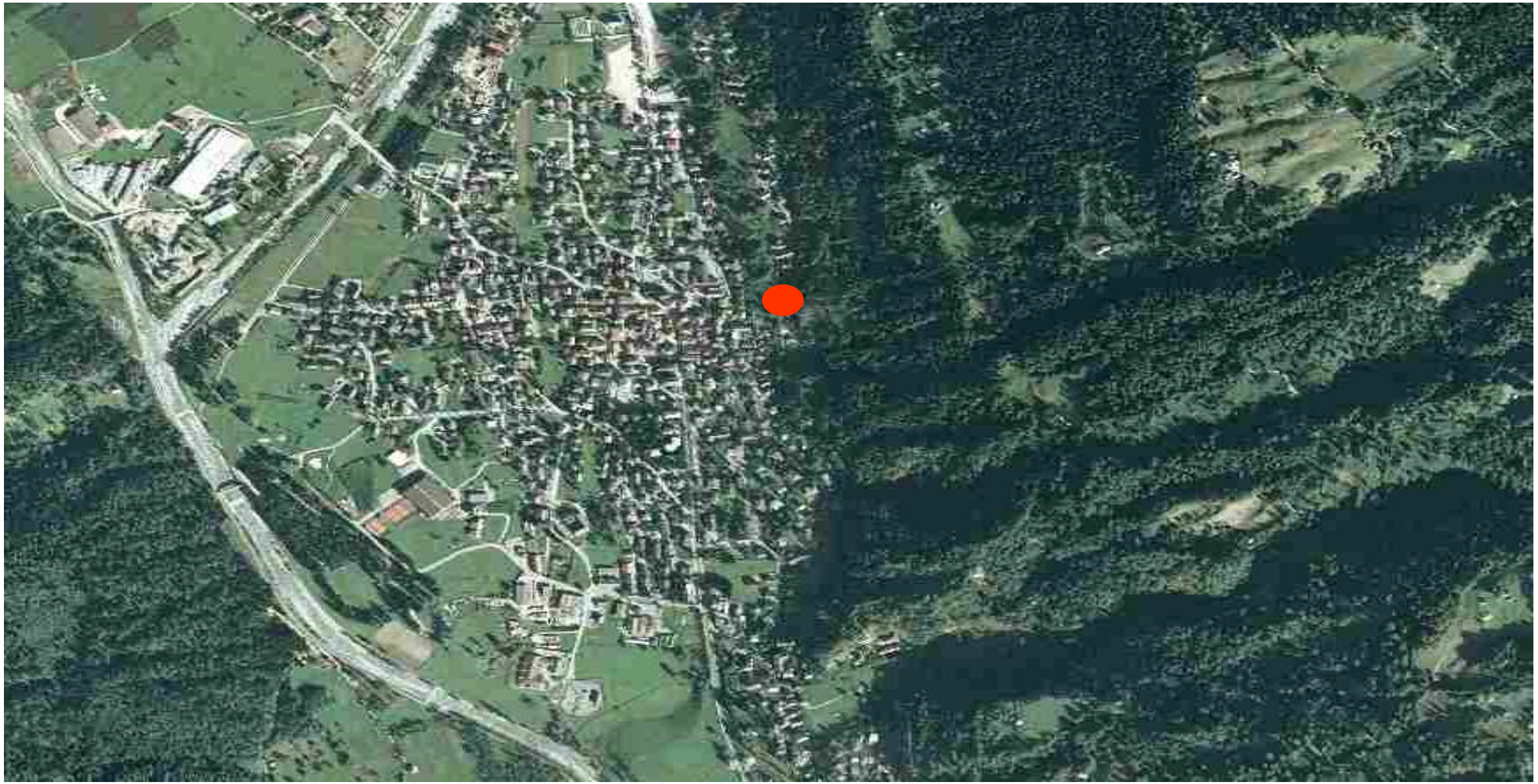
Study area → Trento province:

- Mountainous area 6,212 km^2
- 1,372 km^2 UAA, mainly grassland
- 1,075 dairy farms: the majority are members of cooperative dairies producing PDO cheeses

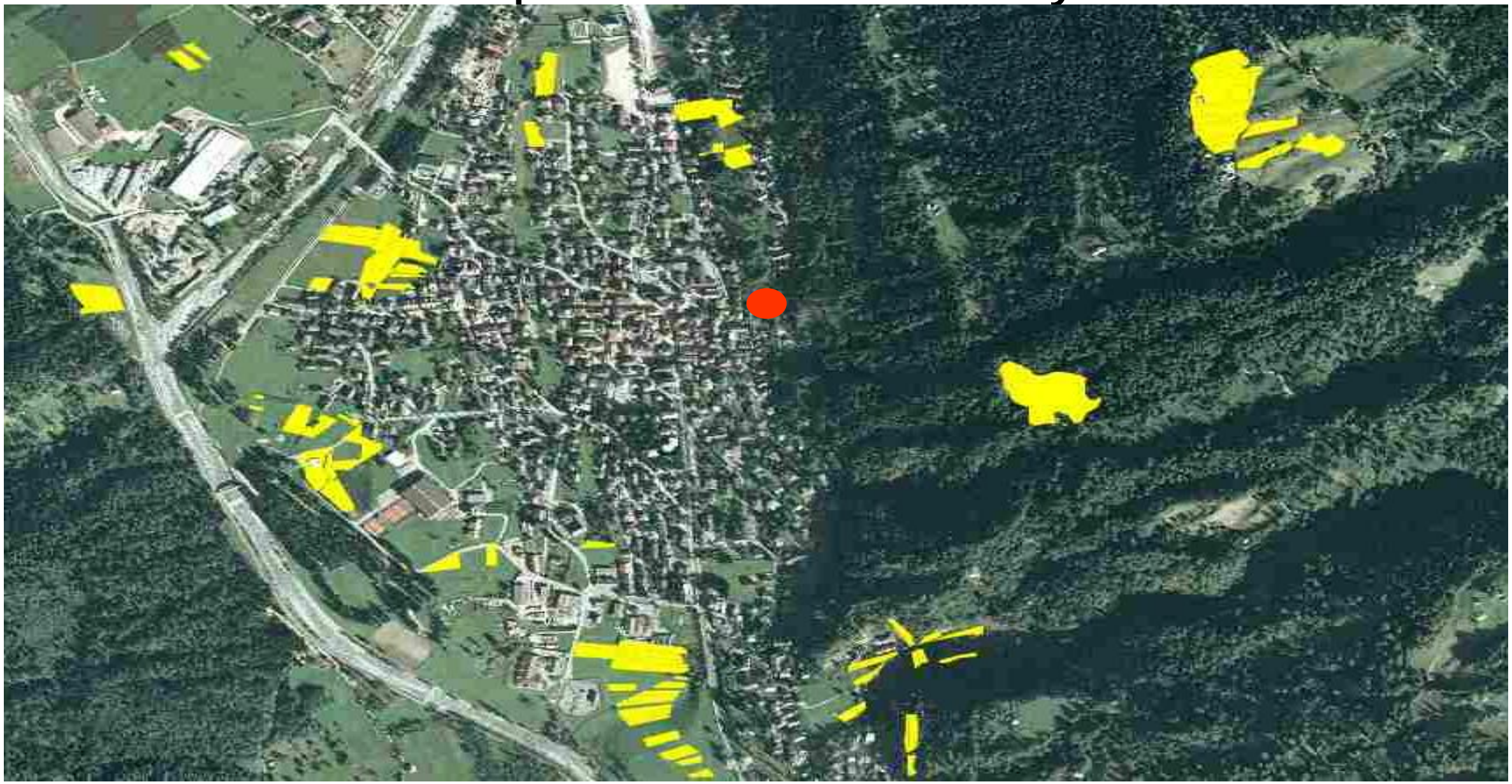
Sampled farms:

- 38 dairy farms with mixed breed herds (2 or more of these breeds: Holstein Friesian, Brown Swiss, Simmental, Rendena, Alpine Grey)

Landscape of traditional dairy farm



Landscape of traditional dairy farm



Goal and scope

- ✓ ***System boundary and delimitations****:* this work studied the dairy farms from cradle-to-farm-gate for a one-year period (2013)
- ✓ ***Functional unit:*** 1 kg of Fat and Protein Corrected Milk at the farm gate
- ✓ ***Allocation***: mass allocation for inputs derived by multifunctional system and for the two main farm outputs (meat and milk)

Life Cycle Inventory - LCI

- 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: estimation of environmental impact of each on-farm feed used at farm level - all 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 and materials used on farm: Emission factors (EF) for off-farm feed, plastic and lubricant were derived by EcoInvent 3.0 and Agri-footprint 1.0 database provided with Simapro software

Life Cycle Impact Assessment - LCIA

Impact Categories:

- Greenhouse gas emission (GHG, kg CO_2-eq)
- Acidification potential (AP, kg SO_2-eq)
- Eutrophication potential (EP, kg PO_4-eq)
- Cumulative Energy Demand (CED, MJ)
- Land occupation (LO, m^2)

Competition with human-edible resources

Use of human-edible feedstuffs → Competition about feedstuffs' destination: Feed vs Food

$$\text{Human-edible Feed Conversion Ratio (HeFCR)} = \frac{\text{MJ (GEI) into the human-edible feedstuffs}}{\text{MJ (GEI) into FPCM produced per farm}}$$

Value for MJ (GEI) per each feedstuff: INRA (2007) reference
Human-edible ratio per each feedstuff: Wilkinson (2011)
Human-edible gross energy per 1 MJ into the milk: Wilkinson (2011)

Results: descriptive statistics of the 38 sampled farms

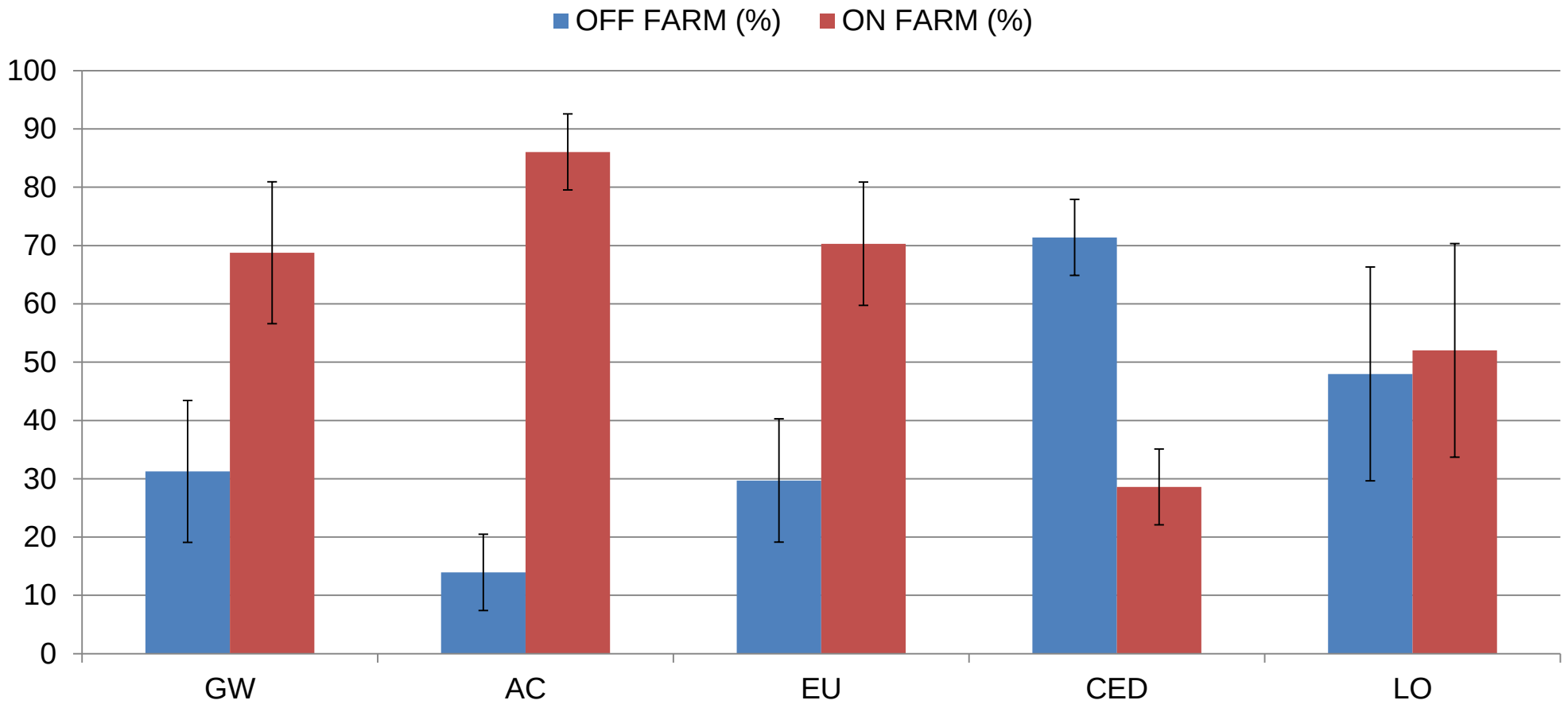
Variable	Mean ± SD
Lactating cows/farm (No.)	42.0 ± 28.8
Herd size (Livestock Unit, LU)	61.7 ± 30.8
Agricultural surface (ha)	22.3 ± 11.9
Milk production (kg/cow/d)	23.0 ± 6.5
Grassland of total surface (%)	93.1 ± 15.8
Stocking rate (LU/ha)	2.9 ± 1.4

Feed administration: 19/38 farms used total mixed ration
10/38 farms used silages

Results

	Unit	Mean ± SD
Impact categories per FPCM (mass allocation)		
Global warming potential	kg CO_2-eq	1.06 ± 0.23
Acidification potential	g SO_2-eq	19.97 ± 4.10
Eutrophication potential	g PO_4-eq	5.82 ± 1.07
Cumulative energy demand	MJ	5.06 ± 1.97
Land occupation	m^2/year	1.38 ± 0.46
Competition with human-edible (He) resources		
He Feed Conversion Ratio	MJ feed/MJ milk	0.72 ± 0.46

Results: ON-farm vs OFF-farm emissions



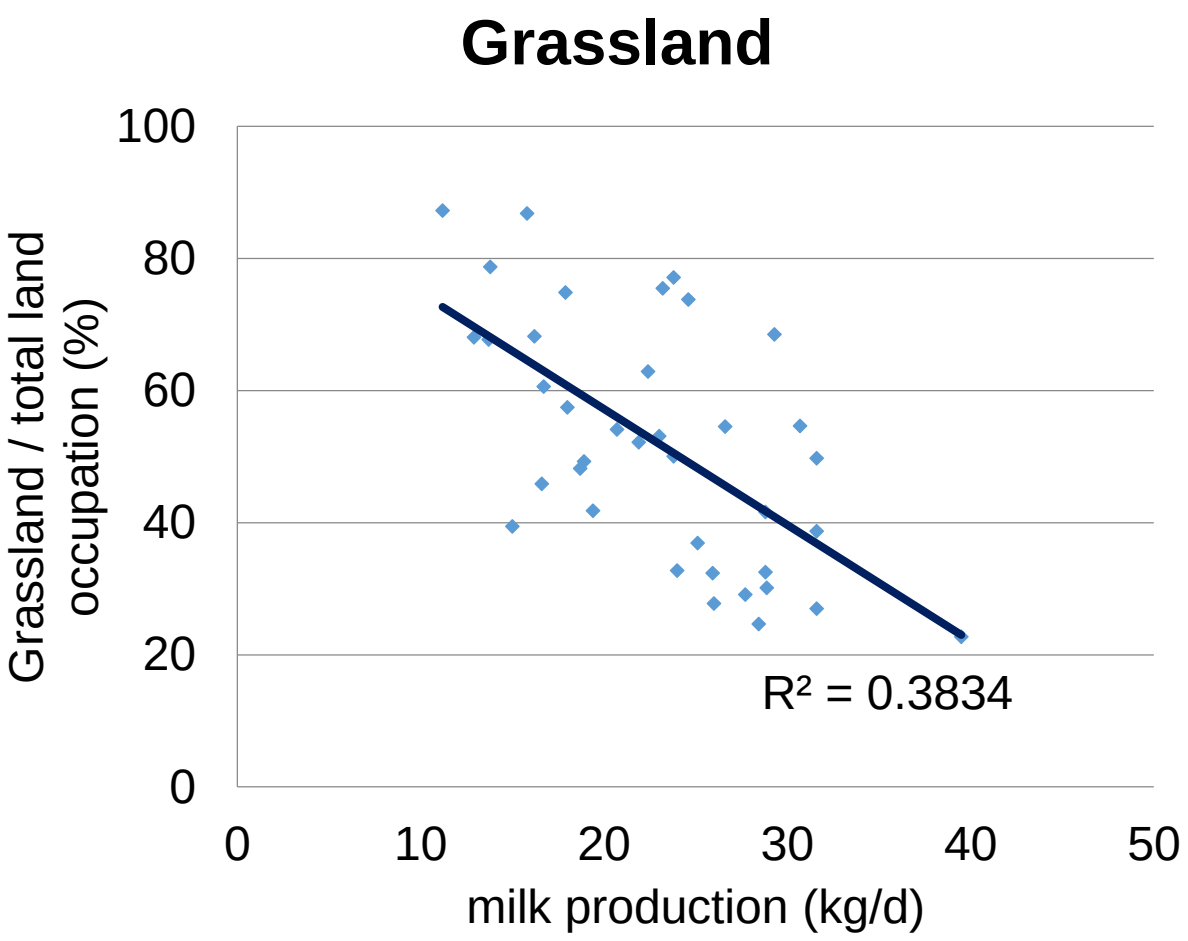
GW: global warming potential; AC: acidification potential; EU: eutrophication potential; CED: cumulative energy demand; LO: land occupation.

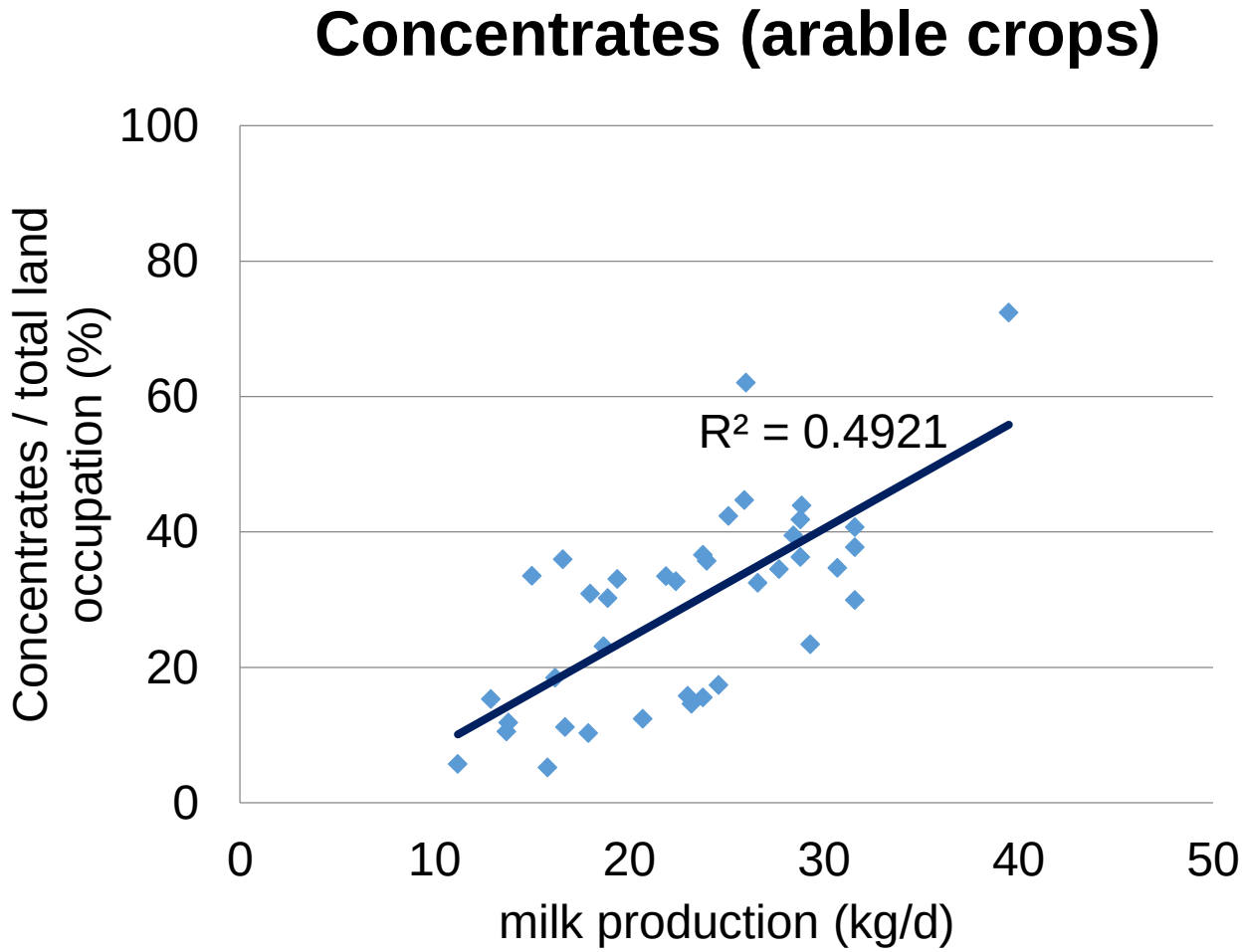
Correlation between the multiple-indicators

	GW	AC	EU	CED	LO	HeFRC
GW		***	***	***	*	**
AC	0.67		***	**	***	**
EU	0.81	0.88		**	**	*
CED	0.64	0.45	0.44		*	**
LO	0.34	0.53	0.47	0.36		**
HeFRC	-0.48	-0.46	-0.37	-0.45	-0.47	

*: P<0.05, **: P<0.01; ***: P<0.001
GW: global warming potential; AC: acidification potential; EU: eutrophication potential;
CED: cumulative energy demand; LO: land occupation

Competition with human edible resources: land occupation and milk production





Conclusions

- The sustainability of mountain dairy farms is strongly linked to the grassland management
- The common impact categories used in LCA for livestock products penalize mountain dairy farms
- The low competition with the use of human-edible feedstuffs has a consequent positive effect on the total food provisioning of mountain dairy farms.
- The sustainability assessment of the mountain dairy sector has to include different type of indicators in order to take into account the characteristics and environmental conditions as well as the products and ecosystem services supplied.