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Effect of farming system changes on life cycle assessment indicators for dairy farms in the Italian Alps

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LCA Food 2010 – Bari 22-24/09/2010

Dairy farming in mountain areas

Scarcity of resources (water and agricultural land) + High production cost

Traditional farms

Intensive farms

Farms that are closing

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Production intensification

- Characteristics:
- ➢ Increase in herd dimensions
- ➢ Increase in animal density per hectare
- ➢ Increase in milk production per cow

➢ By means of:

- o Substitution of traditional breeds with specialized ones
- o Increase in purchased feeds
- o Substitution of grasslands with maize for silage
- o Cessation of alpine summer pasture

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Aim of the study/1

Considering

- That the increasing nutrient burden resulting from the intensification process can affect environmental sustainability of milk production in Alpine areas

- That there is a further risk factor for the Alpine environment considering the central role of grazing livestock systems in preserving natural resources in mountain areas (Casasùs *et al.*, 2007)

Aim of the study/2

The aim of this study was

To evaluate the effects of dairy farming production intensification in Italian mountain areas using the LCA approach

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Sample farms

- 31 dairy farms in a mountain area in Northern Italy (Valtellina, western Alps) subject to an intensification process of dairy production
- Individual farmer interviews + statistical database
- Average farm characteristics: 51.9±54.9 cows, producing 5798±1482 kg FPCM; 2.9±1.3 LU/ha of lowland; highland summer grazing in 48.3% of cases
- Reference year: 2006

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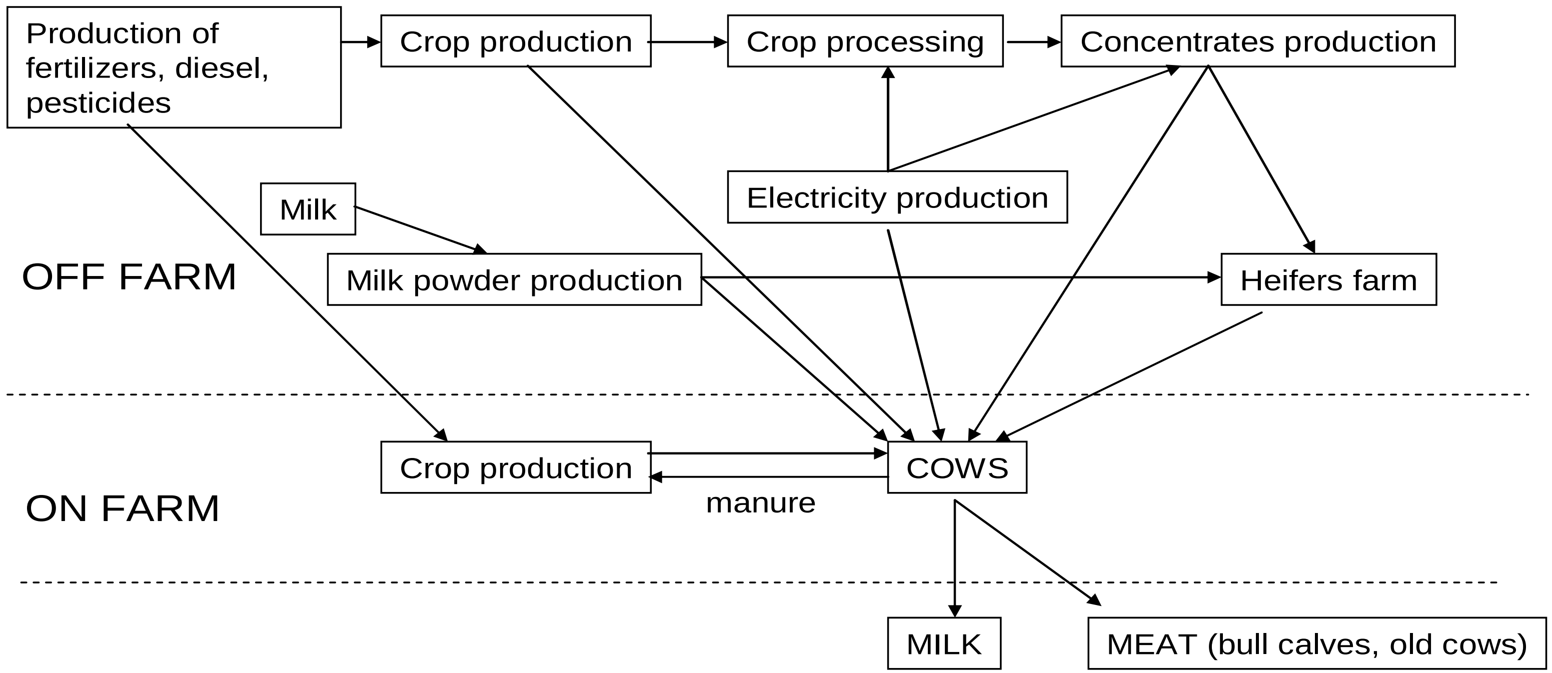
System boundaries of the study

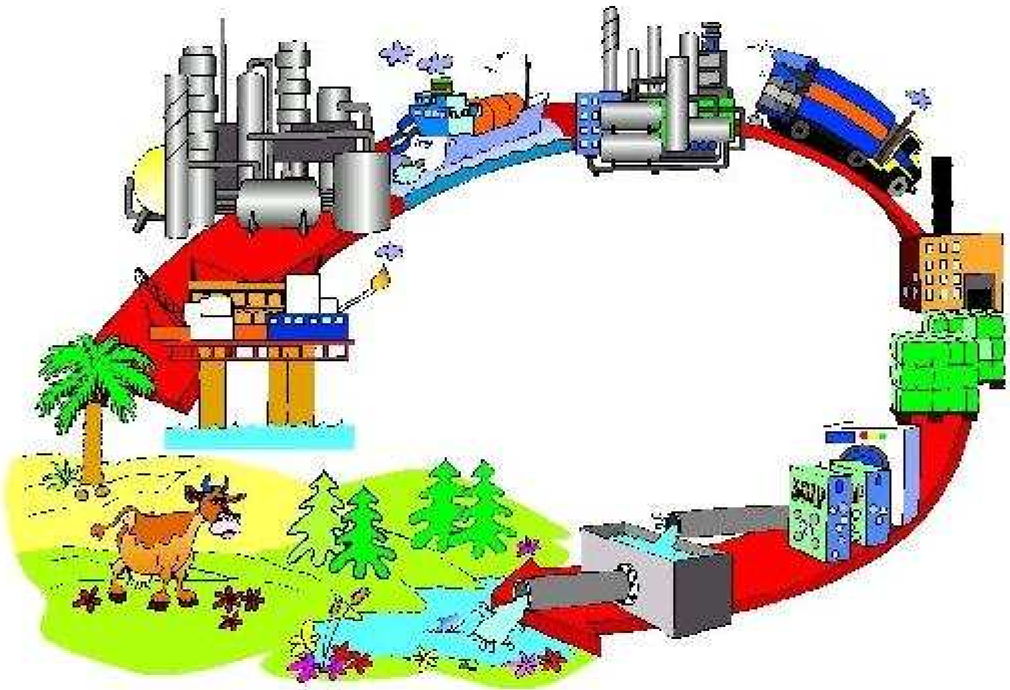
Cradle to farm gate LCA



Main methodological choices

- Functional units:
  1 kg FPCM, 1 ha on
  farm

- Economic allocation
  of co-products



- Impact categories:
  land use (m^2), non-renewable energy use (MJ), climate change (kg CO_2 eq.), acidification (kg SO_2 eq.) and eutrophication (kg NO_3 eq.)

Statistics

- Cluster analysis, based on the usual agglomerative hierarchical clustering and using centroid method (SAS, 2000).
- GLM analysis, using the model:

$$Y_{ijklm} = \mu + PI_i + MP_j + HG_k + Z_l + e_{ijklm}$$

Y_{ijklm}= dependent variables (impact categories);

μ = overall mean;

PI_i = effect of production intensity per ha;

MP_j = effect of milk production per cow;

HG_k = effect of highland grazing of cows;

Z_l = effect of feed self-sufficiency or percentage of lowland hectares used for maize silage production;

e_{ijklm} = residual error.

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Average results LCA/1

	Valtellina	Literature mean values	
	per kg FPCM	organic	conventional
Land use (m^2)			
On farm	1.97±1.91		
Off farm	1.20±0.38		
Total	3.18±1.87	1.8 : 4.0	1.3 : 2.8
Non renewable energy use (MJ)			
On farm	2.58±2.07		
Off farm	2.56±0.90		
Total	5.14±2.02	2.1 : 3.7	2.6 : 5.0
Global warming potential (kg CO_2)			
On farm	0.59±0.20		
Off farm	0.55±0.15		
Total	1.13±0.27	0.9 : 1.9	0.9 : 1.7

Thomassen et al (2008), Corson and van der Werf (2008), Cederberg and Flysjo (2004), Iepema and Pijnenburg (2001), Haas et al (2001), Cederberg and Mattson (2000), Refsgaard et al (1998)

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Average results LCA/2

	Valtellina	Literature mean values		Valtellina	Literature mean values	
	per kg FPCM	org	conv	per ha	org	conv
Acidification (kg SO_2)						
On farm	0.011±0.005					
Off farm	0.010±0.004					
Total	0.021±0.006	0.010:0.022	0.009:0.019	326±227	100:520	116:140
Eutrophication (kg NO_3-eq)						
On farm	0.032±0.015					
Off farm	0.045±0.016					
Total	0.075±0.019	0.034:0.070	0.039:0.110	1150±894	140:600	450:1600

Thomassen et al (2008), Corson and van der Werf (2008), Cederberg and Flysjo (2004), Iepema and Pijnenburg (2001), Haas et al (2001), Cederberg and Mattson (2000), Refsgaard et al (1998)

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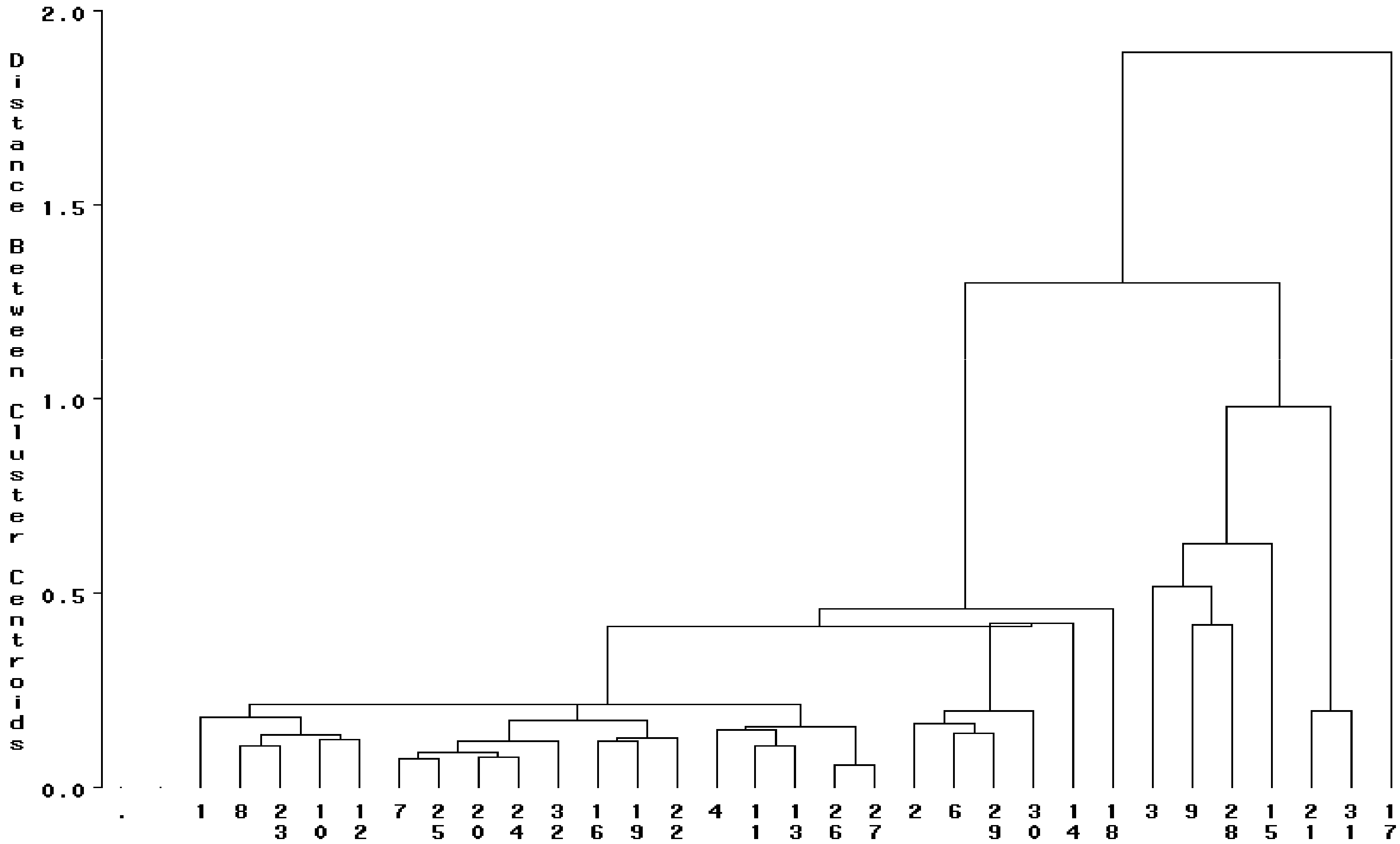
Cluster analysis: cluster tree



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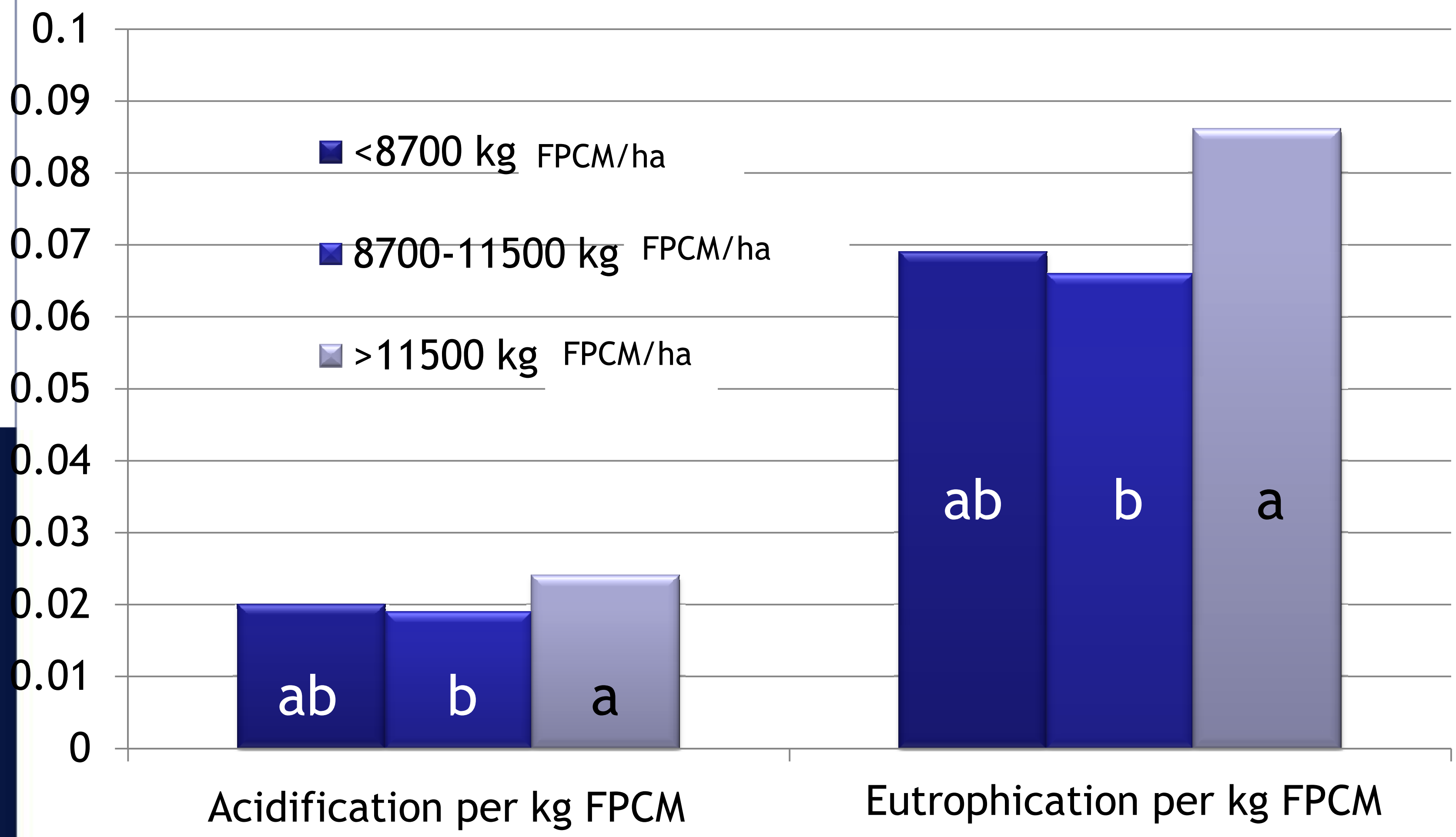
Cluster analysis results per kg FPCM

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5
Farms (n)	5	8	5	6	6
Cows (n)	26.0	55.3	27.4	56.7	90.8
Valley land (ha)	16.1	32.7	12.8	24.5	23.2
Stocking density (LU/ha)	1.9 c	2.2 c	2.2 c	3.2 b	5.0 a
Milk yield (kg FPCM/cow)	5612	5446	5302	5848	6876
Farms pasturing rate	0.60	0.37	0.60	0.16	0.33
Milk yield (kg FPCM/ha)	8593 B	8901 B	9413 B	14124 B	24798 A
Feed self-sufficiency (%)	70.2 A	72.2 A	58.6 AB	58.8 AB	44.7 B
Gross margin (€)	60,038	123,059	47,938	133,345	211,150
Land use off-f /kg FPCM	1.17 b	1.04 b	1.16 b	1.23 b	1.58 a
Energy use /kg FPCM	4.31	4.85	4.59	4.95	5.36
Climate change/kg FPCM	1.05	1.09	1.08	1.11	1.15
Acidification /kg FPCM	0.018	0.021	0.018	0.023	0.026
Eutrophication/kg FPCM	0.063 b	0.073 b	0.065 b	0.078 b	0.095 a

Cluster analysis results per hectare

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5
Farms (n)	5	8	5	6	6
Cows (n)	26.0	55.3	27.4	56.7	90.8
Valley land (ha)	16.1	32.7	12.8	24.5	23.2
Stocking density (LU/ha)	1.9 c	2.2 c	2.2 c	3.2 b	5.0 a
Milk yield (kg FPCM/cow)	5612	5446	5302	5848	6876
Farms pasturing rate	0.60	0.37	0.60	0.16	0.33
Milk yield (kg FPCM/ha)	8593 B	8901 B	9413 B	14124 B	24798 A
Feed self-sufficiency (%)	70.2 A	72.2 A	58.6 AB	58.8 AB	44.7 B
Gross margin (€)	60,038	123,059	47,938	133,345	211,150
Acidification on-f (/ha)	78.8 B	133 B	111 B	201 B	331 A
Eutrophication on-f (/ha)	194 B	380 B	267 B	555 B	949 A

Production intensity (kg FPCM/ha)/1



abc: P<0.05

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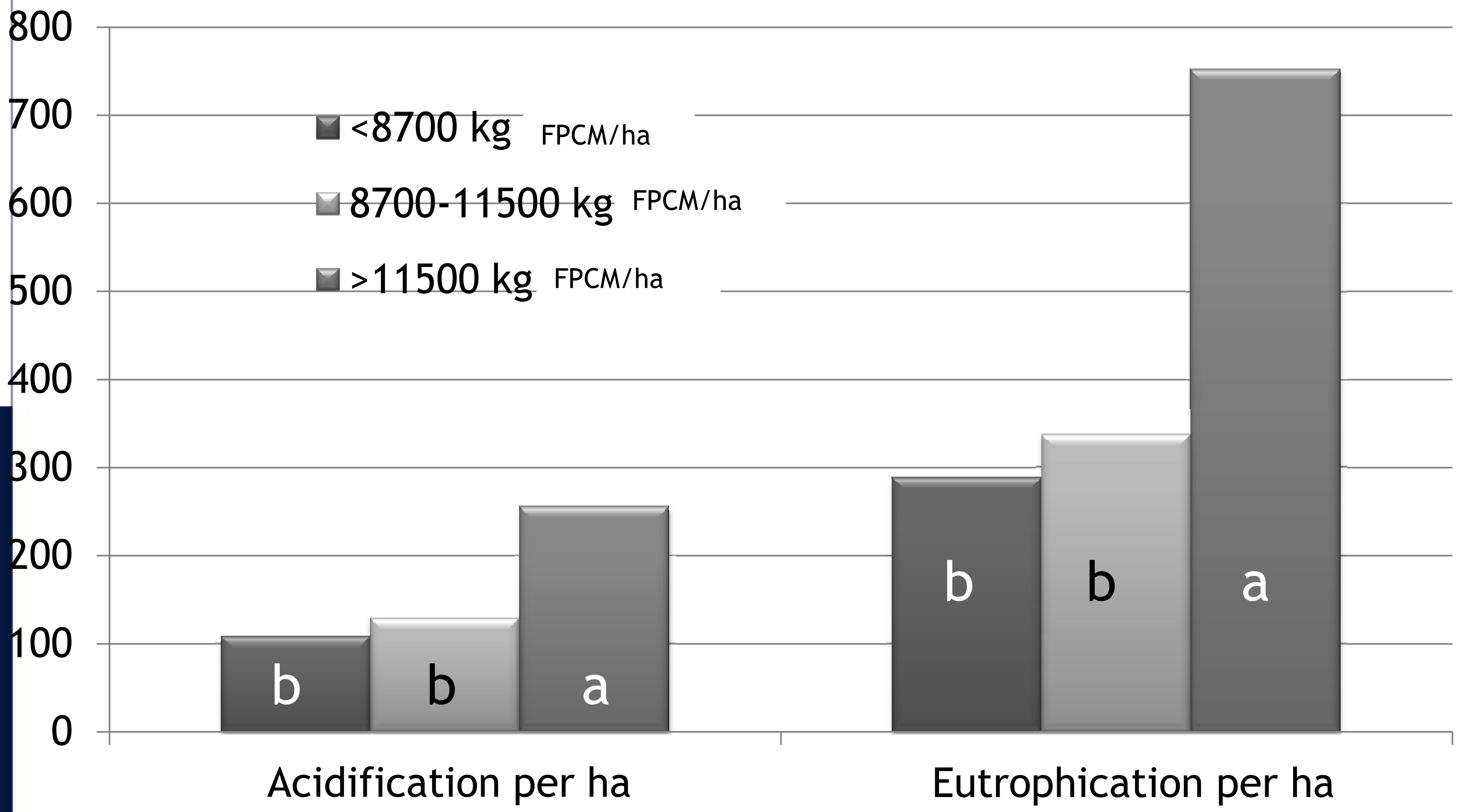
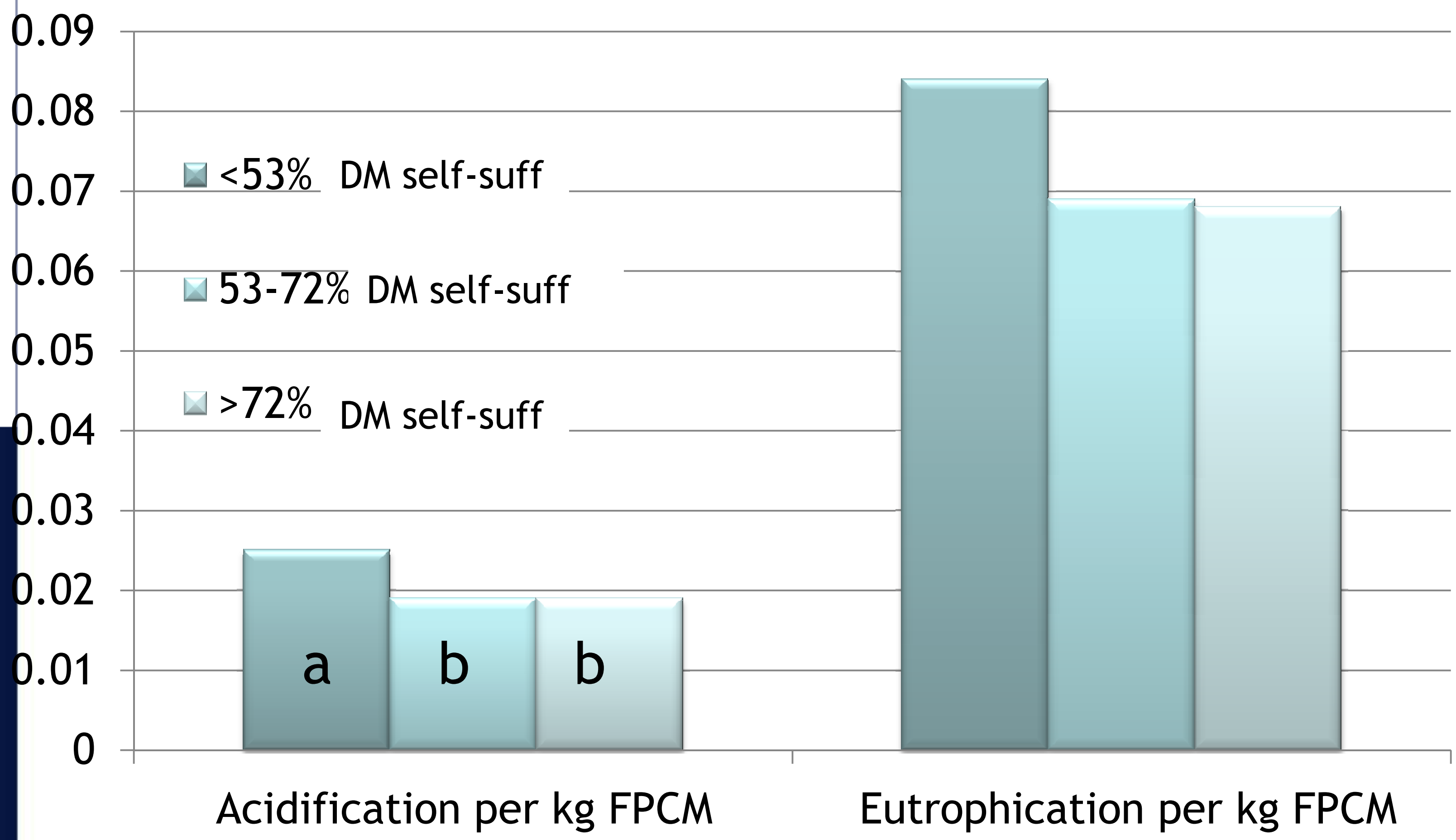
Production intensity (kg FPCM/ha)/2



abc: P<0.05

Feed self-sufficiency (% DM)



abc: P<0.05

Maize land (%)

- Feed self-supply was related to the percentage of maize land

(7.0, 14.6 and 29.2%, for farms with low, medium and high feed self-sufficiency; $P<0.05$).

- On-farm eutrophication significantly grew with increasing maize land

(from 0.020 and 0.030 kg NO_3/kg FPCM with no maize and <22% maize land to 0.035 kg NO_3/kg FPCM with >22% maize land; $P<0.05$).

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Conclusions

Two scenarios of environmentally sustainable evolution for these farms:

- Extensification: decrease in the number of reared animals
- Increase of feed self-sufficiency: improvement of production and quality of self-produced forages
- Summer grazing in the highland: both decreases stocking density in the lowland and increases self-sufficiency

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Thank you for your attention