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Life cycle assessment of grassland-based dairy production systems in Switzerland

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1 Motivation

What are the pros and cons of different dairy production systems from an environmental perspective?

↓

How can the different systems be optimized?

↓

http://www.raumberg-gumpenstein.at/cm4/jdownloads/FODOK/3969-landw-res-moarhof/fodok_4_17260_8_tipps_zum_eingrasen_biolandwirt.pdf

R E S E A R C H G A P →

LCA of dairy production systems **with indoor feeding of fresh herbage**

→ High relevance for alpine countries

GOAL: Compare **a full-grazing system (FG)** with two **indoor feeding of fresh herbage systems** (IF_lc, IF_hc with different concentrate levels) **by means of LCA,** and propose ways to optimize environmental performance of these systems

2 Method I: 3 Systems

	SYSTEMS ANALYSED		
	Full-grazing → Full-grazing with seasonal calving → Up to 300 kg cow^{-1} year^{-1} of concentrate	**IFFH low** → indoor feeding of fresh herbage with reduced concentrate (< 500 kg cow^{-1} year^{-1}) → Part time grazing	**IFFH high** → indoor feeding of fresh herbage with standard concentrate 800 to 1‘200 kg cow^{-1} year^{-1}) → Part time grazing
ANALYSIS OBJECTS: Experimental farm → 2014-16 → Close to Lucerne	2014 2015 2016	2014 2015 2016	2014 2015 2016
ANALYSIS OBJECTS: 12 pilot farms → 2014 → Different regions in CH			

2 Method II: LCA

LCA as a method allows to:

- consider the environmental impacts per product (1 kg ECM)
- include impacts from upstream chains (e.g. of feed & fertilizer production)
- exclude other production sectors (e.g. area and feed for other animals)
- consider different impact categories at the same time

2 Method II: LCA

This study:

- Functional unit: 1 kg ECM
- System boundary: → cradle to farm gate
  → only dairy production
  → including cattle husbandry, feeding and manure management, production of feedstuffs, energy carriers, fertilizers, buildings and equipment.
- Allocation: physical allocation between milk and animals with energy needed for production of 1 kg milk (3.1 MJ) and 1 kg body weight (14.1 MJ)

3 Results - Table

Green, FG: more favorable results full-grazing
Blue, IF_lc: more favorable results indoor feeding with low conc.
Red, IF_hc: more favorable results indoor feeding with high conc.
Dark colour, ++: no overlapping between ranges of the two systems
Bright colour, +: one point overlapping between ranges of the two systems
Grey: more than one point overlapping between ranges of the two systems
Number: how much better off the better system is compared to other (average)

		Experimental farm			**Pilot farms**		
	Impact category	FG vs. IF_lc	IF_lc vs. IF_hc	IF_hc vs. FG	FG vs. IF_lc	IF_lc vs. IF_hc	IF_hc vs. FG
Resource-related impact categories	Non-reneweable energy use	FG 5%	IF_hc 8%	IF_hc 4%	IF_lc 12%	IF_lc 20%	FG 9%
	Water use	FG 1%	IF_hc 5%	IF_hc 5%	IF_lc 7%	IF_lc 0%	IF_hc 7%
	Land use	IF_lc 3%	IF_hc 10%	IF_hc 13%	IF_lc 22%	IF_lc 1%	IF_hc 21%
	Deforestation	FG 4%	IF_lc 18%	IF_hc 22%	FG 58%	IF_lc 63%	++ FG 85%
	P Resource Use	IF_lc 23%	+ IF_lc 42%	IF_hc 25%	FG 45%	++ IF_lc 61%	++ FG 78%
	K Resource Use	++ FG 5%	++ IF_lc 28%	++ FG 72%	FG 17%	++ IF_lc 72%	++ FG 77%
Emission-related impact categories	Global Warming Potential	IF_lc 7%	+ IF_hc 12%	+ IF_hc 18%	IF_lc 15%	IF_lc 7%	IF_hc 8%
	Acidification	IF_lc 12%	IF_hc 9%	+ IF_hc 20%	FG 20%	IF_lc 8%	++ FG 27%
	Terr. Eutrophication	IF_lc 13%	IF_hc 10%	+ IF_hc 21%	FG 22%	IF_lc 8%	++ FG 29%
	Aq. N Eutrophication	++ FG 18%	IF_hc 11%	IF_hc 8%	FG 38%	IF_lc 18%	FG 50%
	Aq. P Eutrophication	IF_lc 2%	IF_hc 9%	FG 11%	IF_lc 9%	IF_lc 9%	IF_hc 0%
	Aq. Ecotoxicity	++ FG 25%	++ IF_lc 34%	++ FG 50%	FG 3%	++ IF_lc 70%	++ FG 71%
	Terr. Ecotoxicity	++ FG 46%	++ IF_lc 33%	++ FG 64%	FG 11%	++ IF_lc 82%	++ FG 84%
	Human Toxicity	IF_lc 2%	IF_hc 0%	FG 1%	IF_lc 17%	+ IF_lc 17%	FG 0%
	Ozone Formation	IF_lc 2%	IF_hc 11%	+ IF_hc 12%	IF_lc 13%	IF_lc 11%	IF_hc 2%
other	Biodiversity	FG 25%	IF_hc 11%	FG 15%	FG 412%	IF_hc 50%	FG 241 %
	Landscape-esthetics	IF_lc 5%	IF_hc 4%	+ IF_hc 8%	FG 3%	++ IF_hc 11%	IF_hc 8%

3 Results - Table

		Experimental farm			Pilot farms		
	Impact category	FG vs. IF_lc	[illegible]	[illegible]	[illegible]	[illegible]	IF_hc vs. FG
Resource-related impact categories	Non-reneweable energy use	FG 5%	[illegible]	[illegible]	[illegible]	[illegible]	FG 9%
	Water use	FG 1%	[illegible]	[illegible]	[illegible]	[illegible]	IF_hc 7%
	Land use	IF_lc 3%	IF_hc 10%	IF_hc [illegible]	[illegible] 22%	IF_lc 1%	IF_hc 21%
	Deforestation	FG 4%	IF_lc 18%	IF_hc 22[illegible]	[illegible] 58%	IF_lc 63%	++ FG 85%
	P Resource Use	IF_lc 23%	+ IF_lc 42%	IF_hc 25%	FG 45%	++ IF_lc 61%	++ FG 78%
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Clear and agreeing results in K-Resource Use and Ecotox: more extensive systems show more favorable values

MOTIVATION | METHOD | RESULTS | CONCLUSION

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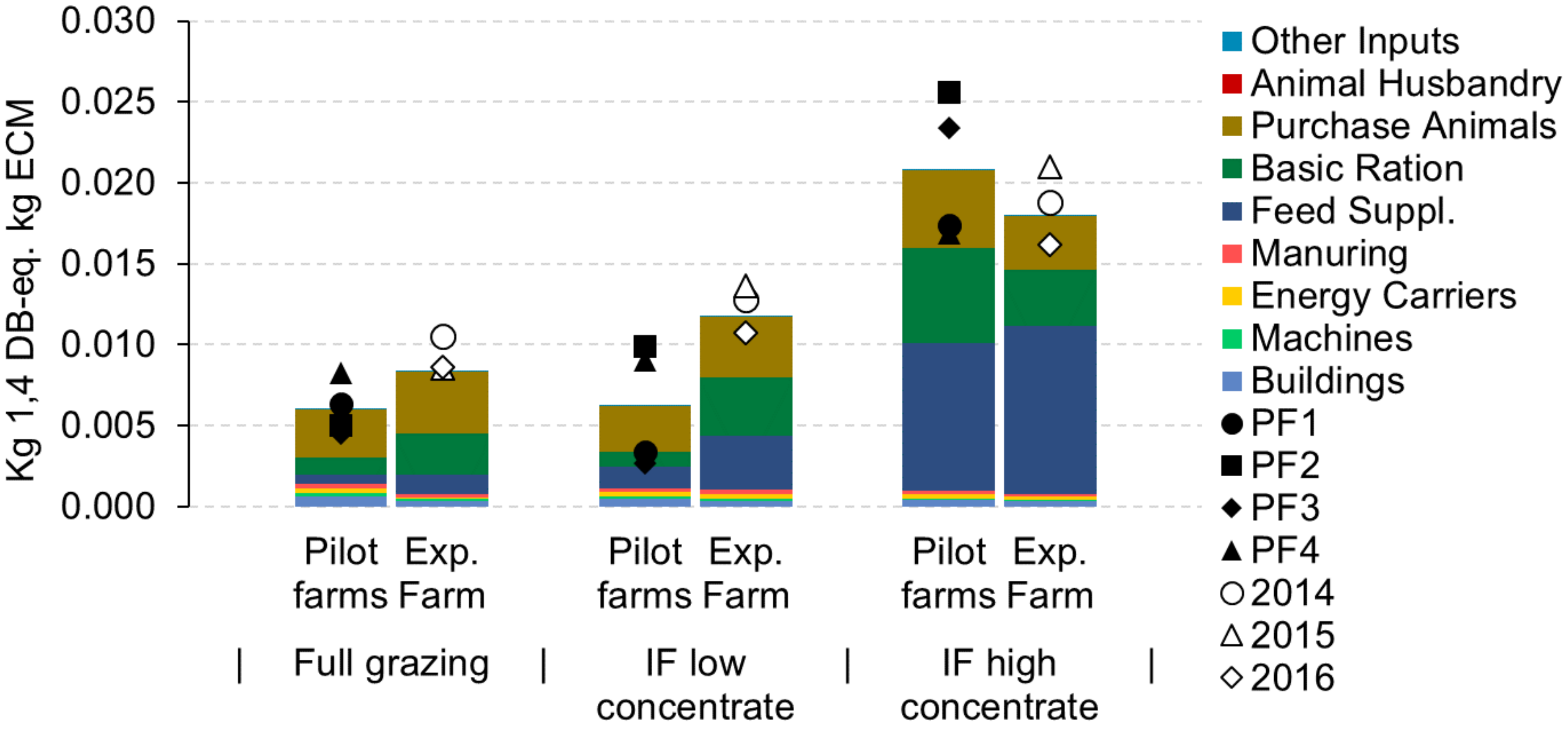
3 Selected Results – aquatic Ecotoxicity

→ System IF_hc clearly shows less favorable values due to concentrate use



3 Results - Table

		Experimental farm			Pilot farms		
	Impact category	FG vs. IF_lc	IF_lc vs. I	IF_hc vs.	FG vs.	IF_lc vs.	IF_hc vs. FG
Resource-related impact categories	Non-reneweable energy use	FG 5%	I				FG 9%
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	Land use	IF_lc 3%	I				IF_hc 21%
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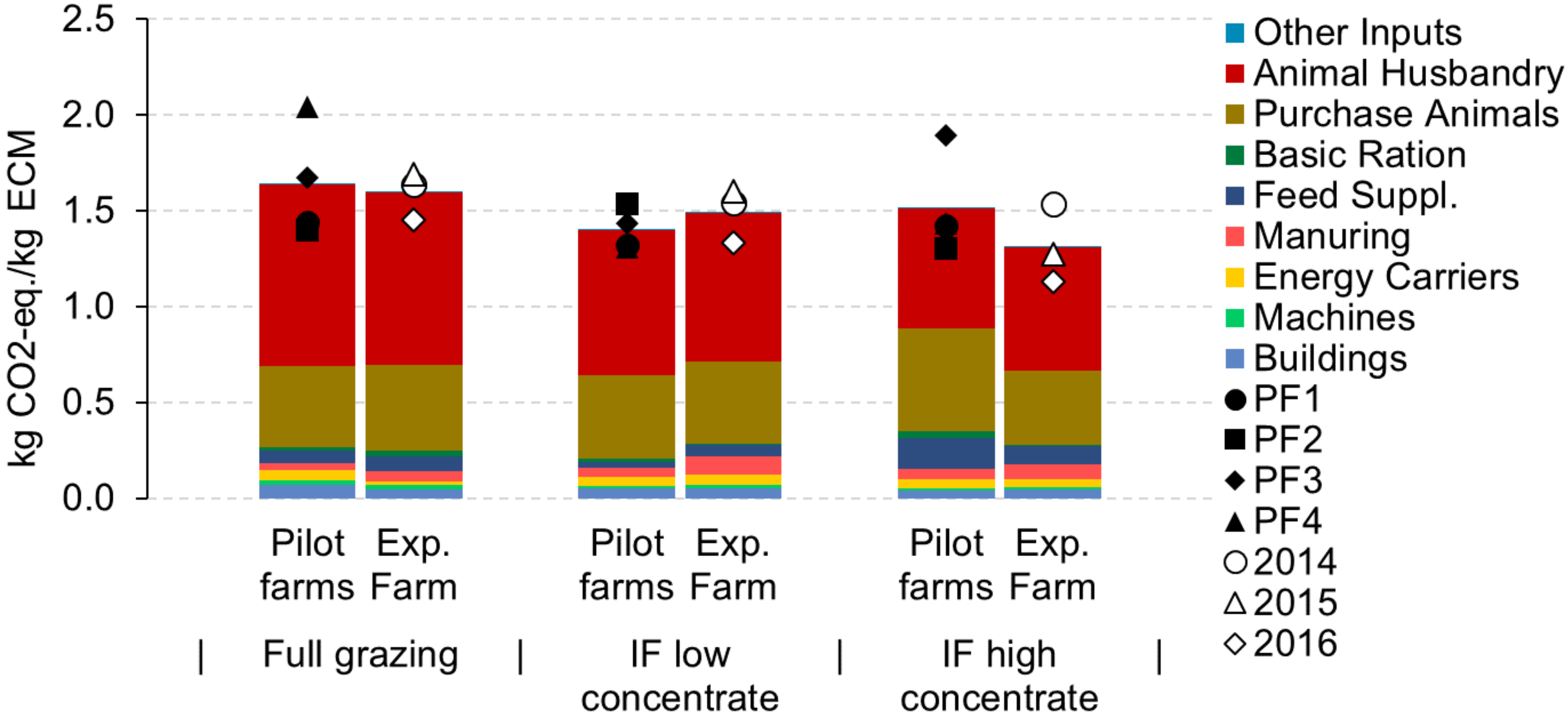
	Landscape-esthetics	IF_lc 5%	IF_hc 4%	+ IF_hc 8%	FG 3%	++ IF_hc 11%	IF_hc 8%

Some indicators: more favorable values for system with high concentrate

3 Selected Results – Global warming Potential

→ System IF_hc shows tendentially more favorable values at exp. farm



3 Results - Table

		Experimental farm			Pilot farms		
	Impact category	FG vs. IF_lc	IF_lc	IF_hc	FG	IF_lc	IF_hc vs. FG
Resource-related impact categories	Non-reneweable energy use	FG 5%					FG 9%
	Water use	FG 1%					IF_hc 7%
	Land use	IF_lc 3%					IF_hc 21%
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	Landscape-esthetics	IF_lc 5%	IF_hc 4%	+ IF_hc 8%	FG 3%	++ IF_hc 11%	IF_hc 8%

Contradicting results for acidification and terr. Eutrophication → N-content of feed

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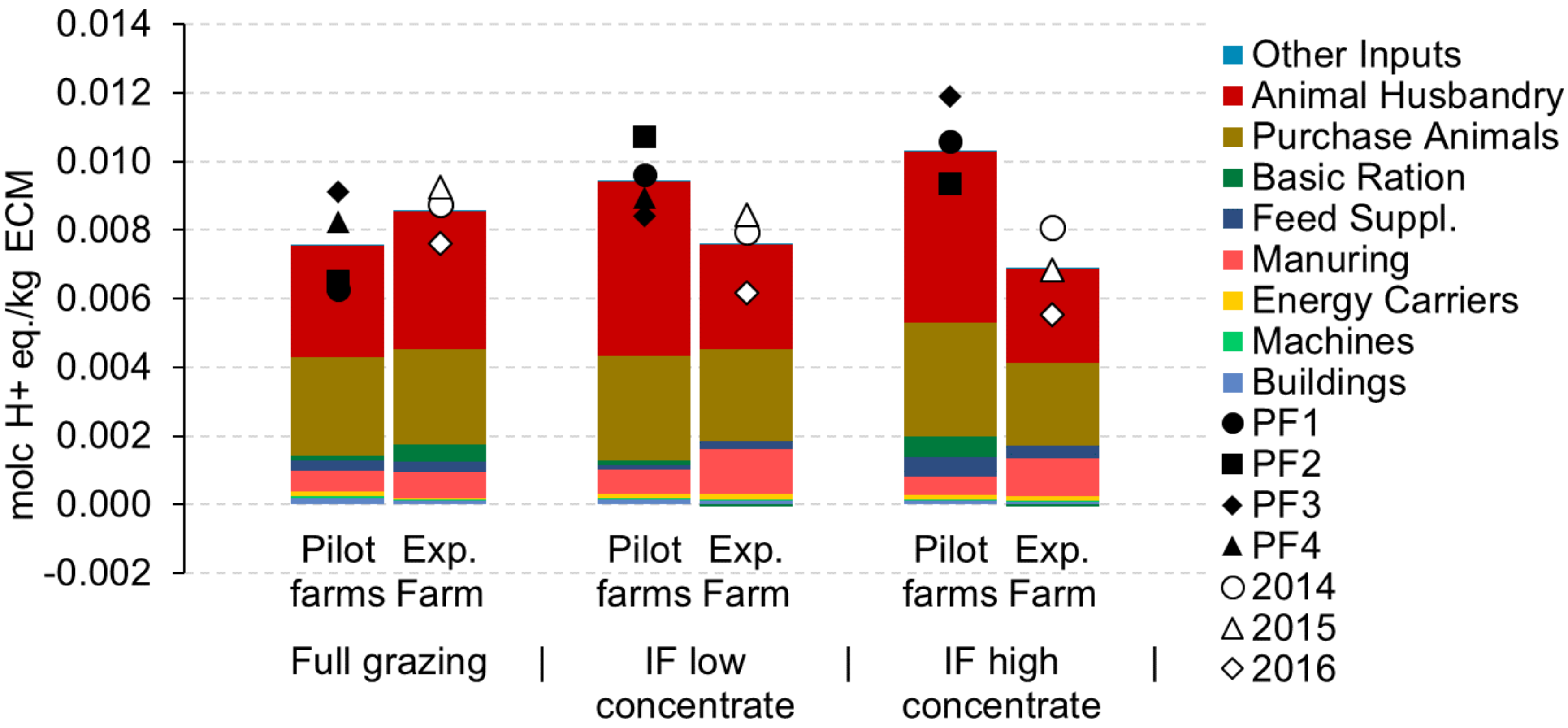
3 Selected Results – Acidification

→ The results between the pilot farms and the exp farm are diverging → due to N-content of the grass



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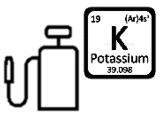
Discussion and Conclusion

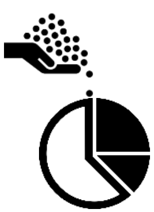
- The three systems are similar, and the **variability** between the years and the farms **is large**

  → for most of the indicators, good scores are possible for all three systems, a good overall management can be more important than the choice of the system (feed efficiency, fertilization, energy use etc.)



- Systems with **less concentrate** should be favorised when **K resource use** and **ecotoxicity** are of specific importance

- Replacement of animals: important contributor for all indicators→ **increasing the lifespan** of the cow means **decreasing environmental impacts**!



- Feed ration: (next to production of concentrate feed) the **feed conversion efficiency** and the **nitrogen content** of the feed influence emissions and environmental impacts

  → if possible, feed ration should be optimized to reduce nutrient losses

  → detailed data on grazing is needed (amount and nutrient content)












Thank you for your attention

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