Wallonie recherche CRA-W

Centre wallon de Recherches agronomiques

LIÈGE université Gembloux Agro-Bio Tech

Net productivity,

A new indicator to evaluate the contribution of specialized dairy farms to food security

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Intensification of livestock

Guided primarily by **gross feed conversion efficiency** :

$$Gross\ efficiency = \frac{Productions}{Consumptions}$$

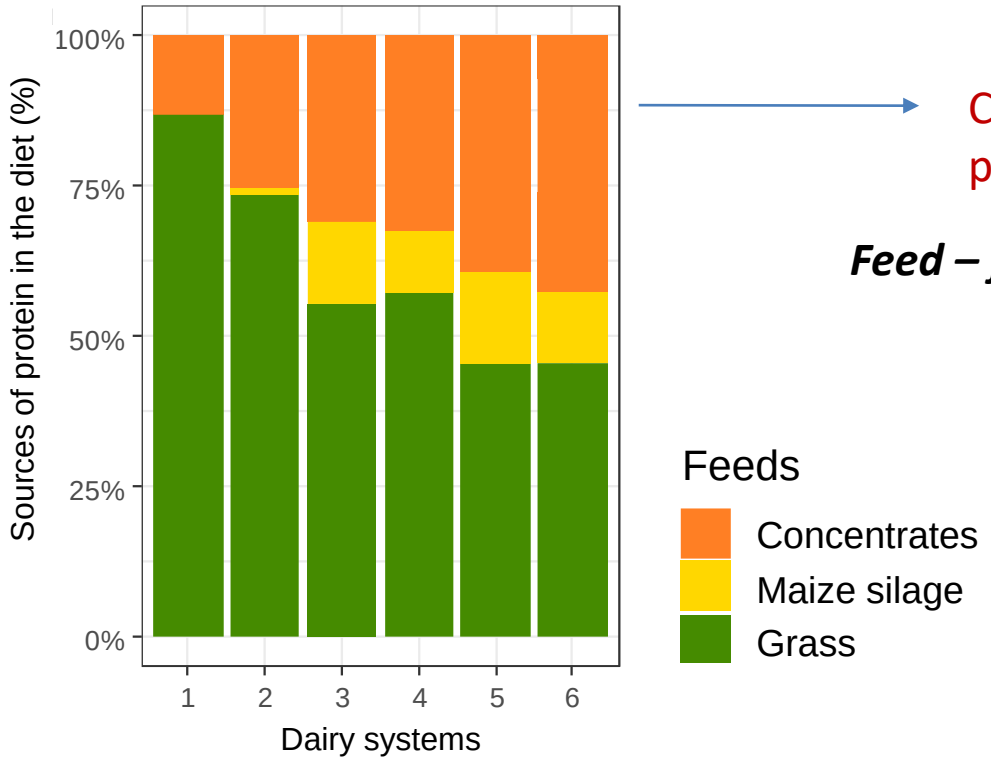
- *Dry matter*
- *Protein*
- *Energy*

The efficiency of livestock has increased, reducing the resources needed per unit of product.

The competition for ressources

Gross protein efficiency gradient

16% → *22%*



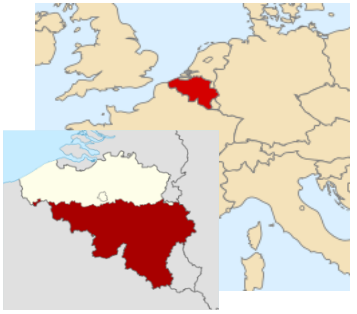
Diet composition (in protein) for different dairy systems
(Data from thesis project)

Cereals,
pulses, …

Feed – food competition

Land Use

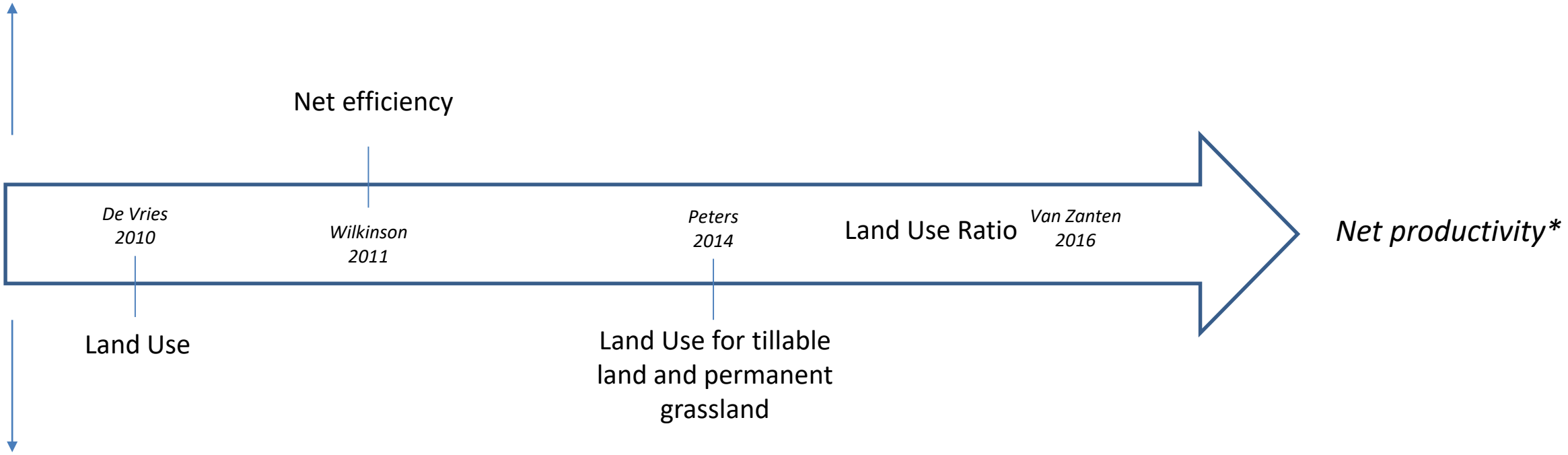
111 sp. Dairy farms
Accounting data



Walloon region

Representing the contribution to food security

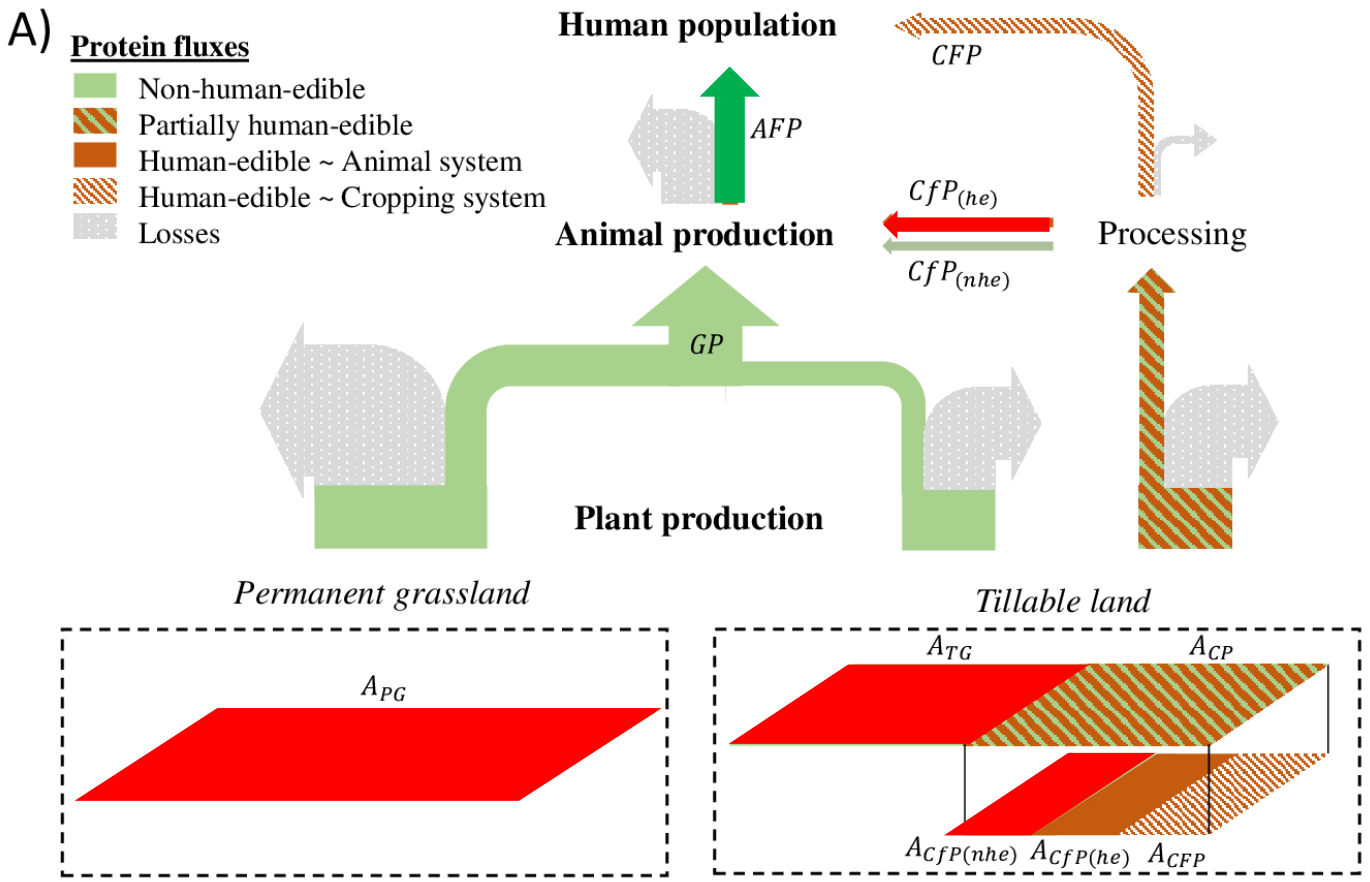
« Net » feed conversion efficiency // Feed-food competition



Land use efficiency // Land use

*Battheu-Noirfalise, C., Mertens, A., Froidmont, E., Mathot, M., Rouillé, B., Stilmant, D. *Submitted to Agronomy fo Sustainable Development 2022.*

Conceptual framework



Protein fluxes in a mixed crop-livestock agroecosystem

Net productivity:

$$\frac{AFP - CfP_{he}}{A_{PG} + A_{TG} + A_{CfP_{(nhe)}}}$$

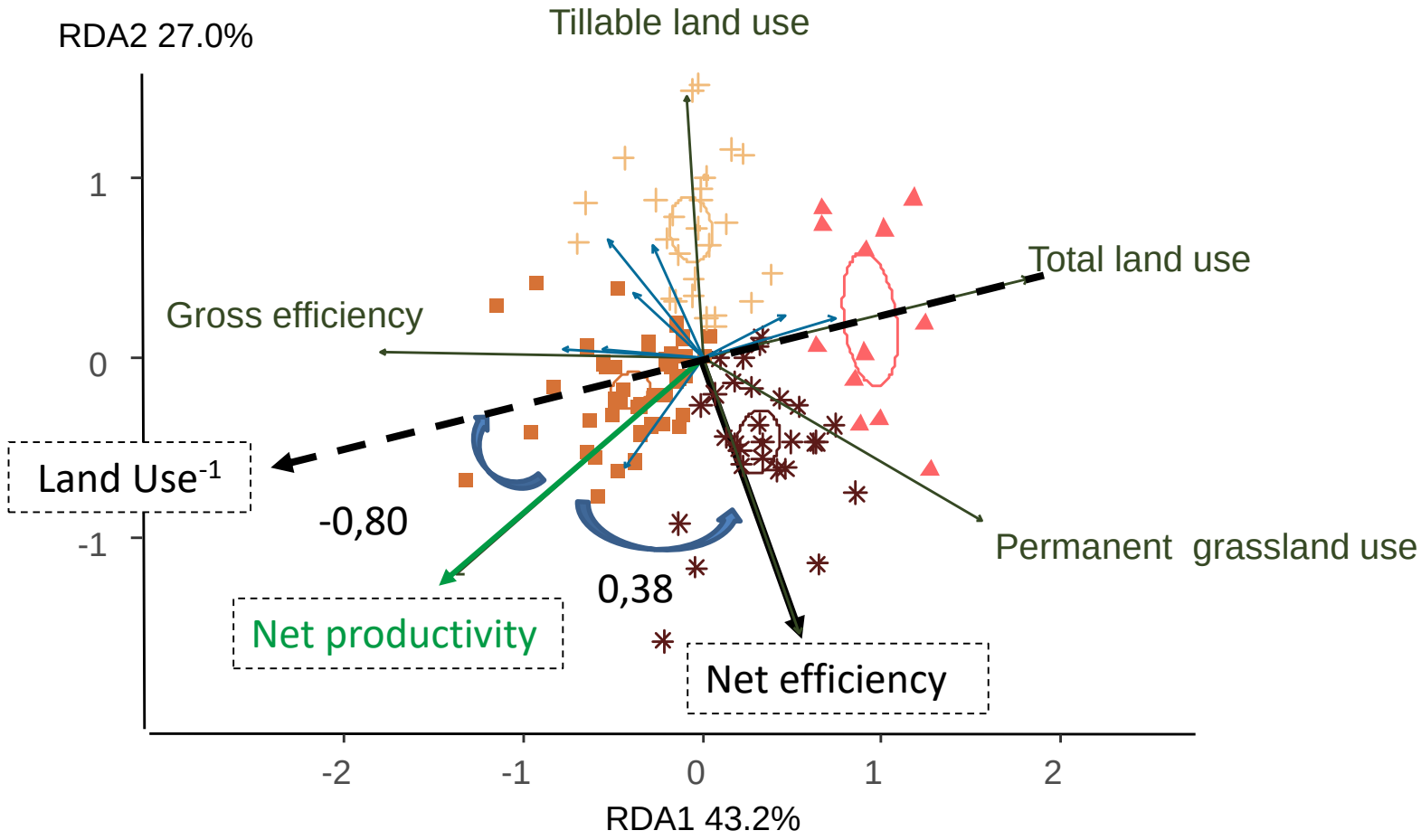
Methodology

We tested the **hypotheses** that :

(1) net productivity was positively correlated with gross and net feed conversion efficiencies and negatively correlated with the agricultural land use (i.e. total, permanent grassland, and tillable land) → Correlations

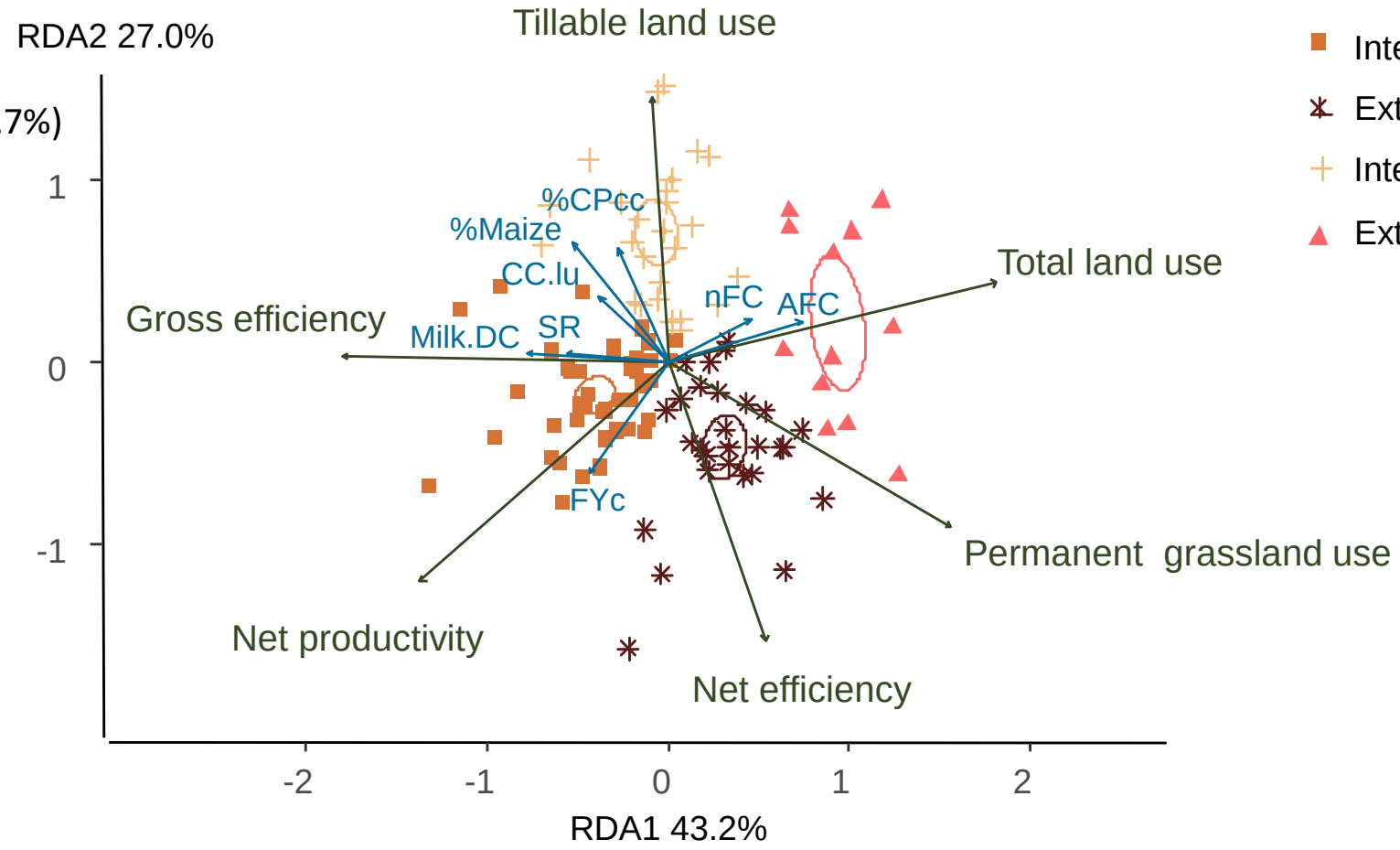
(2) that it is maximised by dairy farm characteristics that differ from those identified by existing metrics → Redundancy analysis + kmeans clustering

Redundancy analysis



Redundancy analysis

Redundancy analysis
8 management parameters (61,7%)



Farm schemes

- Intensive net Efficient
- Extensive net Efficient
- Intensive net Inefficient
- Extensive net Inefficient

Net productivity

Net productivity ↘ →

		Farm strategy				
		InE	**EnE**	**InI**	**EnI**	SEM
	Number of farms	*45*	*28*	*26*	*12*	
Metrics	Gross efficiency (kg CP kg CP^{-1})	0.201 ^{a}	0.169 ^{c}	0.188 ^{b}	0.134 ^{d}	0.0026
	Net efficiency (kg HDP kg HDP^{-1})	6.2 ^{b}	11.0 ^{a}	3.6 ^{c}	6.9 ^{b}	0.38
	Net productivity (kg HDP ha^{-1})	**302** ^{a}	248 ^{b}	**187** ^{c}	146 ^{d}	6.6
	Total land use (m² kg HDP^{-1})	29 ^{c}	38 ^{b}	37 ^{b}	60 ^{a}	1.0
	Permanent grassland use (m² kg HDP^{-1})	18 ^{c}	30 ^{b}	15 ^{d}	42 ^{a}	1.0
	Tillable land use (m² kg HDP^{-1})	10.2 ^{b}	7.8 ^{c}	22.2 ^{a}	18.2 ^{ab}	0.81
Farm characteristics	Milk production per cow (kg FPCM cow^{-1} year^{-1})	8106 ^{a}	6914 ^{b}	7842 ^{a}	5463 ^{c}	116
	Stocking rate (LU ha^{-1} farm^{-1})	2.38 ^{a}	2.19 ^{a}	2.30 ^{a}	1.53 ^{b}	0.054
	Percentage of maize silage (%)	**23** ^{b}	0 ^{c}	**36** ^{a}	11 ^{c}	1.7
	Concentrates per cow (kg DM cow^{-1} day^{-1})	4.6 ^{a}	3.8 ^{b}	4.9 ^{a}	3.1 ^{b}	0.15
	CP of concentrates (%)	**21.3** ^{b}	18.9 ^{c}	**25.7** ^{a}	20.9 ^{bc}	0.39
	Fodder yield correction (%)	**116** ^{a}	110 ^{a}	**89** ^{b}	82 ^{b}	1.9
	Age at first calving (months)	**27.6** ^{c}	30.2 ^{b}	**30.4** ^{b}	34.9 ^{a}	0.31
	Female followers per cow (cow^{-1})	**0.78** ^{b}	1.37 ^{a}	**1.01** ^{a}	1.08 ^{a}	0.076

Net productivity

Net productivity ↘ ——→

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Sensitivity analysis

Variation of **+/- 1 SD** for each parameter :

→ Results for each dairy strategy did not differ significantly ($p > 0,05$) from the baseline scenario.

InE strategy was the most sensitive ($p < 0,10$) to an increase in the human-edible proportion of compound feed !

Conclusion

We developed a new metric to represent the contribution of livestock to food security

Net productivity
land + human-edible feed

Management parameters

~ intensive and net efficient dairy systems
- high milk production per cow
- high fodder yield
- intermediate use of maize silage
- intermediate CP content of concentrates
- efficient management of followers

→ most sensitive to an increase in the human-edible fraction of feeds : EnE ?

Other metrics

~ + feed conversion efficiencies
- gross
- net

~ - ag. land use
- total land
- permanent grassland
- tillable land

Target performances of net productivity should consider additional aspects of sustainability to manage trade-offs while considering local soil and climate constraints.

Thank you !

Any question ?

Correlations

Table 4

Pearson (P) and Spearman (S) correlation coefficients (when data were normally distributed or not, respectively) between metrics of contribution to food security. ns: not significant, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

Metric	Gross efficiency	Net efficiency	Net productivity	Total land use	Permanent Grassland use	Tillable land use
Gross efficiency	1	-0.12^{ns} (P)	0.63*** (P)	-0.75*** (P)	-0.69*** (S)	0.84^{ns} (S)
Net efficiency		1	0.38*** (P)	0.13^{ns} (P)	0.53*** (S)	-0.58*** (S)
Net productivity			1	-0.80*** (P)	-0.29** (S)	-0.40*** (S)
Total land use				1	0.57*** (S)	0.23* (S)
Permanent grassland use					1	-0.51*** (S)
Tillable land use						1

Sensitivity analysis

Parameter varied	Scenario	InI	EnI	EnE	InE
None	Baseline	187	146	248	302
CP content of grass-based fodders	Higher	187	146	248	302
	Lower	187	146	248	302
Yield of grass-based fodders	Higher	187	146	249	303
	Lower	185	145	248	301
CP content of maize silage	Higher	187	146	248	302
	Lower	187	146	248	302
Yield of maize silage	Higher	186	146	248	302
	Lower	187	146	249	302
DIAAS of compound feed	Higher	181	144	245	296
	Lower	192	148	252	308
hePF of compound feed	Higher	174	140	242	289
	Lower	199	152	255	314
LC of compound feed	Higher	185	145	246	298
	Lower	189	147	251	306
Dry matter intake of DC	Higher	186	146	248	302
	Lower	187	146	249	302