Trade-offs Related to Methane Emissions at the Territory Scale Driven by Animal Diet Composition

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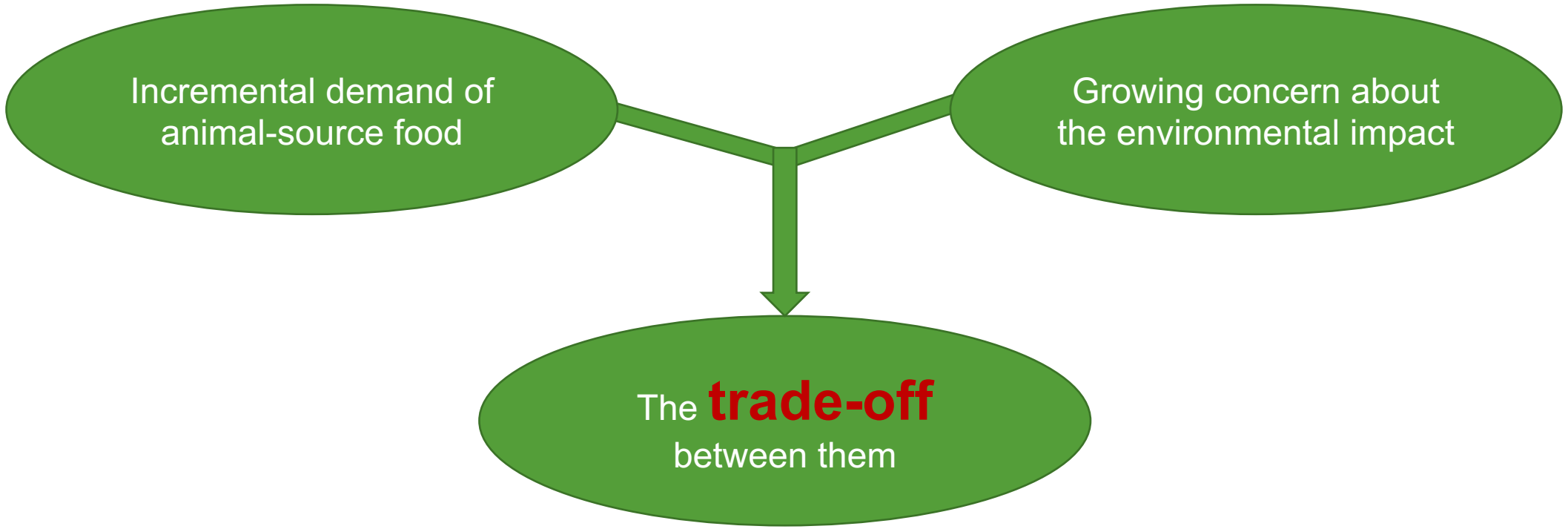
20.07.2020

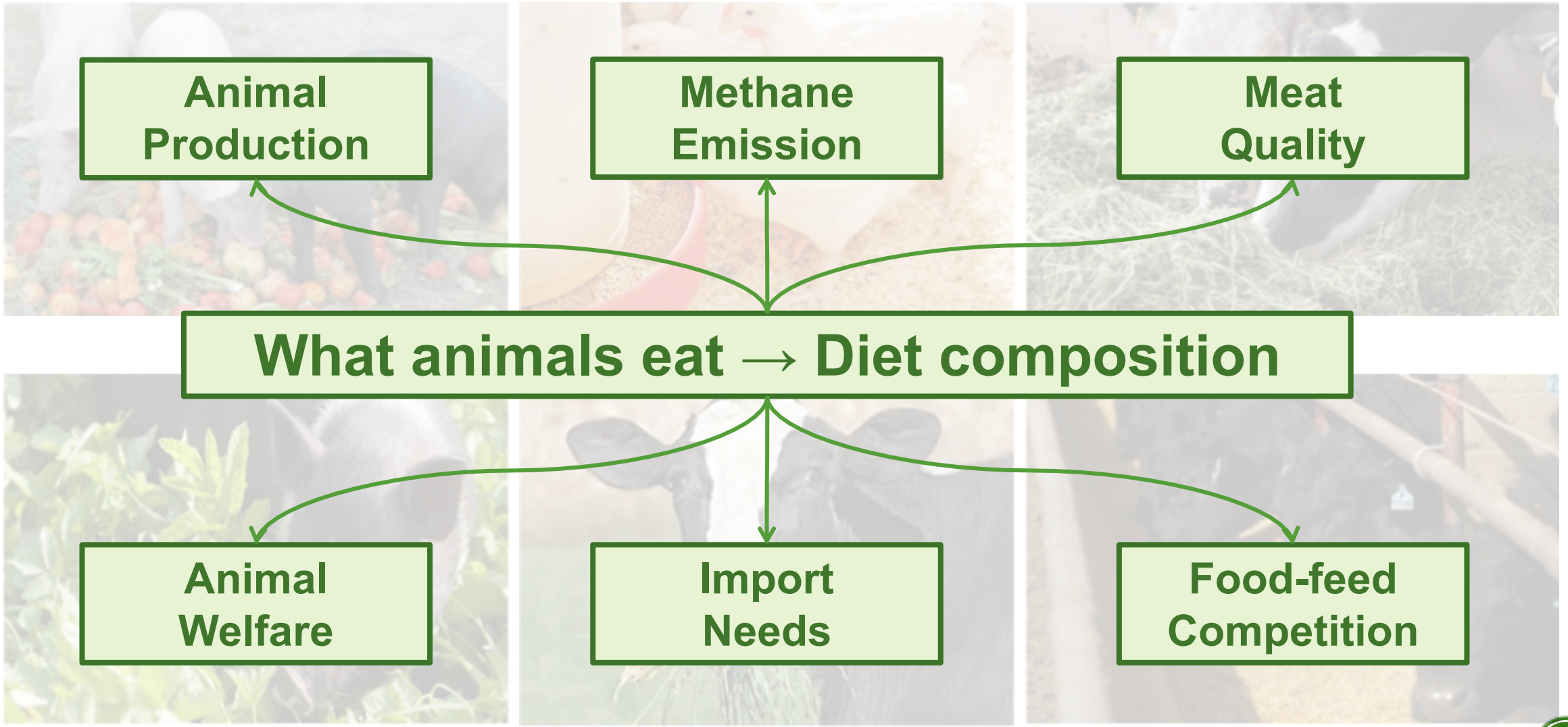
CONTEXT


Incremental demand of animal-source food
Growing concern about the environmental impact
The trade-off between them

CONTEXT

WHAT DO ANIMALS EAT?

CONTEXT


Animal Production
Methane Emission
Meat Quality
What animals eat → Diet composition
Animal Welfare
Import Needs
Food-feed Competition

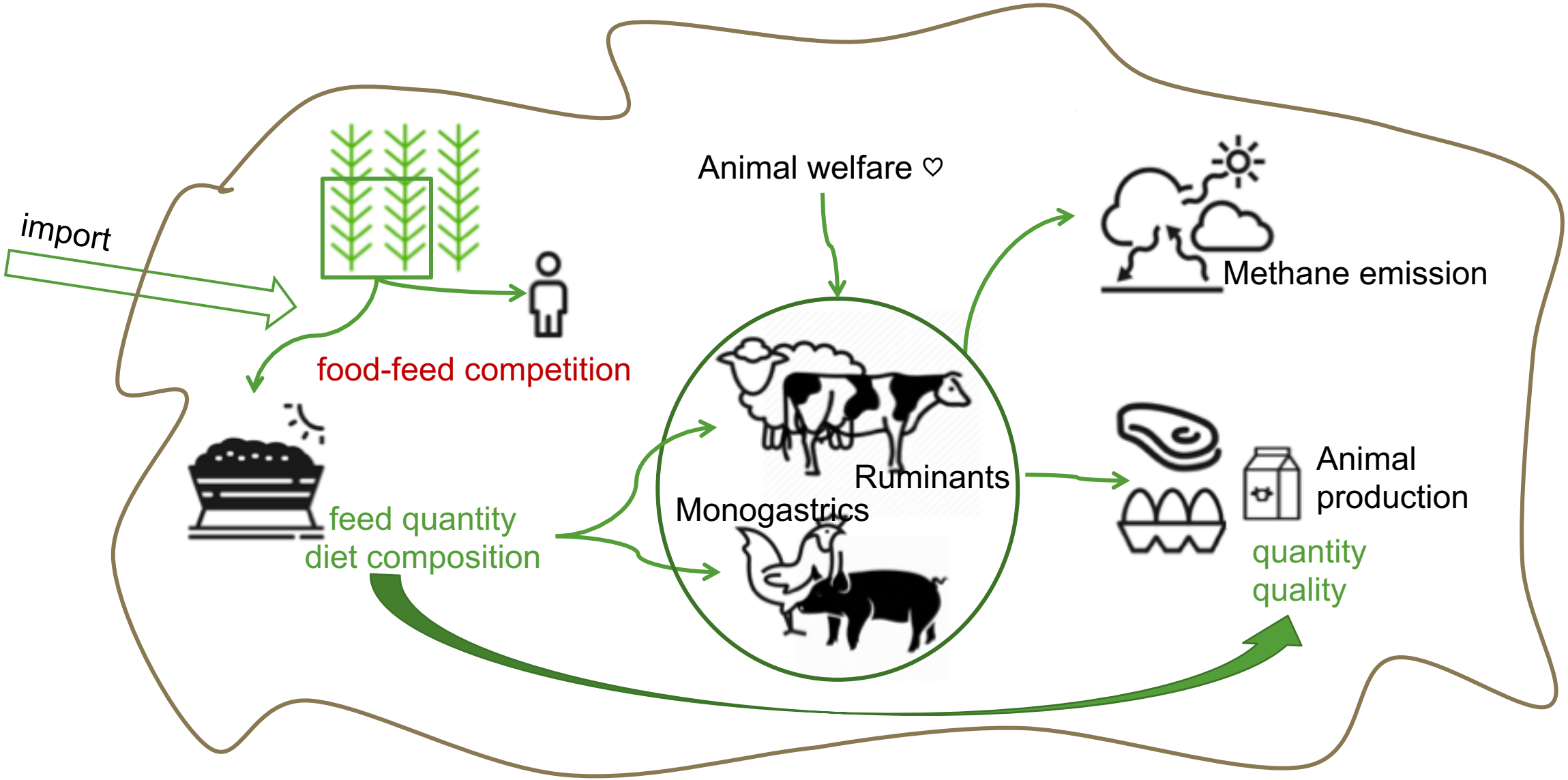
OBJECTIVES

A. the **feed intake** and **diet composition** for monogastric animals and ruminants

B. **animal production** (meat, milk, eggs), **methane emissions**, **meat quality**, **animal welfare** and **resources** management

C. French regional scale

Methodology (schematic plan)



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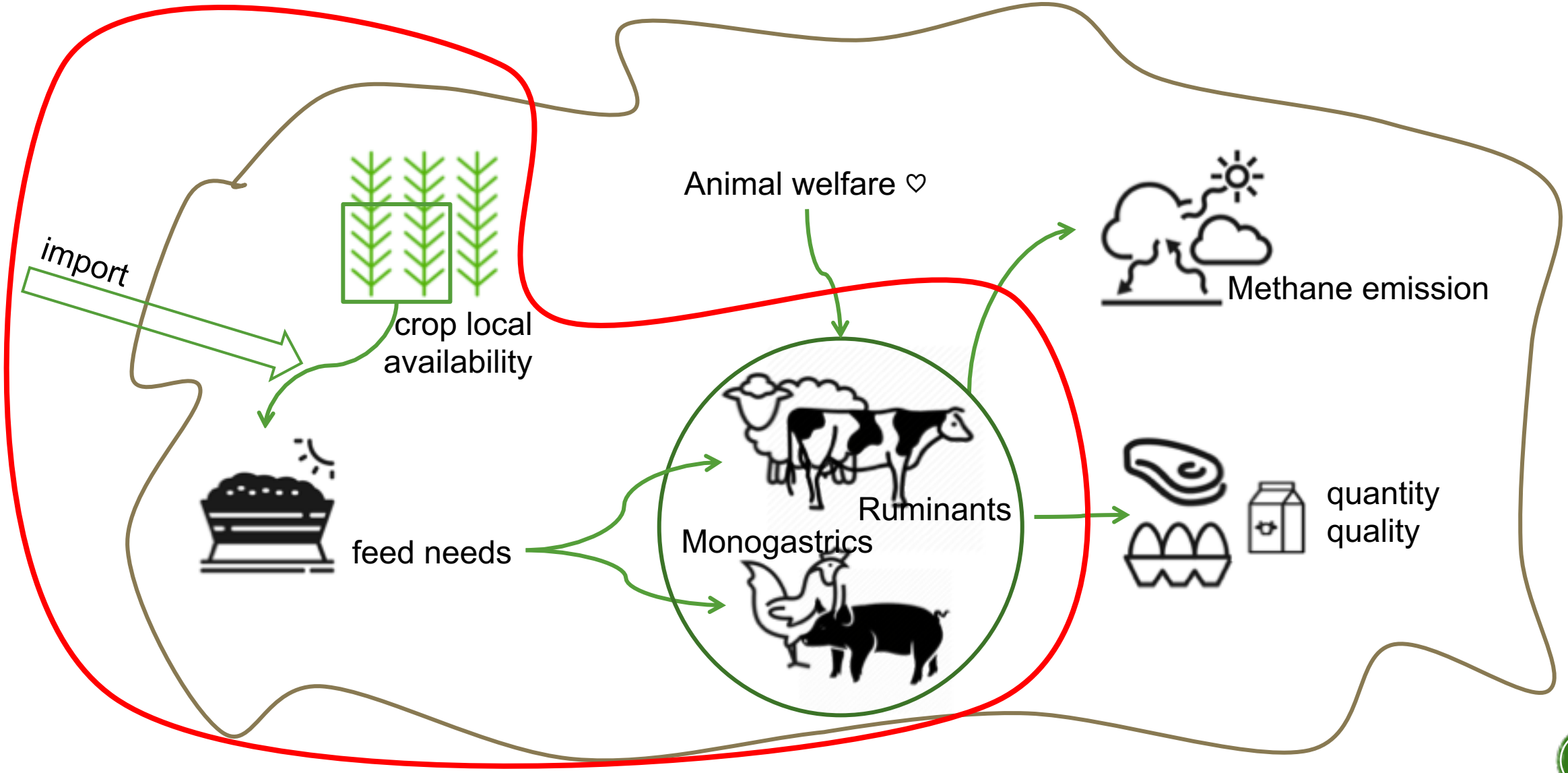

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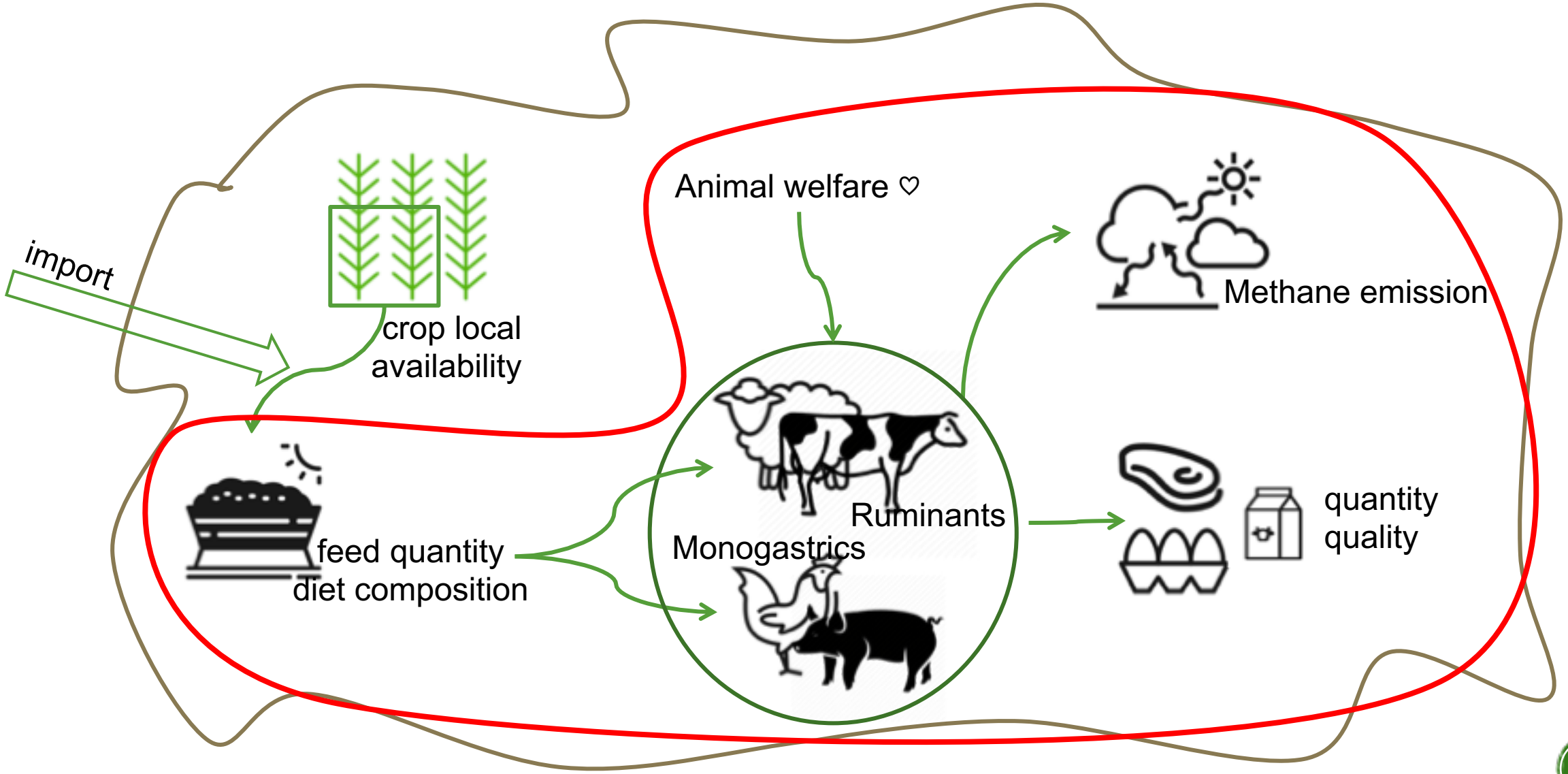


Categories for livestock and feed

	Animal Categories / Feed Categories	Cereals	Co-products	Meals	Oil and Protein	Forage	Grass
Ruminants	Young Cattle						
	Steers (non-castrated)						
	Bulls (castrated)						
	Heifers (females)						
	Dairy Cows						
Monogastrics	Growing Pigs						
	Adult Pigs						
	Broilers						
	Laying Hens						

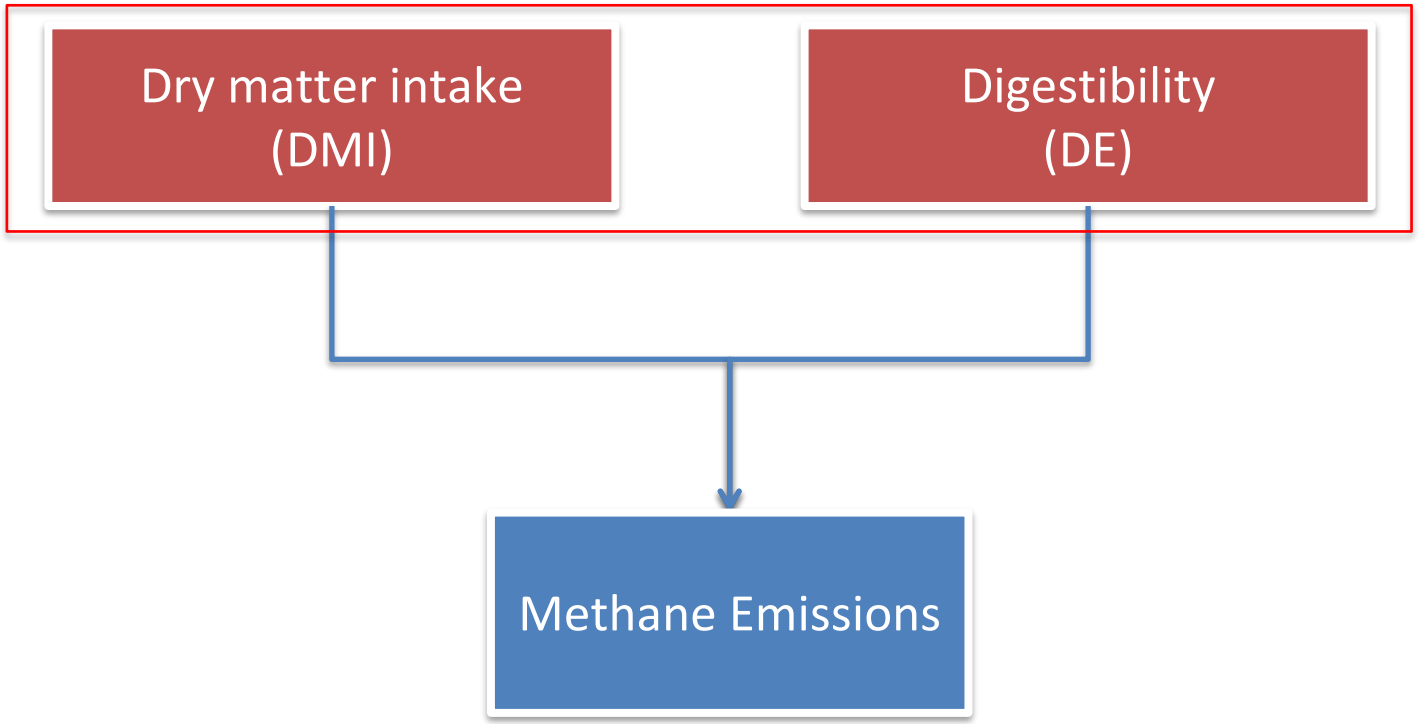
Drivers of the model

Dry matter intake (DMI)

Digestibility (DE)

- Feed item for different animal categories
- Quantity for each feed item
- Gross energy for each feed item

Calculations of Methane Emission



Methodology (calculations for methane emissions)

$$EF = \frac{GE \bullet \left(\frac{Y_m}{100}\right) \bullet 365}{55.65}$$

Where:

EF = emission factor, kg CH4 head-1 yr-1

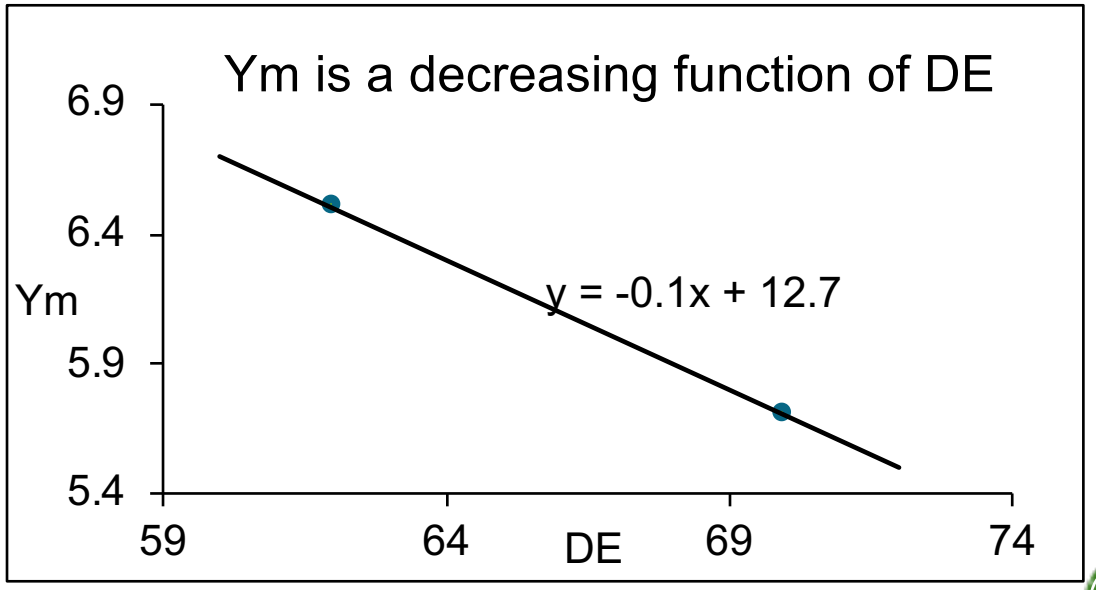
GE = gross energy intake, MJ head-1 day-1

Y_m = methane conversion factor, % of gross energy in feed converted to methane (related to DE)

The factor 55.65 (MJ/kg CH4) is the energy content of methane

From: IPCC. 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use.* Intergovernmental Panel on Climate Change.

Dairy Cows Methane Conversion Factor (Ym)		
Feed Quality Digestibility (DE, %)	Ym	Methane Yield, g CH_4 / kg DMI
>= 70	5.7	19
63-70	6.3	20.0
<= 62	6.5	21.4



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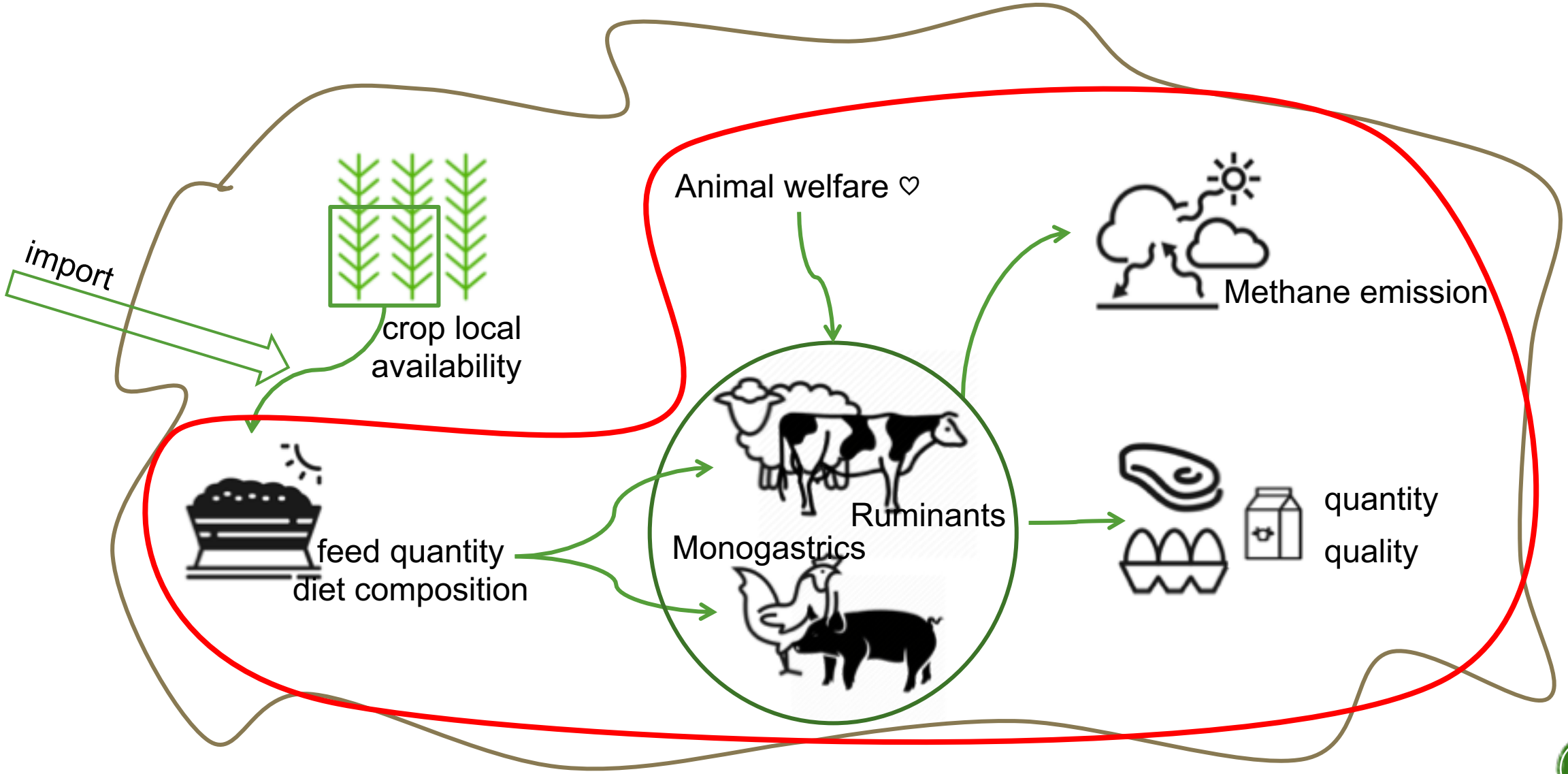
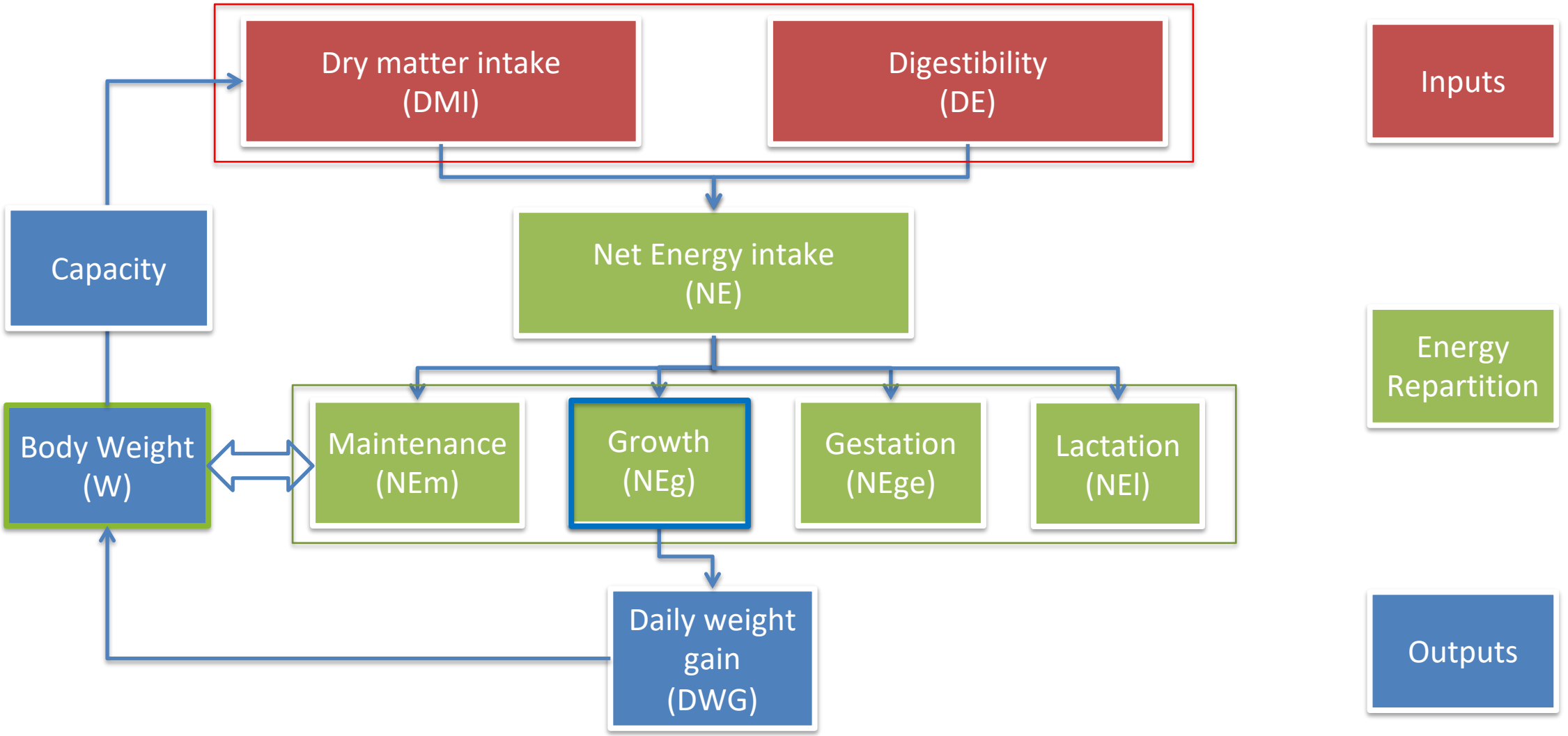
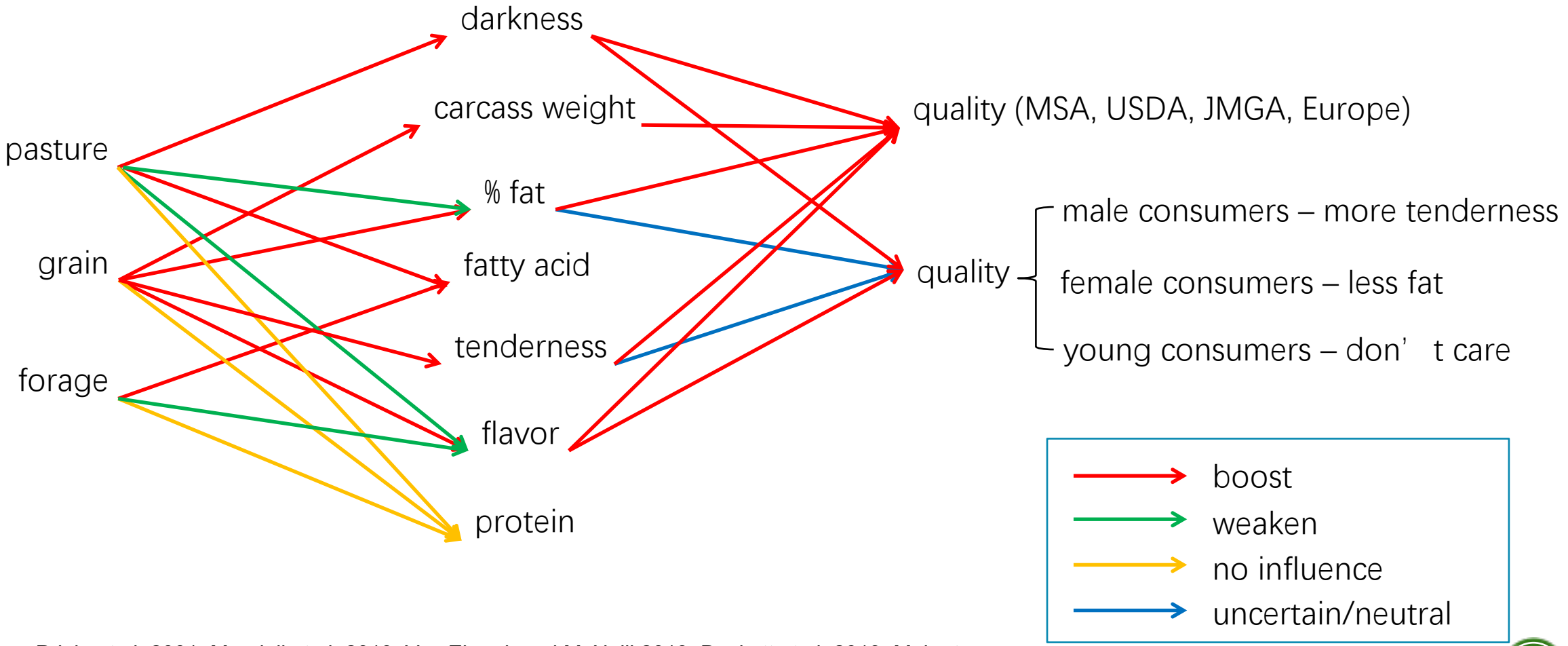


Framework of the quantitative model (e.g. pigs)



Feed Composition - Meat Quality (e.g. beef)



Source: Priolo et al.,2001; Mandell et al.,2013; Van Elswyk and McNeill,2013; Duckett et al.,2013; Muir et al.,1998; Cooke et al.,2004; Steen and Robson,1995; Malossini et al.,1996; Coulon et al.,1995

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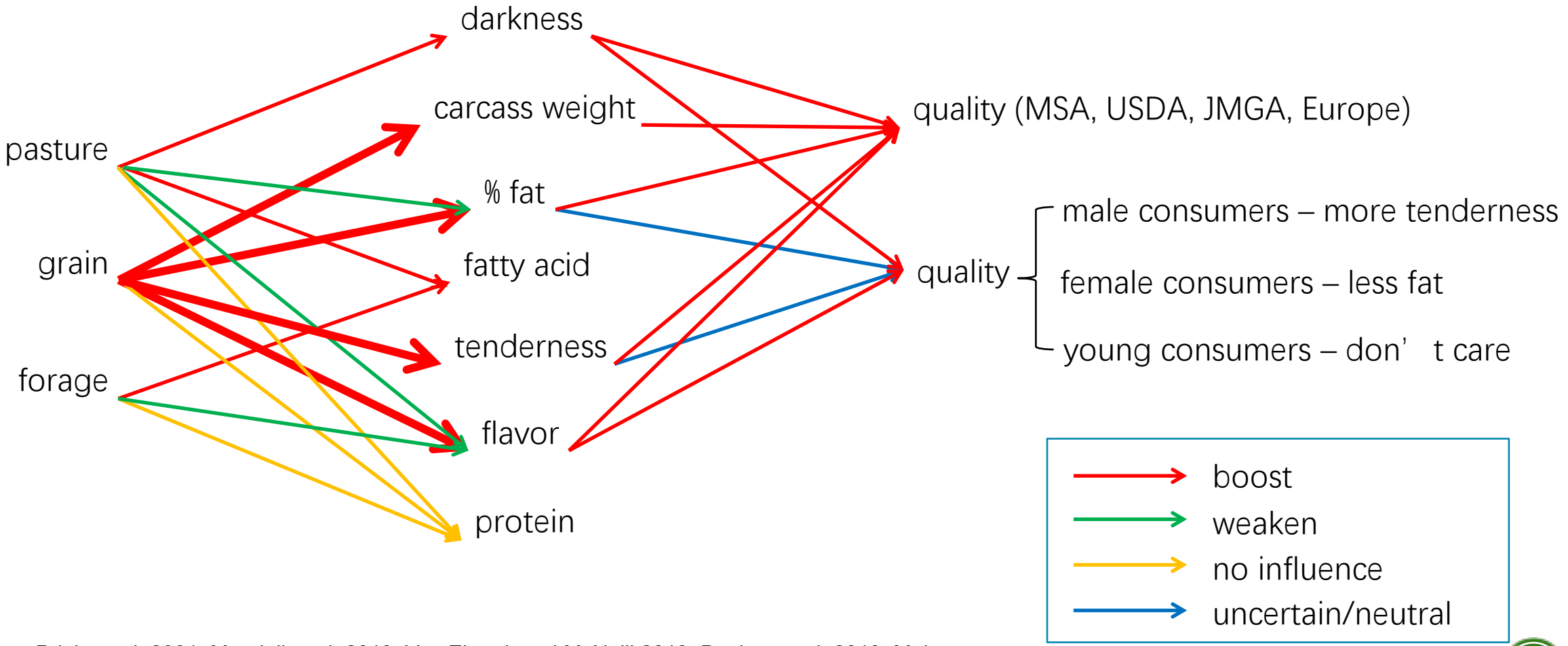

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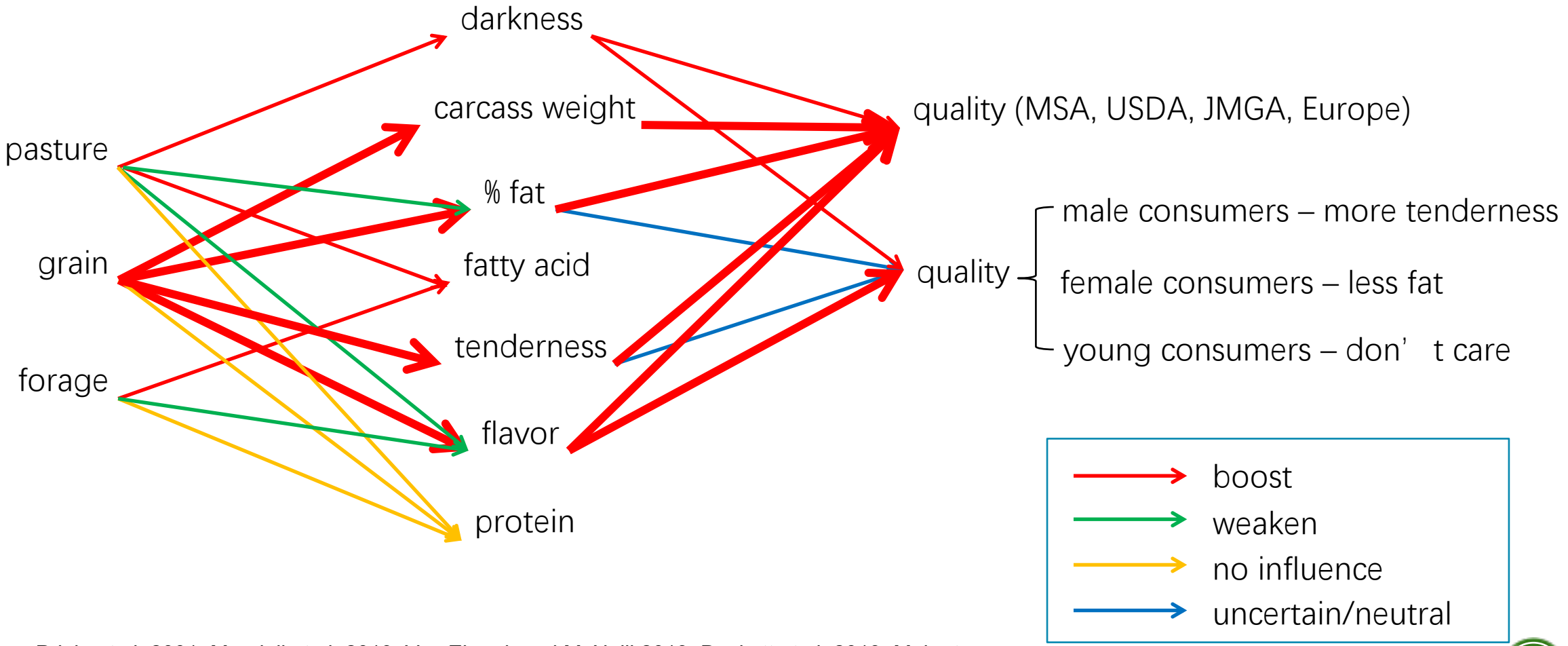

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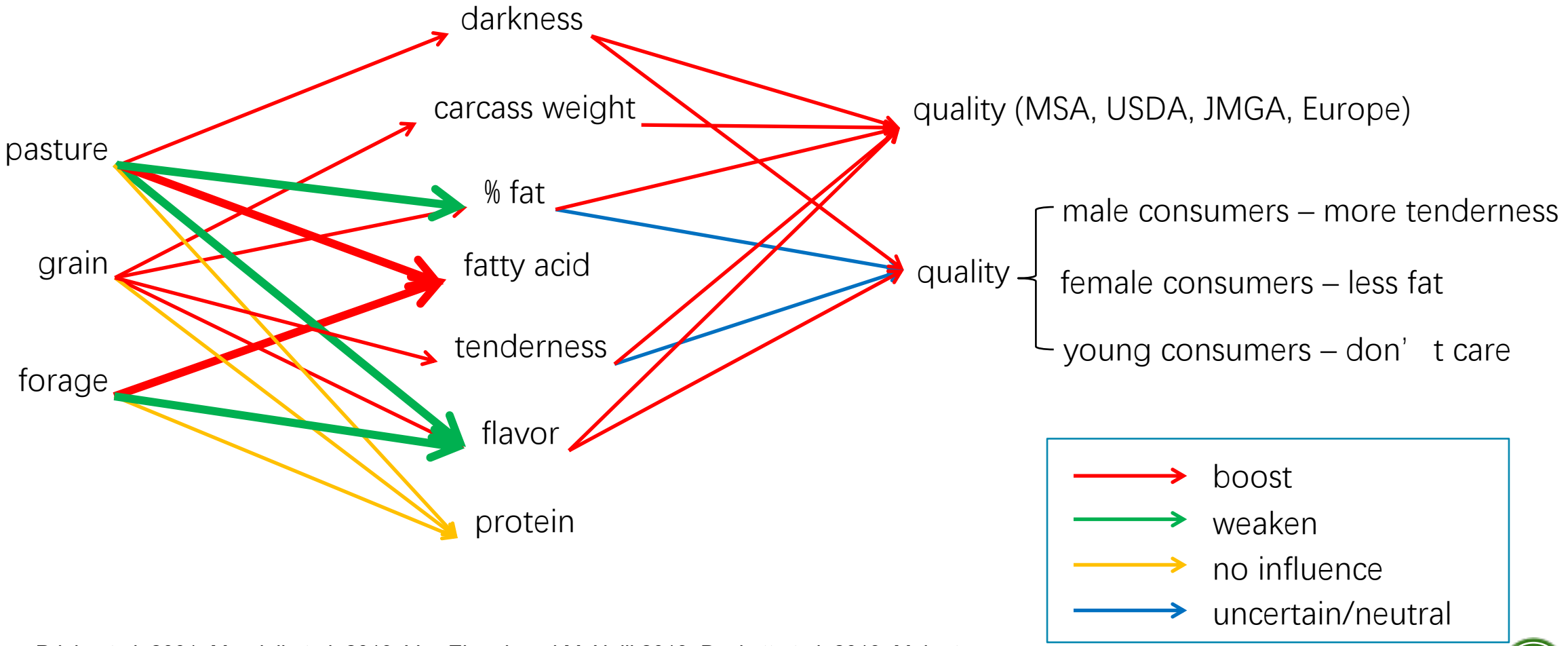

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Animal Welfare

Grain-fed system:

- directed to fatten up
- ↑ diseases
- ↑ mortality
- ↑ restlessness

Grass-fed system:

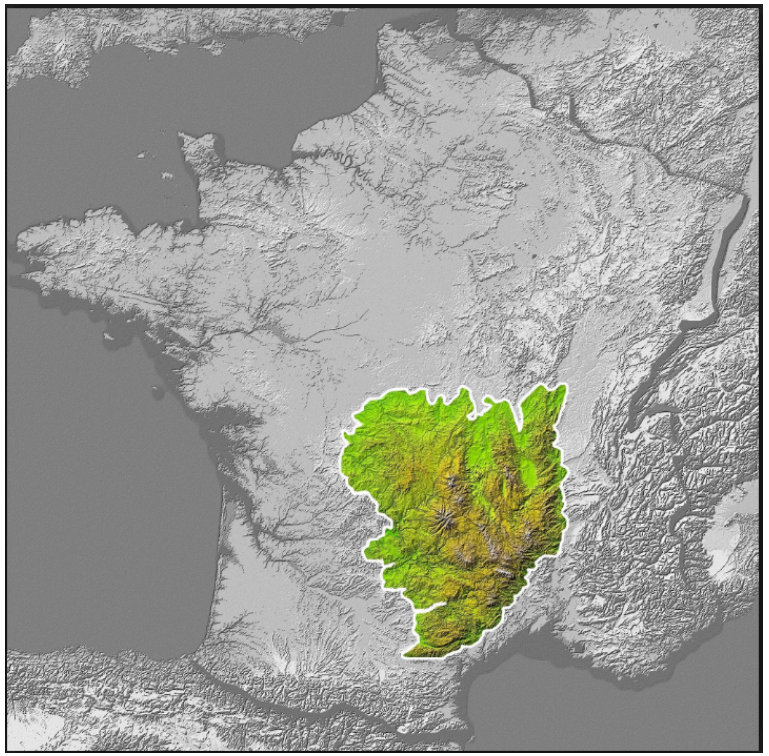
- match to animal's natural metabolism
- ↓ psychological and physiological stress
- healthier
- ↑ Ability to perform natural behaviors
  - ↑ pregnancy rate
  - regular rest time

More Animal Welfare

Source: Arnott *et al.,*2017; Logue et al., 2014; Havard et al., 2018; Mark Rutter., 2010; Charlton and Rutter, 2017

An overview in Bourbonnais

Massif central



Grassland-dominated landscape

Bocage Bourbonnais

An overview in Bourbonnais

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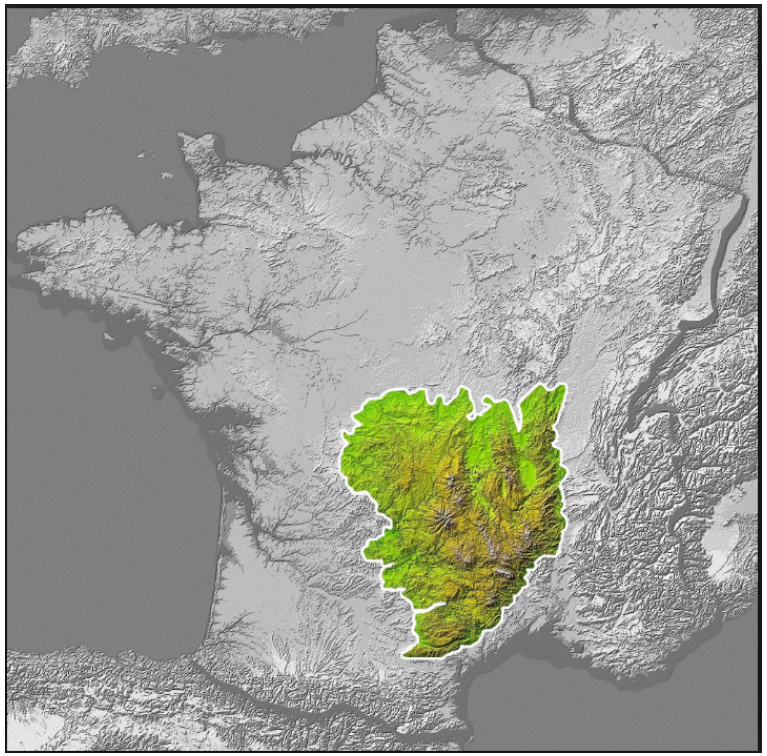

Extensive cattle rearing (transported to Italy)

Vache Charolais

An overview in Bourbonnais

Feed Categories	Intake Quantity (tons yr-1 head -1)	Average Gross Energy (MJ kg $^{-1}$ day $^{-1}$)	Average Digestibility (ruminants)
Cereals	0.215	15.94	0.83
Co-products	0.081	15.90	0.84
Meals	0.096	38.94	0.99
Oil and Protein	0.017	22.28	0.82
Forage	1.690	18.44	0.72
Grass	2.042	18.33	0.75

Data Source: EFESE

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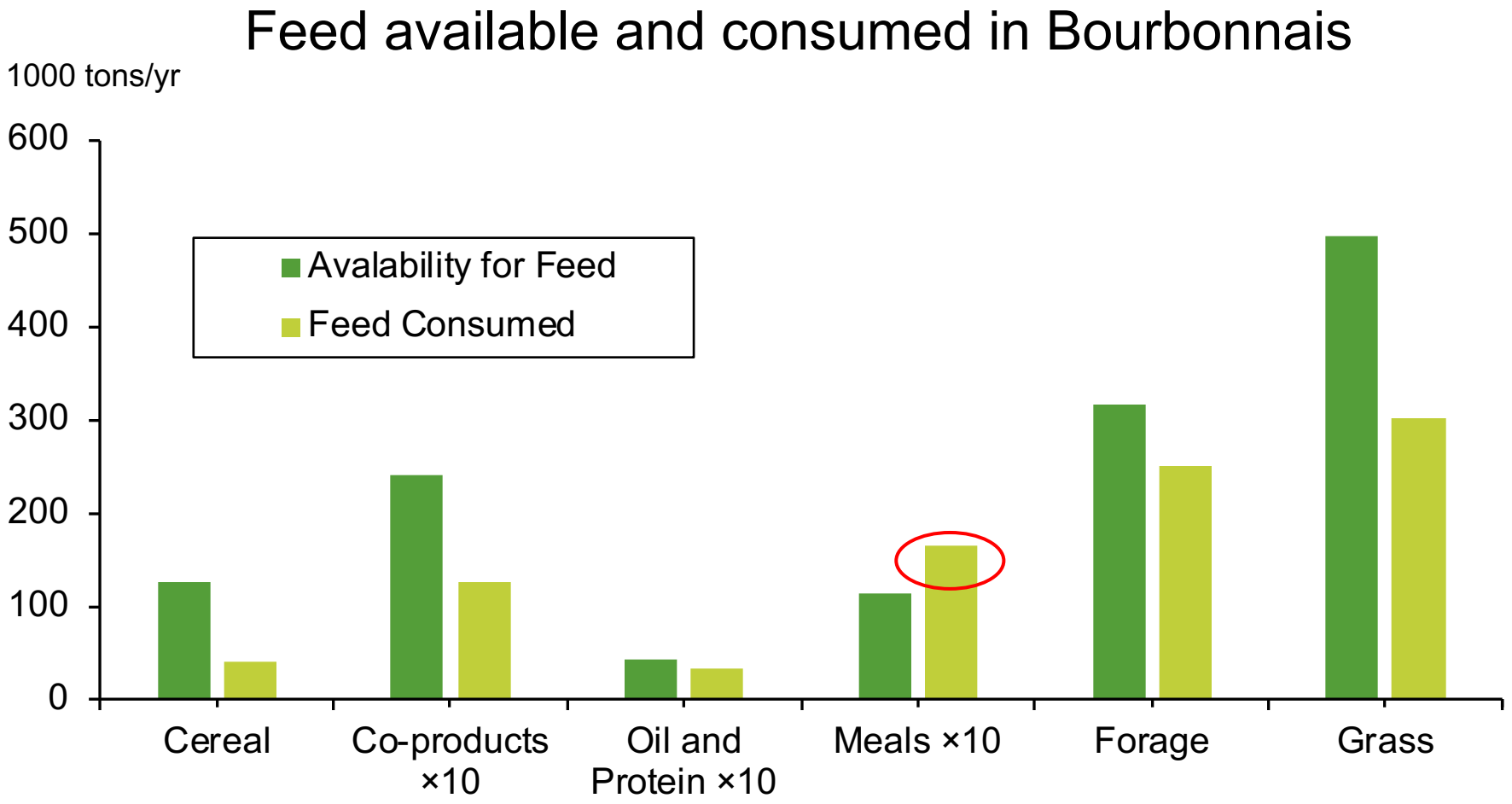
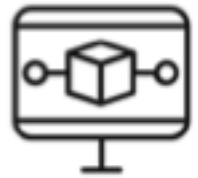


Simulations of models 

Scenarios of Changing Diet for Ruminants

Scenarios (tons yr^{-1} $head^{-1}$)	Cereals	Co-products	Meals	Oil and Protein	Forage	Grass
Baseline	0.215	0.081	0.096	0.017	1.69	2.042
Fattening	+ 0.5	-	-	-	- 0.25	- 0.25
Fattening +	+ 1	-	-	-	- 0.5	- 0.5
Fattening ++	+ 1	-	+ 0.1	-	- 0.5	- 0.6
Grass-fed	- 0.2	-	-	-	+ 0.1	+ 0.1

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↑ Meat quality
↓ Animal welfare

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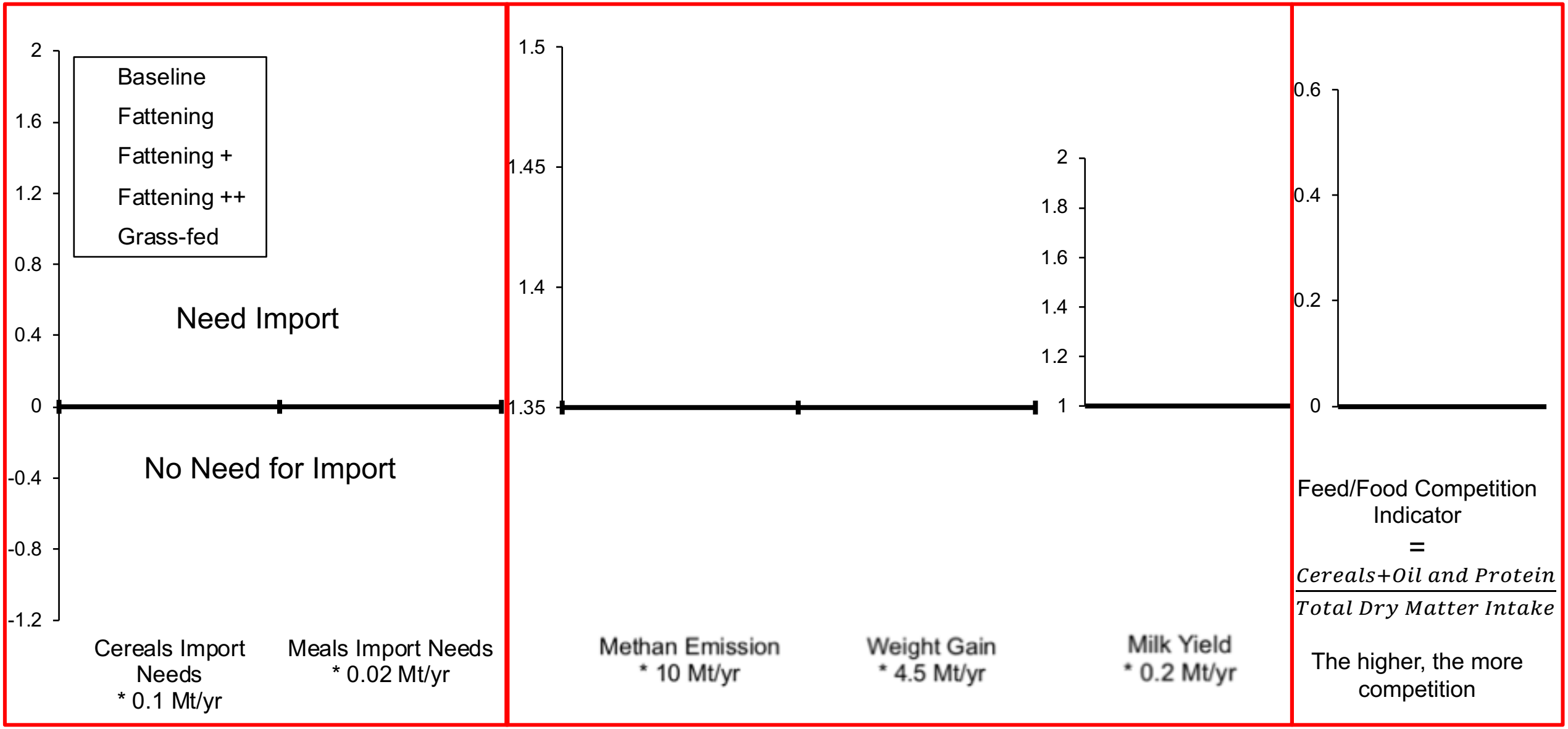

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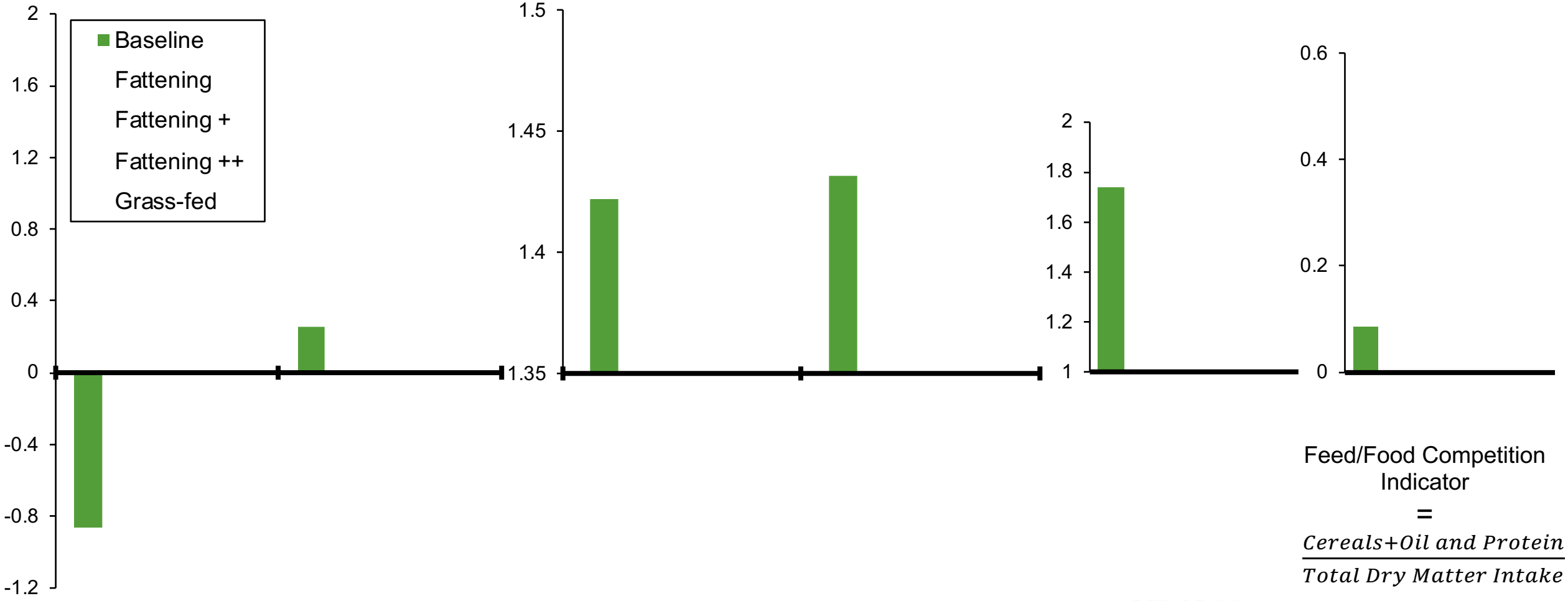


Cereals Import Needs * 0.1 Mt/yr

Meals Import Needs * 0.02 Mt/yr

Methan Emission * 10 Mt/yr

Weight Gain * 4.5 Mt/yr

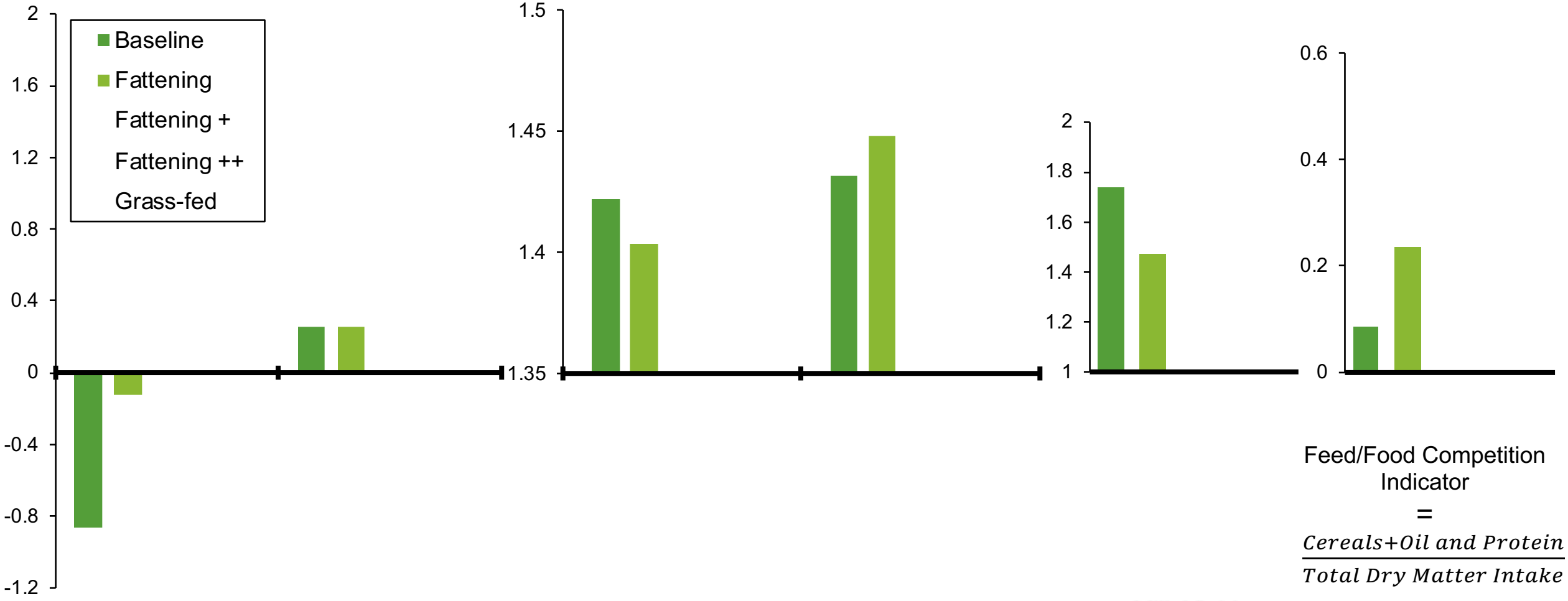
Milk Yield * 0.2 Mt/yr

Feed/Food Competition Indicator

$$= \frac{Cereals + Oil\ and\ Protein}{Total\ Dry\ Matter\ Intake}$$

The higher, the more competition

Scenarios of Changing Diet for Ruminants



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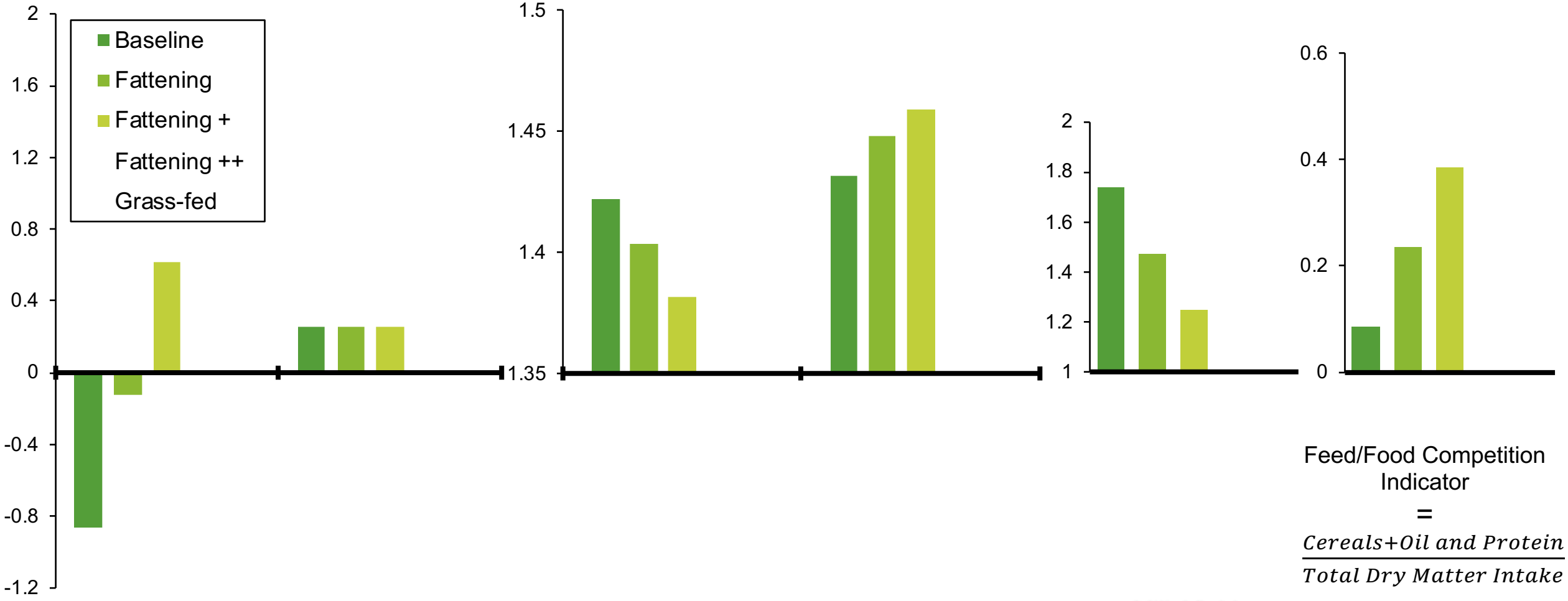

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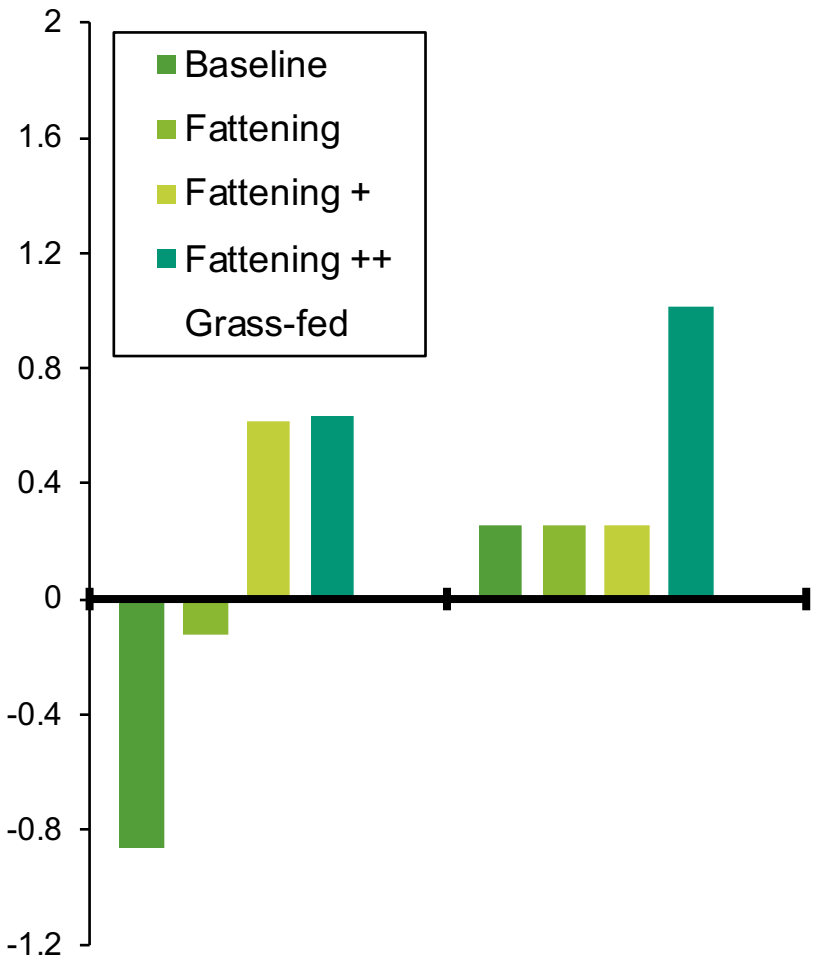

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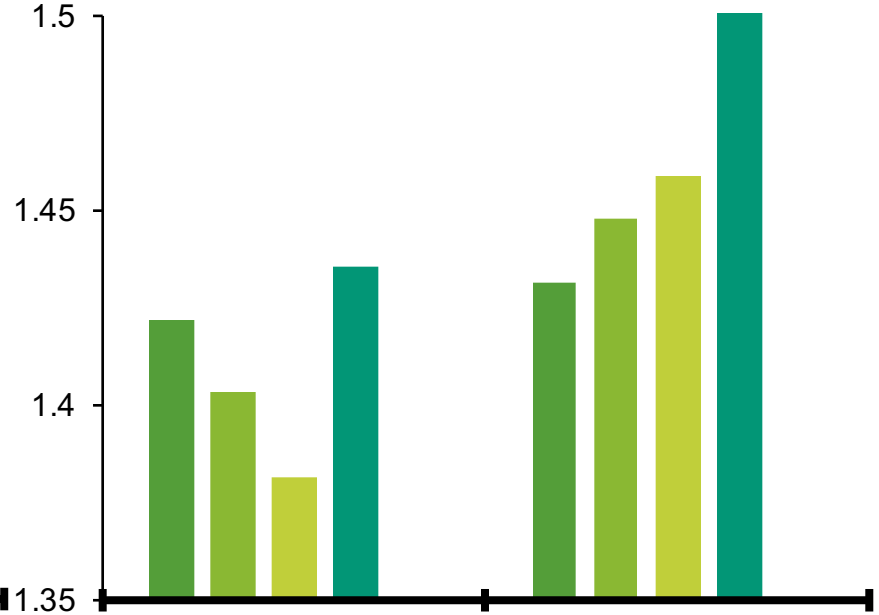

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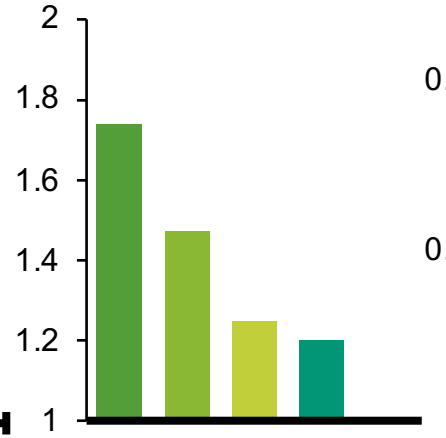

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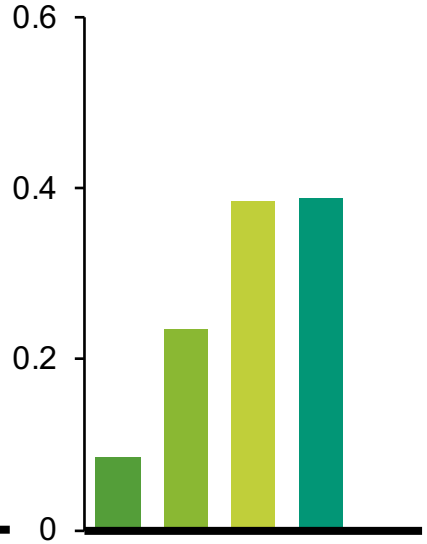

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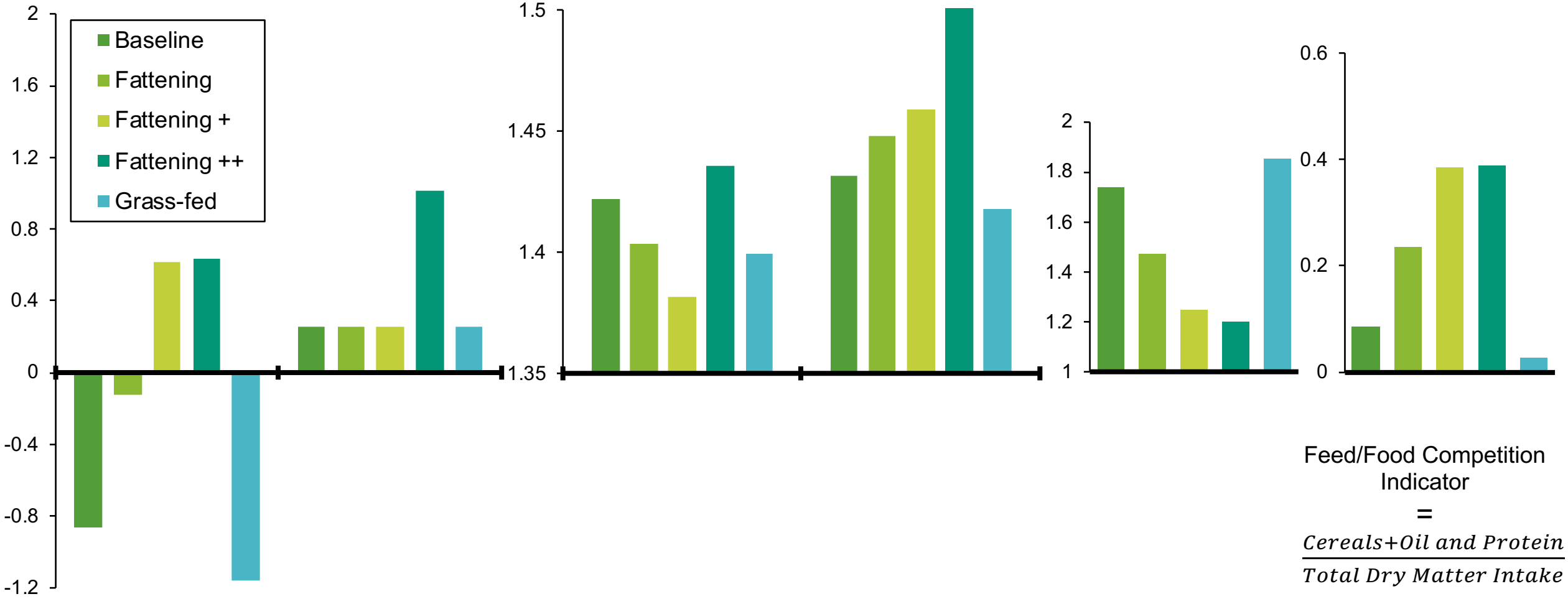

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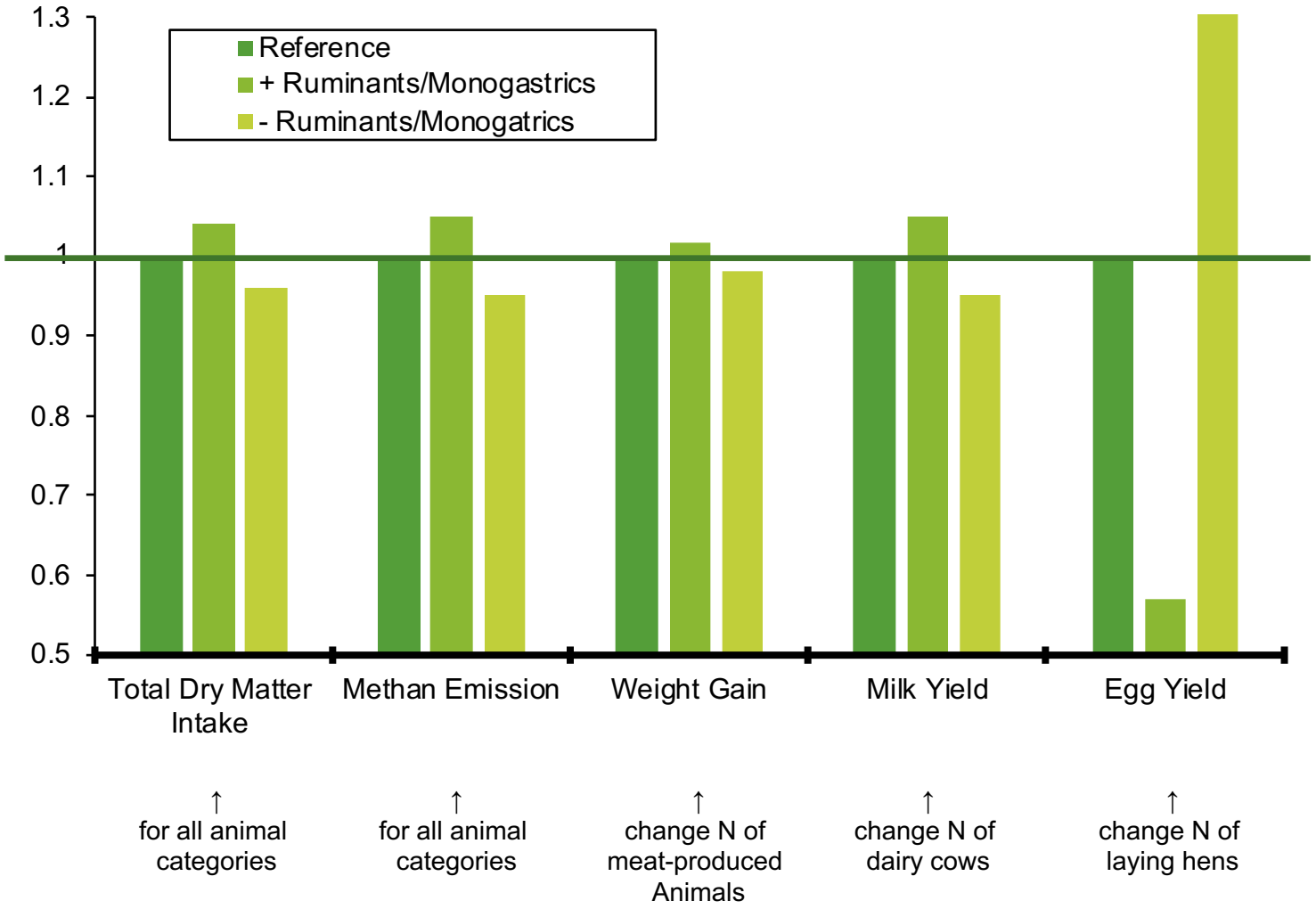
Scenarios of Changing Animal Numbers

The biggest difference between ruminants and monogastric animals : **RUMEN**

- transfer human inedible fiber and protein into human edible nutrients
- methane emissions from enteric fermentation

Scenarios \ Livestock Unit	Ruminant Animals	Monogastric Animals
Baseline	255612	29522
+N of Ruminants/ -N of Monogastrics	+5%	-43%
-N of Ruminants/ +N of Monogastrics	-5%	+43%



CONCLUSION

- Diet composition is a bridge among animal production, impacts on the local land use and methane emission.
- **Cereals** addition provide a **possibility of win-win** on increasing animal meat production and reducing methane emission, but with a cost of **compromising the animal welfare**, and a risk of **intensifying food-feed competition and import needs**.
- **Changing livestock numbers and ratios** could be a lever to optimize the outputs.
- It's of importance on studying methane emission on the regional scale with a **multi-criteria approach**.

Future Perspectives

- Consolidate the model
- Applied and compare with other regions
- Optimize the diet composition in a multi-criteria approach
- Ameliorate herd dynamics
- Other GHG emissions
- …...

Thank you !