Adjusting feed conversion ratio methodologies

considering the added value of animals to valorise non-consumable fractions of plant products and biomass from marginal lands

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Why should we be interested in feed conversion ratios?

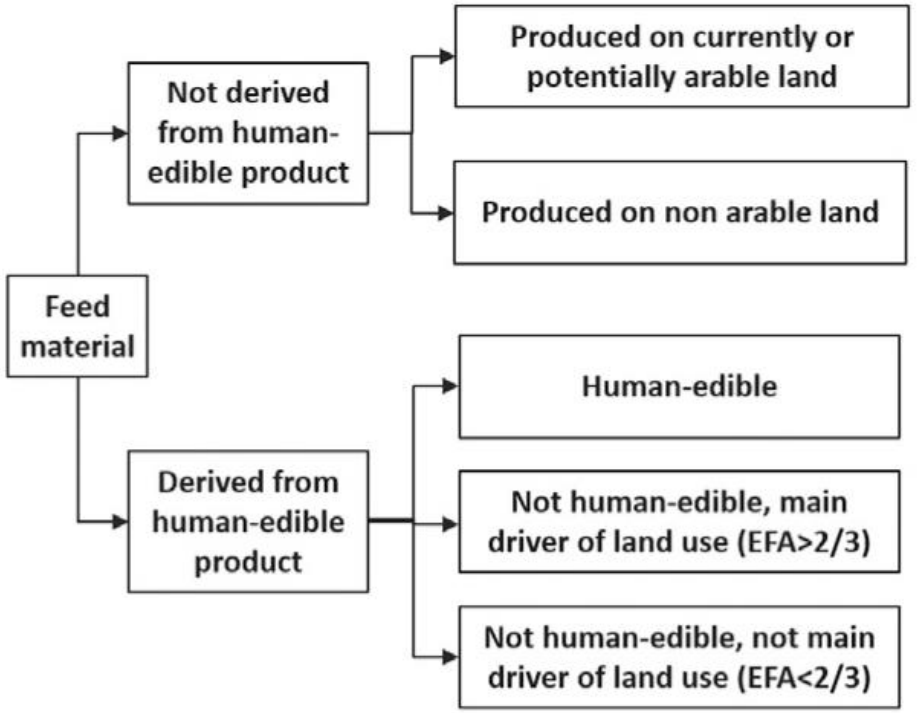
What feed classification do we need?

Feed/food competition: what needs to be considered? What are the implications?

- Demand for animal source food will continue to grow
- Animal feed rations contain products that humans can eat
- Feed may be produced on land suitable for food production
- Efficiency in converting feed into human-edible products varies between systems

- ❑ **Lack of global database of livestock feed**
- ❑ **Existing figures hide diversity of production systems (e.g. total consumption of grain by monogastrics vs efficiency in transforming feed)**
- ❑ **We need a classification of feed material that reflects their diversity**
- ❑ **We need a precise description of the role of livestock in feed utilisation**

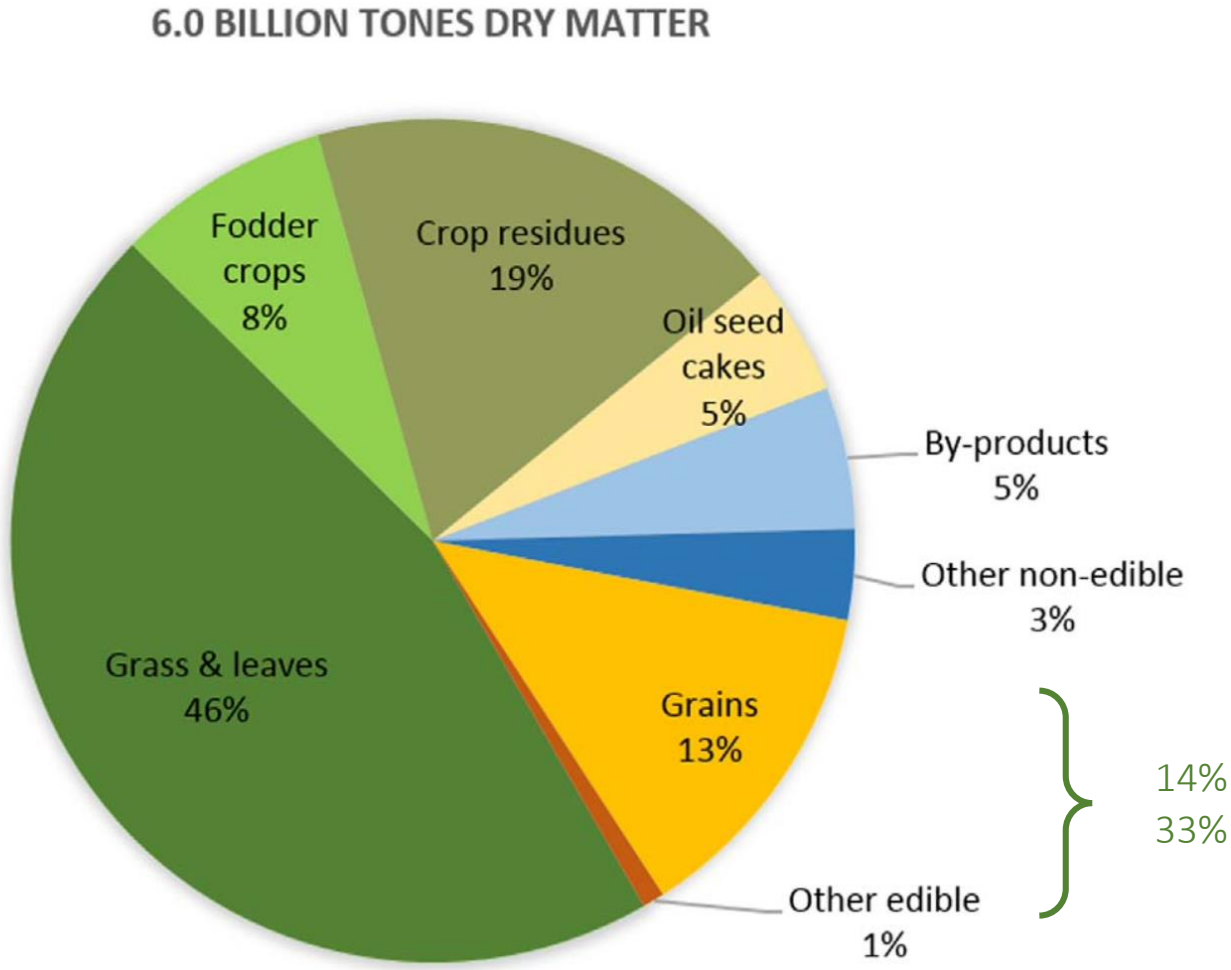
How can we classify the types of feed consumed by livestock?



	Human-edible	Competes with food-crops for land (opportunity cost >0)	Examples of materials	Feed conversion ratio
Produced on currently or potentially arable land	No	Yes	Grass, fodder and silage from grasslands convertible to cropland, cotton seed cakes	FCR1
Produced on non arable land	No	No	Grass and fodder from grasslands unconvertible to cropland, synthetic amino acids, limestone, fish meal	FCR1
Human-edible	Yes	Yes	Cereal grains, soybeans, pulses, cassava	FCR1, FCR2, FCR3
Not human-edible, main driver of land use (EFA>2/3)	No	Yes	Soybean cakes	FCR1 & FCR3
Not human-edible, not main driver of land use (EFA<2/3)	No	No	Cakes from rapeseed, canola and palm kernel, corn gluten feed and meal, brans, straws and stover, pulp, molasses	FCR1

Mottet et al., 2017. Livestock: On our plates or eating at our table? Global Food Security

The global livestock feed intake



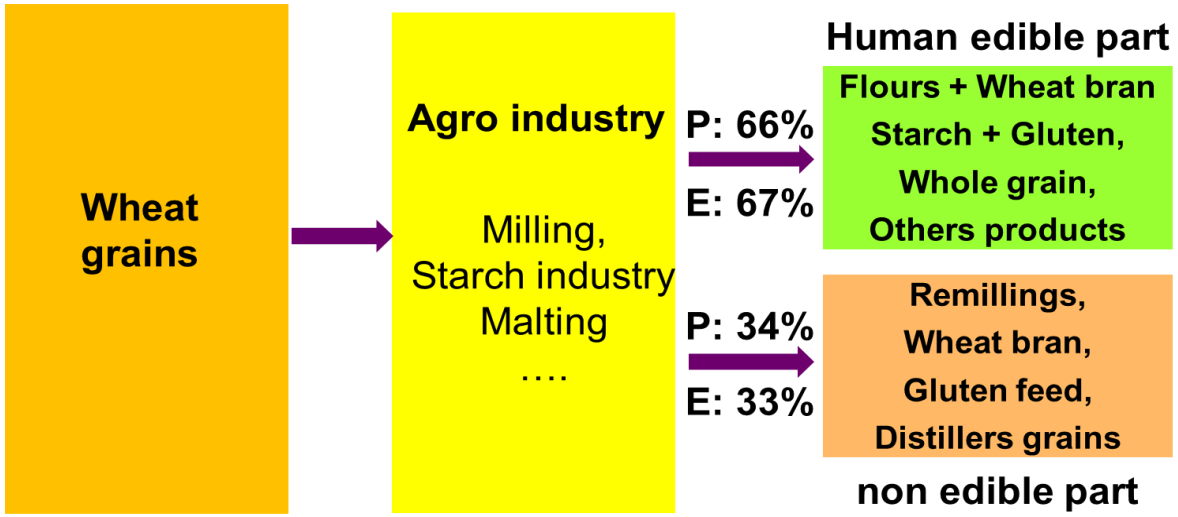
14% edible for humans
33% of global grain production

Fodder crops: grain and legume silage, fodder beets
Crop residues: straws and stover, sugar cane tops, banana stems
By-products: brans, corn gluten meal and feed, molasses, beetroot pulp and spent breweries, distilleries, biofuel grains
Other non-edible: second grade cereals, swill, fish meal, synthetic amino acids, lime
Other edible: cassava pellets, beans and soy beans, rapeseed and soy oil

Mottet et al., 2017.
Livestock: On our plates or eating at our table? Global Food Security

Proportion of edible biomass used as animal feed

- **Non edible fraction of Feedstuffs**



Non-edible fraction	
Grass, herbs (50% AA)	100 %
Wheat	34%
Maize grain	85 %
Soya	40 %
Coproducts, former foods	100%
Former foods	100%

(Laisse et al., 2019)

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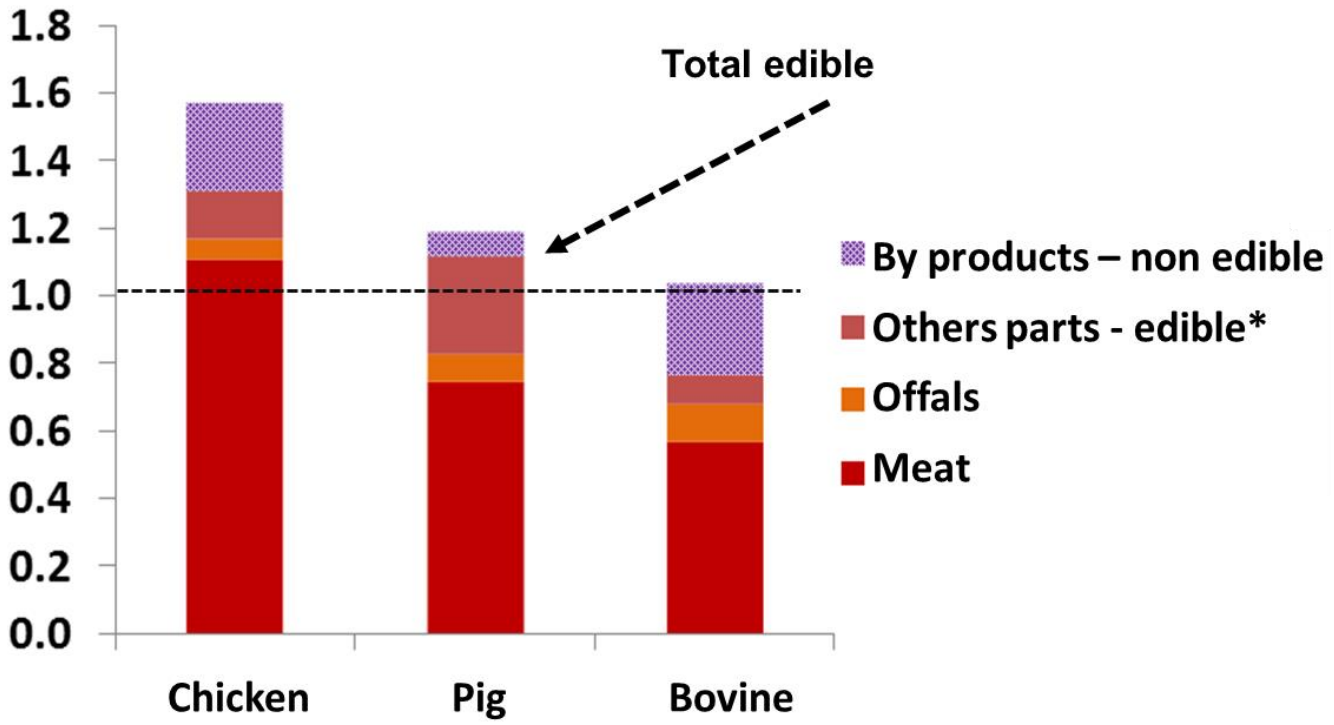
Assessment of the share of animal feeds available for human consumption



(Laisse et al., 2019)

*** Other edible parts: other offals + rind (pork) + skin (chicken) + gelatine**
Non edible proteins: fertilisers, petfood, energy, cosmetics...

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How do efficiencies vary between species and systems depending on the feed considered?

Global feed conversion ratios

	Protein	FCR 1	FCR 2	Meat FCR 2	FCR 3	Protein FCR 2
	Mt/year	Kg DM /kg protein	Kg edible DM /kg protein	Kg edible DM /kg meat	Kg compete DM /kg protein	Kg edible protein /kg protein
Ruminants	**36,355**	**133**	**6**	**2.8**	**6.7**	**0.6**
Monogastrics	**38,246**	**30**	**16**	**3.2**	**20.3**	**2.0**
All	**74,601**	**80**	**12**	**3.1**	**13.7**	**1.3**

- Efficiency in converting feed material varies a lot depending on which feeds are considered.
- Ruminants need a lot of dry matter to produce 1 kg of protein but very little edible plant protein compared to monogastrics.

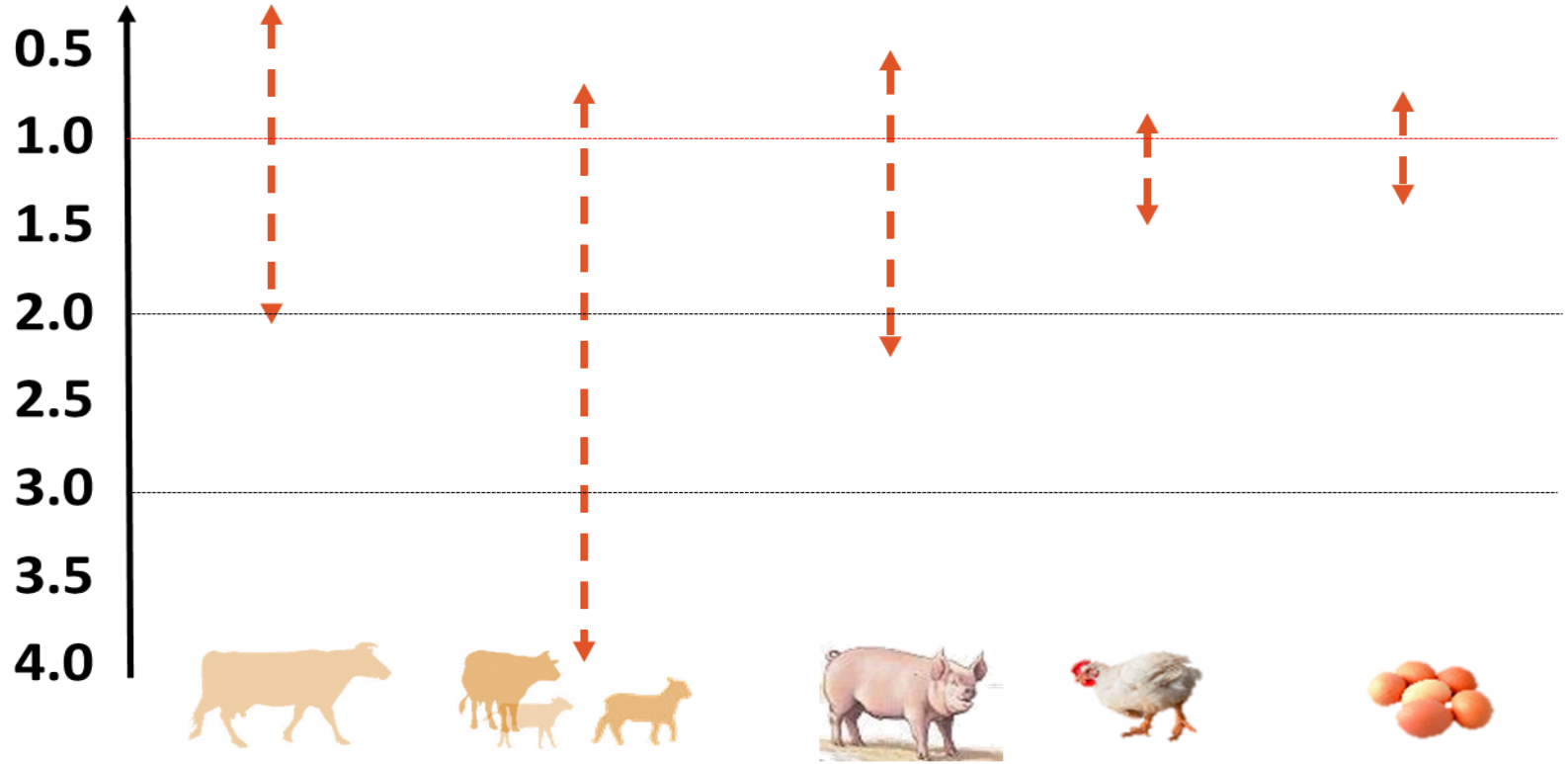
Feed conversion ratio by production systems

	Protein	FCR 1	FCR 2	Meat FCR 2	FCR 3	Protein FCR 2
	% global livestock	Kg DM /kg protein	Kg edible DM /kg protein	Kg edible DM /kg meat	Kg compete DM /kg protein	Kg edible protein /kg protein
Grazing cattle non OECD	8%	195	1.6	0.9	1.9	0.2
Mixed cattle non OECD	18%	171	4.8	3.1	5.6	0.5
Beef feedlots OECD	2%	62	44	9.4	45.4	4.1
Industrial pigs non OECD	7%	29	20	4	24.1	4.4
Industrial broilers OECD	11%	26	18.6	3.5	24.7	5.2

- There are also strong variations between systems in the same species

Feed conversion ratio: the French production systems

Kg of edible plant protein / kg of edible animal protein



(Laisse et al., 2019)

	Dairy	Beef -sheep	Pig	Poultry	Eggs
% edible protein in feed	10 - 26	4 - 15	21 - 35	45 - 67	21 - 28

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Feed conversion ratio for beef systems

Kg of edible plant protein / kg of animal protein

	Intensive (concentrate)	Grassland based or rangeland
Wilkinson (2011) : UK	**3.5**	**1.1**
Wiedeman et al (2015) : Australia	**3.3**	**0.3**

Feed conversion ratio: source of variation among species

	milk	Beef, sheep	pig	poultry
No edible biomass as feed	++	+++	+	-
Animal biological efficiency	+	-	+	++
Edible part in product	+++	-	++	+

Specify the method: the calculation of non-consumable fractions

A method not yet harmonized: consumable fraction in plant

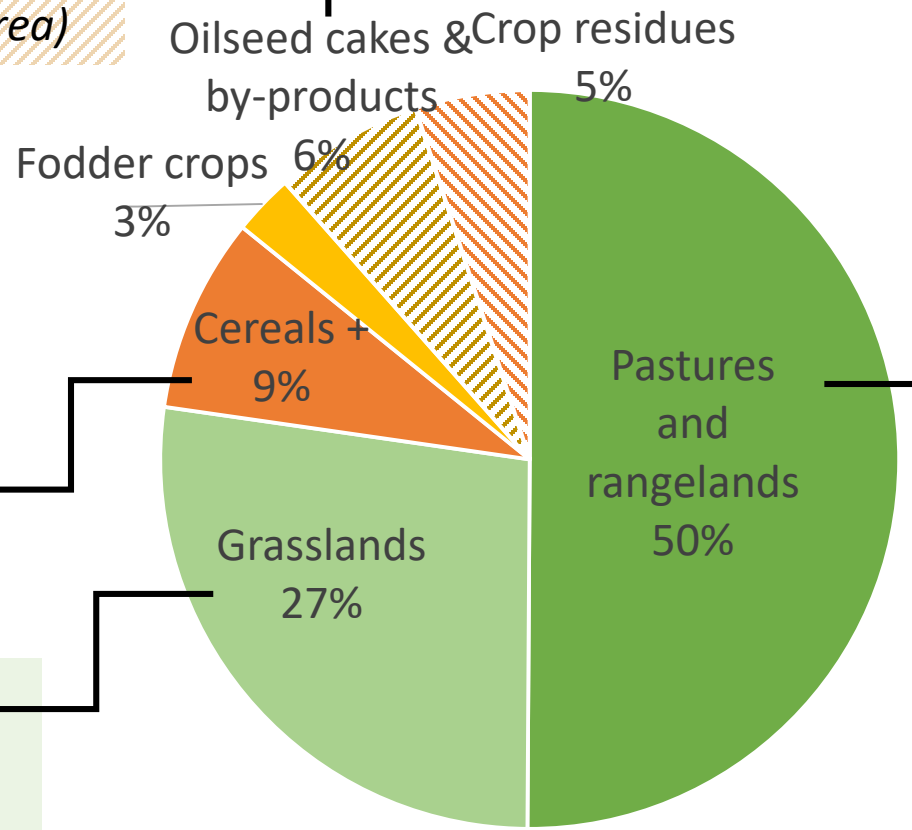
	Laisse et al (2018) France	Ertl et al (2016) Austria	Wilkinson (2011) UK
Maize silage	15	19 - 45	0
Wheat	66 - 76	60 - 100	80
Maize grain	15 - 30	90	-
Wheat bran	90	0 - 20	20
Pea	74 - 88	70 - 90	80
Rapeseed meal	0-55	30 - 87	20
Soybean meal	60 - 90	50 - 92	80

Another dimension of feed-food competition:

Land Use

Livestock use 2.5 billions ha of land (Total ag land = 4.8 billion ha)

This part is an allocation of the area cropped for the main products based on value and mass of the by-products and residues (Monogastrics use 76% of oil seed cakes area)



This part (globally 30% of cropping area but up to 50% in OECD countries) is questionable but acts as market "buffer" (Monogastrics use 65% of that)

This part can only be used by herbivorous (not arable)

This part might be used for crops but it ensures the provision of services for an agro-ecological agriculture

Mottet et al., 2017

Land use: Edible protein yield per ha of arable land

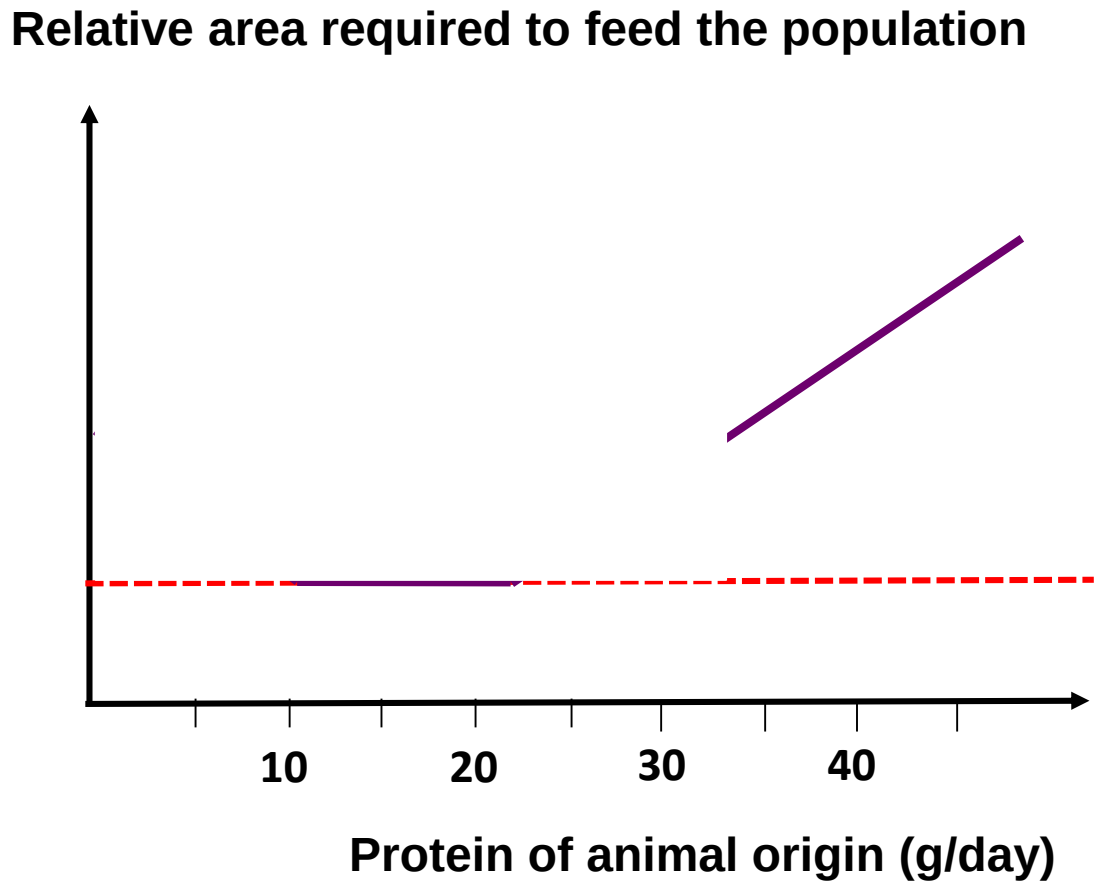
- **Protein yield per ha**

	Pig, Poultry	Egg	Milk	Bovine meat
De Vries and De Boer, 2010	**180 - 220**	**210 - 280**	**200 - 250**	**30 - 80**
Ermgassen et al., 2016	**300** (DE, DK, FR, SP, PO)			
Hennessy and Moran, 2014			**350**	

- **Livestock upgrade the nutritional value of protein of plant origin**

Coupling livestock and crops for a more efficient agriculture

- Complementarity between livestock and crops to maximize food production / ha
  - Valorisation of co-products
  - Valorisation of non-usable land for crop production
- The adoption of such regimes would lead to changes in eating habits that are difficult to accept and may not adequately cover the nutritional needs
- Nutritional recommendations (PNNS) : 60 g protein /day including 30 g of protein of animal origin



(Adapted from Van Kernebeck et al., 2014 et De Boeer et al., 2018)

Food from marginal Land? Ruminants can do!!!

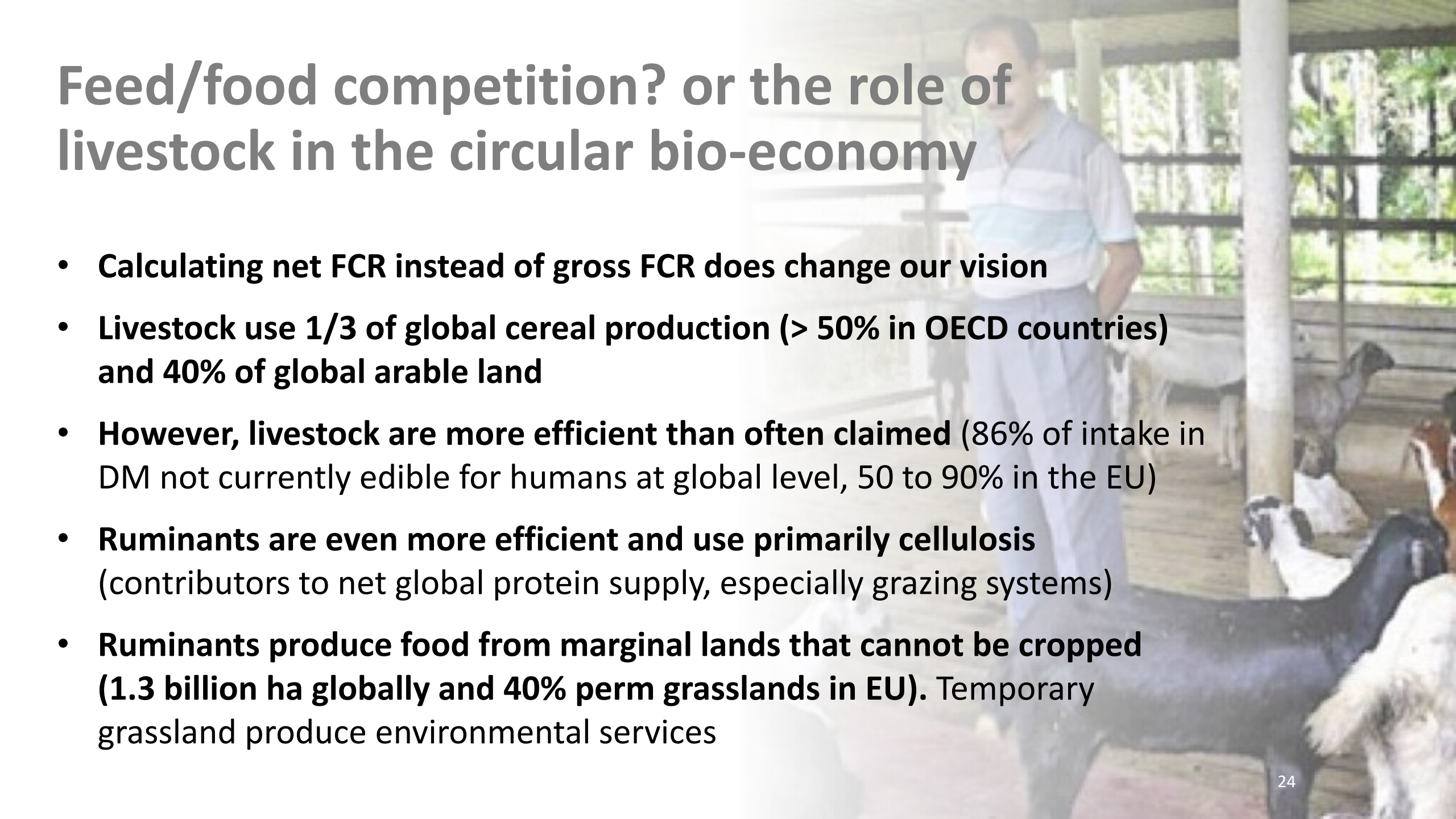
- **Ruminants contribute to food security by valorizing grazing marginal land that are not able to produce plant products**
- **In Europe, permanent grasslands and rangelands cover 73 M ha (40% EU AA)**
- **At world level, 360 million cattle and 600 million small ruminants provide 25% of world animal product from marginal land**

Sere and Steinfeld, 1996

Take home messages

Feed/food competition? or the role of livestock in the circular bio-economy

- **Calculating net FCR instead of gross FCR does change our vision**
- **Livestock use 1/3 of global cereal production (> 50% in OECD countries) and 40% of global arable land**
- **However, livestock are more efficient than often claimed** (86% of intake in DM not currently edible for humans at global level, 50 to 90% in the EU)
- **Ruminants are even more efficient and use primarily cellulosis** (contributors to net global protein supply, especially grazing systems)
- **Ruminants produce food from marginal lands that cannot be cropped (1.3 billion ha globally and 40% perm grasslands in EU).** Temporary grassland produce environmental services



Way forward

- Allocation of land but what opportunity cost?
- Attributable vs consequential and scenario analysis (including changes in diets, land-use etc.)
- **Limitation of the feed vs food competition: prevent further expansion of arable land dedicated to feed production**
  - Use of dual purpose crops: food first then feed
  - Improvement of grassland use efficiency
  - Improvement of FCR
  - Encourage the use of non-edible materials