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Effects of different animal production systems on climate change

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ΓΕΩΠΟΝΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ AGRICULTURAL UNIVERSITY OF ATHENS · cre thi dev · DEMOKRITOS · Université de Jendouba · Université de Carthage · University of Sousse · INGC Institut National des Grandes Cultures · CACC · Latvia University of Agriculture · UNIVERSITÀ DEGLI STUDI DI TORINO

Outline:

- **Introduction**

  -Livestock and climate change

- **Farming practices and environmental impact**

  -general management, breeding, manure treatment, feeds, etc

- **Impact of different farming systems on climate change**

  - Sheep farming systems

  -Cattle farming system

  -Broiler systems

  -Egg production systems

- **Conclusions**

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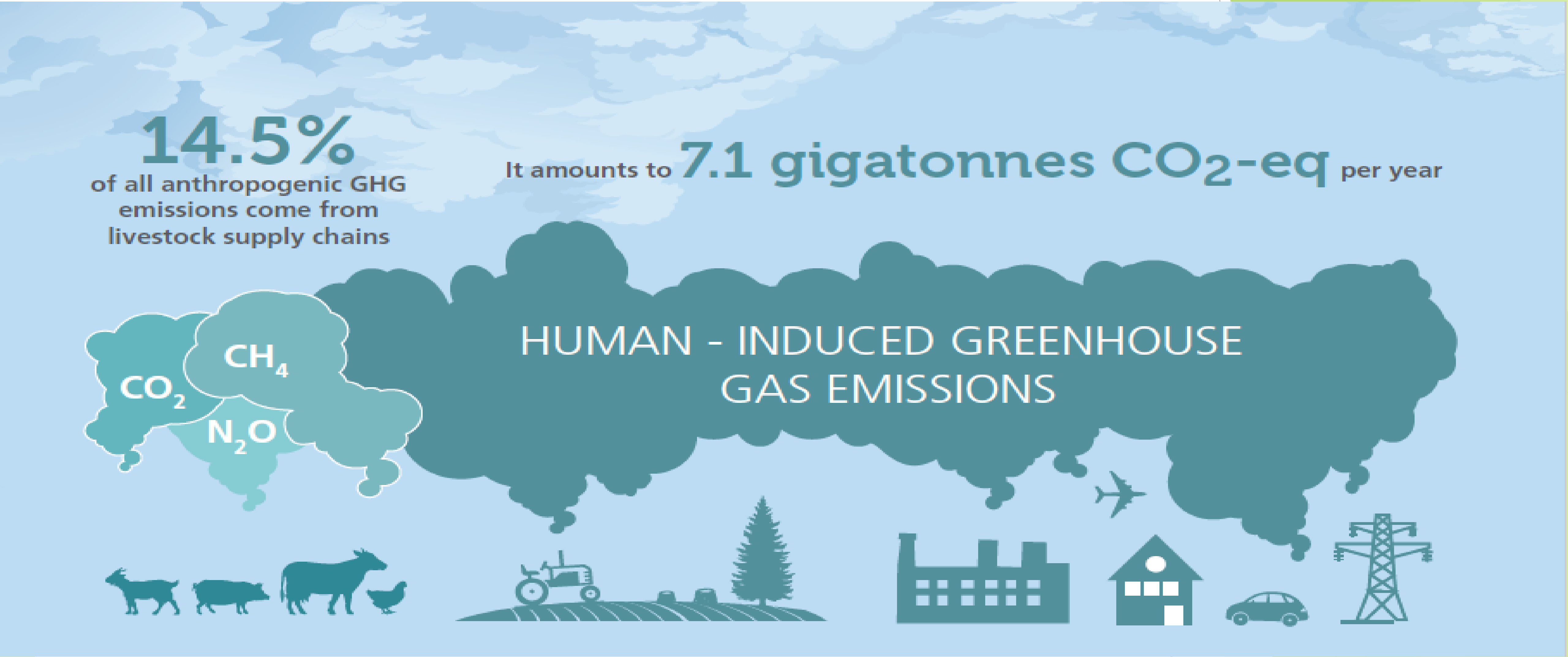
Impact of Animal Production on Climate change

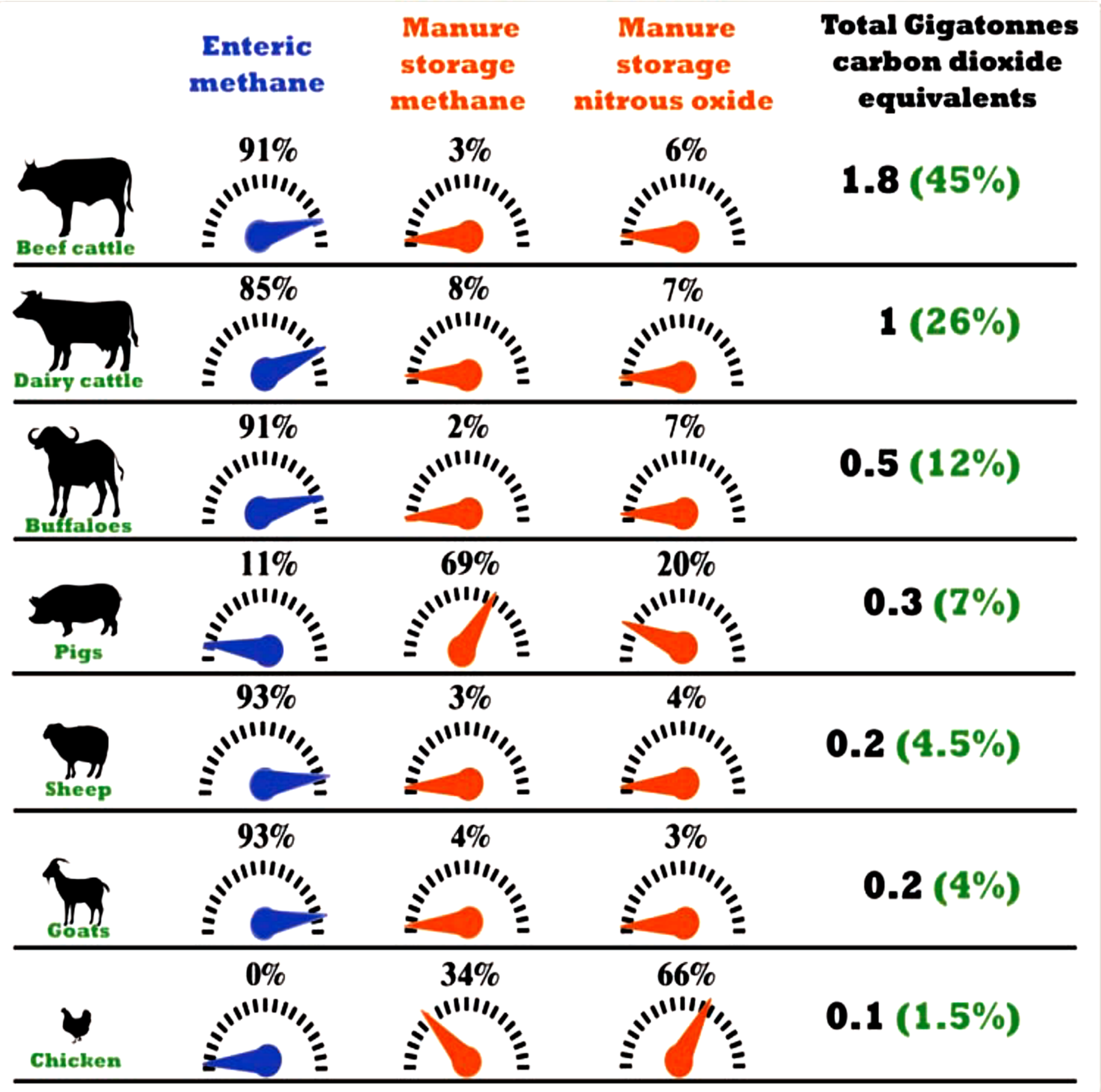
- The increased demands for livestock products is nowadays a certainty
  - population growth
  - urbanization
  - income rise
  - different nutritious needs

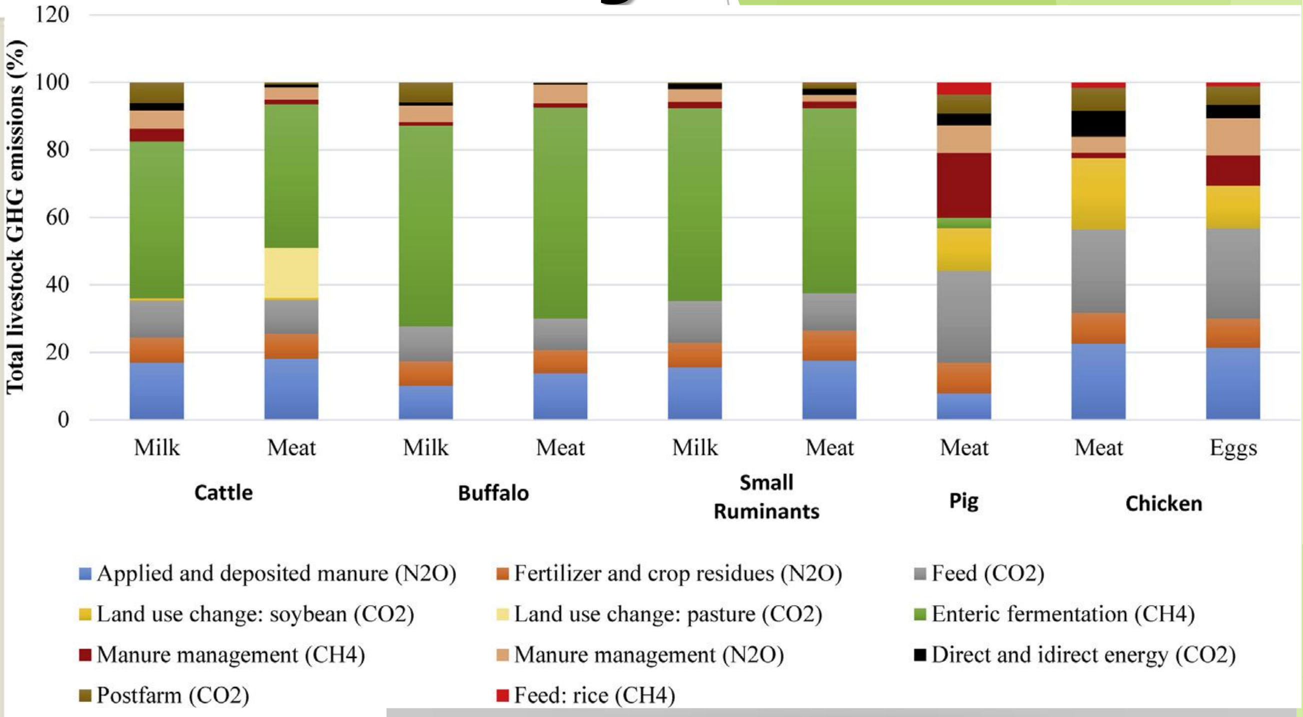
- As a result the livestock sector:
  - Requires a significant amount of natural resources
  - Is responsible for about the 14.5 % of total anthropogenic greenhouse gas emissions (>7 Gigatons of carbon dioxide equivalents)

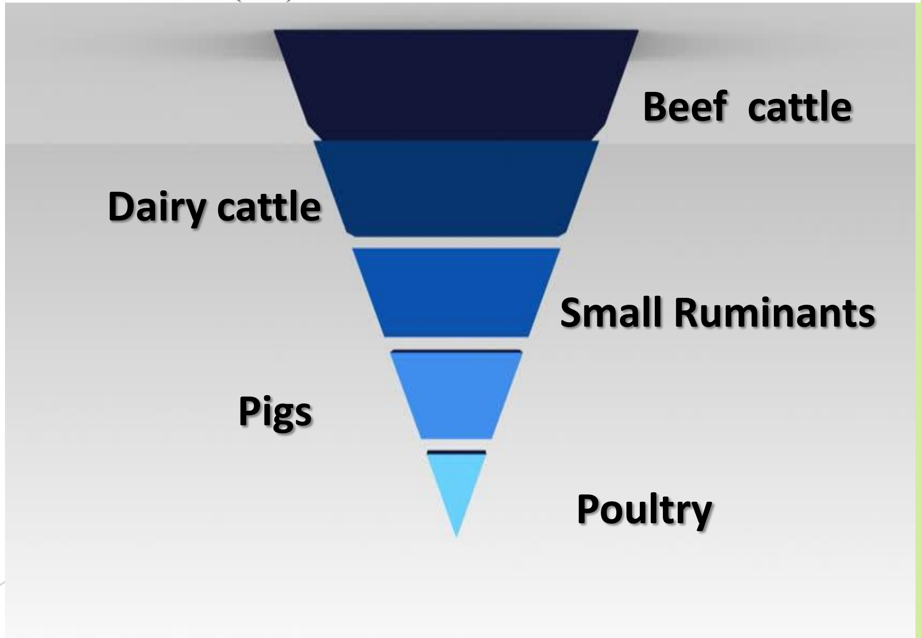
Impact of Animal Production on Climate change



Impact of Animal Production on Climate change








DO ALL THE FARMING SYSTEMS HAVE THE
SAME ENVIRONMENTAL IMPACT ???

Farming systems and management practices: Some examples….

- Mixed crop-livestock systems account for 64% of global methane emissions.
- Grazing systems account for 35% and industrial for 1% of global enteric fermentation.
- Changing feeding practices moderate methane emissions.

  -A 1% increase of dietary fat can decrease enteric methane emissions between 4-5%.

  -Feed antibiotics can reduce enteric fermentation.

  -Reduced protein intake may lead to decrease the nitrogen excreted by animals.

  -Improving diet digestibility by increasing concentrate feeding may reduce by 15% methane emissions per unit of fat protein corrected milk.

  - Physical processing of forages, i.e chopping or grinding, improve digestibility lower (in a small extent <2%) enteric methane production in ruminants

Farming systems and management practices: Some examples....

- Changes in manure management lead to lesser emissions.

  -Frequent removal of manure to an outside storage facility could reduce methane and nitrous oxide emissions >40%.

  -Solid-liquid separation process of manure could lead to a 30% lesser emissions compared with untreated manure.

  -Same positive effect may have the anaerobic digestion of manure, when biogas generated from the process is used in the livestock

- Feed management and GHG emissions.

  -Fertilizers and manure are the major contributors of GHG emissions related to feed production and further processing.

  -Lower methane emissions occur after manure land application, thus a decrease of storage time could assist in reducing GHG emissions.

  -Rotational grazing systems may lead to reduce nitrous oxide emissions (via stocking densities and grazing duration management).

Farming systems and management practices: Some examples....

- Animal management and breeding strategies

  -The more productive the animal is the lower environmental impact will have (per unit of product).

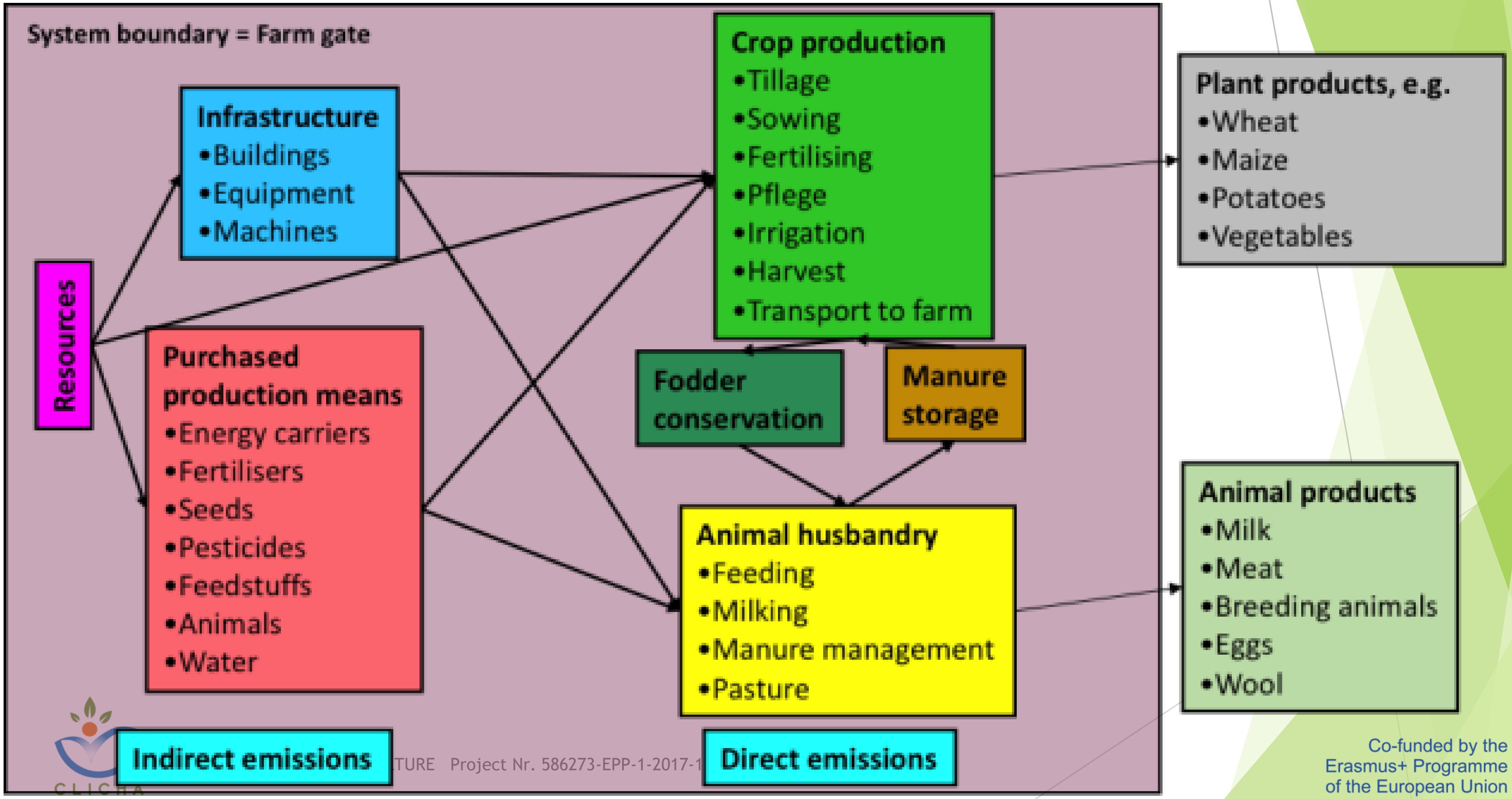
  -Breeding for more productive animals may lead to a diminish of the nutrient requirements→ assist to lower GHG emissions.

  -Improved fertility in dairy cattle could lead to a reduction in methane emissions by 10–24% and reduced nitrous oxide emissions by 9–17%.

  - Cattle diseases can increase greenhouse gas emissions up to 24% per unit of produced milk and up to 113% per unit of produced beef carcass.

→ Multi-actor drivers .....

ENVIRONMENTAL IMPACT OF FARMING SYSTEM AS A HOLISTIC APPROACH



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Approaches on farming systems ….

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Journal of Cleaner Production

Volume 104, 1 October 2015, Pages 121-129

Carbon footprint of milk from sheep farming systems in Northern Spain including soil carbon sequestration in grasslands

Inmaculada Batalla [a], Marie Trydeman Knudsen [b], Lisbeth Mogensen [b], Óscar del Hierro [a], Miriam Pinto [a], John E. Hermansen [b]

- Carbon footprint of sheep milk was estimated on 12 farms in Northern Spain.
- Three different farming systems

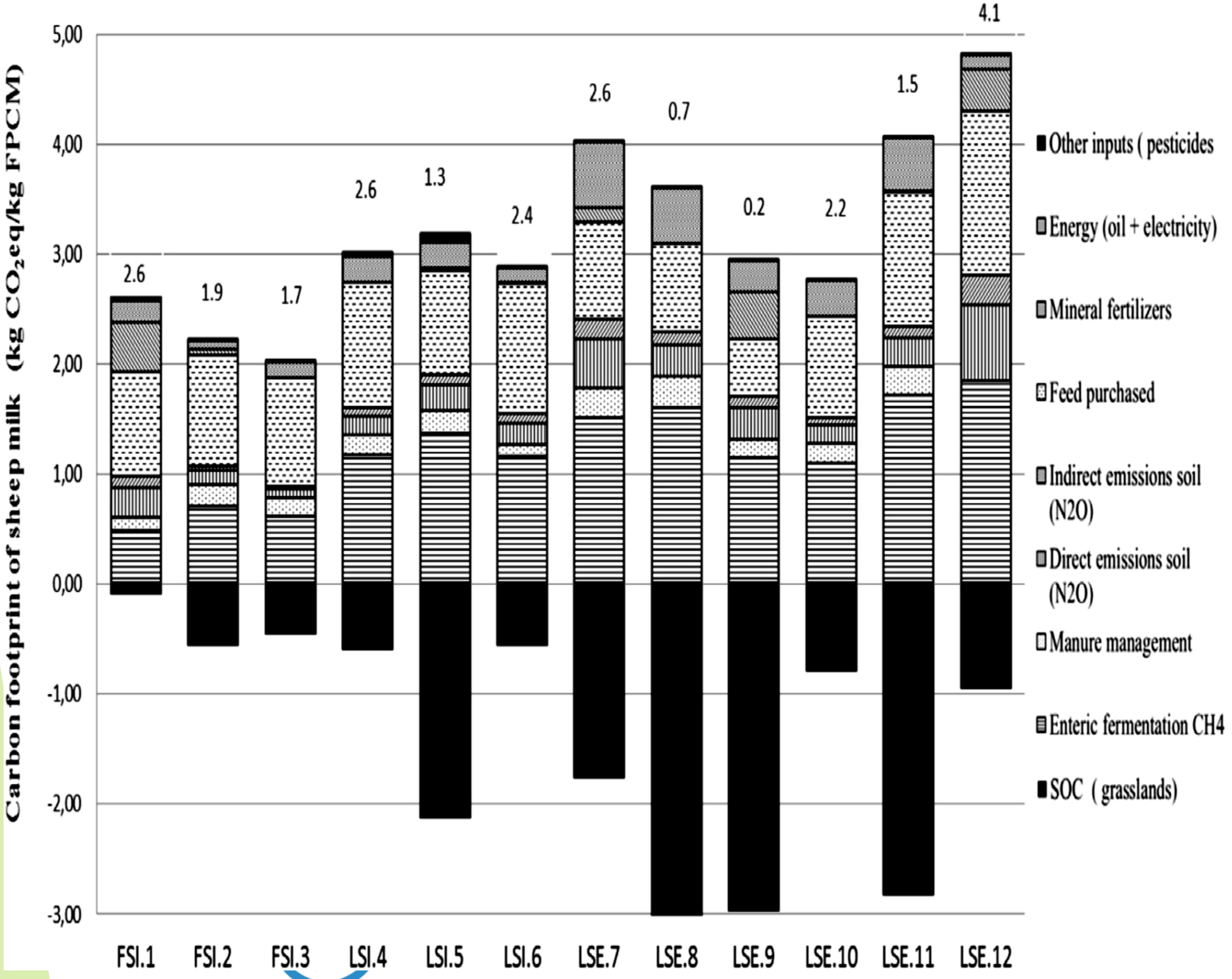
  -FSI: Semi intensive system and foreign breed.
  Kept indoors-no pasture management.

  -LSI: Semi intensive system and local breed.
  Low time grazing per year.

  -LSE: Semi extensive system and local breed.
  Grazing in mountain uplands during summer.

- Carbon footprint estimation (LCA method) + soil carbon sequestration inclusion
- Boundaries: Emissions on farm and emissions associated with production of inputs to the farm. Machinery, buildings and medicines were excluded.

Approaches on farming systems ....



- ✓ The carbon footprint / unit of produced milk ranged from 2.0-to 5.2 kg CO_2eq/kg.
- ✓ the carbon footprint decreased with the increase of milk yield per sheep.
- ✓ more intensive farms with higher levels of milk production per sheep had lower carbon footprint values than more traditional farms with lower efficiency per animal.

BUT, when **soil carbon sequestration** was included in the calculations, **no difference** was found in the carbon footprint of sheep milk from different systems and breeds.

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Approaches on farming systems ….

ELSEVIER

Journal of Cleaner Production

Volume 124, 15 June 2016, Pages 94-102

Environmental assessment of small-scale dairy farms with multifunctionality in mountain areas

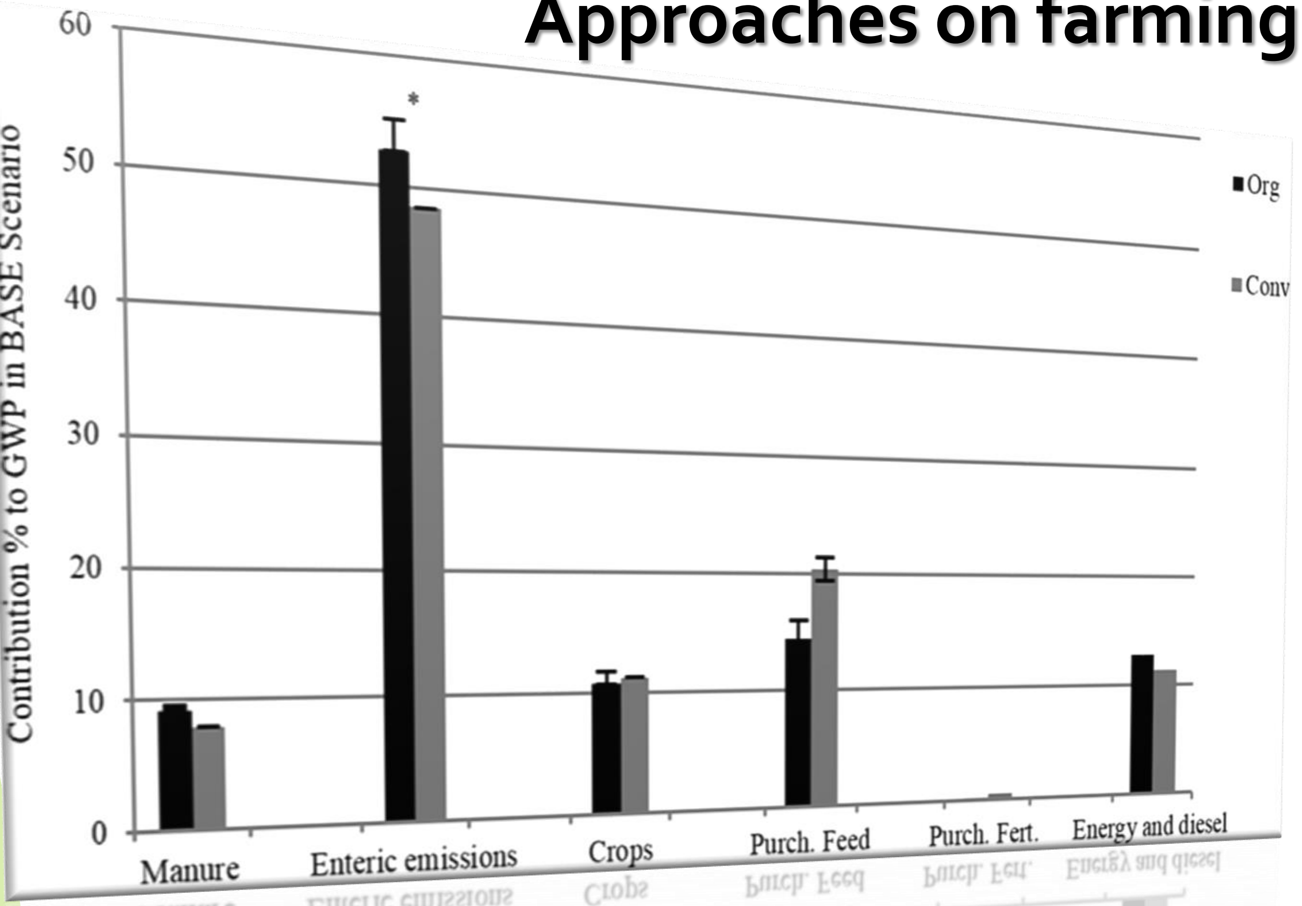
Sara Salvador, Mirco Corazzin, Edi Piasentier, Stefano Bovolenta

- Environmental impact of **organic and conventional** small-scale **dairy farms** in mountain areas

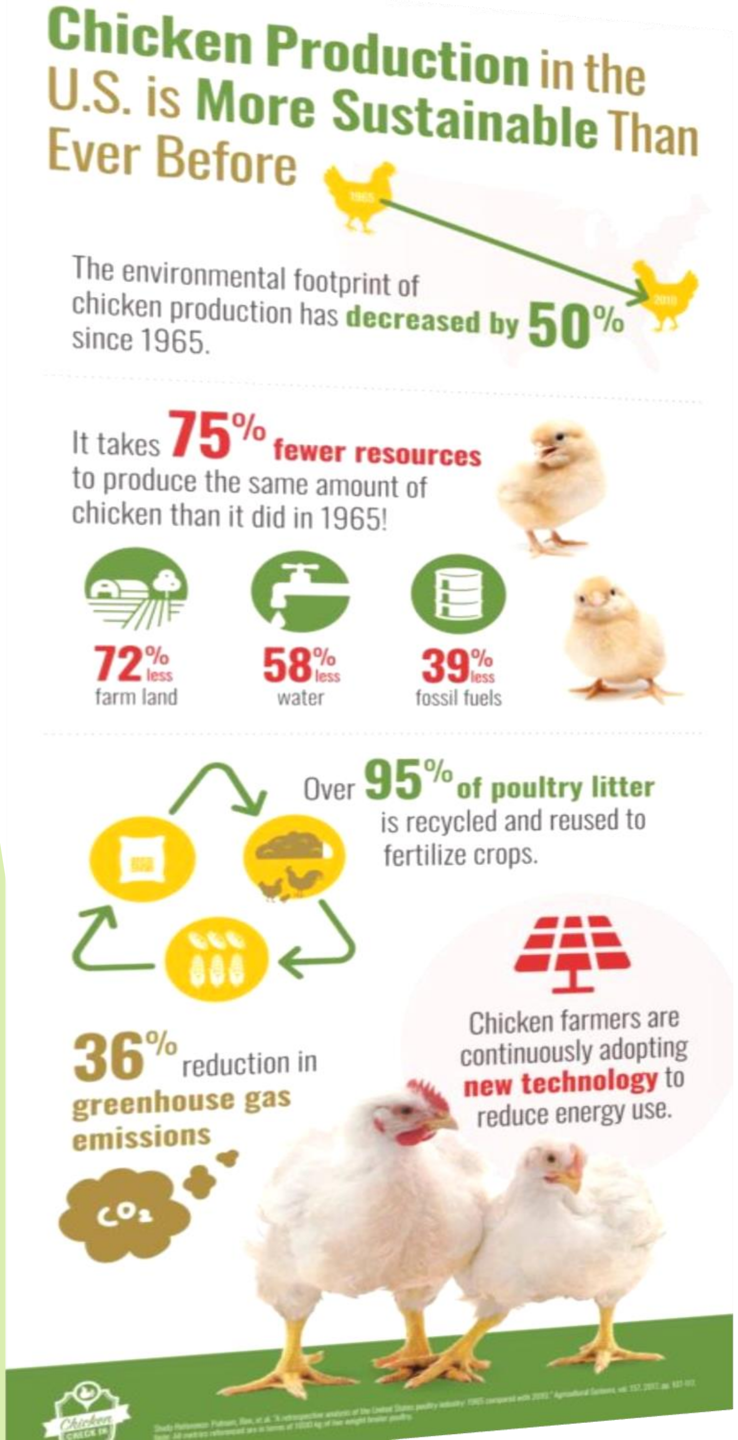
- 16 small-scale dairy farms (East Italian Alps) breeding a local cattle breed, Rendena

- **Boundaries**: all the inputs/processes up to the production of milk. No transport or further processing of milk were included. All the processes related to the on-farm activity (i.e., the animal's rations, manure storage, cropping system, and fuel consumption) were taken into account.

Approaches on farming systems ….



- Over 80% of the total emissions were addressed to milk in both cases, with **a lower percent** in organic farms (82% vs 87%).
- Enteric fermentation were statistically greater in organic farms.
- CO_2-eq emission appeared rather similar between the organic farms and the conventional (either when only produced milk were taken into account or beef as co-product).
- The organic farms had a significantly lower eutrophication impact than the conventional farms.



Approaches on farming systems ….

Producing the same amount of chicken today as 1965 has 50% less impact on the environment.

Many factors contributed to the reduced environmental impact including:

•75% fewer resources required in poultry production;

•39% lesser fossil fuels;

•72% decrease in farm land used in poultry production;

•58% decrease in water used in poultry production.

+++ environmental friendlier energy sources ….

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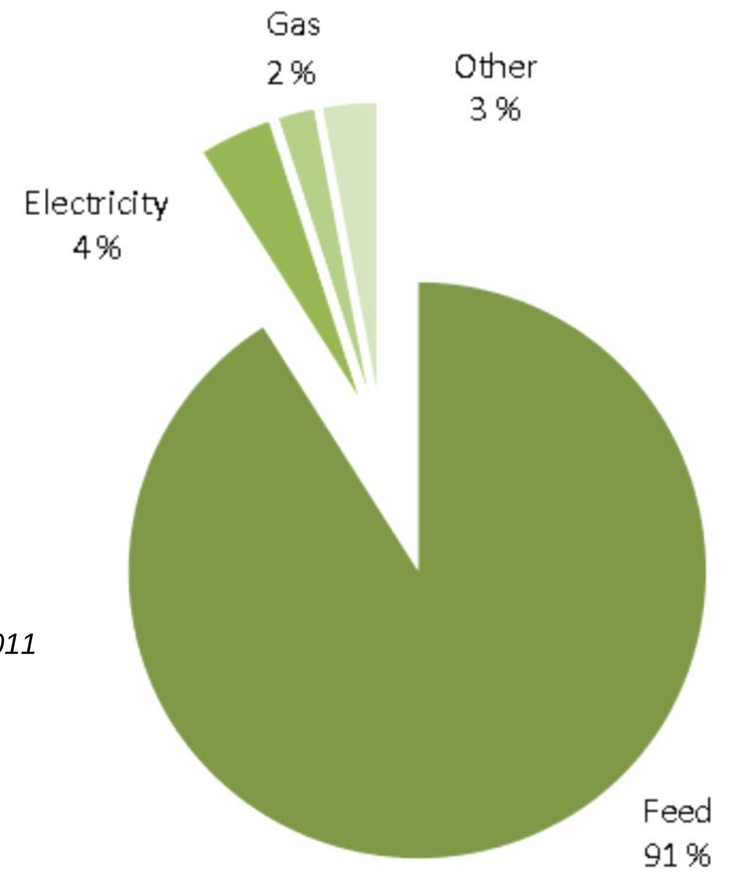
Approaches on farming systems ….

Contribution to the global warming potential (GWP) when producing 1 Danish broiler.

	kg CO_2 eq.
Hatch egg production	0.52
Broiler production incl. manure	2.94
Slaughterhouse	0.39
Total	3.85



Source: Greenhouse Gas Emission from the Danish Broiler Production estimated via LCA Methodology. 2011

Emissions of greenhouse gases per kg bone free chicken meat at the farm gate.

	Kg CO_2-eq per kg bone free meat				
Study	Total	CH_4	N_2O	CO_2	
LCA Food (2006)[1,3]	3.4	0.1	2.0	1.3	
Katajajuuri (2007)[2]	2.7	0.4	1.0	1.3	
Williams et al. (2009)[3,4]	3.4				**Conventional production**
Williams et al. (2009)[3,5]	3.9				**Free range production**
Williams et al. (2009)[3,6]	5.1				**Organic production**
Nielsen et al. (2011), i.e. this study)[7]	3.0	0.1	1.8	1.1	

[1]Results (1.82 kg CO_2 eq./kg live weight) converted from live weight to carcass weight with a factor of 70 %

[2]The functional unit was broiler fillet which was assumed to correspond to bone free meat

[3]Results converted from carcass weight to kg meat with 77 % cutting-out from carcass weight to bone free chicken meat (Sonesson et al., 2009b)

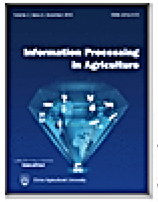
[4]Conventional production

[5]Free range production

[6]Organic production

[7]Results in this report was converted from carcass weight (1489 g) to kg meat with 77 % cutting-out from carcass weight to bone free meat, i.e. per broiler 1147 g of bone free chicken was produced (1489*0.77). The GWP from the hatch egg production was included but the GWP from the slaughterhouse was excluded

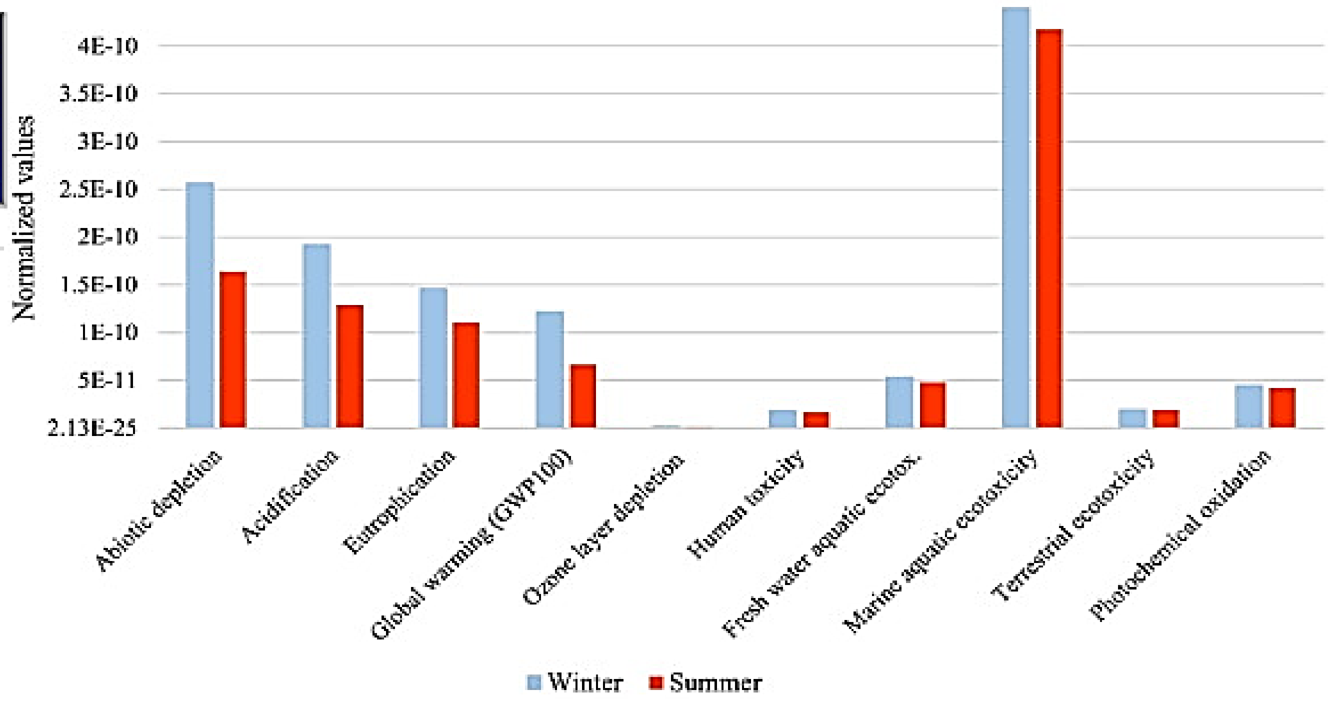
Information Processing in Agriculture
Volume 3, Issue 4, December 2016, Pages 262-271



Environmental impact assessment of chicken meat production using life cycle assessment

Talayeh Kalhor, Ali Rajabipour, Asadollah Akram, Mohammad Sharifi

- *Case 1:* Production of chicken meat in **summer**.
- *Case 2:* Production of chicken meat in **winter**.
- 40 broiler producers+ 1 slaughterhouse (Iran)
- The system boundary comprised all inputs from
  -the broiler production in farms (e.g. feed ingredients and detergents production) to the slaughterhouse gate (packed meat).
  -No further environmental impacts after the slaughterhouse were included.
- Machinery and buildings were not considered in the calculations.



Comparing 1 ton 'chicken meat production' of summer and winter at slaughterhouse; Method: CML 2 baseline 2000 V2.04/ World, 1990/ normalization

- The global warming potential, acidification and eutrophication for production of 1 ton packed meat were higher in winter than in summer.
- The production stage was the main source of environmental impacts (over 50%)

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Approaches on farming systems ….

Predicting the environmental impacts of chicken systems in the United Kingdom through a life cycle assessment: Egg production systems

I. Leinonen,*[1] A. G. Williams,† J. Wiseman,‡ J. Guy,* and I. Kyriazakis*

Global warming potential (1,000 kg of CO_2, 100-yr timescale) for the 4 different systems considered per 1,000 kg of eggs

Material or activity	Cage	Barn	Free range	Organic
Feed + water	2.10	2.22	2.36	2.41
Electricity	0.24	0.48	0.20	0.24
Gas + oil	0.09	0.14	0.18	0.18
Housing + land	0.38	0.48	0.50	0.54
Manure + bedding	0.11	0.13	0.14	0.06
Breeder	0.05	0.04	0.03	0.04
Pullet	0.51	0.55	0.57	0.60
Layer	2.36	2.86	2.78	2.78
Total	2.92^{c} (0.21)	3.45^{b} (0.26)	3.38^{abc} (0.27)	3.42^{ab} (0.34)

$^{a-c}$Different superscripts indicate statistical difference ($P < 0.05$) between systems as based only on A uncertainties, which were considered to vary between systems.

2012 Poultry Science 91 :26–40

Acidification potential (kg of SO_2 equivalent) for the 4 different systems considered per 1,000 kg of eggs

Material or activity	Cage	Barn	Free range	Organic
Feed + water	8.25	8.69	9.24	9.72
Electricity	0.99	1.98	0.84	0.98
Gas + oil	0.15	0.21	0.29	0.25
Housing + land	18.45	20.61	22.58	26.04
Manure + bedding	25.30	27.95	31.17	54.65
Breeder	0.75	0.55	0.52	0.54
Pullet	7.94	7.82	8.02	26.23
Layer	44.45	51.06	55.59	64.86
Total	53.14^c (5.23)	59.43^b (5.99)	64.13^b (6.90)	91.63^a (8.66)

$^{a-c}$Different superscripts indicate statistical difference ($P < 0.05$) between systems as based only on A uncertainties, which were considered to vary between systems.

Eutrophication potential (kg of PO_4 equivalent) for the 4 different systems considered per 1,000 kg of eggs

Material or activity	Cage	Barn	Free range	Organic
Feed + water	7.80	8.23	8.76	21.90
Electricity	0.00	0.00	0.00	0.00
Gas + oil	0.01	0.01	0.02	0.02
Housing + land	3.43	3.83	4.20	4.84
Manure + bedding	7.23	8.24	9.05	10.84
Breeder	0.29	0.21	0.21	0.22
Pullet	2.67	2.62	2.68	7.63
Layer	15.51	17.49	19.13	29.76
Total	18.47^c (1.57)	20.32^b (1.78)	22.03^b (2.01)	37.61^a (4.21)

$^{a-c}$Different superscripts indicate statistical difference ($P < 0.05$) between systems as based only on A uncertainties, which were considered to vary between systems.

2012 Poultry Science 91 :26–4

- Relatively large differences in many categories of the environmental impacts between the 4 different egg production systems. Main contributors apart production itself: feed, manure, electricity.

- Differences in productivity largely affected the differences in the environmental impacts between the systems.

Contribution to the global warming potential (GWP) when producing 1 kg Danish organic eggs.

	kg CO_2 eq/kg eggs
Pullet production	0.28
Egg production	1.52
Total	1.80

Reference	Kg CO_2-eq per kg eggs
LCA Food (2006)[1]	2.0
Carlsson et al. (2009)[2]	1.4
Baumgartner et al. (2008)[1]	2.7
Wiedemann et al. (2011)[1]	1.3
Wiedemann et al. (2011)[3]	1.6
Williams et al. (2009)[1]	1.5
Williams et al. (2009)[3]	1.7
Williams et al. (2009)[2]	1.8

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1: conventional/cage production; 2: organic production; 3: free range production

Livestock Science 232 (2020) 103906

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journal homepage: www.elsevier.com/locate/livsci

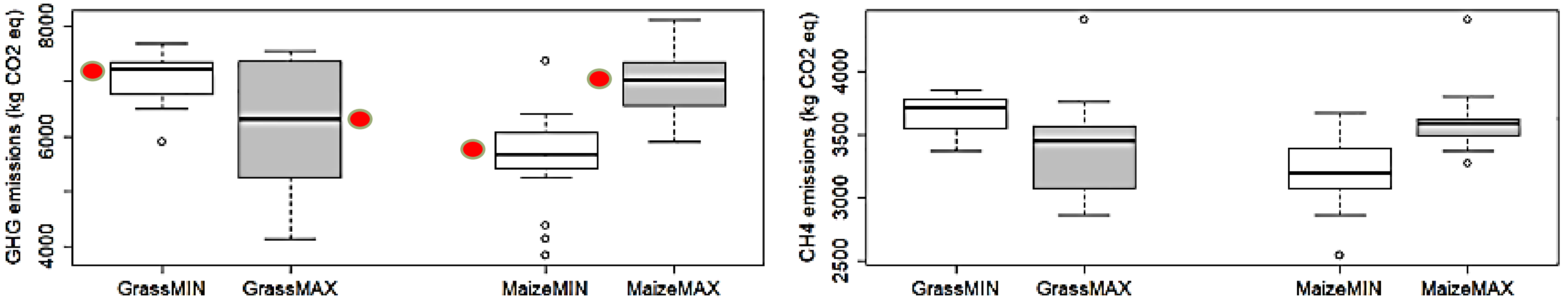
Sensitivity of greenhouse gas emissions to extreme differences in forage production of dairy farms

Check for updates

Tristan SENGA KIESSE*, Michael S. CORSON, Gwenola LE GALLUDEC, Aurélie WILFART

- 78 dairy cattle farms in Normandy (France)
- Holstein breed, Normande or cross-breeds
- 15–20% of dairy farms with extreme minimum amounts of dry matter (DM) intake from pasture grass or maize silage
- 10–15% of farms with extreme maximum amounts of DM intake from one or the other source (grass or maize)

Gross emissions (emissions /farm/year)



CO_2

- Farms with high DM intake from grass (**GrassMax**) had 13% **lower** global warming potential than farms with low DM intake (**GrassMIN**)
- Farms with high DM intake from maize (**MaizeMax**) had 25% **higher** warming potential than farms with low DM intake (**MaizeMIN**)
- On farm energy consumption did not differ.

CH_4

- Same trends like GHG emissions for CH_4 emissions .

  - 6% lower for GrassMAX than GrassMIN

  - 12% higher for MaizeMAX than MaizeMIN

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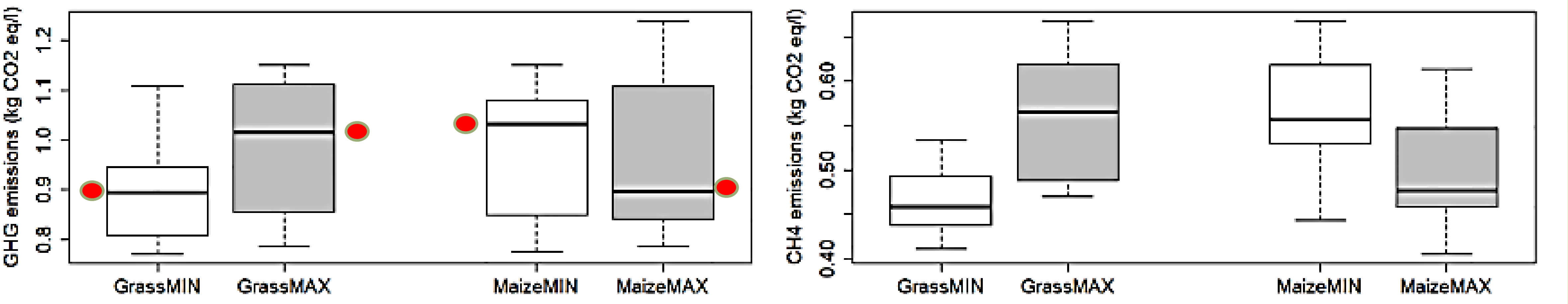
Emissions (expressed in 1 lt produced milk)



CO_2

- Farms with high DM intake from grass (**GrassMax)** had 17% higher global warming potential than farms with low DM intake (**GrassMin**).
- Farms with high DM intake from maize (**MaizeMax**) had 1% lower warming potential than farms with low DM intake (**MaizeMax).**
- On farm energy consumption did not differ.

CH_4

- Same trends like GHG emissions.

  - 20% larger for GrassMAX than GrassMIN

  - 11% lower for MaizeMAX than MaizeMIN

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Conclusions….

- Impacts of farming systems on climate change is a certainty, but the "gravity" of this impact depends on the studied livestock's **boundaries**.

- Farming system **practices** (i.e. organic farming, DM intake, manure treatment etc.) influence the environmental impact of a livestock.

- Although many farming systems withing the same or different species have been studied results are not (**easily**) comparable due to different approaches (different functional units, boundaries, statistical analysis etc.).

- Common agreed guidelines for comparing the impact level of each livestock farming system on climate change may be a solution or case study approach would be a more accurate solution.

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