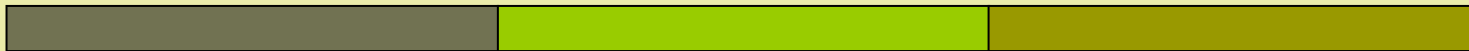


Greenhouse gas emissions of Spanish sheep farming systems: allocating between meat production and ecosystem services



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Introduction

- 2006: Publication of “Livestock's long Shadow” (Steinfeld *et al.*)
- Major impact of animal production increased public and scientific debate.
- Life cycle assessment (LCA) is a holistic method to evaluate the environmental impact during the entire life cycle of a product.
- Many studies quantify the greenhouse gas (GHG) emissions of livestock products from an LCA perspective: beef, pork, chicken, milk and eggs.
- Only few studies on sheep meat production are available.

- Sheep farming systems (SFS) in Mediterranean areas are considered extensive.
- Wide diversity in utilization of inputs, land use and productivity across regions and farms.
- Despite the well-known negative effects, livestock have also many positive side effects.
- Grazing-based SFS are specially multifunctional, with multiple economic, environmental and social functions.
- A holistic approach should consider the ecosystem services provided by livestock.

Goal

Evaluation of the greenhouse gas emissions of three contrasting sheep farming systems in Spain and to account for the ecosystem services provided.



Materials and Methods

Description of 3 systems:

1. Grazing or pastoral system:

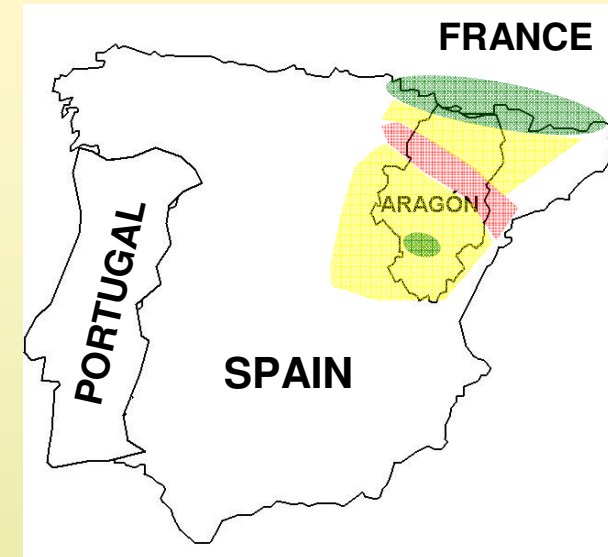
- Alpine mountains.
- 1 lambing per ewe per year.
- Free ranging.

2. Mixed sheep-cereal crop system:

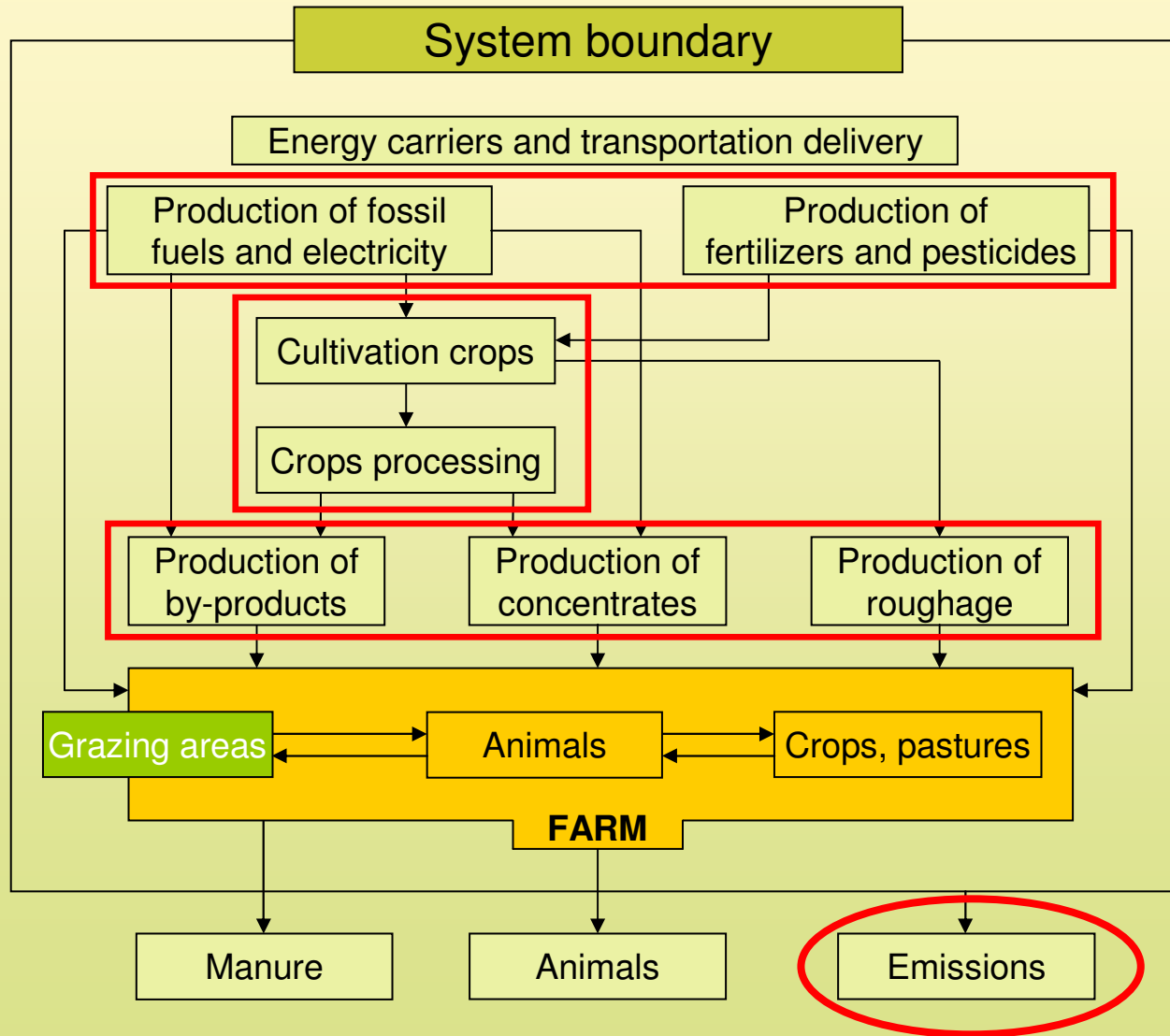
- Mid-altitude Mediterranean ranges and plateaus.
- 3 lambings per ewe every 2 years.
- Grazing daily with shepherd.

3. Industrial system or zero grazing:

- Low altitude semi-arid conditions.
- 5 lambings per ewe every 3 years.
- Kept indoors all year round.



System boundaries and delimitations:



The model framework

- A model was performed to compute emissions from all processes and inputs.
- Functional unit: one kg of live weight.
- Calculations are based on IPCC guidelines (IPCC, 2006).
- Global Warming Potential (GWP) values to convert CH₄ and N₂O into CO₂-eq were 25 and 298 respectively (IPCC, 2007).
- Ecosystem services provided by SFS were valued based on agri-environmental measures from CAP (green payments) regarding sheep production.
- GHG emissions were assigned to meat production or ecosystem services following an economic allocation.

Results

GHG emissions from each SFS

	Total production	Live-weight	Lamb-meat
	Tones of CO ₂ -eq	kg CO ₂ -eq / kg	kg CO ₂ -eq / kg
Grazing	202	28.4	56.7
Mixed	357	24.3	48.5
Zero grazing	1021	19.5	38.9

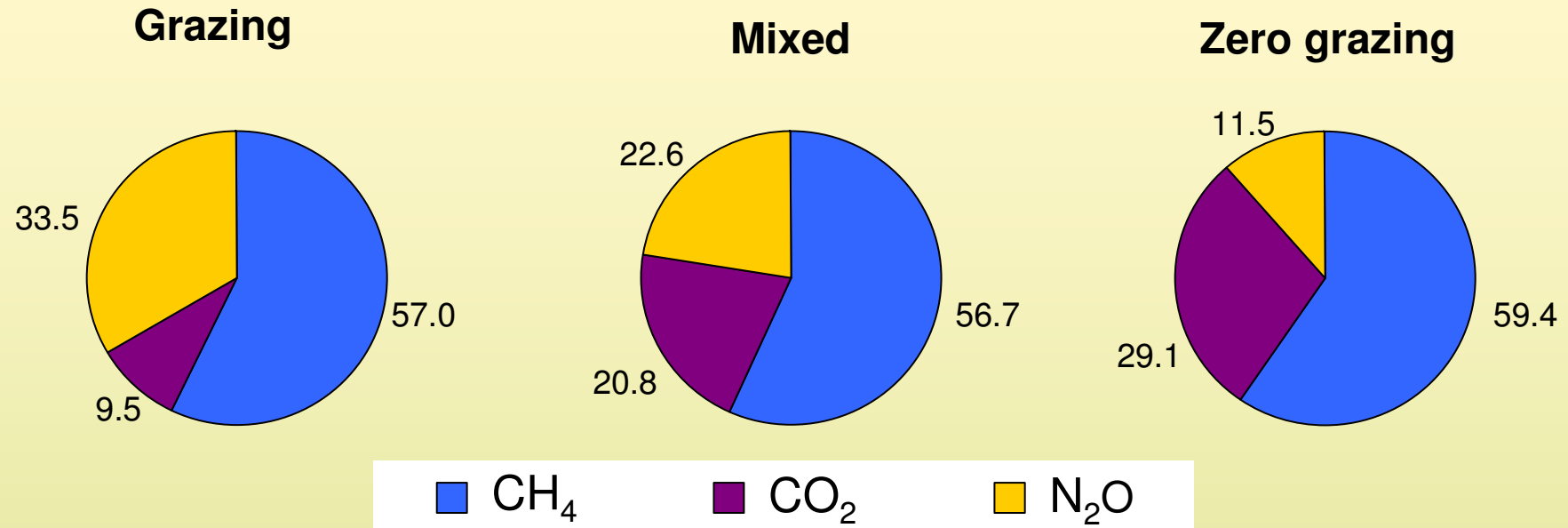
- GHG emissions per kg of product decrease according to a gradient of intensification.
- Several factors explain these results, but productivity plays a major role.
- Other studies in sheep meat production:
 - 8.1 – 143.5 kg CO₂-eq / kg (Edward-Jones et al., 2009)
 - 17.5 – 10.1 kg CO₂-eq / kg; conventional and organic respectively (Williams et al., 2006)
- Beef: 14 - 32 kg CO₂-eq / kg (De Vries and De Boer, 2010)

GHG emissions corrected for each SFS

	No allocation	Allocation	Corrected
	kg CO ₂ -eq / kg LW		kg CO ₂ -eq / kg LW
Grazing	28.4	53.6 %	15.2
Mixed	24.3	73.9 %	18.0
Zero grazing	19.5	100 %	19.5

- Besides food supply, SFS may also provide ecosystem services to society (biodiversity, landscape, wildfires prevention, etc.).
- CAP agri-environmental measures are to compensate loss of income for undertaking such measures (economic value).
- GHG emissions per kg of product increase according to a gradient of intensification.
- Provision of ecosystem services has a cost, not only in economic terms, but also in GHG emissions.

Contribution of CH₄, CO₂ and N₂O in % to total emissions



- CH₄ is the major contributor in each SFS and remains almost steady across the systems.
- N₂O and CO₂ contribution vary depending on the system.
- Use of fossil fuels is responsible for differences of CO₂ contribution.
- Deposition of manure on pastures is related to high N₂O emissions.

Conclusions

- When **no allocation** is performed: Spanish sheep-meat systems emitted from **19.5** to **28.4** kg CO₂eq/kg of live weight; decreasing according to the intensification level.
- When **allocation** is performed: Spanish sheep-meat systems emitted from **15.2** to **19.5** kg CO₂eq/kg of live weight; increasing according to the intensification level.
- There is an important lack of studies and data from an LCA perspective for agricultural and livestock products in Spain.
- Sheep Farming Systems are very diverse and complex and thus, their environmental impacts are difficult to evaluate from a holistic perspective.
- Provision of ecosystems services should be considered and integrated into a standard evaluation framework for environmental impacts.



Thanks for your attention!

