Evaluating ecosystem services and disservices of livestock agroecosystems for targeted policy design and management

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Outline

1. Introduction: ES and EDS of pasture-based livestock systems
2. ES valuation and management (PES)
   – Effect of farming practices on ES
   – PES framework
3. EDS valuation (LCA)
1. Introduction

intensive vs. extensive

Imported feeds
Small (zero) land areas
High input
High output
No multifunctional
Ecosystem disservices

Natural resources
Large land areas
Low input
Low output
Multifunctional
Ecosystem services
Diversity of systems

**Harvest (kg DM)**
- Mountain sheep: 8,922
- Mixed sheep-crops (integrated): 68,738
- Mixed sheep-crops (non-integrated): 373,592

**Self-consumption (%):**
- Mountain sheep: 100
- Mixed sheep-crops (integrated): 100
- Mixed sheep-crops (non-integrated): 35

**Sales (%):**
- Mountain sheep: 0
- Mixed sheep-crops (integrated): 0
- Mixed sheep-crops (non-integrated): 65

**Feeding (%):**
- Grazing
- In-door

**Grazing resources (%):**
- Pastures
- Forages
- Stubbles

Bar and pie charts showing the distribution of grazing resources and feeding for each category.
E.g. resources embedded in lamb meat

Rodriguez-Ortega et al. (2017)
2. ES valuation and management (PES)
ES framework

Objectives

• Evaluate, according to expert knowledge, the contribution of farming practices to ES in Mediterranean agro-ecosystems

• Design a PES system based on management
What ES are relevant to society?

- Provisioning
  - Food (meat and milk)
  - Raw materials (lumber, forage)
  - Water
  - Genetic resources
  - Medicinal resources
  - Ornamental resources

- Regulating
  - Disturbance prevention (forest fires)
  - Water purification/waste management
  - Soil fertility/erosion prevention
  - Air quality regulation
  - Regulation of water flows
  - Climate regulation (incl. C seq.)

- Supporting
  - Gene pool protection (biodiversity maintenance)
  - Lifecycle maintenance (nutrient cycling, photosynthesis)
  - Aesthetic (landscape/vegetation)

- Cultural
  - Recreation/tourism
  - Spiritual experience
  - Culture/art
  - Education/cognitive dev.
What ES are relevant to society?

Bernués et al. (2014)
Effect of agricultural practices on ES

• 10 sheep and mixed farms monitored
• 36 farming practices (out of 66 possible)

• Delphi panel (2 rounds)
  • Researches (n=29)
  • Technicians/managers (n=32)
    • Self appraisal on knowledge
    • Contribution of practices to ES (Likert scale: 0 none to 5 very high)
Effect of agricultural practices on ES

Contribution of farming practices on *wildfires prevention*

1º. 36-Active management of forest (forestry/silviculture)
2º. 30-Grazing in remote and/or abandoned areas
3º. 29-Grazing in semi-natural habitats
4º. 32-Moving flocks seasonally between areas (e.g. from valley to mountain)
5º. 31-Grazing with several species (mixed or sequential grazing)
6º. 8-Retention of drove roads, tracks and paths
7º. 28-Extend grazing annual period
8º. 2-Maintaining grasslands
9º. 33-Maintaining meadow mowing
10º. 7-Retention of water points (ponds, springs,...)
11º. 35-Adapting stocking rate to the carrying capacity of agro-ecosystem
12º. 1- Maintaining semi-natural vegetation (trees and shrubs) of the area
13º. 17-Maintaining fallows in rotation
14º. 3-Managing land in small plots
15º. 4-Retention of hedges, shrubs and trees among arable fields
## Effect of agricultural practices on ES

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Landscape</th>
<th>Biodiversity</th>
<th>Wildfires</th>
<th>Carbon seq.</th>
<th>Quality prod.</th>
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</table>

**Farming Practices**

1 - Maintaining semi-natural vegetation (trees and shrubs) of the area
2 - Maintaining grasslands
4 - Retention of hedges, shrubs and trees among arable fields
10 - Growing locally adapted crop varieties and breeds
20 - Reducing ploughing/tilling
22 - Utilizing manure correctly
23 - Reducing pesticide use
26 - Reducing proportion of animal concentrates
27 - Reducing off-farm dependency (e.g. feed, fertilizers)
29 - Grazing in semi-natural habitats
30 - Grazing in remote and/or abandoned areas
31 - Grazing with several species (mixed or sequential grazing)
32 - Moving flocks seasonally between areas (e.g. from valley to mountain)
35 - Adapting stocking rate to the carrying capacity of agro-ecosystem
36 - Active management of forest (forestry/silviculture)
PES design

FARM
Adoption of beneficial agricultural practices (AP)
- AP₁
- AP₂
- AP₃
- ...

RESEARCH
Contribution (C) of agricultural practices to ecosystem services
- ES₁
- ES₂
- ES₃
- ...

% of contribution

SOCIETY
Ecosystem services (ES) prioritization & valuation

POLICY
Monitoring of beneficial agricultural practices
Budget allocation according to % of contribution
Budget: €
An example

‘Sierra and Cañones de Guara’ Natural Park

Based on Preference of population according to their WTP for ES

Top 5 farming practices
1º. Moving flocks seasonally between areas (e.g. from valley to mountains)
2º. Grazing in semi-natural habitats
3º. Active management of forest (forestry/silviculture)
4º. Maintaining grasslands
5º. Extend grazing annual period
3. EDS valuation (LCA)

e.g. carbon footprint of lamb: a comparison of three contrasting Mediterranean 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.
Where are GHG coming from?

Off-farm feeds

Land (on-farm)

Animals

Manure

Feed basket

External inputs

Products Services

Vellinga (2010)
Contribution of CH$_4$, CO$_2$ and N$_2$O in % to total emissions

- CH$_4$ is the major contributor in each SFS and remains almost steady across the systems.
- N$_2$O and CO$_2$ contribution vary depending on the system.
  - Use of fossil fuels is responsible for differences of CO$_2$ contribution.
  - Deposition of manure on pastures is related to high N$_2$O emissions.
Trade-offs within sustainability pillars
E.g. carbon footprint of lamb meat and ES

<table>
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<th>No allocation</th>
<th>Allocation</th>
<th>Corrected</th>
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<tr>
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<td>kg CO₂-eq / kg LW</td>
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<tr>
<td>Grazing (1L/1Y)</td>
<td>25.9</td>
<td>53.6 %</td>
<td>13.9</td>
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<tr>
<td>Mixed (3L/2Y)</td>
<td>24.0</td>
<td>73.9 %</td>
<td>17.7</td>
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<tr>
<td>Zero grazing (5L/3Y)</td>
<td>19.5</td>
<td>100 %</td>
<td>19.5</td>
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- Non-marketable
- Inherently linked to extensive livestock farming systems

Ripoll-Bosch et al, 2013
Mitigation in feed, the options

What’s better?

- Edible
  - High digestible
  - Low digestible

- Non Edible

Sheep

Beef

Dairy

Swine

Poultry

EMISSIONS PER FUNCTIONAL UNIT
Other limitations

• Direct comparisons are difficult: functional unit, system boundary, allocation method…
• Land use issues: communal pastures, transhumance…
• Carbon sequestration: sequestration potential, soil dynamics, grassland management…
• Data availability, variability…
• Incorporation of multifunctionality, non-use values…
Thank you