Sustainable livestock farming systems - methodologies for trade-offs and synergies

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Outline

1. Sustainability: a complex dynamic concept
   - different understandings
   - trade-offs (among sustainability pillars)
   - trade-offs (within sustainability pillars)
3. Tools to explore trade-offs and win-wins under uncertainty
4. Conclusion: responsible & responsive agriculture
1. Sustainability: a complex dynamic concept

Systems theory:
- from parts to the whole
- from objects to relationships
Sustainability and multi-functional agriculture

The inescapable interconnectedness of agriculture’s different roles and functions

- Health
- Social
- Culture
- Gender
- Tradition

Economic
- Income
- Trade
- Marketing

Food production
- Valuation of environmental services
- Recognition and diversified land use
- Cultivation and commercialization of traditional foods

Environmental
- Water
- Climate
- Biodiversity
- Soils

Social
- Cognitive and social capital
- Social structure
- Social interaction

Agriculture's role in:
- Health
- Social
- Culture
- Gender
- Tradition

Sustainability and multi-functional agriculture
Importance of time

Conceptual framework to study sustainability of LFS

- **multi-functionality**
  - landscape, biodiversity, (ecosystem services)

- **other sectors of the economy**
  - tourism, urbanization, infrastructures

- **management**
  - intensification vs. extensification

- **social factors**
  - family and labour

- **economics**
  - profitability

- **environment**
  - land use, natural resources

**farm**

- **agricultural policies**
  - other sectorial policies
  - trade agreements

- **markets/consumers**
  - consumption trends
  - costs, prices

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- **global change**
  - population
  - energy

- **climate change**
  - droughts, variability, extreme events

- **environment**
  - (institutional, socio-economics, physical)

Sustainability of pasture-based livestock farming systems in the European Mediterranean context: synergies and trade-offs (Bernués et al., 2011)
2. Sustainability assess.: holistic, bottom-up
Sustainability understandings

Farmers indicators for sustainability:
1. **Labour profitability** (Net Margin per Working Unit)
2. Farm **continuity** (15 years, scale)
3. **Diversification** in sources of income (# products)
4. **Salary level** (labour profitability against average salary)
5. Feed **self-sufficiency** (on-farm feed/ total feed)

Policy makers’ priorities
- Climate change (GHG)
- Pollution
- Water
- Land use change
- Landscape
- Biodiversity

Farmers’ priorities
- Maximize grazing
- Energy efficiency
- Use of communals
- Stocking rate
- Local breeds
- Wildlife conflicts

Importance of indicators
- 46% economics
- 35% social
- 19% environmental
Trade-offs among sustainability pillars

An integrated sustainability assessment of Mediterranean sheep farms with different degrees of intensification (Ripoll-Bosch et al., 2012)
**Trade-offs within sustainability pillars:**

**E.g. carbon footprint of lamb meat**

*Accounting for multifunctionality in carbon footprint of lamb meat (Ripoll-Bosch et al., 2013)*

<table>
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<th>No allocation (kg CO₂-eq / kg LW)</th>
<th>Allocation (%)</th>
<th>Corrected (kg CO₂-eq / kg LW)</th>
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<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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- **Multifunctional agriculture**
  - Private goods
    - Animal products
  - Public goods and services
    - Conservation of biodiversity
    - Maintenance of cultural landscape
    - Prevention of hazards: forest fires (Med.)
  - Etc.

- **Non-marketable**
- **Inherently linked to extensive livestock farming systems** IEEP (2009)
3. Trade-offs and synergies under uncertainty

Decision Support Systems:
- bio-economical modelling

Stochastic dynamic simulation
+ Multi-objective optimization
Simulation module

**ANIMAL**
- Voluntary Intake (AFRC)
- Body condition score
- Reproduction (seasonality)

**FLOCK**
- Herd dynamics
- Management Practices
  - Grazing
  - Supplementation
  - AI, rams, etc.

**FARM**
- Grazing resources
- Off-farm resources
- Economy
  - Costs
  - Incomes
Optimization module: genetic algorithms

evolutionary optimization
based on mimicking the
natural selection process that
allows species to adapt to
environment
Synergies between functions: Pareto frontier

Fitness (objectives):
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• minimize GHG emissions

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Synergies between functions: real example

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• minimize economic loss

Herd of 50 milking ewes
• diverse lambing date
• diverse milk potential
• 3 rations during lactation
• animals managed in 1 batch

Pareto frontier

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4. Responsible/Responsive LFS

- Scenario of stability
  - Efficiency
  - Productivity
  - Specialization

- Scenario of change
  - Adaptation
  - Resilience
  - Diversification

Uncertainty
Control of the environment (physical & socio-economic)

Specialization
Diversification

Efficiency
Productivity

4. Responsible/Responsive LFS
New system design (paradigm)

- Linear
- Non-renewable
- Global
- Specialized
- Input-based

- Circular (blue)
- Renewable
- Local/ regional
- Diversified
- Knowledge-based