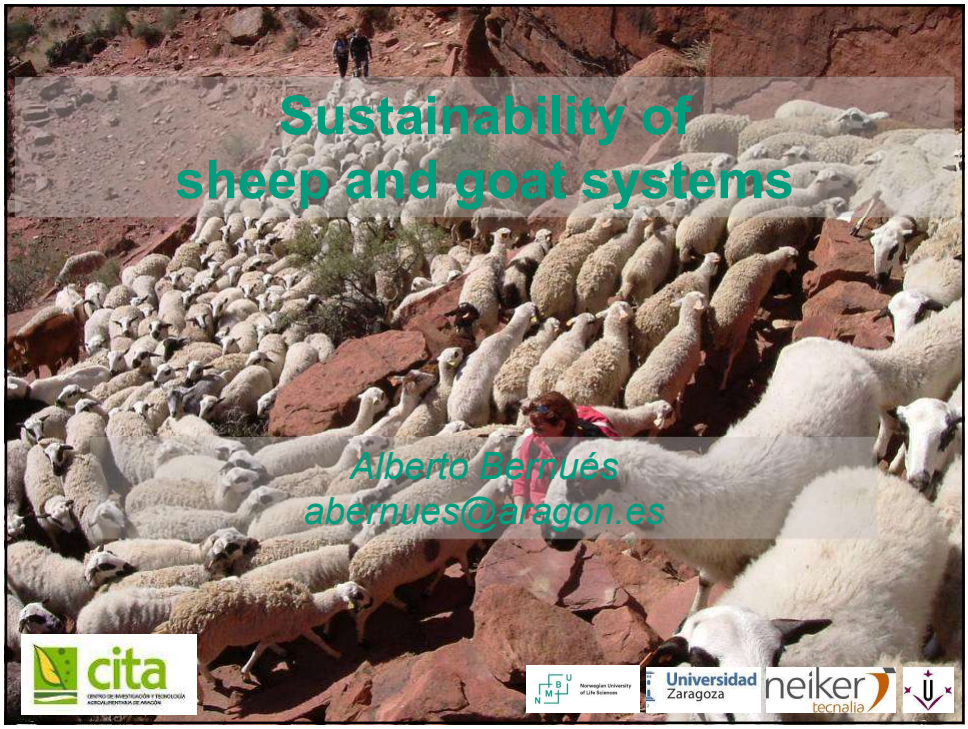


Outline

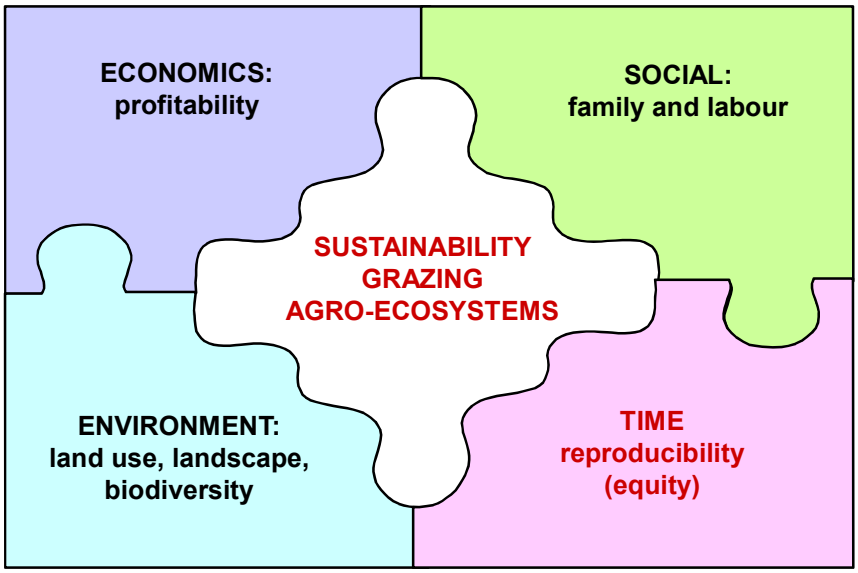
1. Introduction
2. Sustainability assessment
3. Animal production and the environment
   - 3.1 Carbon footprint
   - 3.2 Ecosystem services
4. Wrap-up

1. Introduction

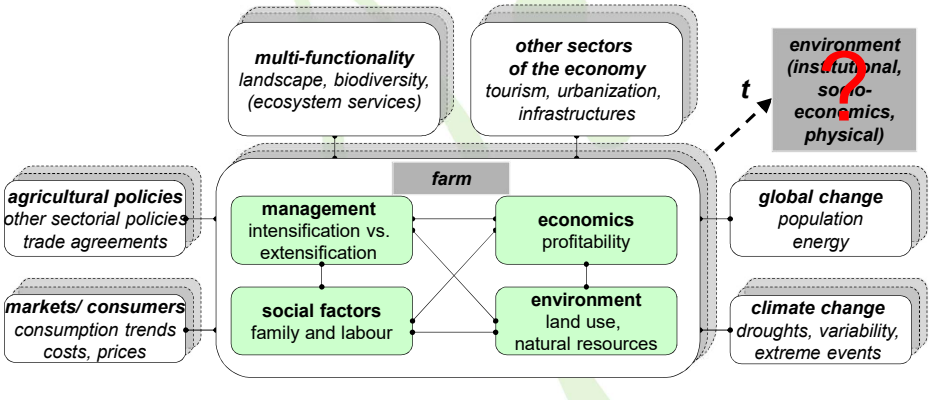
A definition…

"Sustainable development is development that meets the **needs** of the present without compromising the ability of **future generations** to meet their own needs." (UN Brundtland report, 1987)

Sustainability is the capacity to **endure**… it is the **long-term** maintenance of **responsibility**, which has **environmental**, **economic**, and **social** dimensions

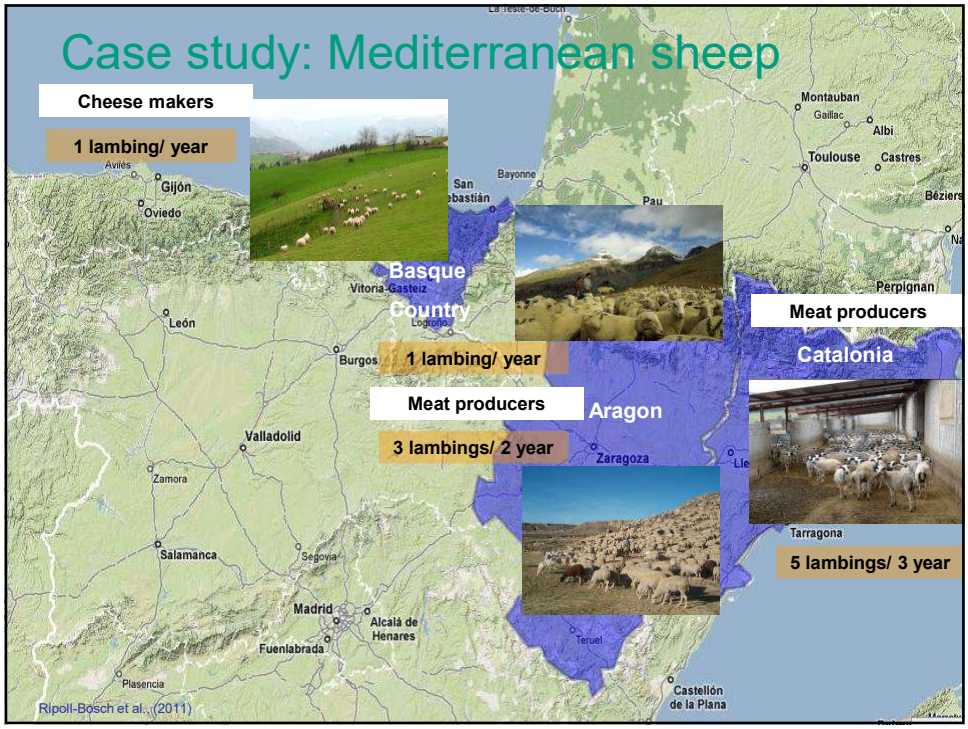


Conceptual framework to study sustainability of agro-ecosystems



2. Sustainability assessment

Case study: Mediterranean sheep



Sustainability issues: participatory SWOT analysis

Weaknesses and Threats:

- ✓ Low productivity
- ✓ Access to land
- ✓ Continuity and generational turnover
- ✓ Abandonment of grazing
- ✓ CAP dependency
- ✓ Increasing dependence on inputs and raising prices
- ✓ Low prices of raw products
- ✓ Conflicts between agriculture and conservation (predation)

Strengths and Opportunities:

- ✓ Systems integrated within their environments
- ✓ Availability of local resources
- ✓ Agro-silvo-pastoralism
- ✓ Low environmental impact
- ✓ Landscape maintenance
- ✓ Adding value activities (cheese)
- ✓ Quality Labels (PDO,PGI)

cita
CENTRO DE INVESTIGACIÓN Y TECNOLOGÍA AGROALIMENTARIA DE ARAGÓN

Indicators, attributes and pillars

ATRIBUTE	INDICATOR	Pillar	INDICATOR	Pillar
Productivity (8)	**Labour productivity 16%**	€	Feed efficiency 13%	€
	Animal productivity 15%	€	Animal sales 12%	€
	Economic efficiency 14%	€	Herd fertility 9%	€
	Land productivity 13%	€	Animal/ WU 8%	€
Stab, rel, res. (5)	**Farm continuity 32%**	S	Facilities 15%	S
	Off-farm income 22%	€	Wildlife conflicts 10%	E
	Advisory services 21%	S		
Adaptability (7)	**No. Incomes 23%**	€	Distance markets 10%	S
	Main agric. income 17%	€	Communal areas 10%	E
	Education 16%	S	Distance to	S
	Land access 17%	S	Slaughterhouse 7%	
Equity (10)	**Salary level 14%**	S	Distance to services 11%	S
	Satisfaction level 13%	S	Hired labour 8%	S
	Grazing 13%	E	Leisure time 6%	S
	Energy efficiency 13%	E	Stocking rate 6%	E
	Protected areas 11%	E	Local breeds 5%	E
Self-sufficiency (7)	**Feed self-sufficiency 18%**	€	Own area 13%	€
	Forage self-sufficiency 16%	€	Subsidies 13%	€
	Indebtedness 15%	€	Added-value 11%	€
	Family labour 14%	S		

Stakeholders perception of sustainability: farmers point of view

Importance of indicators
- 46% economics
- 35% social
- 19% environmental

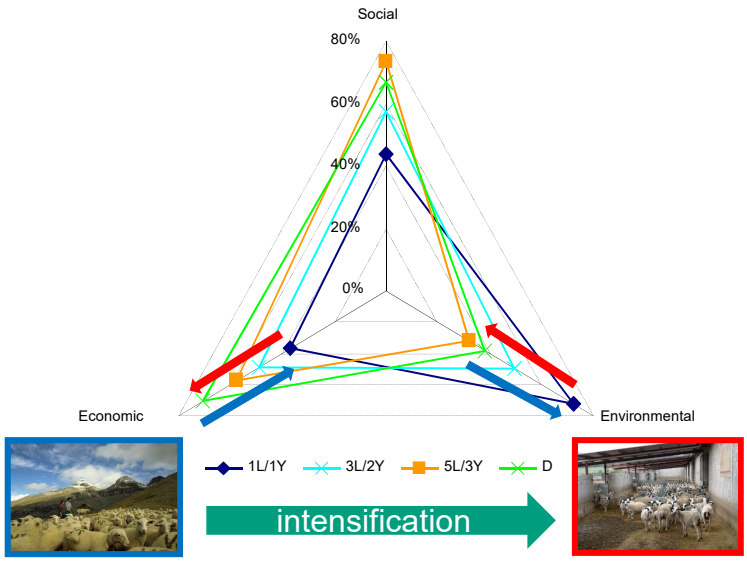
Top 3 per attribute
- 60% economics
- 33% social
- 7% environmental

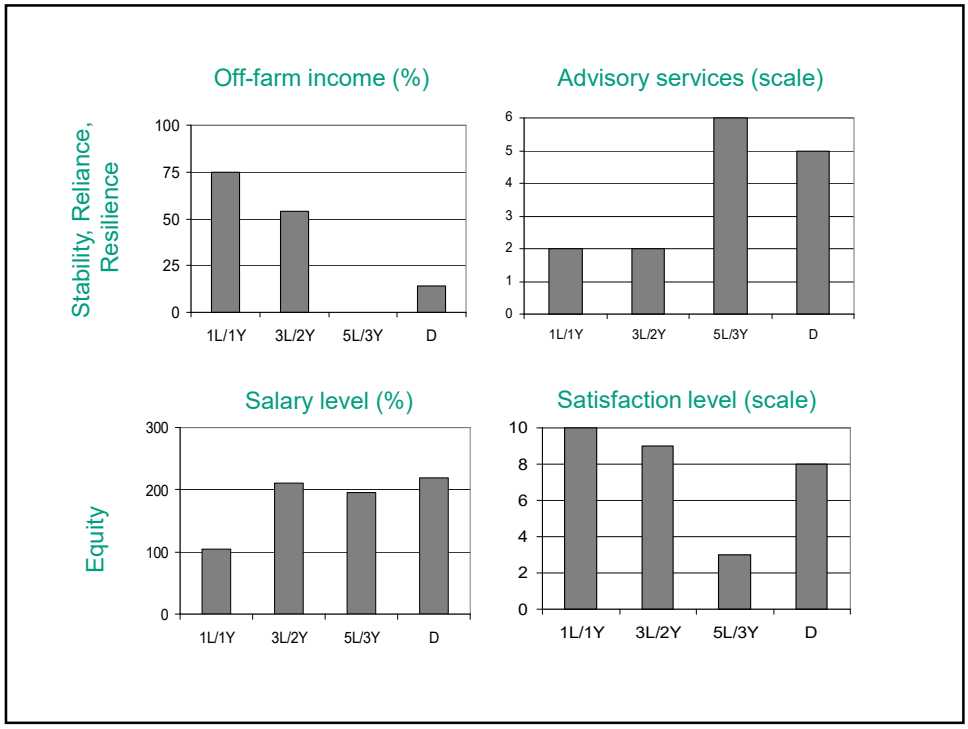
Policy makers' priorities
- Climate change (GHG)
- Pollution
- Water
- Land use change
- Landscape
- Biodiversity

Farmers' priorities
- Maximize grazing
- Energy efficiency
- Use of protected areas
- Stocking rate
- Local breeds
- Wildlife conflicts

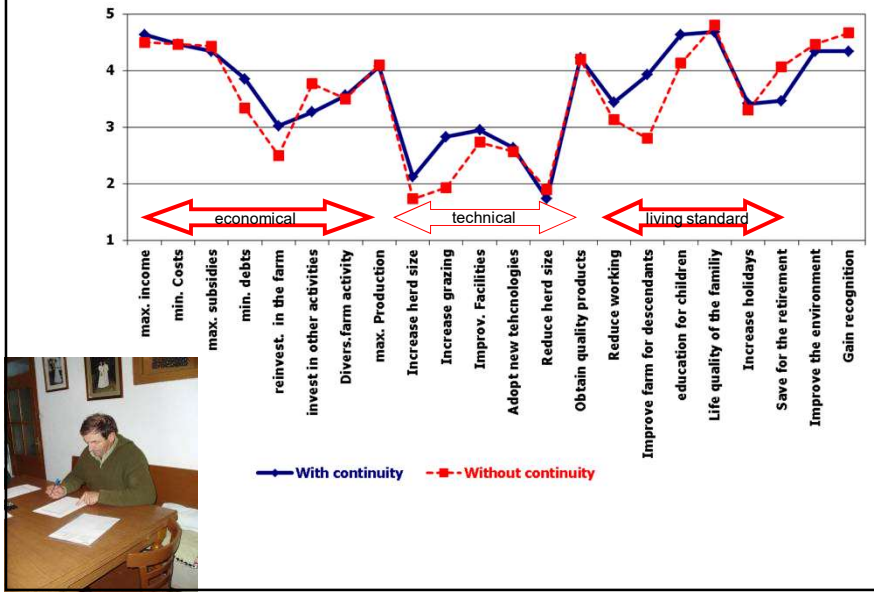
cita
CENTRO DE INVESTIGACIÓN Y TECNOLOGÍA AGROALIMENTARIA DE ARAGÓN

Trade-offs among sustainability pillars

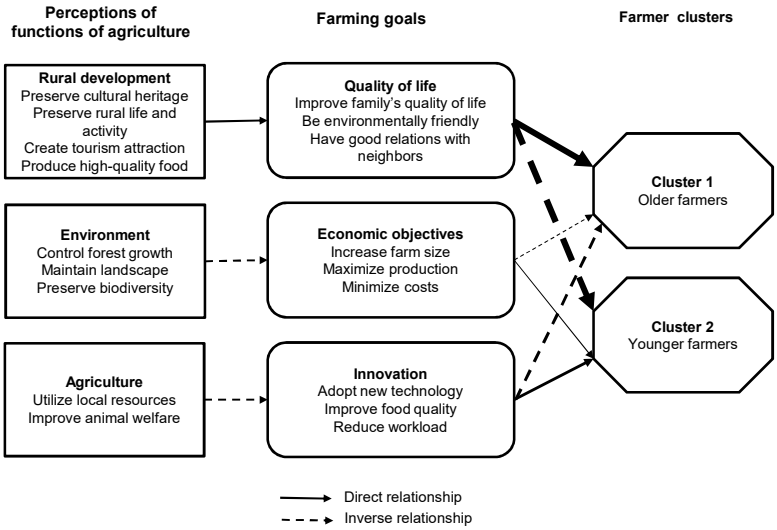




Social factors: farmer objectives



Social pillar: different perceptions and goals



3. Animal production and the environment

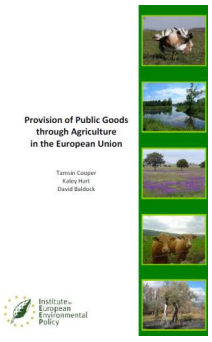
Livestock – environment

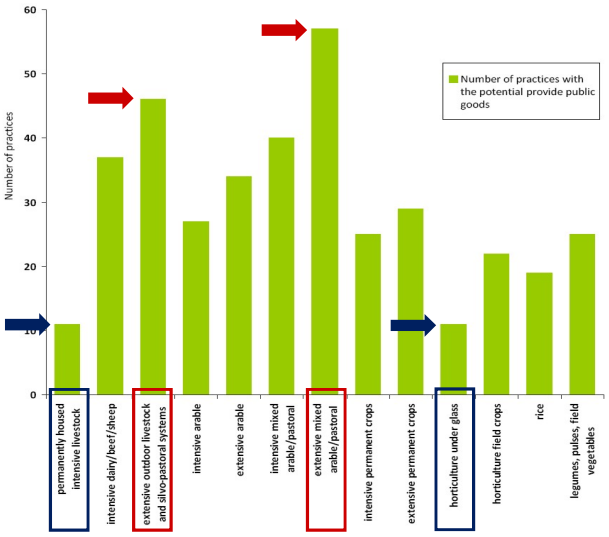
- negative impacts
  - emission of greenhouse gases (CO_2, CH_4, N_2O) and ammonia
  - land degradation and deforestation
  - pollution of soils and water
  - biodiversity loss

- positive impacts
  - extensive systems (low-input): landscape and biodiversity conservation
  - prevention/ regulation of environmental hazards (forest fires, erosion, desertification)
  - storage of carbon in grasslands (34%, forests 39%)

cita
CENTRO DE INVESTIGACIÓN Y TECNOLOGÍA AGROALIMENTARIA DE ARAGÓN

Different farming systems render different ecosystem services/ public goods



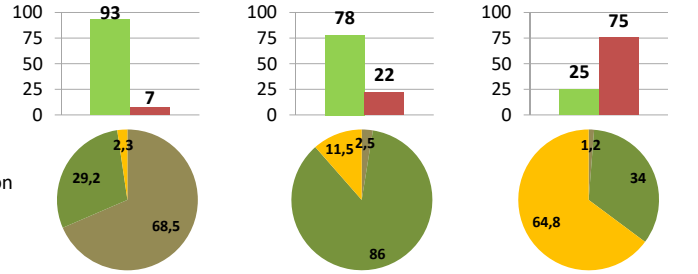


Diversity of farming systems

	Specialized sheep-mountain pastures	*Fully-integrated mixed sheep-permanent crops*	*Partially-integrated mixed sheep-arable crops*
Harvest (kg DM)	8.922	68.738	373.592
Self-consumption (%)	100	100	35
Sales (%)	0	0	65

Grazing/Indoor (%)

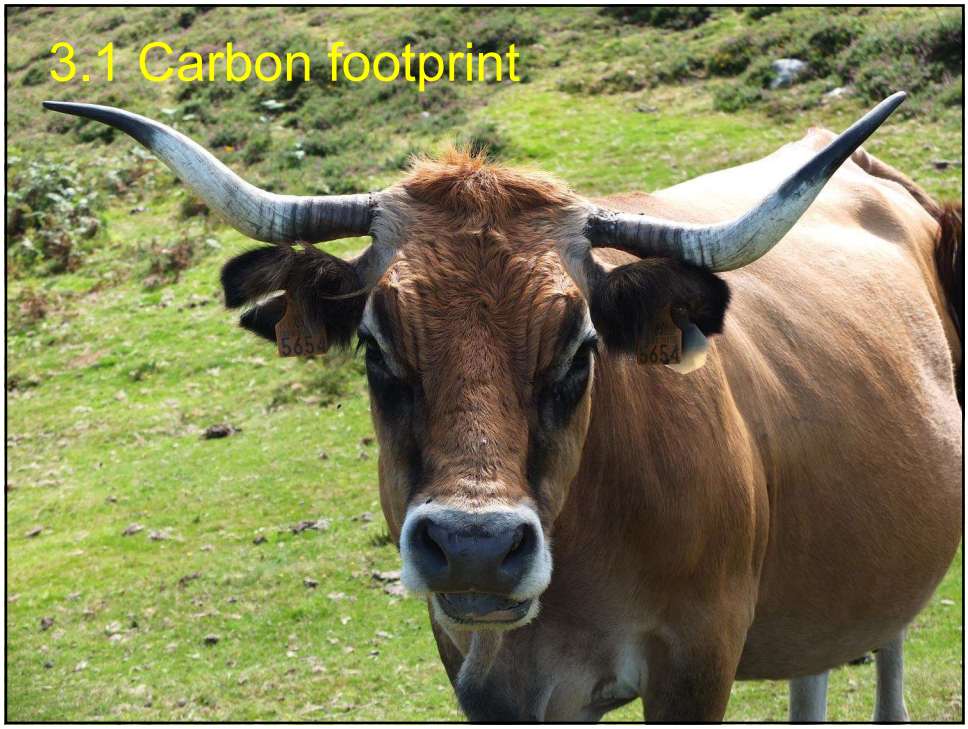
- Grazing
- Indoor



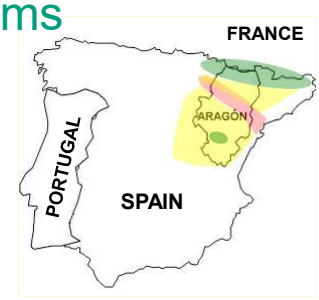
Annual grazing (%)

- Semi-natural vegetation
- Forages
- Stubbles

3.1 Carbon footprint



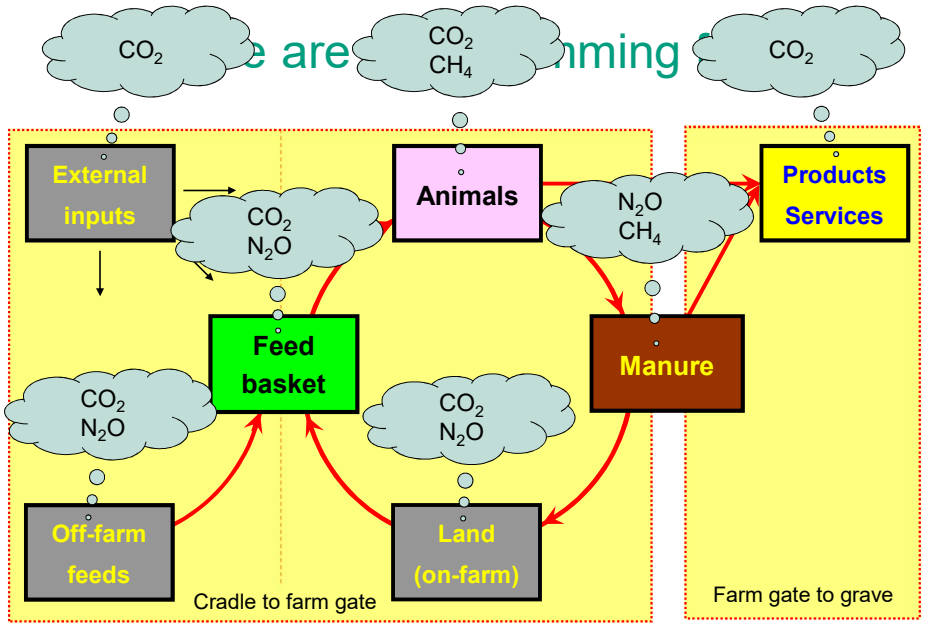
Carbon footprint: 3 contrasting sheep systems



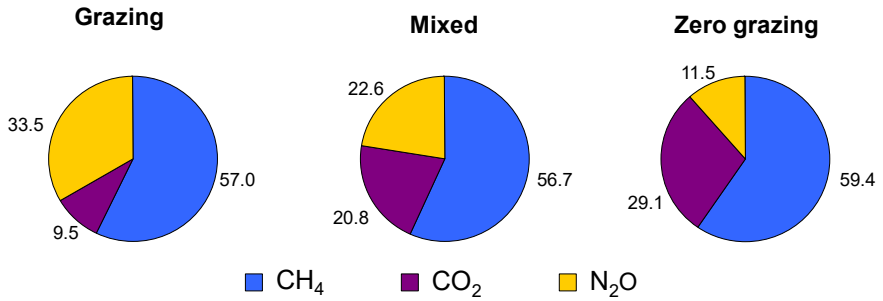
1. **Grazing** or **pastoral system**:
   - Alpine mountains.
   - 1 lambing per ewe per year.
   - Free ranging.

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.



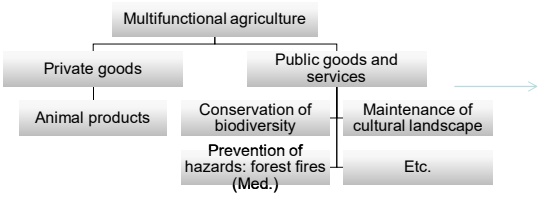
Contribution of CH4, CO2 and N2O in % of total emissions



- CH_4 is the major contributor in each SFS and remains almost steady across the systems.
- N_2O 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_2O emissions.

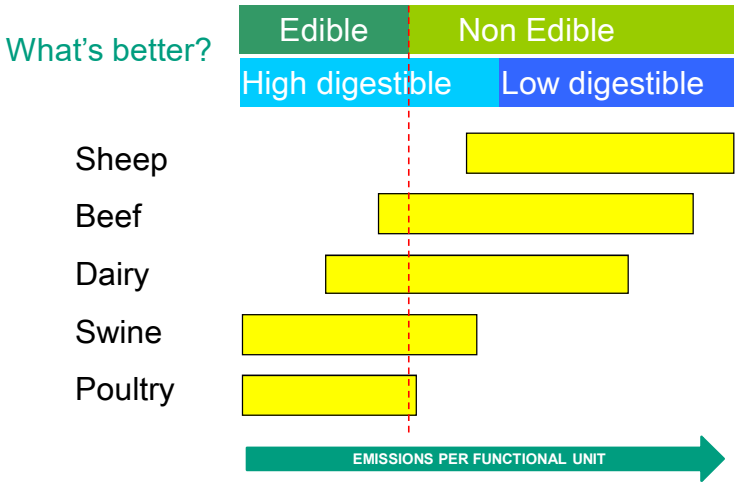
Trade-offs within sustainability pillars
E.g. carbon footprint of lamb meat and ES

	No allocation kg CO_2-eq / kg LW	Allocation	Corrected kg CO_2-eq / kg LW
Grazing (1L/1Y)	25.9	53.6 %	13.9
Mixed (3L/2Y)	24.0	73.9 %	17.7
Zero grazing (5L/3Y)	19.5	100 %	19.5

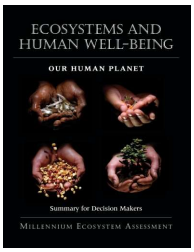


- Non-marketable
- Inherently linked to extensive livestock farming systems IEEP (2009)

Mitigation in feed: the options

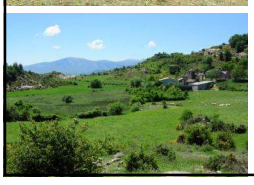


Ecosystem services



Ecosystem services are the direct and indirect benefits people obtain from ecosystems

1. Provisioning: products obtained from the ecosystem, i.e. food, timber, fiber, fresh water, etc.
2. Regulating: benefits obtained from the regulation of ecosystem processes, i.e. regulation of climate, erosion prevention, water regulation, etc.
3. Supporting: ecosystem services that are necessary for the maintenance of all other ecosystem services, i.e. primary production (photosynthesis), soil formation, nutrient cycling, water cycling, etc.
4. Cultural: nonmaterial benefits people obtain from ecosystems, i.e. spiritual enrichment, cognitive development, recreation, aesthetic experience, etc.



Main ES derived from pasture-based livestock systems

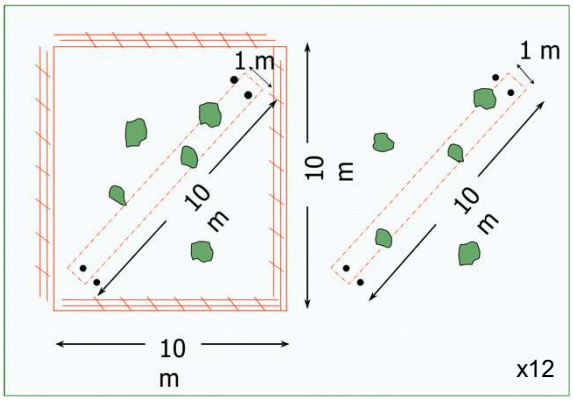
1. Provisioning: quality products linked to the territory
2. Regulating: prevention of forest fires (Euro-mediterranean basin) soil fertility (Nordic regions), etc.
3. Supporting: biodiversity conservation
4. Cultural: agricultural landscapes

Ecosystem Services valuation

- Different functional units
- Different temporal and spatial scales
- Different perceptions by society
- No market price

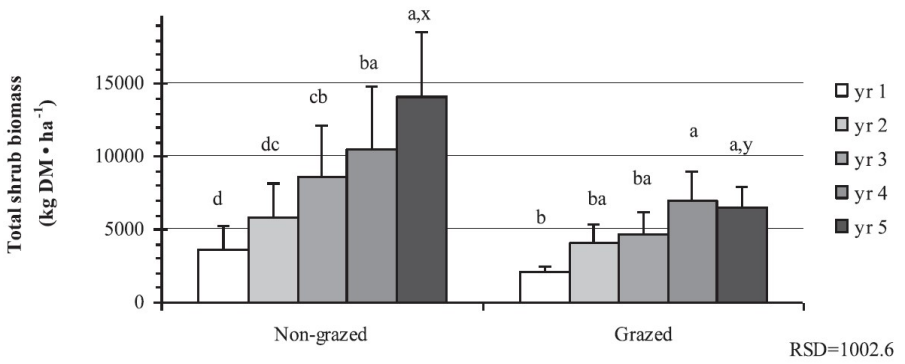
1. BIOPHYSICAL
2. SOCIO-CULTURAL
3. ECONOMIC

Biophysical valuation: grazing and vegetation in Guara N.P.



- Vegetation cover: trees, shrubs, herbs
- Herbaceous: biomass, quality, species
- Shrubs: biomass, species

Evolution of shrub vegetation in Guara

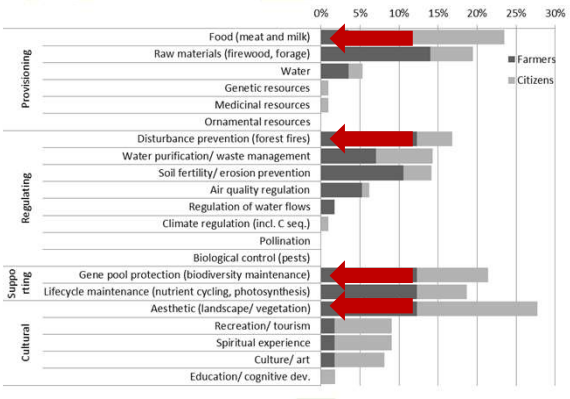


effect of grazing on landscape: current situation

effect of grazing on landscape: abandonment

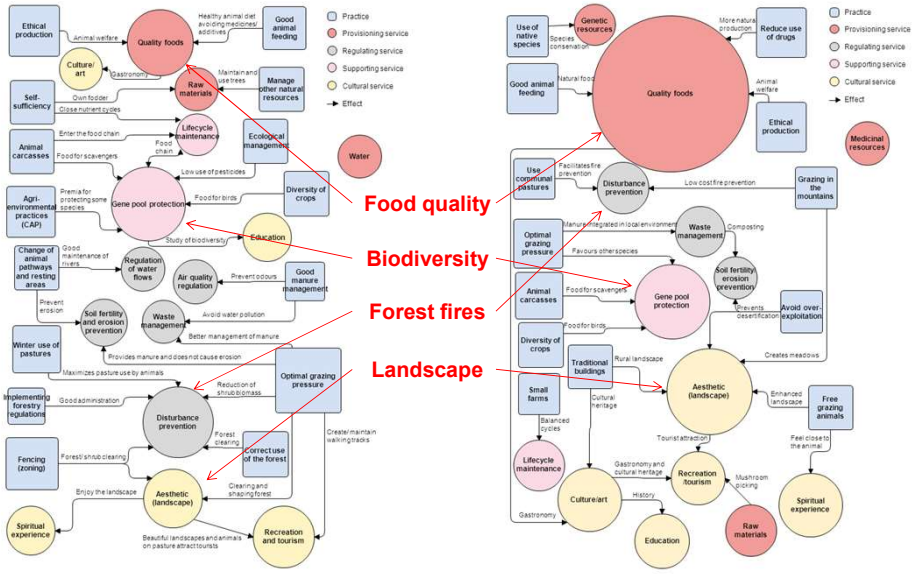
effect of grazing on landscape: optimal

Socio-cultural valuation: views of farmers and other citizens



farmers

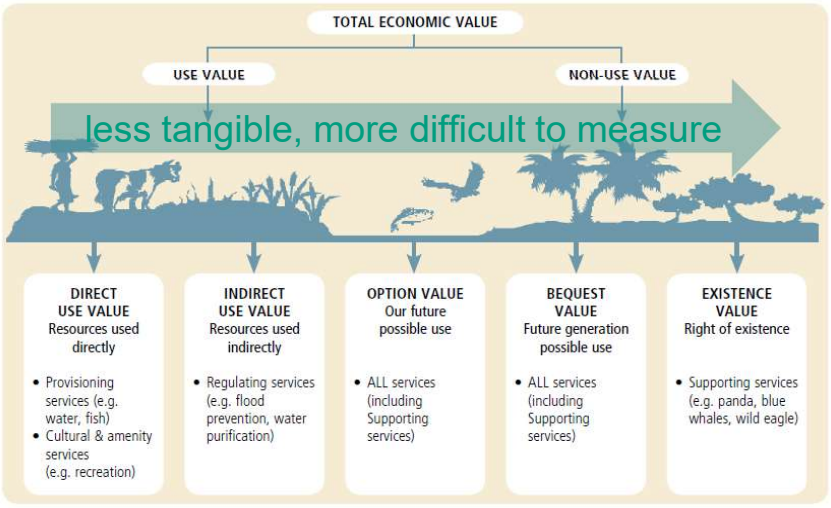
other citizens



Economic valuation: measuring public goods?

Total economic value (TEV): sum of output values (the values generated in the current state of the ecosystem, e.g., food production, climate regulation and recreational value) as well as insurance values, now and in the future.

Total Economic Value (TEV)



Non-use value

- do not involve direct or indirect use of the ecosystem service, but reflect the satisfaction that individuals derive from the knowledge they exist (e.g. enjoyment of a beautiful landscape)
- related to moral, religious of aesthetic properties of individuals
- **markets do not exist**

Stated preference methods

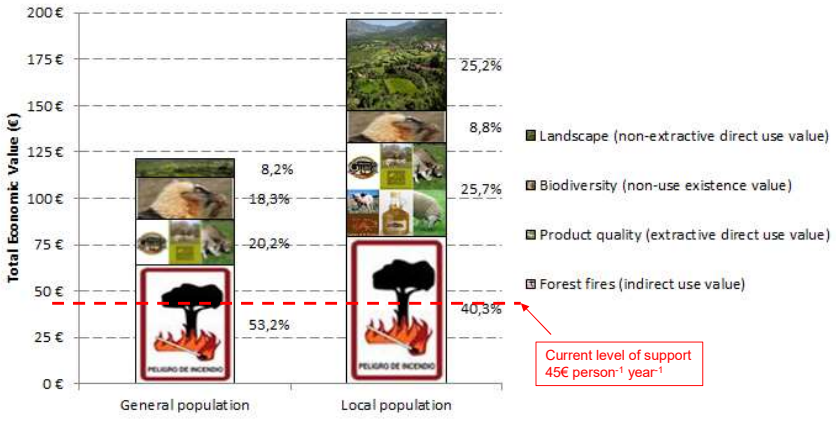
- **Choice modelling** Individuals are asked to choose their preferred alternative among several hypothetical land uses. Each **scenario** of land use is described by a number of attributes (e.g. vegetation cover, landscape fragmentation, biodiversity index, human activities, etc.). Individuals make trade-offs between the levels of the attributes describing the different alternatives in a choice set.
- **Underlying rational decision process**

Choice model for ES in Guara

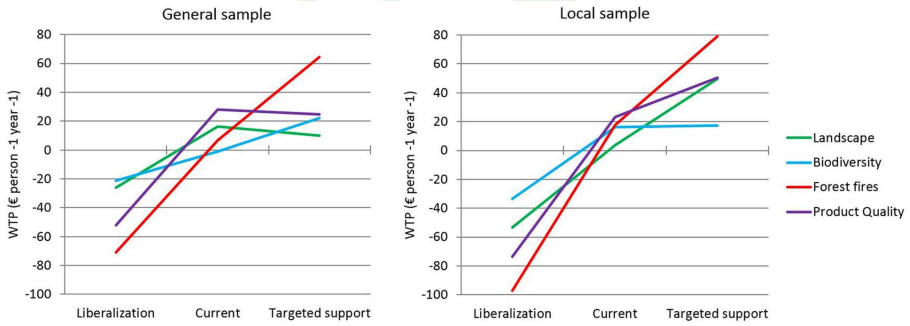
	Policy A	Policy B	CURRENT policy
Landscape	 strong increment of bushes reduction of meadows and crops	 light decrement of bushes light increment of meadows and crops	 light increment of bushes meadows and crops are maintained
Bearded vulture	 7 pairs	 15 pairs	 11 pairs
Forest fires	 6 forest fires per year	 2 forest fires per year	 4 forest fires per year
Product quality linked to territory	 2 quality products available sheep cheese and lamb meat	 6 quality products available sheep cheese, lamb meat, pasture pork meat and olive oil, pasture beef and organic lamb	 4 quality products available sheep cheese, lamb meat, pasture pork meat and olive oil
Annual cost	 15 €	 75 €	 45 €
CHOICE	◯ A	◯ B	◯ C

Economic value of agro-ecosystems in Guara

Willingness to Pay (WTP) (€ person-1 year-1) and composition of the Total Economic Value



Willingness to Pay (WTP) (€ person-1 year-1) for ecosystem services in different policy scenarios



5. Wrap-up

Take-home messages

1. animal production systems are not static, they evolve according to general drivers but also to family/ local circumstances
2. sustainable agriculture ≠ env. friendly agriculture
   - environment
   - economics
   - social
3. multiple trade-offs or compromises
   - e.g. economic vs. environmental
   - e.g. carbon footprint and ecosystem services (biodiversity, landscape)

Take-home messages

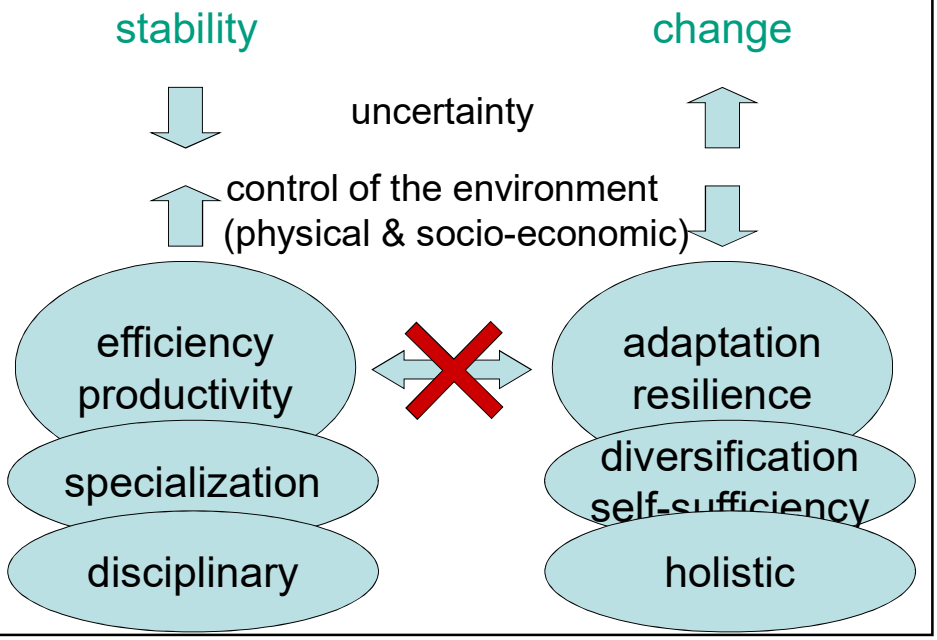
4. animal agriculture can be multifunctional (delivery of public goods or ecosystem services), but not all farming systems are (eg. ecosystem disservices or negative externalities)
5. there is need to objectively value “non-market” functions of animal agriculture and integrate public goods into policy

Take-home messages

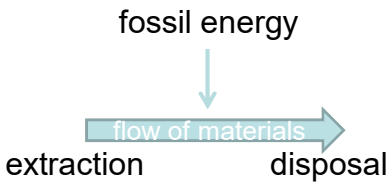
6. to understand sustainability it is necessary a systems perspective:
   - multiple factors or dimensions
   - multiple interrelations
   - diverse spatial and temporal scales
   - multidisciplinary dynamic approaches

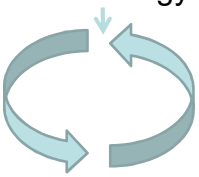
7. uncertainty is huge

Research focus



New system design (paradigm)





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

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

Literature

- Bernués A., Ruiz R., Olaizola A., Villalba D. and Casasús I., 2011. Sustainability of pasture-based livestock farming systems in the European Mediterranean context: synergies and trade-offs. Livestock Science 139, 44-57.
- Ripoll-Bosch R., Díez-Unquera B., Ruiz R., Villalba D., Molina E., Joy M., Olaizola A., Bernués A., 2012. An integrated sustainability assessment of Mediterranean sheep farms with diverse degree of intensification. Agricultural Systems 105, 46-56.
- Ripoll-Bosch R., de Boer I.J.M., Bernués A., Vellinga T., 2013. Accounting for multi-functionality of sheep farming in the carbon footprint of lamb: a comparison of three contrasting Mediterranean systems. Agricultural Systems 116, 60-68.
- Bernués A., Rodríguez-Ortega T., Ripoll-Bosch R., Alfnes R., 2014. Socio-cultural and economic valuation of ecosystem services provided by Mediterranean mountain agroecosystems. PLoS ONE 9(7): e102479.

Other references

- Rodríguez-Ortega T., Oteros-Rozas E., Ripoll-Bosch R., Tichit M., Martín-López B., Bernués A., 2014. Applying the ecosystem services framework to pasture-based livestock farming systems in Europe. Animal 8, 1361-1372.
- Bernués A., Tello-García E., Rodríguez-Ortega T., Ripoll-Bosch R., Casasús I., 2016. Agricultural practices, ecosystem services and sustainability in High Nature Value farmland: Unraveling the perceptions of farmers and nonfarmers. Land Use policy 59, 130-142.
- Bernués A., Clemetsen M., Eik L.O., 2016. Seeing northern European fjord and mountain agriculture through farmers' eyes: a critical step in promoting sustainability. Mountain Research and Development 36, 276–285.
- Rodríguez-Ortega T., Bernués A., Olaizola A.M., Brown M.T., 2017. Does intensification result in higher efficiency and sustainability? An emergy analysis of Mediterranean sheep-crop farming systems. Journal of Cleaner Production 144, 171-179.

Thank you!