



A.D. MDLXII

Società Italiana di Agronomia XLV Convegno Nazionale



La ricerca agronomica verso il 2030: gli obiettivi globali di sviluppo sostenibile

Environmental Implications of Different Production Systems in a Sardinian Dairy Sheep Farm

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Consiglio Nazionale delle Ricerche

INTRODUCTION

SARDINIA (Italy) is the most important EU region for sheep milk production:

- 14,000 sheep farms
- 3.2 million ewes (3.5% of EU total)
- 330,000 t year⁻¹ of milk (~12% EU) (EUROSTAT, 2012)

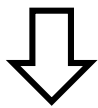


INTRODUCTION

EUROPE 2020 STRATEGY



Eco-sustainability and climate change mitigation



Eco-innovation is a key factor to improve **competitiveness** of sheep farming and to valorize typical Mediterranean sheep milk products



GOAL AND SCOPE

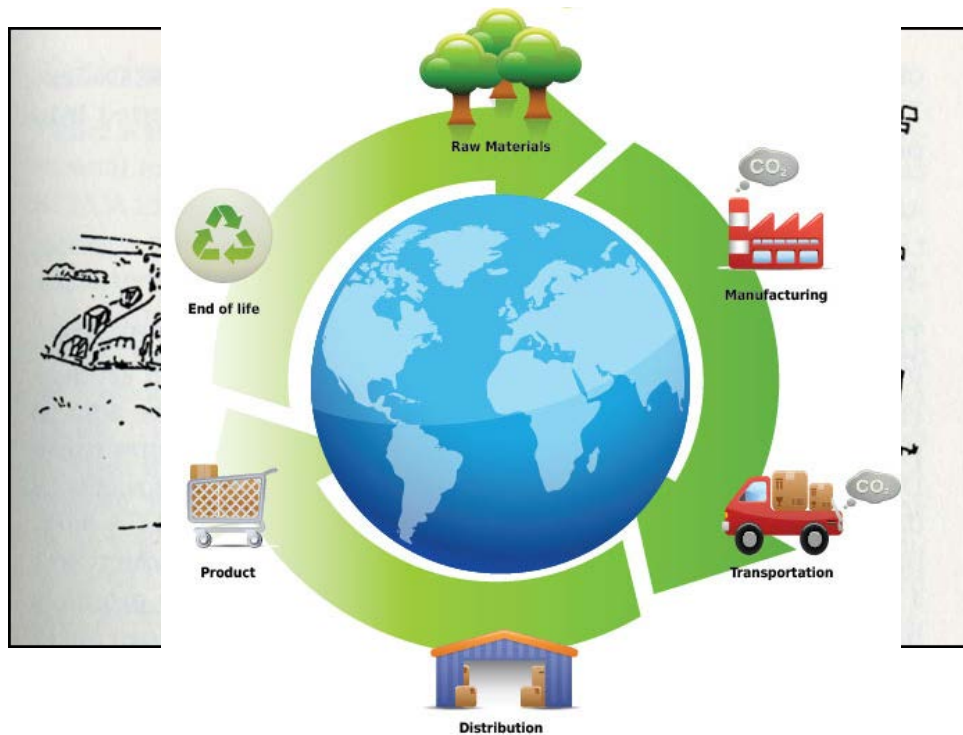
OBJECTIVES:

- I. comparing the environmental impacts of two contrasting sheep milk production processes carried out in the same farm (with inventory data coming from different years).

- II. Finding scientific ways to valorize the environmental quality of a dairy sheep production system.

MATERIALS AND METHODS

LIFE CYCLE ASSESSMENT – LCA



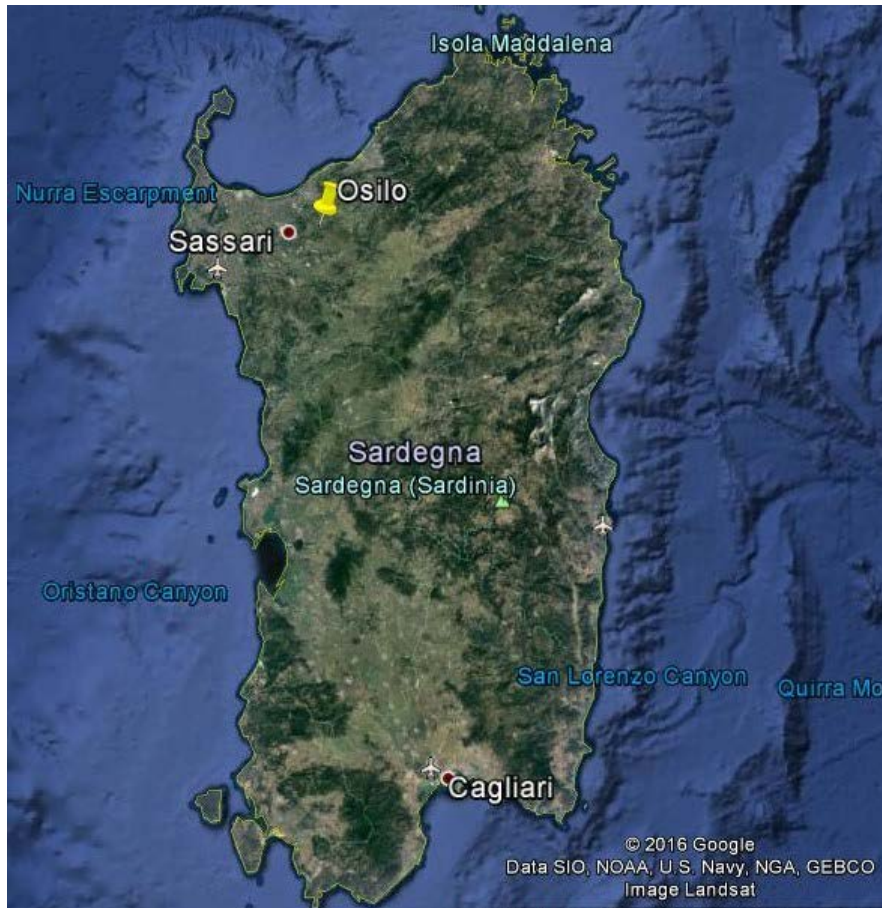
“LCA is a widely accepted, complete and standardized computational tool for providing a widespread knowledge on the environmental aspects associated with products or production processes.” (Hayashi et al., 2006)

When applied to **agriculture**, LCA presents some challenges due to the intensive nature of required data, their limited availability and the multiple-output nature of production (FAO, 2010).

MATERIALS AND METHODS

CASE STUDY

Data were collected from “Azienda Truvunittu” in 2001 and 2011. The farm is located in Osilo (SS), Northwestern Sardinia ($40^{\circ}44'34.39''\text{N}$ $8^{\circ}39'58.97''\text{E}$), Italy.



MATERIALS AND METHODS

Main characteristics of the two production systems adopted by “Az. Truvunittu” in 2001 and 2011.

	2001	2011
Heads (number)	340	320
Stocking rate (ewe ha ⁻¹)	4,6	4,6
Milk pro-capita annual production (kg ewe ⁻¹ year ⁻¹)	248	257
Milk total annual production (kg)	84,230	82,214
Pastures — grazing area (ha)	3	52
Arable land — cereals and annual forage crops (ha)	70	18
Total utilized agricultural area (ha)	73	70
Concentrate feed annual consumption (t)	105	98
Mineral N-fertilizing (kg ha ⁻¹)	72	8
Mineral P ₂ O ₅ -fertilizing (kg ha ⁻¹)	110	29
Irrigated maize (ha)	7	0
Power source	diesel generator	electricity
Milk destination	Cheese industry	On-farm cheese manufacture

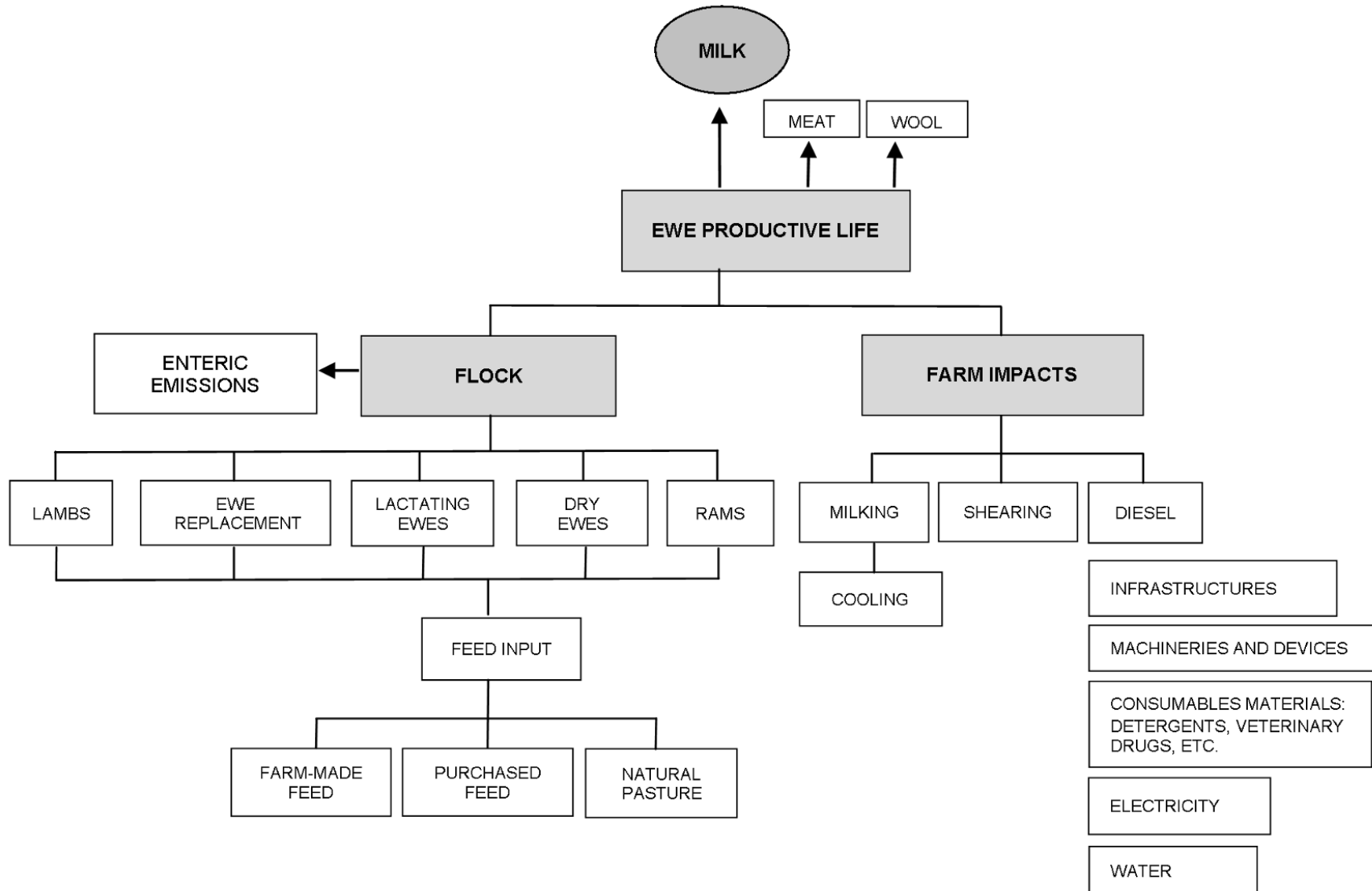
MATERIALS AND METHODS

LCA'S METHODOLOGICAL ISSUES

- Consistent with the international standards ISO 14040-14044 (2006 a, b) and ILCD handbook (International Reference Life Cycle Data system, 2012).
- System boundaries: “from cradle to farm gate”.
- **Functional unit (FU): 1 kg of Fat and Protein Corrected Milk (FPCM).**
- Impact allocation approaches: economic (sheep co-products) and mass (crops co-products) allocation.
- **CH₄ enteric emission factor: Tier 2/3 approach (based on Vermorel et. al, 2008).**
- N₂O enteric emission factor: Tier 2, IPCC (2006).

MATERIALS AND METHODS

Flow chart of sheep milk production (from Vagnoni et al., 2015)



MATERIALS AND METHODS

LCA'S METHODOLOGICAL ISSUES

Two evaluation methods:

1. IPCC, Intergovernmental Panel on Climate Change (2013), which provides estimates on greenhouse gases emitted in the life cycle of products (**Carbon Footprint**), expressed in kilograms of CO₂-equivalents, using a 100-year time horizon;
2. ReCiPe end-point method (**ReCiPe Endpoint (H) V1.12**), that provides a wider assessment of life cycle environmental performances compared to IPCC (2013), considering 18 different categories of environmental impact (Goedkoop et al., 2009).

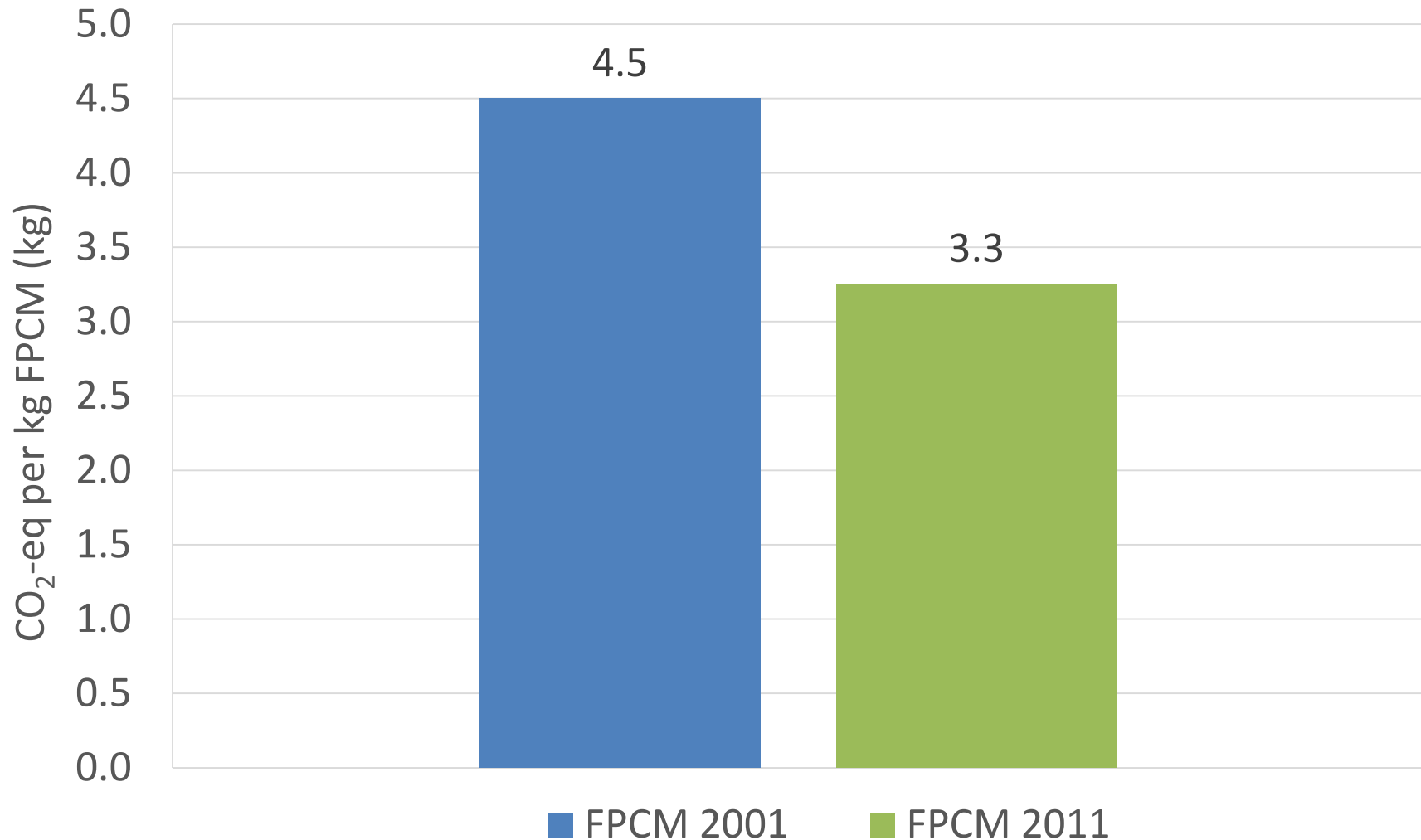
RESULTS and DISCUSSION

Impact category	Unit	2001	2011
Water	m ³	988	1,808
CO ₂	t	107	56
CO ₂ biogenic	t	5.2	3.7
Methane	kg	234	128
Methane biogenic	t	8,1	4,8
Occupation, pasture and meadow	ha	9.3	40.8
Dinitrogen monoxide	kg	95.7	74.9
Transformation from forest	m ²	77.4	127.0
Phosphorus, in water	kg	14.8	14.6
Phosphate	kg	89.5	70.8
Sulphur Dioxide	kg	361.7	229.2
Isoproturon	kg	2.5	2.0
Nitrogen oxides	kg	541.5	272.2
Particulates	kg	111.3	80.1
Crude oil in ground	t	22.4	10.1
Coal	t	16.1	10.0
Occupation industrial area	m ²	752	933

*Inventory of the impact categories for the **total annual production of FPCM** related to the two production systems.*

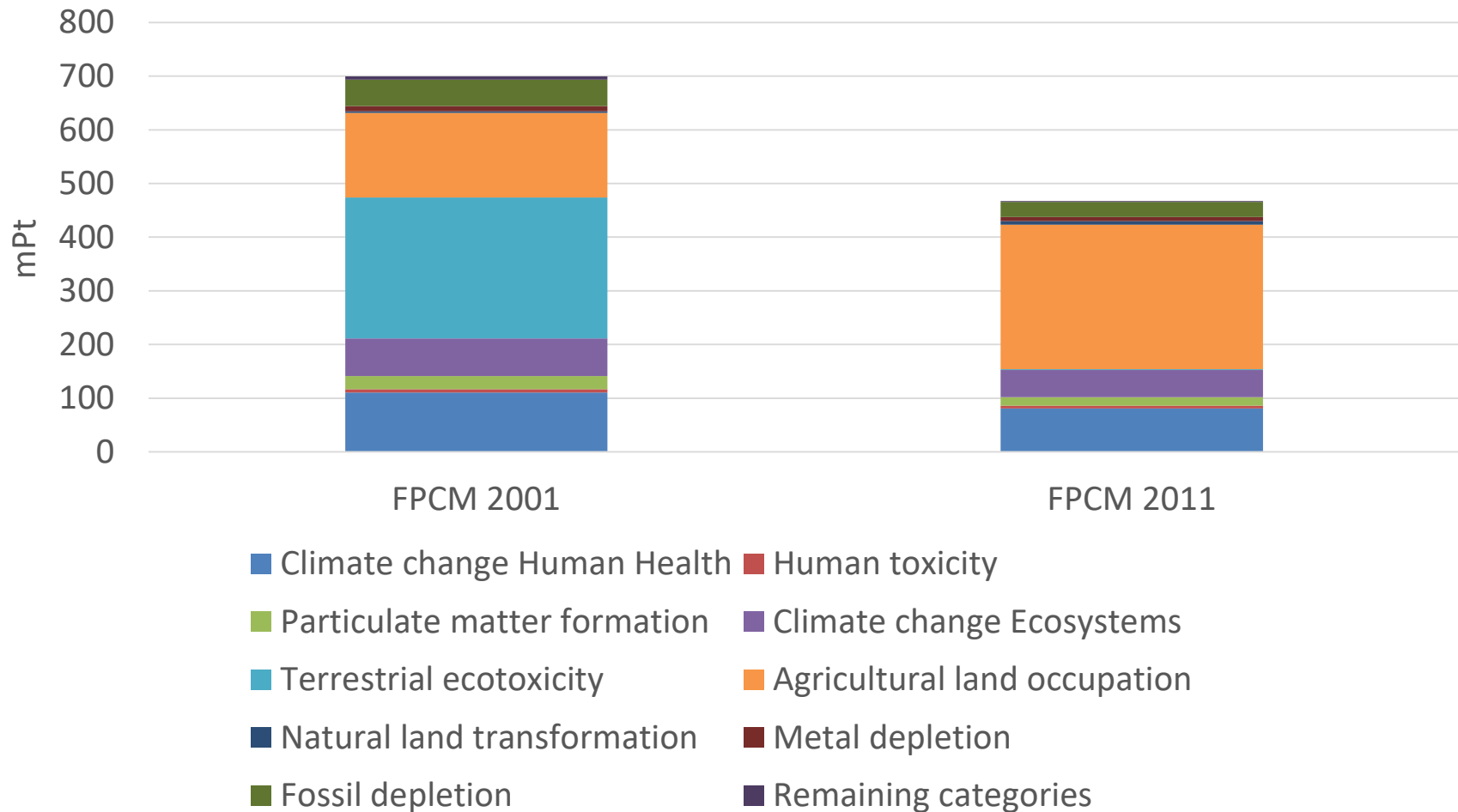
RESULTS and DISCUSSION

Values of the **Carbon Footprint** (IPCC, 2013) of 2001 and 2011 production systems. The functional unit (FU) is 1 kg of FPCM (Fat and Protein Corrected Milk).



RESULTS and DISCUSSION

Values obtained using the **ReCiPe end-point** impact assessment method for the functional unit 1 kg of FPCM for 2001 and 2011 production systems. Impact effects are expressed in milli-ecopoints (mPt). Impact categories with scores lower than 10 mPt are included in the group 'Remaining categories'.



RESULTS and DISCUSSION

Values obtained using the **ReCiPe end-point** impact assessment method for the functional unit 1 kg of FPCM for 2001 and 2011 production system. Impact effects are expressed in milli-ecopoints (mPt). Impact categories with scores lower than 10 mPt are included in the group 'Remaining categories'.

Impact category	FPCM 2001	FPCM 2011
Climate change Human Health	110,61	80,72
Human toxicity	6,25	5,38
Particulate matter formation	24,54	15,66
Climate change Ecosystems	69,83	50,97
Terrestrial ecotoxicity	262,66	1,29
Agricultural land occupation	157,45	268,97
Natural land transformation	3,45	7,09
Metal depletion	9,28	7,66
Fossil depletion	49,20	27,74
Remaining categories	6,35	1,64
Total score	696,16	467,12

RESULTS and DISCUSSION

Percentage contribution of processes to the total environmental impact. The process category “Remaining processes” includes all the processes with a percentage contribution lower than 0,5% for all methods and production systems.

Method Process / Production system	IPCC		ReCiPe	
	2001	2011	2001	2011
Agricultural machinery production	0	2	0	2
Electricity medium voltage	-	3	-	2
Enteric methane emissions	60	57	14	14
Improved pastures	0	0	0	12
Hay from natural pasture	-	0	-	10
Irrigating (infrastructure and water consumption)	1	0	1	0
Concentrate feed, purchased	19	26	29	33
Diesel generator	5	-	3	-
Maize silage, on-farm production	-	-	38	-
Milking parlour, construction	1	1	0	1
Straw	0	0	4	8
Natural pastures	0	0	1	8
Phosphate fertiliser, as P ₂ O ₅	1	0	1	0
Transport, lorry and freight ship	3	5	1	3
Enteric nitrogen dioxide emissions	1	1	0	0
Wheat grain, on-farm production	1	-	0	-
Remaining processes	7	5	7	7

CONCLUSIONS

- The extensification of the production system had a positive influence on the overall farm environmental performances estimated by both IPCC and ReCiPE end-point methods (-27% kg CO₂-eq kg⁻¹ FPCM; -33% mPt kg⁻¹ FPCM).
- Relevant role played by enteric methane emissions, concentrate purchased feed and transports for all production systems and evaluation methods considered.
- LCA analysis, conducted using 1 kg FPCM as functional unit and two different assessment methods (IPCC and ReCiPe), provided a balanced picture of the environmental performances of the sheep farming systems, resulting in a more comprehensive assessment of impacts.

CONCLUSIONS

Future research will be devoted to:

- i. exploring and better defining the environmental implications of the **land use impact category** and **sheep farm externalities** in the Mediterranean sheep farming systems;
- ii. contributing to revise and improve existing **LCA methods and dataset** for Mediterranean farming systems.



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