iSAGE model farm and challenging scenarios

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SIMSSR

iSAGE
Innovation for Sustainable Sheep and Goat Production in Europe

Modelling impacts of climate change, adaptation measures and GHG trade-offs/synergies in small rums. in Europe

Whole iSAGE team

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Main objective of this session




Examine the scope of new strategies, including land-based and management changes and innovations, for making sheep and goats production more sustainable, reducing its environmental impact and enhancing resilience to oncoming challenges (e.g. climate change).

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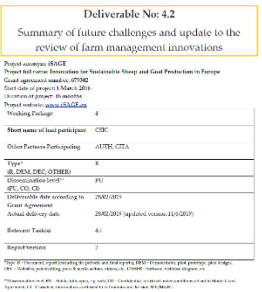
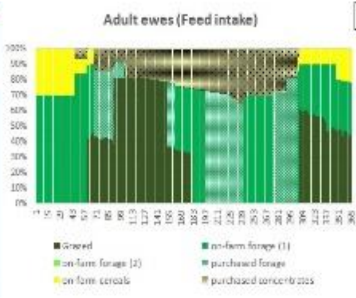
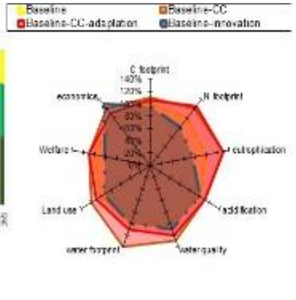
Where does the info in this session come from?


Deliverable No: 4.2

Summary of future challenges and update to the review of farm management innovations





Outputs from the different work packages of the ISAGE project and specific modelling exercises using national GHG inventories methodologies and the new farm model developed in ISAGE ($SIMS_{SR}$)

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Outline

- What are the challenges?
- The tool to analyse farm scenarios: SIMSSR
- Climate change challenge (impacts and as GHG emitter)
- Potential solutions (examples)

Challenges

Most important challenges in European small ruminants sector

Weaknesses

- Low promotion of local breeds
- poor business management training
- Low professionalization
- Slow adoption of innovations
- Low adaptability of high producing breeds.

External threats

- Low consumer education in product
- Low consumer knowledge in products
- Researchers not address real problems
- Unfair trade, lack of traceability
- Poor recognition of public services

Deliverable No: 4.2

Summary of future challenges and update to the review of farm management innovations

Project acronym: **iSAGE**
Project full name: **Innovation for Sustainable Sheep and Goat Production in Europe**
Grant agreement number: **679302**
Start date of project: **1 March 2016**
Duration of project: **48 months**
Project website: www.iSAGE.eu

Working Package	4
Short name of lead participant	CSIC
Other Partners Participating	AUTH, CITA
Type* (R, DEM, DEC, OTHER)	R
Dissemination level** (PU, CO, CI)	PU
Deliverable date according to Grant Agreement	28/02/2019
Actual delivery date	28/02/2019 (updated version 11/6/2019)
Relevant Task(s)	4.1
Report version	2

*Type: R = Document, report (excluding the periodic and final reports); DEM = Demonstrator, pilot, prototype, plan designs, DEC = Websites, patents filing, press & media actions, videos, etc.; OTHER = Software, technical diagram, etc.

**Dissemination level: PU = Public, fully open, e.g. web; CO = Confidential, restricted under conditions set out in Model Grant Agreement; CI = Classified, information as referred to in Commission Decision 2001/844/EC.

Output from participatory process

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Most important challenges in European small ruminants sector

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Output from participatory process

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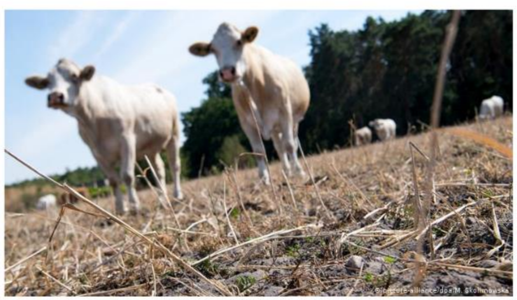
Extra challenges in Mediterranean/European small ruminants sector: climate change

Affected by climate change

Climate change already affecting German farmers

In Germany, some like it hot — this summer's unusually hot, sunny weather, that is. For many farmers, the prolonged heat means smaller harvests and diminished food reserves for their livestock. Will food prices soar?



Cows have little to graze upon in this drought-stricken field in the German state of Saxony

CLIMATE CHANGE ›

Mediterranean is warming up faster than the rest of the planet, report warns

Some 500 million people are at risk of drought, lack of freshwater and food shortages if no action is taken

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Opinion
Climate change

What we eat matters: to change climate crisis, we need to reshape the food system

Jess Fanzo and Mario Herrero

Tue 8 Oct 2019 15.34 BST

719 466

Everything we eat has an effect on global heating, but perhaps the biggest problem is livestock

▲ Livestock contributes 15% of global greeenhouse gas emissions. Photograph: Bloomberg/Bloomberg via Getty

*But, also as **driver of climate change***

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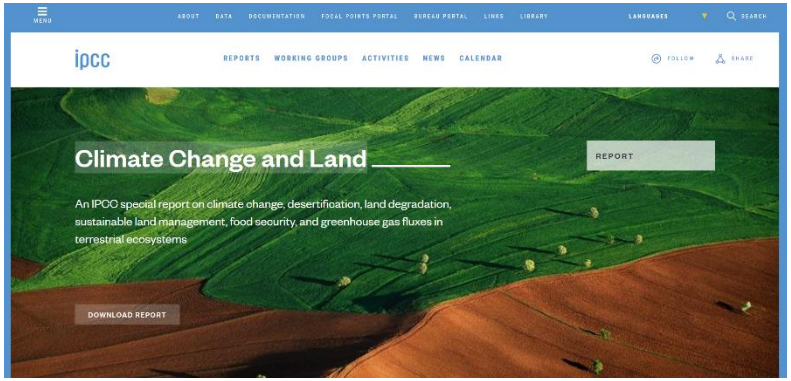
Challenges: climate change (GHG/mitigation)

Latest IPCC-UN report on land claimed that reducing consumption of animal products are key to mitigate climate change



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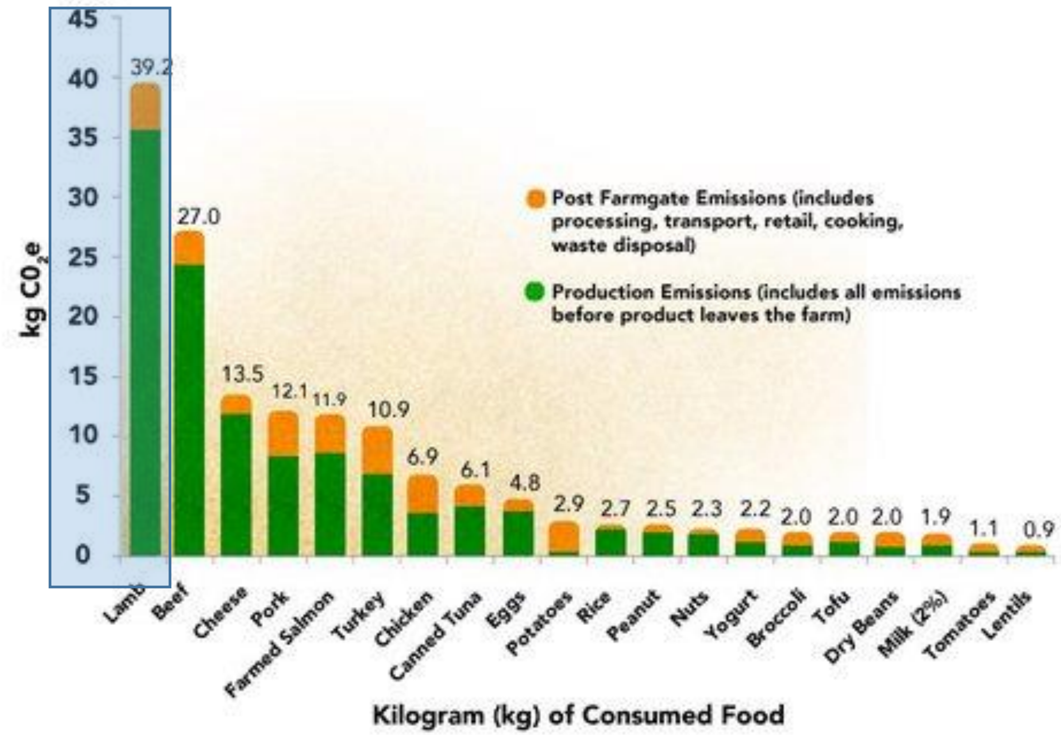
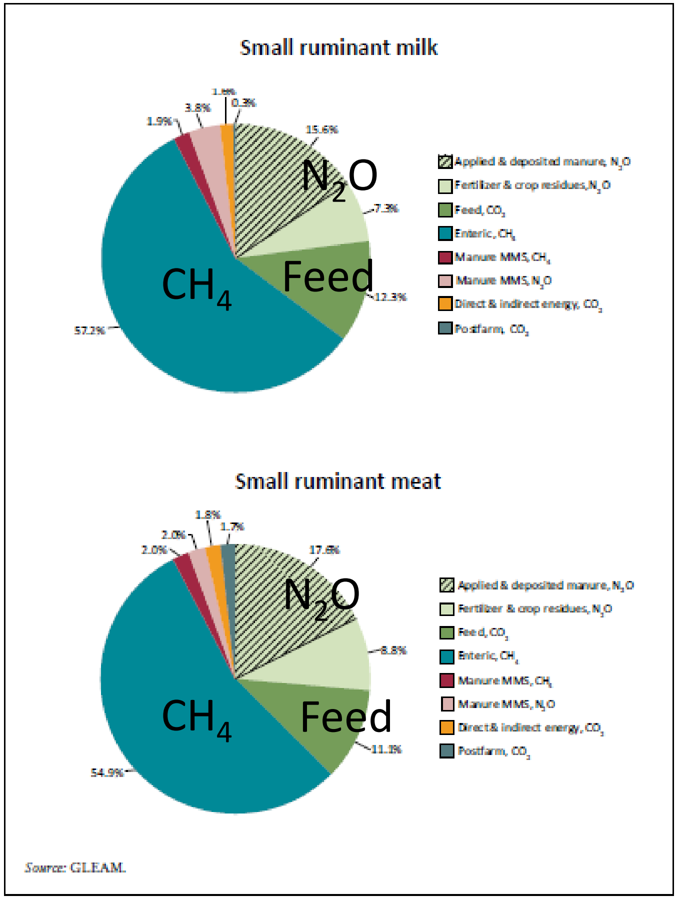
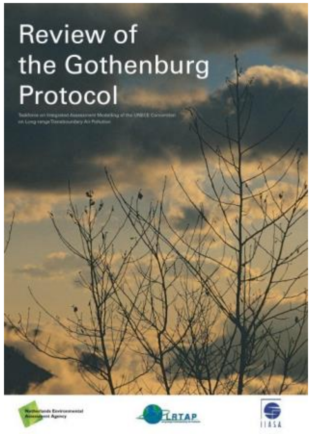
Challenges: climate change (GHG/mitigation)





Extra challenges in Mediterranean/European small ruminants sector: policies

- Different policies affect/may affect in future
- Agricultural policies, climate change (Paris Agreement) and environmental regulations
- Policies need to be considered in integrated frameworks and not in isolation



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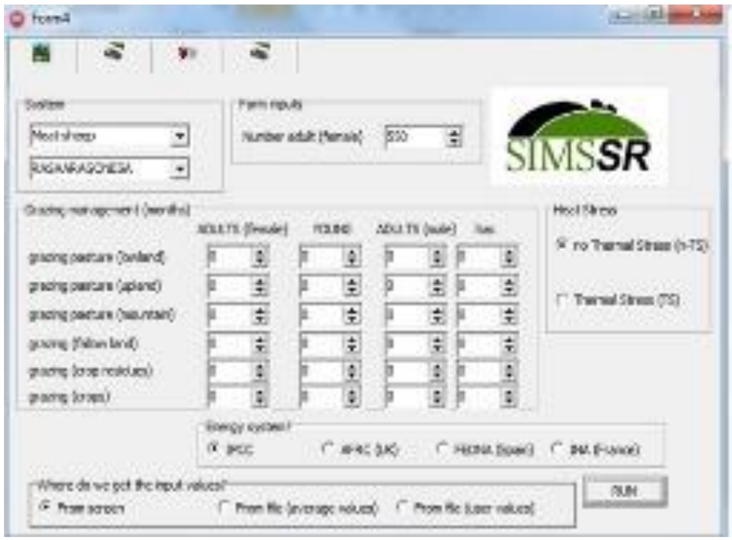
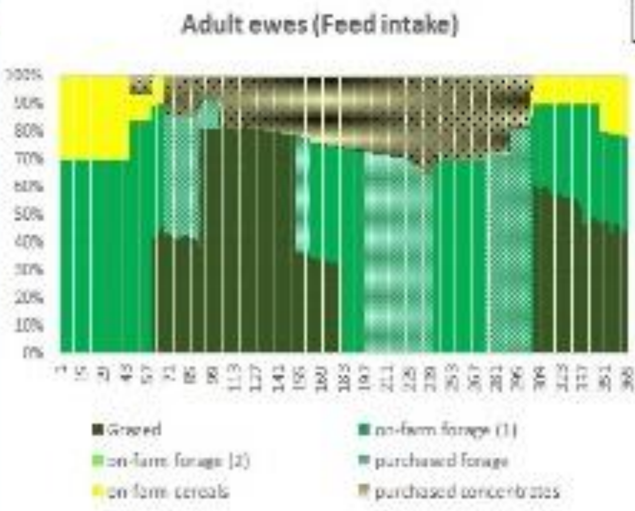
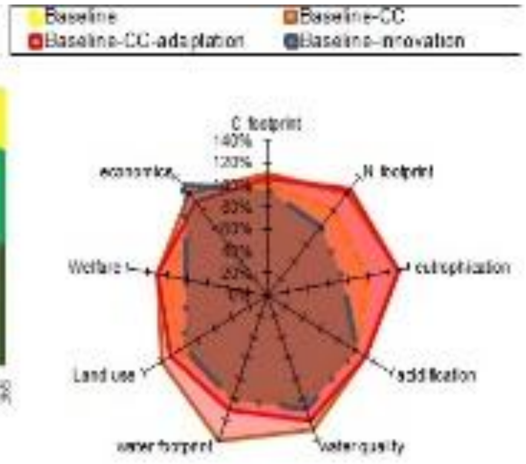
Extra challenges in Mediterranean/European small ruminants sector: **diversity of systems**

- Breeds: >25
- Production systems (typologies)
  - ❑ Intensivity
  - ❑ Feeding
  - ❑ Land use
  - ❑ Climatic conditions
  - ❑ Reproductive systems…

The tool SIMSSR







The tool to analyse farm scenarios: SIMSSR

Innovation for Sustainable Sheep and Goat Production in Europe

Deliverable No: 4.3.

New holistic model that can be used to redesign terrestrial small ruminant's livestock systems

Project acronym: iSAGE

Prjoect full name: Innovation for Sustainable Sheep and Goat Production in Europe

Grant agreement number: 679302

Start date of project: 1 March 2016

Duration of project: 48 months

Project website: www.iSAGE.eu

Working Package	4
Short name of lead participant	BC3
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Deliverable date according to Grant Agreement	28/02/2019
Actual delivery date	28/02/2019

Table 1 – Key information

Country	Spain
Authors of this Report	Agustin del Prado[1], Inmaculada Batalla[1], Guillermo Pardo[1], Asma Jebari[1], Athanasios Ragkos[2], Alexandros Theodoridis[2] and Georgios Arsenos[2] [1]*Basque Centre For Climate Change (BC3)* [2] *Aristotle University of Thessaloniki (AUTH).*
Date	28-02-2019

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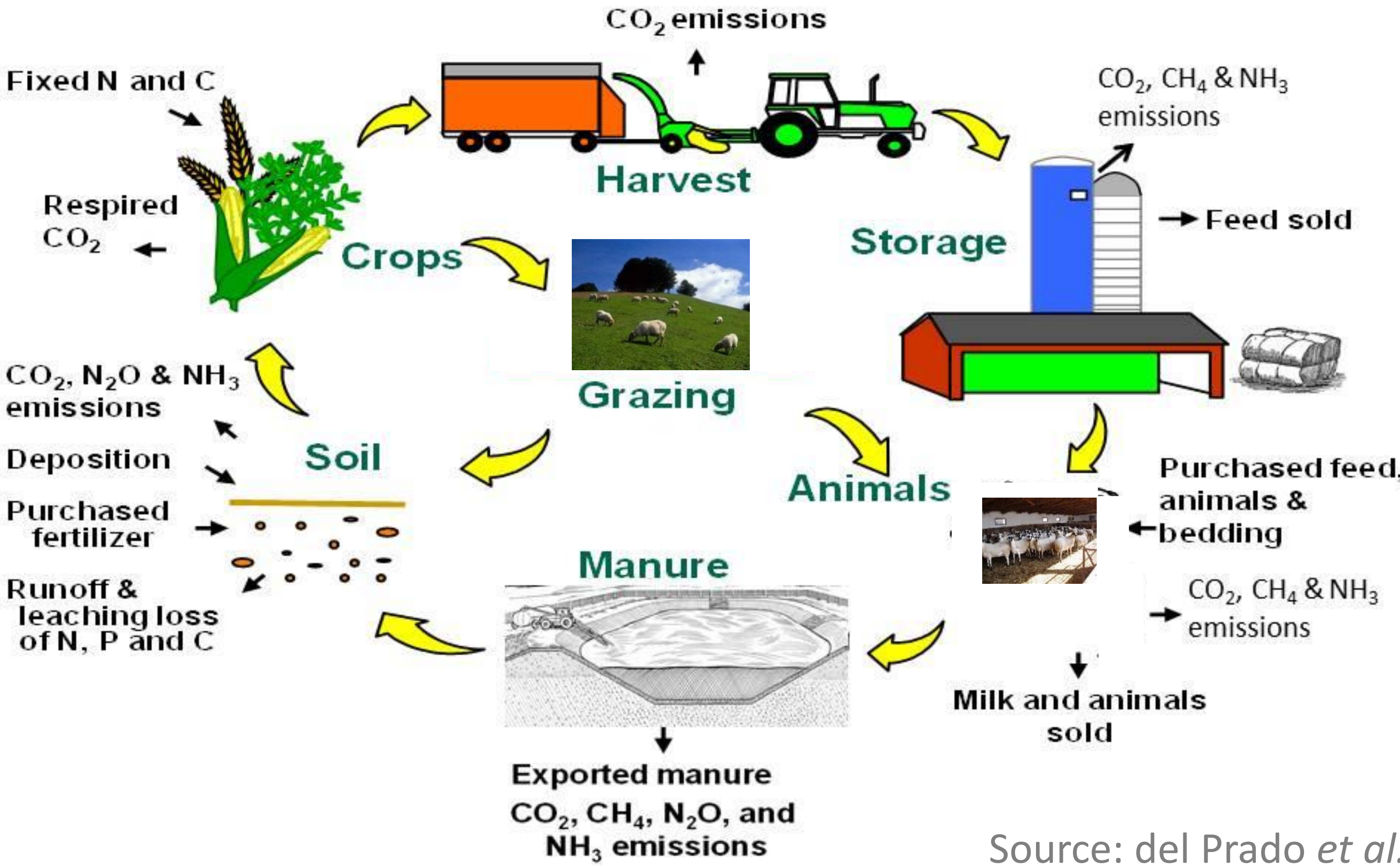
The tool to analyse farm scenarios:

SIMSSR

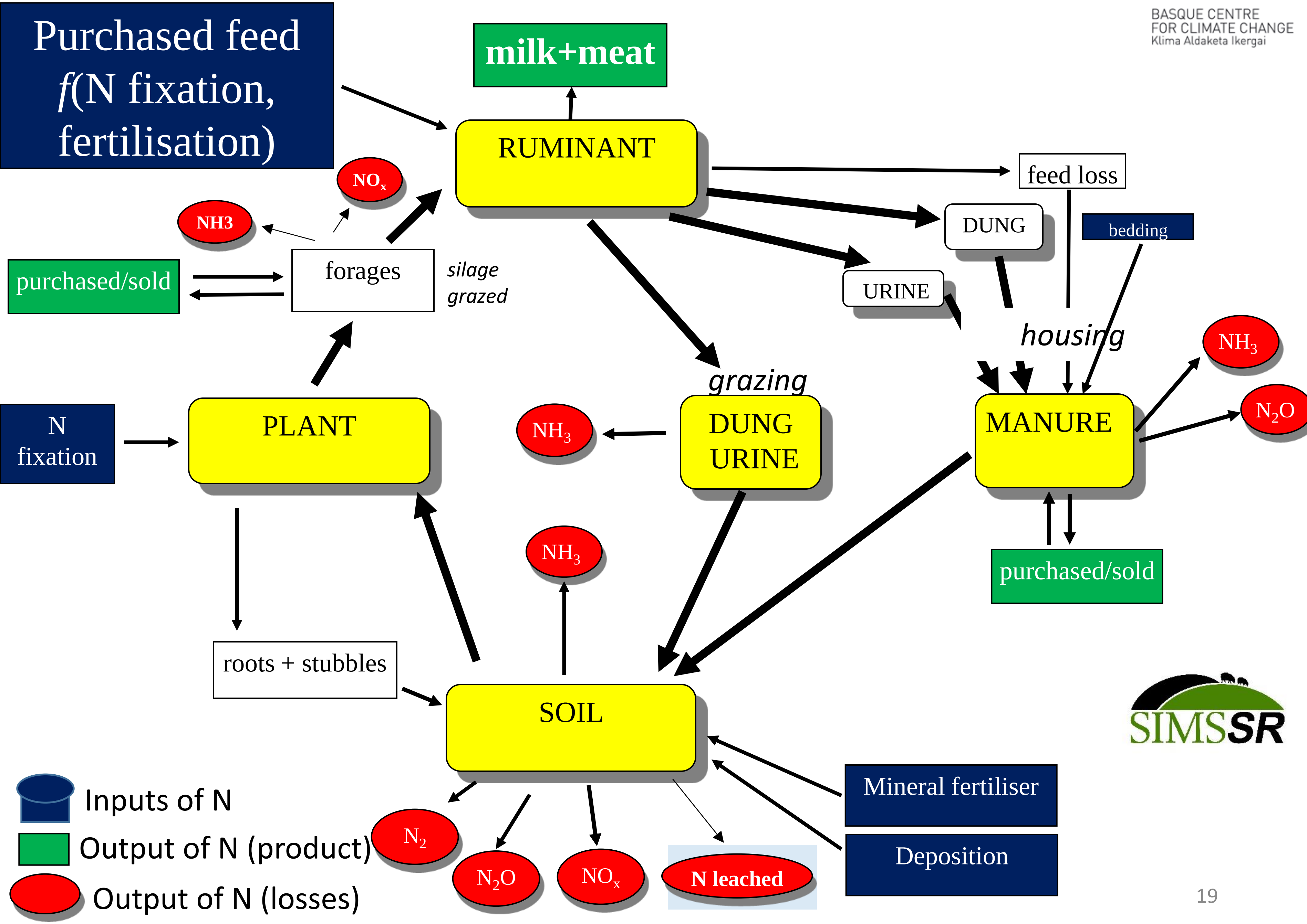
- Simulates the effect of management x genetics x soil x climate on
  - Farm environmental performance (losses of N and C {and sinks of soil SOC})
  - Basic economics
  - Other atributes of sustainability
- Boundaries: Farm, includes pre-farm gate emissions
- Generic submodels
- Semi process-based
- Written in DELPHI (PASCAL-based programming language)
- Main use: strategic run what-if scenarios (current,

Main components of a ruminant livestock system



Source: del Prado *et al.* 2013

N flows at the farm level

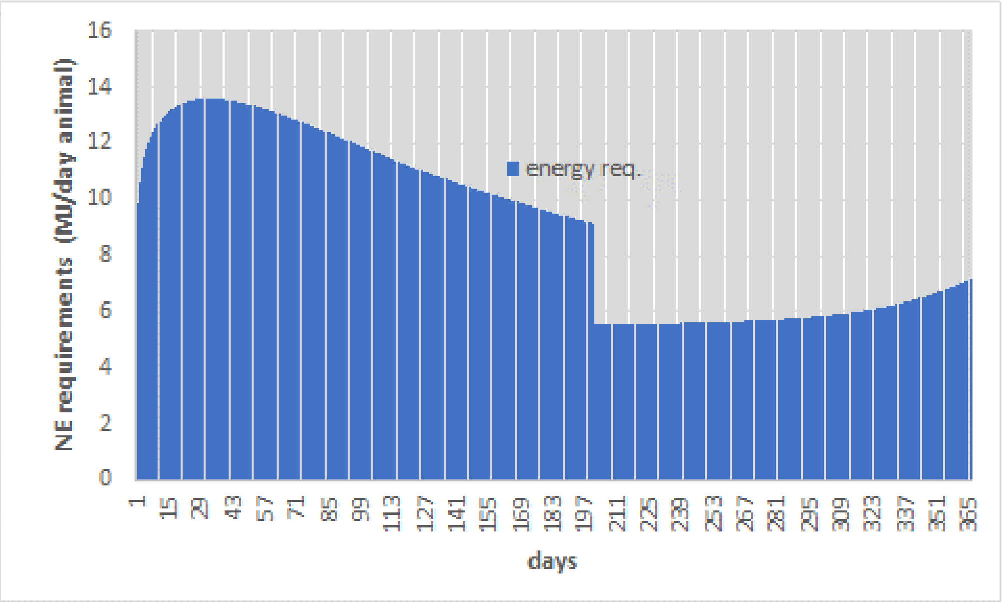


Feeding in SIMSSR

5 Flocks : 3 ewe/doe, adult male, lambs/kids, Young (Non-kids/lambs)

Each flock is simulted (daily) feeding according to:

- Management
- availability of farm feed
- weight/weight gain/loss
- production level



MJ simulated intake/day ewe

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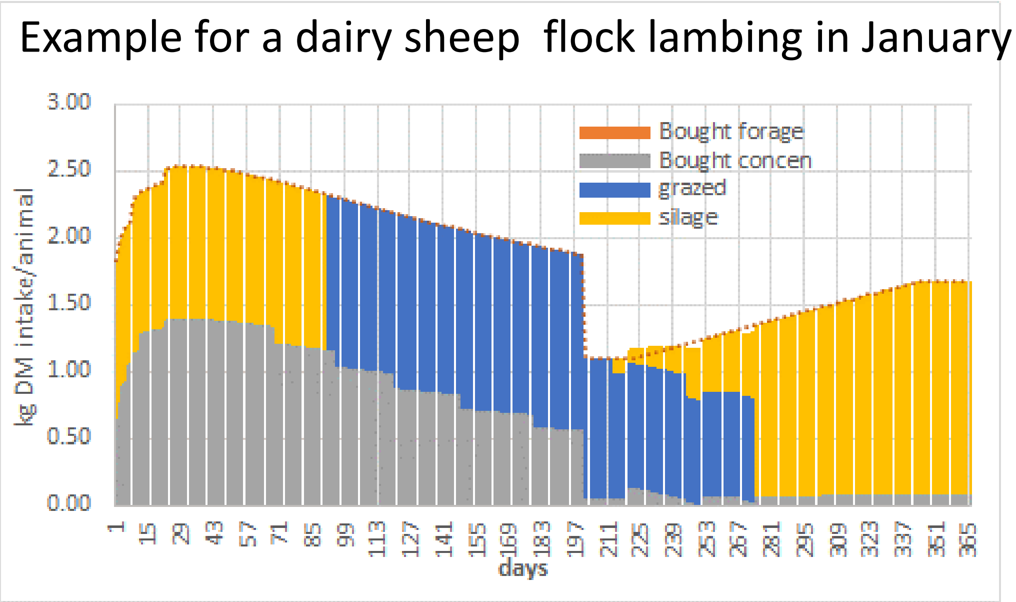
Feed allocation in SIMSSR : calendar

Each flock is simulted (daily) feeding according to:

- Management
- availability of farm feed
- weight/weight gain/loss
- production level



Kg DM simulated intake/day ewe for each type of feed

Feed allocation in SIMSSR : calendar

- **Grazed** forage: Grassland (lowland, upland, Mediterranean, highlands/mountain), grazed fallow, grazed crop residues
- **Home-grown forage for harvest**: Grassland (silage/hay from lowland), forage maize, forage legume
- **Purchased forage**: Any generic type (calculated from forage left required)
- **Home-grown grazed whole crops:** depending on available has and yields
- **Home-grown grains for harvest:** depending on available has and yields
- **Purchased concentrates: different types** (calculated from energy required to meet energy demands)

Feed allocation in SIMSSR : calendar

How much do they eat or meat/milk produce?

- Energy and nutrient requirements (e.g. protein)
- Feed on offer (e.g. fiber, energy, protein)
- Genetics
- Structure of the herd

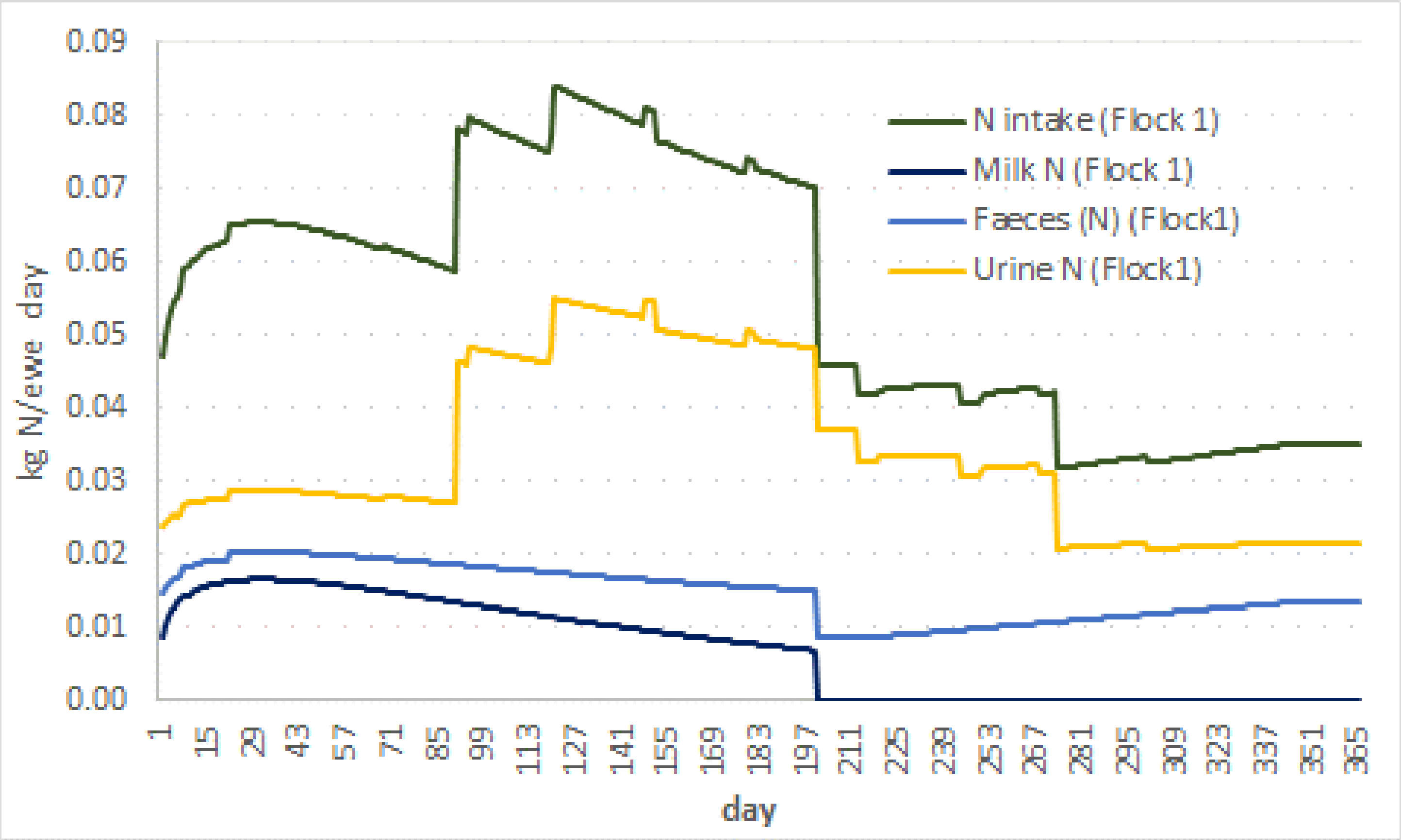
CH_4

CO_2

How much do they excrete? (urine & faeces)

N balance (simulated) at the Flock level

SIMSSR



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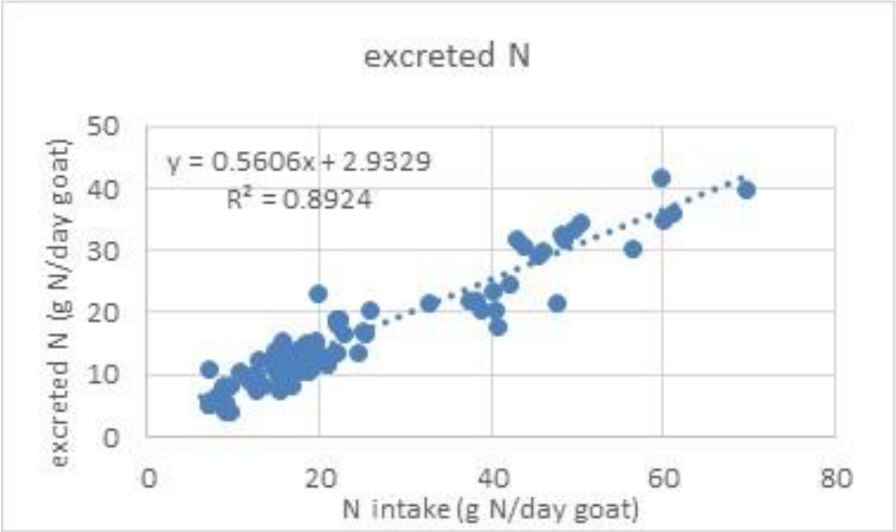
N balance (simulated) at the Flock level

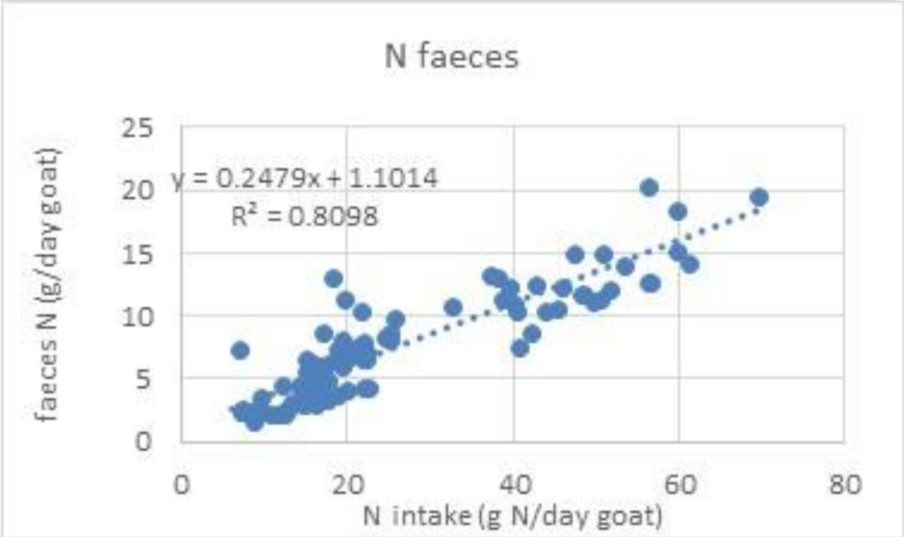
For goats is based on:

- 65 peer-reviewed studies on trials on energy and N balances (goats)
- 18 different breeds

- Different feeding treatments, gender, lactating, other…
- Dry matter intake: 0.93 (0.14-2.51) kg DM/day
- Nitrogen intake: 25 (6.1-69) g N/day
- Body weight: 40 (15-64) kg
- Digestibility (DM): 68 (49-83) %

N balance (simulated) at the Flock level





Excreted N

Urine: faeces ratio

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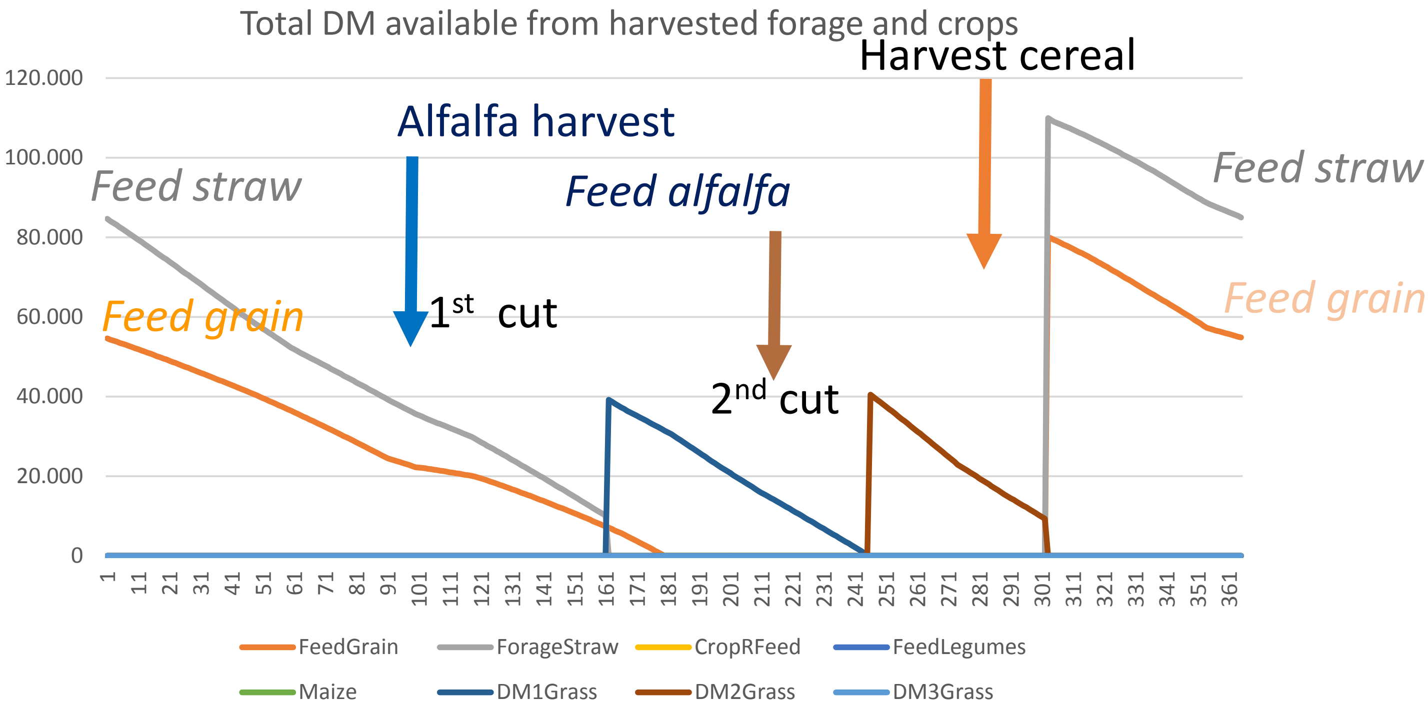
Feed allocation in SIMSSR calendar

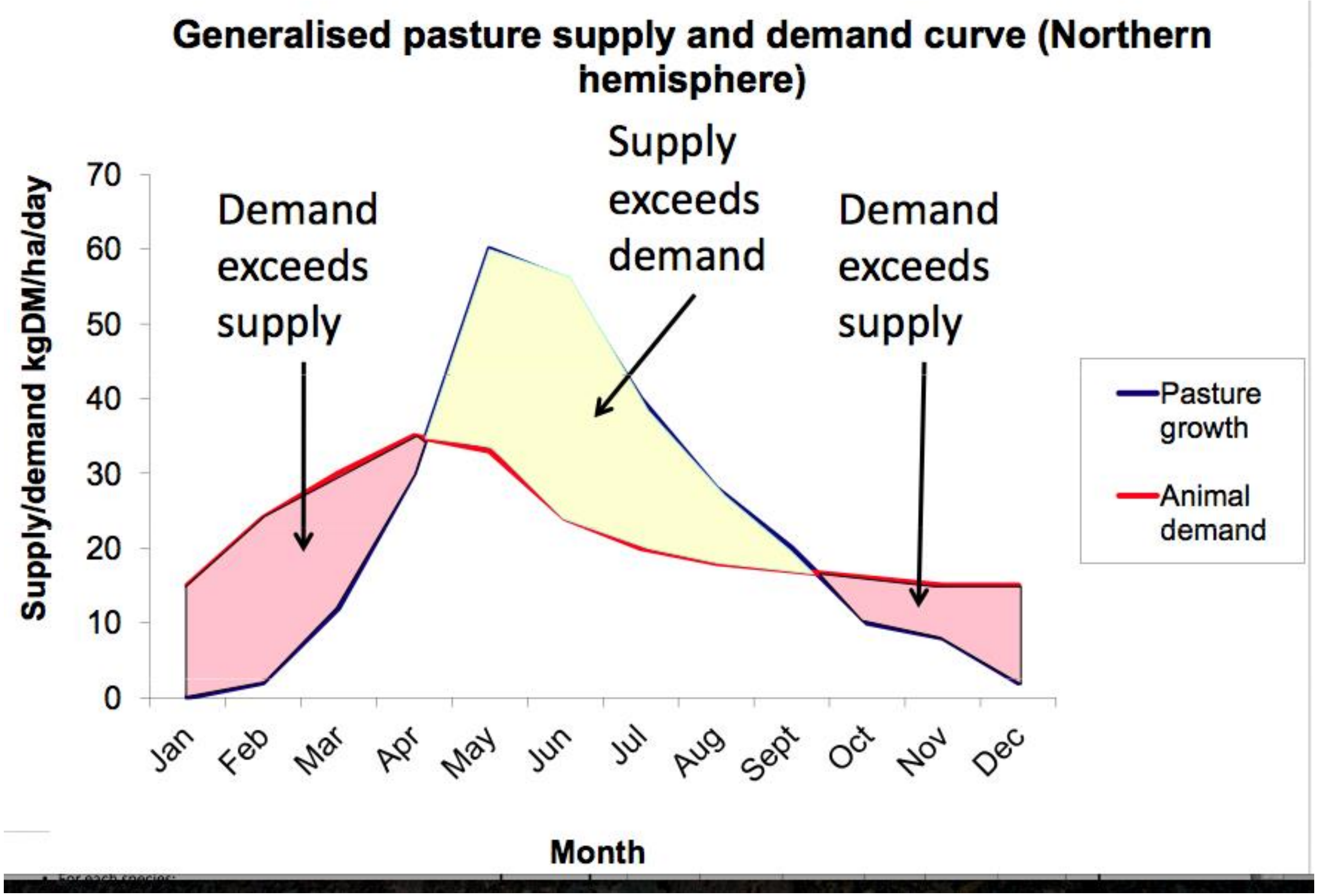


Land

cereal
alfalfa

Straw and alfalfa hay for next year left

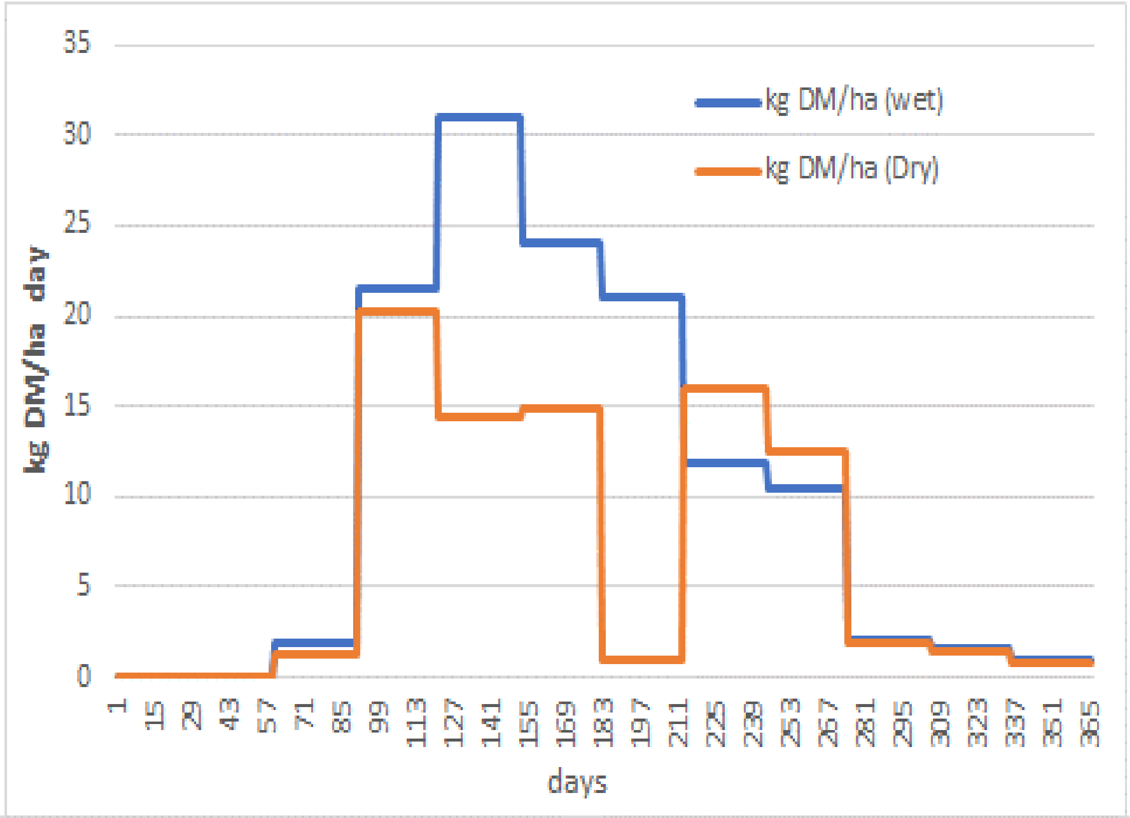
Feed production in SIMSSR grazing



http://bvetmed1.blogspot.com/2013/01/introduction-to-livestock-production.html

- How much herbage is produced?
- Digestibility, protein?
- How much N fixation?

Grass productivity depending on climate



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Default data for different breeds in SIMSSR

Table 1. Input data for dairy sheep breeds.

		Assaf	Churra	Lacaune	Latxa	Manchega	Frizarta	Chios	Lacaune	Manech Red Face	Awassi
Country		Spain	Spain	Spain	Spain	Spain	Greece	Greece	France	France	Turkey
Prolificity	lambs alive/ birth	1.8	1.38	1.65	1.27	1.5	1,6 ± 0,1	1.8-2.2	1.59	1.3	1
Fertility	%	96	96	96	96	96	>90	>90	94.4	90	87
Birth/year	nº/year	1.2	1.2	1	1	1.5	1	1	1	1	1
Lactation	days	1.2	120	150	140	150	190 ± 10	193 ± 35	170	165	162
Milk	litres	400	120	350	180	187.5	260 ± 30	308 ± 96	320	240	243
Fat	%	6.65	6.8	7.04	7.4	7.5	6.4	5-6	7.5	7.05	7.47
Protein	%	5.4	5.6	5.56	5.6	5.96	5.6	5.5	5.6	5.35	5.74
1st birth	month	15	15	14	19	17.6	13	9-10	13	14	15
Milking	number	6	5	6	3	7	6				6
Reproductive live	years	5	6		3.2		6	5-6	3.2	3.9	5
Liveweight	kg	65	50	70	50	70	65	58	75	50	50-55
Wool	kg	2.8	2	2.1	1.75	2	2	1.85	0.8	1.8	2.5
Replacement rate	%	25	20	25	20	20	25		28		25

Table 3. Inputs data for goat breeds.

		Murciano-Granadina	Florida	Saanen
Country		Spain	Spain	France
Main production		Milk	Milk	Milk
Prolificity	kids/birth	1.8	1.8	1.8
Fertility	%	90	90	90
Birth/year	nº/year	1	1	0.8
Liveweight	kg	50	60	75
Milk production	litres	530	575	920
Milking	Days	250	247	300
Fat	%	5.6	4.8	3.68
Protein	%	3.6	3.4	3.36
Age 1st lambing	months		14	12
milking	number	6	7	3.2
Replacement rate	%	20	20	30

- Adult ewe/does
- Adult male
- Young animals (not lamb/kids)
- Lamb/kids

Default lactation curves in SIMSSR

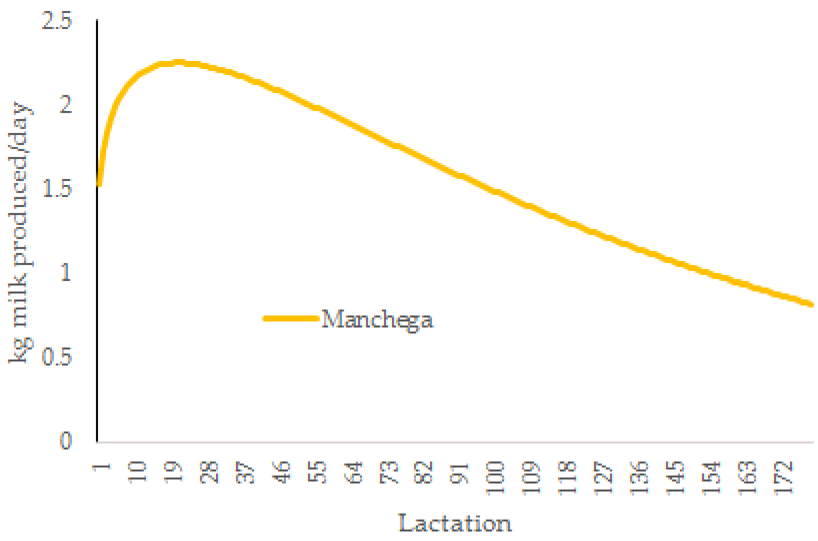

Figure 8. Lactation curve Wood function for Manchega

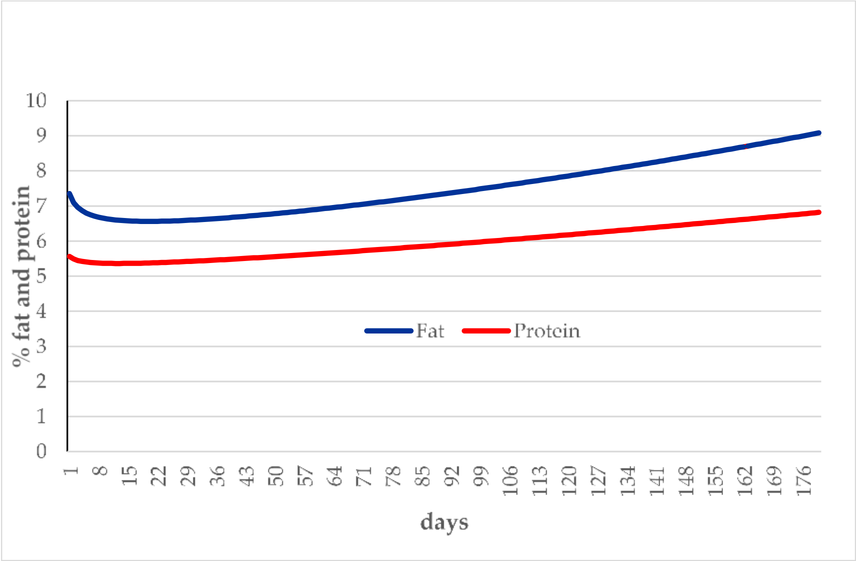

Figure 9. Fat and Protein Curve for Manchega breed using Wood factors.

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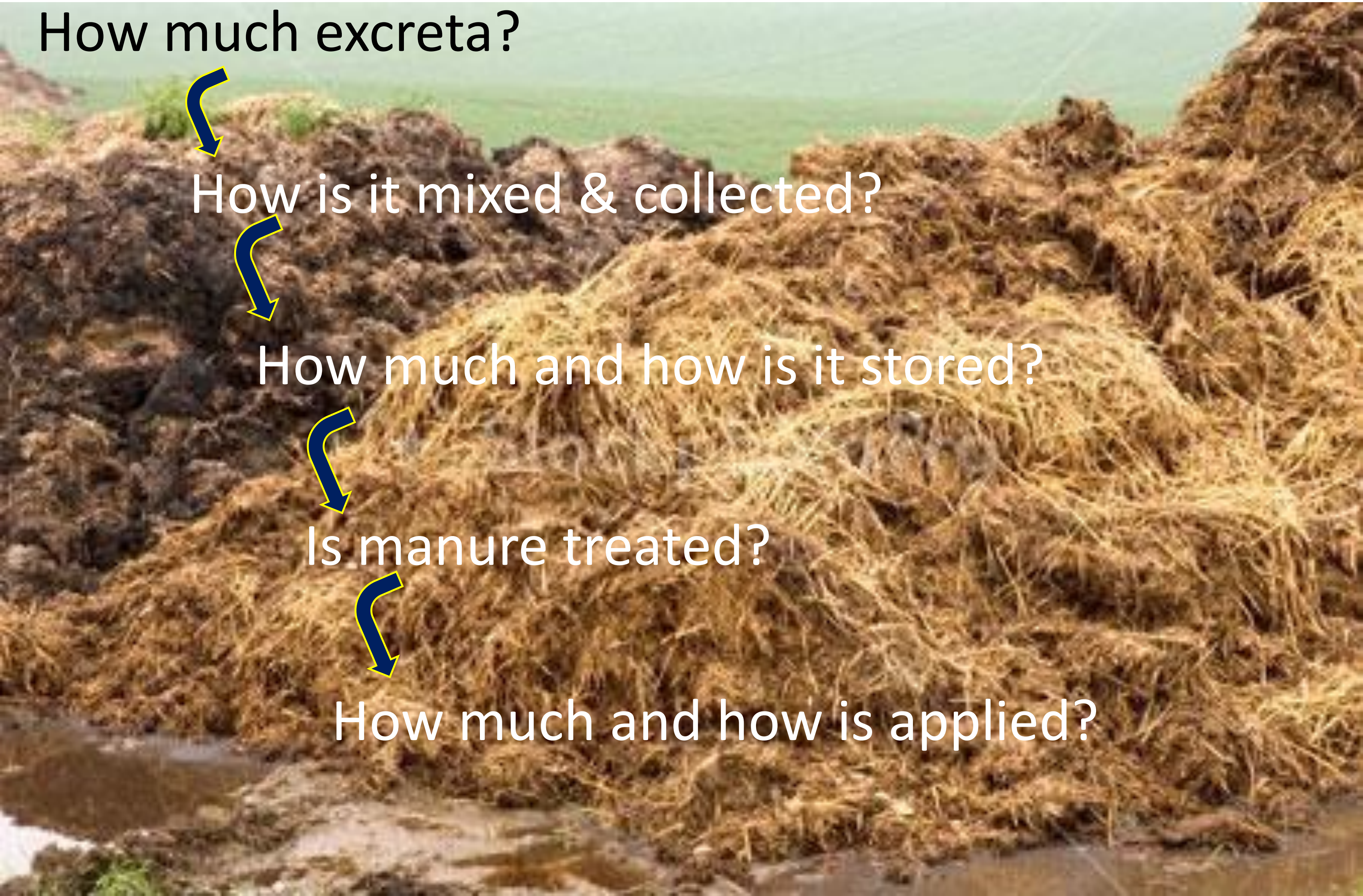
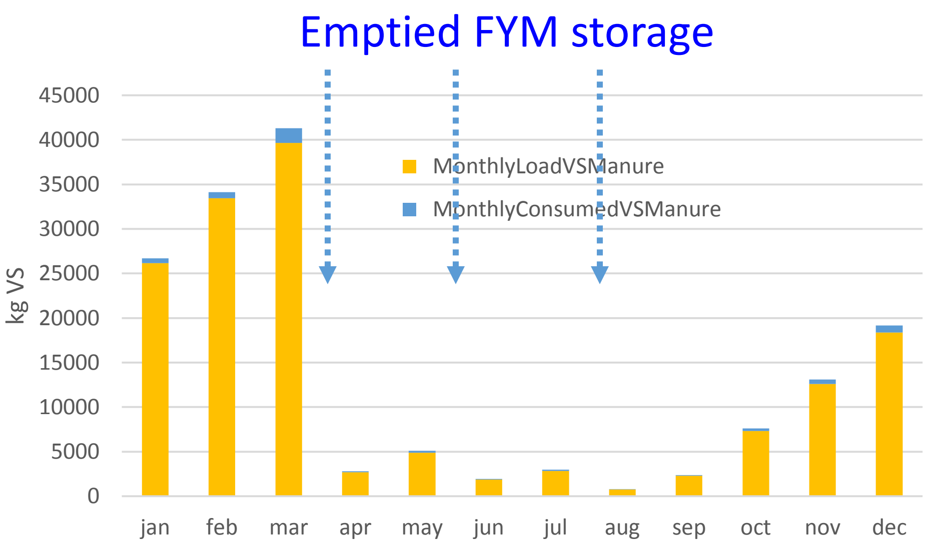
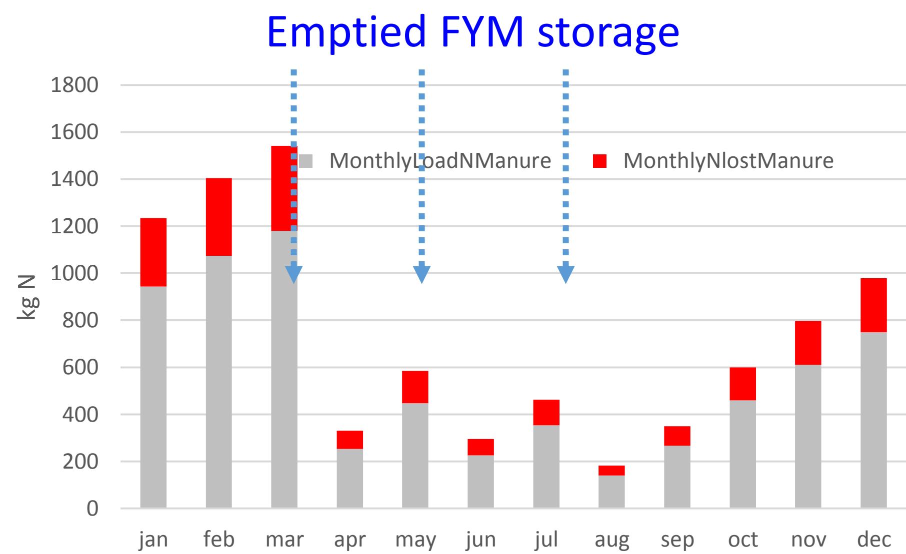
Manure handling in $SIMS_{SR}$



Manure



Manure Volatile solids (load and consumed) at storage



Manure N (load and loss) at storage

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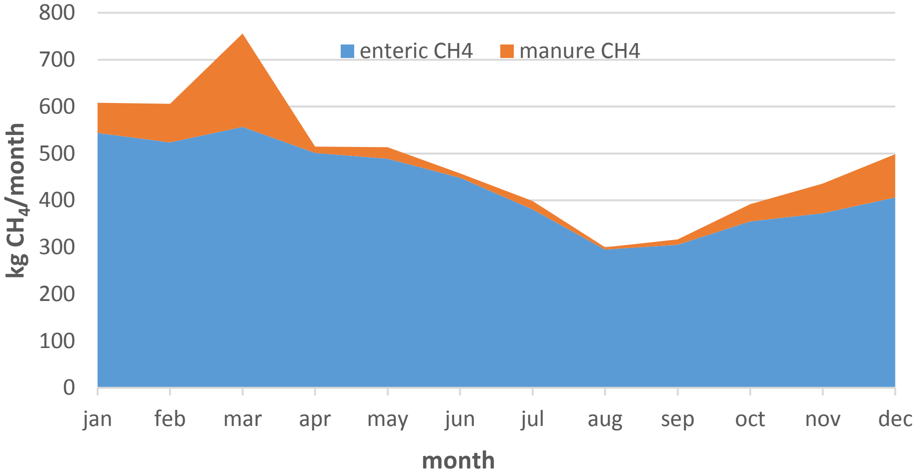
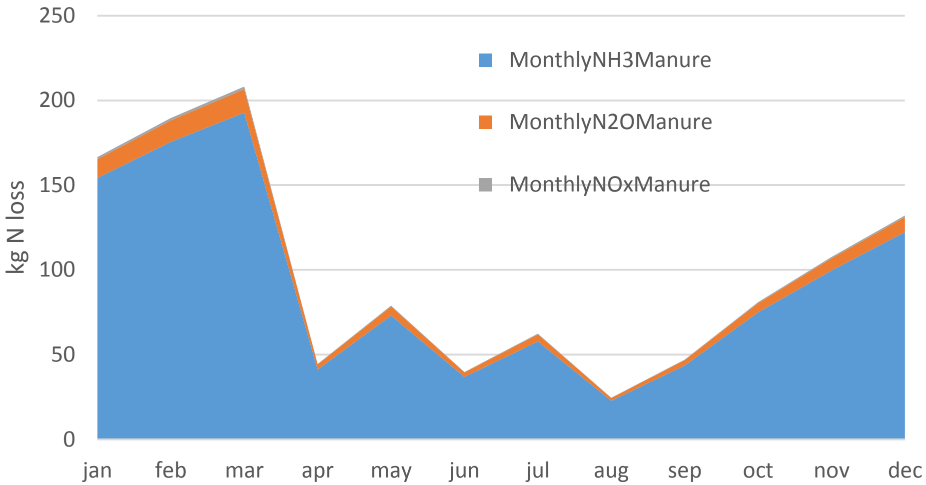
Manure



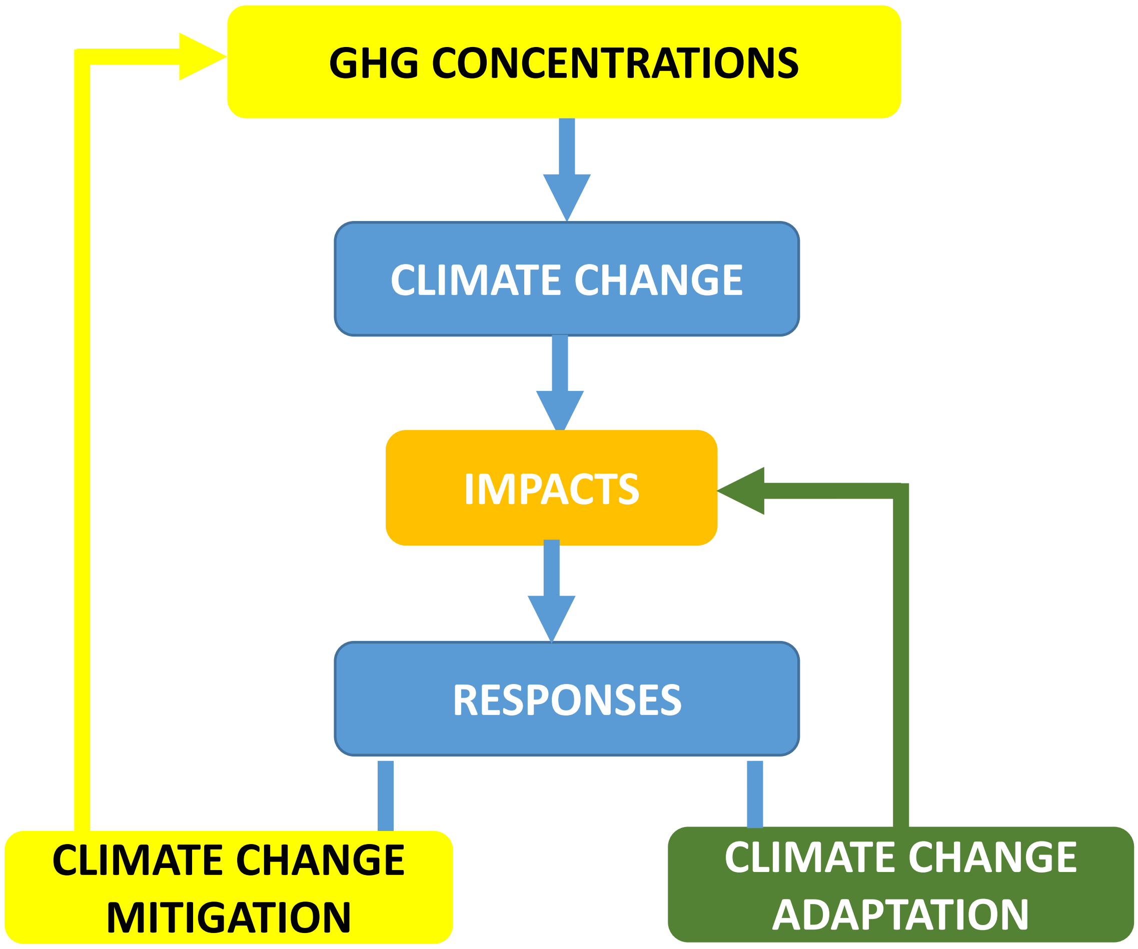
CH_4-enteric vs. CH_4 manure



N losses from FYM storage

Climate change challenge

Climate change dimenssions



Summary of impacts on feed-related issues

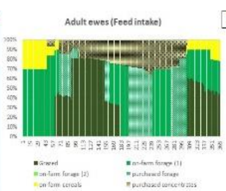
<u>For extensive/semi-extensive systems</u>

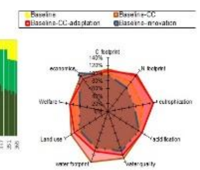
- reductions in available pasture for grazing, forage and cereal production (specially from rainfed systems)
- more dependent on external feed (assuming that no extra, possible even fewer land will be spared for small ruminant productions)
- Will public services be paid for? (market or subsidies)

<u>For intensive systems</u>

- feed prices (product prices too) will affect most the viability of the farms.

Examples at farm level (meat sheep)





Modelled with $SIMS_{SR}$ (Del Prado et al. 2019)

- Breed: rasa Aragonesa
- Meat production (lamb)
- 1.5 births/year
- Location: Zaragoza (Spain)
- Number of ewes: 550

FEED

- Grazed marginal land (pastures)
- Grazed rainfed alfalfa
- Alfalfa hay (homegrown harvest or purchased)
- Cereals (homegrown barley)
- Barley straw (homegrown barley)
- Concentrates

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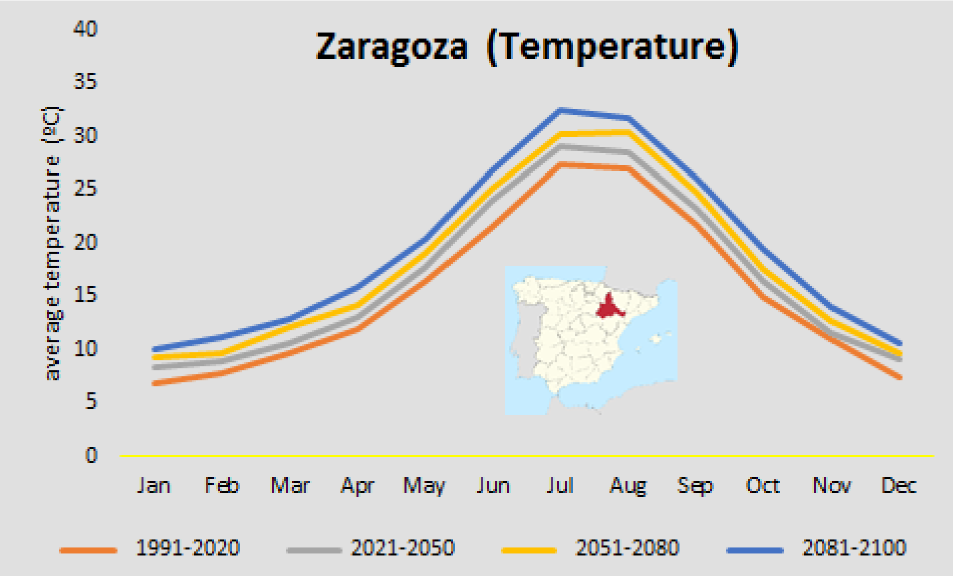
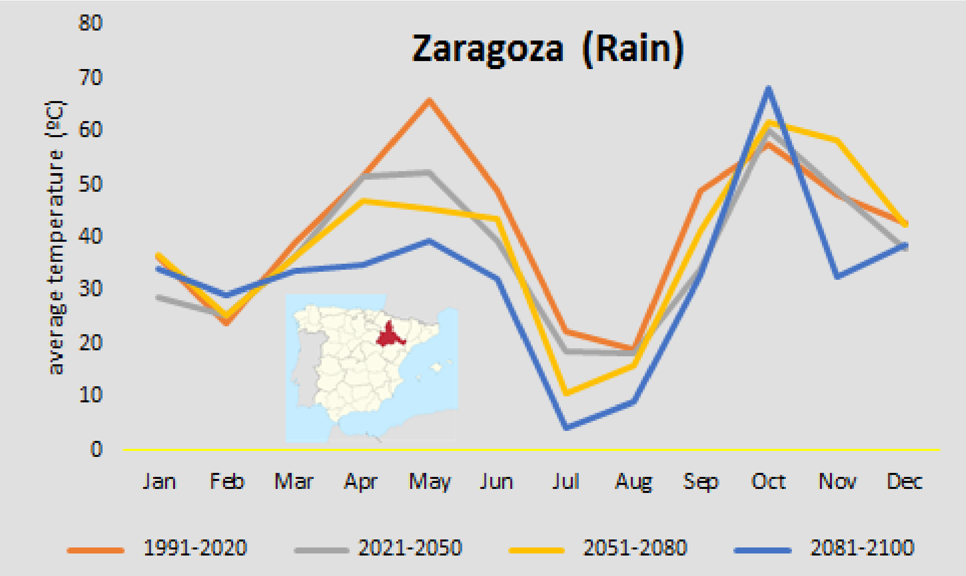
Examples at farm level (meat sheep)





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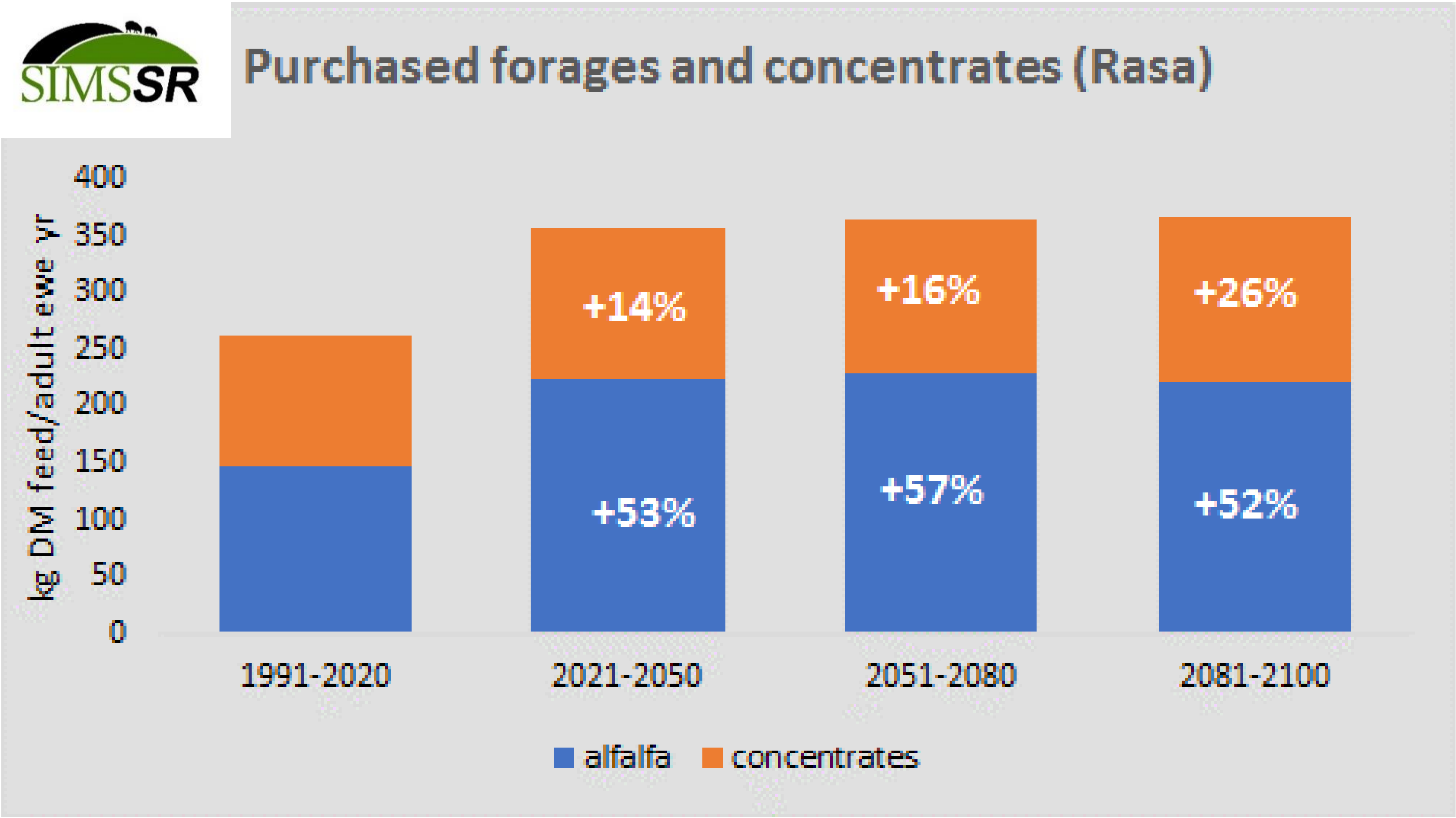
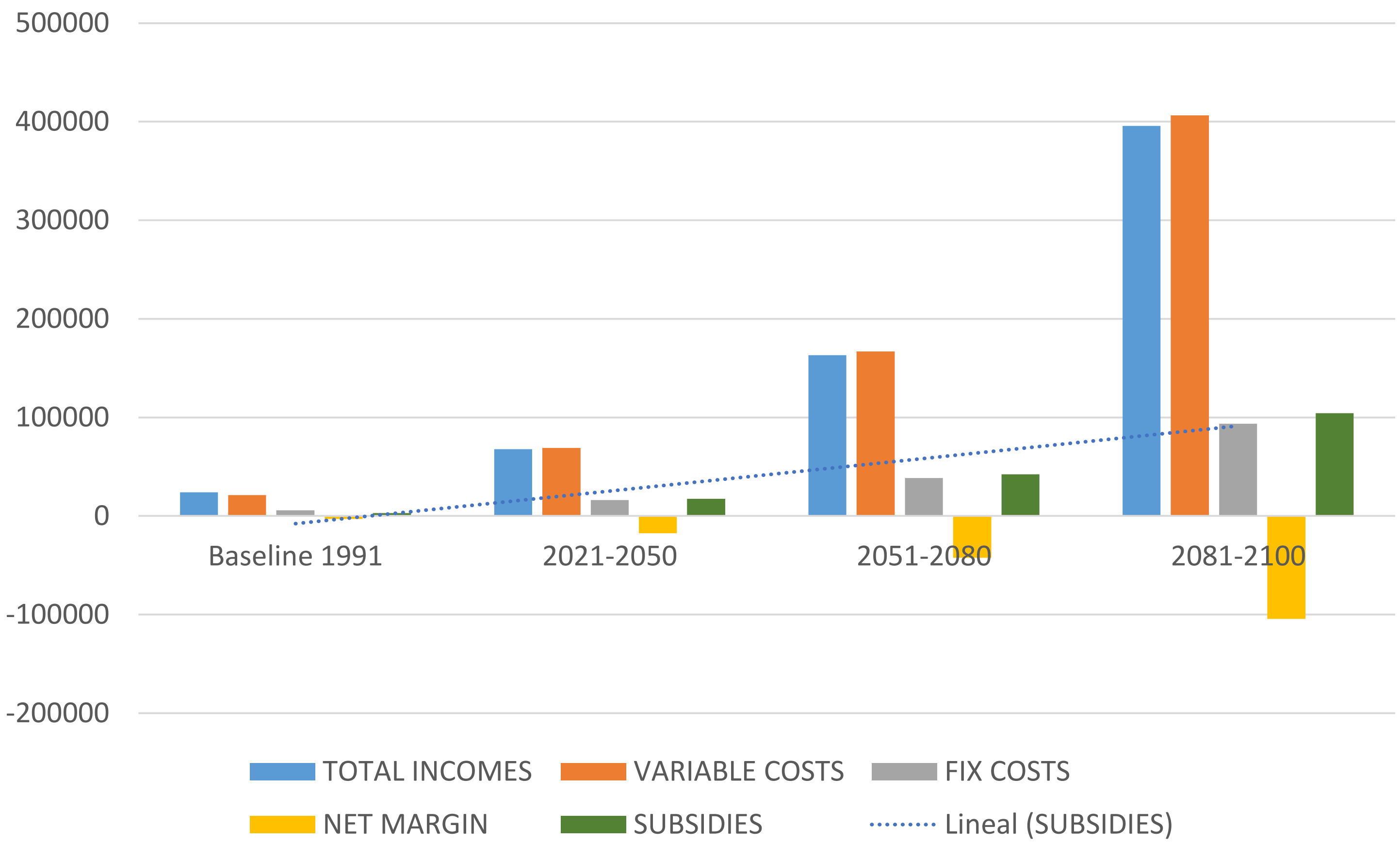
Examples at farm level (meat sheep)



We need to buy more forage and concentrates are required because of reduced yields due to climate change

Examples at farm level (meat sheep)



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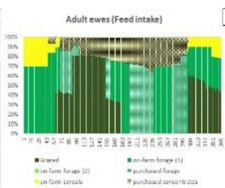
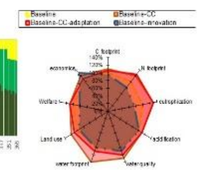
Examples at farm level (dairy sheep)





Modelled with $SIMS_{SR}$ (Del Prado et al. 2019)

Dairy sheep system in Greece

(Chios breed)

Reproductive system: 1 lambing per year

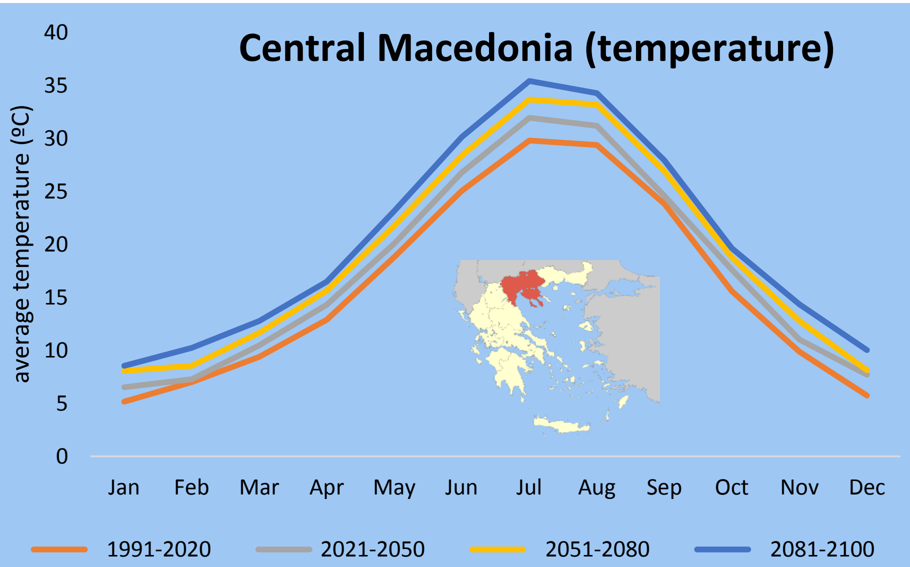
300 ewes

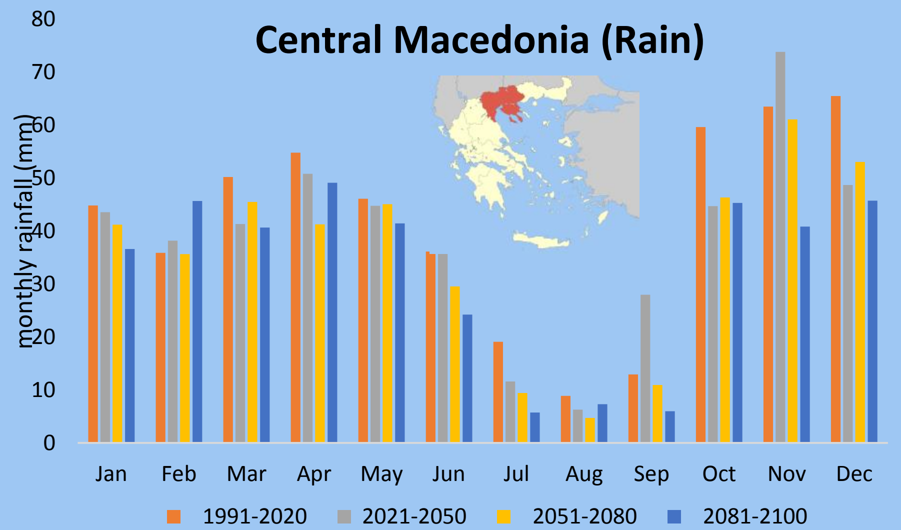
intensive

FEED

- No grazing
- Alfalfa hay from irrigated land (homegrown/bought)
- Cereals (homegrown wheat)
- Wheat straw (homegrown wheat)
- Concentrates

Examples at farm level (dairy sheep)





2021-2050 rainier in autumn, not so drier compared with 1991-2020

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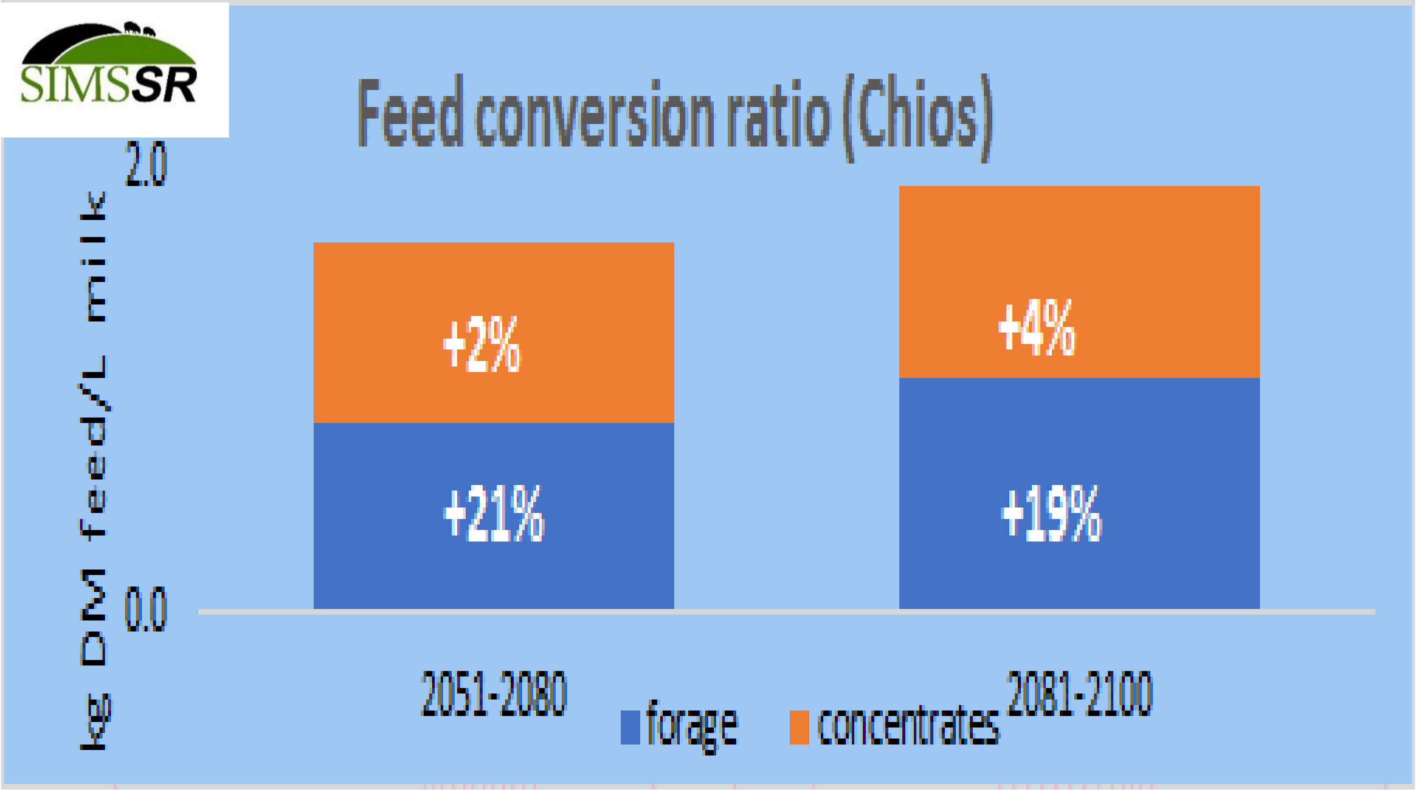
Examples at farm level (dairy sheep)



- No effect for 2021-2050
- over 20% more feed per L produced after year 2050 is required

Adaptations to climate change (examples)

- Breeding (animal or plant)
- More dense diets in heat stress conditions
- Irrigate land
- Spraying/shading

Greenhouse gases from small ruminants productions systems, small ruminants as a driver of climate change

IPCC authors

iSAGE

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What is the role of small ruminants for reducing the effect of agricultural sector on climate change?

- Paris agreement: reductions in GHG emissions. Agriculture?

- GHG Inventories will underpin countries INDCs (Paris agreement) and inform global progress towards -2ºC

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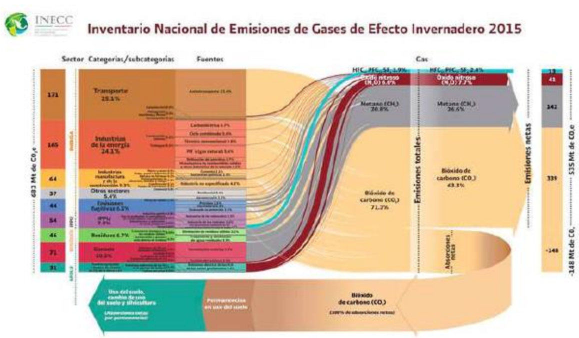
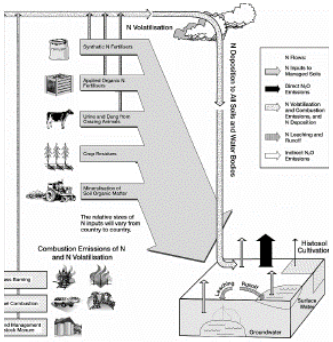
Greenhouse gases-Importance of changes in IPCC National GHG Inventories and methodologies

From 2006 all national inventories have used this guideline (IPCC, 2006)





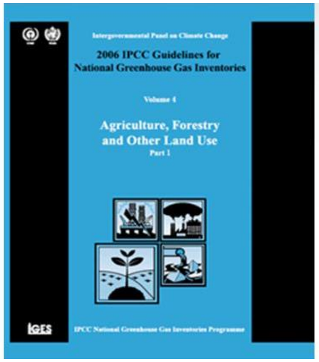
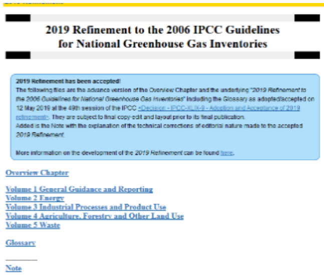


TABLE 11.3
DEFAULT EMISSION, VOLATILISATION AND LEACHING FACTORS FOR INDIRECT SOIL N_2O EMISSIONS

Factor	Default value	Uncertainty range
EF_4 [N volatilisation and re-deposition], kg N_2O–N (kg NH_3–N + NO_X–N volatilised)$^{-1}$ [22]	0.010	0.002 - 0.05
EF_5 [leaching/runoff], kg N_2O–N (kg N leaching/runoff)$^{-1}$ [23]	0.0075	0.0005 - 0.025
$Frac_{GASF}$ [Volatilisation from synthetic fertiliser], (kg NH_3–N + NO_x–N) (kg N applied)$^{-1}$	0.10	0.03 - 0.3
$Frac_{GASM}$ [Volatilisation from all organic N fertilisers applied , and dung and urine deposited by grazing animals], (kg NH_3–N + NO_x–N) (kg N applied or deposited)$^{-1}$	0.20	0.05 - 0.5
$Frac_{LEACH-(H)}$ [N losses by leaching/runoff for regions where Σ(rain in rainy season) - Σ (PE in same period) > soil water holding capacity, OR where irrigation (except drip irrigation) is employed], kg N (kg N additions or deposition by grazing animals)$^{-1}$	0.30	0.1 - 0.8

Note: The term $Frac_{LEACH}$ previously used has been modified so that it now only applies to regions where soil water-holding capacity is exceeded, as a result of rainfall and/or irrigation (excluding drip irrigation), and leaching/runoff occurs, and redesignated as $Frac_{LEACH-(H)}$. In the definition of $Frac_{LEACH-(H)}$ above, PE is potential evaporation, and the rainy season(s) can be taken as the period(s) when rainfall > 0.5 * Pan Evaporation. (Explanations of potential and pan evaporation are available in standard meteorological and agricultural texts). For other regions the default $Frac_{LEACH}$ is taken as zero.

From 2019 national inventories **can use** a new refinement guideline (IPCC, 2019)



https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

IPCC authors

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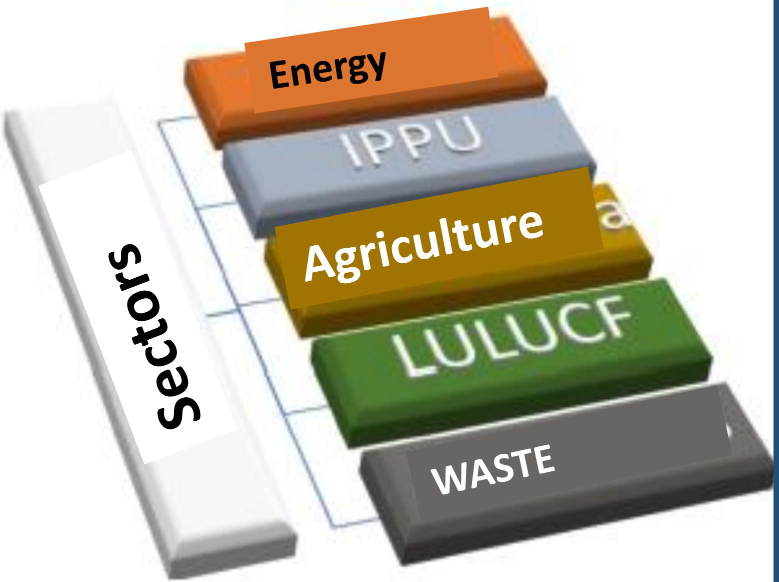
What is a national GHG inventory?



- Antropogenic emissions and sinks
- National territory
- Inventory year and temporal serie
- Greenhouse gases (2006): CO_2, CH_4, N_2O, HFC, NF3, SF5CF3, halogenous ethers and other halocarbons not covered by Montreal Protocol
- Other gases: Nox, NH_3, COVDM, CO, SO_2

Each sector comprises individual categories (e.g. transport) and subcategories (e.g. automobiles).
Countries develop the inventory at the level of subcategory

CHAPTER 10

EMISSIONS FROM LIVESTOCK AND MANURE MANAGEMENT

Some changes relevant for small ruminants

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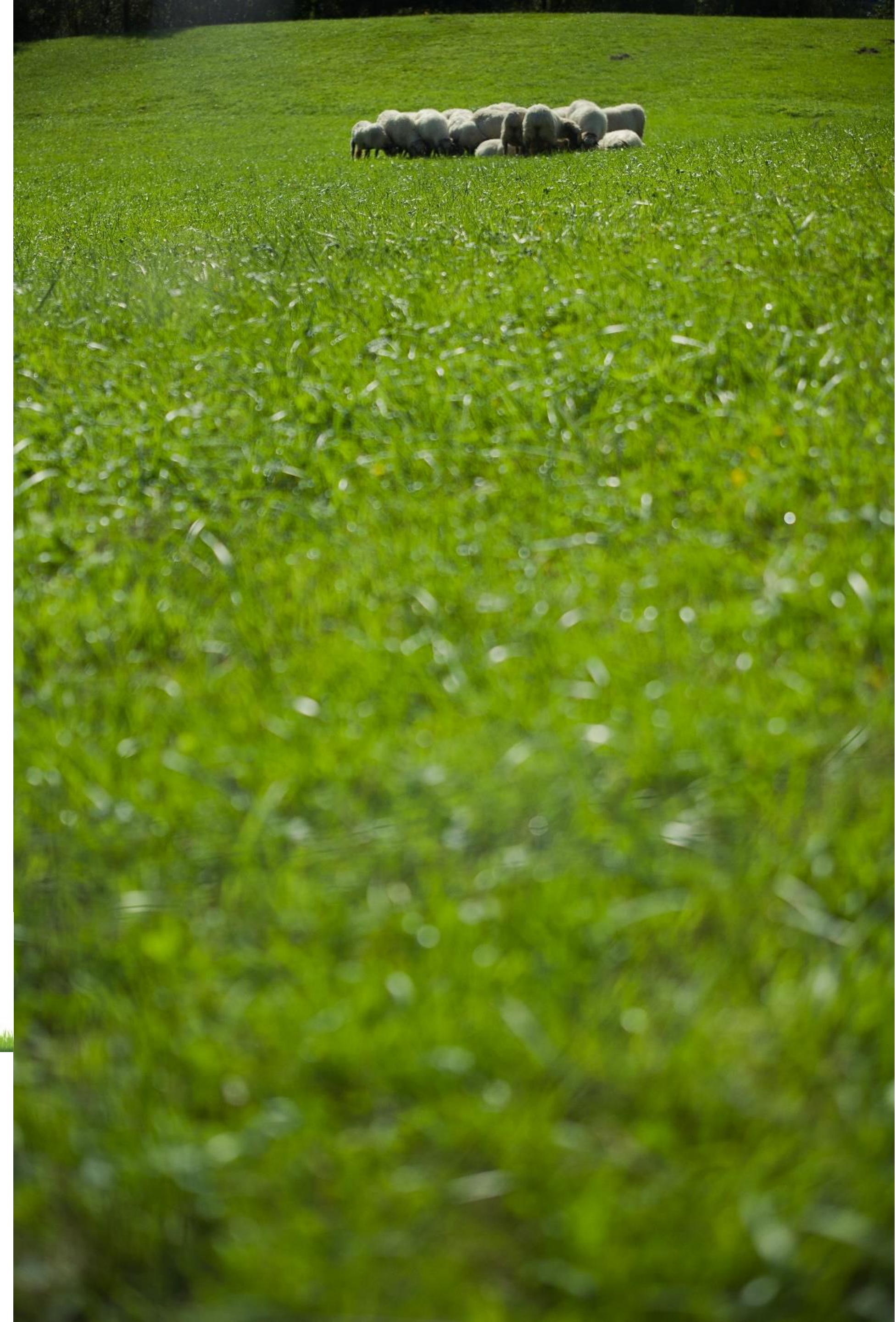
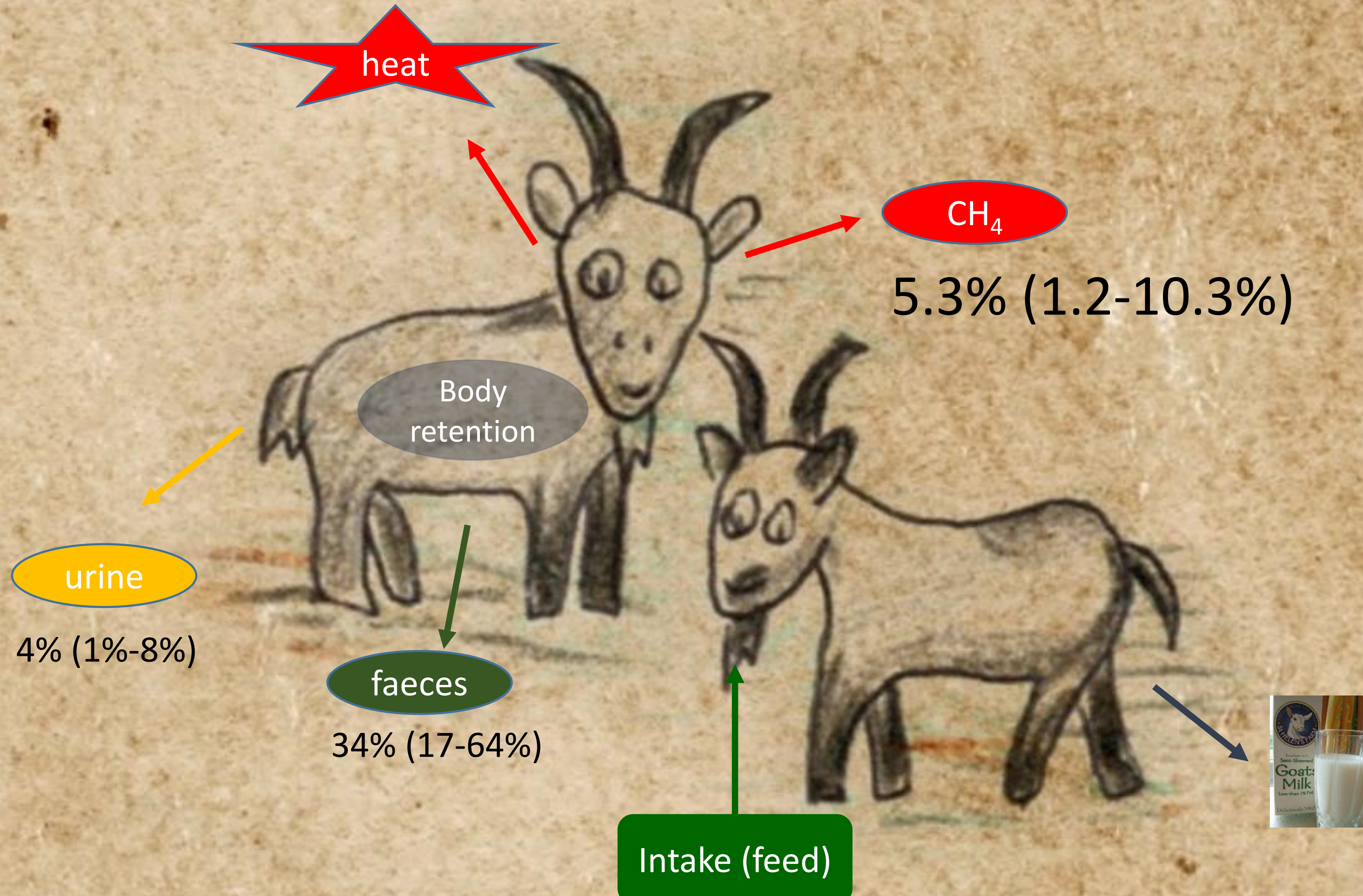
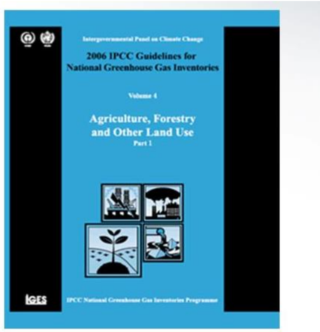


Balances of energy at the animal level

% relative to gross energy (GE) intake



Methane outputs compared with IPCC (2006)



- Provides methods for all emissions and removals from Agriculture and LULUCF
- Required for UNFCCC reporting in 2015

EQUATION 10.21
CH_4 EMISSION FACTORS FOR ENTERIC FERMENTATION FROM A LIVESTOCK CATEGORY

$$EF = \left[\frac{GE \bullet \left(\frac{Y_m}{100} \right) \bullet 365}{55.65} \right]$$

Where:

EF = emission factor, kg CH_4 head^{-1} yr^{-1}

GE = gross energy intake, MJ head^{-1} day^{-1}

Y_m = methane conversion factor, per cent of gross energy in feed converted to methane

The factor 55.65 (MJ/kg CH_4) is the energy content of methane

CH_4

%CH4 from Gross energy intake → 5.3% (1.2-10.3%) (goats)

Y_m=5.5% (goats)

sheep

TABLE 10.13
SHEEP CH_4 CONVERSION FACTORS (Y_M)

Category	Y_m [a]
Lambs (<1 year old)	4.5% ± 1.0%
Mature Sheep	6.5% ± 1.0%

[a] The ± values represent the range.

TABLE 10.13
SHEEP AND GOATS CH_4 CONVERSION FACTORS (Y_M) (UPDATED)

Category	Y_m [1]
Sheep	6.7% ± 0.9
Goats	5.5% ± 1.0

Sources and assumptions to calculate the Y_m for goats are detailed in Annex 10B.3.
[1] The ± values are the the standard deviation of the mean of the Y_m.

CHAPTER 11

N_2O EMISSIONS FROM MANAGED SOILS, AND CO_2 EMISSIONS FROM LIME AND UREA APPLICATION

Some changes relevant for small ruminants

Estimation of GHG from small ruminants

TABLE 11.1 (UPDATED)
DEFAULT EMISSION FACTORS TO ESTIMATE DIRECT N_2O EMISSIONS FROM MANAGED SOILS

Emission factor	Aggregated		Disaggregated			
	Default value	Uncertainty range	Disaggregation[4]	Default value	Uncertainty range	
EF_1 for N additions from synthetic fertilisers, organic amendments and crop residues, and N mineralised from mineral soil as a result of loss of soil carbon[1] [kg N_2O–N (kg N)$^{-1}$]	0.010	0.001 – 0.018	Synthetic fertiliser inputs[5] in wet climates	0.016	1.6%	vs.1% (IPCC 2006)
			Other N inputs[6] in wet climates	0.006	0.6%	
			All N inputs in dry climates	0.005	0.5%	
EF_{1FR} for flooded rice fields[2,7] [kg N_2O–N (kg N)$^{-1}$]	0.004	0.000 – 0.029	Continuous flooding	0.003	0.000 – 0.010	
			Single and multiple drainage	0.005	0.000 – 0.016	
$EF_{3PRP,CPP}$ for cattle (dairy, non-dairy and buffalo), poultry and pigs[3] [kg N_2O–N (kg N)$^{-1}$]	0.004	0.000– 0.014	Wet climates	0.006	0.6%	vs.2% (IPCC 2006)
			Dry climates	0.002	0.2%	
$EF_{3PRP,SO}$ for sheep and 'other animals'[3] [kg N_2O–N (kg N)$^{-1}$]	0.003	0.000 – 0.010	-	-	0.3%	vs.1% (IPCC 2006)

Sources:

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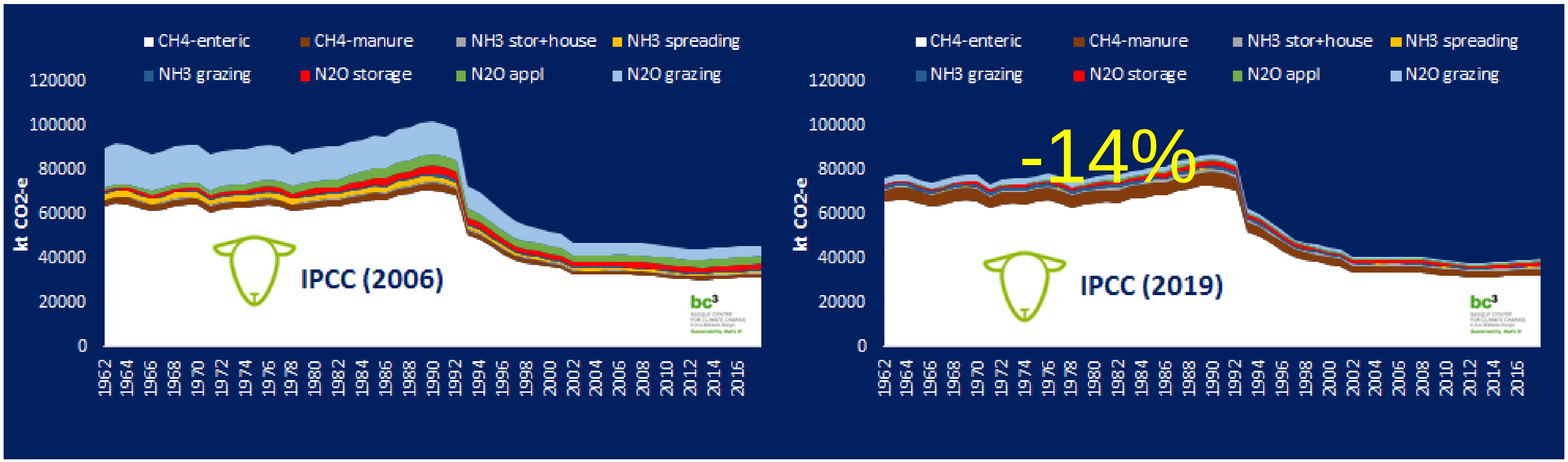
Innovation for Sustainable Sheep and Goat Production in Europe

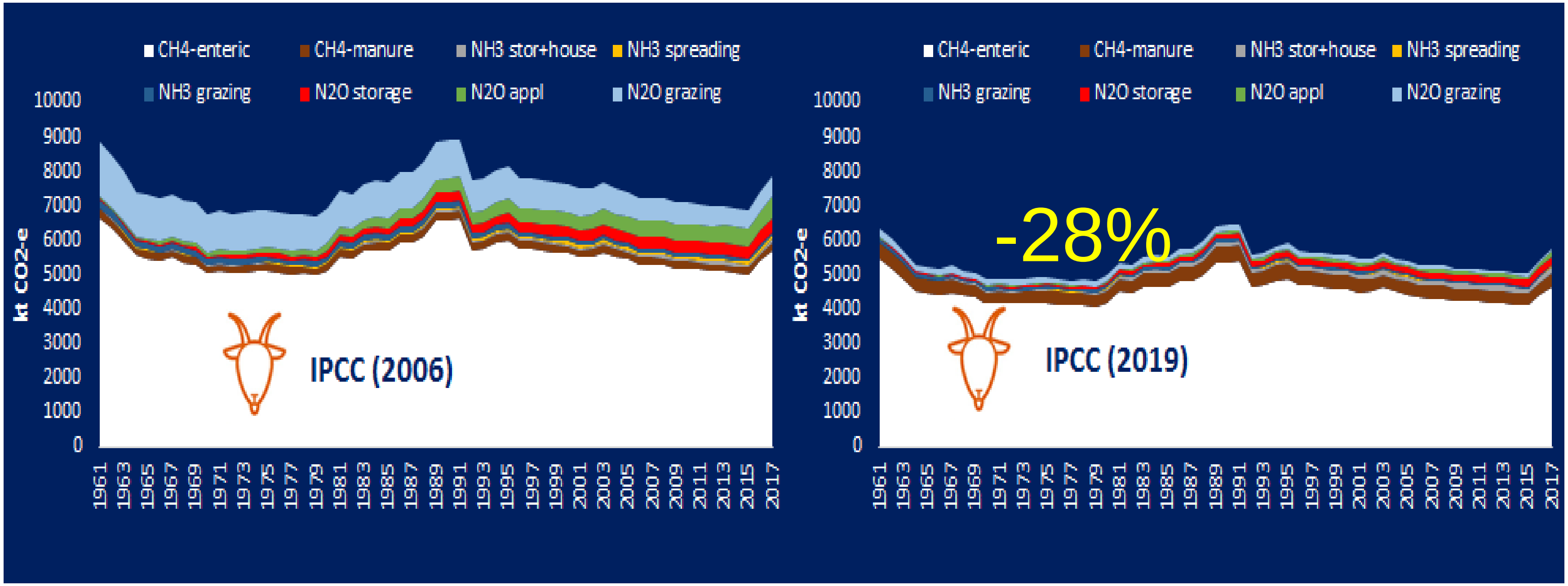
Estimation of GHG from small ruminants in Europe



<u>lower</u> GHG emissions estimates compared with the estimate using the currently widely used IPCC (2006)

iSAGE Innovation for Sustainable Sheep and Goat Production in Europe

Estimation of GHG from small ruminants in Europe



lower GHG emissions estimates compared with the estimate using the currently widely used IPCC (2006)

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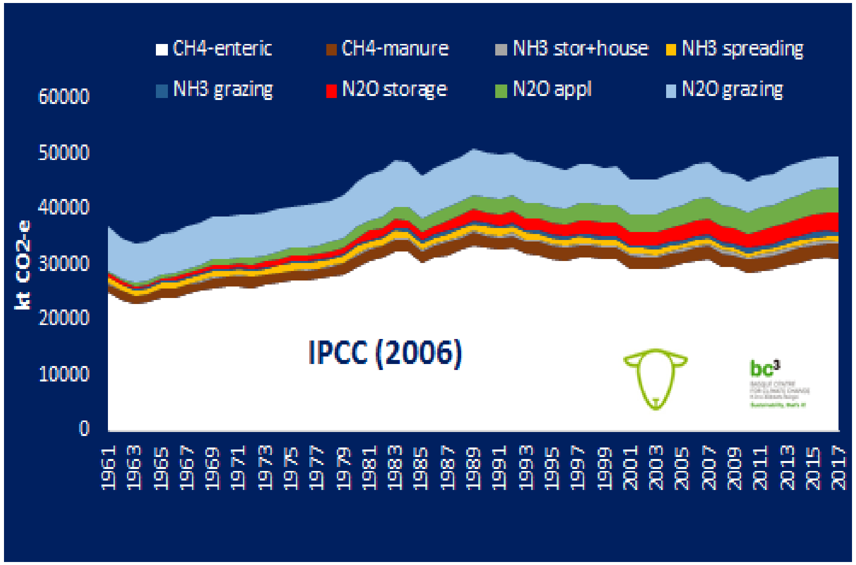
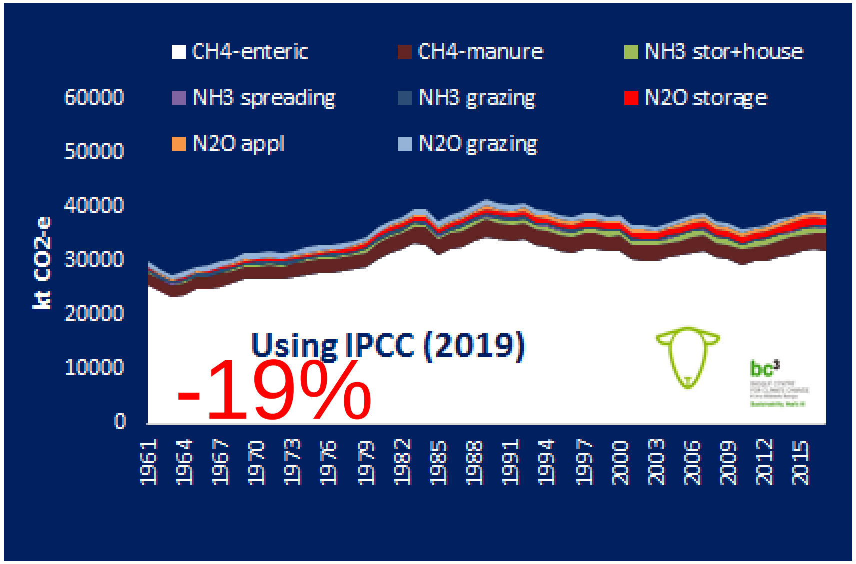
GHG (direct) from sheep in the Mediterranean basin





Using https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

lower GHG emissions estimates compared with the estimate using the currently widely used IPCC (2006)

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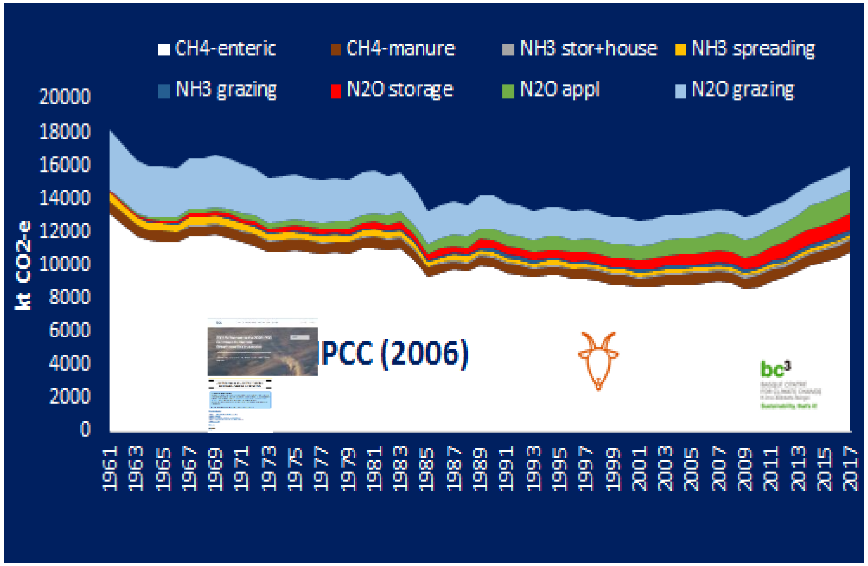
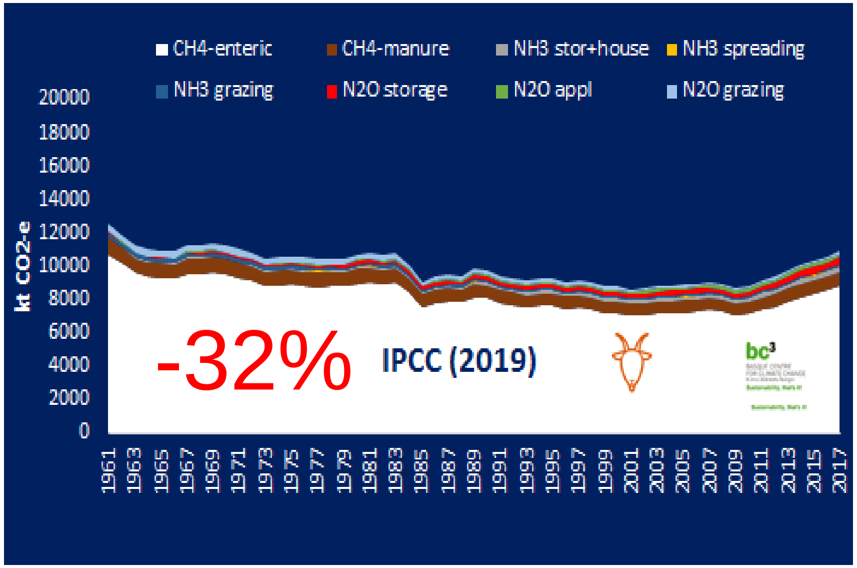
GHG (direct) from goats in the Mediterranean basin





Using https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

lower GHG emissions estimates compared with the estimate using the currently widely used IPCC (2006)

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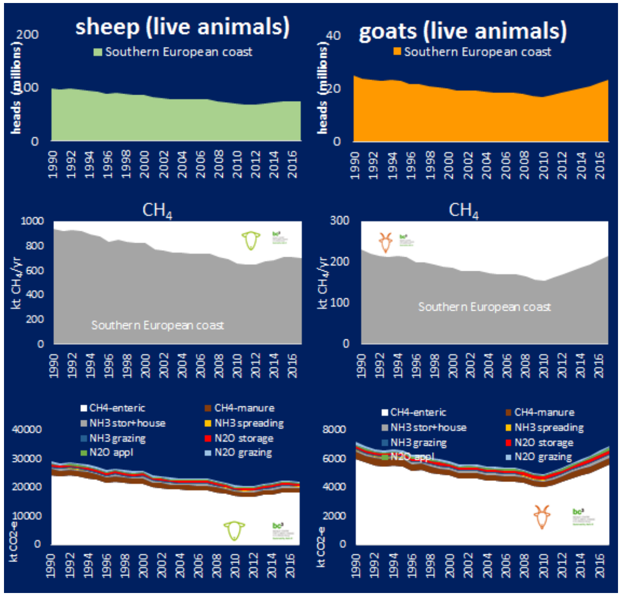
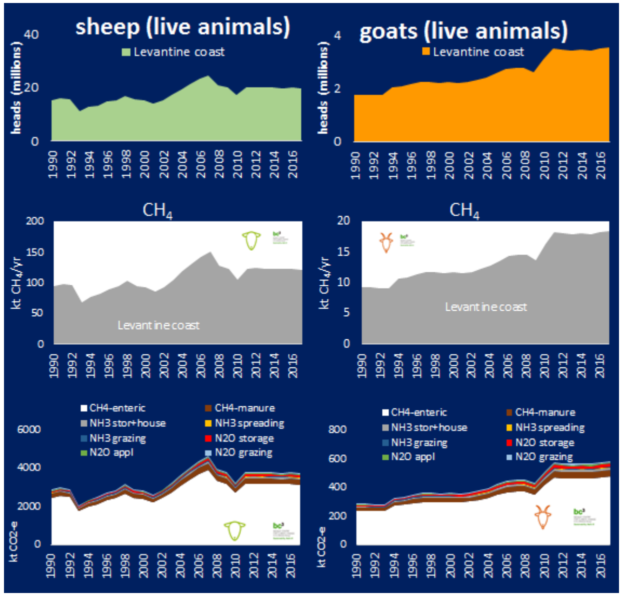
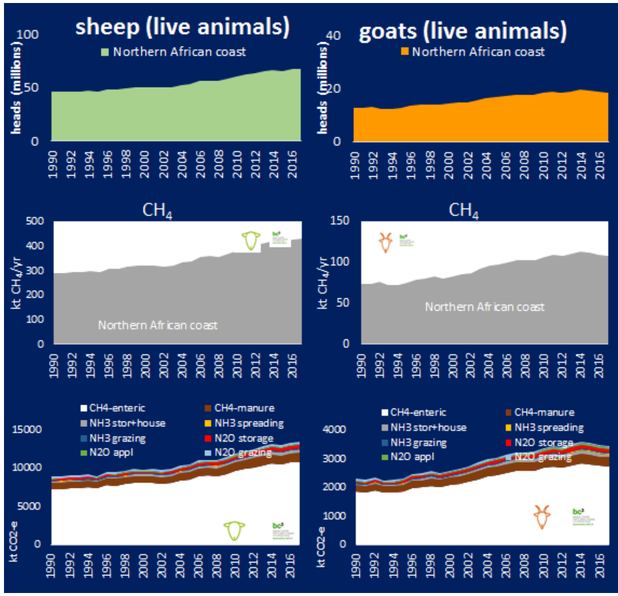
GHG from sheep and goats in the Mediterranean basin



Southern European cost



Levantine coast



Northern African cost

Based on FAOstat and IPCC (2019). Southern European coast, from west to east: Spain, Gibraltar, France, Monaco, Italy, Malta, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Albania, Greece, Turkey, Levantine coast from north to south: Syrian Arab Republic, Cyprus, Lebanon, Israel, Palestine and Northern African cost , from east to west: Egypt, Libya, Tunisia, Algeria, Morocco

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Innovation for Sustainable Sheep and Goat Production in Europe

How can small ruminants contribute to mitigation/adaptation of climate change and increase sustainability?

Reducing grazing in marginal land (for extensive systems), good for the environment?

Do emissions drop by reducing sheep grazing in marginal land?

Example: meat sheep rasa-aragonesa in Spain

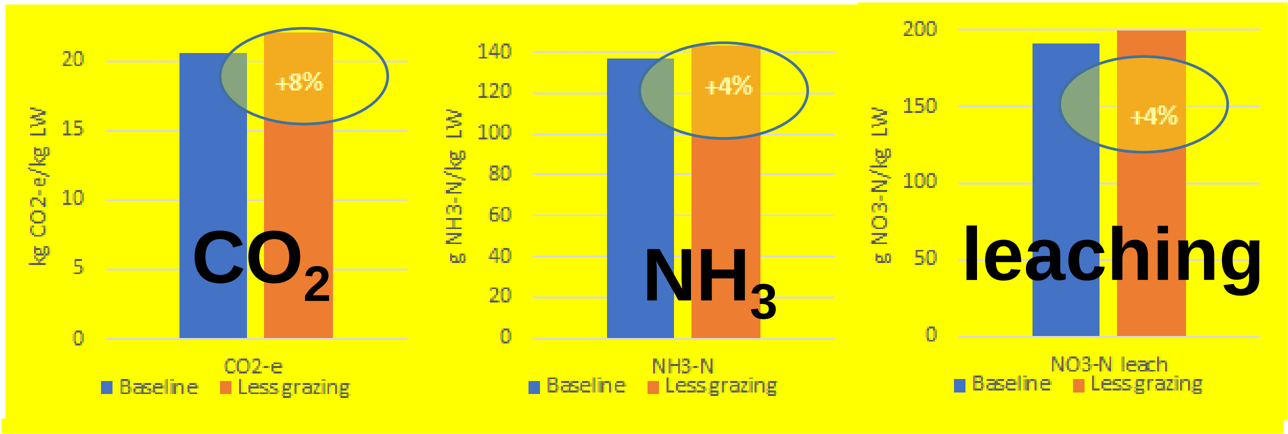
Reducing grazing in marginal land (for extensive systems), good for the environment?

Efficiency

$$\text{Emissions} = \frac{\text{Emissions}}{\text{Animal product}}$$

Reducing grazing in marginal land (for extensive systems), good for the environment?

Do emissions drop by reducing sheep grazing in marginal land?



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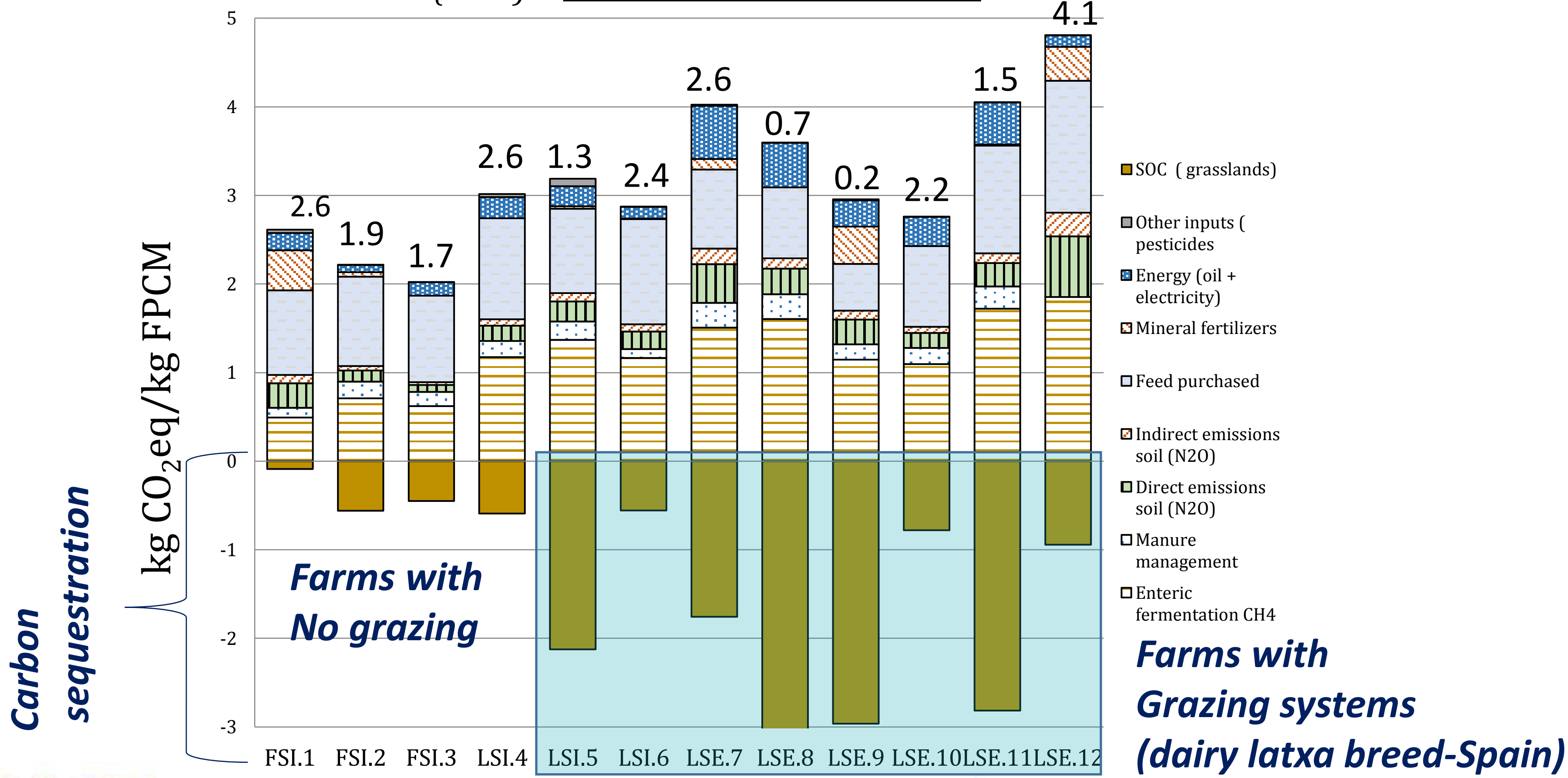
Batalla et al. (2015)

Dairy sheep farms



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Reducing grazing in marginal land (for extensive systems), good for the environment?

Efficiency

$$\text{Emissions} = \frac{\text{Emissions}}{\text{Land (ha)}}$$

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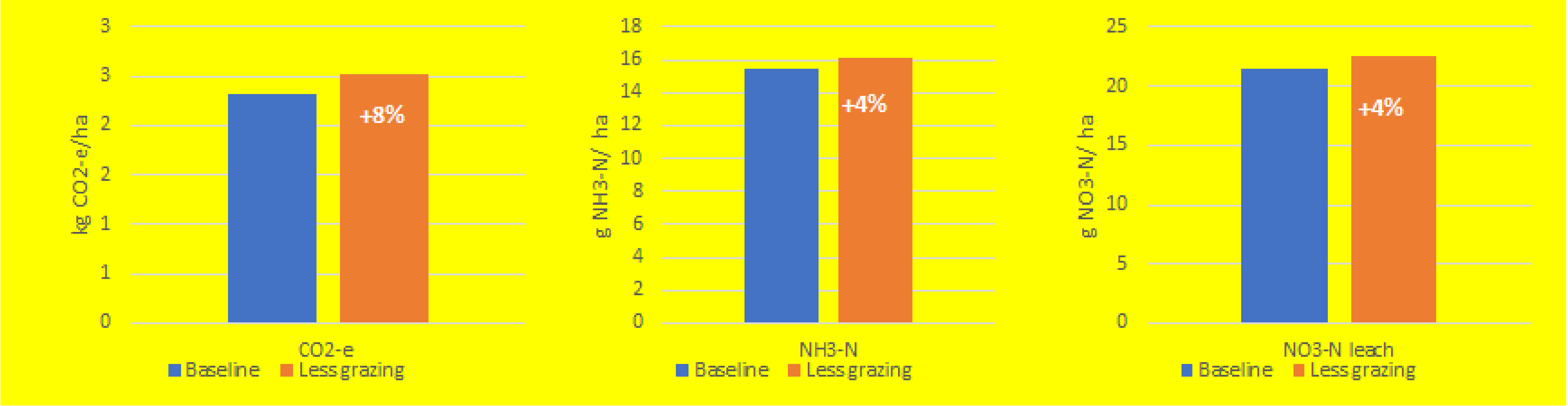
Reducing grazing in marginal land (for extensive systems), good for the environment?

What are the environmental impact expressed per ha?



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Reducing grazing in marginal land (for extensive systems), good for the environment?

What is the efficiency (feed conversion ratio) or quality of land required to produce animal product?

Efficiency

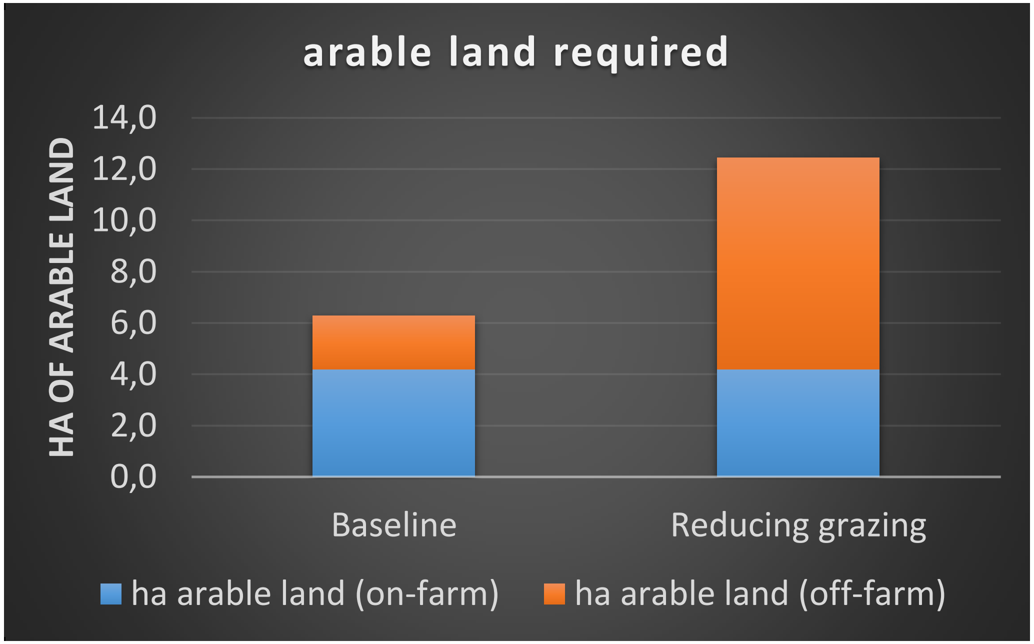
$$FCR = \frac{\text{Kg DM feed}}{\text{Meat}}$$

Reducing grazing in marginal land (for extensive systems), good for the environment?

Reducing grazing requires a shift from using marginal land (not suitable for other agricultural purposes except forest) to using more arable land (land suitable to grow crops that can be directly consumed by humans)

Reducing grazing in marginal land (for extensive systems), good for the environment?

What is the surface used of non-competitive (good/arable) land?



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Reducing grazing in marginal land (for extensive systems), good for the environment?

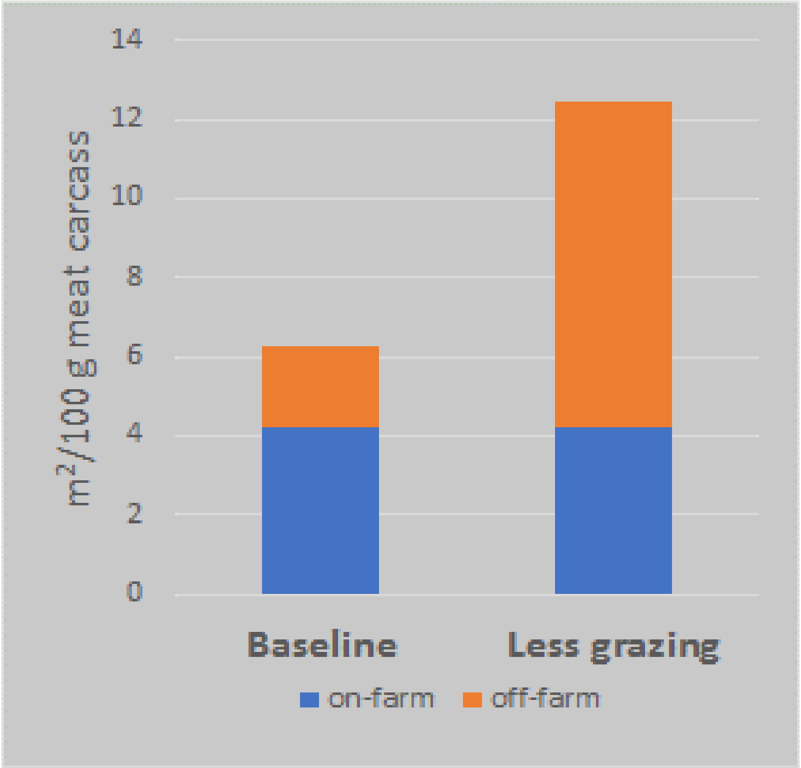
What is the efficiency (feed conversion ratio) or quality of land required to produce animal product?

Efficiency

$$\text{Land impact} = \frac{M^2 \text{ (Good land)}}{\text{Meat}}$$

Reducing grazing in marginal land (for extensive systems), good for the environment?

How much arable land would it be required to produce meat at different grazing level?



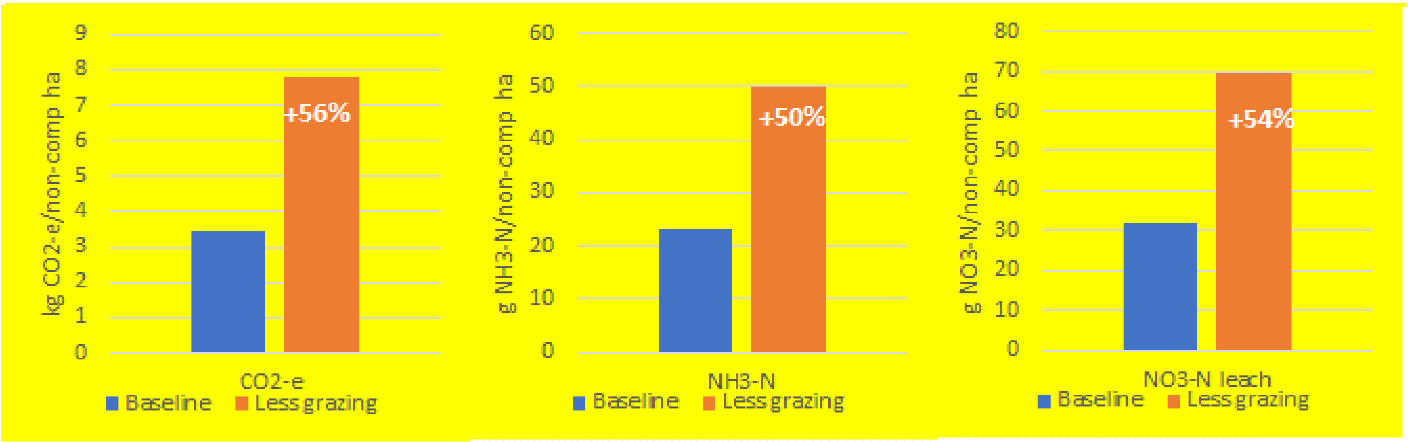
Reducing grazing in marginal land (for extensive systems), good for the environment?

Efficiency

$$\text{Emissions} = \frac{\text{Emissions}}{\text{Good Land (ha)}}$$

Reducing grazing in marginal land (for extensive systems), good for the environment?

What are the environmental impact expressed per ha of non-competitive land?



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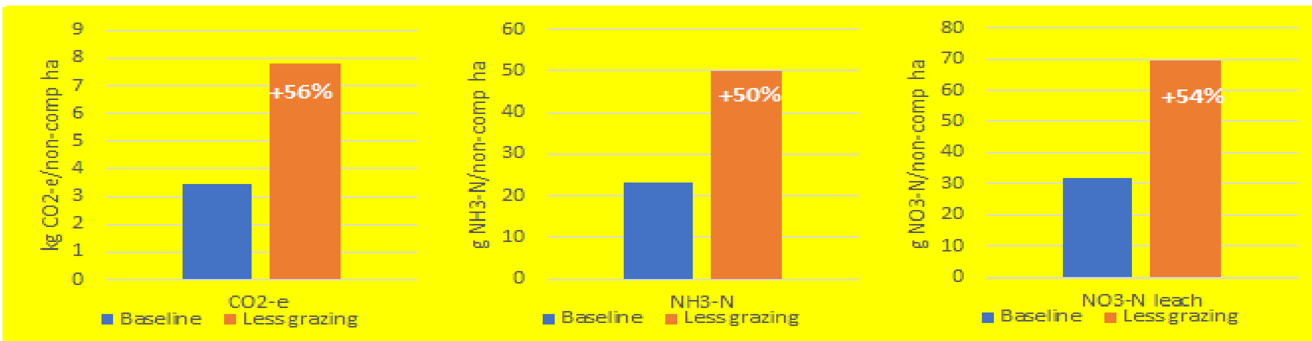
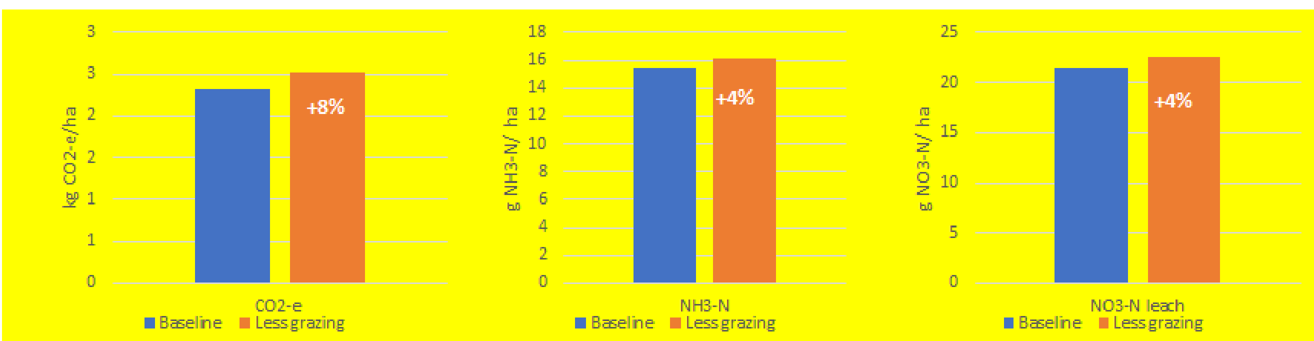
Reducing grazing in marginal land (for extensive systems), good for the environment?

What are the environmental impact expressed per ha of non-competitive land?



Metrics with Non-comp land



Metrics with All land

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Innovation for Sustainable Sheep and Goat Production in Europe

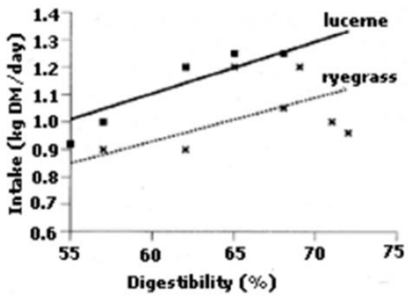
Improving feed sources and use of alternative feed sources for both intensive and extensive systems

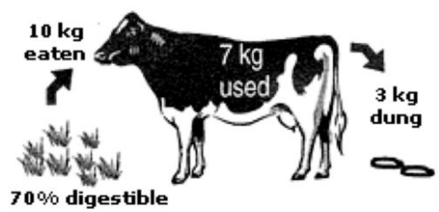
Improving feed quality can be achieved through:

- improved grassland management
- improved pasture species (e.g. grass and legumes mix), forage mix
- feed processing (e.g. chopping, urea treatment)
- strategic use of supplements, preferably locally available (FAO).

Improving feed sources (legumes)

Legumes and diverse forage mixes





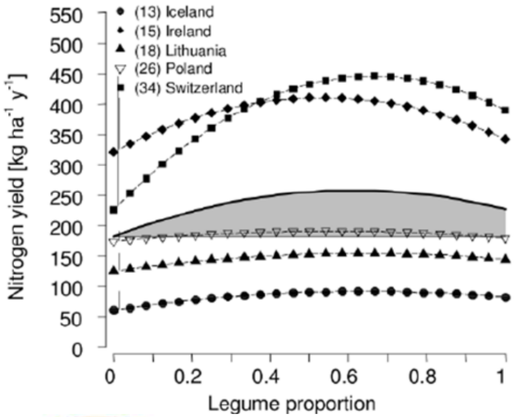
'Increase legumes in grasslands' can increase digestibility and subsequently stimulate an increase in milk yields (Gerber et al., 2013).

Bell, 2006

Improving feed sources (legumes)

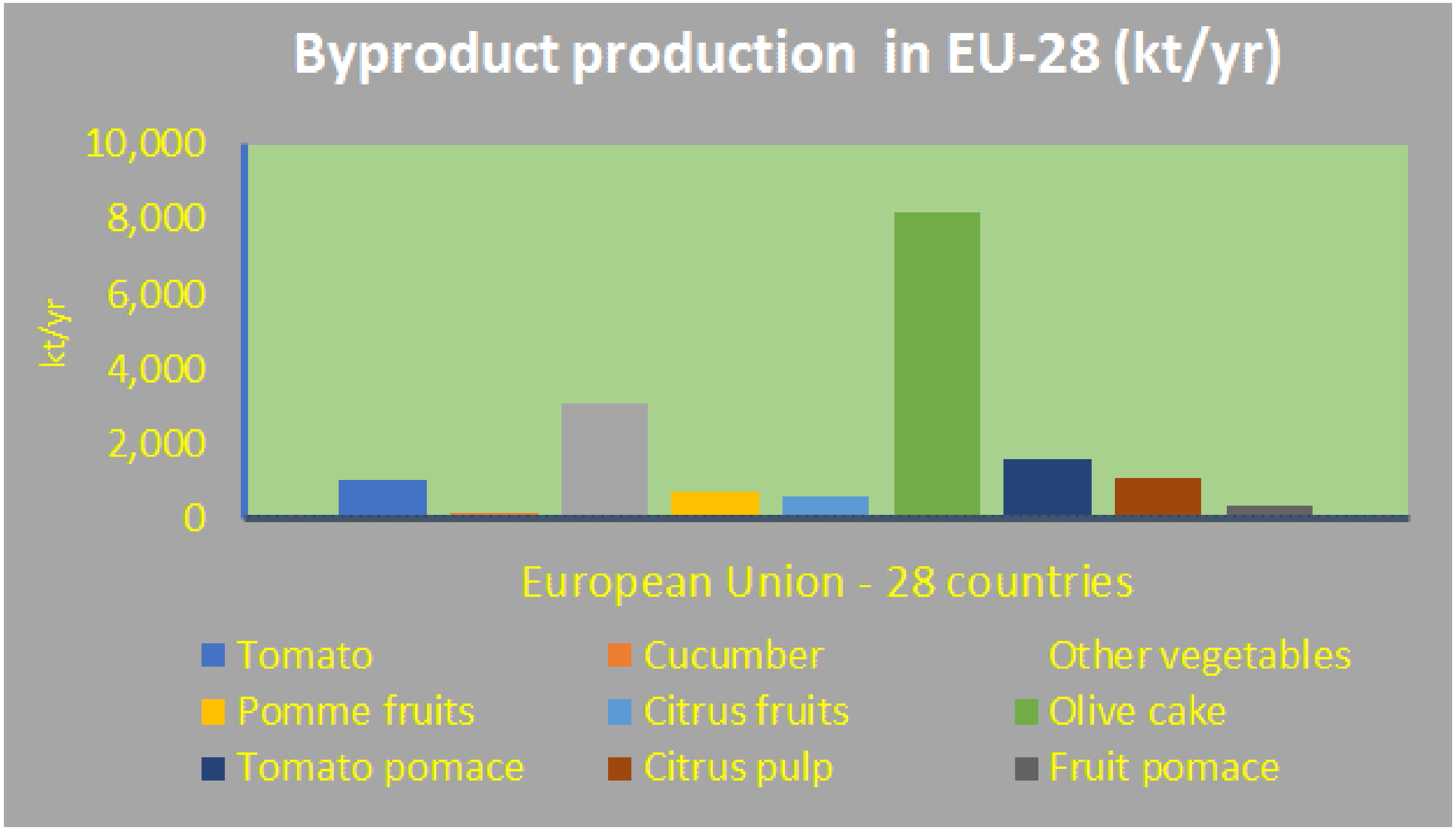
’Increase legumes in grasslands’:

- increases N-use efficiency and productivity (Kirwan et al., 2007).
- legumes can substantially reduce N_2O losses, a major contributor to GHG without loss in productivity.



Carlsson & Huss-Danell 2003 Plant Soil
Nyfeler et al. 2011 Agric Ecosyst Env
Finn et al. 2013 J Appl Ecol
Suter et al 2013

Improving feed sources and use of alternative feed sources for both intensive and extensive systems



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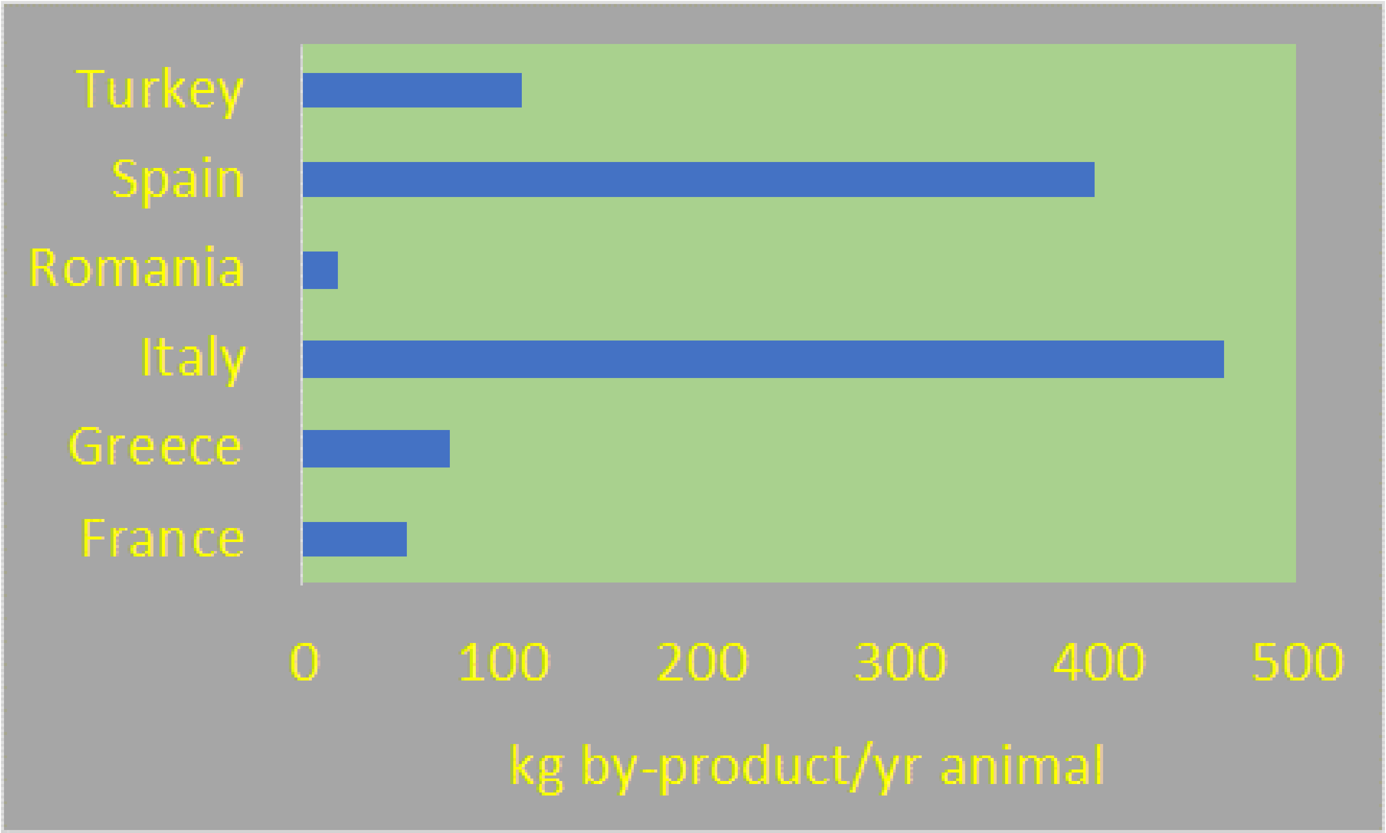
Innovation for Sustainable Sheep and Goat Production in Europe

Improving feed sources and use of alternative feed sources for both intensive and extensive systems



Innovation for Sustainable Sheep and Goat Production in Europe

Improving feed sources and use of alternative feed sources for both intensive and extensive systems

Reference	Basal diet	Alternative feed sources	Supplement type	Type	Animal	Breed
Abbeddou et al 2011	Barley straw/concentrate	Olive cake and leaves, tomato pomace		Dairy	Dairy ewes	Awassi
Arco-Pérez et al 2017	Alfalfa hay/concentrate	Olive cake, Tomato surplus	Silage	Dairy	Dairy goats	Murciano-granadina
Cabbidu et al 2004	Grass hay/concentrate	Olive cake	Silage	Dairy	Dairy ewes	Sarda
Chiofalo et al 2004	Alfalfa hay/concentrate	Olive cake		Dairy	dairy ewe	Comisana
Di Francia et al 2004	Oat hay/concentrate	Tomato pomace	Silage	Dairy	dairy ewe	Comisana
Fegeros et al 1995	Alfalfa hay/concentrate	Citrus pulp	Dried	Dairy	Dairy ewe	Karagouniko
Hadjipanayiotou	Barley straw/concentrate	Olive cake	Silage	Dairy	Dairy [illegible]	Chios, Damascus
Molina-Alcaide et al 2010	Alfalfa hay/concentrate	Olive cake	Feed blocks	Dairy	Dairy goats	Murciano-granadina
Nudda et al 2006	Alfalfa hay/concentrate	Linseed cake	Extruded	Dairy	Dairy goats	AlpinexSarda
Razzaghi et al 2015	Alfalfa hay/concentrate	Pomegranate seed pulp, tomato pomace		Dairy	Dairy goats	Saanen
Romero-Huelva et al 2013	Alfalfa hay/concentrate	Tomato fruits, citrus pulp, brewer's grain and yeast		Dairy	Dairy goats	Murciano-granadina
Romero-Huelva et al 2013	Alfalfa hay/concentrate	Tomato and cucumber fruit wastes	Feed blocks	Dairy	Dairy goats	Murciano-granadina
Romero-Huelva et al 2017	Alfalfa hay/concentrate	Tomato fruits, citrus pulp, brewer's grain and yeast		Dairy	Dairy goats	Murciano-granadina
Sedighi-Vesagh t al 2014	Alfalfa hay/concentrate	Pistachio by-products		Dairy	Dairy goats	Saanen
Volanis et al 2004	Oat hay/concentrate	Orange fruit waste	Silage	Dairy	Dairy ewe	Sfakian
Ben Salem and Znaidi 2008	Wheat straw/concentrate	Tomato pulp, olive cake	Feed blocks	Meat	Lambs	Barbarine
Bueno et al 2002	Grass hay/concentrate	Citrus pulp		Meat	Kids	Saanen
Caparra et al 2005	Oat hay/concentrate	Citrus pulp	Dried	Meat	Lambs	Merino
Denek and Can 2006	Wheat straw/wheat grain	Tomato pomace	Silage	Meat	Rams	Awassi
Eliyahu et al 2015	Wheat hay/concentrate	Pomegranate pulp, grape pulp, avocado pulp	Silage	Meat	Lambs	Assaf
Lanza et al 2001	Wheat straw/barley+maize	Citrus pulp		Meat	Lambs	Barbaresca
Pirmohammadi et al 2006		Apple pomace	Silage, dried	Meat	Rams	Gezel
Scerra et al 2001	Oat hay/concentrate	Citrus pulp	Silage	Meat	Lambs	Merinizzata

Studies with alternative feed sources tested in small ruminants

iSAGE Innovation for Sustainable Sheep and Goat Production in Europe

Improving feed sources and use of alternative feed sources for both intensive and extensive systems

Replace of conventional forage with food by-products

- **Are these feed byproducts nutritionally good?**

(i) leaves and **olive cake** from olive oil extraction process (OS)

(ii) tomato fruit waste (TS) from horticulture.

- **If so GHG emissions? Compared with alternative uses: compost and biogas**

Goat system (murciano-Granadina breed)

Pardo et al. (2016)

Alternative feed as adaptation

iSAGE Innovation for Sustainable Sheep and Goat Production in Europe

Improving feed sources and use of alternative feed sources for both intensive and extensive systems

Replace of conventional forage with food by-products

Table 2. Feed ingredients and nutritive value of the three proposed diets for lactating goats

Feed type	Unit	Conventional diet (CO)	Olive oil by-products (OS)	Tomato by-products (TS)
		Ingredients		
Alfalfa hay	%	30	30	30
Oat hay	%	20	–	–
Oat grain	%	20	20	20
Soybean meal	%	10	10	10
Maize grain	%	10	10	10
Beet pulp	%	10	10	10
		Silage		
Olive leaves	%	–	10	–
Olive cake	%	–	5	–
Tomato waste	%	–	–	14
Barley flour	%	–	5	2
Wheat straw	%	–	–	4
		Nutritive value[A]		
Crude protein	g/kg DM	196	169	177
Neutral detergent fibre	g/kg DM	330	292	353
Metabolisable energy	MJ/kg DM	13.2	13.0	13.9

[A]Nutritive value expressed on dry matter (DM) basis.

Table 3. Results of selected parameters from experiment of lactating goats under the three studied diets
DMI, dry matter intake; FPCM, fat- and protein-corrected milk

Parameter	Conventional diet (CO)	Olive oil by-products (OS)	Tomato by-products (TS)
	Production		
Dry matter intake (kg DMI/day)	0.90	1.45	1.30
Milk production (kg FPCM/day)	0.80	1.07	1.01
Milk yield (kg FPCM/kg DMI)	0.89	0.74	0.77
	Enteric fermentation		
Methane production (g CH_4/kg DMI)	21.4	19.6	19.2
	Faeces		
Excreted (kg/day)[A]	0.28	0.43	0.34
Excreted N (g N/day)	6.6	11.1	8.4
Excreted N (%N_{Intake})	23.3	28.3	22.6
	Urine		
Excreted (kg/day)[A]	1.14	1.43	1.34
Excreted N (g N/day)	15.5	19.3	19.9
Excreted N (%N_{Intake})	55.1	49.2	53.7

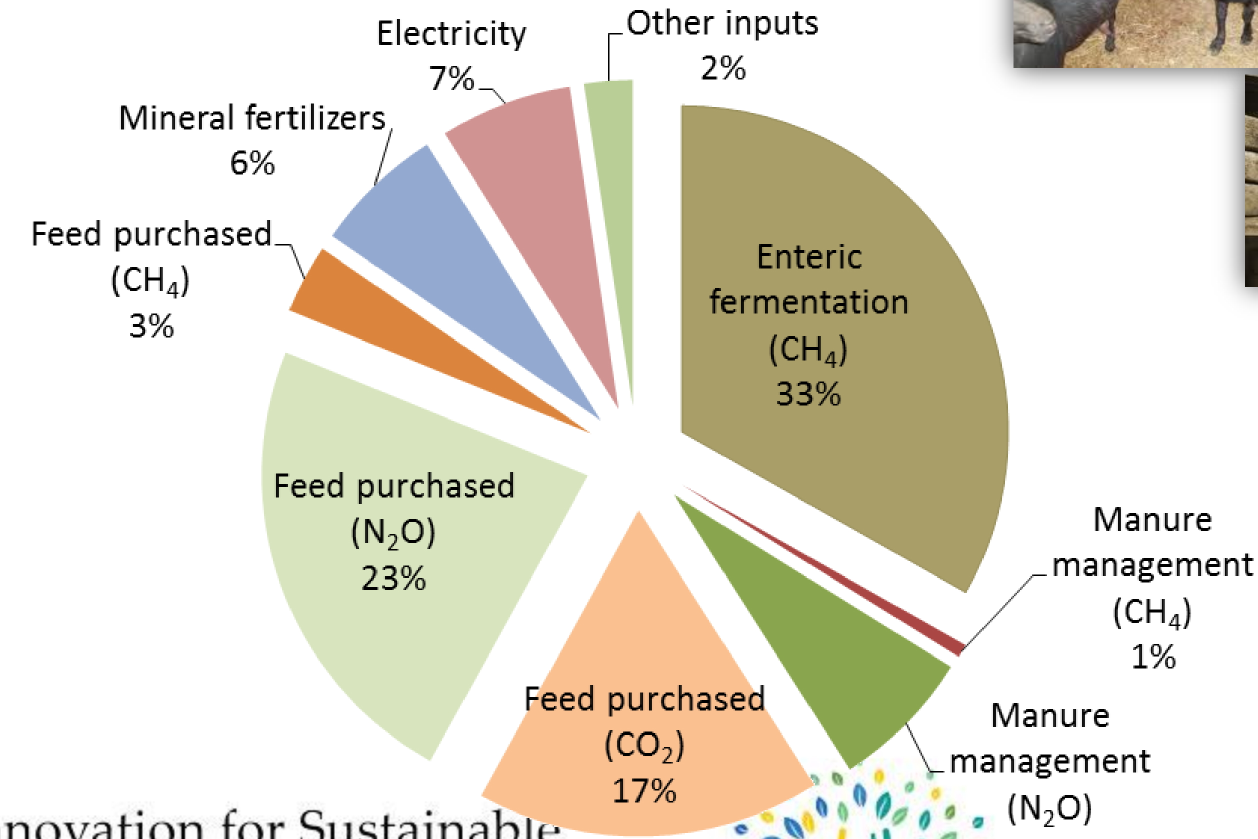
[A]Expressed as fresh weight.

Pardo et al. (2016)

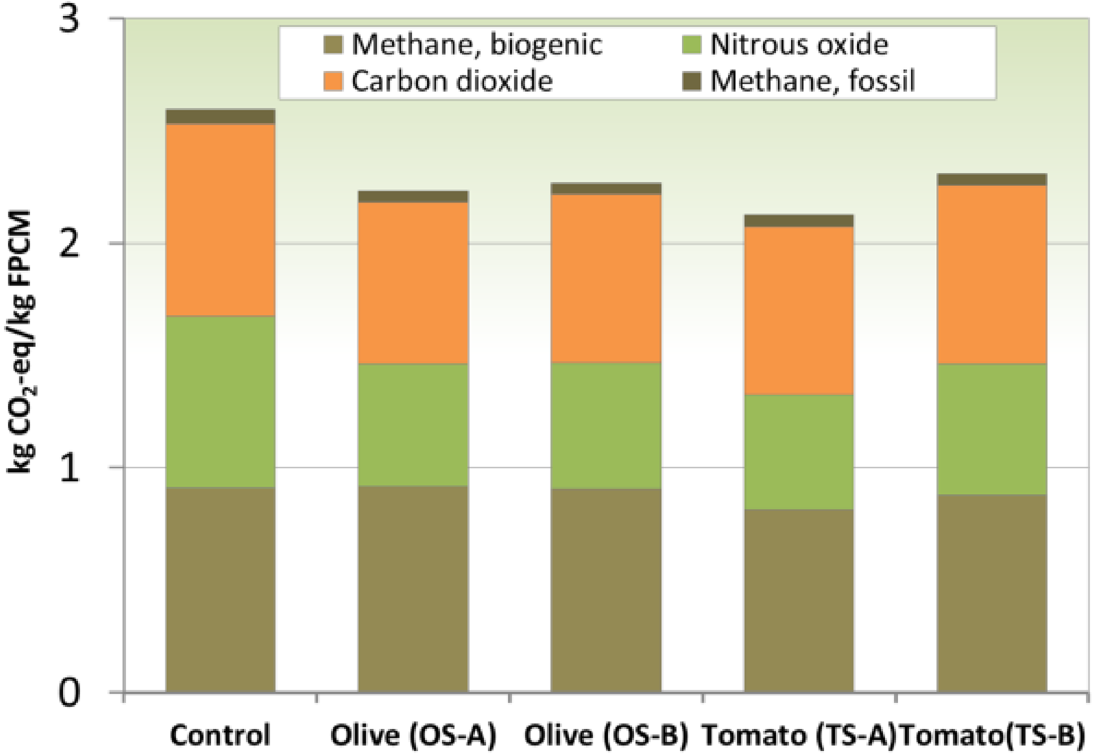
Improving feed sources and use of alternative feed sources for both intensive and extensive systems

Replace of conventional forage with food by-products

- Goat system (murciano-Granadina breed)



Improving feed sources and use of alternative feed sources for both intensive and extensive systems



- **From compost** (A) to feed
- **From biogas** production (B) to feed

New dietary strategies tested achieve **GHG reductions** (~12–19% per kg milk).

Use of agri-food by-products for **feeding is the best option for GHG mitigation** in this case, vs alternative uses: bioenergy or soil amendment.

Other implications and trade-offs from non-GHG impacts must be considered (e.g. soil quality) which may play an important role in the Mediterranean context.

More adapted/resilient animal breeds and grass/pasture breed

The greatest emphasis should be on targeting traits that can have synergistic effects with more than one stressors for animals (e.g. animals with enhanced productivity and fertility regardless of climate) and plants (e.g. grasses that can both tolerate drought and flooding).

More adapted/resilient animal breeds and grass/pasture breed

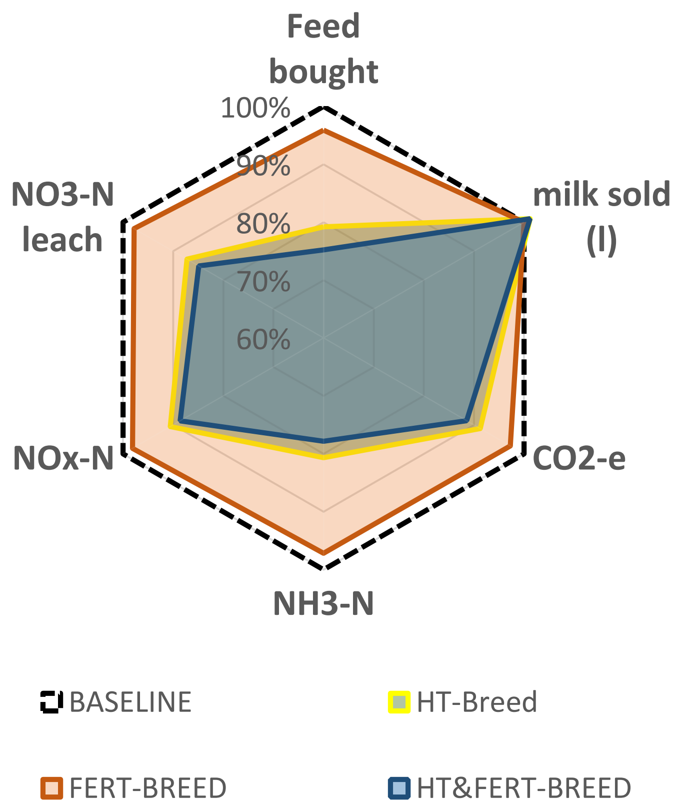
Breeding strategies includes animals that increase animal thermo-tolerance and systems that shift to breeds more adapted to changing environments

Dairy sheep system in Greece (Chios breed)

ANIMAL TRAITS

- Enhanced thermotolerance (HT-Breed)
- Enhanced fertility (Fert-Beed)

More adapted/resilient animal breeds and grass/pasture breed



ANIMAL TRAITS

- Enhanced thermotolerance (HT-Breed)
- Enhanced fertility (Fert-Beed)

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Innovations-Eskardillo

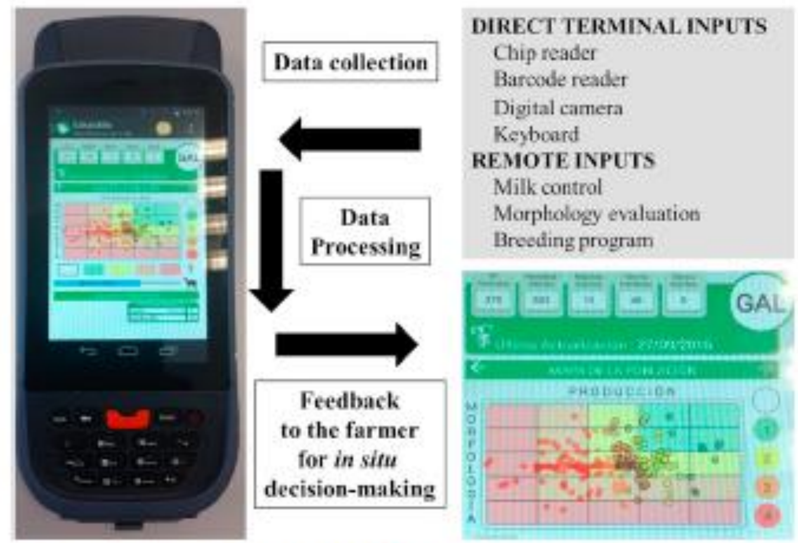

Fig. 1. Image of the Eskardillo terminal, data flows and a screenshot in which the population map of the goats in the farm according to their physiological stage, morphology and productivity are represented.

Innovations-Eskardillo

Table 27. Environmental impact of goat milk of the analysed farms (1 kg FPCM)

	Farm 1		Farm 2		Farm 3		Farm 4	
	2014	2018	2014	2018	2014	2018	2014	2018
Global warming (kg CO_2 eq)	1.77	1.64	1.56	1.33	1.45	1.25	1.48	1.17
Terr. acidification (g SO_2 eq)	14.1	13.3	12.9	10.7	11.8	10.0	12.7	9.9
Freshw. eutrophication (mg P eq)	398	361	312	253	320	263	332	250
Land use (m^2a crop eq)	2.2	1.9	2.2	1.8	1.9	1.5	2.2	1.6
Water consumption (litres)	140	121	355	303	107	76	272	198
Cumul. Energy Demand (MJ)	10.2	9.2	8.0	6.4	6.9	5.6	7.6	5.7

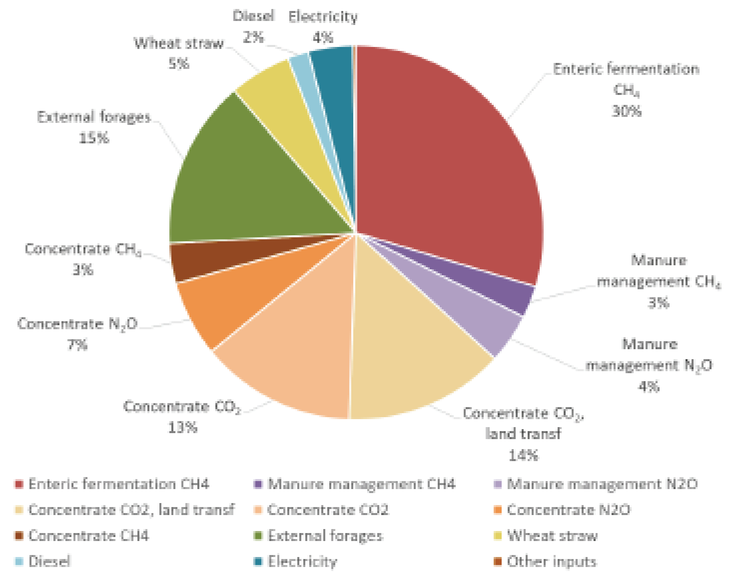

Figure 50. Broken-down representation of the carbon footprint of farm 2 in 2014

Innovations-Eskardillo

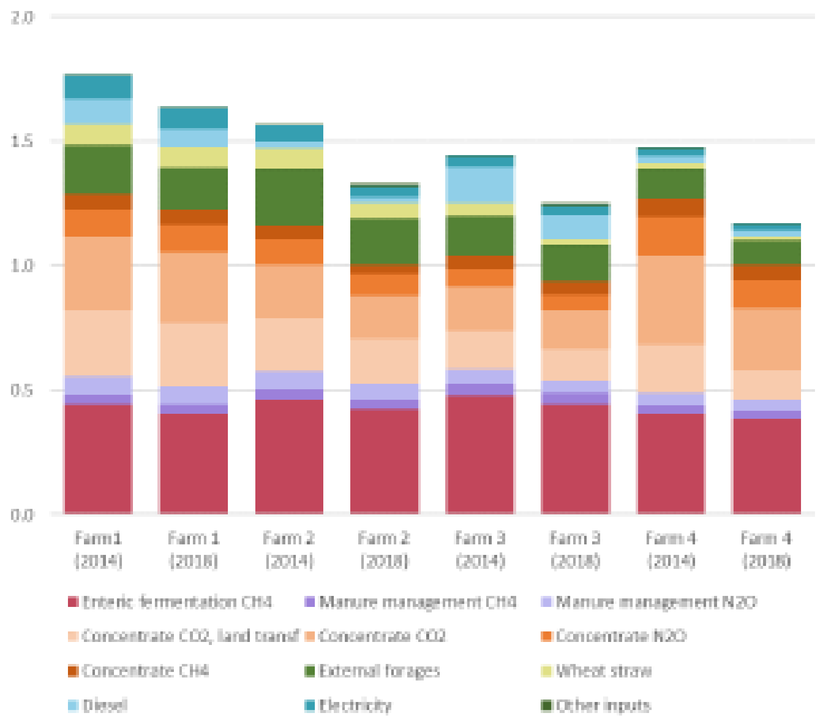

Figure 52. Carbon footprint of 1 kg FPCM in the four dairy goat farms before and after implementation of the Eskardillo tool

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Innovation for Sustainable Sheep and Goat Production in Europe

Innovations-ROA

PROLIFICACY GENES
THE ROA ALLELE

iSAGE

Managing the ROA allele to improve sustainability of Rasa Aragonesa sheep by increasing prolificacy

2007

In 2007 a new allele of the BMP15 gene was discovered in the Rasa Aragonesa sheep breed. The allele (FecX /ROA) was not decribed before that date.

roa

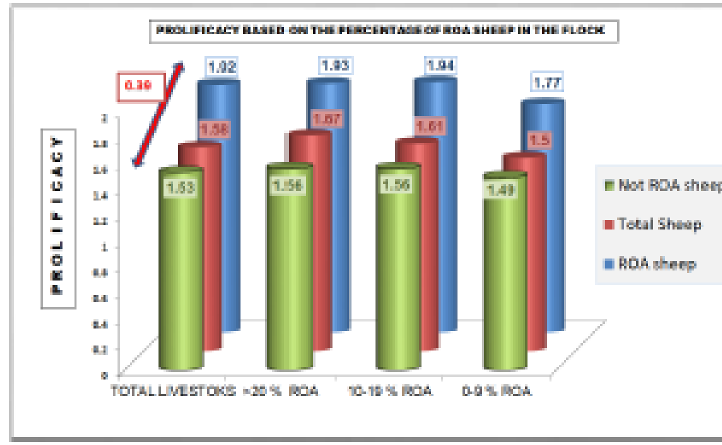
rasa Oviaragón

FEMALES CARRYING THE FecX[R]/ROA IN HETEROZYGOSITY INCREASE PROLIFICACY BY AN AVERAGE OF 0.36 LAMBS PER PARTUM.

Rasa Aragonesa is a local meat sheep breed raised in extensive systems in Aragón, Northeast Spain. It produces a high quality lamb which is marketed under the PGI label "Ternasco de Aragón".

The breed has a well-established breeding programme and an organism that manages the Flock Book, the UPRA. Prolificacy has been managed since 1994. Since its discovery in 2007, the ROA allele has been used to increase prolificacy in Rasa Aragonesa sheep. Artificial insemination is used to disseminate the allele across interested farms.

PRESENCE OF THE ROA GENE INCREASES LAMBS BORN PER PARTURITION BY 0.39.



INNOVATION AND SUSTAINABILITY

The sustainability of the sheep farms can be achieved by making them economically and socially viable. In this sense by incorporating the ROA allele, profitability can be increased without reducing the use of coarse pastures that are only grazed by sheep. It maintains livestock farming in the rural area thus preventing the abandonment of villages and maintain the surrounding landscape.

1. The ROA alelle has been sucessfully spread across the Rasa Aragonesa sheep population increasing to those farms willing technically prepared to increase prolificacy
2. The ROA allele increases prolificacy without increasing fertility or lamb mortality
3. Farmer management of twin lambings and attention to lambs to avoid mortality are key to make the most of the introduction of the ROA allele in the flock
4. Genetic management at farm and population level is key to avoid downsides of the ROA allele related to infertility caused by homozygosity

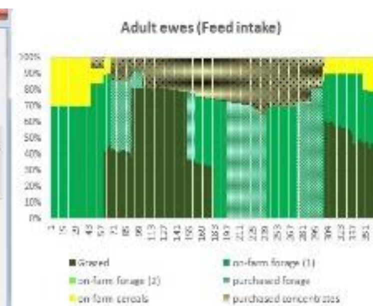
PROLIFICACY GENES INCREASE FARM PROFITABILITY WITHOUT INCREASING FLOCK SIZE OR INTENSIFYING PRODUCTION

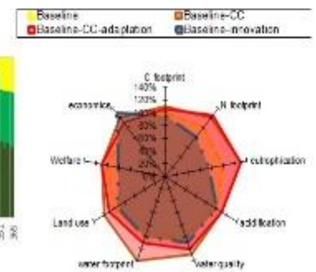
Innovations-ROA

- Breed: rasa Aragonesa
- Meat production (lamb)
- Location: Zaragoza (Spain)
- Number of ewes: 550

FEED

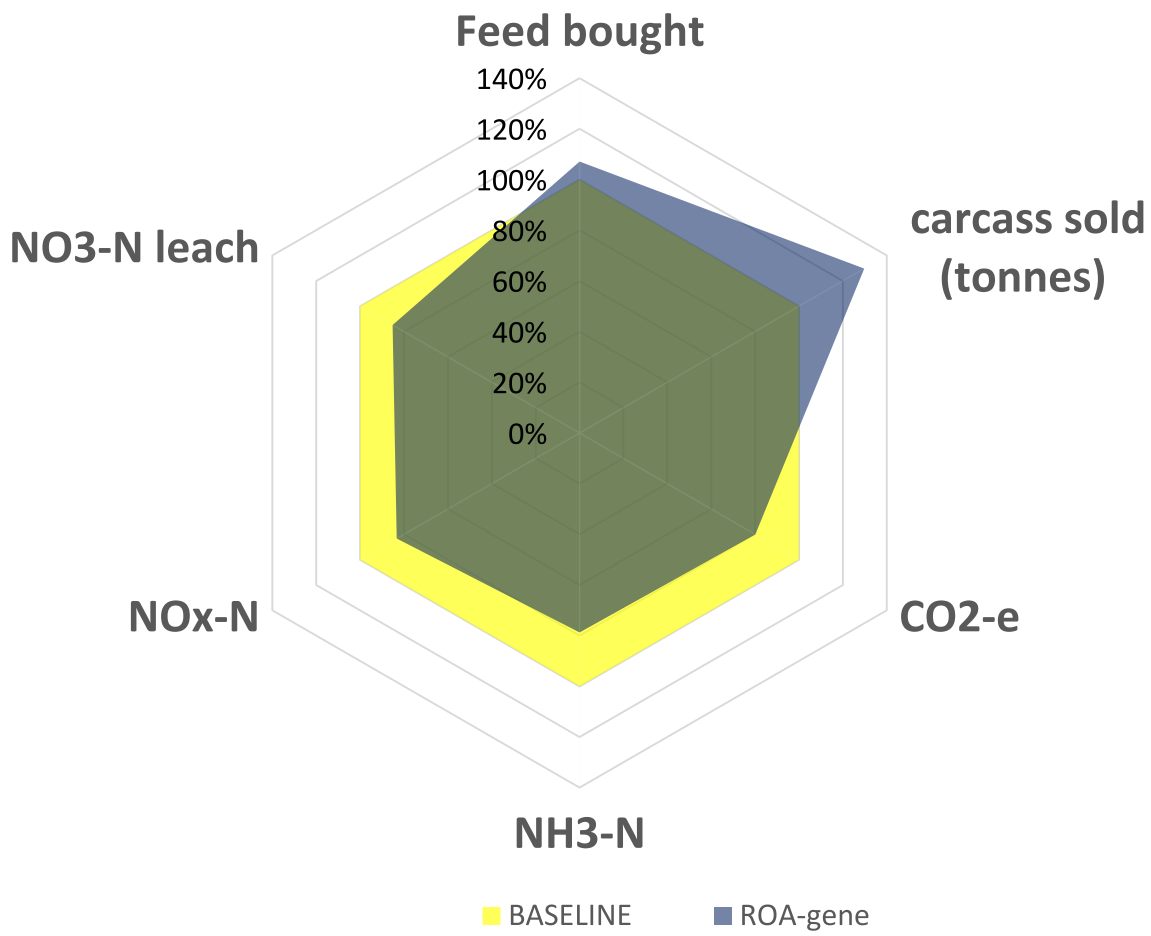
- Grazed mountain pastures
- Grazed rainfed alfalfa
- Alfalfa hay
- Cereals (homegrown barley)
- Barley straw (homegrown barley)
- Concentrates





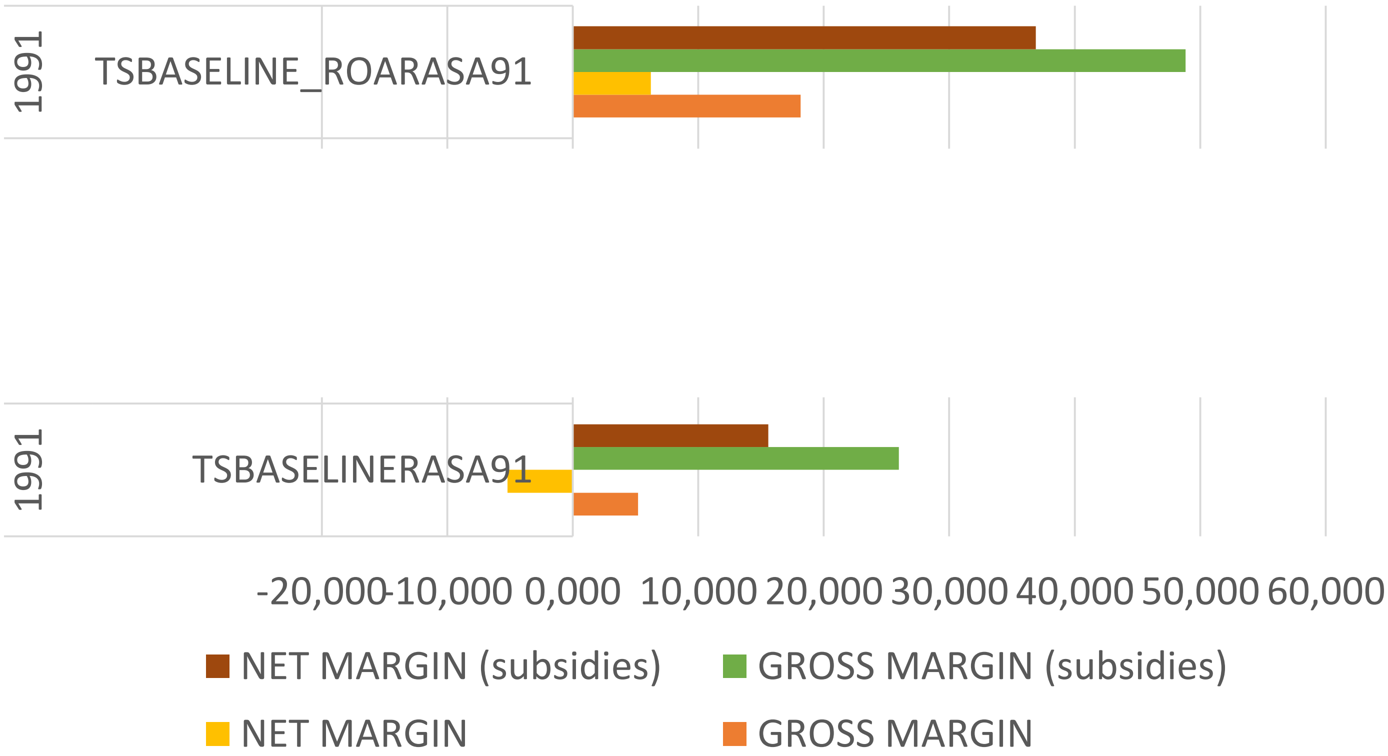
Modelled with $SIMS_{SR}$ (Del Prado et al. 2019)

Innovations-ROA



Innovation for Sustainable Sheep and Goat Production in Europe

Innovations-ROA



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Innovation for Sustainable
Sheep and Goat
Production in Europe