Life cycle assessment of sheep production in Ontario

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Groupe AGÉCO

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About Groupe AGÉCO

Who we are

A firm of experts **at the forefront of the agri-food sector for the past 15** years and a reference in production cost surveys in Canada

15 knowledgeable professionals: ag-economists, engineers, communication specialists

Economic studies | **Corporate responsibility**

What we do

- Economic and political analysis
- Surveys and data management
- Production and compliance costs
- Strategic planning
- Environmental and social Life Cycle Assessment
- Competitive analysis
- Corporate social responsibility approach

Our portfolio includes over +500 projects

A few of our clients

Agri-food sector

PROJECT OBJECTIVES

- **Conduct a streamlined life cycle assessment (LCA) of sheep production in Ontario** to quantify its environmental impact
- **Determine a baseline** against which the sector will be able to benchmark its performance over time
- **Identify priority areas for footprint reduction and mitigation** in the context of an anticipated increase in production
- **Assess potential footprint reduction or increase of different scenarios** (e.g. production intensification, indoor housing trend, etc.)

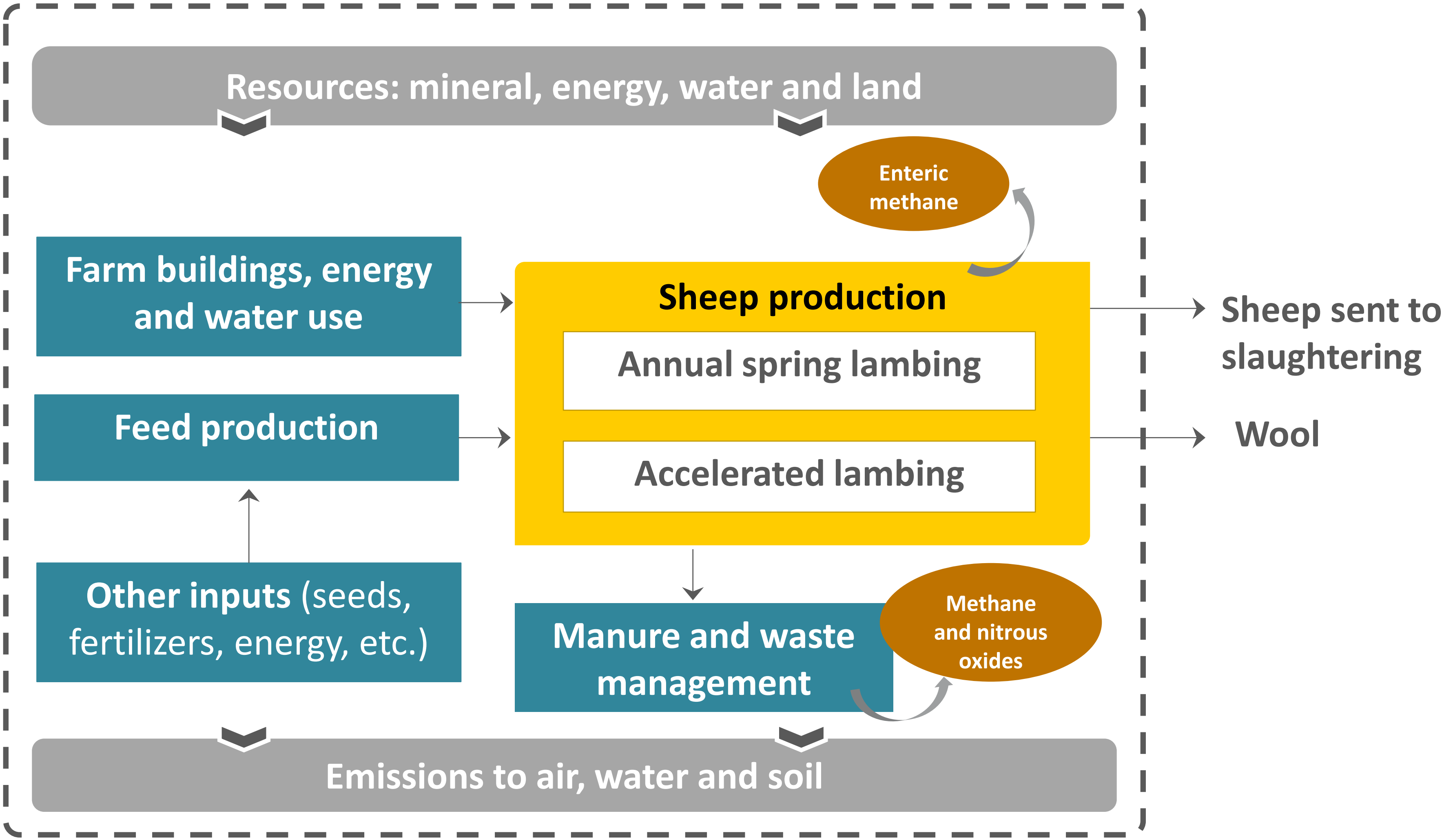
Based on **FAO' Global Livestock Environmental Assessment Model (GLEAM)**:

- When expressed per protein basis, the 'small ruminants' sector has a relatively high emission intensity – from 100 to 300 kg CO2/kg of protein–depending on the regions of production
- FAO's report highlights that there is a significant mitigation potential (30% reduction) assuming that producers would adopt best management practices (BMPs)

Scope of study

Functional unit and system boundaries

The functional unit is defined as 1 kg of live-weight of sheep at the farm gate.



Scope of study

Sheep farm models: annual vs accelerated lambing

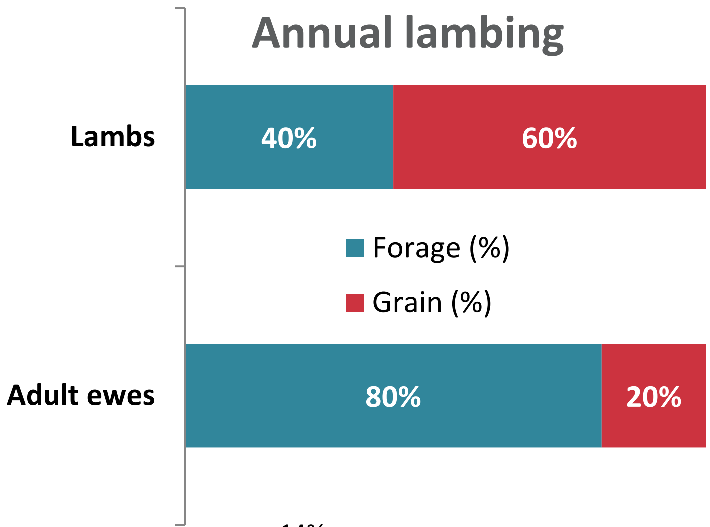
The sheep farm models were developed using parameters representative of the Ontario context, using OSMA and OMAFRA's analysis reports, the ecoinvent database and the expert judgement of sheep producers.

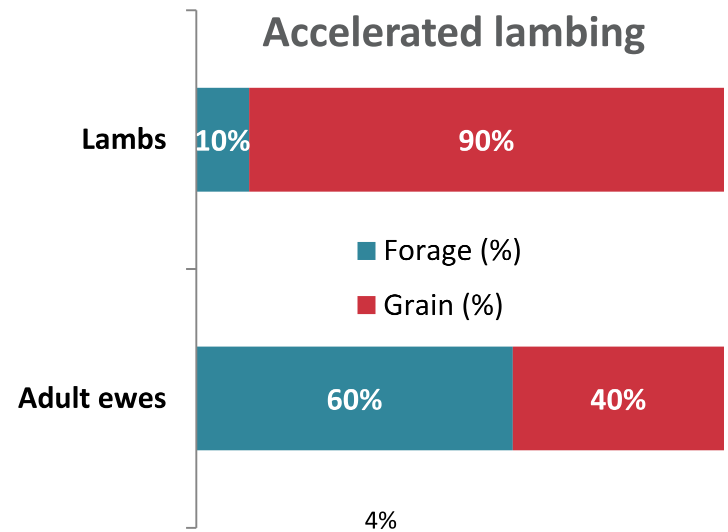
	ANNUAL	ACCELERATED
Adult ewes	584	482
Lambs per ewe	1.4 lambs/ewe	2 lambs/ewe
Lamb sent for slaughtering (kg LW)	41 kg	47.6 kg
Adult ewe (kg LW)	65.7 kg	71.6 kg
Electricity consumption (annual)	58 kWh/ewe	99 kWh/ewe
Heating fuel consumption (annual)	33 MJ/ewe	83 MJ/ewe
Diesel/oil consumption (annual)	114 MJ/ewe	185 MJ/ewe

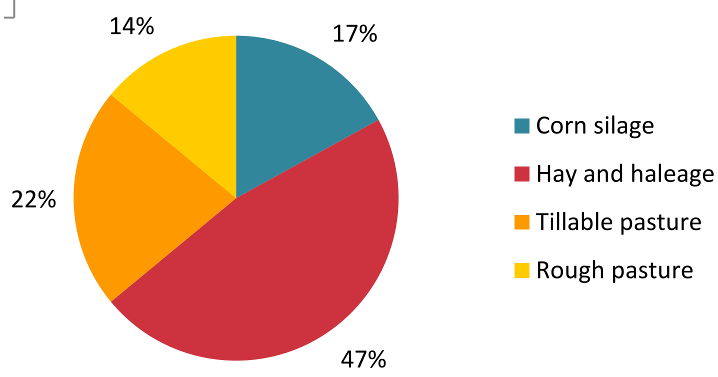
- 65 % of manure is deposited on pastures at the annual lambing farm as opposed to 15 % for the accelerated lambing farm
- The feed intake values and enteric emissions were calculated based on gross energy requirements for each animal category using the IPCC equations (IPCC, 2006).

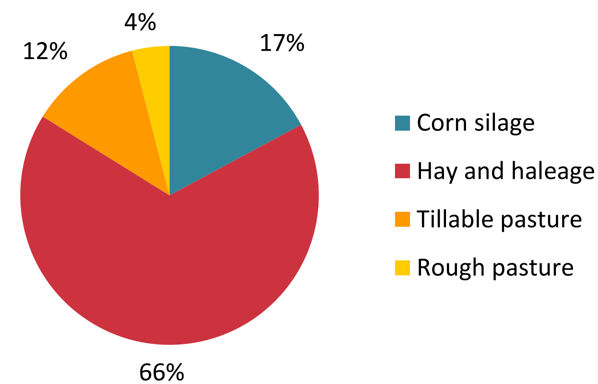
SCOPE OF STUDY

FEED COMPOSITION









Assumption: 90 % of forages and 20 % of the grains are grown on site by sheep producers and that the rest is purchased.

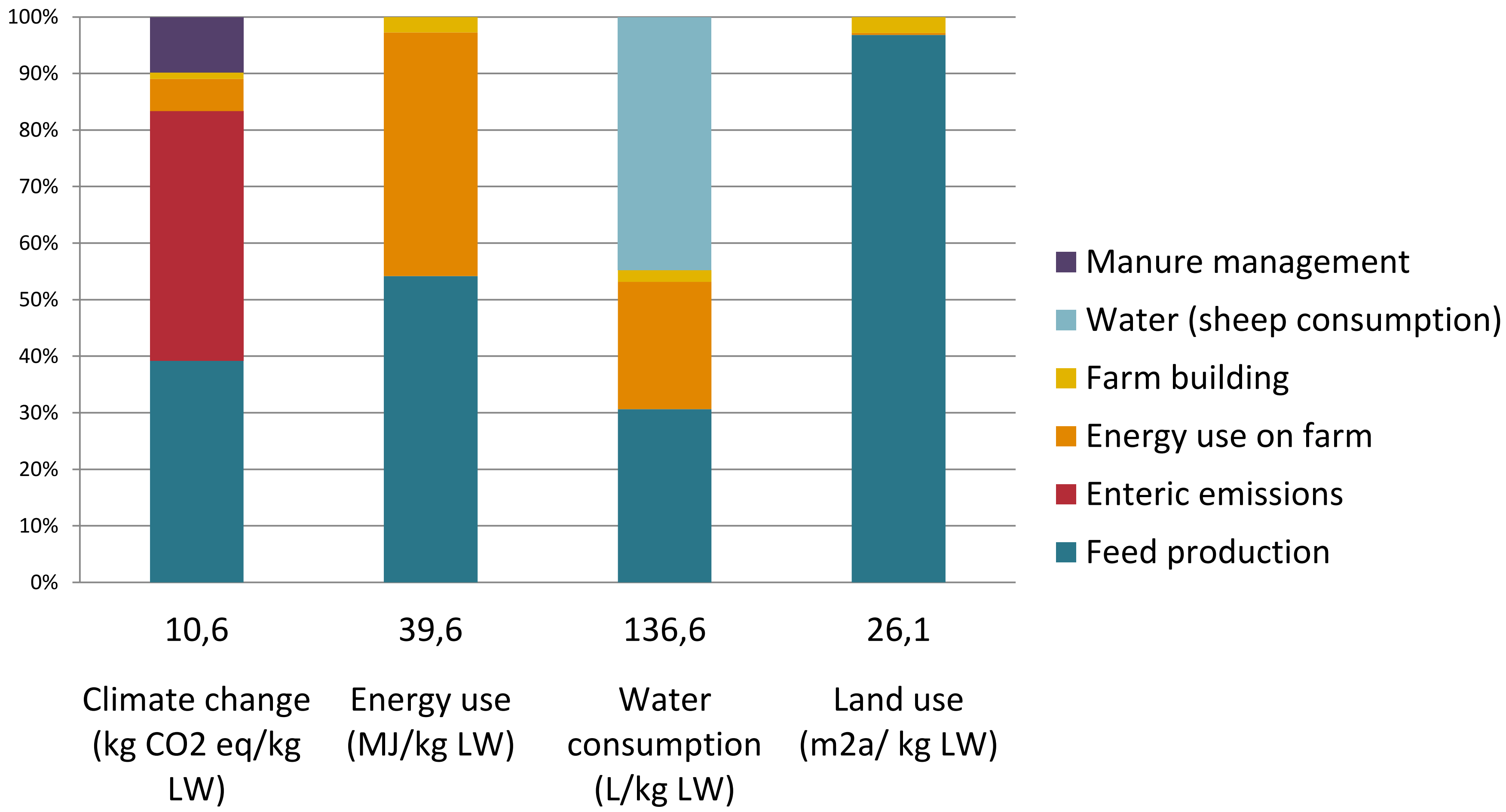
Results

Impact categories

- Climate change (kg CO_2 eq.): IPCC 2013
  - Climate change indicator measures the potential impact on climate change from greenhouse gas emissions. The latest Global Warming Potential (GWP) factors published by the IPCC in the Fifth Assessment Report (AR5) are used.
- Energy use (MJ primary)
  - Resources indicator takes into account non-renewable energy extraction. The result is simply the sum of the High Heating Value (HHV) of all the non-renewable energy carriers extract and used during the life cycle of sheep production system.
- Land use (m2*year)
  - Land use is a measure of the amount of land occupied by the activities related to sheep production life cycle such as feed production. It is expressed as the total area of land used during one year.
- Water consumption (m^3 consumed)
  - Water consumption takes into account water needed, whether it is evaporated, consumed or released again downstream, without water turbined (i.e., water flowing through hydropower dams). It considers drinking water, irrigation water and water for and in industrialized processes (including cooling water). It considers fresh water and sea water.

Results

Baseline results for Ontario



Baseline results for Ontario

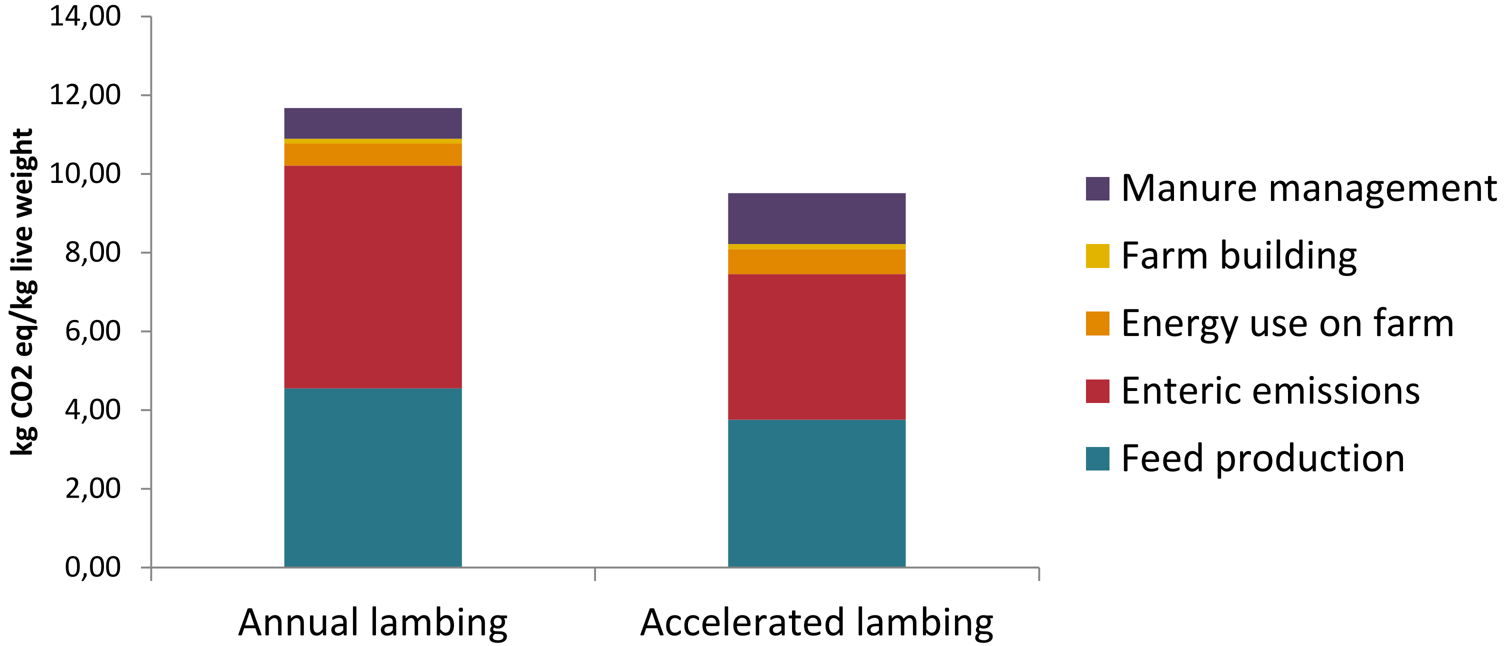
Based on a total production of 167 000 sheep ewes in Ontario in 2017, this translates into an annual:

- 137,000 tonnes of CO_2 eq. for the province of Ontario, the equivalent 30,000 cars on the road for one year
- 1.77×10^9 liters of water, the equivalent of 700 Olympic-size swimming pools
- 5.14×10^8 MJ of energy, the equivalent of 88,000 barrels of crude oil
- 3.38×10^8 m^2a of land use, the equivalent of 63,000 American football fields

Average results are based on the assumption that 50% of Ontario sheep farms use an annual lambing system and 50% use an accelerated lambing system.

RESULTS

CLIMATE CHANGE RESULTS



- The carbon footprint is higher for the annual lambing system (11.7 kg CO_2 eq/kg live-weight) in comparison with the accelerated lambing system (9.5 kg CO_2 eq/kg live-weight).
- On an annual basis, these results translate into the emission of approximately 430 tonnes of CO_2 eq. for an average sheep farm in Ontario.

Results

Climate change

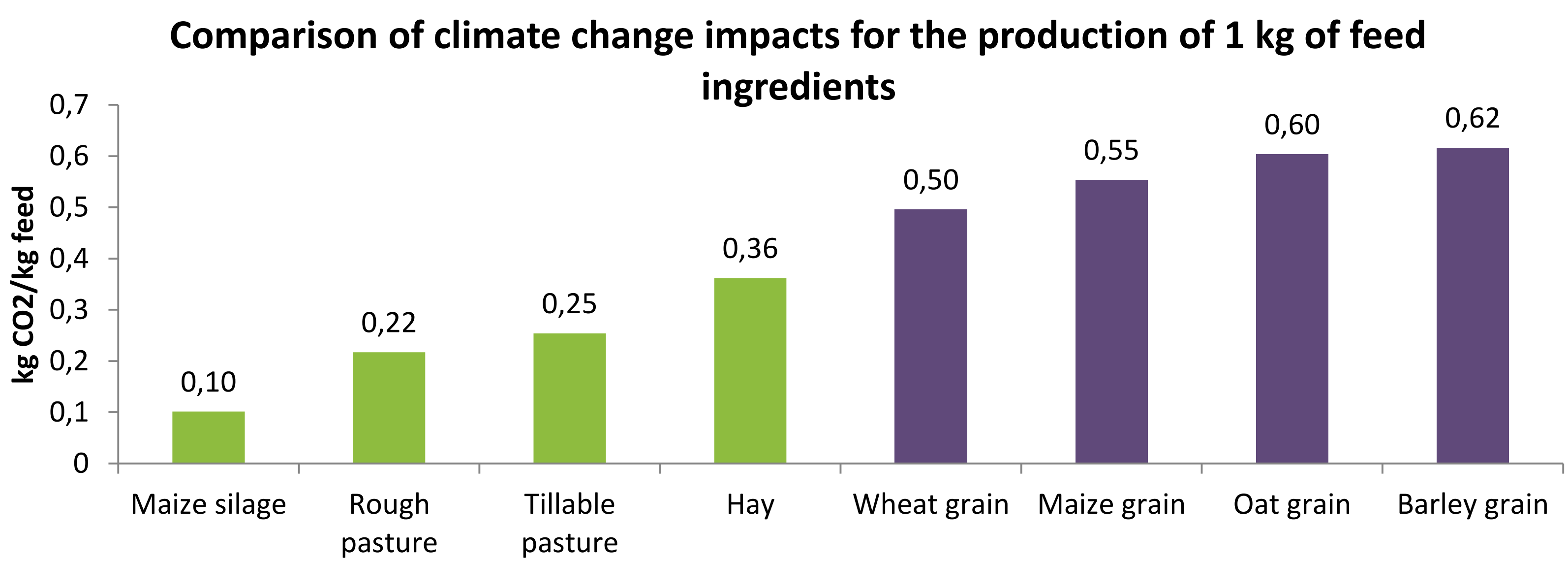
Contribution analysis

- Enteric fermentation is the most significant source of emissions. It accounts for approximately 48% (annual) and 39% (accelerated) of climate change impacts.
  - Sheep in the accelerated system have a higher enteric emission rate per head, the number of animals per kg of live weight produced is much smaller, hence reducing the relative quantity of enteric methane emitted.
  - The amount of enteric emissions produced is also affected by feed digestibility; grain-based diets increase feed digestibility value which ultimately lowers enteric emissions produced
  - The impact of increasing proportion of grains incorporated in the sheep diet has been investigated in a sensitivity analysis

Results

Climate change

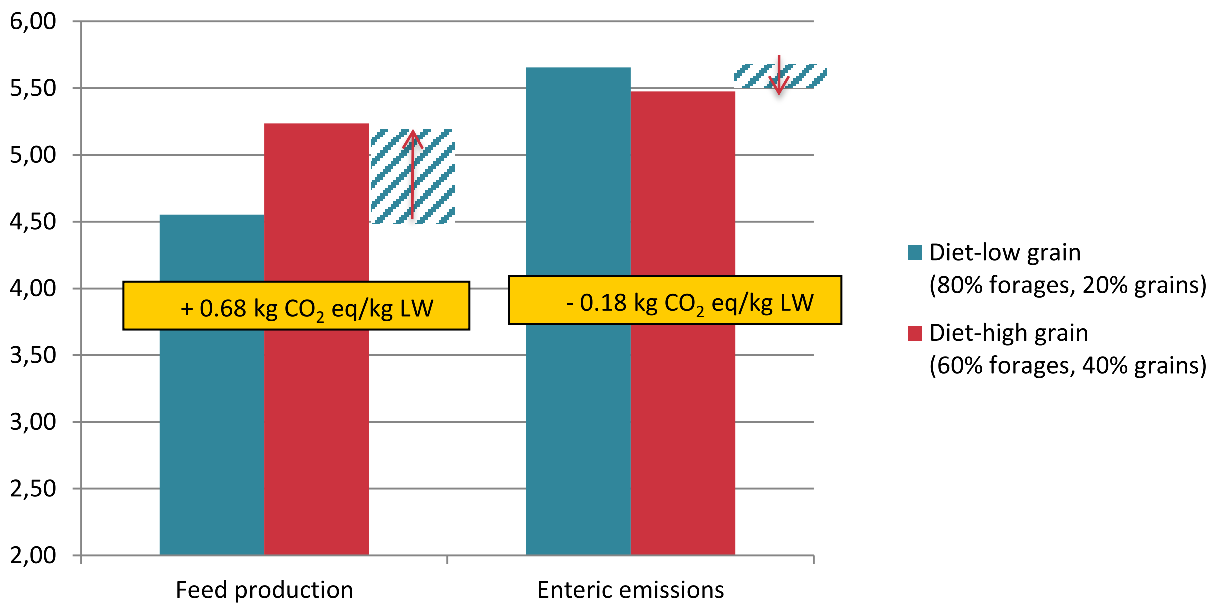
- The second most important contributor is feed production with 39% of climate change impacts.
  - Although the accelerated system uses more feed per head, the impacts are counterbalanced by an overall increase in productivity
  - The grain portion of the diet accounts for most of the impacts mainly due to higher fertilizer application rates associated with grain production



SENSITIVITY ANALYSIS

INCREASING THE PROPORTION OF GRAINS IN ADULT EWE DIET (ANNUAL LAMBING)

- By increasing to 40% the amount of grains fed to ewe sheep, the climate change impacts increase by 4%. Based on these results, increasing the proportion of forages in the diet of sheep does improve the carbon footprint.
- Although high-grain based diets allow to reduce the amount of enteric emissions produced, the carbon footprint reduction is small compared to the carbon footprint increase associated with the feed production phase
- Because perennial forages and pastures develop more extensive root systems and require less tillage than annual crops like grains, they sequester more carbon dioxide and in turn increase the amount of soil organic carbon.



RESULTS

CLIMATE CHANGE-NUTRIENT MANAGEMENT PLAN

- The total nitrogen mass-balance at the farm was calculated for both typical farms (annual and accelerated).

Nitrogen mass-balance at the farm
(90 % of forages and 20 % of the grains produced at the farm)

	ANNUAL	ACCELERATED
N (kg) from manure deposited on pastures	7,581	6988
Total N-requirements (kg N)	5,735	3,325
N (kg) net surplus at the farm	**1,846**	**3,663**

- For both typical farms, the total quantity of sheep manure generated would be too large to be spread entirely on the pastures and crop fields at the sheep farm. This is especially true for the accelerated lambing system where most of the sheep diet is composed of grains, of which only 20% are produced on the sheep farm.
- Consequently, the sheep models assume that the portion of manure not deposited on the pastures is sold or exported.
- Based on this, it is important to ensure that the manure produced is used as efficiently as possible on the farm and elsewhere. This is especially true of producers who own or rent a small land base and who purchase a significant portion of their feed.
- Manure can offset an equivalent quantity of synthetic fertilizers purchased with all the environmental impact associated with their production and use.

Results

Climate change- Carbon sequestration

- While feed production produces greenhouses gases, forage and crop plants in turn sequester carbon dioxide as organic matter in soils through root growth.
- Because perennial forages and pastures develop more extensive root systems and require less tillage than annual crops like grains, they sequester more carbon dioxide and in turn increase the amount of soil organic carbon.
- Due to a lack of established models to calculate carbon sequestration and losses arising from pasture management, carbon sequestration is rarely considered in the models developed for livestock LCA studies.
- Using the average sequestration factor of 0.19 tonne CO_2 eq./ha/year as proposed in the Quantification Protocol for Conservation Cropping (Government of Alberta, 2012) it is possible to estimate the quantity of carbon sequestered in rough pastures.
- The sequestration of carbon would correspond to a reduction of 0.09 kg CO2 eq./kg LW for the annual system and 0.013 kg CO2 eq./kg LW for the accelerated system or up to 1% of the carbon footprint.
- However, because carbon sequestration varies according to soil and weather conditions (FCRN, 2017), large uncertainties are associated with these values.
- Therefore, it is possible that the calculated quantity of carbon sequestered is underestimated and that Ontario pastures would in fact offer a higher sequestration potential.

Results

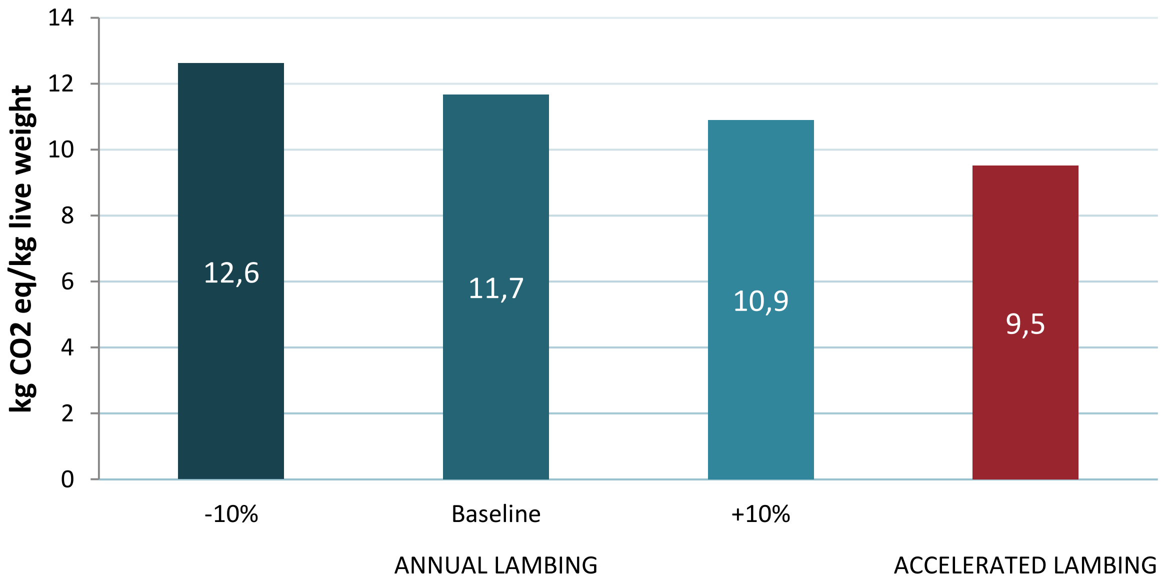
Comparison with GLEAM results (FAO)

- When expressed on a protein basis, the average carbon footprint for Ontarian sheep ranges between 135 and 166 kg CO_2/kg protein. This corresponds to the lower range of the carbon footprint calculated by the FAO's GLEAM initiative, varying between 100 and 300 kg CO_2/kg protein, with an emission of 260 kg CO_2/kg protein for North America.
- Productivity is the key parameter explaining the large variations in emission intensities between regions.
- Although productive sheep emit more enteric CH_4 per head due to higher feed intake, the size of the sheep herds can be reduced to produce the same amount of output.
- High fertility and growth rates, low mortality rates and high feed digestibility promote higher productivity systems.

Sensitivity analysis

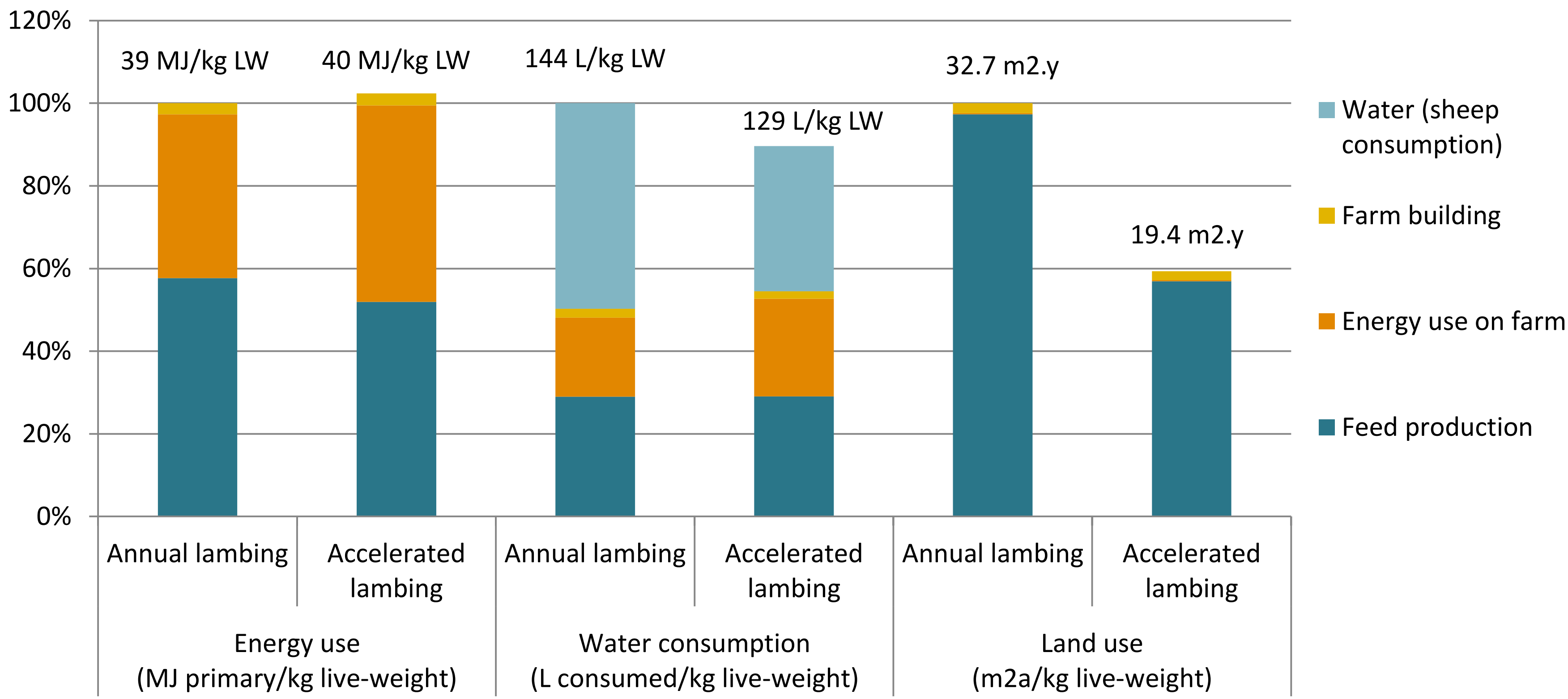
System productivity – Number of lambs per ewe

- The number of lambs per ewe for the accelerated lambing system needs to remain high to allow a significant reduction in the climate change impacts in comparison to an annual lambing system.
- In the case of annual lambing systems, producers who wish to reduce their carbon footprint also need to maintain or increase the level of productivity.
- Management practices that promote animal growth rates and feed efficiency lead to higher levels of sheep meat produced per farm.



Results

Energy use, water consumption and land use impacts



The accelerated lambing system is associated with lower environmental impacts for water consumption and land use impacts

Preliminary results

Energy use, water consumption and land use impacts

Energy use results

- Energy use on farm, mainly electricity, accounts for approximately 40% (annual) and 46% (accelerated) of energy use impacts.
- Feed production accounts for approximately 45 % (annual) and 39 % (accelerated) of energy use impacts, due to the natural gas and electricity consumed to produced synthetic fertilizers.

Water consumption results

- Water consumption for the annual lambing system (144 L water/kg LW) is higher in comparison with the accelerated lambing system (129 L water/kg LW).
- While the main contributor is the water consumed by the animals, the feed production stage is also an important contributor due to the volumes of water used to irrigate feed crops.

Land use results

- The agricultural land devoted to feed production accounts for 97 % of land use impacts.
- Land use impacts are 68% higher for annual lambing where forages constitute the main feed in an annual lambing system. Because pasture yields are generally lower than for grain crops, this leads to a larger agricultural area occupancy.
- This indicator does not capture the benefit of using rough pasture that are potentially not suitable for other agricultural activities, which represents 12 % and 4 % of the land use for annual and accelerated lambing respectively.

Recommendations

Improving the environmental performance of sheep production

- In the context of an anticipated increase in sheep production in the upcoming years, results suggest that opting for an accelerated lambing would minimise the environmental impacts related to the production increase.
- Measures to improve the environmental footprint of sheep production must be directed toward **increasing sheep productivity**, as seen in the accelerated lambing system. While this can be achieved by improving fertility and growth rates and reducing mortality rates, the use of high quality roughages and feed crops also foster productivity.
- **Selecting fertilizers with less environmental impacts** could significantly reduce GHG emissions. Further investigation into the fate of the chemicals in the environment is strongly recommended.
- **Optimizing the use of manure** for fertilization needs is a good way to reduce the use of synthetic fertilizers.
- Adopt an optimal and efficient **nutrient management plan** at the farm is important to improve fertilizer use efficiency.
  - periodic soil sampling and soil testing to identify what nutrients are deficient
  - fertilizer application rates based on agronomic requirements
  - Using optimal timing for fertilizer application

Improving the environmental performance of sheep production

Other measures

- Implementing farm energy efficiency measures for space heating, ventilation and lighting are important levers for sheep farmers.
- Installing on-farm renewable energy production capacity or buying green electricity could also help reduce the consumption of non-renewable resources.
- Optimize mechanical delivery of feeds to sheep and lambs (especially in the accelerated lambing system) by reducing distances between feed storage and sheep.
- Since the main requirement of land is associated with the feed production stage, optimizing land use by improving yields as well as maximizing the use of rough pasture constitutes an important lever for producers.
- Ontario farmers should continue to limit as much as possible the use of irrigation, using carefully calibrated and inspected watering systems to limit losses and leaks.

Thank you!

ANNEX-LCA RESULTS

	Climate change ($kg\ CO_2$ eq./kg LW)		Energy use (MJ/kg LW)		Water consumption (L/kg LW)		Land use (m^2.y/kg LW)	
Life cycle stage	**Annual**	**Accelerated**	**Annual**	**Accelerated**	**Annual**	**Accelerated**	**Annual**	**Accelerated**
Feed production	4,6	3,8	22,6	20,3	41,8	41,9	31,9	18,6
Enteric emissions	5,7	3,7	-	-	-	-	-	-
Energy use on farm	0,6	0,6	15,5	18,6	27,5	34,1	0,1	0,1
Farm building	0,1	0,1	1,1	1,1	3,2	2,5	0,8	0,7
Water (sheep consumption)	-	-	-	-	71,6	50,6	-	-
Manure management	0,8	1,3	-	-	-	-	-	-