

## GHG MITIGATION AND EFFICIENCY IMPROVEMENTS FOR A SUSTAINABLE SHEEP SUPPLY CHAIN: THE SHEEP TOSHIP LIFE STRATEGY

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### Abstract

*Sardinia (Italy), one of the main European regions for sheep milk production and where a broad variety of dairy sheep farming systems coexist, can represent a special context for testing strategies of climate change mitigation for the small ruminant sector. The Sheep ToShip LIFE - Looking for an eco-sustainable sheep supply chain is a EU project launched in 2016 to develop and implement an intervention model for the sheep-dairy supply chain of Sardinia, able to reduce GHG emissions by 20% over the next 10 years through eco-innovative actions. The core of Sheep ToShip LIFE strategy is the evaluation, with a Life Cycle Assessment (LCA) approach, of the environmental impacts of the main Sardinian dairy sheep farming and manufacturing systems by using a case study methodology. The project's goal seems technically feasible by increasing farm efficiency at both flock and field levels. However, the greening of the dairy sheep sector strongly depends on attractive agro-environmental measures (based on effective eco-innovation criteria) within the next Rural Development Plan.*

**Key words:** eco-innovation, climate change, dairy sheep sector, LCA, GHG mitigation.

### INTRODUCTION

Within the increasingly public scrutiny of livestock sector as one of the main anthropogenic source of greenhouse gases (GHG) contributing to climate change, Mediterranean sheep supply chain can contribute to boost animal agriculture in the transition towards a bioeconomy-based society. GHG mitigation is highly correlated with increasing production system efficiency and profitability (Jones et al., 2014), therefore improving the environmental performance of sheep farming could not only help combat climate change by reducing GHG and maximising ecosystem services, but also enhance socio-economic sustainability of local supply chains. This is a key point since in a context of structural economic crisis of the EU sheep sector, the risk that an effort to improve environmental performance would be perceived

by farmers as a threat to their livelihood should be avoided. Understanding the drivers of GHG emissions within a farming system following a Life Cycle Thinking approach could be useful for defining sustainability strategies in an economically feasible way. In particular, addressing the trade-off between agricultural intensification and benefits of multiple services of livestock systems, a crucial topic of the greening agenda, Mediterranean dairy sheep farming system should represent an interesting case study. As Sardinia is the leading sheep milk producer in Europe (Rural Development Programme of Sardinia - RDP, 2014-2020), a proactive benchmark of climate change mitigation strategies for the dairy sheep sector in Sardinia could contribute to this debate. The Sheep ToShip LIFE ([www.sheeptoship.eu](http://www.sheeptoship.eu)), a 4-years (from July 2016 to June 2020) project financed by the EU LIFE Programme Climate

Action 2014-2020 and aimed to improve the environmental sustainability of the dairy supply chain in Sardinia, clearly points in this direction. The overall objective of the project is to reduce by 20% in 10 years GHG emissions from the Sardinian dairy sheep sector. Its actions promote the inclusion of environmental strategies for the sheep sector into rural development programmes, focusing on i) efficiency of production systems and ii) valorisation of the ecosystem services provided by pasture-based farms. The immediate goals of the project are to identify - by a Life Cycle Assessment (LCA) approach - and apply innovative solutions for the reduction of GHG, and to demonstrate the environmental and socio-economic benefits deriving from eco-innovation in the dairy sheep supply chain. The end goal of the project is to transfer the knowledge generated into an Environmental Action Plan for the sheep sector of Sardinia, which harmonizes the project's intervention strategy with regional policies to mitigate climate change. Furthermore, one of the project scopes is to increase the level of knowledge and awareness of stakeholders and general public regarding the environmental quality of products made from sheep's milk and their contribution to the mitigation of climate change. The inclusion of policy makers involved in environmental, climate and rural development sectors at regional, national, and European levels is essential for guaranteeing the project's sustainability and replicability. To achieve their ambitious goals the project cannot ignore the importance of involving policy makers and key stakeholders to ensure that climate change mitigation and adaptation is fully accepted and integrated as part of the regional development strategies for the sheep sector. In line with the project strategy, the Sheep ToShip LIFE partnership involves local authorities responsible for the definition and implementation of policies on environment and livestock production systems (Sardinia Region Department for the Environment), regional agencies for research and assistance services in agriculture (Agris Sardegna and Laore Sardegna), local University (two departments of University of Sassari) and national research center (two institutes of National Research Council of Italy).

## MATERIALS AND METHODS

The evaluation, with an LCA approach, of the environmental implications of the main Sardinian dairy sheep farming and manufacturing systems by using a case study methodology represents the basis of the Sheep ToShip LIFE logical framework (Figure 1). The project adopts this metric procedure to determine the environmental hotspots of the sheep's milk business in Sardinia, including the environmental impacts of Sardinian Protected Designation of Origin (PDO) sheep's cheeses. A cradle-to-farm gate LCA was conducted in 2017/2018, according to international standards (European Commission Recommendation 2013/179/EU). The LCA study analyzes the impacts of 20 sheep farms located in contrasting pedo-climatic zones of Sardinia and representing the main sheep farming systems in Sardinia, as described by Molle et al. (2018). Innovative solutions, based on the preliminary results of this LCA study, are being tested in 10 case study farms with the aim of demonstrating effective way to reduce GHG emissions maintaining quantity and quality standards of milk. In the next year, a Sardinian Environmental Action Plan aimed to reach the general objective of the project (-20% of GHG emissions in 10 years) will be defined on the basis of the assessment of the environmental and socio-economic effects of the Sheep ToShip LIFE implementation actions. The Action Plan will establish priorities and iterative roadmap of sustainable mitigation measures for the Sardinian dairy sheep sector in a way that that it will continuously update/grade the existing regional policy tools such as the Rural Development Programme and the Regional Strategy for Climate Change Adaptation (<https://portal.sardegna.sira.it/piano-regionale-di-adattamento>). As massive adoption of innovations is dependent, among others, on farmers' and other stakeholders attitudes (i.e. beliefs and opinions) towards climate change, a survey was carried out, in 2018, on a sample of 238 stakeholders in order to map the general perceptions and goals related to climate change and their business. These information are propaedeutic to the design and communication of the Environmental Action Plan.



Figure 1. Sheep ToShip LIFE logical framework structured with a Deming cycle approach

## RESULTS AND DISCUSSIONS

The LCA study, identifying the main sources of GHG emissions and technical areas limiting efficiency of milk production, allowed to highlight best practices as well as to define a preliminary mitigation strategy. Moreover, it represents the first step to looking specifically the environmental footprint of the whole Sardinian dairy sheep supply chain.

Diets with greater GHG-generating potential per kilogram, directly related with enteric methane emission (the largest single source of emissions, by far), and off-farm produced protein-based feed represent the key areas of sheep farming to target for mitigation efforts. These results are in agreement with several studies on dairy sector and sheep farming (FAO, 2006; Marino et al., 2016; O’Brien et al., 2016).

Considering that the emissions baseline of Sardinian sheep sector (calculated “from cradle to farm gate”) resulted equal to 1,407 kt of CO<sub>2</sub>-eq (attributable for 80% to milk and 20% to meat) (Atzori et al., 2017), the Sheep ToShip LIFE target reduction is about 280 kt of CO<sub>2</sub>-eq in 10 years (Table 1).

Table 1. Sheep ToShip LIFE plan for reducing GHG emissions in 10 years of Sardinian sheep sector

Year	2017	2027	Variation
Ewe productivity (kg milk/year per present ewe)	150	185	+ 35
Sheep heads (thousand units)	3,300	2,660	- 640
Total annual milk production (kt)	315	315	0
GHG emissions (kt CO <sub>2</sub> -eq)	1,407	1,127	-280

The outline of the technical approach adopted by the project for reducing environmental and economic costs of sheep farming systems are reported below:

### Flock management

- Monitoring of reproduction performance to increase fertility.
- Monitoring of milk production to improve culling strategy.
- Disease control/prevention.
- Feed quality improvement (use of forage legumes, feedstuff analysis to better balance sheep diet, feed blocks for improve the digestibility of straw and cereal stubbles).

### Land use

- Introduction of native self-regenerating legumes-grasses mixtures and Sulla (a biannual forage).
- Low-input agricultural practices (minimum tillage, direct sowing, reduced use of fertilizers, etc.).
- Soil and water analysis to better drive pasture fertilization.

The survey on stakeholders’ attitude found that on climate change related topics, sampled farmers have homogeneous favourable attitude, but on the general topic of innovation they are deemed “conservative” and have heterogeneous attitude on environmental conservation. If on “adaptation” and “effects of farming on climate change” farmers display general agreement, their attitude on causes of climate change and innovation may hinder adoption. Additionally, some different attitudes and perceptions between farmers, researchers and extension

officers were observed. For instance, regarding the importance of experience on farm efficiency improvement (Figure 2), the survey highlighted that farmers and extension officers on one side, and researchers on the other, have diverging opinions. This result indicates that there could be some obstacles in transferring knowledge to improve efficiency from research laboratories to the farm.

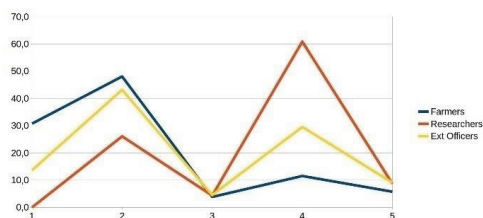


Figure 2. Neyman-Pearson Lemma test on importance of experience on farm efficiency improvement. The score 1-5 indicates not favourable and extremely favourable, respectively

Given the significance and representativeness of the Sardinian sheep sector at European level, Sheep ToShip LIFE proposed Sardinia as a European lab for climate change mitigation and, for this reason, the strategy of the project put special emphasis on networking, communication and dissemination of its results. Therefore, a key aspect is the engagement with European stakeholders as well as governance actions, since the integration between agricultural and environmental policies represents a pillar of the long-term sustainability and replicability of the project. The transferability of the Sheep ToShip LIFE model is essentially based on the following factors: i) the high interest demonstrated by the sector operators, smallholder farmers as well as medium and large dairy companies, towards environmental improvement and valorisation of the traditional livestock products, ii) the analysis of the local and international market trends, where green (and genuine) products are gaining ever-growing importance, iii) the actual guidelines of the European policy on agricultural and food sector, which strongly stresses on innovation and environmental efficiency of the production systems.

Among communication and networking activities, an important place had the first meeting with EU institutions and stakeholders,

titled *Environmental actions for the EU sheep sector* and held on January 23, 2019 at the premises of the Autonomous Region of Sardinia in Brussels. About 40 representatives of the following organizations attended the meeting: European Institutions (DG AGRI, DG CLIMA, ENRD, EASME/LIFE Programme, European Shepherds Network, ENVE Commission of the Committee of the Regions); delegates of 5 EU projects (focused on sustainability of livestock production systems); the Italian Ministry for Agriculture, Forestry and Tourism; the Autonomous Region of Sardinia (Agriculture and Relationships with EU departments); the Permanent Delegation of Castilla y Leon (Spain) and Occitanie (France) Regions to the EU

The meeting highlighted that the scientific efforts by European projects for improving overall efficiency of livestock production systems could provide a basis of knowledge and data to boost the greening of the future Rural Development Programmes.

## CONCLUSIONS

The reduction of GHG by 20% in 10 years in Sardinia seems technically feasible by increasing farm efficiency at flock and field levels. However, new policies are needed to support GHG abatement within and out with the next Rural Development Programme. They should be possibly driven by the evaluation of farm environmental performance through a LCA-based metric. Rural development measures should support actions aimed at increasing animal productivity, quality of forages and reduction of input at field level. Moreover, measures should be tailored as much as possible to background systems and co-designed by the stakeholders (farmers *in primis*) using an approach similar to European Innovation Partnership (EIP), and its impact should be evaluated using smart indicators (effective and cheap).

The Sheep ToShip LIFE initiative can thus serve as a model of good practices for other European contexts, and can contribute to improve the environmental performances of production processes and products of the European small ruminant sector.

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## REFERENCES

- Atzori, A.S., Vagnoni, E., Molle, G., Franca, A., Decandia, M., Porqueddu, C., Pulina, G., Duce, P. (2017). Facing carbon emission mitigation of dairy sheep supply chain: estimation of a baseline trend. *Italian Journal of Animal Science*, 16, 180.
- European Commission Recommendation 2013/179/EU. EC Recommendation of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations. *Official Journal of the European Union*, 4.5.2013 L124.
- FAO (2006). *Livestock's Long Shadow: Environmental Issues and Options*. Food and Agriculture Organization of the United Nations (FAO), Rome (Italy). Available at <http://www.fao.org/docrep/010/a0701e/a0701e00.HTM>.
- Jones, A.K., Jones, D.L., Cross, P. (2014). The carbon footprint of lamb: sources of variation and opportunities for mitigation. *Agricultural Systems*, 123, 97–107. doi:10.1016/j.agsy.2013.09.006
- Marino, R., Atzori, A.S., D'Andrea, M., Iovane, G., Trabalza-Marinucci, M., Rinaldi, L. (2016). Climate change: Production performance, health issues, greenhouse gas emissions and mitigation strategies in sheep and goat farming. *Small Ruminant Research*, 135, 50-59. <https://doi.org/10.1016/j.smallrumres.2015.12.012>
- Molle, G., Decandia, M., Sanna, L., Vagnoni, E., Pintus, G. V., Duce, P., Franca, A., Atzori, A.S., Manca, A., Usai, D. (2018). *Report on the characterization of Sardinian dairy sheep production systems*. Available at [http://www.sheeptoship.eu/images/Report/A.1.3\\_Report%20char.%20Sard.%20pr.%20systems.pdf](http://www.sheeptoship.eu/images/Report/A.1.3_Report%20char.%20Sard.%20pr.%20systems.pdf)
- O'Brien, D., Bohan, A., McHugh, N., Shalloo, L. (2016). A life cycle assessment of the effect of intensification on the environmental impacts and resource use of grass-based sheep farming. *Agricultural Systems*, 148, 95-104. <https://doi.org/10.1016/j.agsy.2016.07.004>
- Rural Development Programme of Sardinia, 2014-2020. Available at <http://www.regione.sardegna.it/speciali/programmasvilupporurale/benvenuto-sul-sito-del-psr-2014-2020>.