



Looking for an eco-sustainable sheep supply chain

Editorial

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Covid-19 pandemic has caused widespread and often dramatic effects at global level, not only impacting healthcare systems but also affecting the social and economy spheres. Lockdown restrictions and confinements introduced by most countries around the world since January-February 2020 change drastically energy demand, such as we never before observed. A study recently published in *Nature Climate Change* (Le Quéré et al., 2020) estimated that in April 2020 the daily CO₂ emissions at global level were 17% below the mean level of 2019. This emission rate corresponds to the level of emissions observed in 2006. The easing of lockdown rules and the recovery of activities will lead to a reduction of CO₂ annual emissions in 2020 of 4.2% - 7.5%, if compared with 2019. This decreasing rate is consistent with the rates of decrease needed year-on-year over the next decades to limit global warming to 1.5 °C. The change in CO₂ emissions have been entirely determined by a forced reduction of energy demand. The analysis focused on six cross-sectoral ac-



tivities: power, industry, surface transport, public, residential and aviation. Agriculture and agro-industry sectors, although not analyzed in detail, have been partially included in the analysis. The study published in *Nature Climate Change* allow us to know both the large growth in global emissions observed during the past 14 years and the size of the challenge we have to limit climate change in line with the 2015 Paris Agreement. It is also clear that this challenge concerns all economic sectors, including agriculture, which is a significant source of greenhouse gas (GHG) emissions. SheepToShip LIFE wants to give a contribute in this direction, focusing on the dairy sheep Sardinian sector. For this sector,

affected by economic and structural crises, SheepToShip LIFE aims at improving the environmental quality of dairy sheep productions by reducing GHG emissions and increasing carbon sequestration capacity: the project approach is based on leveraging innovation and eco-innovation to improve productivity, and promoting a debate on governance models that can facilitate ecological transition and accelerate the adoption of climate-friendly practices. In brief, the overall goal of SheepToShip LIFE is to transfer experience gained so far to appropriate governance tools, which can be adopted by regional authorities in a perspective of climate change mitigation measures and actions.



Summary

SheepToShip LIFE.....	2
StS logical framework.....	3
Contributes of partners:	
Agris.....	4
Uniss.....	5
ISPAAM & IBE.....	6
Autonomous Region of Sardinia	7
SheepToShip LIFE dissemination activities	7

SheepToShip LIFE project

The SheepToShip LIFE (*Looking for an eco-sustainable sheep supply chain*) is a EU project launched in 2016 to develop and implement a model of carbon footprint mitigation for the sheep-dairy supply chain of Sardinia. The project aims to enhance the contribution of the sheep sector from farming to processing milk and dairy products towards climate change mitigation. The project seeks to develop and promote good agricul-

tural and farming practices, in order to reduce greenhouse gas emissions from the sheep farming sector and dairy supply chain in Sardinia, through an efficient use of resources. By promoting innovative and eco-sustainable production models, SheepToShip LIFE aims to achieve its overall objective of reducing by 20% in 10 years greenhouse gas emission from the Sardinian livestock sector and sheep industry.



Sardinia island was chosen as the only intervention area because it represents a valuable model of the entire Mediterranean sheep sector, in terms of both sheep population and representativeness of the typical European husbandry systems. Sardinia can therefore serve as an “open-air laboratory” where a model of actions and measures on climate change at European level could be tested.

StS Project is coordinated by National Research Council - Institute of BioEconomy (IBE–CNR) of Sassari, in partnership with ISPAAM–CNR, University of Sassari with Dept. of Agricultural Sciences and Dept. of Business economy, Autonomous Region of Sardinia, Environmental Defence Council, and regional agencies for research and development in agriculture, AGRIS and LAORE.

Project objectives

- To improve the environmental quality of sheep production systems, demonstrating the environmental, economic and social benefits deriving from eco-innovation in the dairy supply chain and sheep farming sector.
- To promote the implementation of environmental and rural development policies, guided by Life-Cycle Thinking approach, to aim at enhancing the environmental quality of local sheeps milk and cheese supply chains.
- Increasing the levels of knowledge and awareness in stakeholders and the general public, concerning the environment sustainability of products made from sheep’s milk and their contribution to the migration of the climate change.

StS logical framework

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Life Cycle Assessment (LCA) evaluation concerning the environmental impacts of the Sardinian dairy sheep farming system and dairy plants case studies, represents the basis of the SheepToShip LIFE logical framework. SheepToShip uses this metric procedure to determine the environmental hotspots of the sheep's milk business in Sardinia, including the environmental impact of Sardinian Protected Designation of Origin (PDO) sheep cheeses. Eco-innovative solutions are tested in 20 case studies (sheep farms and dairy businesses) through the introduction of low-input techniques while retaining the same quality standards of products. Therefore, on the basis of the assessment of the environmental and socio-economic effect of the SheepToShip LIFE implementation actions, a Sardinian Environmental Action Plan aimed to reach the general objective of the project (-20% of greenhouse gases—GHG - emissions in 10 years) will be defined. The Action Plan will establish priorities

and iterative roadmap of sustainable mitigation measures for the Sardinian dairy sheep sector in a way that it will continuously up-date and upgrade the existing regional policy-tools such as the Rural Development Programme and the Regional Strategy for Climate Change Adaptation. A cradle to gate LCA was conducted according to international standards (European Recommendation 2013/179/EU). The LCA study analyzes the impact of sheep farms located in different pedoclimatic zones of Sardinia and representing the main sheep farming systems of di island, as described by Molle et al (2018). This study identify the main sources of GHG emissions and technical areas, limiting efficiency of milk production, allowing to highlight best practices as well as to define a preliminary mitigation strategy. Moreover it represents the first step to look specifically the environmental footprint of the whole Sardinian dairy sheep value chain. Diets with greater GHG generate potential per Kg, directly related with enteric methane emission, and off-farm produced protein based feed, represents the key areas of sheep farming to target for mitigation efforts. These re-

sults are in similar to those several studies on dairy sector, in which emissions are attributable for 80% to milk and 20% to meat (Atzori et al.2017). The StS LIFE target reduction is about 280 kt of CO2 eq in 10 years. To reach this goal , maintaining the current Sardinia's sheep milk production (about 315 kt of milk per year), it can be reasonably assumed an improvement of production level of about 35 kg/ewe combined to an estimate reduction of about 640,000 ewes plus replacement lambs. The outline of the technical approach adopted to reduce environmental and economic cost of sheep farming system is linked to the innovations applied to flock and land use management.



The Agricultural Research Agency of Sardinia (AGRIS) with the animal nutrition section is partner in the SheepToShip project whose objective is to reduce of 20% in 10 years, emissions of greenhouse gases (GHG) from the sheep sector in Sardinia. Sardinia has been chosen as the area of intervention of the project because it is strongly representative of the whole Mediterranean sheep sector. AGRIS has contributed to the

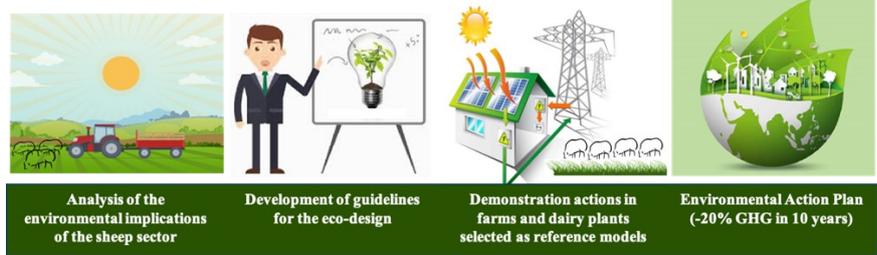


Figure 1. Planned activities of SheeptoShip LIFE project.

project in all the planned activities. For the analysis of the environmental implications, a characterization of Sardinian dairy sheep production system has been run in order to define a methodology for the choice of the most representative farms on which to collect data for the estimation of the environmental impact. The methodology adopted envisaged four successive steps: 1st- creation of a map of all georeferenced sheep farms in Sardinia; 2nd- identification of soil and climatic areas with the highest concentration of sheep farms (sedimentary north, sedimentary south, basalt central western and granit central eastern); 3rd- choice of a sample of farms representative of each area with historical data on farm management and performance; 4th- choice of a smaller subsample of farms on which to carry out the survey for the collection of data to be used to estimate the environmental impact

of the farms. In the survey data collection AGRIS was mainly concerned with animal feeding. Subsequently, the Carbon Footprint (CF, expressed in terms of kg CO₂eq/kg standard milk produced) of sheep farms was estimated using the LCA (Life Cycle Assessment) technique. On the basis of the results of the LCA, the hot spots relating to greenhouse gas emissions were identified. Some mitigation strategies were then studied and partly implemented, an activity carried out under AGRIS coordination. Mitigation strategies have covered different aspects of the production process in sheep farms and for simplicity they have been divided into 4 areas of intervention. For each area, different strategies were considered whose environmental effects, expressed in terms of CF reduction, were estimated through simulations comparing the previous situation with the new one. The results of these simulations will be the basis for the formulation of guidelines and good practices to be presented and discussed with operators in the sector and introduced in model farms.

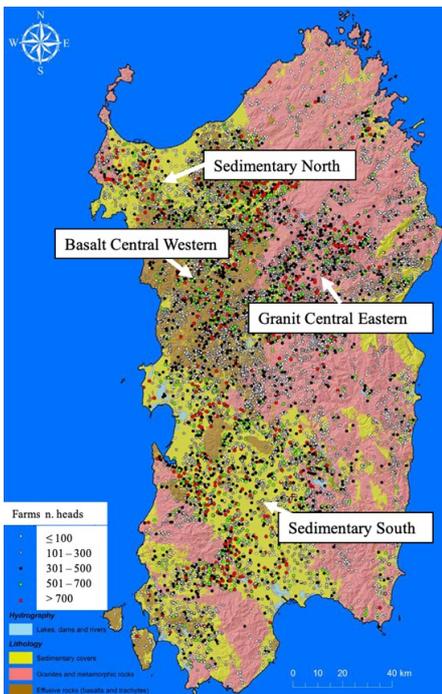


Figure 2. Soil and climatic areas used in the choice of representative sheep farms.



Figure 3. Intervention areas for mitigation strategies.



Figure 5. Early cut hay on the field.

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Animal Sciences section of the Agricultural sciences Dept. at the University of Sassari took part to the SheepToShip LIFE project working in a hand on the quantification of the farm greenhouse gas emissions with the Life Cycle Assessment approach, in the other hand though the implementation of best agricultural practises especially those regarding the improvement of forage quality for sheep nutrition by innovation in forage harvesting techniques. In order to increase diet digestibility, to obtain high milk production levels of the animals facing meantime hard pedo-climatic condition that often limit the farm self-

sufficiency of biomass, farmers often import high amount of off-farm feeds (e.g. cereal grains, protein meals, high protein concentrates, legume hays), which have a large environmental and economic impact. Thus, in order to improve the economic and environmental performance of the farms, the researchers in Animal Science, promote the production and use of high quality forages, such as hay-silage and early cut hays of high nutritional value that can reduce the use of off-farm feeds. The haylage technique belongs to ensiling processes (air elimination and pH reduction) for biomass conservation. It allows to reduce the temporal window of haymaking (up to 2 days), preserving forage from adverse weather conditions which can occur during the traditional haymaking (7 days), and also letting to harvest forages of very high nutritional value. The production of early cut hay allow to obtain high quality forages while the temporal window of cutting oc-



Figure 4. Production of haylage.

curs during vegetative stage when the plants are rich of nutrients and fiber is high digestible with low lignin content.

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The Department of Business and Economics (DISEA) of the University of Sassari is a partner of the SheepToShip LIFE. DISEA's role is the assessment of social and economic effects of innovations for greenhouse gas (GHG) abatement in sheep farming in Sardinia. This assessment is the core of a Socio-Economic Sustainability Study, a report describing the expected environmental and economic outcomes of innovation adoption, barriers to adoption and solutions to overcome them. The report contains an analysis of production systems in sheep farming and its likely evolution with the adoption of GHG abatement innovations. It also includes an investigation of the demand side of the market for sheep milk products in order to assess the consumers' willingness to buy sheep milk cheeses made through the adoption of the projects' innovations. The analysis of market structure and market power aims at identifying the milk price makers of the industry and the conditions necessary to avoid market dominance from a single or groups of operators. The Socio-Economic Sustainability Study is an instrument to support the development of incentives and other measures to abate barriers to adoption of GHG mitigating innovation in Sardinian sheep farming.

CNR - ISPAAM

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CNR – ISPAAM, Institute for the Animal Production System in the Mediterranean Environment, takes interdisciplinary interest on animal production research themes by using a systemic approach. The whole productive system is considered, moving from plant/animal farming up to product quality. ISPAAM mission concerns the enhancement of the forage-livestock system sustainability by optimizing the yield-quality product relation to respond to consumer/market requests, minimizing farming environmental impact. These aims meet the SheepToShip LIFE goals, in which CNR ISPAAM contribute to all the project actions. From studies carried out on SheepToShip model farms, we argue the necessity to adopt tailored mitigation actions, aiming at ameliorate the productive efficiency of the farm system, conserving (or improving) forage productive level (quantity and quality) while reducing economic and environmental costs. It means to reach a major level of forage self-production in farm, meaning less forage booked outside the farm, thanks to techniques of conservative agriculture for improving pastures, targeting persistent ameliorated pastures. Concerning activity developed in SheepToShip LIFE, in seven dairy sheep farm all over different pedoclimatic areas of Sardinia island, we built ameliorated pastures, with soft soil tillage and new seedling activities or upper seedlings of multifunctional blends, identified using legumes and annual self-seeding grasses (medica polymorphous, underground clover, frothy, michelian and vesicular clover, stiff ryegrass, etc.) associated, on deeper and fresher soils) with leguminous and perennial grasses (medica sativa, dactylis glomerata). An improved pasture with mixtures of varieties adapted to the specific conditions of the farm and adequately managed, with correct animal load and well calibrated shifts and with low input weed control (shredding of dry residues at the end of summer) has the potential to persist in the soil for several years, maintaining a high regenerative capacity and a high nutritional value, the latter linked to its "induced" floristic composition.



Figure 6. Seed bank on the soil surface after self seeding of annual forage crops



Figure 7. Electrified networks for the management of rotational pastures



Figure 8. Summer flaking of dry forage residues

Autonomous Region of Sardinia

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Regional Council for the Environment Protection

Through the Service for Environmental Sustainability and Informative Services (SASI), the Regional Ministry of Environment Defense of the Autonomous Region of Sardinia participates in the SheepToShip LIFE project as a partner which contributes to the implementation of all project activities and the achievement of expected results with a role of particular importance as coordinator of the project action C.4 relating to the execution of the Environmental Action Plan for the Sardinian sheep sector. The Plan

represents the main operational tool that SheepToShip LIFE project develops to achieve the final objective of the project, that is, the reduction of greenhouse gas emissions (CO₂ equivalent) of the sheep sector in Sardinia by at least 20% in 10 years. In consideration of this objective and of outputs as well as intermediate results achieved (milk and cheese LCA studies, good practices manuals for the mitigation of environmental impacts in farms and cheese factories and demonstrative actions), the Action

Plan will formulate the mitigation policies for the sector with the involvement of the main stakeholders by promoting a participatory governance approach. More in detail, the Plan will identify eco-innovation techniques as well as technological improvements for the sheep sector from an environmental point of view, in order to encourage their adoption by final beneficiaries supported by regional planning tools such as the Rural Development Program (PSR Sardegna).



The SheepToShip LIFE innovation framework appears in the Handbook Green Economy as a development opportunity for EU islands.

The SheepToShip LIFE Strategy and intervention model are featured in the volume *Green economy as a development opportunity for EU islands*, a handbook of good practices, for EU islands on the following topics: climate change, renewable energy and

energy efficiency, sustainable tourism, sustainable and circular economy. The handbook is the work of the Green Islands for sustainable mobility and circular economy. The Handbook shows main results of the *Green islands for sustainable*

cohesion policy, partnership composed by Sardinia, Balearic islands, Corsica and Crete, established in Bruxelles, in 2018, during the “European Week of Region and Cities”.



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