COMPARISON AND MANAGEMENT OF DAIRY CATTLE, SHEEP AND GOAT FARMS ACCORDING TO THE CRITERIA OF SUSTAINABLE INTENSIFICATION

DAIRYCHAIN PROJECT:

Integration of dairy cattle, goat and sheep farms into a unified and sustainable supply chain.

FONDO EUROPEO AGRICOLO PER LO SVILUPPO RURALE: L'EUROPA INVESTE NELLE ZONE RURALI

Project finalized with the contribution of the European Fund for Rural Development, PROGRAMME OF DEVELOPMENT RURAL 2014-2020, SUBMEASURE 16.1 - SECOND STAGE "Support for the establishment and management of pei operational groups on agricultural productivity and sustainability."

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- CAO Cheeses - Sheep Breeders Cooperative
- Azienda Agricola Magnani Società Agricola Soc. Semplice
- Taviani Manolo Farm
- Azienda Agricola Petucco Sandro e Marco Soc. Agricola Soc. Semplice
- Ena Giuseppe Farm
- Demontis and Scanu Agricultural Society

Acknowledgements

The researchers of the Department of Agriculture, University of Sassari for their support and valuable and continuous collaboration would like to thank:

- Partner breeders, industry technicians: applied field research and dissemination
- Breeders and member farms of the Coop. Arborea Milk and the Coop. CAO Cheese Dairy
- UNISS colleagues, students and collaborators on applied field research and outreach

The DairyCHAIN project, articulated over the three-year period 2023 - 2025, stems from the need to overcome the traditionally productivist approach of the Sardinian dairy sector, historically divided by species (cattle, sheep and goats), in favor of a unified management model, oriented toward quality and sustainability. It is proposed to create a "unified milk chain," which is not based on differentiation by species, but on common criteria for management, control and performance enhancement. This new vision aims to better respond to market and consumer needs, prioritizing nutritional quality, economic efficiency and environmental sustainability.

The main objective of the project is to create an integrated dairy supply chain that unites cow, sheep and goat milk production through a shared management and performance evaluation system. This system will be supported by information technology tools, monitoring protocols and management models (G_HACCP and Lean Management) to increase production efficiency, product quality and environmental sustainability. Integration will be fostered by training, cooperation and dissemination of results. The project is structured around three main areas of action, each of which includes specific objectives aimed at building a unified, multispecies, efficient and sustainable dairy supply chain.

Area A - Cooperation and stakeholder engagement

This area aims to foster the adoption of a new shared organizational model among partner companies. The specific objective is to promote a culture of cooperation through training activities, operational meetings and the establishment of a stable working group. In this way, it strengthens the awareness of the role of each actor in the supply chain and lay the foundation for participatory co-design.

Area B - Monitoring of business performance

Several activities are focused in this area that aim to evaluate and improve farm performance in multiple aspects. Protocols will be implemented to monitor the nutritional quality of livestock feed, milk and wastewater (**B1.1**), while data collection tools will allow the analysis of the technical-economic efficiency of farms (**B1.2**), highlighting management strengths and criticalities. In parallel, a system of indicators will be implemented to measure environmental sustainability (**B1.3**), through standardized methodologies such as Life Cycle Assessment. To support these activities, an IT platform (**B1.4**) will be developed to store data, calculate indicators and facilitate comparison between companies in a homogeneous and transparent manner.

This area aims to introduce innovative management tools to increase the efficiency of companies. An approach inspired by the HACCP model but oriented toward business management (G_HACCP) will be adopted, with the aim of identifying critical points in production processes and implementing corrective actions (**B2.1**). In addition, the introduction of lean management (**B2.2**) will make it possible to simplify operational flows, reduce waste and increase the value generated, through the direct involvement of staff in goal setting and change management.

Area D - Integration and Outreach

The last area aims to consolidate the unified supply chain through integration between the different supply chains (beef, sheep, goat), promoting strategic alignment among partners through the support of innovation brokers. In addition, dissemination and transferability activities of the results and tools developed will be put in place, both to partner cooperatives and to other entities interested in adopting the model, to amplify its impact on the territory.

The panorama of livestock farming in Sardinia

In Sardinia, milk production is one of the mainstays of the regional agrifood economy. The sector is characterized by a strong specialization in dairy sheep farming, which is strongly linked to the landscape, agricultural practices and socioeconomic dynamics within the island. Although less significant in terms of numbers, cattle and goat breeding also play an important role, especially in certain geographical areas and market niches.

Dairy cattle farms are concentrated mainly in the plains and irrigated areas of Campidano and northern Sardinia, where intensive or semi-intensive production patterns have become established. Breeds used include mainly the Italian Friesian and to a lesser extent the Brown breed. Specialized dairy farms make use of modern milking technology and feeding systems based on locally grown fodder, such as corn and ryegrass, supplemented generally with purchased feed for a self-sufficiency of about 55 percent of the food consumed. In recent years, the number of dairy cows in Sardinia has stood at just over 45,000, of which about 30,000 are on specialized dairy farms with a high level of production.

Much more represented, dairy sheep farming includes about 2.6 million animals raised on more than 10,000 farms and represents the largest sheep milk production area in Italy and Europe. The farms describe a climax of production systems from the most extensive with low animal loads to the most specialized with high inputs and productive level of animals.

The farms are mainly linked to the family management model and the milk produced is mostly destined for processing into cheeses with protected designation of origin, first and foremost Pecorino Romano, which is widely exported. The sector has strong critical issues, including price volatility and climatic vulnerability, which affect forage availability and production efficiency and difficult generational turnover.

Goat farming, while representing a smaller slice of the regional landscape, plays a strategic function especially in marginal and mountainous areas such as Nuorese and Ogliastra. It includes more than 280,000 goats raised destined for high quality local dairy production, often linked to short or organic supply chains and in small part to the production of drinking milk in mixed or highly specialized and stallion systems. The production organization is largely family-based.

Dairy cattle, sheep and goats are partly raised in farming systems with strong technification and production specialization. About 30 percent of the herds contribute 60-70 percent of regional milk production and are strongly linked to the international dynamics of the cheese milk trade. It is essential that these farms compare themselves with the widespread farming systems in the global arena to adopt management approaches and best practices that make them competitive and sustainable.

Area A - Cooperation and stakeholder engagement

DairyCHAIN is an initiative that aims to integrate beef, sheep and goat farms into a unified, digital and sustainable dairy supply chain. At the helm is Latte Arborea (3A), joined by selected dairy farmers, IT partners and the Department of Agriculture of the University of Sassari. The protagonist is the farmer, no longer just a milk producer, but a conscious entrepreneur, capable of reading data, managing people and making strategic decisions. Cooperation among partners is the key to the project to build a shared management model. A system in which each actor in the supply chain - from the farmer to the technician, from the digital partner to the researcher - defines and recognizes his or her role. This new approach overcomes traditional fragmentation by species and focuses on business management by production systems, where sheep, cattle and goats can share tools and methods to improve efficiency and profitability.
The goal of the project is to systematize the cattle, goat and sheep supply chains with a common approach of auditing production and organizational quality to:

- Improve decision making in companies according to efficiency parameters;
- To increase the awareness of processing co-ops with respect to the performance of manufacturing companies in the three supply chains;
- To define synergistic development goals at the territorial level with the involvement of the 3 species.

DairyCHAIN was created with the specific goal of bringing concrete tools to the stables: software for managing economic and livestock data, systems for monitoring environmental performance, nutritional protocols based on advanced analysis, techno-economic indicators for evaluating productivity, feed efficiency, personnel management and cash flow. All elements that make up the mosaic of modern business management.

The project is based on a clear vision: the farmer today must play the role of entrepreneur and lead the farm with technical, organizational and economic skills that if not his own can be acquired with a team of company and external technicians.

Dairy Chain aims to create the basis for forming a "unified dairy chain" by eliminating the focus by species and considering that the management approach of high-productivity cattle, sheep, and goat farms that send their products to processors is fundamentally similar within farming systems. With this in mind, specialized dairy sheep, cattle, and goat systems (intensive, stall-based, high-input, high-productivity) should be managed with similar management approaches and protocols, different from those used in multifunctional or extensive or mixed-livestock systems. Specialty farms are characterized by performing "food provisioning," the production of milk and meat for market, as their main ecosystem service, and should orient their management toward business approaches that can minimize the cost of production and environmental impact and maximize the product brought to market per unit of input, per unit of land, and per operator employed in the process. The Dairy Chain project aimed to decline this criterion in a study, research and cooperation approach cross 3 supply chains oriented with respect to objectives of:

- Nutritional quality for animal feeding management on farms, ù
- (ii) management quality to ensure technical efficiency and high profits for the producer;
- (iii) Environmental quality to ensure sustainability in resource use and minimization of greenhouse gas impacts especially.

The real quantum leap only occurs if those who work with animals also adopt tools for analysis, planning and control. This means knowing not only "how much milk is being made," but also "how much more milk (or income) could be made."

That is why training is central. The project involves accompanying partners with technical meetings and a steering committee that meets periodically to check progress and course-correct, just as in a real enterprise. The support of the University of Sassari with PhDs and experimental activities, such as the automatic feeding station for sheep and goats, testifies to the strong link between research and practice.

In an environment where companies are often small, family-owned, and where skilled labor is hard to find, cooperation is the only possible answer. DairyCHAIN does not just connect farms: it builds a network that shares problems, solutions and visions. An ecosystem where the farmer is no longer alone, but part of a system that supports and enhances him.

In summary, DairyCHAIN is more than a project: it is a paradigm shift. An invitation to move away from management based on urgency and routine, and embrace a strategic, data-driven, cooperative organization.

Action B.1.1. - Monitoring nutritional quality

Action B.1.1 - Monitoring nutritional quality.

Within the DairyCHAIN project, which aims to build a more integrated, sustainable and competitive Sardinian dairy supply chain, Action B1.1 had a central task: to assess the nutritional quality of feed used on cattle, sheep and goat farms. The goal is clear: to improve production performance, animal welfare and environmental efficiency through more conscious feed management.

To achieve this goal, an operating manual has been produced for the farms involved, which precisely describes how to carry out the sampling of food, milk, feces and livestock effluents. Adherence to these guidelines ensures that samples are collected correctly and representatively, an essential condition for obtaining reliable and comparable analyses.

Feed sampling follows well-defined protocols. For hay and wraps, for example, core drills are used to take material from 15 to 20 bales, then mixing everything into a single sample.

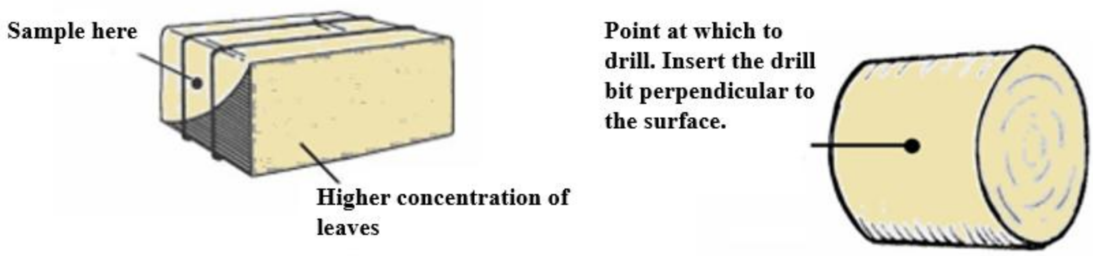

Figure 1. Core sampling of rectangular hay bale (left) and hay bale rotobale (right).

Figure 2. Coring of banded hay.

Silage forages, such as corn or mixed grass, are taken from different points in the silos, depending on their type, to avoid oxidized or contaminated areas. In the case of grazing, a 50-cm square frame is used that is placed at several points along two ideal diagonals of the grassland. The collected grass is then mixed to obtain a final sample of at least 1.5 kg.

Figure 3. Horizontal trench silo (left) and vertical silo (right).

Figure 4. Sampling of a pasture by the square frame method.

Unifeeds and concentrate feeds also require attention. Unifeeds are sampled from 6- 10 points before distribution, while concentrates and grains are sampled with special probes or proportional sampling systems.

HAY SAMPLING

MATERIALS NEEDED

- **Probe**
- Container/Bucket
- Plastic bags
- PennPermanent marker

Figure 1. Hay sampling.

SAMPLING PROTOCOL

• Analyse each batch of fodder separately. Sample 15-20 bales per batch

• Insert the corer to its full length into the centre of the end of the bale, perpendicular to the surface

• Combine the 15-20 samples taken from the same batch, known as primary samples, in a clean bucket. Mix to obtain a composite sample

• Place the entire sample in a clean plastic bag or other container and seal tightly. Do not divide the sample. It is normal for leaves and stems to separate and settle in the sample

• Label each sample with the name of the company, address, sample number and type of hay

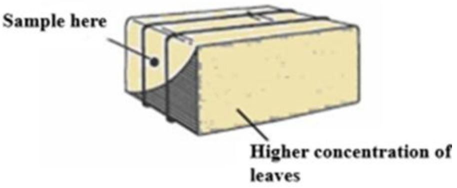

Figure 2. How to sample a small rectangular bale.

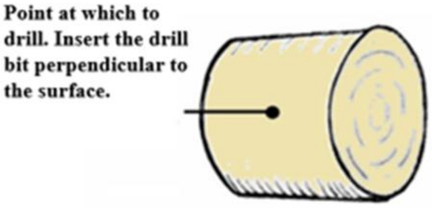

Figure 3. How to sample a round bale.

WRAPPED HAY SAMPLING

MATERIALS NEEDED

- Probe
- Moisture Meter
- Container / Bucket
- Plastic Bags
- Permanent marker

Figure 1. Sampling wrapped hay

SAMPLING PROTOCOL

- Measure moisture using the moisture meter
- Insert the probe to its full length perpendicularly into s the side, towards the center of the wrapped bale
- Mix elementary samples to obtain a a global sample, from which a final sample of approximately I kg to laboratory
- Store samples in tightly sealed plastic bags to prevet moisture and volatile compound losses
- Label each sample with company name, ID number and hay type
- Refrigerate the sample until it delivered to the laboratory, which be occurr within a few hours

Figure 2. Measuring moisture

Figure 3. Wrapped hay bales

HORIZONTAL SILO SAMPLING

MATERIALS NEEDED

- Forage probe
- Container/Bucket
- Plastic bags
- Permanent marker

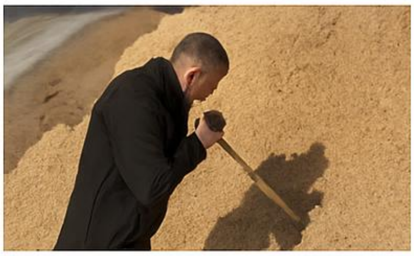
Figura 1. Sampling a bunker silo

SAMPLING PROTOCOL

- Use a propbe without tip at 10-12 points of the silage face face.
- Samply a bunker upou opening or during feed-out. Collect frot.he entire silage face, avoiding at ileast 10-lreserecendy exposed areas).

  In an alternative, sfnot with probe:

  - Rake the sitage face for sample pile or horzontaly —a pile on a pile on the silo floor, avoiding from rake caretuaily.
  - Randomly collect five cups of material from the raked unprocol on a bucket, and mix well.
- Take a representative sample for analysis and place it in a clean plastic bag or alternative carefully.
- Label each sample with the farm name, sample ID number, and type of silage.


Figura 2. Bunker silo


Figura 3. Sampling with a probe

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SILO BAG SAMPLING

MATERIALS NEEDED

- Container/Bucket
- Plastic bags
- Permanent marker

Sampler (optional)

Figure 4. Silo bag.

SAMPLING PROTOCOL

• Take 8 to 10 samples with the core sampler along the sides of the pipe at various distances and seal the holes in the plastic with adhesive tape after sampling

• If you do not have a core sampler: collect several manual samples from different positions along the exposed surface of the silage. After removing part of the silage from the bag, take a second set of samples from the new exposed surface for a total of 10 samples

• Combine all samples in a clean bucket, mix thoroughly and take a representative sample for analysis

• Place approximately 0.5-1.0 kg of sample in a clean plastic bag or other container and seal thoroughly

• Label each sample with the company name, address, sample number and type of forage

• Send the sample to the laboratory for analysis. If necessary, store in a freezer or cool place until shipment

PASTURE SAMPLING

MATERIALI NECESSARI

- Rigid frame 50 cm x 50 cm
- Grass cutting tool
- Plastic bags
- Permanent marker

Figure 1. Pasture sampling..

SAMPLING PROTOCOL

- Draw two diagonals in the area to be sampled
- Throw the frame at various points in the field, following the two diagonals drawn
- Cut all the grass that falls within the metal frame thrown into the field. The grass collected in each throw will constitute a basic sample
- Perform 5-10 throws, collecting one sample for each throw, depending on the availability of grass and the heterogeneity of the turf. Avoid areas that are clearly abnormal
- Combine the 5-10 elementary samples and mix well to obtain the global sample
- From the bulk sample, take a final sample of at least 1.5 kg (green grass) and place it in clean plastic bags
- Label each sample with the name of the company, address, sample number and type of pasture

UNIFEED SAMPLING

MATERIALS NEEDED

- Container / Bucket
- Plastic bags
- Permanent marker

Figure 1. Unifeed ration.

SAMPLING PROTOCOL

- Collect 6-10 samples from the feeding lane and mix them thoroughly
- Take samples before the animals start eating. The animals are selective and, over time, the composition of the feed in the trough changes
- Take samples along the entire length of the feeding lane, collecting samples from the top to the bottom: when the feed is distributed, the heavier particles tend to settle at the bottom, while the lighter ones remain on the surface
- Collect the samples in a clean bucket, then turn it upside down on a large, clean surface and lift it carefully, leaving the cone-shaped sample intact
- Use a thin piece of wood or metal to divide the sample in half, then in half again
- Keep a quarter of the sample for analysis and discard the rest

Figure 2. Unifeed distributed in the feeding lane.

Figure 3. Unifeed distributed in the feeding lane.

SAMPLING CONCENTRATES

MATERIALS NEEDED

- Sampling tools
- Divider plates;
- Suitable containers/receptacles
- Plastic bags
- Permanent marker

Figure 1. Corn kernels.

SAMPLING PROTOCOL

- Take and prepare samples, taking the necessary precautions to avoid any alteration or contamination of the product. The surfaces, containers and instruments used must be clean and dry
- Take the required number of incremental samples at random from the batch to be sampled. The incremental samples must be of approximately equal size
- Combine the incremental samples to form a single aggregate sample and mix thoroughly.
- Place each sample in a suitable container/vessel and use dividers to divide the sample into equal parts. If the nature of the food does not allow the use of a divider or if no divider is available, the sample may be reduced by the quartering method.
- Then form final samples of approximately equal size from the reduced samples, in accordance with the quantitative requirements

  Pack the samples, seal and label the containers or packages so that they cannot be opened without breaking the seal. The complete label must be incorporated into the seal

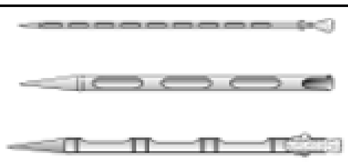

Figure 2. Probe for sampling grains.

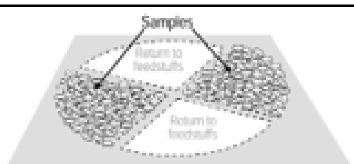

Figure 3. Quartering method.

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Action B.1.1 - Monitoring nutritional quality.

Regarding milk, two types of sampling are distinguished: bulk sampling, carried out in the tank after proper agitation and collected in refrigerated tubes, and individual sampling, carried out manually on individual animals after cleaning and stimulating the udder.

Figure 5. Individual milk sampling (left) and mass milk sampling (right).

Figure 6. Fecal sampling from rectal ampulla (left) and sewage sampling (right).

Feces are taken directly from the rectal ampulla, while for slurry and manure, deep sampling or sampling from several points in the pile is done, always following a careful homogenization procedure. All samples are kept cool and analyzed within 24- 72 hours.

MILK SAMPLING

MATERIALS NEEDED

- Sterile test tubes
- Identification labels
- Mixing devices
- Disposable gloves
- Water and detergent

SAMPLING PROTOCOL

MASS MILK

- Homogenise the milk to distribute fats and solids evenly.
- Collect using a sterile device.
- Store in a labelled container.
- Record: date, time, batch number and other relevant information.
- Store at a controlled temperature until analysis.

Fig. 1. Mass milk sampling.

INDIVIDUAL MILK

- Identify the animal.
- Clean and disinfect the udder.
- Discard the first few squirts of milk.
- Collect in a sterile container with a legible label.
- Store until delivery to the laboratory.

Fig. 2. Individual milk sampling.

TRANSPORTATION OF SAMPLES

- Transport in refrigerated containers.
- Timely documentation and communication of results for corrective or improvement actions.

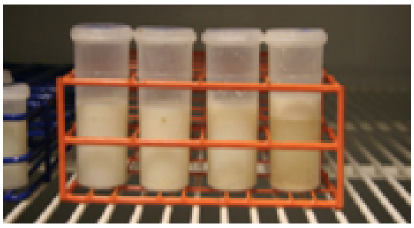

Fig. 3. Samples in sterile refrigerated test tubes.

STOOL SAMPLING

MATERIALS NEEDED

- Disposable gloves
- Airtight containers or plastic bags
- Identification labels
- Permanent markers
- Refrigerated transport containers
- Disinfectant for cleaning

Fig. 1. Rectal stool sampling.

SAMPLING PROTOCOL

- Wash your hands thoroughly and disinfect all instruments
- Wear disposable gloves
- Prepare containers and labels
- Take the sample directly from the rectal ampoule
- Use the glove as a container, turning it inside out to collect the sample
- Seal and label the sample correctly.
- Record information such as animal ID, date, and group.

STORAGE AND TRANSPORT OF SAMPLES

- Store samples at 4°C if they are not analysed immediately.
- Use thermal containers or dry ice to maintain the temperature.
- Ensure rapid transport to the laboratory.
- Clearly label samples with all necessary information.

Fig. 2. Animal identification and sample labelling.

SAMPLING OF SLURRY AND MANURE

MATERIALS REQUIRED

- Samplers
- Telescopic rod with scoop sampler
- Bucket with rope
- Manual auger with extensions
- Containers
- Sterile containers
- 1.5 litre bottles
- Sterilisation tools
- Flambé burners
- Boiling water Ipoclorito di sodio

Fig. 1. Auger.

Fig. 2. Alms box sampler.

SAMPLING PROTOCOL

SLURRY

- Homogenise for at least 20 minutes.
- Take samples from at least five different points.
- Sample from a single point if the slurry is in motion.
- Use remote-controlled samplers for static deposits.

Fig. 3. Sewage collection.

MANURE

- Check the density of the material.
- Check for sedimentation layers.
- Use augers to take samples at different depths.
- Apply the ‘surface quartering’ technique.

Fig. 4. Quartering of the manure sample.

STORAGE AND TRANSPORT OF SAMPLES

- Form the composite sample and reduce the volume to 2-5 litres
- Store in containers filled to 3/4 capacity and refrigerated
- For salmonella: take five separate samples in sterile containers
- Record the date of sampling and identify the tank

Action B.1.1 - Monitoring nutritional quality.

Seven farms were monitored during the project: three cattle, three goat and one sheep. In each, the chemical and nutritional composition of the feeds used was described in detail, including both those produced on the farm and those purchased. Stored forages such as alfalfa, grass or clover hay, corn, ryegrass and mixed grass silage, as well as mash, by-products such as brewers' grains or beet pulp, and, of course, commercial feeds and energy and protein concentrates were analyzed.

Analyses covered the key parameters: dry matter, crude protein, neutral detersed fiber (NDF), starch, ash, net lactation energy (NEL) and total digestible nutrients (TDN).

One of the most striking findings is the wide variability in nutritional values, both among different farms and within the same farm throughout the year. This variability especially affects forages, which are strongly influenced by climatic conditions, crop management and storage techniques.

Silomais, for example, showed good energy values (TDN > 40%, NEL between 0.9 and 1.0 Mcal/kg), but with significant differences between farms.

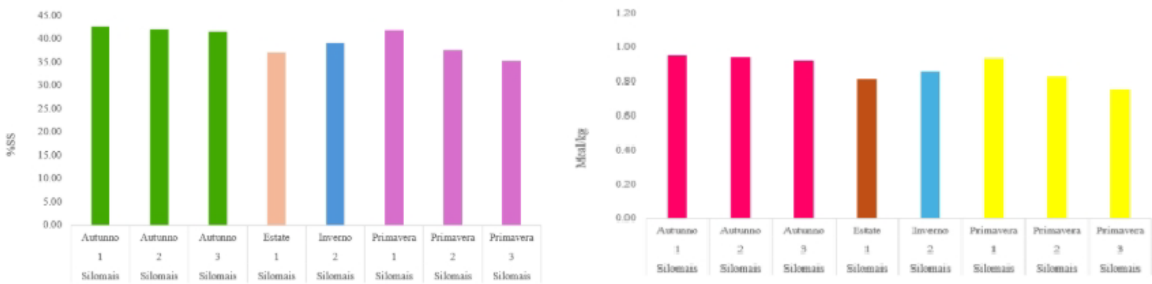

Figure 7. Trend of TDN (sx) and NEL (dx) values in silomais from partner cattle farms in different seasons.

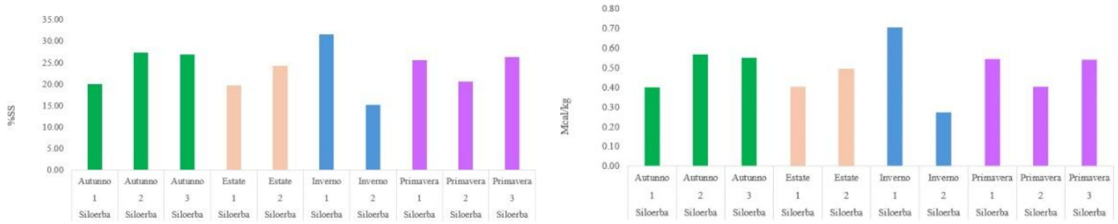

Figure 8. Trend of TDN (left) and NEL (right) values in the silo grass of partner cattle farms in different seasons.

Siloerbs proved to be more unstable, with NEL ranging between 0.26 and 0.57 Mcal/kg. Corn mash, used particularly on the sheep farm, recorded very high values of TDN (over 80 percent). Among the hays, alfalfa and clover hays proved to be richer in protein than natural grass hays. Very interesting was the case of ryegrass and clover wraps, used on a goat farm in winter, which achieved a NEL of 1.9 Mcal/kg and a TDN of 78%.

Feeding strategies also vary widely among different species. The cattle farms all use a unifeed system, that is, a mixed ration distributed as a block. These rations are well balanced, with crude protein between 14.4 percent and 17.5 percent, fiber between 28.5 percent and 41.7 percent, and starch between 23 percent and 28 percent.

Action B.1.1 - Monitoring nutritional quality.

Table 1. Food and chemical composition of the ration distributed by Company 1 in different seasons.

	Winter	Spring	Summer	Fall
Alfalfa hay, kg DM	2,300	0,930	0,740	
Grass hay or autumn grain, kg DM		1,320		
Grass silage, kg DM		5,490	8,030	5,660
Silage corn, kg DM	8,775	4,500	3,060	7,940
Soybean meal, kg DM	3,520	3,340	3,170	3,340
Commercial feed, kg DM *	0,880	1,760	1,760	1,760
Flaked cereal grains, kg DM	1,900	2,350	2,220	1,850
Grits or cornmeal, kg DM	4,440	5,480	5,420	4,380
Fibrous by-products, kg DM	2,640	1,660	1,940	0,704
Fats and oils, kg DM	0,200	0,210	0,300	0,290
Molasses, kg DM	0,450			
Straw, kg DM	1,340			
kg DM / head / day	26,45	26,96	25,53	26,09
kg AI/head/day	50,00	54,41	53,70	51,89
Chemical composition				
DM, %	52,32	49,55	47,53	50,27
CP, %,	14,41	15,86	15,06	15,89
NDF, %	35,03	37,01	36,23	33,34
Starch, %	27,83	24,88	26,19	24,89

*Commercial feed with a protein content of 19-28%.

Action B.1.1 - Monitoring nutritional quality.

Table 2. Food and chemical composition of the ration distributed by Company 2 in different seasons.

	Winter	Spring	Summer	Fall
Alfalfa hay, kg DM	1,000			1,740
Grass hay or autumn grain, kg DM	1,000			
Grass silage, kg DM	2,531	2,203	5,486	2,373
Silage corn, kg DM	5,956	8,070	3,228	7,500
Soybean meal, kg DM	3,608	4,136	4,136	4,048
Commercial feed, kg DM *	1,140			
Grits or cornmeal, kg DM	5,28	5,28	7,04	5,28
Fibrous by-products, kg DM	0,880	1,936	2,640	0,880
Minerals and vitamins, kg DM		0,200	0,200	0,200
Straw, kg DM		1,350	1,260	
kg DM / head / day	21,40	23,18	23,99	22,02
kg AI/head/day	50,40	47,60	53,30	49,80
Chemical composition				
DM, %	42,46	48,69	45,01	44,22
CP, %,	17,40	15,66	14,43	17,55
NDF, %	30,32	41,68	41,20	34,50
Starch, %	27	24,19	23,4	24,77

*Commercial feed with a protein content of 19-28%.

Table 3. Food and chemical composition of the ration distributed by Company 3 in different seasons.

	Winter	Spring	Summer	Fall
Grass hay or autumn grain, kg DM	0,270	0,450	0,450	0,584
Grass silage, kg DM	3,723	4,800	4,000	3,866
Silage corn, kg DM	6,256	6,300	6,300	7,832
Corn mash, kg DM	2,900		2,52	
Soybean meal, kg DM	4,500	4,320	4,320	4,140
Commercial core, kg DM *	0,871	0,871	0,871	0,931
Grits or cornmeal, kg DM	2,681	3,574	2,860	2,949
Flaked cereal grains, kg DM	1,928	3,068	1,928	2,630
Fibrous by-products, kg DM	0,534	0,712	0,712	0,712
Fats and oils, kg DM	0,297			0,248
Minerals and vitamins, kg DM	0,585	0,926	0,926	0,829
Straw, kg DM	0,862	0,431	0,431	0,56
kg DM / head / day	25,41	25,45	25,32	25,28
kg AI / head / day	47,00	49,05	49,45	47,10
Chemical composition				
DM, %	54,06	51,89	51,2	53,68
CP, %,	17,3	17,3	17,24	16,8
NDF, %	29,54	30,99	30,35	28,52
Starch, %	28,36	27,12	27,27	28,24

*Commercial core with a protein content >28%.

In the case of goats, the differences are more pronounced. One farm still relies extensively on grazing and adapts rations to the seasons, reaching peaks of 28 percent crude protein in the summer months. Another maintains a more constant feeding plan but with rather low energy values. The third uses a mixer wagon and formulates seasonal rations that, in the winter months, reach a NEL of 1.93 Mcal/kg.

The sheep farm, on the other hand, adopts an automated feeding system with Lely Vector robots and a fixed year-round ration based on few but high energy ingredients. Here, the highest values are recorded: NEL up to 2.02 Mcal/kg, TDN over 80 percent, crude protein at 17.4 percent and fiber around 33.5 percent.

Table 4. Indices of nutritional quality in the autumn season.

Food	Company	Season	TDNm	NEL3m
Ryegrass hay	1O	Fall	53.37	1.05
Ryegrass silage+ oats	2C	Fall	52.10	1.03
Fascia of ryegrass+ clover	3C	Fall	68.56	1.50
Corn mash	1O	Fall	82.47	2.02

Milk composition directly reflects feed quality. Sheep milk was found to be the richest and most stable, with average fat contents between 5.58 and 6.70 g/100g and protein between 5.07 and 5.54 g/100g. On goat farms, greater variability is observed: quality improves in the spring months but drops sharply in the summer, with milk that can drop to 3.65 g/100g fat and 2.89 g/100g protein.

Table 5. Seasonal variations in fat, protein and lactose content on the three goat farms and the sheep farm.

	Winter	Spring	Summer	Fall	p-value[1]
Az. 1C					
Fat (g/100g)	5,07^{a}	4,99^{a}	5,41^{a}	4,12^{b}	0,0004
Protein (g/100 g)	4,13^{a}	4.09^{ab}	4,28^{a}	3,91^{b}	0,003
Lactose (g/100g)	4.78^{ab}	4,68^{b}	4,36^{c}	4,93^{a}	2,44e$^{(-)(5)}$
Az. 2C					
Fat (g/100g)	4.28^{ab}	3.87^{bc}	3,70^{c}	4,36 ^{a}	0,0007
Protein (g/100 g)	3,87 ^{a}	3,42^{b}	3,20^{b}	3,66 ^{a}	4,05e$^{(-)(6)}$
Lactose (g/100g)	4.62^{ab}	4,70 ^{a}	4,50^{b}	4.58^{ab}	0,03
Az. 3C					
Fat (g/100g)	4,22^{a}	3,43^{b}	3,28^{b}	3,86 ^{a}	< 0,00001
Protein (g/100 g)	3,86 ^{a}	3,20^{b}	3,20^{b}	3,86 ^{a}	2,24e$^{(-)(7)}$
Lactose (g/100g)	4.42^{ab}	4,53 ^{a}	4,26^{c}	4.28^{bc}	0,004
Az. 1O					
Fat (g/100g)	5,58^{b}	5.71^{ab}	6.48^{ab}	6,70 ^{a}	0,01
Protein (g/100 g)	5,16	5,07	5,41	5,54	0,06
Lactose (g/100g)	4,92^{a}	4.86^{ab}	4.67^{bc}	4,65^{c}	0,003

Table 6. Seasonal average values of milk analysis in the three cattle farms.

	Fat (g/100g)	Protein (g/100 g)	Lactose (g/100g)	Cell/1000 (cell/ul)	Bact./100 (ufc/ul)	pH	Urea FT (mg/dl)
Az. 1							
Winter	4,16	3,41	4,74	181,40	37,60	6,78	23,26
Spring	3,98	3,29	4,76	163,89	47,89	6,79	24,21
Summer	4,06	3,26	4,73	197,82	63,91	6,80	20,26
Fall	4,31	3,45	4,73	195,55	69,18	6,79	19,46
Az. 2							
Winter	4,49	3,59	4,71	190,67	12,22	6,80	29,47
Spring	4,35	3,56	4,73	244,83	11,00	6,79	26,24
Summer	4,13	3,57	4,73	258,44	15,89	6,79	27,01
Fall	4,33	3,69	4,71	298,58	13,83	6,78	22,63
Az. 3							
Winter	4,17	3,48	4,79	214,21	33,13	6,80	22,38
Spring	4,19	3,43	4,81	224,58	42,92	6,81	21,91
Summer	4,04	3,37	4,76	223,00	26,92	6,80	22,85
Fall	4,30	3,50	4,73	233,94	30,69	6,80	23,25

Table 7. Nutritional quality indices of cattle farms in the fall season.

Food	Company	Season	TDM1 (%DM)	NEL3 (Mcal/kg)
Ryegrass hay	1	Fall	22.76	0.46
Grass silo	1	Fall	20.06	0.40
Grass silo	2	Fall	27.34	0.57
Grass silo	3	Fall	26.91	0.55
Grass silo	1	Fall	42.65	0.96
Grass silo	2	Fall	42.06	0.94
Grass silo	3	Fall	41.47	0.92
Grass silo	1	Fall	14.31	0.26

Cattle produce poorer milk (fat 4.13-4.33 g/100g, protein 3.35-3.60), but with a more stable composition throughout the year, although in summer there is a deterioration in sanitation quality (SCC and bacterial load).

Regarding digestive efficiency, cattle rations proved to be quite balanced (TDN 42.6 percent, NEL 0.96), mainly due to the use of well-preserved forages such as silomais. Sheep farms stand out for a very high energy intake, higher than standard requirements but useful in an intensive production context. Goat farms present more mixed results, with only one case of a well-formulated ration and two situations where the energy intake is lower than required.

A clear picture emerges from the analyses: many companies do not have up-to-date data on the actual quality of the food they use and tend to rely on standard tables, which often do not correspond to reality.

This leads to balancing errors and overestimation of the nutritional value of foods. Action B1.1 of the DairyCHAIN project emphasizes the importance of regular feed analysis, at least at each season change, and rationing based on real data. Only through constant monitoring of feed efficiency and milk quality can production be optimized, waste reduced, and animal welfare improved.

To truly build a unified Sardinian milk supply chain, it will be necessary to focus on farmer training, forage quality, standardization of best practices, and more widespread and informed use of nutritional analysis.

Action B.1.2 - Monitoring management quality

Action B.1.2 - Monitoring management quality.

Technical efficiency over the years has always been one of the most important factors for breeders and technicians, but not always linked to farm economic efficiency. Integrating technical data into the daily business routine helps the farmer in decision making. In addition, farmers with management software have higher revenues per dairy cow than other farmers. These indicators once calculated support the decision- making process of the farmer and the technicians working on the farm. If properly analyzed they will allow for improvements in farm management and production. Current trends in the livestock sector are pushing farms toward sustainable growth and the adoption of innovative practices, with a focus on economic management. In order to improve the future outlook of farms, it is essential that livestock farmers gain a thorough understanding of their economic indicators and know how to use them strategically. The rationale and method of calculating these indicators can be transposed to the three species by considering due differences in breeding types.

The most common partial indicators within dairy farms are:

- Feed efficiency (EA) given by the ratio of dry matter intake to milk supplied;
- Income Over Feed Cost (IOFC, given by the difference between milk income and feed costs, is extremely affected by fluctuations in the market and it is important to consider a normalized scenario;
- Income Equal Feed Cost, (IEFC), given by the ratio of feed cost to milk price per liter, could support farmers' decisions, but it only considers feed cost;

- Milk-to-feed price ratio (MFPR), which considers feeding costs, milk price and milk quality as additional value.

As can be surmised from the many indices mentioned above, there is no overall indicator that takes into account the whole business system. For this reason, some researchers recommend the use of multiple efficiency metrics to better characterize overall production efficiency. However, maximizing one indicator at a time for performance improvement may directly or indirectly affect other related inputs or outputs. Improving technical efficiency is usually driven by the goal of maximizing annual profits, but doing so could decrease economic efficiency. Therefore, the company's efficiency should be evaluated by considering technical performance and economic performance simultaneously. It is also necessary to develop efficiency and profitability indicators, classify decision-making units, and develop a benchmarking system among them by advising different companies. Economic comparison between different companies can help evaluate their technical improvements and identify the most inefficient aspects. Therefore, identifying aggregate criteria of economic and technical indicators would help to reduce the complexity and redundancy and redundancy resulting from different partial indicators, and thus improve decision-making processes that increase efficiency and profitability and allow reducing variable costs. Of course, the indices should be monitored as a whole in order to give the farmer the tools needed to improve management a should be analyzed taking into account farm variability.

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Data collection is divided into inputs to be collected normally and from the outputs to be calculated at different frequencies, as for the inputs are:

- Twin/trigeminal deliveries, no./day
- Dead lambs/kids, no./day
- Animals present at milking, no./day
- Animals present with lamb, no./day
- Ration administered per head, kg/d
- Liters of milk delivered, l/day
- Liters of milk processed, l/day
- Milk price on account
- Finished milk price

Following these inputs, outputs can be calculated on a daily (Table 8) and monthly basis.

Action B.1.2 - Monitoring management quality.

Table 8. Indexes and formulas for calculating partial indicators.

Index and units of measurement	Calculation formula
DM ingestion per head, kg/day	sheep= $-0.545 + 0.095\ x\mathrm{MW} + 0.65\ xLN$ goats = $0.043\ x\mathrm{MW} + 0.33\ xLatte\ prodotto\ \frac{kg}{d} + 0.12\ (aggiiustamento\ perla\ razza)$
Ingestion grazing for head, kg/day	DM ingestion per head kg/d - DM ingestion ration administered
Liters of milk conferred/head, l/day	Liters of milk delivered/total number of animals being milked per day
Cost kg of DM, €/kg	(cost ration per head theoretical)/(kg ration AI head x DM% ration
Head food cost, €/day	Cost kg DM ingested x Ingestion kg DM head
Herd food cost, €/day	Head food cost x total number of heads
Chief revenue, €/day	Liters of milk conferred head x milk price per liter
Herd revenue, €/day	Liters of milk conferred flock x milk price per liter
Meat revenue, €/day	No. head x head weight x price per kg of P.V.
IOFC daily head, €/day	Head revenue - Actual head cost present at milking.
IOFC daily flock, €/day	Herd revenue - herd feed cost
IOFC milk+ meat, €/day	(Milk revenue+ Meat revenue) - Food costs
Food efficiency (EA)	Liters head milk per day/S.S. Ingested per head per day

B.1.2.1. Farm-level applications on semi-extensive farms

As part of the Dairy Chain Project, a data collection using the indicators reported earlier was structured. On a semi-extensive mixed farm where both Sardinian-bred sheep and Sardinian- Maltese-bred goats were raised. In comparing sheep and goats, at the end of data collection, a comparison was conducted between flock IOFC (Income Over Feed Cost) (Figure 9) and IOFC per head (Figure 10), separated by sheep and goats. For the calculation, they were used milk selling prices of €1.60/liter for sheep's milk and €1.20 €/liter for goat milk.

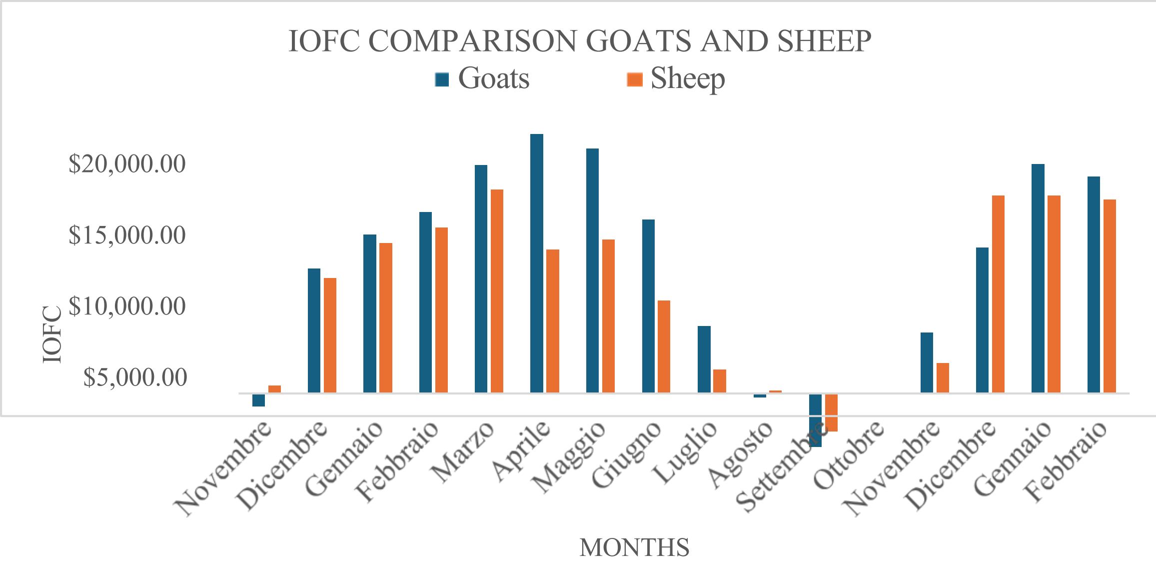

Figure 9. IOFC comparison between sheep and goats.

Analysis of IOFCs by flock shows that values for goats are significantly higher than those for sheep, following a trend closely related to the goat lactation curve. However, negative IOFCs are observed in some specific months, particularly November (-860.35€), August (-272.10€) and September (-3,576.80€). In August and September, the negative value is attributable to a considerable reduction in milk production, combined with a feed ration that has to take into account gestation requirements, with a cost of €0.45/head. Since IOFC Indicators calculated at flock level do not provide an accurate view of the differences between the two species, due to the different number of animals present, it was necessary to compare IOFCs by individual animal (Figure 10).

From the analysis it emerges that sheep have a higher IOFC/head than goats. Values for sheep range between figures close to 0€ and values close to 2.5€ per day, while for goats it is rare to exceed 1€. As can be seen from Figure 21, both species show very high seasonal variability, reflecting the typical production cycles of each species. Sheep, while having higher peaks than goats, show greater stability over time. Goats, on the other hand, experience a significant increase in IOFCs/goat as the days become longer and spring temperatures rise. During this period, in addition to taking advantage of arable grazing, they benefit from Mediterranean scrub shoots, which promote higher nutrient intake and increased yields. In addition, this practice helps reduce feed costs during the spring season. In the summer period, particularly in August and September, the IOFCs/head of goats are significantly lower than those of sheep. This phenomenon is mainly due to two factors. First, although goats produce a higher amount of milk than sheep during this period, the selling price of their milk is lower: €1.20 per liter versus €1.60 per liter for sheep.

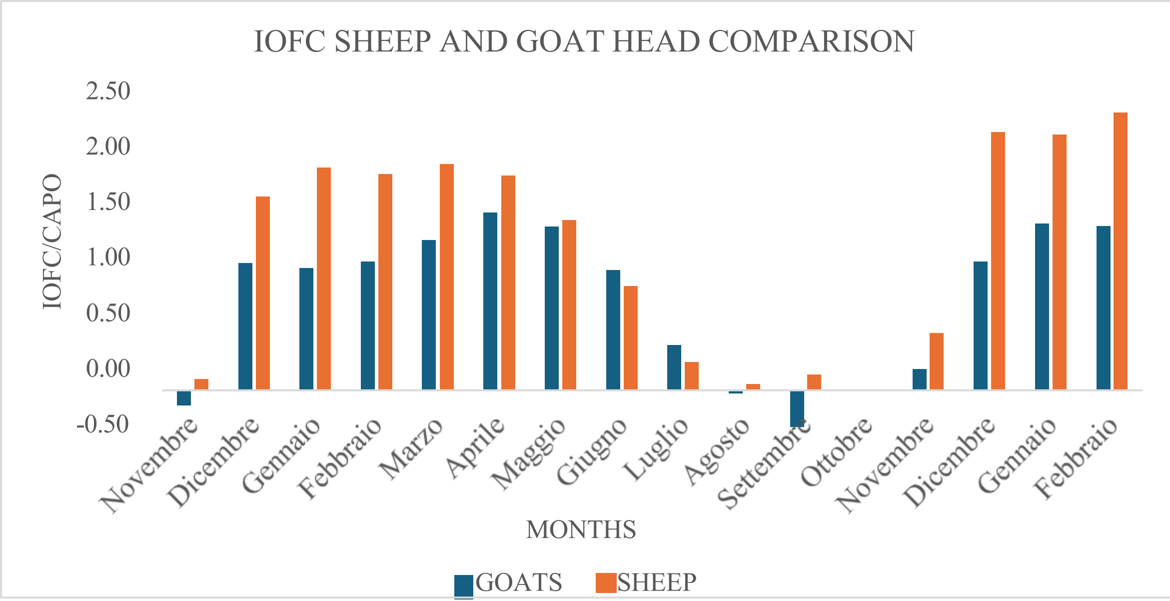

Figure 10. IOFC comparison per head between sheep and goats.

This price difference drastically affects the economic indicator by reducing the IOFC/goat of goats. Secondly, from the ultrasound scans and data collected, it was found that goats have a higher percentage of twins than ewes, about 70% on adults, 40% on lambs, respectively, and a 5% rate of triplet births for goats and about 20% for ewes. To adequately support twin pregnancies and ensure uncomplicated deliveries and quality future lactation, it is necessary to provide a richer and more expensive diet. This additional cost contributes to a further reduction in IOFC/head of goats during the summer period. From Table 9, despite lower milk production, sheep benefit from a higher sale price, which helps to keep IOFCs/head more stable and high over time. To reduce the negative impact of milk price on goats during the summer period, it would be necessary to optimize management and feeding costs by continuing to use high quality food but trying to improve the overall efficiency of management.

A 'further difference is that of IOFCs per head considering also the sale of lambs and kids (Table 9). For both goats and sheep, IOFCs show strong seasonal variability, with peaks in the winter months (December, January, February) and lows in the summer months (July, August, September). Sheep show greater stability in IOFC values than goats, especially in the summer months, where goats record negative values. Sheep generally have higher milk IOFCs than goats. For example, in December sheep reach €50.96 versus €33.41 for goats, and in March €59.47 versus
€39.51 for goats. In the summer months (July, August, September), goats record negative or very low values in IOFCs

of milk (e.g., -0.74€ in August), while sheep maintain positive, albeit reduced values (1.69€ in August).
The inclusion of meat sales significantly improves IOFCs for both species, but the impact is greater for goats. For example, in December IOFCs for sheep increase from €50.96 (milk only) to €51.73 (milk + meat), while for goats they increase from €33.41 to €89.13. In the winter months, goats benefit significantly from the sale of kids, with IOFCs increasing significantly. This is due to the increased twinning of goats and the sale of kids over the Christmas period. The annual total IOFC of sheep (€350.65 milk only; €391.73 milk + meat) is higher than that of goats (€253.53 milk only; €352.72 milk + meat). In this case, sheep sheep are more profitable on an annual basis due to a higher milk price and greater production stability.

Table 9. IOFC per head per month, considering or not considering the income from meat.

Months	Iofc milk goats	Iofc milk meat goats	Iofc milk sheep	Iofc milk meat sheep
November	-3.78	22.80	2.89	33.09
December	33.41	89.13	50.96	51.73
January	32.06	33.36	58.63	58.59
February	31.65	43.57	53.20	49.09
March	39.51	41.92	59.47	61.03
April	45.27	46.42	54.60	54.60
May	43.05	43.13	44.69	44.64
June	30.58	30.58	26.52	39.70
July	11.91	11.91	7.48	7.44
August	-0.74	-0.71	1.69	1.55
September	-9.39	-9.39	-9.48	-9.73
TOTAL	253.53	352.72	350.65	391.73

However, goats show greater profitability potential in the winter months, when kid sales contribute significantly to IOFCs. The most critical months for both species are July, August and September, with negative or very low values. However, goats suffer more during this period, with more negative values due to the need for increased sustenance caused by twin pregnancies and a higher herd size. Sheep have an economic advantage due to higher milk prices and greater production stability throughout the year. Goats, on the other hand, while having high profitability potential in the winter months (due to the sale of kids), are more sensitive to seasonal fluctuations and management costs, especially in the summer months. With the collection of these indicators n almost all months, the IOFC (Income Over Feed Cost) of sheep milk is higher than that of goats. November and September show negative values for both, with September particularly critical (-9.48€ for sheep,
-9.39 € for goats). The highest values are recorded in January and March for sheep (over 58 €), while for goats they remain lower (highest in March with 39.51 €) . In the summer months (July-August), margins drop significantly for both groups. Sheep show higher margins derived from milk, and goats partly compensate with significantly higher meat revenue. However, the overall margin (milk + meat) remains higher for sheep at €43.60.

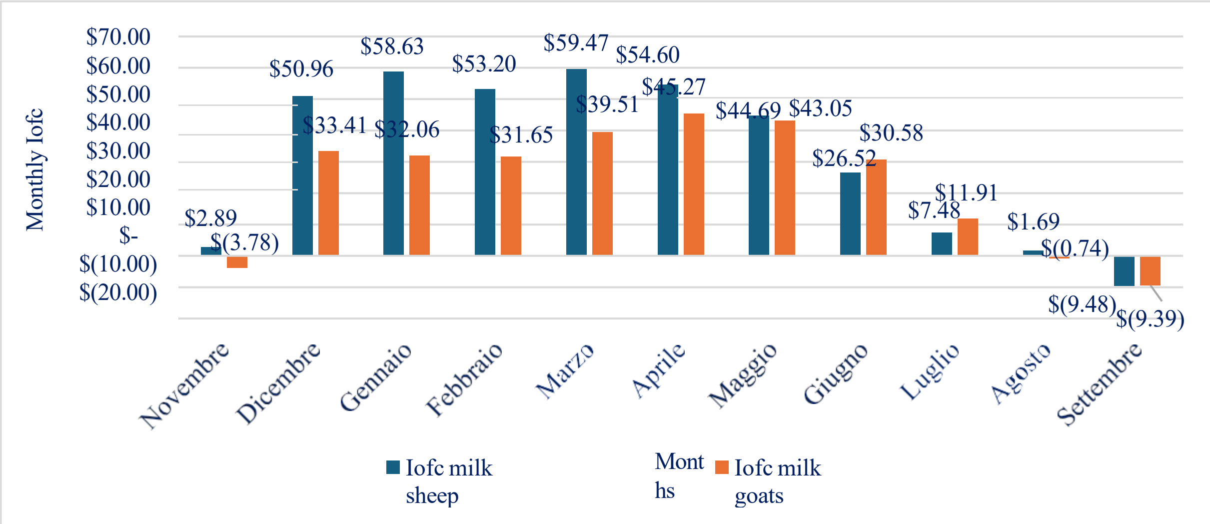

Figure 11. IOFC mensilized sheep vs goat milk only.

B.1.2.2. Collecting and monitoring partial indicators for dairy cattle

Again, the collection is divided between inputs and outputs calculated at different levels for inputs:

- Cost kg of DM =(cost ration per head theoretical)/(kg ration AI head x DM%ration);
- Unifeed unloading, measured from the wagon scale, kg/day;
- Milk product conferred, measured by tank, liters/day;
- Residue in feeder, kg/day;
- DM% unifeed, measured weekly with the stove by the farm owner in charge of feeding;
- heads milked, no. of animals/day;

- Ingested robot feed, detected by Crystal® software, kg head/day;

- Cost of 1 kg of DM, €/kg;

- total milk price, given by down payment price and premiums both taxed at 10%, €/l.

All the above data are entered for each group into which the herd is divided. These data are the basis for generating partial indicators exclusively for lactating animals, both daily and monthly.

Table 10. Daily indices and calculation formula.

Index and units of measurement	Calculation formula
kg of DM feed ingested/head, kg/day	kg robot feed ingested x DM% feed[1]
Ingestion dry matter/head, kg/day	$\frac{(scaricounifeed - residuo)x\,SS\%unifeed}{n°capi\ munti}$ $+kgdissmangime\ capo$
Liters of milk conferred/head, l/day	$\frac{litridilatteper\ \ gruppo}{n°capi\ munti}$
Efficiency food (EA)	$\frac{litridilatte\ \ capo}{ingestioness\ \ capo}$
Chief revenue, €/day	Liters of milk conferred head x milk price per liter
Head food cost, €/day	Cost kg DM ingested x Ingestion kg DM head
IOFC daily leader, €/day	Head revenue - Actual head cost

At the monthly level, on the other hand, through the weighted average of the two groups, while costs and revenues were summed.

Table 11 .Monthly indices and calculation formula.

Index and units of measurement	Calculation formula
Total milk delivered by group, l/month	Sum of total liters of milk conferred per month
IEFC (income equal feed cost) per head, (Pepin, 2009), liters/head	$\frac{Costoalimentaremedio\ \ capo}{prezzofinitolitrodi\ \ latte}$
Monthly group lactation food costs, €/month	Head food cost day x no. of animals milked day x no. of milking days
monthly group revenue, €/month	Total milk delivered by group x finished milk price
IOFC monthly group, €/month	Monthly group revenue- monthly group lactation food costs
Food cost per liter of milk, €/l	$\frac{Costialimentarilattazione\ \ mensili}{Litridilatteprodotti\ \ mensili}$
IOFC per liter of milk, €/l	Finished milk price- food cost per liter of milk

As part of the project, the trend of partial indicators of a dairy cattle farm with 225 milking animals was analyzed. The total number of milking animals with the exception of January when there were 225 animals (Table 12), did not vary considerably over the months, in fact on average there were 231 animals.

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Table 12. January-April indices.

	January	February	March	April
Average n animals	225	228	232	233
Average lactation days	157	157	164	171
Average head ingestion of DM kg/day	23.1	25.8	26.0	25.8
Total milk conferred, l/month	219723	212875	243680	235567
Average milk, l/day x head	31.5	33.4	33.8	33.7
Food efficiency	1.37	1.30	1.31	1.31
Down payment price €/liter+ VAT	0.37 €	0.37 €	0.40 €	0.40 €
Premiums €/liter+ VAT	0.03 €	0.04 €	0.05 €	0.05 €
Milk price €/liter	0.40 €	0.42 €	0.45 €	0.45 €
Total monthly revenues	87,881 €	88,963 €	108,817 €	105,757 €
Average daily revenue per head	12.59 €	13.95 €	15.11 €	15.12 €
Total monthly food costs	54,956 €	55,615 €	63,303 €	60,934 €
Daily food cost per head	7.88 €	8.73 €	8.79 €	8.71 €
Cost per kg of DM ingested	0.34 €	0.34 €	0.34 €	0.34 €
Average cost of liter of milk	0.25 €	0.26 €	0.26 €	0.26 €
IOFC monthly breeding	32,925 €	33,349 €	45,514 €	44,823 €
Average daily IOFC per head	4.71 €	5.23 €	6.32 €	6.41 €
IOFC per liter of milk	0.15 €	0.16 €	0.19 €	0.19 €
IEFC average, breakeven liters per head	19.7	20.9	19.7	19.4

The average milk production per head was 33 l/day and peaked in June with 35.2 l/day (Table 13), the average lactation days do not seem to have considerably affected EA and milk production, these range from a low of 157 in January and February (Table 12), to a high of 179 in July (Table 13). Monthly IOFC varies during the period under consideration, dependent mainly on: milk price, DM cost and milk production per head. During the period from January to April (Table 12), the cost per kg of DM remained unchanged and there was an increase in monthly revenues from €87.881 in January to €105.757 in April due to both an increase in average per head (+2.2 l/day) and an increase in milk price, being in January-February of 0.37 €/l down payment and 0.03 €/l premium while in March-April it increased to 0.40 €/l balance and 0.05 €/l premium in fact maximum peak of monthly IOFC in January-April period was in February with 45.514 € (Table 12). As for the period between May- August saw a gradual decrease in monthly IOFC from €43.654 in May to €27.162€ in August (Table 13) with an increase in feed cost per liter of milk of €0.08 €/l due to the increase in DM cost from June to July by 20% from €0.34/kg to €0.43/kg. In fact, the average cow cost increased by about €2/head per day.

Table 13. Total indices May-August period.

	May	June	July	August
Average n animals	232	234	234	233
Average lactation days	168	175	179	173
Average head ingestion of DM kg/day	26.2	25.6	25.5	25.4
Total milk conferred, l/month	251503	246811	240492	236137
Average milk, l/day x head	35.0	35.2	33.1	32.7
Food efficiency	1.34	1.37	1.30	1.29
Down payment price €/liter+ VAT	0.41 €	0.41 €	0.43 €	0.43 €
Premiums €/liter+ VAT	0.01 €	0.02 €	0.00 €	0.01 €
Milk price €/liter	0.43 €	0.43 €	0.44 €	0.44 €
Total monthly revenues	107,369 €	105,800 €	105,473 €	104,160 €
Average daily revenue per head	14.95 €	15.07 €	14.53 €	14.44 €
Total monthly food costs	63,716 €	75,549 €	77,890 €	76,998 €
Daily food cost per head	8.87 €	10.76 €	10.73 €	10.67 €
Cost per kg of DM ingested	0.34 €	0.42 €	0.42 €	0.42 €
Average cost of liter of milk	0.25 €	0.31 €	0.32 €	0.33 €
IOFC monthly breeding	43,654 €	30,251 €	27,582 €	27,162 €
Average daily IOFC per head	6.08 €	4.31 €	3.80 €	3.77 €
IOFC per liter of milk	0.17 €	0.12 €	0.11 €	0.12 €
IEFC average, breakeven liters per head	20.8	25.1	24.5	24.2

This was despite the fact that production performance did not decline, in fact June had the highest EA and average production per head with values of 1.37 kg of milk/kg of DM and 35.2 l/day, respectively, but it was the third worst month in terms of monthly IOFC, this is because the increase in costs was not matched by an increase in the milk advance price. During the reporting period, apart from the first two months of the year, revenues did not fluctuate significantly.

Going back to what was previously said, normalizing DM costs and milk price as already explained, in the first months of the year the trend is similar to the actual one (Table 13) in fact, revenues and monthly IOFC increase from

February to March by €13.554 and €6.778, respectively. In the summer months, on the other hand, the normalized monthly IOFC does not drop drastically as in reality because there is no increase in food costs but remains at an average of €54.800. As for average food costs per head, they do not fluctuate much and on average stand at €7.62/head, apart from the month of January which has a cost per head that is €0.7 lower than the average. On the other hand, comparing the average daily normalized head IOFC with the real one shows that there is a difference of 3.48 €/head more than the real one in the month of June (Figure 12).

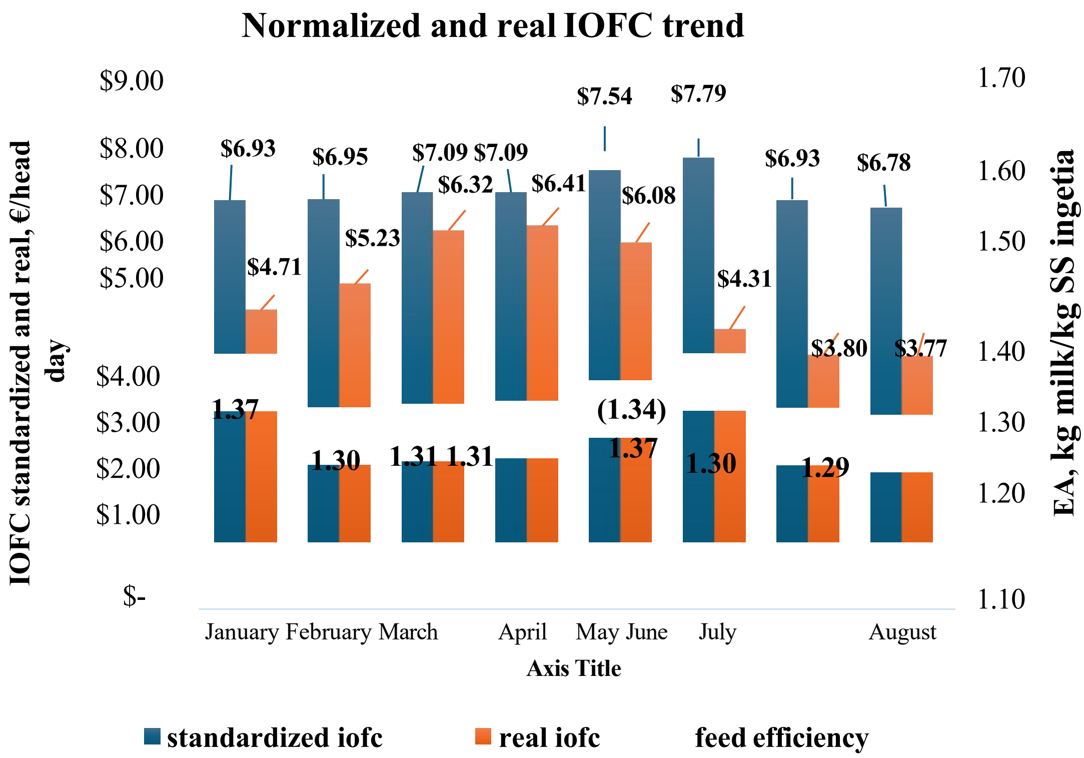

Figure 12. Standardized vs actual IOFC trend.

This difference remains large in July and August, this allows the market effect to be unbundled in fact if it were not for the increase in food costs, June would have been the month with the highest normalized head IOFC

(7.79 €/head). In general, on the other hand, the value of the hypothetical ±0.1 increase in EA (Figure 13) is equivalent to about ±0.84 €/head day IOFC; if carried over to the barn, considering 232 lactating animals, it would be about 194 € more per day and 5.829 € per month. It can also be seen that for daily IOFC values greater than €8/head the detected EA is always greater than 1.42.

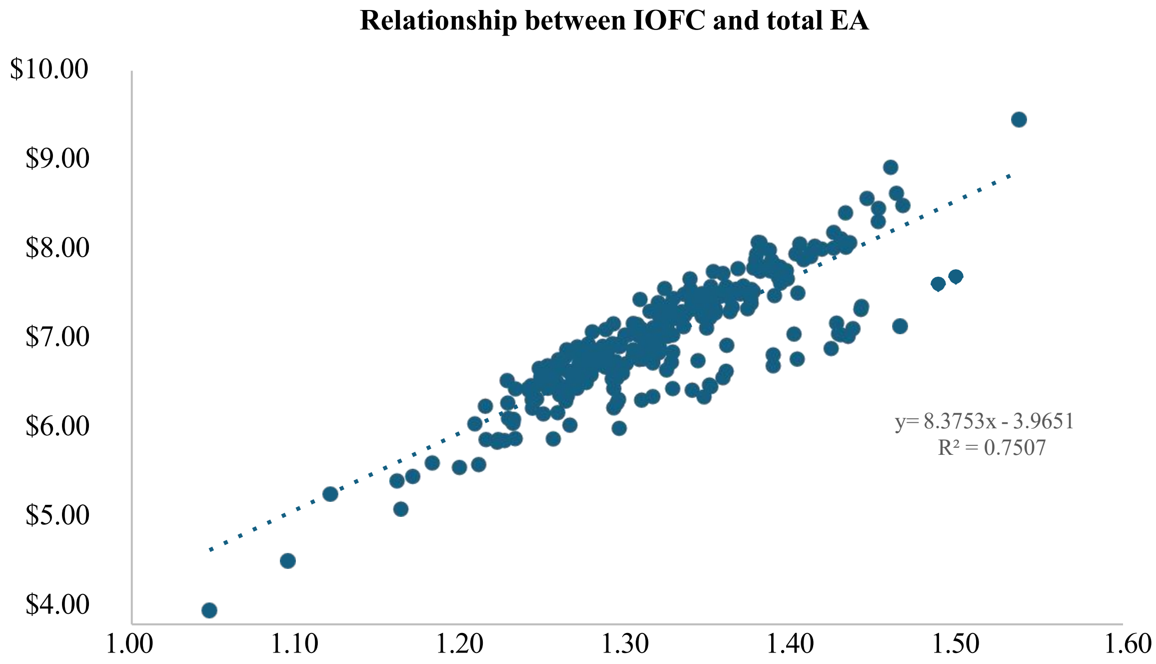

Figure 9. Relationship between IOFC (Income Over Feed Cost) and total EA (feed efficiency) proceDMed from the daily data collected.

B.1.2.3. Technical and economic indicators for comparing sheep, goat and beef farms

Technical-economic indicators are parameters for assessing the profitability, efficiency and economic sustainability of a livestock or agricultural activity. They combine technical data such as production, consumption and efficiency with economic data such as costs, revenues and margins to provide a clearer view of a company's production and financial performance. Partial indicators are used to compare the performance of companies in the entrepreneur's short-term decisions.

Summarizing the calculable indicators for the 3 species of interest are:

- feed efficiency (EA), which is equivalent to the ability of the herd to process the ingested feed into milk;

- Average production, measures the amount of product per head raised;

- Cost kg of DM, measures the cost of feeding based on the amount of dry matter;

- Normalized milk CME, is a standardized value that takes into account its composition, allows for a fair assessment of production among farms with different milk quality;

- Normalized and no cost liter of milk measures the cost to produce a liter of milk. It is used to evaluate the profitability of the herd and normalized allows for the evaluation of several herds;

- EA economic, measures how much income is generated relative to the cost of food and is used to assess the economic viability of a breeding and optimize feed ration costs;

- ECM /KG LW, measures the amount of normalized milk (ECM) produced per kg of live weight of the animal. It is a useful parameter for assessing

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- The production efficiency of a herd in relation to the body mass of the animals;

- IOFC ECM / KG LW, measures the net income generated by normalized milk production per kg of live weight of the animal. It helps assess how economically efficient an animal is relative to its body weight;

- Index of relative efficiency (IER), compares the profitability of two species of animals usually cattle and sheep based on IOFC per kg live weight;

- Food capital efficiency (ECA), is a technical economic indicator that measures food efficiency

- ECA/IER, compares food capital efficiency with index of relative efficiency to understand how food efficiency affects economic competitiveness between the two species;

- Milk-to-feed price ratio MFPR, ratio of milk price to of the administered food, which considers food cost, milk price and milk quality as added values.

Table 14. Summary and calculation of partial indicators.

Letter	Item	cattle	sheep	MU.	Formula
A	Number of animals	212	138		
B	LIVE WEIGHT.	725	47	Kg	
C	total milk	7957	127	L	
D	medium milk head/d	37.6	0.921	L /head / d	C / A
E	IDM average chief/d	26.5	1.76	Kg	Total Kg /A
F	EA	1.42	0.52	L / Kg DM	D / E
G	liter milk price	0.58	1.50	€ / L	
H	cost head day	10.78	0.46	€ chief/d	E * € /kg DM
I	Cost Kg DM	0.41	0.26	€ / Kg	H / E
L	Normalized Milk (CME)	36.6	1.39	L ECM / d	D*(0.122*fat% + 0.077*protein% + 0.253)
M	IOFC (CME)	10.43	1.63	€ chief/d	(L * G) - h
N	IOFC liter milk CME	0.17	1.24	€ / d	G - I
O	cost liter milk (CME)	0.29	0.33	€ / L CME	L / H
P	EA economic	4.90	0.44	€	F / (G - O)
Q	MILK ECM /KG LW	0.050	0.030	L / Kg / LW	L / B
R	IOFC ECM /KG LW	0.014	0.035	€ / Kg LW	M / B
S	IER	2.41		A D	R bov / R ov
T	ECA	3.39	3.05	€	L / H
U	ECA/IER	1.41	1.27	A D	T / S
V	MFPR	1.42	5.79	A D	G / I

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The most important indicators for comparing farms with different species are those normalized for ECM and LW. Economic efficiency is highly dependent on food costs, so ECA, MFPR, IOFC ECM are critical to assess profitability. Data collection must be accurate and regular. A comprehensive analysis with these indicators helps farmers make more informed decisions about which species to raise and how to optimize.

As already pointed out, the project stems from the need to overcome the historical fragmentation of the three most relevant dairy supply chains in Sardinia-beef, goat and sheep-and to set up a unified management model that would allow each type of milk to be enhanced with high value-added products, while ensuring profitability for producers, nutritional quality for consumers and lower environmental impact; to achieve these objectives, the project partners-the 3 A Cooperative of Arborea, the CAO Formaggi Cooperative and the Department of Agriculture of the University of Sassari-designed an information system based on a data survey protocol that, through technical, economic and environmental indicators, allows dairy farms to be characterized with homogeneous criteria and to build a database capable of guiding management decisions and investments along a single supply chain. To feed such a system, a structured questionnaire was administered directly to the owners of the nine sample farms, aimed at collecting detailed information on land size, livestock management, feed rations, agronomic practices, energy consumption and manure disposal methods; the choice of guided interviews reduced the margin of error and produced a consistent primary dataset that was subsequently proceDMed to extract key indicators-including, on the technical side, fertility and feed conversion index, and on the economic side, feed cost, Income Over Feed Cost (IOFC) and Income Equal Feed Cost(IEFC)-indicators capable of

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Directly link livestock inputs and economic performance. Analysis of the three cattle farms in Arborea reveals a profile of high intensification: permanently housed farms with herds ranging from 140 to more than 350 head, standard lactation duration of 305 days, and total productions ranging from 86000 to more than two million liters of fat and protein standardized milk (FPCM); performance per milked head often exceeds 30 kg daily, with unifeed rations rich in silage maize, silo-grass and protein cores, with lactation ration costs ranging between 6.9 and 7.9 euros per day and a feed efficiency of 1.18-1.34 kg of FPCM milk per kg of dry matter ingested. While incurring significant costs, farms benefit from a milk price of 0.54 €/l and achieve lactation IOFCs reaching up to 10.6
€/day per head, maintaining a production cost per liter under €0.42, with a carbon footprint around 1.1 kg CO_2eq/kg FPCM, values that highlight the competitiveness of the intensive cattle model. In contrast, the three goat farms, distributed in different parts of the island but united by the use of the Saanen breed, show widely varying sizes: 87 hectares to 260; lactating animals range from 220 to more than 650, and annual standard milk production ranges between 156000 and 33000 liters, with individual yields that, while lower than cattle yields, are between 1.7 and 1.9 kg per head per day milked; management is predominantly stallion-based with rations based on ryegrass and clover hay, corn and energy cores supplemented by beet pulp and soybean, and with a feed efficiency around 0.97 kg FPCM/kg DM. Lactation ration costs remain between 0.71 and 0.86 €/day per head, while the significantly higher goat milk price (1.65 €/l) allows IOFC of more than 2 €/day and an average production cost of between 0.63 and 0.85 €/l FPCM the carbon footprint reaches 1.3 kg CO_2eq/kg FPCM in the least efficient systems; it emerges

in this regard the decisive role of food cost structure and energy intensity, such that the farm with an agrophotovoltaic system obtains the best net margins.

The three sheep farms, based on the Sarda breed, represent a more heterogeneous picture: the farm with the most extensive management with 522 milked ewes produces 92000 kg of FPCM milk with fertility of 74 % and feed efficiency of 0.59, the others reaching up to 270 days of lactation obtaining 351000 kg of FPCM milk with yields of just over one kilogram per head and milk costs between 0.75 and 1.43
€/l FPCM; the differences are reflected in the carbon footprint, which ranges from 2.6 to over 4.2 kg CO_2eq/kg FPCM, values that highlight the emisson impact of low feed efficiency systems. In general, the price of sheep milk, set at €1.80/liter, covers feed costs in the more extensive systems, with lactation IOFCs hovering around €1/day per ewe and IEFCs hovering around 0.2-0.3 kg of milk needed to cover the daily ration, while the more intensive farm reality reduces the cost per liter to €0.81 due to the production push and improved feed conversion. The overall comparison between species and between management models shows that the productive superiority of cattle depends both on genetic potential and on the high level of nutritional and reproductive control, which allows maximizing the difference between revenues and costs as well as maintaining a low environmental impact; goats achieve good technical performance and excellent unit revenue due to the higher milk price, but exhibit greater sensitivity to feed fluctuations and require more attention on feed efficiency to contain environmental impact; finally, dairy sheep show the widest margins for improvement, as the prevalence of grazing and less management standardization result in lower yields, high variability between farms, and production costs often close to the

sales, a situation that can be improved by introducing more calibrated rations, as well as by expanding the adoption of homogeneous data collection tools that fill the information gaps found in some companies. In conclusion, the approach proposed by the project, which combines continuous KPI mapping, a managerial HACCP model to identify critical points of efficiency, and a Lean approach aimed at reducing waste and optimizing processes, forms the basis for a unified milk supply chain that balances economic needs, nutritional and environmental needs, and experiments conducted on nine farms show that where technical information and related indicators are applied regularly, tangible progress is achieved in both profitability and sustainability, suggesting scalability of the method to a wider number of regional farms.

Table 15. Description consistency and production data of dairy cattle farms.

Cattle farms		**Az. 1**	**Az. 2**	**Az. 3**
Hectares used (UAA)	has	34	87	72
Adult cow weight	kg	600	600	600
Adult cows	N of heads	110	180	230
Productive cows	N of heads	90	151	180
Culling animals	N of heads	52	29	110
Stocking rate	Head/ha	3,24	2,07	3,19
Annual fertility	%	81,8	83,9	78,3
Milk fat	%	3,90	4,06	4,27
Milk protein	%	3,24	3,35	3,37
Lactose	%	4,90	4,90	4,90
Milk fat/protein ratio	g	1,20	1,21	1,27
Milk energy	Mcal/kg milk	0,73	0,75	0,77
Energy of milk produced	Mcal/d	19,2	25,1	24,3
Milk solids	g/l	0,07	0,07	0,08
Milk solids produced	g/d per head	1,87	2,47	2,40
Total annual production of standard milk	l/year	833.837	1.777.257	1.998.371

Total annual production of standard milk	kg/year	860.520	1.834.130	2.062.319
Production level (FPCM)	kg/year	9.561	12.147	11.457
Production level (FPCM)	kg/year for adult cows*	7.823	10.190	8.967
Average daily production	kg/d of CVT per head milked	26,2	33,3	31,4
Milk milked per unit weight of adult females	kg FPCM/ kg weight	13,0	17,0	14,9
Daily ingestion	kg/d of DM per head	22,03	23,45	22,66
Food Conversion Index (FCI)	kg DM/kg FPCM	0,85	0,75	0,77
Milk production per unit weight of adult females	kg FPCM/kg weight	0,044	0,055	0,052
Milk production by ingestion (FE)	kg milk/kg DM	1,21	1,40	1,33
Lactation feeding efficiency (FE)	kg FPCM/kg DM	1,18	1,34	1,30
Herd feed efficiency (FE)	kg FPCM/kg DM	0,97	1,13	1,02
Lactation group ration cost	€/year	214.360	338.674	372.194
Herd ration cost	€/year	324.943	538.797	563.224
Lactation ration cost	€/d per cow milked	7,94	7,48	6,89
Herd ration cost	€/d per production unit**	9,89	9,78	8,57
Cost of milk production	€/l of milk	0,40	0,31	0,30
Cost of milk production	€/l FPCM	0,42	0,32	0,30
Milk price	€/l	0,54	0,54	0,54
Milk revenue	€/year	475.204	985.166	1.078.703
Income Over Feed Cost (IOFC) Lactation	€/d per head milked	6,28	10,59	10,15
Income Over Feed Cost (IOFC) Herd	€/per production unit**	4,57	8,10	7,85
IEFC of lactation	IEFC/d per head milked	14,62	13,77	12,69
IEFC of the herd	IEFC/d by production unit	18,22	18,00	15,79
Carbon Footprint (CF)	kg CO^2eq/kg FPCM	1,10	1,10	1,13

Table 16. Description consistency and production data of dairy goat farms.

Progressive Num.		Az. 4	Az. 5	Az. 6
Hectares used (UAA)	has	87	260	52
Adult goat weight	kg	70	70	70
Adult goats	N of heads	356	270	677
Productive goats	N of heads	350	220	652
Culling animals	N of heads	126	200	80
Stocking rate	Head/ha	4,09	1,04	13,02
Annual fertility	%	98,3	81,5	96,3
Milk fat	%	4,05	3,69	3,87
Milk protein	%	3,54	3,49	3,52
Lactose	%	4,50	4,50	4,50
Milk fat/protein ratio	g	1,14	1,06	1,10
Milk energy	Mcal/kg milk	0,75	0,71	0,73
Milk energy per milk produced	Mcal/d	1,38	1,23	1,22
Milk solids	g/l	0,08	0,07	0,07
Milk solids produced	g/d per kg milk	0,14	0,12	0,12
Total annual production of standard milk	l/year	247.687	151.293	320.153
Total annual production of standard milk	kg/year	255.613	156.134	330.398
Production level (FPCM)	kg/year	730	710	507
Production level (FPCM)	kg/year per goat present*	718	578	488
Average daily production	kg/d of CVT per head milked	1,85	1,72	1,67
Milk milked per unit weight of adult females	kg FPCM/ kg weight	10,3	8,3	7,0
Daily ingestion	kg/d of DM per head	2,07	2,02	2,01
Index of Food Conversion (ICA)	kg DM/kg FPCM	1,03	1,04	1,45
Milk production per unit weight of adult females	kg FPCM/ kg weight	0,026	0,025	0,024
Milk production by ingestion (FE)	kg milk/kg DM	1,02	1,05	0,77
Lactation feeding efficiency (FE)	kg FPCM/kg DM	0,97	0,96	0,69
Feed efficiency of the flock (FE)	kg milk/kg DM of the herd	0,95	0,78	0,67
Lactation ration cost	€/year	78.638	56.613	139.792
Herd ration cost	€/year	128.361	100.264	204.238
Lactation ration cost	€/d per milked goat	0,75	0,86	0,71
Herd ration cost	€/d per production unit**	0,95	0,78	0,67
Cost of milk production	€/l FPCM	0,63	0,85	0,73
Milk price	€/l	1,65	1,65	1,65

Milk revenue	€	443.896	281.299	606.179
Income Over Feed Cost (IOFC) Lactation.	€/d per head milked	2,31	1,99	2,04
Income Over Feed Cost (IOFC) flock	€/per production unit**	2,47	2,25	1,69
IEFC of lactation	IEFC/d head milked	0,45	0,52	0,43
IEFC of the flock	IEFC/d by production unit**	0,61	0,76	0,52
Carbon Footprint (CF)	kg CO^2eq/kg FPCM	1,05	1,61	1,27

Table 17. Description consistency and production data of dairy sheep farms.

		Az. 7	*Az. 8*	*Az. 9*
Hectares used (UAA)	*has*	119	115	140
Adult sheep weight	*kg*	45	45	45
Adult sheep	*N of heads*	703	950	1500
Productive sheep	*N of heads*	522	920	1450
Culling animals	*N of heads*	143	250	250
Stocking rate	*Head/ha*	5,91	8,26	10,71
Annual fertility	*%*	74,3	96,8	96,7
Milk fat	*%*	6,46	6,40	5,85
Milk protein	*%*	5,54	5,54	5,20
Lactose	*%*	4,50	4,50	4,50
Milk fat/protein ratio	*g*	1,17	1,16	1,13
Milk energy	*Mcal/kg milk*	1,08	1,08	1,01
Milk energy per milk produced	*Mcal/d*	0,69	0,97	1,02
Milk solids	*g/l*	0,12	0,12	0,11
Milk solids produced	*g/d per kg of milk*	0,08	0,11	0,11
Total annual milk production	*l/year*	89.409	233.072	340.599
Total annual milk production	*kg/year*	92.270	240.531	351.499
Production level of the herd	*kg/year*	177	261	252
Production level of the herd	*kg/year sheep present**	131	253	244
Average daily production	*kg/d of CVT per head milked*	0,64	0,90	1,01
Milk milked per unit weight of adult females	*kg FPCM/ kg weight*	2,9	5,6	5,4
Daily ingestion	*kg/d of DM per head*	1,02	1,41	1,30
Index of Food Conversion (ICA)	*kg DM/kg FPCM*	3,10	2,36	3,03
Milk produced per unit weight of adult females	*kg FPCM/ kg weight*	0,014	0,020	0,023
Milk production by ingestion (FE)	*kg milk/kg DM*	0,56	0,54	0,64
Lactation Feeding Efficiency (FE)	*kg FPCM/kg DM*	0,59	0,77	0,04
Feed efficiency of the flock (FE)	*kg milk/kg DM of the herd*	0,44	0,75	0,03

Lactation group ration cost	*€/year*	51.210	169.231	178.759
Herd ration cost	*€/year*	99.462	211.145	245.993
Lactating head ration cost day	*€/d per head milked*	0,33	0,61	0,41
Herd ration cost	*€/d per production unit***	0,52	0,63	0,46
Cost of milk production	*€/l of milk*	1,42	1,02	0,75
Cost of milk production	*€/l FPCM*	1,43	1,03	0,81
Milk price	*€/l*	1,80	1,80	1,80
Milk revenue	*€*	162.07 0	424.669	658.143
Income Over Feed Cost (IOFC) Lactation.	*€/d per head milked*	0,82	1,00	1,41
Income Over Feed Cost (IOFC) flock	*€/per production unit***	0,33	0,64	0,78
IEFC of lactation	*IEFC/d per head milked*	0,18	0,34	0,23
IEFC of the flock	*IEFC/d by production unit***	0,29	0,35	0,26
Carbon Footprint (CF)	*kg CO^2eq/kg FPCM*	4,26	2,60	2,78

The decision to integrate Sardinia's historic beef, goat and sheep supply chains into a single supply chain stems from the need to overcome traditional segmentation by species and to respond to a consumer increasingly attentive to nutritional quality, environmental sustainability and process transparency; to give solidity to this vision, the partners - the Arborea Cooperative, the Department of Agriculture of the University of Sassari and CAO Formaggi - have developed a data collection protocol that, through guided interviews and structured questionnaires, has allowed them to collect for nine sample farms a primary dataset on livestock consistency, agronomic management, rations, energy consumption and economic results, generating a homogeneous analytical framework in which each piece of information is translated into Key Performance Indicators related to the technical, economic and environmental dimensions of the milk produced; KPIs-most notably Feed Efficiency, defined as the ratio of kilograms of standardized milk (FPCM) to kilograms of dry matter ingested; Income Over Feed Cost, which measures the net margin gross of feed costs only; Income Equal Feed Cost, which estimates the liters needed to cover the cost of rations; and the carbon footprint expressed in kilograms of CO_2 equivalent

per kilogram of milk-was chosen because it allows direct correlation of nutritional inputs, animal productivity, revenues and environmental impact while providing the farmer with a control dashboard and the project with an inter-species comparative basis; as for the sample analyzed, the three cattle farms operate in permanent housing, manage herds between 140 and over 350 adult cows with an average weight of 600 kilograms, and have normalized annual yields ranging from 860000 to over two million kilograms of FPCM milk with daily yields of 26-33 kilograms per milked animal and dry matter ingestion around 23 kilograms, values that result in a lactation feed efficiency between 1.18 and 1.34 kilograms of milk per kilogram of DM and a feed conversion index around 0.76 kilogram DM per kilogram of milk; the average cost of the lactation ration is €7.44 per day, the total cost of production on the liter is
€0.35, while the selling price set at €0.54 allows an IOFC of €6.52 per head per day and an IEFC of 13,69 liters, with a carbon footprint per kg of milk produced of 0.04 kg CO_2eq per kg of milk and 0.05 kg CO_2eq per Mcal of energy produced, indicators that make the cattle system more environmentally and productively sustainable.

The three goat farms raise Saanen breeds in groups of 220-650 lactating goats, have productions between 170000 and 370000 kg FPCM, daily yields of about 1.7-1.9 kg per head, ingestion of 2.03 kg DM and feed efficiency between 1.02 and 1.05 kg FPCM/kg DM, ration costs of 0,77 euros per day, liter cost of 0.74 euros and milk price of 1.65 euros allowing an IOFC of 1.81 euros and even 1.21 euros margin per kilogram of milk sold, while the IEFC of 0.47 liters indicates that less than half a liter is enough to cover feed; on the environmental front, the carbon footprint per kg of milk produced averages 0.75 kg CO_2eq per kg of milk and 1.04 kg CO_2eq per Mcal, intermediate values that,

related to the high price of the product, preserve the economic competitiveness of the system. Finally, sheep farms raise between 520 and 1450 Sardinian ewes with some Assaf crosses, produce 92-351 thousand kg FPCM per year with individual yields around 0.6-1.0 kg daily and ingestion of 1.24 kg DM, achieving feed efficiency of 0,59-0.77 and ration costs of only 0.45 euros per day, but paying for the low intensity with a production cost per liter exceeding 1.09 euros, an IOFC of only 0.55 euros per day, and a significantly higher carbon footprint per kg of milk produced: 4.10 kg CO_2eq per kg of milk and 3.86 kg CO_2eq per Mcal, although mitigated by a selling price set at 1.80 euros and an IEFC of only 0.25 liters revealing the convenience of low-input grazing. Cross-case analysis of the data reveals that dry matter ingestion reflects energy requirements, rising from 22.72 kg in cattle to 2.03 in goats and 1.24 in sheep, while the unit cost of DM is inversely proportional: 0.34 euros/kg in cattle,
0.46 in goats, 0.39 in sheep, an indication that the more concentrated diets of cattle, while affecting the budget, are offset by the very high processing into milk; the comparison of margins per unit of energy and solids, however, makes it clear that goats obtain an average IOFC of 1.65 euros per Mcal and over 16 euros per kilogram of solids, far exceeding the 0.39 and 3.96 euros of cattle and the 1.21 and 10.91 of sheep, which shows that, even with reduced volumes, the nutritional and nutraceutical value of goat milk represents an overwhelming competitive advantage. It is very interesting the IOFCs per unit flock weight/mandria as cattle and sheep have very similar values, this i s given by the fact that the IOFCs of the herd are given by the high productivity of cattle which averages 30.29 ± 3.67 kg/d of FPCM per milked head, while the IOFC per unit flock weight can be attributed to the higher selling price of sheep milk.

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When cross-referencing profitability with environmental impact, cattle emerge as the species with the best IOFC ratio per kilogram CO_2-equivalent (8.11 euros) compared to 1.68 for goats and 0.36 for sheep, evidence that rewards well-managed intensive systems, while in terms of carbon footprint per kilogram live weight, sheep emerge as the least virtuous with over 0.07 kg CO_2eq/kg compared to 0.02 for goats and 0.004 for cattle.

In conclusion, the analysis shows that economic and environmental superiority depends not only on the volume of milk but on the balance between product energy density, feed cost, and market price, and that governance based on shared indicators makes it possible to identify different levers for improvement for each species, tracing a path toward more profitable, transparent, and sustainable dairy production for the entire island territory.

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Table 18. Technical, economic and environmental indicators of selected companies.

		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Hectares used	has	34	87	72	87	260	52	119	115	140
(UAA)	kg	600	600	600	70	70	70	45	45	45
Weight of adult females	N number of animals	110	180	230	356	270	677	703	950	1500
Number of adult females	N number of animals	90	151	180	350	220	652	522	920	1450
Number of productive females	N number of animals	52	29	110	126	200	80	143	250	250
Number of animals	kg FPCM	860.520	1.834.130	2.062.319	269.028	170.484	367.381	92.270	240.531	351.499
per return	kg/year per milked animal	9.561	12.147	11.457	769	775	563	177	261	242
Total standard annual milk production	kg/year per adult animal*	7.823	10.190	8.967	756	631	543	131	253	234
Production level (FPCM)	kg/d of FPCM per milked animal	26,2	33,3	31,4	1,85	1,72	1,67	0,64	0,90	1,01
Production level (FPCM)	kg FPCM/kg weight	13,0	17,0	14,9	10,8	9,0	7,8	2,9	5,6	5,2
Average milk production	kg FPCM/kg weight	0,04	0,06	0,05	0,03	0,02	0,02	0,01	0,02	0,02
Milk produced per unit of adult weight	kg/d of SS	22,03	23,45	22,66	2,07	2,02	2,01	1,02	1,41	1,30
Milk production per unit of adult weight	kg SS/kg FPCM	0,85	0,75	0,77	0,98	0,95	1,30	3,10	2,36	3,15
Milk production per unit of adult weight	kg FPCM/kg SS	1,18	1,34	1,30	1,02	1,05	0,77	0,59	0,77	0,04
Intake	kg FPCM/kg SS	0,97	1,13	1,02	1,00	0,85	0,74	0,44	0,75	0,03
Feed conversion ratio (FCR)	kg milk/kg SS	1,19	1,42	1,39	0,89	0,85	0,83	0,63	0,64	0,78
Lactation feed efficiency (FE)	€/year	214.360	338.674	372.194	78.638	56.613	139.792	51.210	169.231	178.759
Herd/flock feed efficiency (FE)	€/year	324.943	538.797	563.224	128.361	100.264	204.238	99.462	211.145	245.993
Milk production per intake (FE)	€/d per production unit**	8,09	8,20	6,71	0,99	1,02	0,83	0,39	0,61	0,45
Lactation group ration cost	€/d per milked animal	7,94	7,48	6,89	0,75	0,86	0,71	0,33	0,61	0,41
Herd/flock ration cost	€/l FPCM	0,42	0,32	0,30	0,63	0,85	0,73	1,43	1,03	0,81

Herd ration cost	€/l	0,54	0,54	0,54	1,65	1,65	1,65	1,80	1,80	1,80
Lactation ration cost	€/year	452.774	965.051	1.085.115	408.683	249.633	528.253	160.936	419.530	613.079
Milk production cost	€/year per milked animal	5.031	6.391	6.028	1.168	1.135	810	308	456	423
Milk price	€/year per kg weight of milked animal	8,38	10,65	10,05	16,68	16,21	11,57	6,85	10,13	9,40

		Bovini			**Caprini**			**Ovini**		
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Milk revenue	€/year per kg weight of flock or herd	4,66	7,70	5,32	12,11	7,59	9,97	4,23	7,77	7,79
Milk revenue	€/l FPCM	0,12	0,22	0,25	1,02	0,80	0,92	0,37	0,77	0,99
Milk revenue	€/d animal	3,89	7,73	7,94	2,19	1,86	1,36	0,32	0,62	0,69
Milk revenue	€/day per lactating animal	6,28	10,59	10,15	2,31	1,99	2,04	0,82	1,00	1,41
Milk revenue	IOFC/year per kg of flock or herd weight	0,006	0,013	0,013	0,031	0,027	0,019	0,007	0,014	0,015
Income Over Feed Cost (IOFC) per head	IEFC/day per milked animal	14,62	13,77	12,69	0,45	0,52	0,43	0,18	0,34	0,23
Income Over Feed Cost (IOFC) lactation	IOFC/kg of milk	0,24	0,32	0,32	1,25	1,15	1,22	1,29	1,12	1,39
IOFC per unit of flock/herd weight	IOFC/Mcal of milk	0,33	0,42	0,42	1,67	1,62	1,68	1,19	1,04	1,39
IEFC	IOFC/milk solids	3,36	4,30	4,23	16,41	16,05	16,54	10,74	9,36	12,62
IOFC per kg of milk	IOFC/kg animal weight	0,006	0,013	0,013	0,031	0,027	0,019	0,007	0,014	0,015
IOFC per Mcal of milk	kg CO2eq/kg FPCM	1,10	1,10	1,13	1,05	1,61	1,27	4,26	2,60	2,78
IOFC per milk solids	IOFC/kg CO2 eq per kg of milk	5,71	9,63	8,98	2,20	1,23	1,61	0,19	0,39	0,51
IOFC per weight of adult females	CF/IOFC	0,28	0,14	0,14	0,48	0,87	0,93	13,20	4,19	4,01
Carbon Footprint (CF)	IEFC/kg CO2 eq per kg of milk	13,29	12,52	11,23	0,43	0,32	0,34	0,04	0,13	0,08
IOFC per CF	CF/kg animal weight	0,0018	0,0018	0,0019	0,0150	0,0230	0,0181	0,094	0,0578	0,0618
CF per IOFC	CF/Mcal	0,06	0,04	0,05	0,76	1,31	1,04	6,16	2,69	2,73

IEFC per CF	CF/kg FPCM	0,04	0,03	0,04	0,57	0,93	0,76	6,66	2,89	2,74
CF per weight of adult females	CF/milk solids	0,59	0,45	0,47	7,47	13,01	10,28	55,52	24,23	24,82

Table 19. Averages and standard deviations of technical, economic and environmental indicators of selected companies.

		Media bovini	SD bovini	Media caprini	SD caprini	Media ovini	SD ovini
Hectares used (UAA)	ha	64	± 27	133	± 111	125	± 13
Weight of adult females	kg	600	± 0	70	± 0	45	± 0
Number of adult females	N number of animals	173	± 60	434	± 215	1051	± 408
Number of productive females	N number of animals	140	± 46	407	± 222	964	± 466
Number of replacement animals	N number of animals	64	± 42	135	± 61	214	± 62
Total annual standard milk production	kg FPCM	1.585.656	± 638.267	268.964	± 98.449	228.100	± 130.061
Production level (FPCM)	kg/year per milked animal	11055	± 1339	702	± 120	227	± 44
Production level (FPCM)	kg/year per adult animal*	8993	± 1184	643	± 107	206	± 66
Average daily production	kg/d of FPCM per milked animal	30,29	± 3,67	1,75	± 0,09	0,85	± 0,19
Milk produced per unit weight of adult animals	kg FPCM/kg weight	14,99	± 1,97	9,19	± 1,53	4,58	± 1,46
Milk production per unit weight of adult animals	kg FPCM/kg weight	0,05	± 0,01	0,02	± 0,00	0,02	± 0,00
Daily intake	kg SS/d per animal	22,72	± 0,71	2,03	± 0,03	1,24	± 0,20
Feed conversion ratio (FCR)	kg SS/kg FPCM	0,79	± 0,05	1,08	± 0,19	2,87	± 0,45
Lactation feed efficiency (FE)	kg FPCM/kg SS	1,27	± 0,08	0,95	± 0,15	0,47	± 0,38
Herd/flock feed efficiency (FE)	kg FPCM/kg SS	1,04	± 0,08	0,87	± 0,13	0,41	± 0,36
Milk production per intake (FE)	kg milk/kg SS	1,33	± 0,12	0,86	± 0,03	0,68	± 0,09
Carbon footprint (CF)	kg CO2eq/kg FPCM	1,11	± 0,02	1,31	± 0,28	3,21	± 0,91
Lactation group ration cost	€/year	308.409	± 83.156	91.681	± 43.096	133.067	± 71.050
Flock/herd ration cost	€/year	475.655	± 131.090	144.288	± 53.785	185.533	± 76.549
Herd ration cost	€/d per production unit**	7,67	± 0,83	0,94	± 0,10	0,48	± 0,11
Lactation ration cost	€/d per milked animal	7,44	± 0,52	0,77	± 0,07	0,45	± 0,15
Milk production cost	€/l FPCM	0,35	± 0,07	0,74	± 0,11	1,09	± 0,32
Milk price	€/l	0,54	± 0,00	1,65	± 0,00	1,80	± 0,00
Milk revenue	€/year	834.313	± 335.832	395.523	± 139.775	397.848	± 226.850
Milk revenue	€/year per milked animal	5.817	± 704	1.038	± 198	396	± 77
Milk revenue	€/year per kg weight of milked animal	9,69	± 1,17	14,82	± 2,82	8,79	1,72

		Media bovini	SD bovini	Media caprini	SD caprini	Media ovini	SD ovini
Milk revenue	€/year per kg of flock or herd weight	5,89	± 1,60	9,89	± 2,26	6,59	± 2,05
Milk revenue	€/l FPCM	0,20	± 0,07	0,91	± 0,11	0,71	± 0,32
Income Over Feed Cost (IOFC) per animal	€/d head	6,52	± 2,28	1,81	± 0,42	0,55	± 0,20
Income Over Feed Cost (IOFC) lactation	€/d lactating head	9,01	± 2,37	2,11	± 0,17	1,08	± 0,30
IOFC per unit of herd/flock weight	IOFC/year per kg of flock or herd weight	0,011	± 0,004	0,026	± 0,006	0,012	± 0,004
IEFC	IEFC/d milked head	13,69	± 0,97	0,47	± 0,05	0,25	± 0,08
IOFC per kg milk	IOFC/kg of milk	0,29	± 0,05	1,21	± 0,05	1,27	± 0,14
IOFC per Mcal milk	IOFC/Mcal of milk	0,39	± 0,05	1,65	± 0,03	1,21	± 0,17
IOFC per milk solids	IOFC/milk solids	3,96	± 0,52	16,33	± 0,26	10,91	± 1,64
IOFC per CF	IOFC/kg CO2 eq per kg of milk	8,11	± 2,10	1,68	± 0,49	0,36	± 0,16
CF per IOFC	CF/IOFC	0,19	± 0,08	0,76	± 0,25	7,13	± 5,26
IEFC per CF	IEFC/kg CO2 eq per kg of milk	12,35	± 1,04	0,37	± 0,06	0,09	± 0,04
CF per adult female weight	CF/kg head weight	0,00	± 0,00	0,02	± 0,00	0,07	± 0,02
CF per milk energy	CF/Mcal	0,05	± 0,01	1,04	± 0,28	3,86	± 1,99
CF per kg milk	CF/kg FPCM	0,04	± 0,00	0,75	± 0,18	4,10	± 2,22
IOFC per adult female weight	IOFC/kg head weight	0,01	± 0,00	0,03	± 0,01	0,01	± 0,00
CF per milk solids	CF/milk solids	0,50	± 0,08	10,25	± 2,77	34,86	± 17,90

Action B.1.3 - Environmental Quality Monitoring.

B.1.3.1. How is the environmental impact of a farm calculated?

Based on the guidelines provided by the ISO 14000 series standards, in order to implement a life cycle analysis we must follow these 4 steps:

1) Define the purpose of the analysis (What do we want to evaluate? Why do we want to evaluate it? To whom do we want to communicate our results?);
2) Conduct inventory analysis, capturing data on all material and energy flows required to produce the analyzed product;
3) Assess life cycle impact, using specific software or relying on dedicated spreadsheets;
4) Interpret the results obtained in light of the assumptions made in defining the scope.

In Specifically, when you want to evaluate the impact environmental of a farm it is necessary to calculate:

1) Enteric methane emissions, which can be determined using equations provided by the Intergovernmental Panel on Climate Change (IPCC) or using more specific equations provided by other scientific studies (Vermorel et al., 2008);
2) Methane emissions from wastewater, also to be determined according to IPCC formulas;
3) Nitrous oxide emissions from wastewater, which can be determined using equations from the IPCC and other scientific work (Jarvis, 2001; Atzori et al., 2013; Laubach et al., 2013);

4) Emissions from on-farm use of off-farm livestock feed, generally calculated using emission coefficients derived from specific databases;

5) Emissions related to on-farm food production from the use of seeds, fertilizers, pesticides and fuel; they are determined using emission coefficients derived from both scientific papers and specific databases;

6) Emissions from the use of energy sources, which consider electricity used on the farm and fuel consumption not used in the production of farm food.

A flowchart representing primary milk production is shown below as an example.

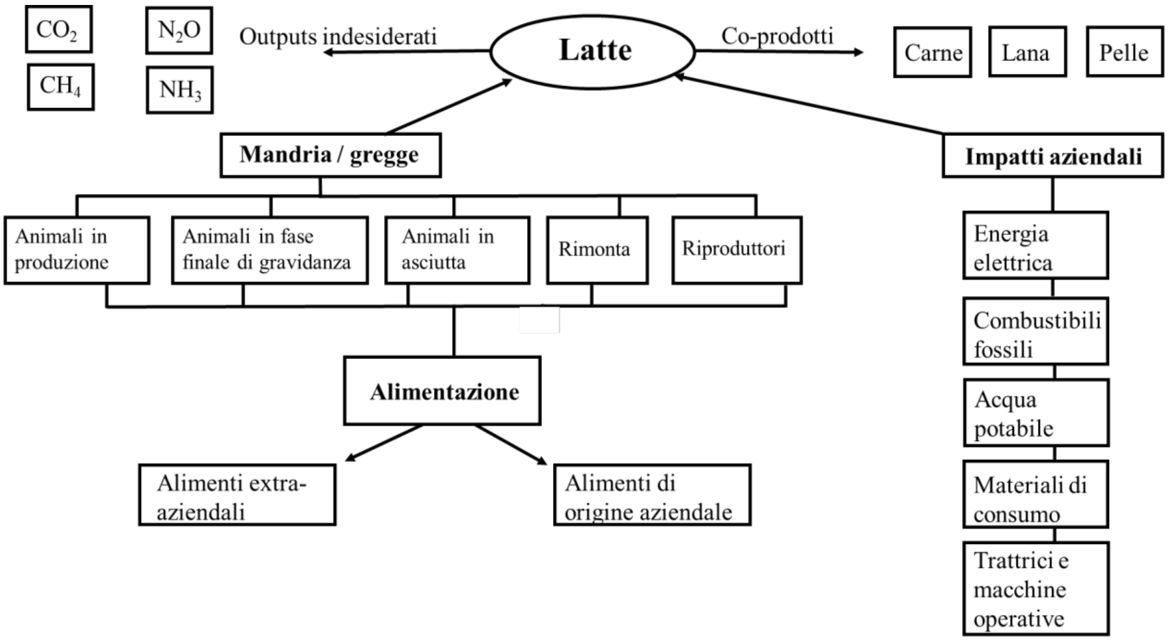


Figure 14. Flow chart of milk production.

B.1.3.2. Results Action 1.3

The DairyCHAIN project stems from the need to rethink the milk production system in Sardinia, overcoming a fragmented logic that for decades has rigidly distinguished the three main regional supply chains: cattle, goat and sheep. In a context in which the market demands not only quantity and quality, but also environmental sustainability and management coherence, the need to integrate production strategies in a unified perspective has become increasingly evident. The goal of the project is therefore ambitious but necessary: to build the foundations for a unified Sardinian milk supply chain, where farms of different species operate according to common standards of efficiency, quality and environmental responsibility. Action B.1.3 within DairyCHAIN addressed one of the most complex challenges: measuring and characterizing the environmental impact of dairy farms through a rigorous scientific methodology known as Life Cycle Assessment, or LCA. This internationally recognized approach makes it possible to objectively quantify the greenhouse gas emissions associated with the production of a commodity-in this case, milk-taking into account all the stages and activities that make its existence possible, from fodder production to milking. Nine farms were involved, three for each species, chosen on the basis of their willingness to provide complete and up-to-date data, as well as their representativeness within the reference cooperatives: the 3A Arborea and the Cooperativa Allevatori Ovini (CAO) Oristano. The farms are located mainly in the provinces of Oristano and Sassari, in lowland and hill areas, and show considerable variety in terms of size, organization and resource management. The data collected cover every aspect of the production cycle:

from land use characteristics to crop management, from the type of animal feed to the amount and mode of storage of livestock manure, from energy consumption to the use of consumables such as detergents, disinfectants and agricultural fuels. A key element of the analysis is the use of the functional unit, represented by 1 kg of Fat and Protein Corrected Milk (FPCM), which allows the impact of milk within the same species to be compared with each other, taking into account its composition. The system analyzed is cradle-to-gate, meaning it includes everything that happens on the farm up to the time the milk leaves the barn to be transported to the dairy. The results that emerged from the analysis are extremely interesting and draw a clear picture of the differences between the different species. Cattle farms are confirmed as the most environmentally efficient, with an average impact of 1.11 kg of CO_2 equivalent per kilogram of milk produced. They are followed by goat farms, with an average impact of 1.31 kg CO_2eq/kg FPCM, while sheep farms have a significantly higher impact of 3.21 kg CO_2eq/kg FPCM. The main cause of emissions on all farms is enteric methane, which is the gas emitted as a result of digestion. This gas, although biologically natural, has a much more potent greenhouse effect than CO_2 and accounts for 50 percent of emissions on cattle farms, 64 percent on goat farms, and 69 percent on sheep farms. It is followed by emissions from manure management, accounting for about 18-19% in cattle and sheep farms, but only 6% in goat farms. The purchase of feed and food from outside has a considerable weight in cattle farms, where it accounts for 22 percent of emissions, compared with 7 percent in goat farms and 3 percent in sheep farms, which rely more on grazing and self-production. Finally, energy consumption has a variable impact: 7 percent in cattle, 16 percent in goats and 8 percent in sheep. In addition to the average data, it is important to note the variability observed within each group. Cattle and goat farms show some uniformity in results, regardless of their size, confirming that environmental performance is related more to management than to farm scale. The situation is different for sheep farms, which show strong variability in results: while this element signals less standardization in management, it also represents a great opportunity for improvement. Where there is variability, in fact, there is room for intervention, improvement, and innovation. The study also calculated the average impact for milk delivered to cooperatives: 1.08-0.98 kg CO2eq/kg FPCM for cow's milk, 1.33-1.32 for goat's milk, and 3.43-3.41 for sheep's milk, depending on the allocation criterion between milk and meat. The results are perfectly in line with those reported in scientific literature at the European level, confirming the soundness of the applied method and the validity of the conclusions. These numbers, however, should not be read statically. On the contrary, they represent a starting point, a fundamental reference for all companies wishing to embark on a path of environmental improvement. The practical recommendations that emerge from the study are clear: increase productivity per liter of milk, so as to dilute emissions per kilogram of milk produced; reduce dependence on external feed by focusing on indoor cultivation and efficient forage rotations; and optimize manure management to reduce nitrogen losses and make better use of farm resources. For sheep farms in particular, it will be essential to activate systematic monitoring and training programs to help farms identify their critical points and introduce good sustainable practices. The introduction of a management system based on environmental KPIs (Key Performance Indicators), already planned by the project, represents a key strategic lever in this regard. In summary, Action B.1.3 of the DairyCHAIN project does not just take a snapshot of the state of the art of emissions in Sardinia: it provides concrete, comparable, useful tools for all companies in the supply chain. It is a virtuous example of how science can be translated into operational support, and how the concept of sustainability can be integrated into the daily management of livestock farms. Environmental awareness, today, is no longer a luxury for the few, but a necessity for everyone: for producers, who want to ensure the survival of their farms; for cooperatives, who need to enhance the value of the product on the market; and for consumers, who demand transparency, responsibility and respect for the environment. Sardinian milk has all the right cards to play a leading role in this transformation, provided it continues to invest in quality, data, and knowledge sharing. Only in this way can it remain competitive in a market that increasingly looks to sustainability as an indispensable value.

Table 20. Main characteristics of the companies under study.

	u.m.	**Bovine Companies**			**Caprine Companies**			**Ovine Companies**		
		Az. 1	Az. 2	Az. 3	Az. 4	Az. 5	Az. 6	Az. 7	Az. 8	Az. 9
Superf. total	has	34	87	72	87	260	52	119	115	140
UBA	n	184	352	463	49	98	32	91	123	182
Loading animal	UBA/ha	3.94	4.04	6.43	0.56	0.37	0.61	0.76	1.06	1.30
Number employees	n	2	5	5	3	6	2	5	2	5
Autoprod. energy	Y/N	S	N	N	N	S	S	S	N	N

Table 21. Size, head distribution and milk production per head milked for different farms.

	u.m.	**Bovine Companies**			**Caprine Companies**			**Ovine Companies**		
		Az. 1	Az. 2	Az. 3	Az. 4	Az. 5	Az. 6	Az. 7	Az. 8	Az. 9
Total heads	n	234	445	577	493	977	420	905	1230	1819
Adult females	n	110	213	290	356	677	270	703	950	1500
Lactating females	n	90	180	230	350	652	220	522	920	1450
Remount	n	41	107	170	126	280	80	143	250	300
Remount	%	37	50	58	35	41	30	20	26	20
Milk prod.	kg	875'146	1'814'302	1'986'562	277'636	379'137	175'933	92'920	243'476	416'906
Prod. per head milked	kg/head	9'723	10'079	8'637	793	581	799	176	261	267

Action B1.4 - Information tool engineering.

Action B1.4 - Information tool engineering.

Area B1.4 involved the engineering of a monitoring information tool through the construction of an information platform for storing farm inputs and calculating technical, economic and environmental indicators, with the aim of mapping farm performance both at the farm level and at the territorial level. The tool had the ability to spatialize the information collected and make it usable for comparative purposes. The action aimed to develop a tool that could be extended to the member farms of the partner cooperatives, with the goal of fostering the transferability of the approach to the territory, aimed at benchmarking farm performance.

B.1.4.1. Software User Guide

As part of the Dairy Chain project, in collaboration with ARA Lombardia, the ARAL-G€co software was tested. The ARAL-Geco project is implemented by ARAL and UNIMI - Department of Political and Environmental Sciences and is financed by the European Agricultural Fund for Rural Development under the RDP 2014-2020. It aims to promote the dissemination of knowledge and tools necessary for the preparation of the farm balance sheet. The operational horizon of the G€co includes the main specialized production units, such as cattle breeding, dairy sheep, fattening, agricultural sector and energy production from biogas.

B.1.4.1.1. Sections and operation

Through input, divided between the two main items, revenue and cost, it is possible to construct the economic output, of an entire year or even of periods of less than a year. The software is managed through a dashboard in which all major functions are present.

Leaving aside the dashboard for a moment, the first important function to fill out is the **Master** Data section: under this section, enter data inherent to the farm, such as name, VAT number and location. Next, under the Production Units section, located in Master Data, enter data pertaining to the type of farm, the UAA, divided into rented and owned, and other data, such as numbers of animals in production and the VAT regime.

Figure 105. Master data section.

Next is the section that deals with company personnel management, under the heading **Manpower** (Figure 2**)**. Labor management is divided into family member and employee. The master data of each employee or family member, their respective salary, broken down into salary, severance pay, or contributions are requested.

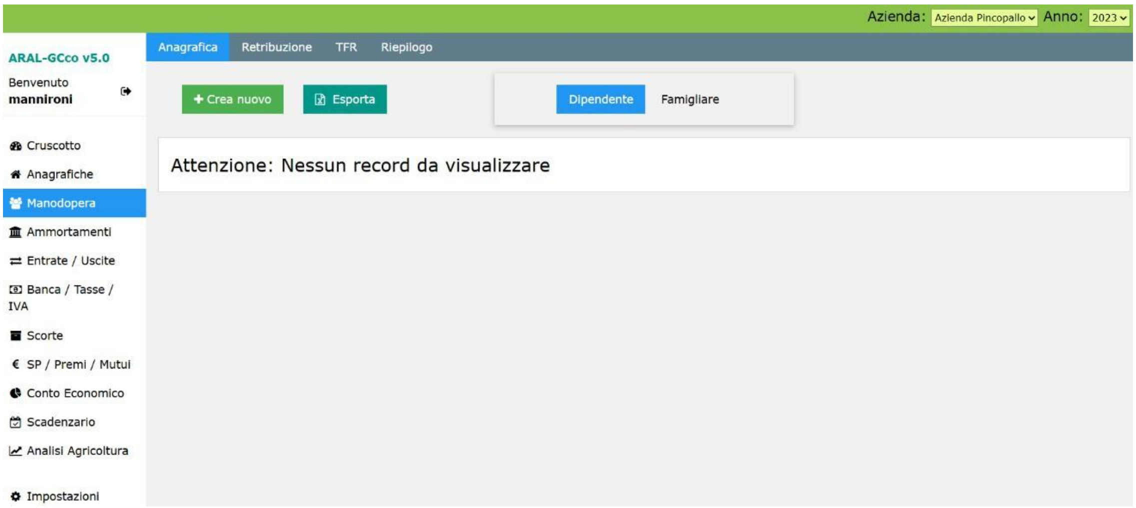


Figure 16. Labor section.

Next, the management of depreciation, if any, on the farm is discussed. Various types of depreciation are considered, pertaining to buildings, plant and vehicles/equipment of agricultural type or used in stables. For the calculation of depreciation, the type of depreciation, month and year of purchase and the respective purchase value and years of depreciation are requested. Generally, a depreciation period of 30 years is considered for depreciation of property such as stables and/or warehouses. For farm and barn equipment, 10 years is considered; for equipment, the period varies from 5-8 years. Generally, the depreciation period varies depending on the initial purchase value and the type of asset being depreciated.

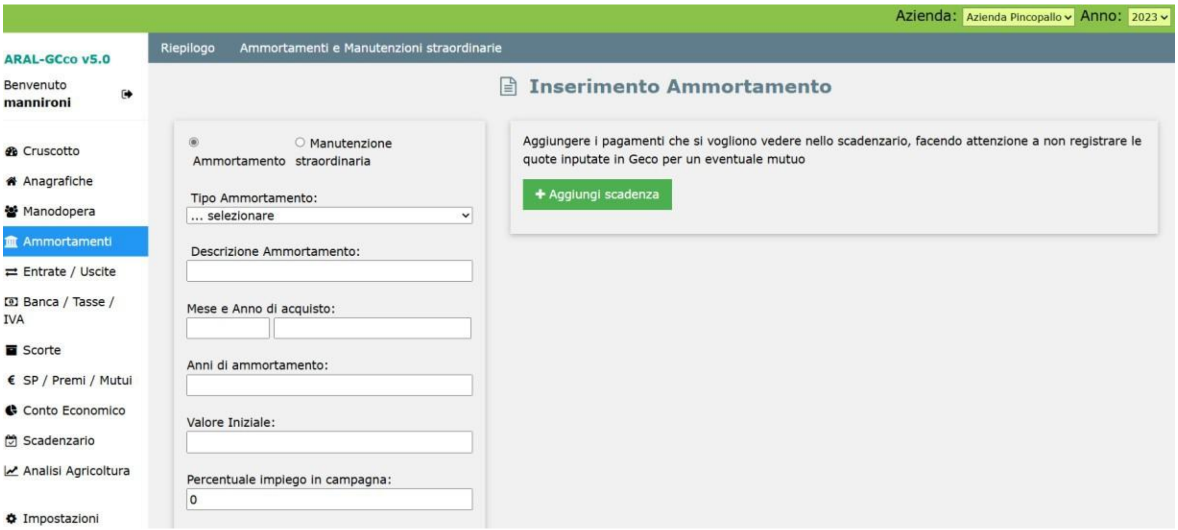


Figure 17. Depreciation section.

Once the business data, concerning labor and depreciation, has been entered, we move on to the economic input loading system, which is divided into Revenue Items (Table 22) and Cost Items (Table 23).

Table 22. Software revenue items.

Revenue centers	**Legend and specifications**
MILK	Milk delivered in the period to external customer
ANIMAL SALE	Waste cattle, male calves, heifers, and/or lifetime cattle
AGRICULTURAL SALES	Agricultural productions not used in livestock feeding and given to third parties
STOCK MANAGEMENT	Divided into livestock and dead stock, counted at the beginning and end of the period under review
PRODUCT VALUE RE-EMPLOYMENTS	Example: milk reused for farm dairy, silage for corporate biogas
OTHER SALES.	Non-farm sales, agricultural means, etc.
PAC AND CONTRIBUTIONS	Yearly contributions received by the farm: CAP, ecoschema1, etc.
EXTRAORDINARY MANAGEMENT	Insurance premiums
PARKING (values not counted in the total)	Previous year's milk balance, milk delivered in December of the previous year

In the 'analysis, "parked" milk, i.e., milk delivered in December of the previous year, the period under review, is taken into account in the analysis but is not counted during the preparation of the financial statements.

Table 23. Cost items.

Cost centers	Legend and specifications
FOOD PURCHASED	Food purchased for feeding the herd (no straw for bedding)
STALL	Detergents and sanitizers, bedding, carcass disposal, F.A. salt, fly prevention, general barn supplies, LCP, etc.
PURCHASED ANIMALS	Animals purchased to supplement breeding
WATER AND ELECTRICITY	Water used by the farm (no irrigation), electricity for the operation of barn apparatus (milk fridge, milking, fans, lights, pumps for handling manure, etc.).
MEDICINALS	Antibiotics, vaccines, medicines in general
AGRICULTURE	Fertilizers, weed killers, seeds, silage coverings, packing nets, irrigation water cuts
CONTOTERZISM	Work carried out on the farm by third parties (sowing, weeding, chopping, transporting and spreading manure, etc.).
STABLE VEHICLE MAINTENANCE	Maintenance (routine) carried out on milking system, unifeed wagon, milk fridge, ventilation, effluent handling, bunks, minor flooring work
AGRICULTURAL EQUIPMENT MAINTENANCE	Maintenance (routine) performed on agricultural vehicles and equipment (excluding unifeed wagon), irrigation systems
GASOL	Agricultural and regular diesel fuel, gasoline, tractor lubricants
SERVICES AND ACCOUNTING	Farm bookkeeping, agronomist, veterinarian, farrier, waste collection, analytical laboratory, occupational medicine, design, etc.
INSURANCE	Insurance of farm vehicles, buildings, liability, crops
FAMILY LABOR	Referable to family members: salaries, wages, social security contributions
EMPLOYED LABOR	Referable to employees: salaries, wages, social security contributions, severance pay

TAXES	Fees exclusively referable to the company
FINANCIAL CHARGES	Interest expense, bank interest on loans, cost of current account
EXTRAORDINARY MANAGEMENT	Capital gains
BARN MACHINERY AND EQUIPMENT DEPRECIATION	Value-as-new divided (10 years) into annual installment of milking system, unifeed wagon, milk fridge, ventilation, effluent handling, kennels and gates, racks, electrical and plumbing, straw shooter, etc.
AGRICULTURAL MACHINERY/EQUIPMENT DEPRECIATION	Agricultural tractors used in cultivation, means for tillage and product harvesting, irrigation system, land leveler. Etc.
PLANT DEPRECIATION	Photovoltaic system, attached to farm buildings
BUILDING DEPRECIATION	Stables, roofs and canopies, sheds, tanks and slabs for wastewater storage, yards, storage trenches, and structures in general (not to be included in the same depreciation)
EXTRAORDINARY MACHINERY MAINTENANCE	Example: tractor engine rebuild (can be included in depreciation)
EXTRAORDINARY MAINTENANCE BUILDINGS	Example: re-roofing (can be included in depreciation)
LAND RENTAL	All forms of lease or use of agricultural land
BUILDING RENTAL	All forms of rental or use of rural buildings
MACHINERY RENTAL/LEASING	Operating or financial leases and rentals of machinery and equipment and vehicles
VALUE PRODUCTS REUSED	Estimated value of products reused on the farm (silage, feed, etc.).
PARKING (values not counted in the total)	Inventory differences or items to be regularized

The two tables just given are extremely essential for proper loading and placement of all inputs. These inputs are managed and loaded through the input of the invoices (active and passive) of the company, which refer to the period under consideration.

B.1.4.1.2. Loading invoices

Continuing with the description of the dashboard, we enter the main part that powers the software, which is the **Income/Expenditure** function, characterized by the entry and management of invoices. Invoice entry can be done either manually, under the "invoices" section, by entering the supplier, invoice number, date and its description, if any.

Figure 18. Entering purchased invoices.

The second method of entering invoices appears to be faster, as it involves loading invoices in electronic format. Under "electronic invoices" it is possible to automatically upload invoices. The program allows loading invoices in a few seconds, even in the case of an entire year (large number of invoices).

This is possible through the use of the tax drawer. This service allows consultation of tax information such as:

- biographical data,
- data from tax returns,

- reimbursement data,
- Data of payments made via F24 and F23 forms

In the Invoices and Fees section you can view and download the company's sales and purchase invoices. These invoices are originally processed in XML (extensible markup metalanguage) format.

Figure 19. Tax drawer operation.

Invoices in XML format→ their content is described through "tags" marked in brackets <>.As an alternative to acquiring electronic invoices

through the tax drawer, it is possible to request them from authorized agricultural assistance centers (CAAs), which send the requested invoices in XML format via e-mail. After the electronic invoices are uploaded, they must be allocated to the respective revenue or cost centers.

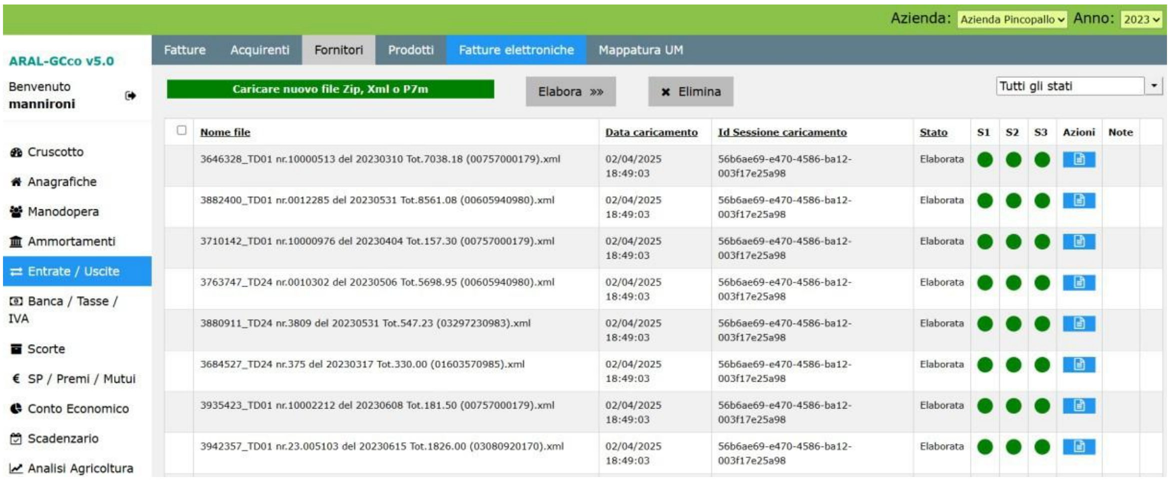
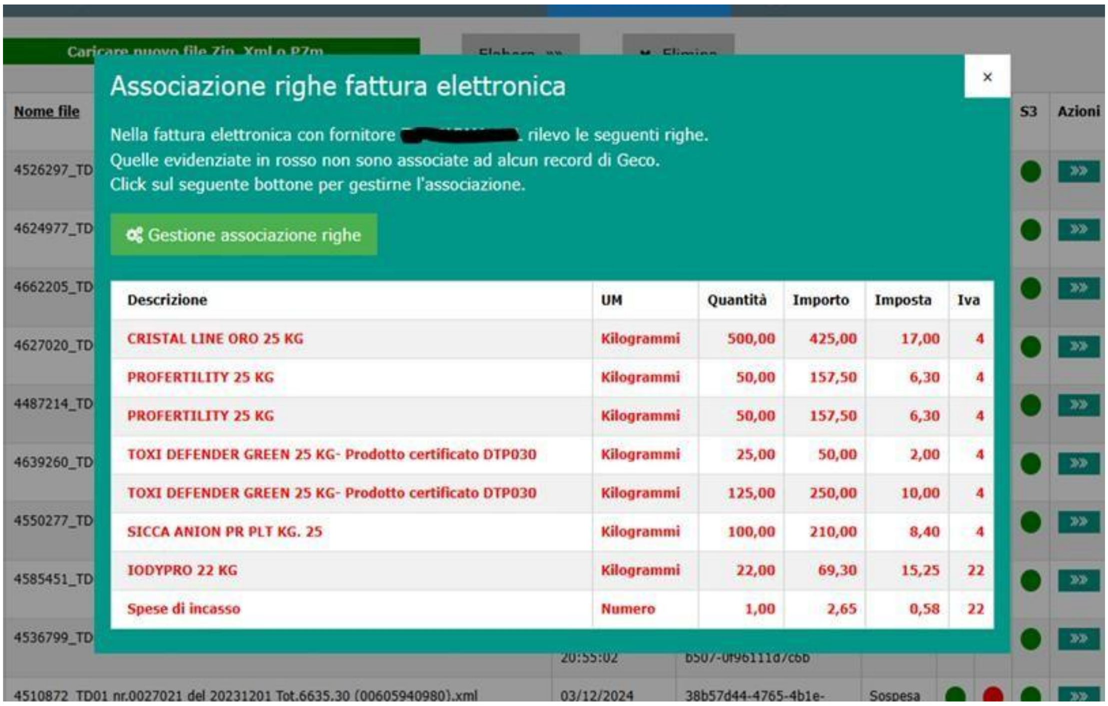


Figure 20. Invoice status screen.

Each row represents an invoice, described by name, upload date, session, and status. Initially, the "S2" column has all red dots. This is because the loaded invoices have not yet been allocated to their respective cost centers, so the invoice will be "suspended." For it to be processed, the red dot must be pressed, which will open the interface of placement of the invoice.



Descrizione	UM	Quantità	Importo	Imposta	Iva
CRISTAL LINE ORO 25 KG	Kilogrammi	500,00	425,00	17,00	4
PROFERTILITY 25 KG	Kilogrammi	50,00	157,50	6,30	4
PROFERTILITY 25 KG	Kilogrammi	50,00	157,50	6,30	4
TOXI DEFENDER GREEN 25 KG- Prodotto certificato DTP030	Kilogrammi	25,00	50,00	2,00	4
TOXI DEFENDER GREEN 25 KG- Prodotto certificato DTP030	Kilogrammi	125,00	250,00	10,00	4
SICCA ANION PR PLT KG. 25	Kilogrammi	100,00	210,00	8,40	4
IODYPRO 22 KG	Kilogrammi	22,00	69,30	15,25	22
Spese di incasso	Numero	1,00	2,65	0,58	22

Figure 21. Invoice accounting screen.

Through **Line Association Manager,** you can associate each individual product into their respective revenue or cost centers by selecting them from the list. Very often, there are several products within a single invoice that are different from each other in terms of revenue or cost centers. Therefore, the allocation of products in an invoice can be done either individually or, in the case of an invoice containing all products in the same "matrix," unique for all products.
There are 3 solutions that allow products to be associated with various revenue or cost centers:

- Solution 1→ Association of a product with an existing one.
- Solution 2→ Creating new products for selected products only.
- Solution 3→ Association to a general product for selected products only.

Continuing through the control panel of the software, you arrive at the **Bank/Tax/VAT** management. In this section you can manage the various bank charges, including fees, interest and principal. In addition, you can manage VAT, broken down into collected and paid. Next is the section that deals with stock management, divided into food/products, fuels/lubricants, and animals. When entering a new stock, the initial value and quantities defined at the beginning and end of the period under consideration are requested. **Balance sheet/ premiums/ loans:**

- Mortgages: in this section it is possible to manage the inherent part of mortgages by entering the installment amount, the date of the first and last installment, and the frequency of installment payment.

- Premiums: the premium amount and type are also required for premium management.
- Balance sheet: define the set-aside, divided into capital share, employee severance pay, and fixed social shares from third parties.

B.1.4.1.3. Processing and output

Income Statement: Based on all the inputs mentioned above, a "reclassified" income statement is prepared. Through the determination of gross saleable production (GVA), taking into account all variable costs of production and value added (VA), obtained through the deduction from the GVA of costs concerning services and the costs of raw materials and consumables, the gross operating margin (GOP) is obtained, to which costs related to depreciation, capital allowances still accrued and rents are then counted, to arrive at operating income (RO). Costs related to finance charges, taxes, and extraordinary expenditures are subtracted from RO to arrive at net income (RN). Finally, costs inherent in family and employee labor, taking into account interest, are subtracted from RO to arrive at final net income (UN). In addition to viewing the income statement, the company's balance sheet, divided into assets and liabilities, can be viewed in this section. In addition to the reclassified income statement, it is possible to determine an income statement that relates to the production unit. In this section, it is possible to make a comparison between the income statement by production unit and the budget previously determined in the "budget forecast" section. Finally, it is possible to analyze the income statement taking VAT into account. **Schedule** On this page you can consult the schedule by selecting the month of interest. Or you can select the item Pending, to view invoices with payment due. **Agriculture Analysis** On this page you can perform a simplified analysis of agricultural costs, broken down by crop practiced.

B.1.4.2. Example of tool use on dairy farms

Below (Figure 8) is the reclassified income statement of farm A (cattle) for the period from January 1, 2025 to March 31, 2025. The total value of production is € 133053.74, derived exclusively from milk sales, with no income from other sales, stock changes, or other income. Variable costs amount to € 62,418.11, with most of the expenses related to raw materials (€ 59,412.49), including purchased feed (€ 39,923.48) and barn expenses (€ 15,915.15). Services accounted for€ 3,005.62, mainly for accounting and machinery maintenance. The value added, calculated by subtracting variable costs from the value of production, is € 70,635.63. After subtracting the cost of salaried labor (€ 9,900.00), gross operating margin (GOP) is€ 60,735.63. Depreciation expense amounts to € 7,083.34, mainly for machinery and equipment (€ 6,666.67). There are no operating provisions, rentals or leases, bringing operating income to
€ 53.652,30. Taxes have a positive impact of € 8,875.86, thanks to the special or flat-rate tax regime (VAT in the budget). There are no CAP contributions, financial charges or extraordinary management. The final net income of the company is € 62,528.

RECLADMIFIED PROFIT AND LODM ACCOUNT		
A - VALUE OF PRODUCTION		€/quarter
1 - Revenues from sales	**total**	**€ 133.053,74**
	Milk	€ 133.053,74
PLV: GRODM SALEABLE OUTPUT (1+2+3)		€ 133.053,74
B - VARIABLE COSTS OF PRODUCTION		
4 - Raw materials, consumables and goods	**total**	**€ 59.412,49**
	Food purchased	€ 39.923,48
	Barn	€ 15.915,15
	Medicines	€ 1.893,86
	Agriculture	€ 1.680,00
5 - Services	**total**	**€ 3.005,62**
	Services and accounting	€ 1.479,62
	Machinery and equipment maintenance	€ 1.526,00
VA: VALUE ADDED (PLV - 4 - 5)		€ 70.635,63
6 - Wage labor cost	**total**	**€ 9.900,00**
	Employee labor	€ 9.900,00
MOL: GRODM OPERATING MARGIN (VA - 6)		€ 60.735,63
7 - Quotas	**total**	**€ 7.083,34**
	barn equipment	€ 5.000,00
	farm equipment	€ 1.666,67
	Building depreciation allowances	€ 416,67
RO: OPERATING INCOME (MOL - 7 - 8 - 9)		€ 53.652,30
12 - Taxes	**total**	**-€ 8.875,86**
	flat-rate (VAT on the balance sheet)	-€ 8.875,86
RN: NET INCOME (RO+ 10 - 11 - 12 - 13)		€ 62.528,16

Figure 22. Income statement first quarter 2025 company A.

Action B 2.1 - Implementation of HACCP-like integrated management plan.

Action B2.1 led to the creation of an operational manual that introduces and applies an innovative farm management system inspired by the HACCP model, called G- HACCP (Gestional-HACCP). This tool was developed to support livestock farms - dairy cattle, goats and sheep - in identifying and controlling critical points in their production processes, structured as a practical and replicable tool. The underlying rationale is not only to reduce risks (as is the case with traditional HACCP), but to optimize overall farm management, improving production performance, product quality and the sustainability of the entire system.

The manual starts from the need to map business processes through Business Process Mapping tools, and then identify Critical Control Points (CCPs) and Points of Particular Attention (POPAs). These are combined with objective performance measurement indicators, the so-called Key Performance Indicators (KPIs), which enable regular monitoring of the efficiency and effectiveness of internal processes. This methodological framework enables companies to visualize their processes, identify their bottlenecks, risks and areas for improvement, and activate targeted corrective or preventive actions. Moreover, the G-HACCP approach is highly customizable, and can be adapted to the size, species raised (cattle, sheep, goats) and production characteristics of each farm.

B.2.1.1. The application areas analyzed

The G-HACCP manual has been applied to some key macro areas of business management, with an analysis of each stage, supported by flowcharts, monitoring sheets, KPI examples and summary tables. The main areas covered are:

B.2.1.1.1. Food procurement and ration preparation

Feed management is a key element on livestock farms, as it directly affects animal health, productivity, and product quality. A poorly prepared or unevenly distributed ration can compromise nutrient intake, causing imbalances and declines in performance. It is therefore essential that ration preparation is done accurately, following technical criteria and continuous monitoring.

In this context, several Points of Particular Attention (POPAs) are identified, i.e., steps that do not pose an immediate risk but which, if neglected, reduce process efficiency. Unlike Critical Control Points (CCPs), POPAs require management attention rather than urgent corrective action. The only exception is silage: if contaminated with mycotoxins or pathogens, they can constitute a true CCP.

Process analysis begins with the preparation of the mixing wagon. The quality and dosage of the ingredients (hay, silage, premixes, etc.), the level of filling of the wagon (optimal around 70%), the mixing time (approximately 6+6 minutes) and the distribution of the unifeed along the lane are monitored. The quality of the ration depends on the homogeneity of the mixture, uniform distribution, and proper load management. Errors in these steps can result in differences between formulated and distributed rations, affecting ruminal health and uniformity of ingestion among animals. To ensure the effectiveness of the process, visual monitoring tools, sensory and chemical analyses are used and KPIs (key performance indicators) are defined for each stage. Among the most relevant are:

- Food quality control by analysis and visual inspection;
- Verification of homogeneity of premix and distribution in the lane (maximum desirable deviation <5%);
- Measurement of preparation time and wagon load level;
- analysis of the distributed ration compared to the theoretical ration, both in nutritional values and consistency across the lane.

These actions keep ration quality high, ensuring nutritional uniformity and reducing the risk of digestive imbalances, feed selection and production declines.

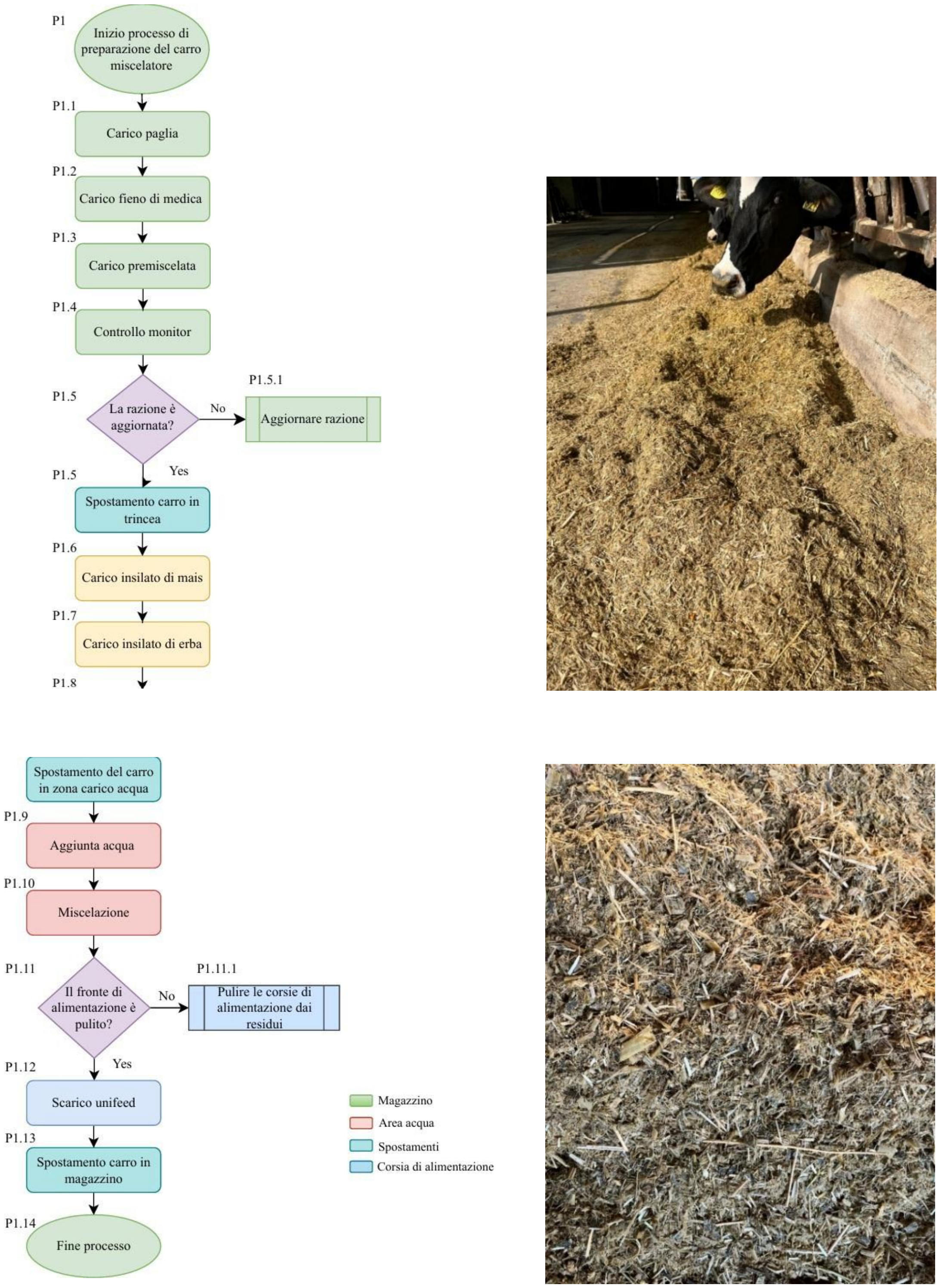


Figure 23. Flow chart of the preparation process of a mixer wagon and related unifeed ration distributed in the feed lane.

Table 24. Identification of POPAs and their monitoring methods and KPIs at different stages of the process.

Phase		**POPA**[1]	**Monitoring**	**KPI**[2]
P1.1-P1.2- P1.3	Food	Food quality	Chemical analysis Sensory analysis	Verification of parameters by food
P1.3	Premixed	Homogeneity of the mixture	Chemical analysis Physical analysis	D< 5% among p.p.[3]
P1.6-P1.7	Silage	Silage quality Silage sanitation	Chemical analysis Microbiological analysis	Verification of parameters by food
	End of food loading	Wagon fill level	Visual verification	70%
P1.10	Mixing	Mixing time	Timekeeping	5/6 min
P1.12	Unifeed unloading	Even distribution Ration quality Deviation from formulated ration	Physical analysis Chemical analysis Calculation	D <5% between p.p.[3]Verification of parameters Deviation <5%

[1]POPA= Points of Particular Attention.
[2]KPIs= Key performance indicators.
3 D< 5% between p.p.= Less than 5% mismatch between sampling points

B.2.1.1.2. **Milking management for mastitis control and milk quality**

Dairy farming is one of the most complex and sensitive activities in animal production. Ensuring milk quality, especially in terms of health and technology, is a daily challenge for dairy farmers. One of the main indicators is the somatic cell count (SCC), which reflects the health status of the udder: high values are often a sign of mastitis, one of the most widespread and costly diseases, with a direct impact on the quantity and quality of milk produced.

A systematic approach inspired by HACCP and applied to milking management is adopted to effectively address this problem. The entire process is broken down into operational steps, each of which is analyzed to identify Critical Control Points (CCPs), associated risks and preventive actions. In particular, a distinction is made between activities directly involving animals and those involving the milking plant.

During milking, the greatest risk is the entry of bacteria through the teat sphincter, which remains open for some time before and after the passage of milk. For this reason, five main CCPs are defined, each of which requires specific operational attention:

- CCP1: Preparation of the udder

Washing, drying, foremilking, and pre-dipping make it possible to reduce microbial load and stimulate milk descent. The use of disposable towels and appropriate disinfectants prevents infection and limits milk contamination.

- CCP2: Milking cluster attachment

Proper attachment protects the teats from trauma and prevents air or bacteria from entering. It is critical to ensure the hygiene of the facility, replace sleeves regularly, and segregate infected animals to avoid cross-contamination.

- CCP3: Post-milking disinfection.

This step protects the udder while the sphincter is still open. The disinfectant should be applied evenly, covering the nipple tip well to ensure effectiveness.

- CCP4: Facility operations poorly adjusted milker can cause teat damage or alter the vacuum, promoting infection.

  Regular maintenance and checks on technical parameters are essential.

- CCP5: Milk Quality

Milk is the final product and is a true indicator of the status of the entire herd. In addition to SCC and total microbial load (CMT), fat/protein ratio, urea and pH are monitored. These parameters also provide valuable information on the nutritional status of the animals and the quality of the ration.

For example, a fat-to-protein ratio that is too low may indicate ruminal acidosis, while a ratio that is too high is typical of animals with a negative energy balance. Urea levels in milk also allow detection of protein imbalances in the ration, which can adversely affect fertility, health and dairy yield.

Finally, milk pH is a useful indicator of both microbiological quality and the presence of mastitis. Abnormal values may signal alterations in milk storage or damage to the mammary gland.

Thanks to this approach, milking is no longer just a technical operation, but becomes a true integrated control process that contributes to animal welfare, product quality and farm sustainability.

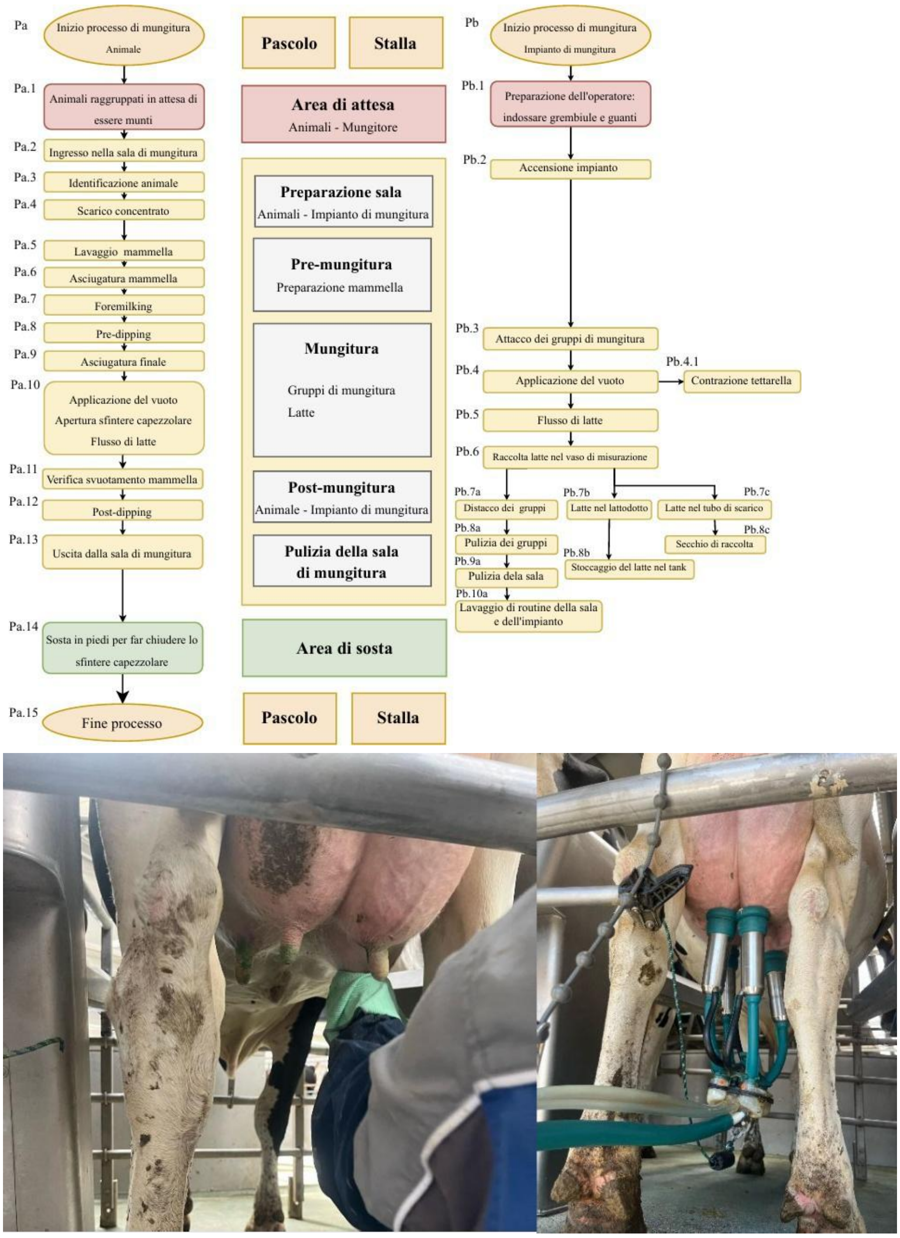


Figure 24. Above: flow chart of the milking process, left animal factor and right milking plant factor. Below: milking process stages, left udder cleaning and right milking stage.

Table 25. Recommended control practices and measures for each CCP.

	CCP[1]	Phase process	Control practices and measures
CCP1	Breast preparation	Pa.5 Pa.6 Pa.7 Pa.8 Pa.9	Udder washing Udder drying Foremilking Pre-dipping Final drying with disposable wipe
CCP2	Milking cluster attachment	Pb.3 Pb.4 Pb.4.1 Pb.5 Pb.6 Pa.10 Pb.7.a Pb.8a Pb.9a Pb.10a	Adequate plant hygiene Rubber quality control Segregation and disinfection of milking units Correct method of group attack Balancing correct of milking units Proper method of removing the milking unit
CCP3	Post-milking teat disinfection	Pa.12	Post-dipping Quality of products used
CCP4	Operation of the milking plant		Maintenance
CCP5	Milk quality	Pb.5 Pb.6 Pb.7b-c Pb.8b-c	Verify proper separation of waste milk

[1]CCP= Critical Control Points.

Table 26. CCPs, related risks, monitoring methods and KPIs for mastitis and milk quality control.

CCP[1]	Risk[2]	Monitoring	KPI[3]
CCP1	a b c d	Visual inspection Milk quality monitoring sheet	Recent infection rate Total bacterial count
CCP2	b d	Visual inspection Monitoring sheet for milking machine washing protocol. Segregation monitoring sheet Monitoring sheet for sleeve replacement frequency Milk recording Sheath quality Management of infected animals	Recent infection rate Chronic infection rate Clinical mastitis rate Percentage of respected washing protocol compared to total (control T water, t washing and concentrations of detergents and disinfectants) Percentage of correctly segregated animals Vacuum pressure Number of milkings/sheaves Number of sleeves replaced
CCP3	b c d	Visual inspection	Recent infection rate
CCP4	a b c d	Assessment of the nipple ends Manual vacuum test Evaluation of conduit slippage Inspection of plant equipment Sheath change date	Number of nipples with signs of injury or infection Compliant vacuum values according to milked species Percentage of liners that do not slide properly during milking Changing liners every 2500 milkings
CCP5	d	Verification of proper separation of waste milk Milk analysis (especially observe fat/protein ratio - urea in milk - pH - SCC - CMT) Mycotoxin analysis	Verify parameters by species Check the limits of aflatoxin M1

[1]CCP = Critical Control Points. CCP1= Udder preparation; CCP2 = Milking cluster attachment; CCP3 = Post milking teat disinfection ; CCP4 = Milking equipment operation
[2]a = presence of mastitis pathogens on the teat orifice; b = opening of the teat sphincter; c = physical introduction of pathogens into the udder; d = bacterial contamination of milk
[3]KPIs= Key performance indicators.

B.2.1.1.3. Management of health problems

1) Management of mastitis

Mastitis is one of the most prevalent and costly diseases on dairy farms, with an average annual incidence of 28% and losses of up to €185/head. It is a complex, multifactorial disease that requires an integrated approach, from prevention to diagnosis and treatment. Somatic cell count (SCC) is the main indicator to monitor its presence.
Early identification is made by observing abnormalities in the milk (lumps, blood, consistency) or udder (swelling, heat, pain). Diagnosis is completed with CMT tests, microbiological cultures, and analysis of the animal's production history. Based on severity, the veterinarian determines whether to intervene with systemic or intramammary antibiotics, always following selective protocols.
To control mastitis, CCPs and POPAs are identified in the following areas:

- Milking: proper udder preparation, post-milking disinfection, equipment operation, and milking parlor hygiene are central to prevention.
- Bulk milk: SCC and bacterial load allow assessment of herd health; animals with high SCC should be segregated or reformed if chronically infected.
- Nutrition: balanced diets strengthen immune defenses. Deficiencies or contamination by mycotoxins increase the risk of mastitis, especially in the peri- partum period.
- Hygiene and environmental management: cleanliness of stalls, quality of bedding, and separation of sick animals are essential to contain infections.

- Dry phase: it is crucial to regenerate the breast and prevent new infections. Sealants and antibiotics (selectively or completely) are applied according to the clinical profile of the animal.

An effective plan requires staff training, regular monitoring and timely recording of cases so that timely action can be taken to reduce infectious pressure in the herd.

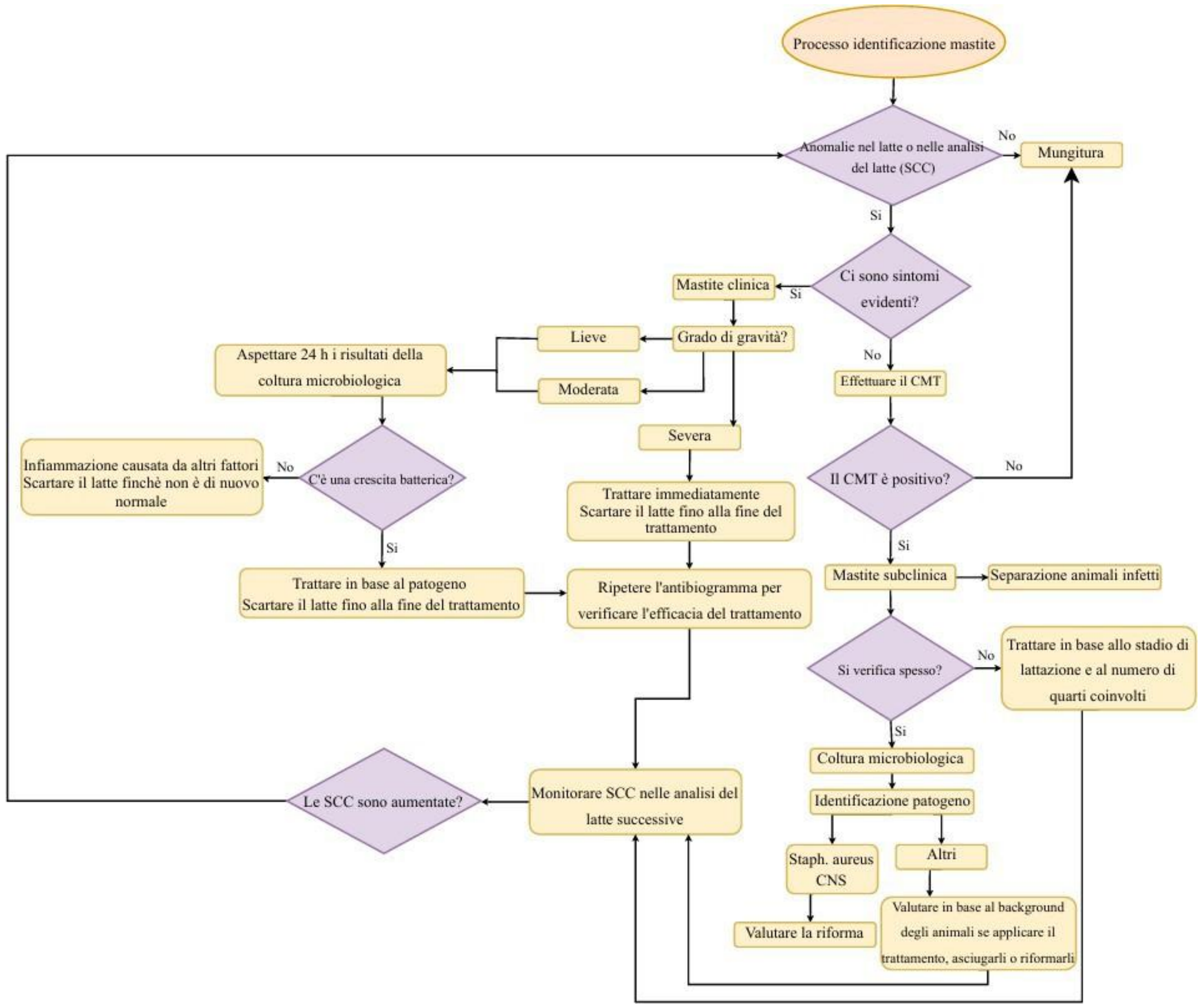


Figure 25. Flowchart of the mastitis identification and treatment process.

Table 27. Factors and management practices affecting Somatic Cell content in milk.

Factors causing the increase of Somatic Cells in milk	**Factors contributing to the reduction of Somatic Cells in milk**
Infections of the mammary gh.	Animal health and mammary gh.
Injuries of gh. Mammary	Proper milking practices
Poor environmental hygiene	Adequate hygienic conditions (milking, operators, barn, etc.).
Advanced stage of lactation	Regular breast screening
Increase in the number of lactations	Appropriate treatment of infected animals
Changes in housing or feeding	Administration of antioxidants
Non-separation of sick animals	Reform of animals with chronic mastitis
Cado-humid climate	Post- dipping
Stress Factors	Knowledge and awareness regarding mastitis and dry handling of animals
	Selection of animals

Table 28. CCP-POPA, related control practices, monitoring methods and corrective actions for mastitis control.

CCP[1]- POPA[2]		Control practices and measures	Monitoring and verification	Corrective actions
Milking process and udder hygiene	CCP[1]	As per Tables 2-3*	As per Tables 2-3* Specifically: Udder visual inspection Milk visual inspection. CMT SCC	Adopt appropriate milking methods Hygiene Separation of infected animals Implement prevention protocols
Milking plant operation	CCP	As per Tables 2-3*	As per Tables 2-3* Specifically: Technical Verification Nipple Scoring Report maintenance	Technical intervention on machine
Management of dry animals	CCP	Nipple hygiene Treatment protocol (antibiotic/ selective)	Protocol execution control New infection rate	Review of the nipple hygiene/preparation procedure and protocol adopted
Environmental Hygiene	POPA	Regular cleaning, disinfection and replacement of litter box	Inspection of the cleanliness condition of the barn	Increase the frequency of cleaning Replace bedding with safer materials
Management of animals during the birthing period	CCP	Birthing box hygiene Density Management stay.	Birthing area inspection Incidence of mastitis and new infections in the first 60 days post childbirth	Hygiene improvement Box logistics improvement Management of density/overcrowding

Other:
Power supply
Herd health management Fly control
Do not feed waste milk to young animals Monitoring and eradication of bovine viral diarrhea virus

[1]CCP= Critical Control Points.
[2]POPA= Points of Particular Attention.
*Please refer to Tables 2 and 3, section 2.2 for detailed description. Milking management for mastitis control and milk quality

2) Management of lameness

Lameness is a condition that severely compromises animal welfare and farm profitability. The most common causes are hoof horn lesions (such as sole or white line) and digital dermatitis. It is a multifactorial disease, linked to more than 80 potential environmental, management and individual risk factors.

The identified CCPs and POPAs concern:

- Environmental factors: standing on concrete floor, inadequate bunks, humidity and presence of sewage increase vulnerability

Of the nails.

- Management and biosecurity: absence of footbaths, lack of regular draw and systematic monitoring (e.g. locomotion score) undermine prevention.
- Nutritional and metabolic factors: subacute ruminal acidosis, related to rations too rich in starch, predisposes to laminitis. Mineral or vitamin deficiencies (e.g., selenium, vitamin E) also worsen foot health.
- Genetic factors: predisposing morphologies may favor the development of lameness and should be considered in selection programs.

Prevention requires an integrated approach: environment optimization, balanced feeding, regular foot care, frequent monitoring, and staff training. Only multidisciplinary management involving breeders, veterinarians and farriers can reduce the incidence of lameness and improve welfare and productivity.

Table 29. Risk factors for lameness.

Risk Category.	CCP/POPA[1]	Risk factors
Environmental	Extended parking on concrete	Overcrowding Prolonged standing in waiting areas Hard resting surface Abrasive resting surface Inadequate conformation of bunks (difficulty getting up or lying down) Cows lying in passageways Absence or insufficiency of training in the use of bunks
	Predisposing factors to nail trauma	High steps or edges (>160 mm) Areas with high slope (>20%) Sharp or eroded concrete Uneven or damaged concrete Slippery concrete Presence of crushed stone Entrances with coarse crushed stone Heifers not separated from adult cows (risk of aggression) Overcrowding of feeding/watering areas (aggression risk) Dead ends (risk of aggression) Long paths (>1.6 km) on hard surface Concrete gratings Nails too long Gates or structures that cause impacts
	Presence of sewage or persistent moisture on the floor	Presence of standing water and sewage on the pavement Inadequate slurry collection (mode and/or frequency) Slurry accumulation on damaged concrete Uneven conformation of structures and paddocks (difficult slurry removal) infrequent manual collection in inaccessible areas

		to the tractor Overcrowding (berth and aisle widths <2.4m) Flooded grounds, passageways, entrances, and water points Wet litter (bunks or pens with straw)
	Permanence prolonged on sewage	Integrated risk factor resulting from the combination of prolonged standing on concrete and the presence of sewage or persistent moisture on the floor
Managerial	Insufficient biosecurity measures	Lack of biosecurity among different age groups Inadequate prevention and treatment of lameness Introduction of animals from other farms without quarantine Free access to visitors without preventive measures Unsafe fences for livestock
	Non-ideal nail conformation (early lactation)	Absence of routine farriery before or after delivery Absence of individual supervision Absence of corrective treatment with foot baths in case of heel erosion or soft horn
	Inadequate podiatric care (before delivery)	Heifers calving with active lesions of digital dermatitis Heifers with severe heel erosion Heifers with poorly pronounced or too steep foot angles
Managerial	Inadequate detection and/or treatment of lameness	Abnormal locomotion not detected within 24 hours for acute lameness or 7 days for subacute lameness Abnormal locomotion not treated within 48 hours of detection Insufficient lameness treatments relative to the prevalence of the problem Unconventional treatment methods Lack of adequate farrier facilities Workers not trained on nail cutting Lack of monitoring of treatment responses (locomotion score, animal separation)
	Inadequate detection and/or treatment of digital dermatitis	Infrequent footbaths with an effective disinfectant No strategic use of antibiotic footbaths Improper use of foot bath (e.g., wrong concentration of disinfectant) No monitoring of infectious skin lesions Infectious skin lesions not detected and treated promptly (<7 days) Injuries not cleaned and dried before antibiotic application et too dirty before foot bath

		Footbath disinfectant is changed too rarely The footbath is not 75-130 mm deep on both ends The foot bath is less than 2.4 m long
Animal	Ruminal disorders	Inadequate diet during the transition period Inadequate silage analysis Feeding practices that could limit access to forage Overcrowding at the feeder Excessive administration of concentrates in milking Suboptimal ration composition (fiber deficiency and/or excess starch and/or protein) Rations predisposing ruminal instability Rations or rumen conditions predisposing biotin deficiency
	Inadequate phenotype/morphology of heifers	Absence of selection/reformation for morphology Heifers with suboptimal conformation Heifers calving before 2 years of age or after 2.5 years of age Diet of heifers with dry matter content< 45% Suboptimal incidence of problems such as mastitis, metritis, placental retention

[1]CCP= Critical Control Points; POPA= Points of Particular Concern.

Table 30. CCP-POPA, related control practices, monitoring methods, KPIs and corrective actions for lameness control.

CCP/POPA[1]	Practices control and monitoring	KPI[2]	Corrective actions
Hygienic condition of the floor (presence of sewage or persistent moisture on the floor)	Verification of programming of automatic cleaning systems Verification scheduling of manual interventions Visual inspection of the stable	Slurry removal frequency Percentage dry area Drainage system efficiency	Frequent cleaning of surfaces Adequate drainage Remediation of critical areas
Prolonged parking on concrete	Visual inspection of animals Visual inspection of bunks Stay in the room of waiting	Percentage of cows lying in bunks Bunks/cows ratio Breeding density	Review milking time management Improved bedding/resting area
Predisposing factors to nail trauma	Maintenance steps Visual inspection of surfaces Locomotion score	Percentage of uneven or damaged pavement Slope of lanes Percentage of cows with gait irregular	Structural intervention u Risk reporting to technician/operator
Prolonged stay on the slurry	Visual inspection Verification of programming of automatic cleaning systems Verification scheduling of manual interventions	Percentage of cows with dirty limbs Frequency of berth cleaning	Frequent cleaning of surfaces
Inadequate detection and/or treatment of lameness	Health and farrier records Locomotion score Operator training Monitoring sheet Of treatment responses	Average interval between lameness detection and treatment Percentage of cows with locomotion score > 3 Rate of lameness recurrence	Implementation of treatment protocols Training of operators Provision of suitable area for farriery

Detection and/or treatment of digital dermatitis	Inspection of animals Verification of protocol for use of footbath Monitoring of identified lesions	Incidence of digital dermatitis in the herd Frequency of footbath use Frequency of changing footbath solution Efficacy of treatment	Use of appropriate disinfectants Proper use of the foot bath Injury monitoring
Insufficient biosecurity measures	Quarantine for incoming animals Verification of the presence and use of biosafety devices Staff training	Percentage of new animals quarantined Number of visitors using disposable socks Frequency of staff training on biosafety protocols	Implementation of a protocol for incoming animals Implementation of a protocol for visitor behavior Staff training
Non-ideal nail conformation (early lactation)	Visual inspection of animals Farrier interventions	Percentage of animals subjected to preventive balancing Percentage of cows with excessively long hooves Frequency of	Implementation of a protocol for farrier interventions Corrective treatments with foot baths in cases of heel erosion or soft horn
Ruminal disorders	Stool analysis BCS milk analysis Unifeed analysis Breeding density	BCS fecal score Percentage of cows with abnormal diarrhea or feces Fat/protein ratio in milk Milk production	Review the ration Adjust the number of animals according to the availability of space
Condition and phenotype of heifers	Farm reproductive data Morphological assessment Growth monitoring	Average age at first delivery Incidence of postpartum pathology Reform rate for podiatric problems	

[1]CCP= Critical Control Points; POPA= Points of Particular Concern.

[2]KPI= Key performance indicator

B.2.1.1.4. Management of reproductive aspects

Reproductive efficiency is a key factor in the profitability of dairy farms. To improve it, critical stages of the reproductive cycle, from heat identification to pregnancy diagnosis to dry period and transition management, must be carefully monitored.
A flowchart summarizes the main decision-making stages of the reproductive pathway, highlighting the moments when management intervention can make a difference. The main POPAs concern:

- Detection of oestrus: essential to inseminate at the right time.

It is based on behavioral signs (immobility at stud, restlessness, vulvar swelling) and can be supported by tools such as podiums or collars. Frequent observation (4-5 times a day) improves effectiveness.

- Artificial insemination: should be carried out about 12 hours after the start of the signs of oestrus or according to the indications of automated devices. It is important to handle the semen correctly and record any useful data.

- Diagnosis of pregnancy: ideally between 28 and 35 days post-insemination by ultrasound, with a second confirmation between 60 and 90 days to detect any embryonic loss.

- Dryness and transition: crucial stages in preparation for lactation and subsequent fertility. BCS (Body Condition Score) monitoring, dietary adaptation and prevention of metabolic disorders are crucial.

- Uterine involution: the complete recovery of the uterus after delivery is necessary for new conception. It is important to monitor uterine discharge, placental retention, and schedule postpartum gynecological visits.

To evaluate the effectiveness of reproductive management, parameters such as:

- Pregnancy rate (PR): percentage of pregnant cows among those that can be fertilized every 21 days. A good value is ≥35%.
- Heat detection rate (HDR): percentage of animals in oestrus actually inseminated (target: 80%).
- Conception rate (CR): percentage of inseminated cows that remain pregnant (average: 40% cows, 70% heifers).

Other operational indicators include: voluntary waiting period (VWP), fixed time insemination (FSTAI), first heat detection (FSED), and fertilization exclusion policy (DNB).

An effective system integrates observation, technology, accurate records, and veterinary support, with the goal of reducing the calving-conception interval, optimizing production, and improving the economic sustainability of the herd.

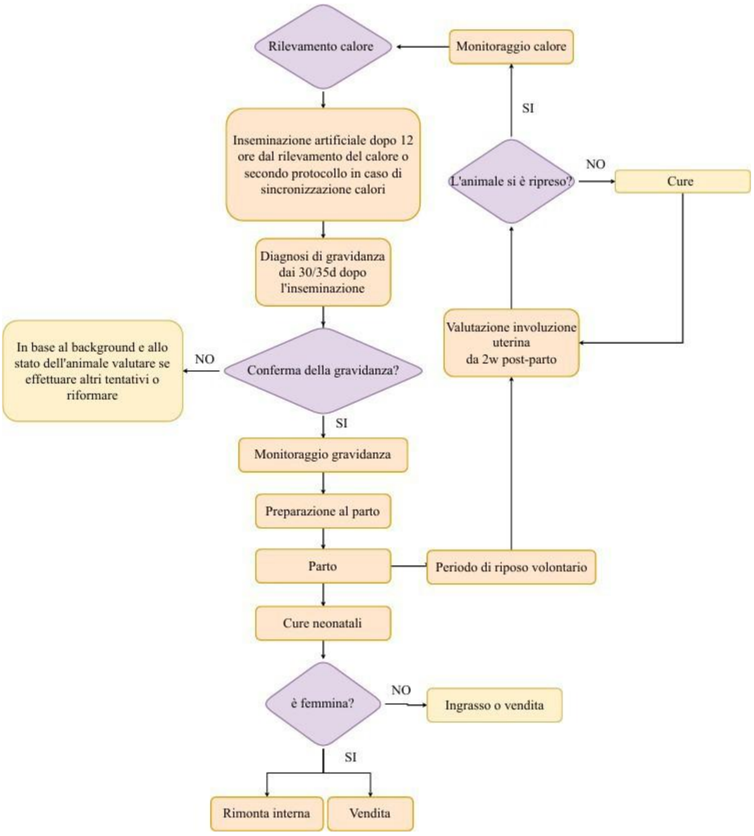


Figure 26. Flow chart on reproductive management of a dairy cow.

Table 31. The effect of different heat detection and conception rates on the percentage of the herd that is non-pregnant after a 90-day breeding season (Diskin and Sreenan, 2000).

		Conception rate %			
		60	50	40	30
Heat detection rate %	90	4	9	17	29
	70	11	18	27	39
	50	24	32	41	52
	40	33	41	50	60

Table 32. POPA and related KPIs for monitoring and managing dairy cattle reproduction.

POPA[1]	**Monitoring**	**KPI**[2]
Detection of oestrus	Number of daily observations Correct reporting of primary and secondary signs Use of automatic detection systems (collars, podiatrists)	4 observations/d between 06:00 and 10:00 p.m. HDR[3]≥ 80% Detection error rate< 10%
Artificial insemination	Time between heat detection and insemination (AM-PM rule) Proper handling of semen Insemination registration	% cows inseminated after 12- 18h after oestrus detection CR[(4)] ≥40% cows, ≥ 70% heifers
Early diagnosis of pregnancy	Ultrasound diagnosis between 28-35 days post insemination Reconfirmation at 60-90 days	% cows diagnosed pregnant ≥ 40% at first follow-up Late embryo loss rate < 10%
Dry	BCS[5] DCAD monitoring[6]Nutritional monitoring.	BCS[(5)] 3.25-3.5 Clinical mastitis incidence during dryland < 5% See reference values for dry cattle
Transition period	BCS[5]pre and postpartum Ingestion Incidence of metabolic diseases	Loss of BCS[5]≤ 0.5 points Incidence of ketosis/hypocalcemia < 10%
Uterine involution	Control of uterine discharge Gynecological examination at 21-30 days postpartum	% normal uterine involution ≥ 90% Clinical metritis incidence< 10%

[1]POPA= Points of special attention.
[2]KPI= Key performance indicator
[3]HDR= Heat Detection Rate - Heat detection rate.
[4]CR= Conception Rate - Rate of conception.
[5]BCS= Body Condition Score

B.2.1.1.5. Management of comeback and reform

Rebreeding is essential to ensure the continuity of production and profitability of the herd. Every reformation (due to production, health or reproductive problems) must be balanced by a ready-to-enter heifer so that herd size remains stable. Strategic management of reformation also allows the herd to improve in terms of genetics and performance. On modern farms, reformation rates are around 35-45% per year.

1) Management of the comeback

The rehoming process runs from calf birth to the first calving of the heifer, which ideally occurs at 22-24 months of age at 85% of adult weight. The most critical stages include:

- Neonatal care: assisting delivery, early removal of the calf from the maternal environment, cleaning the umbilicus, and ensuring thermal comfort.

- Colostrum intake: should be given within 1-2 hours after birth, in adequate quantity and quality, to ensure passive transfer of immunity. Colostrum should have an IgG concentration ≥50 g/L.

- Milk stage and weaning: milk or its substitute is supplemented early with starter to stimulate ruminal development. Weaning occurs gradually when starter ingestion reaches 1.5 kg/day.

- Prepubertal stage: target growth of 800-900 g/day with balanced rations, preventing fattening and promoting body and breast development.

- First insemination: takes place between 13 and 15 months, when the heifer has reached 55-60% of adult weight. Success at first insemination should be ≥70%.

- Pregnancy and calving preparation: the goal is to arrive at calving at 85% of adult weight. The ration is gradually adjusted to the lactation regime. A second pregnancy check is recommended at 90-100 days.

Good management of the comeback allows:

- To advance the age at first delivery without compromising health;

- To optimize breeding costs while maintaining efficiency and welfare;

- to reduce early reform through careful selection and good postpartum management.

A well-managed comeback is an investment that strengthens the herd, improves productivity and ensures farm sustainability.

Figure 13. Reassembly management with focus on heifer rearing.

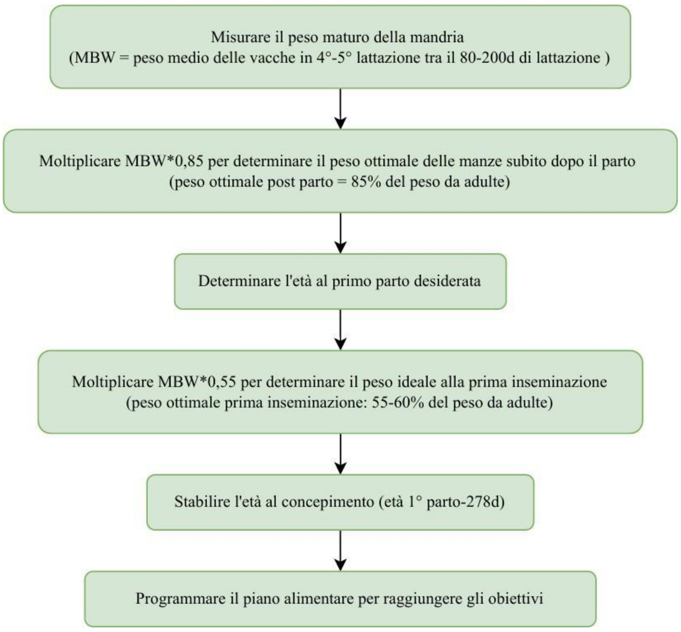


Figure 27. Example of planning for optimal heifer growth.

Table 33. CCP/POPA and related KPIs to monitor the management of the comeback.

	CCP/POPA[1]	Monitoring	KPI[2]
Colostral phase	Time of administration Immunological quality Bacterial contamination	Refractometer Visual inspection	% calves not given colostrum within 1h of birth % quality colostrum - N samples Ig[3]> 50 g/L
Milky phase	Ingestion starter Average calf health growth Ambient temperature	Weighing/Measuring Thermometer	Morbidity rate Mortality rate Ambient temperature between 15-25°C
Weaning	Starter consumption Weight gain Rumination	Weighing/Measuring Observation	% calves weaned within 90 d % calves with ingestion> 1 kg/d of starter
Prepubertal stage	Average BCS accretion[4] Content protein content of the ration	Weighing/Measuring	% heifers with optimal growth (ADG[5]800-900g/d) % heifers with BCS 2.75-3.0 CP in ration 14-16%.
Postpubertal phase	BCS body weight[4] Age first insemination First service success rate	Weighing/Measuring	% heifers with LW[6]at conception equal to 55-60% adult LW[6] % heifers with BCS 3 % heifers with first insemination age 13-15 months % of pregnant heifers> 70%
Pregnancy	BCS[4]at delivery Body weight at delivery Feeding for the transition period Environmental conditions	Weighing/Measuring	% heifers with BCS at calving 3.0-3.5 % heifers with first calving age 22-24 months % heifers with postpartum LW(6) equal to 85% of adult LW[6] Incidence of postpartum dysmetabolias

[1]CCP= Critical Control Points; POPA= Points of Particular Concern.
[2]KPI= Key performance indicator
[3]Ig= Immunoglobulin
[4]BCS= Body Condition Score
[5]ADG= Average daily increase.
[6]LW= Live weight

2) Reform management

Culling, or the removal of cows from the herd, is a frequent but complex choice, influenced by production, health, reproductive and economic factors. It can be voluntary, when a choice is made to replace low-productivity or surplus animals, or involuntary, related to disease, infertility or death.

Culling decisions must balance production, fertility, age, health status, and availability of replacement heifers. A high incidence of disease such as mastitis or lameness increases the risk of reforming, but the economic value of the animal and the cost of replacement are equally crucial. For a healthy and profitable herd, it is important to reform strategically, not just in response to health emergencies.

The turnover rate (preferable to the term "reform") represents the percentage of cattle replaced in a year relative to the average population. It can vary between farms and over time, but values above 35-40% require attention. It is calculated as:

Replacement rate (%) = (No. of cows reformed/Average no. of cows present) × 100

Having a good reformation rate does not mean having low values, but making decisions that are consistent with the business goals, economic and health context. For example, in a herd of 1,000 cows with a 33 percent turnover rate, 330 replacements per year are estimated. A farm can also estimate how many cows complete a lactation by calculating the monthly replacement rate and adjusting it for the calving- parturition interval.

In summary, well-managed reform enables:

- Improve the productive longevity of animals,

- Control replacement costs,
- Promote genetic improvement,
- Maintaining the structural balance of the herd.

Periodically assessing causes and frequency of reformation helps to identify critical management issues and improve overall farm efficiency.

B.2.1.2. Potential mitigation strategies for environmental sustainability of livestock farms

In dairy farming of cattle, sheep and goats, the steps that generate the greatest environmental impact are mainly related to climate-altering emissions produced during the management of animals and farm resources. The most significant source is enteric methane emissions, generated during digestion, particularly in adult lactating ruminants. This is followed by emissions from manure management, both during collection and storage and during field distribution, which can release methane and nitrous oxide. Another significant component involves emissions associated with feed purchases, especially when they come from long supply chains or input-intensive crops. Emissions from fertilizers and from on-farm crops used for fodder production are another source of greenhouse gases, particularly when synthetic nitrogen fertilizers are used. Finally, emissions related to fuel and electricity consumption from mechanized operations and equipment in the barn, such as milking machines, ventilation and lighting, should be considered.

Analyzing and acting on these steps is essential to improve the environmental sustainability of livestock farming.

In dairy cattle, sheep and goat farms, mitigation of climate-changing emissions and reduction of environmental impact can be pursued through an integrated set of best practices. From an animal management point of view, it is essential to increase the longevity and productivity of animals by reducing the replacement rate and selecting animals with high production efficiency. The use of pregnancy diagnosis allows better planning of the calving season, reduction of unproductive animals, and consequent better use of resources. Nutrition and proper use of pasture play a key role: practices such as rotational grazing, extension of the grazing season, use of high- quality silage, and proper mineral supplementation improve feed efficiency. It is also important to avoid overfeeding and control the body condition of animals at critical stages such as mounting and gestation. Regarding soil and fertilizer management, rational use of fertilizers, replacement of high-emitting products with more sustainable alternatives (e.g., protected urea), low-emitting application of slurry, and incorporation of manure is recommended. Health management contributes to sustainability through parasite control, vaccination programs and lameness prevention, improving health and thus production and reproductive efficiency. Finally, practices such as maintaining permanent pasture, agroforestry and tree incorporation, and on-farm development of arboreal areas can contribute to carbon sequestration by providing ecosystem services, such as biodiversity protection, fire prevention, water regulation, and conservation of territory, important not only environmentally, but also socially and economically.

Table 34. Good environmental practices to be adopted in farm management.

Management breeding	Animal Management	Increase the longevity of animals, thereby reducing the replacement rate Obtain more individually weighed offspring at birth Increase the growth rate of young animals (calves, lambs, and kids) to bring them to a weight suitable for slaughter more quickly Use breeding stock registered in herd books, which can ensure the genetic improvement of the herd Genetically select the most productive lactating animals (cow, sheep, and goat) Management of deliveries (Diagnosis of pregnancy) Proper management of slurry and manure through the use of the manure bin. Rotational grazing system	
	Grazing/nutrition management	Power supply mounts	
		Feeding mounts Extend the grazing season	Check BCS Male effect and control female/male ratio Feeding control before the mounting period: adequate grazing, availability and accessibility, avoid overfeeding
		Silage - Grass silage with high nutritional value Adequate mineral supplementation Reduce concentrates at the end of pregnancy Reduce excessive protein intake	

Table 34. Good environmental practices to be adopted in land use management.

Land use management	Fertilization	Conducting soil analysis for optimal fertilizer use (targeted use of P and K) Replacement of calcium ammonium nitrate and pure urea with protected urea Use manure from the barn and incorporate it into the soil Slurry application using low-emission spreading techniques (Trailing shoe)
	Carbon sequestration	(Grazing) (permanent) Agroforestry: trees and grazing animals Conversion of grassland/meadows to meadows/pastures

Table 36. Good environmental practices to be adopted in sanitary and veterinary farm management.

Health/veterinary management	Internal and external pest control Perform stool analysis periodically in order to detect parasites and perform targeted treatment Lameness control

Action B2.2 - Lean Management

Action B 2.2 aimed to develop and implement a Lean management plan to optimize company production processes, with a focus on personnel management and role definition. The approach was applied in several key areas:

- Food procurement and ration preparation
- Milking and milk quality management
- Reproductive and genetic management
- Management of comeback and reform
- Health management

Integration between barn activities and agronomic processes for livestock feed production. At least one improvement action was implemented on each farm involved, identifying the process with the greatest potential for optimization.
Lean is an approach to operations management that considers any resource spent that does not add value to the end customer to be wasteful. Lean emphasizes a number of tools and methods, to aid managers and workers in improvement, each designed for specific types of problems in order to identify and remove sources of waste through systems redesign. These tools and methods include value stream mapping, Kanban and pull, demand leveling, one-piece flow, 5S, kaizen events, A3 reporting, visual management and more." Womack and Jones in "Lean Thinking" summarized TPS into some simple and easily understood concepts from the five Lean principles:

B.2.2.1. Lean Management in Animal Husbandry

In an effort to help dairy farmers identify areas where greater efficiency can contribute to greater profitability, Phil Durst, extension educator at Michigan State University, uses the philosophy of Lean Management.

Jana Hocken, who has worked as an engineer with Toyota and lean management consultant around the world, was horrified by what she saw on the family farm when she and her husband took over the management of 1,000 cows. At that point, she realized that the same principles of Lean management, which she had helped introduce in large companies, could be successfully applied on farms

Analyzing the processes of a dairy cattle farm, these, can essentially be divided into three cyclical processes that must be managed simultaneously. The three processes essentially create the annual farming season, which is mostly the same each season. The important thing about barn management is that while the decision-making process may be different, the actual process is the same. Whether it is done daily, weekly, monthly or annually, most agricultural processes are repeated so that we can learn from them and continue to develop, evolve and improve them.

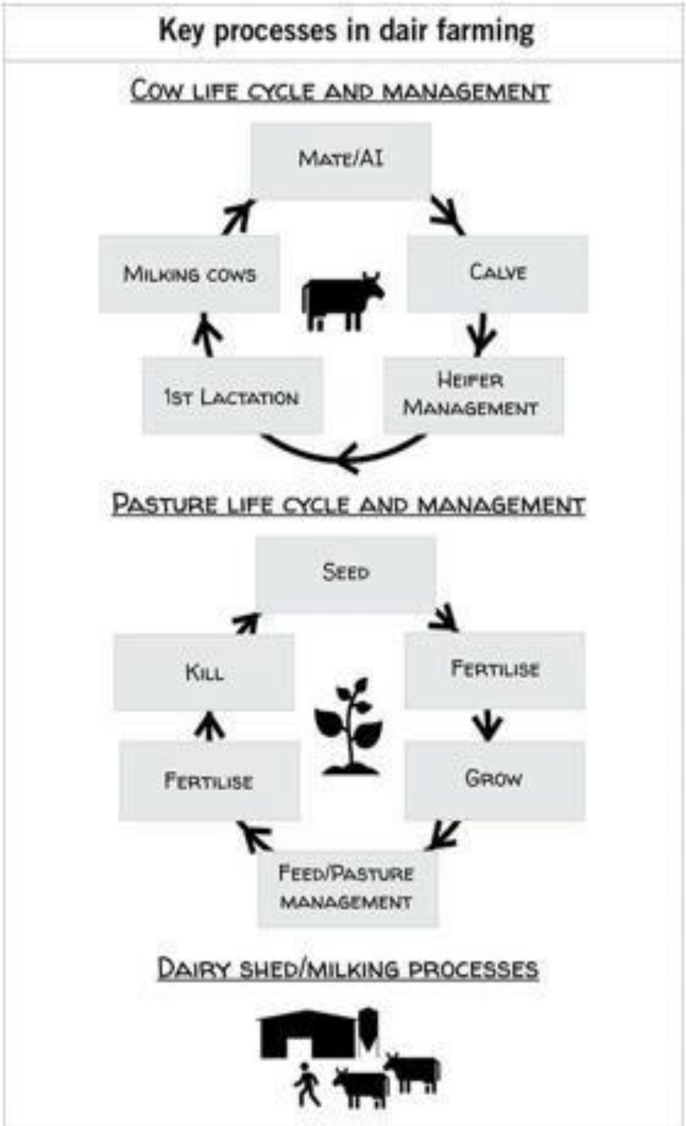


Figure 28. Key processes in dairy farms.

Lean Management is for all farms, small and large scale, that are open to change. For these, Lean can be seen as an extra gear that provides higher earnings and greater employee satisfaction without the need for investment. It is important to note that Lean will not solve all of a company's problems. It cannot change many factors that are inherent in agriculture, referred to as "external factors."

These include: weather, global dairy prices, interest rates, taxes and political regulations. What Lean can help with are the things that can be controlled directly in the company. These are the "internal factors" and include: work environment, what is done and how it is done, quality, waste, efficiency.

The Lean method aims to convert business inputs such as people, machines, equipment, and materials through highly efficient and effective processes into the right business outputs such as high quality products/services in the right quantity that are produced and delivered on time, at the lowest cost, resulting in satisfied customers and employees, and ensuring safe, animal and environmentally friendly practices. Lean helps create processes and operations that deliver the right results for the business.

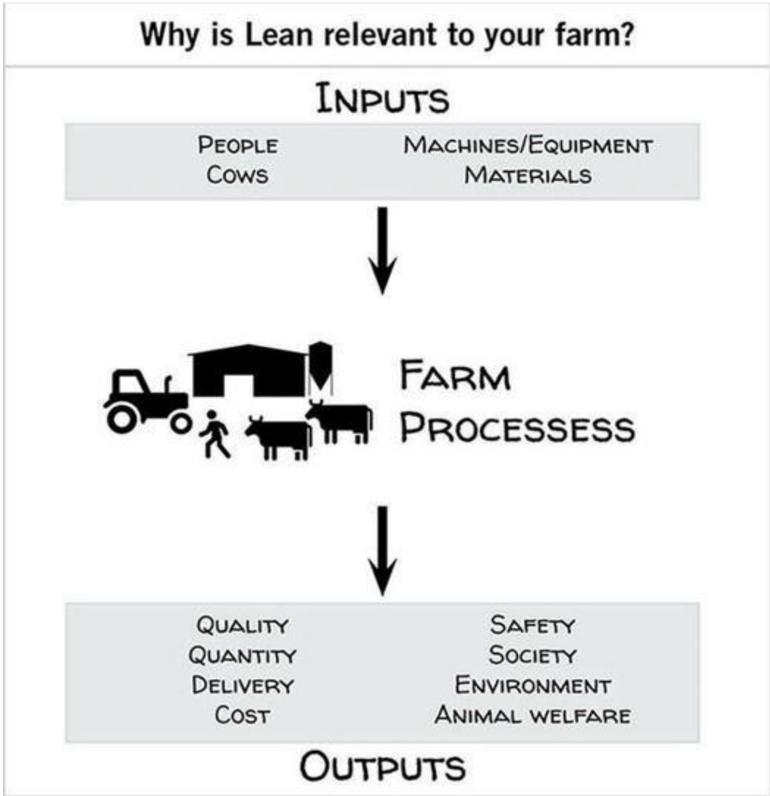


Figure 29. Why is Lean relevant to your farm?

As we have seen, Lean is based on five fundamental principles. These principles are key elements of the Lean mindset, Vibeke Fladkjær Nielsen and Susanne Pejstrup in "Lean in agriculture" have adapted these principles to the livestock world:

1. Identifying value: producing only what has value to the customer. Customer value can be an unfamiliar concept when it comes to internal customers. The 'farmer can be both a supplier and a customer in the process. But it is important to consider only the "customer side," that is, to produce only what has value to the customer. When describing what has value to a customer you have to be specific. If, for example, you choose to look at the part of production called "feed production," there is both a supplier and a customer: The supplier is the fields and the customer is the cows. Then you will describe what will create value for the animals. When you are precise, you know both what to do to meet the customer's requirements and what not to do. This last aspect is equally important when dealing with waste. If, for example, it does not add value to the customer to feed six times a day, you should not do it. And if it adds value to feed at fixed times, it should be done.

2. Identify value stream and eliminate waste: do only what creates value for the customer and do it in the most efficient way using as few resources as possible, that is, with as little waste as possible. Value flow is nothing more than value creation, consequent to every process and every movement that takes place in the company, thus to the work. When feed is moved from the silo, mixed and fed to the animals, a chain of actions is created that creates a value stream.

3. Creating value flow: flow means that work flows without unnecessary interruptions. Flow helps make work efficient. On a dairy farm, flow can be recognized from many situations, such as flow in milking, flow in harvest work, or flow in animal handling. Harvesting is a good example. When the trailers arrive at a uniform rate, the value of flow can be assessed. The milking parlor is another place where flow is of great importance for efficiency. Flow in the milking parlor can be affected by several factors such as number of cows getting ready at a time, number of milkers there are in the milking parlors compared to the capacity, over milking, different tasks that need to be performed, number of cows that have slow milking.

4. Establish the "pull": you produce only what the customer wants and not what you have the capacity for. It means that you do not start producing until the customer needs the product, that is, you produce the amount the customer wants, and at the time the customer wants it. This also applies to the internal suppliers of a farm, for example, the farrowing unit is the internal supplier of the weaning unit, which in turn is the internal supplier of the rearing unit. If you push all the young animals you produce through the system, you have 'pushed production.' You may not need all the young animals and it may not be profitable to get heifers from them. The solution is to sell the surplus of young animals and adjust the deliveries so that only those you need are transferred to the herd. This way you have so-called pull production. Continuous Improvement: One of the central principles of Lean is continuous improvement. In the original Japanese expression, it is called Kaizen. Kai means.

change and Zen means well. The Lean principle is central because Lean cannot be implemented as a single change in production. There must be many small improvements. Therefore, we also talk about a Lean culture. Employees must be involved because those who work with things on a daily basis are the ones who can make suggestions for improvement. Continuous improvement can be sought in many aspects. In Lean, one thinks of small improvements that can be implemented with little money. So it could be, for example, making a gate, modifying a passage in the barn to make the handling of cows faster, etc., all small improvements that make work on the farm more streamlined.

B.2.2.2. Lean analysis in dairy cattle

A 220-head lactating dairy cattle farm was examined, where the survey of activities performed by farm personnel was carried out. Preliminary meetings with the farmer made it possible to define the number of workers, the activities carried out and the frequency of their performance (daily, weekly, monthly). Four family members and one employee work on the family-owned farm. Since, individual observation of each worker would have taken an excessively long time, to collect the information, it was decided to use the Work sampling method in the survey.

B.2.2.2.1. The Work sampling

Work sampling, or activity sampling as it is also known, is an established methodological approach to estimate, accurately and precisely, the percentage of work time that people spend engaged in each of several predefined work activities, reports what are the basic principles of work sampling, essentially: the identification and recording of activities that workers are performing at a number of randomly occurring sample points. Traditionally, this is achieved by one or more observers visiting the workplace at predetermined intervals and recording the activities taking place. Once data have been collected from a sufficiently large number of sample points, it is then possible to estimate the percentage of work time that people spend engaged in each activity. The greater the number of sample points, the more precise the estimates of time percentages and the greater the confidence one can have in this precision.

B.2.2.2.1. Application of the work sampling method in surveying

At the indication of the farmer, the hourly ranges of the 5 workers were derived and, for each, a specific stage of the production process, in which they work most, was indicated, as well as an identifying number from 1 to 5 (Table 37). From this, it was possible to identify the hourly ranges in which all the workers were in the company and a table was created, on the Excel software, to generate daily, throughout the test, random times in which to carry out the surveys. At the time of the survey, the observations made on the individual worker were instantaneous and were marked on the spot in the survey sheet. For each schedule, the surveys were made on all 5 workers. The surveying activity, within the company, did not follow a predetermined route, but randomly, so that workers could not be influenced in the performance of their duties.

Table 37. Working hours and specific production stage for each worker.

Worker	Morning hours	Evening hours	Production stage
1	07:00-13:00	15:30-18:00	Cows and administration
2	08:30-11:00	16:30-19:00	Calf ranch
3	06:00-11:00	16:30-18:30	Power supply
4	04:30-08:00	16:00-18:30	Milking
5	08:30-11:00	16:00-18:30	Campaign and maintenance

- Rehoming: this area included all activities concerning the management of the rehoming phase, understood from birth until the heifers are moved into the dry cow group (Table 38);

Table 38. Work sampling sheet of the remontage area, used during the survey, with list o f activities and respective frequency.

	WORK SAMPLING - Lean Dairy Farm	
Zone	**Activities**	**Frequency**
Remount	Newborn calf management	2/day
Remount	Calf feeding	2/day
Remount	End-of-cycle cage cleaning	1/w
Remount	Decoration	1/w
Remount	Identification	1/w
Remount	Multiple box calf displacement	2/m
Remount	Vaccinations	1-2/m
Remount	Moving calf to barn	1/m
Remount	Moving heifer to calving area	1/m
Remount	Moving heifer in groups	1/m
Remount	Veterinary examination	1/w
Remount	Protocols and insemination	4/w
Remount	Stuffing heifer barn	1/w
Remount	Multiple box cleaning	1/m
Remount	Multiple box stuffing	1/w
Remount	Calf control	
Remount	Cleaning	

- production: all activities concerning the management of animals in production were included in this area (Table 39);

Table 39. Work sampling sheet of the production area, used during the survey, with list of activities and their respective frequency.

WORK SAMPLING - Lean Dairy Farm		
Zone	**Activities**	**Frequency**
Production	Milk filter change	2/day
Production	Detergent control	1/w
Production	Traditional milking	2/day
Production	Cleaning passages	1/dd
Production	Checking anomalies (data)	2/day
Production	Protocols (for insemination)	4/w
Production	Insemination	2/day
Production	Veterinary examination	1/w
Production	Jaws x necessity	1/w
Production	Jaw x dry	1/w
Production	Displacement from dry groups	1/w
Production	Moving between groups	1/w
Production	Stuffing bunks	1/w
Production	Lime in the bunks	1/w
Production	Cow feeding	
Production	Therapies	
Production	Parts	

- Feeding: this area included all activities directly, or indirectly, associated with the feeding of production and dry cows (Table 40);

Table 40. Work sampling sheet of the feeding area, used during the survey, with list of activities and respective frequency.

WORK SAMPLING - Lean Dairy Farm		
Zone	**Activities**	**Frequency**
Power supply	Pre Wagon Cows	2/day
Power supply	Filter and engine cleaning	1/dd
Power supply	Wagon Maintenance	1/w
Power supply	Cleaning Trenches	1-2/w
Power supply	Straw/Medical/Cane Ball Preparation	1/dd
Power supply	Gasoil Wagons	1-2/w
Power supply	Cleaning Feeding Aisles	1/dd
Power supply	Approach Eating	5/day
Power supply	Cleaning Troughs	1/w
Power supply	Cartridge Unloading and Data Entry Power Supply on pc	1-2/w
Power supply	Order Products and Entry Bubbles at ECOSTALLA management system	1/w
Power supply	DM ration determination	
Power supply	Comparison with Alimentarist on Animal Production Trend.	1-2/w

- Services: this area included activities concerning the cleaning of common areas and milking robots, and also slurry management (Table 41);

Table 41. Work sampling sheet of the service area, used during the survey, with list of activities and respective frequency.

WORK SAMPLING - Lean Dairy Farm		
Zone	**Activities**	**Frequency**
Services	Cleaning common areas	
Services	Slurry management	1/w
Services	Robot cleaning	1/dd

- Other activities: in this area, all those activities that cannot be directly linked to a specific stage of farming were reported (Table 42).

Table 42. Work sampling sheet of the area other activities, used during the survey, with list o f activities and their respective frequency.

WORK SAMPLING - Lean Dairy Farm		
Zone	**Other activities**	**Frequency**
Activities	Move materials	
Activities	Move equipment	
Activities	Moves with half with empty load	
Activities	Moves with half with full load	
Activities	Walk with empty load	
Activities	Walk with full load	
Activities	Labor Discussion	
Activities	Discussion	
Activities	Fill out documentation	
Activities	Waits	
Activities	Rest	
Activities	Absent	
Activities	Absent due to illness	
Activities	Absent for meeting	
Activities	Physiological break	

Next, the working hours of company personnel were identified and based on these determined the hours at which to take the surveys. It was chosen to take 12 surveys in the morning in the time slot between 8:00 a.m. and 11:00 a.m. and 12 in the afternoon in the time slot between 3:00 p.m. and 7:00 p.m. In addition, twice a week the surveys began at 5:00 a.m. which turned out to be the time at which worker number 4 started work. The times at which the surveys were carried out were determined randomly on a daily basis within the established time intervals. Activity identification was done by marking, the box corresponding to the type of work each employee was performing at the time of the survey, on the Excel sheet. Activity recording was from Monday to Friday for 2 consecutive weeks.

B.2.2.3. Sheep farm application

B.2.2.3.1. The Work sampling

During the data collection activity, a total of 1079 surveys were carried out, grouped according to whether they belonged to specific areas:509 surveys for the other activities area, 213 surveys for the production area, 97 surveys for the service area, 116 surveys for the food area, 144 surveys for the remontage area, and 0 surveys for the countryside area (Table 43).

Each activity was identified into one of the following types: "value-added" (VA) activities, i.e., those activities that create added value for the customer (farmer), or "non-value-added" (NVA) activities, i.e., those activities that do not necessarily add value for the customer but still need to be performed, or "waste" (W) activities, i.e., those activities that do not add any value to the customer but only add costs to the activity. For each area, total surveys by type were identified: for the other activities area, 128 surveys are VA, 197 surveys are NVA, and 184 surveys are W; for the productions area, 163 surveys are VA, 39 surveys are NVA, and 11 surveys are W; for the reassembly area, all surveys are VA; for the power supply area, 98 surveys are VA and 18 surveys are NVA; finally, for the services area, 93 surveys are VA and 4 surveys are NVA (Table 43).

Table 43. Total number of surveys by area and number of surveys, grouped by type (VA, NVA and W), For each area.

Area	No. of surveys	Type	No. of surveys
Other activities	509	VA	128
		NVA	197
		W	184
Production	213	VA	163
		NVA	39
		W	11
Remount	144	VA	144
Power supply	116	VA	98
		NVA	18
Services	97	VA	93
		NVA	4
Campaign	0	-	0
Total	1079		

In the area of "other activities," for the VA type, the relief related to data compilation was found to be the most incident (49%), for the NVA type, the relief that had the most impact was "work discussion" (51%), while, for the W type, the relief "moves with unloaded vehicle" was found to be the most incident (34%). Data compilation is one of the strengths of the company under study, which collects and uploads a great deal of information, which is essential to gain insight into the current situation and to plan company activities. Job discussion, on the other hand, implies that there is a need to delve into aspects of business processes that should already be learned by workers. Among the activities that represent waste, moving by vehicle with an empty load represents the most incident; this could be an indication of a suboptimal layout of the facilities, resulting in long journeys on the vehicle (e.g., after unloading rations at the feeder, the mixer wagon has to be returned to the feed storage area for reloading). In the "production" area, for type VA, the most incidental finding was "milking traditional" (26%), for the NVA type "milking delays" (97%) and for the W type "checking data anomalies" (100%). Traditional milking represents a VA type of activity as a fundamental process; in fact, although milking robots are present on the farm, a group of animals is allocated to milking in the parlour. Although the presence of the milking robots implies that the cows go spontaneously to be milked, some animals take a long time to get used to this type of milking and need to be guided by humans to the robots; this represents a necessary activity, but one that does not bring value since in an optimal condition there should be no animals reluctant to enter the milking robot. Also in the view of an optimal condition, any anomalies should be reported quickly to the workers and the workers should not be the ones to look for them. In the "re-milking" area, all detected activities are at value because all are necessary; of these, the one that had the greatest impact is calf feeding. In fact, a single worker is dedicated to the management of heifers from birth to 6 months of age, and in surveying this activity, the preparation of milk, its administration, the addition of starter feed and water in pre-weaning, and the addition of complete feed for post-weaning heifers were also taken into account. In the "feeding" area, for the VA type the activity that had the most impact was "pre-cow wagon" (31%) and for the NVA type "wagon maintenance" (38%), no activities were noted for type W. "Pre- cow wagon" represents a VA type of activity in that part of the unifeed consisting of the hay and concentrates is prepared in the evening, so that the following morning, wagon preparation is faster as only silage is added, ensuring early access to the first daily meal. As for wagon maintenance, it was listed as an NVA activity because it does not bring any value to the feeding phase, but it is an essential activity that must be carried out in order not to compromise the smooth operation of the mixer wagon. In the area of "services," for the VA type, the activity that affected the most was "slurry management" (51 percent) and for the NVA type "common area cleaning" (100 percent); no activity was found for type W. Slurry management, which during the time of the year in which the test was conducted involved only the emptying of the manure collection tank inside the storage tanks, is an essential activity for fixed housing livestock farms. Being located in the "nitrate vulnerable zone" (NVZ), the farm can only spread manure in the field at certain times and in certain quantities, so collection in special storage tanks is essential. Cleaning common areas is not a value-adding activity but a necessary activity because working in a tidy and clean environment increases the quality of work performed by all operators (Table 44).

Table 44. Percentage of incidence of activity with highest relief by type (VA, NVA and W) and area.

Area	Type	Activities	%
Other activities	VA	Fill out documentation	49%
	NVA	Labor Discussion	51%
	W	Moves with half discharge	34%
Production	VA	Traditional milking	26%
	NVA	Milking delays	97%
	W	Checking data anomalies	100%
Remount	VA	Calf feeding	58%
Power supply	VA	Pre-cow cart	31%
	NVA	Wagon maintenance	38%
Services	VA	Slurry management	51%
	NVA	Common area cleaning	100%

Although the work sampling activity carried out during the experimental trial made it possible to identify for each worker what are the percentages of activities at VA, at NVA, and at W, in the present thesis work the purpose was not to investigate the individual worker, but was to carry out a survey of the totality of activities carried out, regardless of the individual. In fact, of the total number of surveys conducted, 50 percent were attributed to VA activities, or 538 surveys, 34 percent to NVA activities, or 365 surveys, and 16 percent to W activities, or 176 surveys (Table 11). By way of example, the percentage of reliefs, by type of activity, of Worker 1, for which a total of 312 reliefs were made, of which: 134 referred to VA activities (43%), 105 to NVA activities (34%), and 73 to W activities (23%) (Table 45), has been reported.

Table 45. Number and percentage of surveys conducted by type (VA, NVA, and W) and total number of surveys, for all workers and, as an example, for worker 1.

Team			Worker 1		
Type	No. of surveys	% reliefs	Type	No. surveys	% reliefs
VA	538	50%	VA	134	43%
NVA	365	34%	NVA	105	34%
W	176	16%	W	73	23%
Total	1079		Total	312	

The distinction between VA, NVA and W activities was also made for each area. In the "other activities" area, VA activities account for 39%, NVA activities for 25% and W activities for 36% (Figure 3). In the "production" area, VA activities account for 77%, NVA activities 18% and W activities 5%. In the "comeback" area, all activities were considered to be at VA, thus, they account for 100% of the total activities surveyed. In the "feeding" area, to which no activities were attributed to W, activities at VA account for 84% and those at NVA for 16%. Finally, the "services" area also has no W activities, but VA activities account for 96% and NVA activities account for 4%.

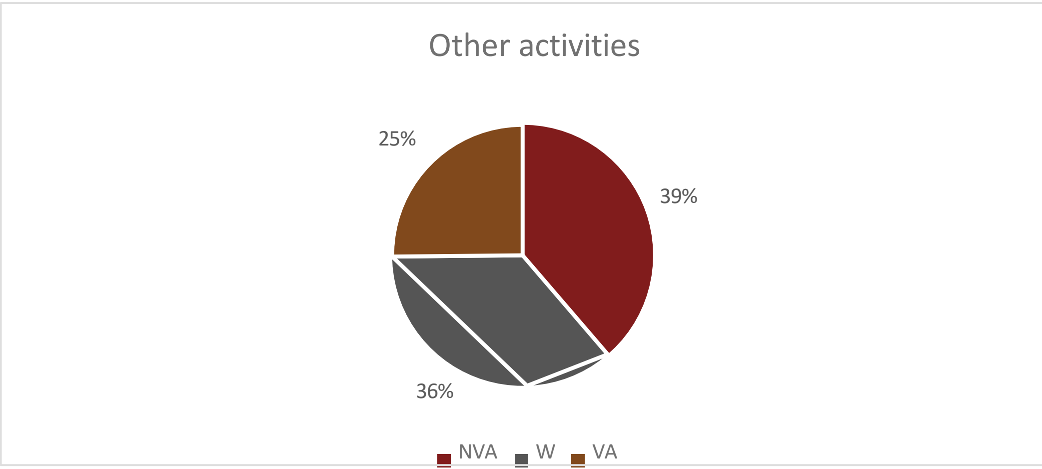


Figure 30. Percentage of surveys conducted, for the area other activities, grouped by type: 39% VA, 25% NVA and 36% W.

B.2.2.3.2. Lean implementation in a sheep farm

The activity was carried out at a sheep farm covering 71 ha, 50 of which are owned, while the remaining 21 are leased. The owned land turns out to be distributed as follows: 22 ha of naturally grassed pasture, which is grazed year-round, 12 ha of grassland, of which 8 are grazed while 4 are devoted exclusively to grazing, and finally we find 8 ha of woodland. Of the leased land: 3 ha is forest area, 9 of naturally grassed pasture, which is grazed year-round, while the remaining 9 ha is sown, of these: 8 are devoted to grazing and haymaking, while the remaining ha is used exclusively for hay production. The grassland is managed with minimal tillage for seedbed preparation: in the year surveyed, a nitrogen fertilizer was exploited and the crop sown was oats. The land used for grazing covers 48 ha, some of which relates to plots quite distant from the main farm body: the latter are usually exploited for lactating sheep, particularly in the interval between milkings and for dry sheep. Milking is mechanized and the farm features a 24-post milking machine. The management of lactating ewes involves two daily milkings starting in December, the period when the farmer begins with mechanical milking; from this time on until the whole of April the animals are all kept together in the same group, then, starting in May, the animals are separated into three separate groups in such a way as to create three different mating groups. Instead, the management of pregnant ewes and animals that have just given birth involves keeping them grazing in the allotments adjacent to the main farm body is also provided for the feeding of concentrate and other operations related to assisting in the lactation of lambs, carried out in the interval between milkings of the lactating group. Animals that have just calved are also stalled in the evening. Rehousing management requires that animals be stalled at least until May and then sent out to pasture.

B.2.2.3.3. Analytical approach used

Given the previously defined objectives, it was decided to go in and evaluate all aspects revolving around grazing and pasture management, in particular it was decided to use the Quality Cost Delivered approach method originated in the British automotive industry that involves analyzing quality, cost and time for a given process. With regard to grazing, the analysis was carried out on: Quality of grazing, Costs associated with it, and Time spent on its management and utilization. For each of these aspects, several parameters were taken into consideration, according to which forms and other tools needed to acquire and analyze data were defined; the latter being nothing more than the result of various field observations, estimates for the months after the work was carried out, and time series of data provided by the farmer. In processing the information and defining the outputs, the data were either referred to an area unit or to the individual animal in a way that made the parameter comparable.

1) Quality

The quality aspect of grazing was analyzed from a series of inputs related to data provided by the farmer and observations made in the field, shown in Table 2. The data refer to the characteristics of the group of lactating animals and in particular these are the number of milking animals from January to March, while for the months of April, May, June and July the number of milking animals and rations were estimated for the individual months. Then, from an average animal weight of 48 kg and the expected milk production, based on the historical data series held by the farmer, the daily dry matter ingestion per head was estimated using the formula: ingestion kg/d of DM per head = -0.545+0.095*animal live weight, kg^0.75 + 0.65*average milk, kg/d (Pulina et al, 2013). Next, grazing DM ingestion per head was calculated as the difference between estimated total ingestion and expected feed ingestion for those months, and then multiplied by the days and animals expected to be milked, so as to find the total grazing production for the months under consideration. From the sum of the monthly values defined above, the total DM production from grazing for the period under consideration was then derived. The figure thus obtained was then divided by the number of ha that are grazed by the group of lactating animals, i.e., 26, in this way the DM production per hectare was found to be 17.4 quintals per ha. The second parameter that was taken into consideration for the qualitative assessment of grazing was crude protein (CP). From monthly CP values expressed as a percentage of DM kg, derived from grass analysis carried out by the farmer in the past year, monthly protein production from the pasture was estimated as the product between these values and DM production, in the month under consideration. The sum of these outputs led to an estimate of the total CP produced during the period under review. Then relating this value to the number of hectares grazed yielded the amount of crude protein produced per ha, which stood at 2.67 quintals per ha. The third parameter that was considered for the qualitative assessment of grazing was fiber NDF. Starting with monthly NDF values expressed as a percentage of DM kg, derived from grass analysis carried out by the farmer in the past year, the monthly fiber output from the pasture was estimated as the product between these values and the DM output, in the month under consideration. The sum of these outputs led to an estimate of the total NDF produced during the period under consideration. By then relating this value to the number of hectares grazed, the amount of neutral detersed fiber produced per ha was obtained, which stood at 8.14 q/ha.

Table 46. Data on lactating animals and ration administered.

	January	February	March	April	May	June	July
Days no.	31	29	31	30	31	30	31
Milking animals, no.	74	102	129	174	144	144	144
Average production, l/d	2.1	2.1	1.9	1.8	1.7	1.6	1.4
Feed AI, kg/head	0.8	0.6	0.8	0.8	0.9	0.85	0.7
Percentage CP grazing	20%	25%	18%	15%	12%	10%	10%
Percentage NDF grazing	32%	35%	38%	44%	51%	55%	67%

2) Costs

All costs associated with the purchase of raw materials (fuel, seed, fertilizer), the use of the tractor (maintenance) and fixed costs (personnel, rent) were taken into account to define this yardstick, while no costs associated with the use of a contractor were considered, as the contractor was employed only for operations associated with haying. The cost of fuel was calculated based on purchase invoices related to farm work and consumption during haying, using farm histories. It was noted that about 90 percent of the fuel purchased annually is for cultivation activities. To obtain the total amount, the price per liter was multiplied by the total liters consumed. As for the cost of seed, the quantities were considered of purchased seed and the price per quintal. The following items were reported in the income statement:

- Quantity: total amount of seed used for the crop plan, broken down by crop type.

- Price: cost for each seed used, expressed in euros per quintal.

- Value: actual total cost of each seed, obtained by multiplying the quantity used by the price per quintal. Total seed cost is the sum of the values of all seeds used.

The cost of manure was calculated similarly to the cost of seed, considering the manure purchased and the price per unit weight. Manure expenses were then obtained by multiplying the quantity of manure purchased by the unit price. Maintenance expenses were divided into ordinary and extraordinary. Ordinary maintenance included periodic expenses such as oil coupons, filter cleaning, and various greasing. They were quantified in euros per month and summed to get the total annual amount, if available. No extraordinary maintenance was found. Included in fixed costs are land rent, personnel costs. Personnel costs were calculated by multiplying the hourly rate stipulated in the national contract by the number of hours spent in carrying out the crop plan, including soil preparation, seeding, fertilizing, mowing, raking and harvesting. To the fixed cost of rented land were added charges for farm machinery rentals, additives and fodder inoculums, as well as other specific costs indicated by the farmer, added to the amounts of leased land.

3) Time

The Work Sampling methodology was used to analyze this aspect: thanks to a series of field observations, it was possible to scan at the time level the daily routine of the farmer, as shown in Table 3. In defining the workday, all activities carried out by the farmer were examined, with a particular focus on those related to grazing management of the different animal categories. The time spent on grazing management of lactating ewes was grouped under the heading "Lactation grazing displacement" (Table 21), this activity included leading the animals to pasture following morning and evening milking and returning the animals to the farm before both milkings. Similarly, activities associated with grazing management were grouped together for the categories of remontage and dry ewes under the heading "Move pasture remontage and dry." Within lactating animals, the time related to milking was also quantified, starting with an average milking time per individual animal was then multiplied by the number of animals being milked in the different months. The result thus obtained was then doubled in such a way as to merge the two daily milkings. In predicting the timing for the months of May, June July, consideration was given to the fact that the lactation groups would become 3 (herd groups) and that there would be some variation in the number of animals milked. The other process taken into consideration was that related to the management of the ewes that had just lambed, particularly the activities of administering concentrate and assisting in lactating the lambs. In this case, in relation to the data provided by the farmer and the observations made in the field, an average management time per animal was estimated and multiplied by the number of animals in the category under consideration; this process was also carried out by the farmer both in the morning and in the evening, and the whole of these activities was grouped under the heading "Ewe management with lambing." The last two processes taken into consideration were those of "Cattle rearing and drylot management" and "Cleaning of facilities and premises"; for the first process it must be said that the drylot was fed practically exclusively in the pasture, while the ewe rearing turned out to be stalled at least until May, in accordance with the time series of data provided to us by the farmer. As for the process of cleaning the premises and facilities, an average daily time was considered, constant throughout the period considered.

Table 47. Survey sheet used for Work Sampling.

Months Plot	January	February	March	April	May	June	July
Milking heads							
Sheep with lamb							
Bringing animals back into the fold							
Morning milking							
Cleaning and flushing the system							
Taking sheep to pasture							
Management of lambed sheep							
Bringing animals back into the fold							
Food administration							
Taking sheep to pasture							
Comeback management							
Management of lambed sheep							
Bringing animals back into the fold							
Evening milking							
Cleaning and flushing the system							
Moving animals							

4) Quality

Regarding DM, the first values found were the average daily ingestions per individual animal in the different months examined; it was observed that the maximum ingestion was reached in February with 1.97 kg/d while the minimum ingestion value can be seen in the months of

June and July and stood at 1.48 kg/d. Then summing the amount of DM from concentrate and the DM from grazing ingested, the total amount of dry matter ingested was obtained, where the highest value was recorded in January with 2.56 kg/head and the lowest ingestion, on the other hand, was found to be in July, with the amount standing at 2.10 kg/head. The trend of these values appears to be in line with what is the decrease in the amount of grass grazing in the summer months and persistence of the lactation curve. From these first data, the incidence of the ingestion of grazing DM on the total ration was then expressed as a percentage; in this case the trend was increasing in the first two months, the maximum in fact being reached in January with an incidence of grazing at 77.75% of the total ingested, and then taking a decreasing trend in the following months, reaching a minimum in the month of May, in which grazing DM was 65.45% of the total. The reaching of this minimum value in the month of May and not in the summer months is probably due to the mowing done by the farmer to go to hay production. Then, from the grass analysis carried out in the previous year, we went on to estimate the percentages in terms of CP and NDF on the DM.

Table 48. Dry matter (DM) ingestion.

Months	January	February	March	April	May	June	July
Feed ingestion, kg/d of DM per head.	0.72	0.56	0.70	0.70	0.79	0.75	0.62
Grazing ingestion, kg/d of DM	1.84	1.97	1.72	1.65	1.50	1.48	1.48
Estimated pasture ingestion, qli/month of DM	42.1	58.6	68.7	86.3	66.9	63.9	66.1
Average production, l/d	2.1	2.1	1.9	1.8	1.7	1.6	1.4
DM ingestion estimated in ration	2.56	2.54	2.42	2.36	2.29	2.23	2.10
% DM grazing on DM ration	72	77	1	70.14	65	66	70

The trends of these quality variables had opposite signs, as usual, in fact crude protein reached its maximum in February, with a percentage of 25%, and a minimum in July with a value of 10%; as for in NDF content, this parameter reaches its minimum value in January, 32%, while it reaches a maximum value in July, with a percentage of 67%. These values are in line with what is the decrease in grass quality in the summer months. Next, we went to investigate the amount of CP ingested at pasture: starting from the product between the daily DM ingestion and the percentage of grass protein, the amount, expressed in kg DM/head ingested daily was obtained; again, the maximum value was recorded in February, 0.49 kg/head, while the minimum value was obtained in June and July with amounts standing at 0.15 kg/head. The values per head per day were then multiplied by the number of head so as to obtain the total ingestion of the lactation group in terms of kg of CP per day. The value thus obtained was multiplied with the number of days in the month, obtaining the monthly ingestion of the group. The sum of the monthly ingestions showed the total production of grazing CP in the months under consideration to be 69.45 quintals. Starting from the percentage of CP of the feed, the value of CP on dry matter was derived, then the percentage value of CP on the DM of the pasture was considered, then the percentage of CP of the total ration was calculated. Again, as expected, the highest value o c c u r s in February, with a percentage of 24%, while the lowest value occurs in July, with a percentage of 13%. Again the values are in line with the outputs obtained previously, in fact going by the trend of the incidence of grazing DM on the total ration and the percentage of CP on grass, it turned out to be quite predictable the trend of the percentage of CP in ration. Along the lines of the reasoning done for CP, the amount ingested of NDF on grazing was calculated, which reached its maximum value in July with 1 KG of DM, while the minimum value is touched in January with the value of 0.59 kg. From these values, the average amounts ingested by the group in the different months were obtained and multiplied by the number of days, the total amount of NDF produced by grazing during the period under consideration was estimated, i.e., 211 q. The values of the total grazing yields of the three parameters used were then related to the number of ha grazed in such a way as to obtain average yields per ha; specifically, 17.41 q of DM, 2.67 q of CP and 8.14 q of NDF per ha were produced during the period under review.

5) Costs

From the different cost items defined above, a sum of these was made; the total was related to the quantity of grazed hectares in such a way as to define a cost expressed as €/ha: this value stands at 307 €/ha. Next we went on to estimate the cost for the quanti-qualitative parameters used in the grazing analysis, as described in Table 6. Starting from the amount of DM produced per hectare, derived from the ratio of total DM produced in the period under consideration to the number of ha grazed, the cost per q of DM produced from grazing was obtained, which is 18 €/q. The value obtained was derived from the market price per q of a hay at 15% CP and 47% NDF, of 17.60 €/q of such. Then the cost was referred to the amount of CP produced the pasture and a cost of 1.1 €/kg CP was obtained (Table 6). The same procedure was carried out with reference to the amount of NDF produced at pasture: in this case the cost was found to be 37.70 €/q of NDF. Both costs were found to be significantly lower than the cost of the same parameters associated with the feed fed by the farmer to the lactating group. Next, the incidence of costs associated with DM ingested in ration was calculated; due to the lower cost of DM from pasture than from feed, despite a much higher ingestion of DM from pasture than from feed, the latter always had a greater impact on the cost of the ration than from pasture, except for the month of February when grass ingestion was highest: in this case, the incidence of the cost of pasture on the total ration was 54%.

6) Time

In relation to time evaluation, the initial form that went to define the daily routine of the farmer for the different months was modified by going to amalgamate different activities, depending on the different groups on the farm and the different type of task (Table 23); the processes were defined as follows: Moving pasture lactation, Milking ewes without lambs, Cleaning facilities and rooms, Managing ewes with lambs, Managing comeback and dry, Moving to pasture comeback and dry.

Table 49. Activity mapping sheet

Months	January	February	March	April	May	June	July
Moving lactation pasture	45	45	45	45	122	122	122
Milking ewes without lambs	68	94	119	160	132	124	117
Facility and room cleaning	60	60	60	60	60	60	60
Sheep management with lamb	32	36	49	0	0	0	0
Comeback and dry management	40	40	40	30	30	30	30
Dry pasture displacement	42	42	42	10	10	10	10
Tot min	287	317	354	305	354	346	339
Tot hours	4.8	5.3	5.9	5.1	5.9	5.8	5.6

This first part of the analysis was done by taking into account an average time for moving lactating animals to pasture, in accordance with data provided by the farmer who alternates grazing for this group on two different plots: the first 5 minutes away from the farm, the second 30 minutes. Next, the incidence of the various phases, on the total work time spent in the working day, was calculated. The activity that has the greatest time impact on the average farmer's day is the milking of ewes without lambs, and this occurs in all the months taken into consideration; the maximum value is obtained in the month of April in which this task impacts 52 percent of the total time spent on the farm, while the minimum value is observed in January, in which the incidence is 24 percent. These values are strictly dependent on the number of animals milked per month, as the calculation was set from an average time per head of 0.45 seconds, studied on the basis of observations made in the field, so the outputs obtained are in line with the data from which we was in poDMeDMion at the beginning, where we can observe for the month of April a number of milking cattle of 174, while in the month of January were milked 100 fewer sheep. Another activity that greatly affects the farmer's routine that of "Lactation pasture moving," in which as much as two hours per day are spent on this task, in the months of May, June, July while the time spent drops significantly in the months of January, February, March and April in which 45 minutes are required to complete this work. In this case the substantial difference between the first four months and the last quarter considered stems from the fact that in May the lactating animals are divided into three stud groups, so it is the time for moving is tripled. With regard to the hourly incidence of the other processes, it was seen that the activities related to replacement and dryness progressively impact less, due to the fact that part of the dryness in January calve in the Easter period, becoming part of the group of lactating animals, while it is noted that the activity of "Management of ewes with lambs" does not persist throughout the period considered, since all the lambs present in March are destined for slaughter. The activities related to rehousing and drying impact to the maximum extent of 14 percent in January and to the minimum extent of 8 percent in May Figure 4. "Management of ewes with lambs," on the other hand, impacts to the maximum extent of 14 percent in March.

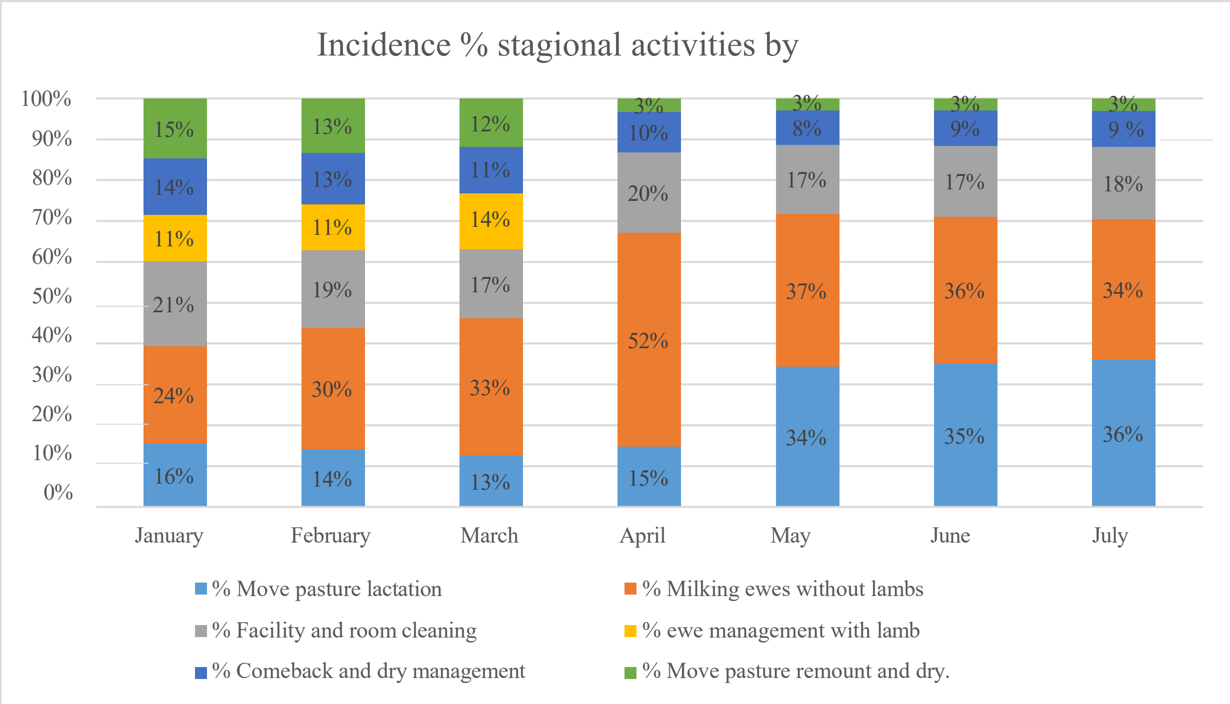


Figure 31. Incidence of different activities on daily routine.

In contrast, the "Plant and room cleaning" activity of 60 minutes daily remains constant throughout the period under consideration. After this first part of the analysis, we wanted to investigate the time-level differences that would have been observed if the grazing of the lactation group had been carried out continuously on the first pasture, 5 minutes away, an eventuality identified as "Scenario A" or on the second pasture, 30 minutes away, referred to as "Scenario B," as described in Table (24).

Table 50. Cost€ kg DM/head of pasture, fodder with similar characteristics that can be purchased on the market, and feed.

	January	February	March	April	May	June	July
Milking heads	74	103	129	174	144	144	144
€ kg DM/real head	0.32	0.35	0.30	0.29	0.26	0.26	0.26
€ Kg DM/head market	0.37	0.39	0.34	0.33	0.30	0.30	0.30
€ Kg DM/head feed	0.38	0.30	0.38	0.38	0.42	0.40	0.33
€ chief ration (DM)	0.71	0.65	0.68	0.67	0.69	0.66	0.59
€ pasture/€ ration %	46%	54%	45%	44%	38%	39%	44%

For the months in which the herd groups are defined, the time considered was still the average time, because in this case the farmer could not disregard the alternation of plots. With this type of analysis, it was noted how there is a difference of one working hour throughout the period considered between scenario A and scenario B, which originates a reduction in economic efficiency in the first four months considered; in fact, in this period despite the absence of the mating groups, a factor that has the greatest impact on a temporal level in the movement of animals in this farm reality, the working day turns out to have a similar length, between the first four months and the last quarter of the period considered. The length of the working day turns out to be longer when considering the month of March (Table 24) in scenario B than in the last three months considered.

B.2.2.3.4. Business implications

In this paper, analyzing the data collected in the business reality examined, we wanted to highlight the importance of evaluating the different aspects characterizing grazing.

The latter is an important resource for livestock farming, but it needs to be properly managed. In the reality examined through the Quality Cost Delivered approach methodology, an attempt was made to evaluate the aspects associated with the quality, cost and time required to manage this resource. From a quality and economic point of view, it was observed that the unit cost for the parameters examined (CP and NDF) turns out to be lower than for foods with similar nutritional characteristics purchased off-farm. Particular emphasis was placed in the analysis of the time required for operations related to grazing management, an aspect very often under-considered in grazing evaluation. The method used to go time scanning the activities related to grazing was Work Sampling, a technique that allows a mapping of the different activities, identifying any inefficiencies. In relation to the reality analyzed, it was noted that the time spent on grazing-related activities appears to be an important factor in the daily routine considered. In order to highlight how different grazing management leads to significant variations in the length of the working day, two scenarios were assumed in land management based on the time taken to reach them. In scenario A, the farmer was assumed to graze lactating animals daily in a pasture less distant from the one in scenario B; the different choice of pasture employed results in a different length of the working day. As mentioned, the use of grazing in sheep farming can be advantageous from an economic point of view while presenting costs associated with labor. It should be mentioned that the utilization of the grazing resource is, however, subject to quanti-qualitative variations depending on the soil and climate characteristics of the land under consideration, so the analysis methodology should always be contextualized. In any case, the achievement of efficiency in pasture utilization should be based on management approaches, such as mapping activities with the Work Sampling method, that allow for the best possible planning of the management of the resource during the year.

2.2.4. Conclusions

The companies under study has recently embarked on t h e path of applying the Lean management methodology. In both companies there has been the use of the work sampling method, focusing on what are the activities of the staff. This study showed that a rilavant share of activities, carried out by company staff, are of the non-value (NVA) and waste (W) type compared to value actions (VA). This means that although companies are undergoing a major shift in efficiencies both in terms of the type of farming and to the methodology of work (relevant use of software for data collection, technical approach, etc.), they also have significant waste, understood as the organization and management of staff activities, which must be reduced in conjunction with the structural improvement the company is having. It will be important to plan f o r change in both the short and long term. It is important to establish a plan in the long run, in order to understand the leap you want companies to have in terms of production and management in the coming years. This, following the Lean methodology, can be implemented, with a sharing by all stakeholders, by redesigning the activities that are carried out through the use of value stream mapping. This consists of a graphical mapping of all the processes and activities that are carried out in the company, not aimed at improving a single process but to the general and continuous improvement of all processes carried out for production. For the implementation of this process one must first identify the non-value activities (Actual State Map) and identify a goal, a business growth, to which one wants to aspire (Future state Map); organize, in favor of this, a path that allows to eliminate those factors that do not allow the achievement of the goal to which one wants to aspire. From the perspective of the long term, during the study, starting from the analysis of work time management and economic management of the comeback, it was tried to evaluate the critical issues and trying to create a new optimized situation, setting the improvement according to the components Lean VA, NVA W. For the work, it is necessary to optimize the work activities, dialogue and tasks of the business team so as to devote the remaining time to the physical organization of the workplace (order, cleanliness, routines, etc.) and to define work protocols for each stage of the production process. For rebreeding, noting that the number of animals is determined by the availability of facilities, the current system of young animal management can be optimized by reducing compulsory rebreeding and using sexed semen to produce more females for sale for life and more males for industrial crossbreeding. A final comment concerns the LEAN method. The method is still in preliminary use on dairy farms and requires further study in the methodological approach that needs to be modeled for the livestock sector in identifying the farmer as the end customer. In particular, in this study it is pointed out that classification of VA, NVA and W activities, needs to be detailed so that the attribution of business activities and processes to the criteria and structure of

LEAN analysis. Such deepening should also allow for the alignment of the enterprise vision of industrial and manufacturing conceptualization with the biological and seasonal processes that characterize agribusinesses and their operators.

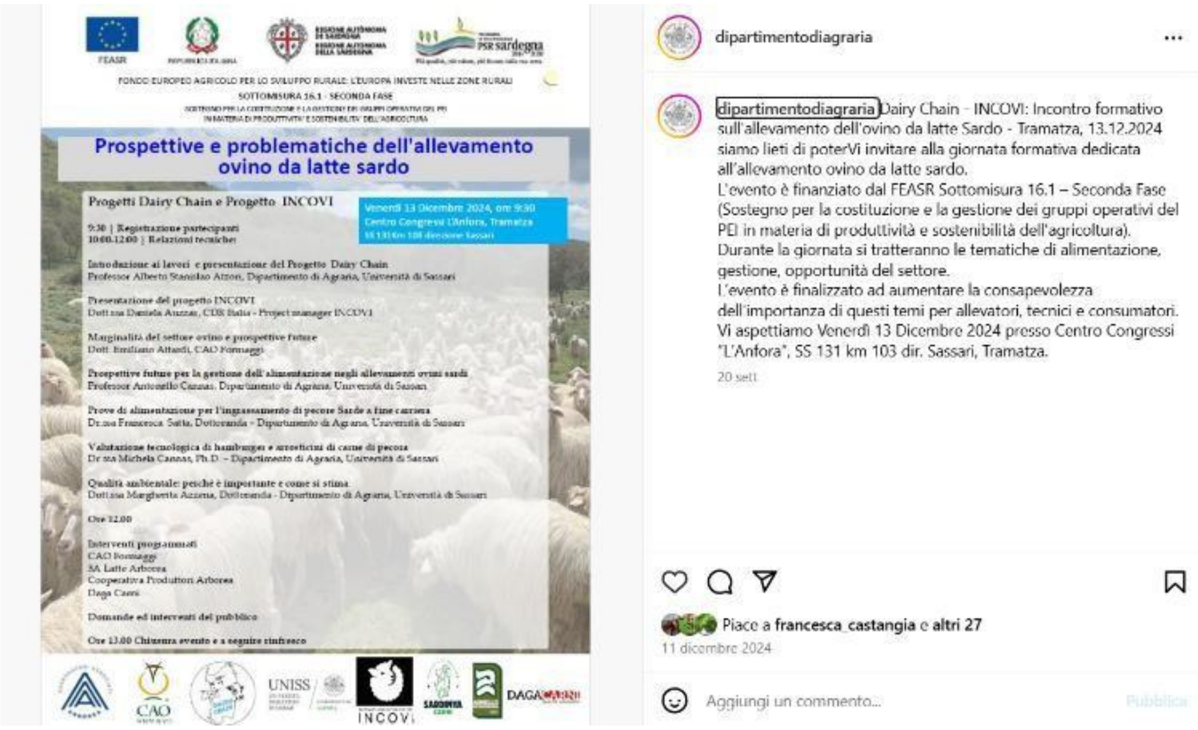
Action D - Dissemination and training

During the course of the DairyCHAIN project, six thematic conferences dedicated to training, technical discussion and scientific dissemination in the dairy sector were organized. The events were promoted through the creation and dissemination of specific posters for each conference, accompanied by communication activities on social media, particularly through the Instagram and Facebook channels of the Department of Agriculture of the University of Sassari and the Animal Husbandry Section. In addition, a system of targeted email invitations was activated for each event, targeting professionals, students, livestock breeders and industry professionals. Attendance of participants was recorded during the events, and on some occasions university credits (CFUs) were awarded to students who took part in the activities. Images and materials from the conferences held were shared online to ensure wide visibility and dissemination of the content covered.

Dairy Chain - INCOVI: Prospects and problems of Sardinian dairy sheep farming

December 13, 2024 – Tramatza

The inaugural conference of the DairyCHAIN project, in collaboration with INCOVI, presented the first results of experiments on fattening sheep at the end of their careers and enhancing their meat through feeding strategies and processing techniques. It emerged how the use of vitamin E improves the sensory characteristics of meat, making it more attractive to the market. In addition, environmental sustainability in the sheep sector was addressed, with the introduction of LCA methodologies, carbon footprint and environmental certifications, highlighting the importance of an integrated approach to farm management.




Centro Congressi
L'Anfora
Tramatza


I pilastri della sostenibilità
Centro Congressi
L'Anfora
Tramatza

DairyCHAIN:
From passion to professionalism: the farmer's journey to business growth
January 10, 2025 - Sassari

This conference explored the transition of livestock farms from family businesses to modern, structured and digitized enterprises. Professor Atzori presented the tools developed by the DairyCHAIN project to improve organization, data management and operator training. Business and legal testimonies highlighted the importance of planning, digitization and counseling to address growth and generational transition. Gian Simone Sechi's speech emphasized the urgency of introducing management control to ensure economic sustainability.


PROGETTO DAIRY CHAIN
COLTIVARE I NUMERI PER DECISIONI CONSAPEVOLI: IL CONTROLLO DI GESTIONE NELL'ALLEVAMENTO DA LATTE


Sottomisura 16.1 – II FASE PSR Regione Sardegna 2014/2020
Esigenze e priorità tecniche e organizzative dell'allevamento ovino, caprino e bovino da latte
Alberto Stanislao Atzori

DairyCHAIN:
The new animal husbandry: synergy between knowing and knowing how to be
February 6, 2025 - Sassari

The conference introduced the concept of *One Welfare* to academia for the first time, fostering a systemic view of animal, human and environmental welfare. Moderated by the editors of ExDairyPRESS, it hosted talks that addressed animal welfare, multidisciplinary approaches in education, entrepreneurial creativity, and the importance of inclusive and stimulating work environments. The testimonies highlighted the central role of the farmer as a technical and social figure at the center of sustainability.


IL RUOLO DEL VETERINARIO BUIATRA
NELLA ZOOTECNIA PASSATA, PRESENTE E FUTURA


DAIRY CHAIN:
Integrazione gestionale di aziende bovine, caprine e ovine da latte in una filiera unificata e sostenibile
Università di Sassari
6 Febbraio 2025


DAIRY CHAIN:

DairyCHAIN: The national and European context of dairy farming

February 20, 2025 - Arborea

This meeting analyzed the short- and medium-term market scenario for the dairy sector, with reference to international data and production trends. Italy's growth in efficiency and exports and the strategic role of the sheep sector were highlighted. The second part expanded on the concept of economic sustainability, emphasizing the importance of integrating technical analysis with the cultural and social dimensions of farms.

DairyCHAIN: Nutritional efficiency in dairy farms

February 28, 2025 - Arborea

The conference explored the importance of precision nutrition and integrated food management to improve efficiency and sustainability. Professor Atzori reiterated the centrality of data and digitization in farm management. Professor Gallo presented the risk posed by mycotoxins in forages and mitigation strategies. Prefemurs Masoero and Formigoni brought technical contributions on nutritional models and use of technologies in livestock farms, highlighting the potential of personalized feeding to increase productivity.


Qualità e sanità degli insilati, in ottica della nutrizione di precisione
Prof. Antonio Gallo


Il progetto DAIRY CHAIN

DairyCHAIN: New generations, new strategies: how to innovate the management of dairy sheep, cattle and goat farms?

April 3, 2025 - Torregrande

The concluding conference took stock of the results of the DairyCHAIN project and future challenges for an integrated and sustainable supply chain. Prof. Atzori presented the tools developed for technical, economic and environmental management of farms. Emiliano Attardi (CAO Formaggi) illustrated the use of the DIGICAO platform, while Sebastiano Curreli (Latte Arborea) showed the results of the environmental certifications obtained. Lawyer Elena Gargiulo discussed the topic of generational transition and business leadership. Drs. Podda presented a business process mapping model and Dr. Azzena compared the environmental performance of different supply chains. Gian Simone Sechi closed by emphasizing the importance of management control in consolidating business efficiency and resilience.


Il progetto DAIRY CHAIN


SENZA DATI SUBISCI


Produttività e impatti a confronto in allevamenti bovini, ovini e caprini