INTEGRATED WATER RESOURCES MANAGEMENT IN KOSOVO (IWRM-K) - PHASE 2

May 2024 – April 2029

TRAINING MATERIAL ON SUSTAINABLE LIVESTOCK FARMING AND MANURE MANAGEMENT

PROJECT
ENHANCING ENVIRONMENTALLY FRIENDLY MANURE MANAGEMENT PRACTICES IN LIVESTOCK FARMING IN KOSOVO

The IWRM-K is a Swiss Agency for Development and Cooperation (SDC) and Government of Kosovo Program, implemented by Skat Consulting Ltd. (Switzerland) in consortium with the Environment Agency Austria (EAA).

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MATERIAL 1: SUSTAINABLE MANAGEMENT AND ECONOMIC BENEFITS IN DAIRY FARMS

Prof. Dr. Arben Musliu
Faculty of Agriculture and Veterinary,
University of Prishtina, Kosovo

Introduction: Sustainable Management in Dairy Farms
The concept of sustainable management is becoming increasingly widespread across many fields and throughout all agricultural subsectors. Dairy farms are no exception to this concept, and all agricultural subsectors will need to evolve in this direction. The concept of sustainable agriculture refers to the capacity of agriculture in general, and dairy production farms in particular, to contribute to overall well-being by providing sufficient quantities of food and dairy products produced in economically efficient and profitable ways, while also being socially responsible and contributing to improved environmental quality. It is a concept that may have different implications in terms of appropriate technologies, whether considered at the farm level, at the level of the agri-food sector, or within the context of the broader local or global economy.

Technological progress, driven by market demand for low-cost production and high yields, has also led to considerable consumer concerns regarding the safety and quality of food produced in modern intensive agricultural systems. From an ecological and social perspective, the technologies adopted after the Second World War, which enabled Europe to overcome food shortages, have become increasingly less sustainable in light of the changing objectives that society sets for agriculture. In a world undergoing rapid and profound changes, we must all consider what needs to be done to be "sustainable." Farmers need to assess how "sustainable" their agricultural operations are, while governments need to examine the "sustainability" of their policies, programs, and structures. Liberalized market forces may produce precisely the opposite outcome.

Food production in many developing countries is insufficient to meet current market demands, and the situation is expected to worsen further due to rapid population growth. Countries in this position cannot afford to allow food production to stagnate. However, in the long term, countries cannot afford, nor can they continue, to produce food at the expense of environmental damage or degradation of the natural resource base. Clearly, more sustainable growth in agricultural production is needed in order to balance the negative effects of intensive production and exploitation of the resource base, while simultaneously optimizing food production. Livestock serves as a means of recycling nutrients, as well as a source of energy and value-added production.
However, there is growing consensus among policymakers, planners, and scientists that livestock production in developing countries is not expanding at a sufficient rate to meet the needs of the world's growing population. The increase in the production of animal products in these countries has largely resulted from an increase in the number of animals rather than from increased productivity.

While higher production levels are welcome, they do not necessarily equate to sustainable increases in productivity. On the contrary, in many cases they may lead to declining productivity and degradation of the natural resource base. The reality is that there has been little improvement, either in the efficiency or in the sustainability of livestock production in developing countries. Innovative technologies need to be developed, taking full account of the multifaceted role of livestock in agriculture. For such technologies to be acceptable to producers, they must be appropriate, affordable, and provide tangible benefits. Promising technologies already exist that optimize local feed resources for animals, particularly crop residues and agro-industrial by-products. The optimal use of many different types of legumes and their integration into existing agricultural practices will be a decisive factor in achieving sustainable agriculture. Two important animal-derived products, manure and animal traction power, are currently extremely underutilized, and specific programs will be needed to maximize their use.

Dairy Production at a Crossroads

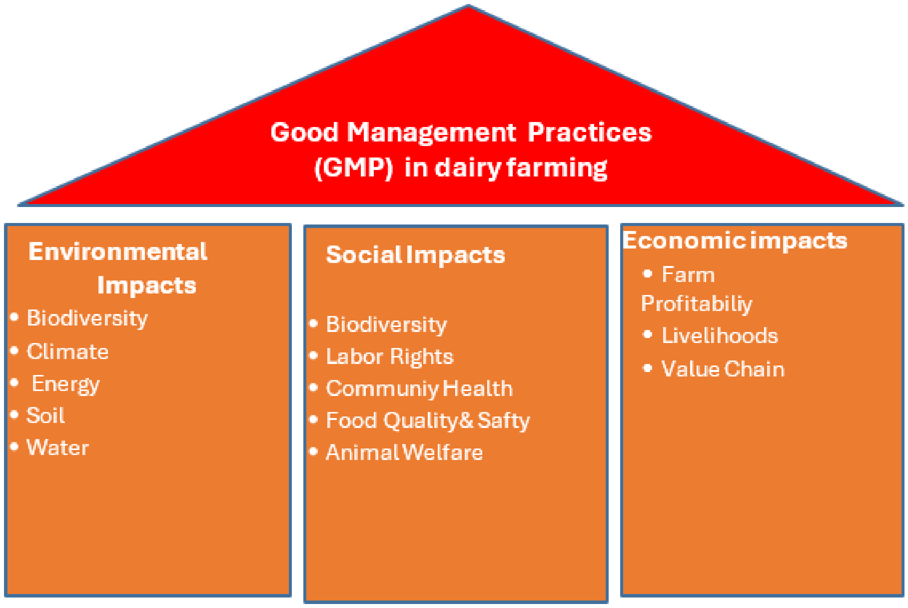
Since the introduction of government policies, the objective of agricultural development projects has been to increase productivity. Only now is it becoming clear that production systems shaped by this narrow objective are not sustainable. The disadvantages are numerous and complex: high costs, environmental pollution, soil erosion, and stress on people and animals are consequences of modern agricultural practices. Many of these are the result of the agricultural intensification process itself. Thus, increasing methane emissions, potentially one of the most harmful greenhouse gases, can be traced to the growing population of ruminant animals, particularly in developing countries. It also appears that the presence of methane gas in natural terrestrial ecosystems has increased as a result of burning crop residues and the heavy application of synthetic chemical fertilizers.

The Need for Sustainable Systems in Dairy Farms

The world's population is expected to increase dramatically over the next 40 years, from 6.7 billion in 2009 to 9.2 billion by 2050. To feed the world, and to feed it well, global food production will need to double by 2050. The problem, however, is that half of the world's habitable land is already used for agriculture.
Since resources are limited, the challenge is to achieve global food security while having a positive impact on the environment and society. Sustainable agricultural practices provide the solution.

The Three Dimensions of Sustainable Management in Dairy Farms

Sustainable dairy production has environmental, social, and economic dimensions, and all three pillars must be considered together. Focusing on one or two pillars while neglecting another will not produce the desired results. Protecting and improving the natural environment are essential, and issues such as climate change, energy, water scarcity, biodiversity, and land degradation must be addressed. The social dimension covers labour rights and community health, including access to and affordability of food, workers' rights, and community health. Food quality and safety, as well as animal welfare, are also important social aspects. From an economic perspective, sustainable agriculture is productive, efficient, and competitive. The benefits should be reflected in farm profitability, thriving local economies, and throughout the entire value chain.



Good Management Practices (GMP) in dairy farming.
Good Management Practices for dairy farmers involve the implementation of sound practices on dairy farms, collectively referred to as Good Dairy Farming Practices. These practices should ensure that the milk and dairy products produced are safe and suitable for their intended use, while also ensuring that the dairy farming business remains economically, socially, and environmentally sustainable in the long term. Most importantly, dairy farmers are engaged in producing food for human consumption; therefore, they must ensure the safety and quality of the milk they produce. Good Dairy Farming Practices support the production of milk that meets the highest expectations of the food industry and consumers.

Environment
Increasingly, consumers are concerned that food production is sustainable and carried out in harmony with the environment. To address these concerns, it is important for dairy farmers to produce milk in a way that meets the expectations of the wider community, uses natural resources efficiently, and minimizes any negative impacts on the environment. Every dairy farmer can play a role in protecting their industry and the future of their business by adopting management practices that improve the environmental sustainability of their farming system.
The recommended good environmental practices for a sustainable farming system are presented under the following headings:

- **Implement an environmentally sustainable farming system.**
- **Establish an appropriate waste management system.**
- **Ensure that dairy production practices do not have a negative impact on the local environment.**

Implement an environmentally sustainable farming system

Use farm inputs, such as water and animal feed, efficiently and sustainably.

Some dairy production systems rely heavily on external inputs, such as irrigation water, fertilizers, and animal feed. Dairy farmers should consider the short- and long-term impacts of using these resources on the land they cultivate. There may also be broader impacts on the environment and/or the local community. Good dairy farming practices aim to improve productivity through the efficient and sustainable use of farm inputs.

Minimizing Environmental Pollutant Generation from Dairy Farms

Practices that manage the risks associated with the release of environmental pollutants from the farm help protect the surrounding environment and can also benefit the farm business. While nutrients can cause problems outside the farm, they are a valuable resource within the farm. Careful fertilizer application and the implementation of an effective effluent management plan can minimize off-farm impacts and improve productivity.

Greenhouse gas emissions can be more difficult to control. Practices that improve productivity, such as feeding more digestible diets and applying fertilizers appropriately, can reduce methane and nitrous oxide emissions, respectively, per unit of milk produced. Ensuring that the nutritional requirements of crops and animals are adequately met will help reduce and manage potential nutrient losses.

Managing Livestock to Minimize Adverse Environmental Impacts

Implement appropriate grazing and housing strategies that minimize environmental impacts. Protect waterways and other sensitive areas from livestock access to prevent damage and pollution.

Selecting and Using Energy Sources Appropriately

Dairy farmers should assess energy consumption on their farms and consider opportunities to reduce it. Useful energy resources can be recovered from dairy farm waste streams, as well as from waste heat generated by milk cooling systems or equipment.

In some circumstances, non-renewable energy sources, such as electricity and fossil fuels, can be supplemented or partially replaced by renewable sources, such as solar energy, biofuels, geothermal energy, and wind energy.

Conserving and/or Promoting Biodiversity on the Farm

Although most dairy farms operate within highly managed environments, there are still opportunities to conserve and promote biodiversity. Protect sensitive areas, such as waterways, by restricting livestock access to them. Set aside non-productive land as habitat for native plants and animals.

Preserve remaining areas of natural ecosystems and, where possible, create connections between non-productive areas to support biodiversity at the local level.

Have an appropriate waste management system

Implement Practices to Reduce, Reuse and Recycle Farm Waste

Implement practices to reduce, reuse and/or recycle farm waste wherever possible. Reuse and recycling are also good dairy farming practices. Many farms can reduce water and energy consumption through proper maintenance of equipment and infrastructure, as well as by making small changes to their daily work routines. Opportunities to recycle plastics and other consumable materials should also be explored.

Manage the Storage and Disposal of Waste to Minimize Environmental Impacts

Waste storage areas, such as manure storage facilities and farm waste disposal areas, should be appropriately located, taking into consideration their impact on the local community, including visual and odour-related aspects, as well as the risk of environmental pollution and pest infestation.

Regularly inspect permanent slurry storage facilities and manure piles for signs of leakage or potential structural failure in order to minimize the risk of leaks that could contaminate the environment. Ensure that other waste materials, such as unsuitable milk, dead livestock, plastic silage wrapping, farm chemicals, and fertilizers, are disposed of appropriately to prevent environmental pollution and potential health and disease risks. Potential breeding sites for flies and other disease-carrying pests should be eliminated.

Develop a Simple Waste Management Plan

Develop a simple waste management plan that identifies when, where, and at what application rate manure, slurry, and other organic wastes should be spread, in order to minimize the risk of causing pollution.

Waste management plans should take into consideration:

- Compliance with local regulations and contractual obligations;
- Avoiding potential contamination of waterways, ponds, lakes, reservoirs, wells, and groundwater, particularly when applying waste to shallow soils and/or areas with fractured rock;
- Avoiding potential contamination of habitat areas, such as forests and protected or recognized areas of flora and fauna;
- Ensuring that appropriate buffer zones (areas where waste is not applied) are maintained near vulnerable or sensitive areas, such as water sources, habitat areas, and similar locations;
- The timing and application rate on sloping land, heavy or impermeable soils, and areas subject to flooding;
- Optimal application rates in areas that already have high soil fertility;
- Current and forecast weather and soil conditions at the time of application, such as frost, frozen soil, heavy rainfall, and/or waterlogged soils; and
- National and regional environmental requirements and controls.

All organic waste, including manure and slurry, should be spread or incorporated into the soil at times and under conditions when the risk to the environment is minimized.

Ensure dairy farming practices do not have an adverse impact on the local environment

Prevent Waste Runoff on Dairy Farms

Dairy farmers should implement systems that minimize the risk of contamination of the local environment. Facilities for storing fuel, silage effluent, wastewater, and other pollutants should be located in safe and appropriate areas. Precautionary measures should also be taken to ensure that accidents do not result in contamination of local water sources. Avoid disposing of agricultural or veterinary chemicals in areas where there is a risk of them entering the local environment.

Proper Use of Agricultural and Veterinary Chemicals and Fertilizers to Avoid Local Environmental Contamination

Protect the environment by using only approved agricultural chemicals and veterinary products in accordance with the instructions provided on the label. Ensure that farm chemicals are stored safely, preferably away from areas where milk is stored. Ensure the safe disposal of expired or unusable chemicals and their containers. Consider biological and other non-chemical approaches to farm pest control, such as eliminating pest breeding sites. Apply integrated pest management practices where appropriate. Apply fertilizers in a way that minimizes the risk of nutrient losses and adverse impacts on the surrounding environment. Avoid using fertilizers that contain toxins, heavy metals, or other contaminants. Ensure the safe disposal or, where possible, reuse of empty fertilizer bags.

Ensure that the Overall Appearance of the Dairy Farm Is Appropriate for a Facility Producing High-Quality Food

To limit the potential negative impact of dairy production on the landscape and to create a positive image of dairy farming, farmers should ensure that access roads and the surroundings of the farm are kept clean, farm buildings and facilities are properly maintained, and pathways used by dairy cattle are clean and free from runoff. Care should also be taken to ensure that dairy farm activities do not negatively affect neighbors or the comfort of the local community by controlling dust, odors, lighting, noise, flies, and other potential nuisances.

Socio-Economic Management

Being **"socially responsible"** and **"economically sustainable"** are integral parts of good dairy farming practices, as they address two major risks to the farm business.

Effective management and care for the farm's human resources are essential for business sustainability. In many parts of the world, this applies primarily to the farmers and other people who live and work on the dairy farm. However, dairy farmers should also consider the role their business plays in the wider community, including as an employer, a user of natural resources, and an activity that may have an impact on neighboring communities.

Similarly, dairy farms are businesses that produce products, in this case milk and meat. Like all businesses, dairy farms need to be financially sustainable to ensure their long-term future.

Suggested good practices for the socio-economic management of dairy farms include:

- Implement effective and responsible human resource management.
- Ensure that farm tasks are carried out safely and competently.
- Manage the farm enterprise to ensure its financial sustainability.

Implement effective and responsible management of human resources

Implement Financial Management Systems

Managing a dairy farm is a highly demanding job. Even on a small scale, dairy farmers are responsible for producing quality food from livestock that requires daily care and attention. Dairy farmers should consider their own health and well-being, as well as that of their families and farm workers. The workload for everyone should be reasonable and sustainable. Society also has a responsibility towards dairy farmers in this regard by ensuring a fair return for agricultural products.

Employ staff in accordance with national laws and practices.

Farm staff should be engaged under clearly defined and documented conditions. Labour productivity increases when dairy farm staff clearly understand their duties and responsibilities; therefore, a documented job description can be useful. Employment contracts should comply with applicable legislation.

Manage human resources effectively, ensuring that working conditions comply with applicable laws and international conventions.

Farmers and dairy farm staff should ensure that they are able to cope with the physical and mental demands of dairy farming. Dairy farmers should have realistic expectations of their staff. Advance planning through work schedules and open communication play an important role in workforce productivity and safety. Working hours should be consistent and should not exceed the limits established by law.

Ensure that the Farm Working Environment Complies with Relevant Occupational Health and Safety Requirements

Farm equipment and infrastructure should not pose a risk to the health and safety of farm staff or visitors. Proper design and maintenance can eliminate many hazards. Appropriate facilities and equipment should be provided for the safe handling of large dairy animals. Personal protective equipment, toilets, and washing facilities should be provided where required. Vaccination of staff and/or animals should be considered to prevent zoonotic diseases. Routine health assessments, such as vision and hearing checks, may also be beneficial.

Ensure farm tasks are carried out safely and competently

Provide Appropriate Procedures and Equipment for Carrying Out Tasks on Dairy Farms

It is important to ensure that tasks carried out on the farm are performed safely, correctly, and consistently by all farm staff. It is the responsibility of dairy farmers to ensure that farm staff are informed about and understand the procedures specific to their farm. They should also clearly identify who is responsible for particular tasks.

It is good practice to develop a written procedure, commonly known as a **Standard Operating Procedure (SOP)**, which describes how a task should be carried out in a controlled and repeatable manner. The procedure should cover all requirements for performing the task, including details of the process, the equipment and materials required, and any important risk and safety considerations. A risk assessment may be necessary for potentially hazardous tasks.

Clear procedures, implemented competently, minimize risks to personnel, animal health and welfare, as well as to milk quality and safety.

Introduce and Appropriately Train/Educate Staff for Their Work

Farm staff should be properly trained to work productively and safely. This includes a formal introduction to the working environment and to their specific roles.

New staff should be supervised by a competent person until they become familiar with their duties and understand the farm's specific management systems and potential risks. Training opportunities for existing staff can also improve productivity and increase job satisfaction. Training and education can be used to review farm procedures and provide feedback for continuous improvement.

Ensure that Staff Carry Out Their Duties Competently

Good managers have systems in place to ensure that tasks performed by others on the farm are carried out competently and in a timely manner. Good communication, supported by visual checks, proper record-keeping, or other verification methods, is good practice.

Manage the enterprise to ensure its financial viability

Implement Financial Management Systems

Most decisions that support good dairy farming practices have financial implications for the farm business. Use appropriate records and record-keeping systems that can provide dairy farmers with up-to-date information on the farm's financial position. Access to this information supports informed and effective decision-making.

Adopt Farming Practices that Contribute to the Productivity and Profitability of the Business

Dairy farmers operate in physical and market environments that are constantly changing. Implementing good dairy farming practices also means adapting to change. Dairy farmers should adopt new technologies and practices that are aligned with their goals.

Examples include using different varieties of forage crops or implementing irrigation practices that are better suited to changing conditions resulting from climate change.

Feed and labour represent significant costs for most dairy farm businesses; therefore, improvements in these areas can have a significant impact on the financial sustainability of the farm. Sustainable businesses are able to adapt to changes and take advantage of opportunities to improve their operations as they arise.

Plan Ahead to Manage Financial Risks

Budgeting for the farm's future income and expenditure should be used to manage financial risks within the farm business. Budgeting can help identify and manage potential cash-flow issues, as well as minimize financing costs.

Sustainable dairy farm management -Implication on profitability

The sustainability of a dairy farm is not possible without the economic sustainability of the farm business itself. Economic sustainability requires income from milk production to cover operating costs, taxes, and debt servicing, while also providing a reasonable return for dairy farm owners and operators.

Good management is a critical factor in the success of any business, and dairy farms are no exception. The demands placed on management and its ability to deal with problems have a significant impact on the overall performance of any business, including dairy farms. Record-keeping and data analysis are essential functions of dairy farm management.

What does dairy farm management involve?
Dairy farm management includes:

- Efficient use and allocation of resources;
- Adapting to changes;
- Making logical decisions based on available information;
- Continuously reviewing and adapting decisions in response to changing conditions.

Some managers make decisions based on habits or previous practices, while good managers continuously review their decisions and adapt them to changing conditions.

What are the functions of management?
The functions of management, which distinguish managers from workers, include three main categories:

- **Planning**
- **Implementation (organization, staffing, and direction)**
- **Control**

Planning – means selecting a course of action. Without a clear plan, it is difficult to achieve the desired results. To plan effectively, a manager must establish objectives, identify and allocate resources for different and competing uses, while realistically assessing the resources available. Once a plan has been developed, it must be implemented and put into practice.

Implementation – to implement the plan, the manager must secure the necessary resources and materials and oversee the process. This requires coordinating resources, including personnel, procurement, financing or credit, where necessary, as well as supervising activities. Implementation must take place at the appropriate time and include cash-flow management, particularly sales and payments.

Control – is the "feedback" function. To exercise effective control, the manager must monitor results, record information, compare results with established standards or objectives, and take corrective action when necessary. This function is closely linked to record-keeping and accounting, as changes in farm conditions may make the original plan unrealistic. Effective managers adapt to these changes and, in many cases, can prevent or minimize negative impacts.

Financial control is particularly important for the sustainability of the farm and requires continuous monitoring of income, expenses, and cash flow, as well as taking corrective measures when necessary.

Dairy farm record keeping

Farm record-keeping is widely recognized as essential for business management purposes. Without proper records, it is impossible to assess basic indicators, such as whether the farm is generating a profit or incurring losses. An important challenge in Kosovo is the lack of basic records on the use of financial and physical resources, as well as the income generated at farm level.
A business with limited or no records can be compared to a ship without navigation in the ocean, as it lacks the basic ability to determine which direction it should take and how long it will take to reach its destination. Records show the manager where the business has been and whether it is on the right path toward achieving its established objectives. They also show the results of management decisions and provide one of the main tools for assessing business performance.
The management and decision-making processes of any business, whether large or small, cannot function properly if accurate and up-to-date records are not considered a routine part of management. If dairy farm records are incomplete or inaccurately recorded, the analysis may be misleading and can often lead to inappropriate decision-making. Accurate records are the foundation of every business management

function, and agriculture is no exception in this regard.

Record-keeping on dairy farms is particularly important for:
1. Measuring profitability and assessing the financial condition of the dairy farm business;
2. Providing data for analyzing the performance of the dairy farm business;
3. Supporting applications for loans from financial institutions;
4. Supporting the analysis and planning of new investments;
5. Assisting with debt management and repayment.

Accounting System

Before entering data and transactions into an accounting system, several decisions need to be made regarding the type of system to be used. A number of options are available and can generally be grouped into the following areas:
1. Which accounting period will be used?
2. Should a cash-based or accrual accounting system be used?
3. Should a single-entry or double-entry accounting system be used?
4. Should a basic or full accounting system be used?

Double-Entry Accounting System
A double-entry accounting system records changes in the value of assets and liabilities, as well as income and expenses, using equal and corresponding entries for each transaction. This results in a greater number of transactions being recorded during the reporting period, but it has two important advantages:
1. **It improves accounting accuracy**, as accounts can be kept in balance more easily.
2. **It enables the preparation of complete financial statements**, including the balance sheet, at any time based on the information already recorded in the system.

The improved accuracy of double-entry accounting comes from the fact that each transaction is recorded on two sides. In practice, this means that **total debits must equal total credits** for every transaction recorded. It also ensures that the basic accounting equation is maintained:
Assets = Liabilities + Owner's Equity
Therefore, a double-entry accounting system continuously maintains the value of assets and liabilities within the accounting system. As a result, financial statements can be generated directly from the information recorded in the system without requiring additional information from external sources.

Gross Margin System
The calculation of gross margin is a key indicator in agricultural production and one of the most widely used methods for analyzing the performance of an agricultural business. However, gross margin does not measure profit, as it considers only the costs directly associated with each individual enterprise, i.e., variable costs. The sum of all enterprise gross margins results in the farm's overall gross margin. The main purpose of gross margin analysis is to identify enterprises that

provide the best return on the inputs used in their production.
Definition of gross margin: The gross margin of an enterprise is the value of its output minus its variable costs.

Forward dairy farm budget
Forward farm budgets provide an estimate of the income, expenses, and potential profit for a specific enterprise. Each type of crop or livestock activity is considered an enterprise, for example, milk production, wheat, maize, etc. The basic unit for crops is usually one hectare, while for livestock it is generally one animal or another appropriate unit.
Enterprise budgets form the basis for developing the overall farm plan. They can be prepared for different levels of production, so there may be more than one budget for each enterprise.
The main purpose of dairy farm budgets is to forecast the potential income, expenses, and profit of the business. Once prepared, the budget can be used for various planning purposes, particularly to identify the most profitable enterprises that can be included in the overall farm plan.
The budget is specific to each farm and is used as a forward-planning tool. It reflects management's best estimate of what is expected to happen in the future if the planned decision is implemented.

Analysing dairy farm budgets

A **dairy farm budget** includes information on input expenditures, as well as the costs of labour, capital, land and, where applicable, management. Data from the dairy farm budget can be used for several types of analysis, including:

1. **Cost of production**
2. **Break-even yield**
3. **Break-even price**

Cost of Production
The term **"cost of production"** is used to describe the average cost of producing one unit of a product. The cost of production is a useful concept, particularly when considering the sale of a product. Without knowing the cost of production, it is impossible to determine whether a profit is being achieved, regardless of the selling price.
The formula is simple:

Cost of Production = (Total Fixed Costs + Total Variable Costs) / Total Units Produced
The cost-of-production calculation is relatively simple and provides a useful starting point for carrying out further analyses, as described below.
Break-Even Yield
The data contained in an enterprise budget make it possible to analyze yield and price. The break-even yield is the yield required to cover all expenses (costs) at a given product price.
The formula is:
Break-Even Yield = (Total Fixed Costs + Total Variable Costs) / Product Price

Break-Even Price
The break-even price is a similar analysis, but it indicates the selling price required to cover all costs at a given level of production.
The formula is:
Break-Even Price = (Total Fixed Costs + Total Variable Costs) / Expected Yield

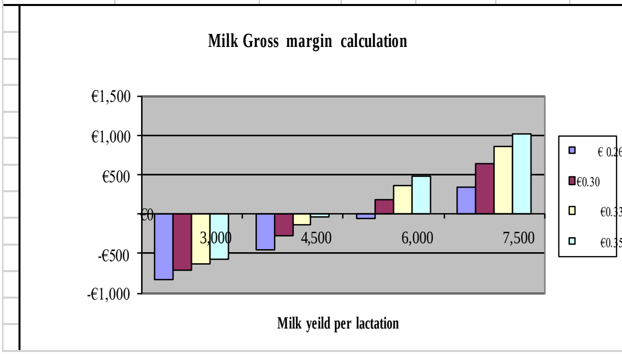
Planning dairy farm budget

Many factors influence milk production and the variable costs of milk production. To assess these factors, it is necessary to have a detailed breakdown of physical and financial information related to milk production. A dairy farm budget has been developed to address the issue of cost allocation. The system divides costs into two categories and focuses on the performance of the dairy enterprise by linking output to input costs. Many factors can affect the profit margin of a dairy farm. Although managing cows, ensuring feed supply, and managing the manure system require daily attention and leave little time for long-term planning, it is essential for dairy producers to regularly set aside time to review the overall operation of the farm and identify inefficiencies. Production efficiency can be improved through changes in production practices, reproductive efficiency, milk quality, and feeding practices. The ability of the dairy sector to grow and progress should be based on improvements in farmers' business management and operational practices.A dairy production budget has been developed to identify the key cost drivers in milk production. This helps in preparing plans to improve the efficiency of dairy farms and enables dairy farmers to maintain the sustainability of their businesses. The calculations indicate that the selling price of fresh milk and milk yield are among the most important factors influencing the economic sustainability of dairy farms.

Table 1 Margins at different yield and price per cow

	Milk Gross margin calculations												
	Cost of production		**0.27**										
	Break even yeild		**5375**										
Inflows													
				Unit	Price/l	**Amount**							
	Milk		*6,000*	litres	0.30	**€ 1,800**							
	Calf value		100	*kg*	€ 1.80	**€ 180**							
	Suckled milk		300	litres	€ 0.25	**€ (75)**							
	Replacment costs	5 years		Amort/vit	€ 100	**€ (100)**							
	Total income					**€ 1,805**							
Variable Cost													
			Inputs	unit	Price	cost							
	Vet services		1	#	50	€ 50							
	AI		2	#	20	€ 40							
	Cow mortality		0.05	#	1000	€ 50							
	Bedding		1	kg	30	€ 30							
	Labor cost		0.07	Year	1800	€ 120							
	Other expenses		1	#	30	€ 30							
	Expenses before feeding					**€ 320**							
				GM befor feed									
Feed							Feed ration for 25 l of milk a day						
			Inputs	unit	Price	cost		lac cow		dry cow			
	Com silage		4860	kg	0.05	243.00	15.00	0.75	6.00	0.3	4500	360	4860
	Grass& legume hay		2460	kg	0.10	246.00	7.50	0.75	3.50	0.35	2250	210	2460
	Com grain		1668	kg	0.20	333.60	5.50	1.10	0.30	0.06	1650	18	1668
	Wheat bran		615	kg	0.15	92.25	2.00	0.30	0.25	0.0375	600	15	615
	Wheat grain		618	kg	0.20	123.60	2.00	0.40	0.30	0.06	600	18	618
	Soya bean meal		498	kg	0.38	189.24	1.50	0.57	0.80	0.304	450	48	498
	Vit & min		81	kg	0.80	64.80	0.25	0.20	0.10	0.08	75	6	81
						€ 1,292		***4.07***		**1.1915**			
	Total direct expense					**€ 1,612**	***Total feed expenes /day/cow /lac***			**Total feed expe/day/dry cow**			
				BM after fe		**192.51**							
					11%								
	Sensitivity analyses as price / yeild changes												
				Milk Yeild									
		Litres/day	*10*	*15*	*20*	*25*							
			3,000	*4,500*	***6,000***	*7,500*							
	Price /litre	*€ 0.26*	-€836	-€446	-€56	€334							
		€0.30	-€716	-€266	**€184**	€634							
		€0.33	-€626	-€131	€364	€859							

€0.35	-€566	-€41	€484	€1,009
Return on operative capital				**11%**



The partial productivity measures

Partial productivity measures are indicators of how efficiently farms produce milk. Each of these measures assesses the efficiency of a specific aspect of farm management, such as fertilizer-use efficiency or feed-use efficiency. Together with sustainability assessments, these measures provide an overview of the optimal farm system for sustainable grazing and concentrate-based milk production.

The partial productivity measures included are:

Milk production	**(Litres per cow per day):** This measure should be used with caution, as milk production per cow is not necessarily an important indicator of the overall efficiency of the farm.
Milk Production	**(Litres per farm per day):** This measure is used to assess the farm's overall production and to calculate the cost of milk production.
Concentrate Use for Lactating Cows	**(Kilograms per litre):** This measure indicates the total amount of concentrate feed, in kilograms, fed to lactating cows during a day, divided by the total amount of milk produced on the farm during that day. It is a simple indicator of feed conversion efficiency. Concentrates are among the most expensive forms of feed; therefore, the lower the efficiency of concentrate use, the lower the potential profitability of milk production.

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MATERIAL 2. ENHANCING LIVESTOCK HOUSING, HYGIENE, AND WELFARE: STANDARDS FOR SUSTAINABLE FARM MANAGEMENT

Prof. Dr. Medin Zeqiri
Lecturer at University for Business and Technology, Prishtinë, Kosovë

Executive Summary

Housing of dairy cows has a direct impact on animal health, welfare, and milk production. According to Dorta, Witskowska, and Poinewaz (2022), proper design of space and maintenance conditions reduces disease incidence and increases productive longevity. Meanwhile, Nuh Ugurlu and Selda Uzal (2022) emphasize the importance of selecting an appropriate housing system and good management to ensure comfort, natural behavior, and freedom of movement for dairy cows.

Ventilation removes excess heat, moisture, and harmful gases such as ammonia, ensures uniform air distribution, and improves overall comfort. Dairy cows are highly sensitive to heat stress; the optimal ambient temperature ranges from 0 to 20 °C, while temperatures above 21 °C lead to reduced feed intake and milk production (MBPZHR, 2013–2023). Natural ventilation is achieved through sidewall and roof openings, using air currents to provide 40–60 air changes per hour (University of Wisconsin–Madison, 2025). Mechanical ventilation relies on fans with positive or negative pressure to ensure constant air circulation and is often combined with water-based cooling systems to reduce air temperature (The Dairyland Initiative, 2015).

Modern systems use Temperature–Humidity Index (THI) sensors to regulate ventilation automatically. Ideal relative humidity ranges between 50 and 80%. THI values have a direct effect on production and health: THI $\leq$ 68 indicates optimal comfort; THI 73–78 represents moderate stress; and THI > 84 causes extreme stress and serious health risks (The Dairyland Initiative; University of Wisconsin–Madison, 2025). Barn design plays a crucial role in welfare and productivity. Recommended barn dimensions range from 20–40 m in length and 10–40 m in width. Tie-stall systems allow individual cow care but are more labor-intensive for workers. Free-stall systems provide greater space for resting, movement, and expression of natural behaviors (Frank J. C. M. van Eerdenburg & Lars Erik Ruud, 2021). Recommended stall dimensions include a bed length of 182–220 cm and a minimum width of 137 cm. The placement of the tie rail and chain must allow natural standing and rising movements. Proper design results in reduced heat stress and respiratory diseases, improved feed intake and milk yield, and increased comfort and expression of natural behavior.

High-quality milk production requires a combination of physiological factors, balanced nutrition, proper milking hygiene, and adequate milk storage. Key factors affecting milk quantity and quality include breed, stage of lactation, health status, stress level, animal welfare, and hygiene of udders and the milking environment (Martin, 2025; IPESA, 2019). Milk must be cooled immediately to 4–6 °C, and milking equipment must be cleaned and disinfected after each use to prevent microbial contamination.

Milking practices are divided into three stages: before, during, and after milking. Before milking, hand washing, checking cow and teat health, wearing gloves, and discarding the first milk streams into a separate container are essential to prevent mastitis spread. Regular mastitis testing using the California Mastitis Test helps identify subclinical infections. During milking, strict hygiene of udders and equipment is critical, while the use of milking machines reduces direct contact and mechanical stress on the udder (Miltenburg et al., 2004; Graves et al., 2007). After milking, teats are disinfected, cows remain standing for 30 minutes, and milk is immediately cooled. Equipment must be cleaned using alkaline and acidic solutions according to manufacturer instructions, with appropriate temperatures and contact times to ensure microbiological safety. Regular weekly, monthly, and annual inspections of milking machines are essential to maintain optimal function and prevent damage that could affect milk quality (FAO, 2011; IPESA, 2019).

Collection and storage of animal and plant waste in separate, dry, and protected areas help preserve nutrients and prevent environmental pollution. This practice improves the quality of organic manure by maximizing the benefits of its nutrient components. Monitoring animal welfare in dairy farms is essential to ensure good health, comfort, and increased productivity. According to IPESA guidelines (2019) and the Five Freedoms framework (Webster, 2001), welfare includes freedom from hunger and thirst, pain and disease, fear and distress, discomfort, and the ability to express natural behaviors. Practices include providing adequate feed and water, a safe and healthy habitat, well-ventilated and well-lit environments, and sufficient space for movement and social behavior, while minimizing stress and injury risks. Calm and respectful handling of cows helps maintain optimal milk production, reduce disease incidence, and improve product quality. Systematic monitoring of behavioral, health, and productivity indicators allows early problem detection, timely intervention, and improved farm management, contributing to higher efficiency and reproductive performance (Welfare Quality, 2023; Management of Livestock Behavior, 2021). In the context of Kosovo, the use of practical and easily measurable indicators, combined with training for farmers and veterinarians, supports the integration of these standards even in farms with limited capacity.

Introduction

Housing design for optimal ventilation, temperature control, and animal comfort
Proper housing of dairy cows in barns has a direct impact on their health and welfare by reducing disease prevalence and extending the productive lifespan of the herd through appropriate space design and maintenance conditions (Dorta, Witskowska, & Aneta Poinewaz, 2022). According to Nuh Ugurlu and Selda Uzal (2022), the choice of housing system and good management are key factors in ensuring comfort, natural behavior, and overall welfare of dairy cows, as they improve resting conditions, feeding, and movement within the barn.

Importance of ventilation and temperature control for dairy cows
Ventilation is a critical process because it enables air exchange within barns: it introduces fresh air through planned openings, thoroughly mixes outdoor and indoor air, removes excess heat, moisture, and air pollutants, and expels warm, humid, and contaminated air from the facility.
Many factors must be considered in barn design, including the suitability of the building for housing dairy cows, local climatic requirements for shelter during hot and humid periods, access to resources such as water and a reliable supply of bedding materials, construction costs, ongoing management and maintenance expenses, implications for animal health and welfare, manure and slurry management systems, building lifespan, specific regional and local requirements, and future expansion planning. Another important aspect of housing design and ventilation is that proper building design is essential to ensure adequate ventilation that maintains air quality and temperature throughout the year, regardless of external weather conditions. Ventilation maximizes cow comfort and health by removing excess heat, excess water vapor (from respiration and perspiration), reducing the effects of humidity, removing microorganisms, dust, and gases especially ammonia ensuring uniform air distribution, and minimizing direct drafts on animals.
Dairy cows have a wide thermoneutral zone but are highly sensitive to heat stress and may experience thermal discomfort in environments that humans consider comfortable. The optimal ambient temperature for dairy cows ranges from 0 °C to approximately 20 °C, while temperatures above 21 °C cause heat stress, leading to reduced feed intake and milk production. This makes temperature control crucial for both comfort and productivity.

In Kosovo, the Ministry of Agriculture, Forestry, and Rural Development (MAFRD) (2013–2023), through rural development programs, has supported milk producers with infrastructure grants for dairy barns, including ventilation systems. Investments for dairy cows have included the construction of barns with minimum dimensions of 20.40 m × 10.40 m for both tie-stall and free-stall housing systems, equipped with internal infrastructure such as feed troughs, water supply systems and drinkers, housing areas for adult cows and calves, front and side doors, horizontally positioned windows, installation of internal electrical networks, and a milk room. Additional investments include closed milking systems, milk cooling equipment (milk cooling tanks) with capacities of 500, 1,000, and 2,000 liters, as well as supporting farm infrastructure such as manure storage facilities (liquid and solid), silage bunkers (horizontal systems), and storage facilities for roughage (hangars), in accordance with the criteria established by the MAFRD.

Photos 1, 2, 3: (Photo: Verdi Rexhepi, 2025). Tie-stall farm in Kosovo supported by MAFRD.

Photos 4, 5, 6: (Photo: Medin Zeqiri, 2024). Farm in Kosovo – tie-stall system without natural or mechanical ventilation. Poorly designed farm leading to low production, compromised health, and poor welfare.

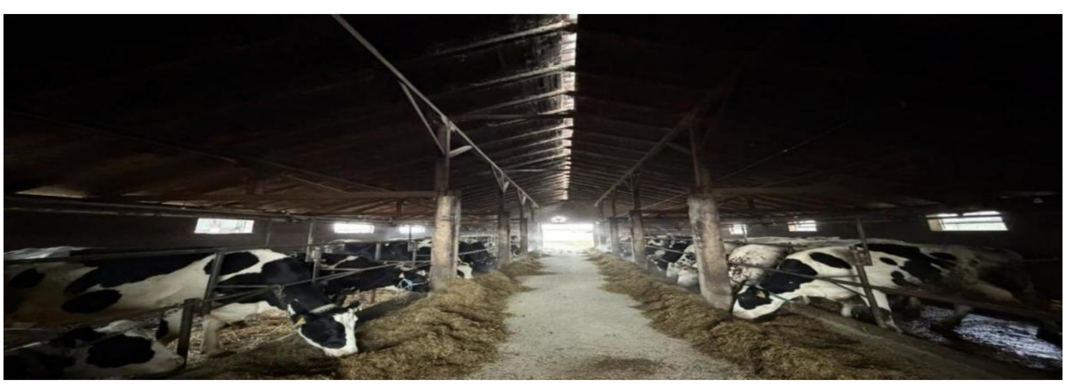


Photo 7: (Photo: Xhevdet Morina, 2025). Farm in Kosovo.

Photo 8, 9, 10: (Photo: Shpetim Shabani, Viti, Kosovo). Tie-stall farm with natural ventilation.

Photos 11, 12, 13: (Photo: Muhamet Shala, 2025, Kosovo). Farm with sidewall openings and natural ventilation (dimensions: 29 m L × 20.5 m W × 6 m H).

Photos 14, 15: (Photo: Fidan Krasniqi, 2025, Prizren, Kosovo). Intensive farm with natural and mechanical ventilation.

Photos 16, 17: (Photo: Fidan Krasniqi, 2025, Prizren, Kosovo). Intensive farm with natural and mechanical ventilation.

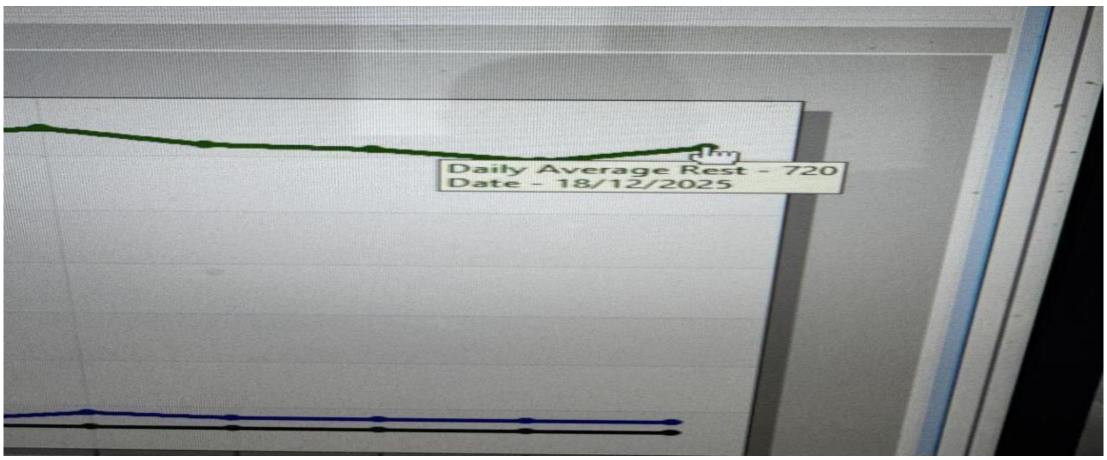


Photo 18: (Photo: Fidan Krasniqi, Dec 18, 2025, Prizren, Kosovo). Screen display: measuring cow rest time using a pedometer.

According to Photo 18, on-screen measurements using a pedometer show that the cow rested 720 minutes, or 12 hours per day, indicating good comfort for the cow in the barn and a well-designed infrastructure, including proper ventilation, lighting, space for movement and rest, good and comfortable bedding, and proper manure management.

Natural Ventilation

Ventilation can be natural, achieved through openings in the barn walls above the height of the animals and through chimneys at the barn roof where air enters through the walls and exits through the chimney. This system uses side openings and roof openings to create air circulation by utilizing wind and the rise of warm air. Under conditions with sufficient wind, natural ventilation systems can achieve 40–60 air changes per hour (ACH), which is sufficient for most warm periods (University of Wisconsin–Madison, 2025).

Mechanical Ventilation

Mechanical or artificial ventilation is achieved through fans installed in barn walls and powered by electricity. There are two types of fans: positive pressure, where the fan pushes air into the barn, and negative pressure, where the fan pulls air out of the barn. In large barns or when wind is insufficient, positive or negative pressure fans are used to ensure constant air circulation and automatic temperature control, especially in long barns or barns with many rows (The Dairyland Initiative, 2015).

Temperature Control and Comfort

Cows are sensitive to the combination of heat and humidity, so ventilation should account for both sensible heat and latent heat transfer, ensuring air circulation in resting areas. Relative humidity should be maintained within 50–80% to avoid pathogen growth and condensation problems. Ideally, the ventilation system should use Temperature–Humidity Index (THI) sensors to automatically control fans based on actual barn conditions (The Dairyland Initiative).

Table 1: Ideal Temperature–Humidity Index (THI) Values for Dairy Cows and the Effects of Temperature and Humidity Changes on Health and Milk Production

THI (Temperature Humidity Index)	Temperature (°C)	Relative Humidity (%)	Condition of Dairy Cows	Effects on Cows	Source
THI ≤68	≤20	50–60	Optimal thermal comfort	Normal production, minimal stress, good health	The Dairyland Initiative
THI 69–72	21–23	40–60	Mild heat stress	Slight reduction in production, increased water intake	The Dairyland Initiative
THI 73–78	24–27	50–70	Moderate heat stress	Noticeable reduction in production, increased risk of disease and reproductive problems	The Dairyland Initiative
THI 79–84	28–30	60–80	Severe heat stress	Major drop in produc-tion, high health risk, re-duced fertility	The Dairyland Initiative
THI > 84	> 30	> 80	Extreme heat stress	High health risk, significant production loss, serious health and reproductive problems	The Dairyland Initiative

Source: University of Wisconsin–Madison (2025). *The Dairyland Initiative.*

Photo 19. Source: extension.psu.edu+2Dairy+2 (University of Wisconsin-Madison, 2025)

Mechanical ventilation is often combined with water-based cooling systems, such as **"cooling pads,"** shown in **Figure 19**. These wetted pads help reduce the temperature of incoming air and, consequently, improve animal comfort during periods of high temperatures. Water can also be used to enhance the cooling process through **fine misting** or an **evaporative cooling system**, which reduces the air temperature before it reaches the cows (University of Wisconsin–Madison, 2025).

According to the **Code of Welfare: Dairy Cattle – New Zealand, Version 2, October 2019**, as well as **Minimum Standard No. 9 – Housing of Cattle and Calves**, natural or mechanical ventilation should be sufficient to maintain temperature and humidity at levels that do not cause heat or cold stress in dairy cows. The ventilation system should also prevent direct exposure of animals to draughts and avoid the accumulation of harmful concentrations of dust and gases.

As an example, according to the above-mentioned guide, for a barn housing **50–100 cows**, the following approximate parameters are recommended:

- **Barn width:** 25–30 m
- **Barn length:** 60–70 m
- **Number of fans:** 10–16

An effective ventilation system should allow **air to enter through the sides and exit through the roof**, while fans should be positioned to ensure effective air movement over the areas where cows are housed. A clean, well-ventilated barn designed to provide adequate animal comfort contributes to cow welfare, helping to **maintain milk production and reduce the risk of disease** (Dairy Cow Housing Guide, 2019).

Photo 20. Source: A good practice guide for dairy housing in New Zealand - Version 2 October 2019

The air requirement per cow is **300 m³/hour,** while the capacity of one fan is **4,000 m³/hour.**

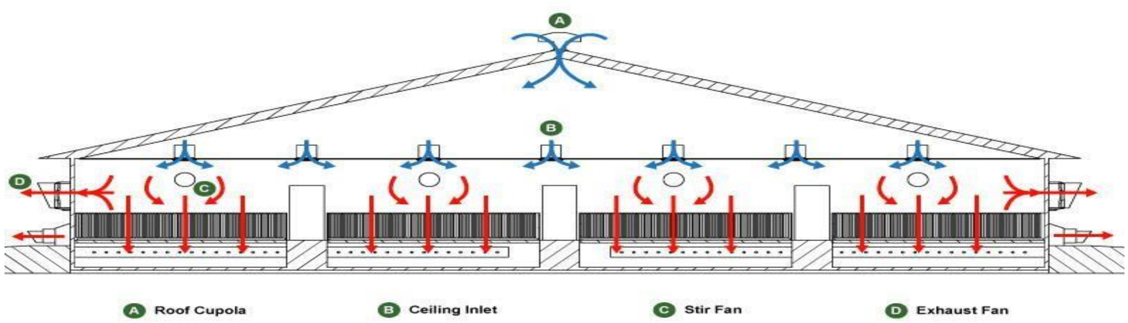


Figure 1: (Source: *A Good Practice Guide for Dairy Housing in New Zealand*, Version 2, October 2019).

A – Roof ridge opening, B – Ceiling air inlet, C – Air mixing fan, D – Exhaust fan
Dairy cow barn ventilation according to Figure 1

Ceiling air inlet (B)
Fresh air enters through the openings in the ceiling.
In winter, the incoming air is directed upward so that it mixes with the warm indoor air, preventing direct cooling of the cows. In summer, greater air intake is allowed to improve natural cooling.
Purpose: To provide fresh air without creating direct draughts over the cows.

Air mixing – Mixing fans (C)
The fans are installed above the alleys or over the areas where cows are housed.
They mix fresh air with indoor air and help improve overall air circulation.
This contributes to reducing humidity, ammonia concentrations and other harmful gases, helping to achieve:
- fewer cases of mastitis;
- improved breathing;
- reduced heat stress.

Horizontal air circulation
Air moves evenly along the barn, preventing the formation of hot or stagnant-air zones.

Exhaust of contaminated air – Exhaust fans (D)
The fans remove warm and humid air together with harmful gases.
They create negative pressure, which helps continuously draw fresh air into the barn.
Contaminated air is removed particularly from areas where it is more likely to accumulate, such as above manure and resting areas.

Natural ventilation – Roof ridge opening (A)
Warm air rises and escapes through the roof ridge opening.
This system is particularly effective during spring and autumn and helps reduce electricity consumption.

Benefits for dairy cows: Increased milk production, reduced heat stress, fewer respiratory problems, reduced humidity and unpleasant odours, improved comfort and enhanced animal welfare.

Practical indicative parameters:
- Ideal temperature: 5–20°C
- Relative humidity: 50–75%
- Air velocity at cow level: 0.1–0.3 m/s in winter and 0.5–1.5 m/s in summer.

Fan placement – see Photo 20
Fans should be installed above the cows, slightly tilted downward and arranged in a row. **Recommended height:** approximately 3 m above the floor; **distance between fans:** approximately 10 m; **diameter:** 1.3–1.5 m.

Photo 21: (Source: *A Good Practice Guide for Dairy Housing in New Zealand*, Version 2, October 2019).

In Photo 21, shows a comfortable and suitable resting stall that allows cows to lie down and rest freely. The resting surface is dry and non-slip, providing appropriate conditions for rest and animal welfare.
Indicative resting stall dimensions: width **1.2 m**, length **2.5 m**. Suitable bedding materials include **sawdust, straw, or rubber mats** (Dairy Cow Housing Guide, 2019).

Photo 22: (Source: *A Good Practice Guide for Dairy Housing in New Zealand*, Version 2, October 2019).

During summer: *The sides of the barn should remain open, and the fans should operate throughout the day.*
During winter*: The sides of the barn should be partially closed while ensuring adequate removal of stale air and sufficient air circulation.*

Tie-Stall Housing for Dairy Cows

Tie-stall barns were once one of the main forms of housing for dairy cows in the United States. In 2007, the USDA reported that 62% of dairy cow barns in the United States still used tie-stall systems. Many of these barns require updating to improve cow comfort and welfare.
Farmers should pay particular attention to details when constructing or remodeling a barn. Proper barn design and accurate dimensions of the resting stalls are essential both for optimizing production and ensuring cow comfort.
The tie-stall system allows for individualized care of each cow. However, like any housing system, it also has some disadvantages. The milking process can be intensive and physically demanding for workers,

as it requires considerable walking, bending, and kneeling. Poor barn design can lead to problems such as lameness, tail injuries, swollen joints, neck injuries, and reduced cow cleanliness.

Barn Design

When evaluating the barn structure, it is important to consider ventilation to ensure good air circulation. Many existing structures have low ceilings, which can restrict air movement and create stagnant-air conditions. This is particularly problematic during summer, when controlling heat stress is essential.

Installing fans can help improve air movement inside the barn. Sprinkler systems are generally not used in tie-stall barns to avoid excessive wetting of the bedding.

Barn orientation is also important. In addition to providing sufficient shade, an east–west orientation can help minimize direct exposure of cows to solar radiation.

When constructing a new tie-stall barn, tunnel ventilation may also be considered. This system consists of one wall equipped with exhaust fans and an open wall on the opposite side, improving air exchange and air circulation within the barn, while also helping to protect cows from direct exposure to sunlight.

Photo 23: (Source: Photo by University of Wisconsin–Madison). Tunnel-ventilated dairy buildings.

Stall Dimensions and Design

Understanding the spatial needs of dairy cows is essential when designing or improving a tie-stall barn. Cows spend most of the day lying down and resting. Disruption of this natural behaviour can have negative effects on production and welfare. Barn design should allow cows to lie down comfortably and rise naturally. Breed is an important factor, but there are also variations within the same breed; therefore, individual measurement of cows is recommended.

Unlike free-stall barns, tie-stall barns allow sections with different dimensions to be provided for cows at different stages of life, such as heifers in their first lactation, lactating cows, and dry cows. This can improve welfare, cleanliness, work efficiency, and management.

Stall Length

Stall length refers to the space in which the cow lies down. It is determined by the space occupied by the cow when lying down, from the knee to the tail. Stall length should be **182–220** cm for adult cows. For heifers in their first lactation, the length is usually approximately **5 cm shorter.**

Stall Width
Studies have shown that insufficient width restricts resting positions and reduces cow comfort. Currently, a minimum width of **137 cm** is recommended for an adult Holstein cow. Cows benefit from additional space. Heifers and lactating cows should have the same minimum width, while dry cows or cows with special needs should have a stall approximately **15 cm wider**. Sufficient space for workers during the milking process should also be taken into consideration.

Bedding
Concrete flooring may be used in tie-stall barns, but it should always be provided with an additional bedding layer, such as **sand or straw**. No surface is sufficient without an appropriate bedding layer. Cow behaviour, health, and production can serve as indicators of their level of comfort. Cows tend to increase their lying time as the amount of bedding increases.

Tie Rail and Chain Length
The tie rail is located at the front of the stall, above the feeding area. Its correct placement is essential to allow proper standing and natural rising movements. The height is calculated by multiplying the cow's hip height by **0.8**. For example, if the hip height is **152 cm**, the tie rail should be positioned approximately **122 cm above the stall floor**. For heifers, the rail is usually positioned approximately **5 cm lower**.
The chain should be neither too long nor too short. A chain that is too long may cause contamination or injuries, while a chain that is too short may restrict natural behaviour and cause neck injuries.

Manure Management
The manure channel is located at the rear of the barn and should be sufficiently sized to allow for the efficient collection and removal of manure. Cleaning can be carried out manually or using a mechanical system.
According to *Frank J.C.M. van Eerdenburg and Lars Erik Ruud (2021),* comfortable free-stall barns that are adapted to the size and needs of cows allow them to rest and express normal behaviour. Comfortable environments are associated with higher milk yield, better udder health, higher milk quality, and improved animal welfare. They can also result in higher income for the farmer compared with environments that are not designed according to the size and needs of the cows.
Furthermore, cows living in a well-designed environment maintain better health and may have a longer productive life. Achieving this requires careful attention to the design and placement of every element of the barn. On every farm, observing cow behaviour, together with signs of conflict between the cow and the barn environment, can serve as a useful tool for assessing the suitability of free-stall design.
In general, an optimal free-stall barn should, first and foremost, have a **clean, dry, and soft floor** suitable for resting. A floor slope of approximately **3%** can help keep the barn clean.

The free-stall barn should provide cows with sufficient traction and adequate space to express normal behaviours, including:

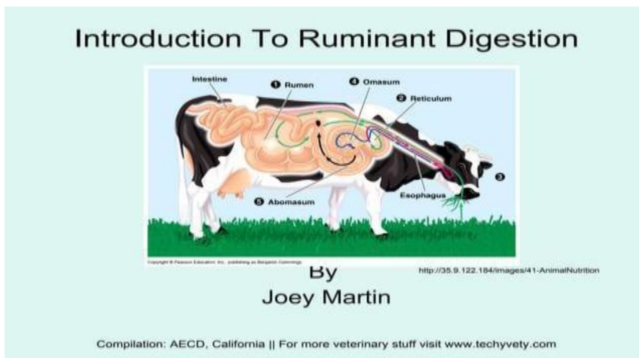
- sufficient space for the forward extension of the front legs;
- sufficient space to stand or lie laterally, with adequate free space for the neck and head;
- sufficient resting space for the legs, udder, and tail to remain on the resting platform; and
- most importantly, sufficient space for the body to move forward or, secondarily, sideways during the lying-down and rising movements.

Clean milking procedures and strict milk hygiene protocols

Kinds milk	Categorization	Microorganisms	Somatic Cell	Correction
Cows Milk	Extra Class	≤ 80.000	≤ 300.000	1.15
	Class I	≤ 100.000	≤ 400.000	1.00
	Class II	≤ 300.000	≤ 500.000	0.95
	Class III	≤ 500.000	≤ 750.000	0.80

Table 2. Standards of Quality and Classification of Raw Milk in Kosovo / Source: Administrative Instruction (MAFRD) No. 02/2025.

Diets should be balanced and include fresh grass, high-quality hay, silage, concentrates, mineral supplements, and clean water to ensure higher milk production and better milk quality.



Source: Joe Martin

Factors Determining Milk Production and Quality

1. **Physiological factors:** Cow breed, feeding, health status, stage of lactation, stress, and cow welfare.
2. **Milking and hygiene:** Cleanliness of the animals and barn, hygiene of milking personnel and equipment, hygienic practices during milking, and the risk of microbial contamination.
3. **Storage and transport factors:** Milk storage temperature in the bulk milk cooler, which should be approximately 4°C, as well as the conditions and equipment used for milk storage and transport.
4. **Physicochemical composition:** Specific gravity, freezing point, temperature, percentage of fat, protein and lactose, milk pH (usually 6.6–6.8), and water content.
5. **Organoleptic parameters:**
    - **Colour:** should be white to creamy white.
    - **Taste and odour:** should be free from foreign tastes, abnormal acidity, or unpleasant odours.
    - **Consistency:** should be uniform.

Main Milking Practices

Good milking practices for dairy cows are divided into:

- **Practices before milking;**
- **Practices during milking;**
- **Practices after milking.**

(Guide to Good Dairy Farming Practices, Northern Ireland Regulations 2006).

Cow and Milking Hygiene

- Cows should have a clean and dry area for resting. Regularly check udder health.
- Monitor cows during the late lactation period and throughout the dry-off period. Ensure that the necessary dry-cow therapy is applied, where appropriate and as recommended by a veterinarian, including the use of the **California Mastitis Test (CMT).**
- Keep records of all treatments related to mastitis infections.
- Check milk for any physical, chemical, or organoleptic abnormalities.
- Surfaces that come into contact with milk should be cleaned and disinfected immediately after each milking. All equipment should be kept clean and in good working condition.
- Milk storage equipment, such as milk cans and bulk milk cooling tanks, should be cleaned and disinfected after each use and maintained in good condition.
- Ensure that sufficient quantities of clean water are available for cleaning the udder, equipment, hands, and contaminated floors during and after milking.
- Take measures to control insects, rodents, and birds in the milking area in order to prevent contamination.
- Regularly check milking equipment for vacuum level, **pulsation frequency, and pulsation ratio.**
- Portable equipment should be cleaned between each milking. Mineral deposits, fat residues, and milk protein residues should be removed. Effective cleaning can be carried out using hot water, disinfectants, or other appropriate chemical agents.
- Neglecting equipment cleaning, even on a single occasion, may result in the rejection of the next milk delivery following quality testing and, consequently, the rejection of subsequent milk deliveries.

Step-by-Step Milking Procedure

- Hands should be thoroughly washed before starting the milking process and kept clean and dry before each milking.
- Fingernails should be kept short and free of nail polish.
- Where possible, clean gloves should be worn during milking.
- Work clothes should be clean and used exclusively in the milking area.

Why is this important?

Milk contamination can originate from the milker’s hands and clothing. According to FAO (2011), approximately 60% of microorganisms found in raw milk may be associated with poor hygiene practices among operators.

Gloves

Milkers’ hands are difficult to wash thoroughly; therefore, wearing gloves is recommended. Fewer bacteria remain on gloves.

First Streams of Milk
Discard the first streams of milk into a separate bucket:

- to prevent the spread of bacteria that cause mastitis in the environment;
- to detect signs of clinical mastitis.

California Mastitis Test (CMT)
Use the California Mastitis Test (CMT) regularly to detect subclinical mastitis.
Use the CMT specifically:

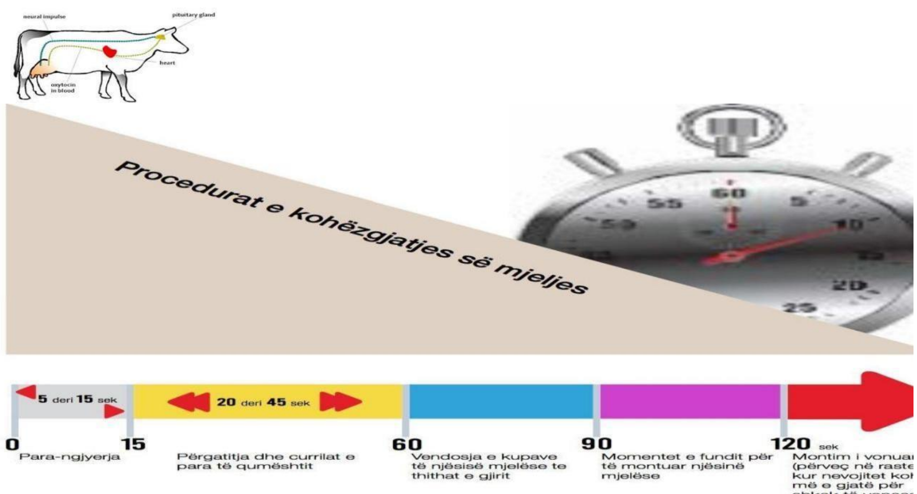
- after mastitis treatment;
- before the drying-off period;
- at the beginning of lactation.

Reducing a high somatic cell count (SCC) may take a long time.

Pre-milking cleaning/disinfection
Wash the teats with a cleaning, disinfecting, and treatment solution. Do not wet the entire udder; focus on the teats.

Teat drying
Dry the teats with a paper towel. Pay particular attention to the teat ends.

Hygiene During Milking: The number of milkings per day has a significant impact on milk production. Milking three times a day at regular intervals can increase milk production by 10–20% compared with milking twice a day (Graves et al., 2007).
Milking is carried out either by hand or using milking machines and usually takes 5–8 minutes. The use of milking machines offers clear advantages over hand milking, as it avoids direct contact between the udder and the hands, helps maintain milk hygiene, reduces milking time, and minimizes mechanical stress on the udder (J.D.H.M. Miltenburg et al., 2004).
Hygiene during the milking process is crucial. Hands, containers (buckets, cans), and the animal's udder should be cleaned and disinfected before milking. Disinfection after cleaning with products such as iodophors or hypochlorite significantly reduces the microbial load (Ruegg, 2003).
Attach the milking machine immediately before opening the teats.



Source:
https://www.scribd.com/document/128991817/Www-delaval-com-12Golden-Rules-for-Milk-ing?utm_source=chatgpt.com

Post-Milking Cleaning/Disinfection
Immediately after milking, clean and disinfect the milking clusters. Remove the teat cups promptly to avoid teat damage. After use, clean and disinfect the milking clusters properly. Choose a teat cleaning/disinfecting product with appropriate viscosity, optimal treatment properties, and effective disinfectant properties.

Disinfection of Milking Cups
Immediately after milking, clean and disinfect the milking cups. Remove the teat cups in a timely manner to avoid teat damage. Select a wash/disinfectant with the correct viscosity, optimal treatment, and disinfecting properties.

After Milking
Keep the cows standing for about 30 minutes after milking to reduce the risk of infection, as the teat canal remains open for up to 30 minutes after milking.

The milk should be cooled immediately in the milk cooling tank to a temperature of 4–6 °C and should not be left in the barn, as it may absorb odors from the barn environment. After milking, clean the milking machine and all other equipment that has come into contact with the milk.

The milking machine and other equipment used during milking should first be rinsed with cold water until the water runs clear.

Then, prepare the alkaline solution. If the concentration of the alkaline solution is 80%, add 50–80 ml of the solution to 10 liters of water. The water should be at a temperature of 60–70 °C. Use this solution to clean all milking equipment, and allow the equipment to remain in the solution for approximately 10 minutes. Always follow the manufacturer’s instructions regarding concentration, temperature, and contact time.

Milking equipment should be cleaned with an acid solution once or twice a week, depending on the chlorine content of the water. Prepare the acid solution by mixing 50–80 ml of acid with 10 liters of water. Use this solution to clean all milking equipment. The water temperature during cleaning should be 60–70 °C, and the cleaning process should last approximately 5 minutes. Special cleaning brushes should be used for cleaning.

Photo

25, 26 |

Photo: Muhamet Shala (2025, Kosovo) - Milking platform and milk storage in tank

Photo 27: Medin Zeqiri, Gjilan | Photo 28: Ferma Bjellopoja, Istog Bjellopoja Istog

Photo 29 | Photo: Medin Zeqiri, adapted from milk equipment

After each milking, regularly clean the milking machines and equipment with clean, hygienic water and store them in the appropriate place, as shown in the photos above: 25, 26, 27, 28, and 29.

According to FAO, milking machines and equipment should be maintained and inspected as follows:

- **Weekly inspection:** Check the operation of the pulsator on all milking clusters by placing the thumbs on the teat cups (liners).

a) Check the pulsation ratio between the compression and release phases.
b) Check the number of pulsations per minute.

Inspect all rubber tubes for bending, crushing, or damage, particularly the short pulsation tubes and milk tubes, for cracks or holes. Replace them if necessary.
Most pulsators are designed to operate within a range of 50–60 pulsations per minute. The pulsation rate can also be checked during milking by applying light pressure to a short pulsation tube with the thumb and index finger.

- **Monthly inspection:** Disassemble and clean weight-operated vacuum regulators. Use a soft brush and a solvent, such as methyl alcohol (denatured alcohol), taking care not to damage the valve surfaces. Follow the manufacturer's instructions.
- **Annual inspection:** A complete inspection of the milking machine should be carried out once a year by an experienced technician, in accordance with the international standards **ISO 5707, "Milking Machine Installations – Construction and Performance"**, and **ISO 6690, "Milking Machine Installations – Mechanical Tests."**

Collection and Storage of Organic Waste

Animal waste (manure) should be collected in a designated area, ideally in a structure protected from rainfall, to prevent nutrient losses. This helps preserve the valuable components of the manure and minimizes water pollution.

Plant residues after harvesting, such as leaves, dry straw, etc., should be collected in manageable quantities and stored in dry, protected areas. Proper management of these residues allows them to be used as organic material and contributes to improving the quality of organic fertilizer.

Monitoring Animal Welfare Indicators to Improve Productivity and Compliance

People should be patient. Cows are living and sentient beings. Remember that this is the "House of Mothers." Treat every cow as you would treat your own mother. Giving milk is a characteristic of motherhood; rough handling reduces milk secretion. This harms both me and the cow. Always keep this idea in mind when handling cattle. *(W. D. Hoard, 1885, Hoard's Dairyman).*

According to a manual prepared by the IPESA project team (2019), Ministry of Agriculture of Albania, cattle health on a dairy farm is an essential part of good husbandry and an animal welfare programme. One of the foundations of animal welfare is ensuring that animals are free from pain, injury, and disease. Diseases can be prevented through herd health programmes, healthy nutrition, and good management practices that improve animal welfare.

If disease is present, diagnosis should be carried out immediately and appropriate treatment should be provided. A dairy farm maintains cattle health by providing appropriate feed, adequate housing, as well as measures for disease prevention and treatment. © 2019 – IPESA Project

The welfare of animals whose survival depends on humans is based on the concept of the Five Freedoms (Webster, 2001):

1. Freedom from hunger and thirst
2. Freedom from pain, injury, and disease
3. Freedom from fear and distress
4. Freedom from discomfort
5. Freedom to express normal behaviour

Freedom from Hunger and Thirst

- By continuously providing **fresh water and sufficient, accessible feed** to keep the animal healthy and strong.

Photo: Medin Zeqiri (2020, Viti, Kosovë)

Photo: Shqiperia.com

Freedom from Pain, Injury and Disease
By providing a safe and suitable environment where the animal cannot injure itself or other animals, as well as ensuring the timely prevention, diagnosis, and treatment of diseases.

Photo: Shqiperia.com

Freedom from Fear and Stress

Preventing physical or psychological abuse by people or other animals, as well as avoiding high temperatures and excessive heat to reduce stress.

Providing good living conditions, including **adequate ventilation, natural lighting, sufficient space for movement, and a calm environment during milking**.

Photo: Shqiperia.com

Freedom from Discomfort

Providing sufficient space for normal behaviour, feeding, and resting.

Photo: Shqiperia.com


Freedom to express natural behaviors

Providing sufficient space for movement, contact with other animals of the same species, and a stimulating environment to prevent boredom.

Foto: Shqiperia.com


Foto: Shqiperia.com


Source: Free Farm Animal Welfare Photos

Why Should We Monitor Animal Welfare on the Farm?

A farm with healthy animals and a good level of animal welfare has the potential for higher productivity, better product quality (milk, meat, etc.), as well as fewer diseases and losses.

Systematic welfare monitoring helps identify and prevent stress, abnormal behaviours, diseases, and inadequate housing conditions. It also helps identify the need for interventions that can improve animal health, welfare, and farm efficiency.

Standardizing indicators and using science-based protocols ensures the application of reliable methods for responsible animal management practices. It also contributes to increasing product credibility in the market and among consumers.

Some Specific Studies and Protocols

How Can You Use This Table as a Farmer?

Measure the indicators regularly, on a weekly or monthly basis, record changes and trends, and compare them with the relevant standards. This will help you assess whether the barn and farm conditions provide an appropriate environment for animal welfare. Systematic monitoring helps identify and prevent health problems, as well as improve milk productivity and quality.

Table 3. Welfare and Productivity Indicators for Dairy Cows/

Category	Indicator	How Measured & Why It's Important	Reference Value / Standard
Housing	Comfort at Rest	Lying time and comfort	Clean environment, sufficient space
	Thermal Comfort	Temperature / humidity in the barn	Avoid overheating or excessive cold
	Freedom of Movement	More movement = less stress	Enough space to move and lie down
Feed & Water	Hunger	Feeding frequency and body condition	Cows should not suffer from hunger
	Thirst	Clean and sufficient water daily	Water must be clean and accessible
Health	Disease / Morbidity	Number of disease cases (lameness, mastitis)	Fewer cases = better welfare

Behavior & Reactions	Normal Social Behavior	Expression of natural behaviors (feeding, resting, calm)	Abnormal behavior indicates stress
	Stress Behavior	Agitation, aggression, loss of appetite	Helps identify welfare problems
Productivity	Average Milk Yield / Day	Average liters per cow per day	Higher milk yield = higher farm productivity
	Milk Quality	Fat / protein content	Related to overall animal welfare
Performance	Reproduction	Interval between calvings, conception	Reproductive health is linked to welfare

Source: Welfare Quality (2023)

Table 4. Indicators (Barn Design, Reproductive Management, Behavior, Comfort) in Relation to Welfare

Type of Indicator	Positive Impact (Welfare and/or Productivity)
Barn, housing, and equipment design considering animal behavior in barn layout and management	A suitable environment reduces stress and injuries, allows smoother and more effective movement, and improves health and comfort.
Careful reproductive management	Reduces stress for the mother and offspring, lowers health problems, and supports better reproductive re- cover and post-calving welfare.
Behavior monitoring to detect disease early (e.g., gait analysis to predict lameness)	Earlier detection = faster treatment = better health and fewer productive losses.
Positive human–animal interactions (calm, gentle, respectful handling)	Animals are less stressed, display normal behavior, and have more trust, which positively affects growth, reproduction, and ease of milking/management.
Addition of “behavior/comfort facilities” — e.g., space for movement, social separation/space, appropriate staff, opportunities for natural behavior	Helps animals express natural behavior, stay healthy, improve reproduction, enhance welfare, and increase productivity potential.

Source: Management of livestock behaviorto improve welfare ad product

Why Is It Important for Farms?
The benefits are not limited to animal welfare but also include economic and productive benefits: fewer diseases, lower losses, higher efficiency, and increased production (milk, meat, reproduction, etc.).

Suggestions for Adaptation to the Kosovo Context
Given that farms and agricultural practices in Kosovo are often small- to medium-scale, while technological and financial resources may be limited, the following is recommended:

- Use practical and easy-to-measure indicators, such as those included in protocols for sheep, cattle, etc.
- Combine routine monitoring with more comprehensive periodic audits.
- Provide training for farmers and veterinarians to understand the importance of animal behaviour and welfare, not only for assessment purposes but also for improving productivity and animal health.
- Develop and maintain farm documentation, including checklists, monitoring schemes, and rules for housing, feeding, hygiene, behaviour, etc.

General Situation

The overall situation presented in the material clearly shows that the welfare of dairy cows and the quality of milk production are closely linked to barn design, ventilation, temperature control, milking hygiene practices, waste management, and continuous monitoring of welfare indicators.
Well-designed housing, with sufficient space, effective natural or mechanical ventilation, and appropriate thermal conditions, directly contributes to the health, comfort, and productive lifespan of cows.

Cows are particularly sensitive to heat and humidity stress. Therefore, maintaining temperatures within the thermoneutral zone and ensuring continuous air circulation are key elements for preventing disease, reducing stress, and maintaining milk production.
In Kosovo, through programmes of the Ministry of Agriculture, Forestry and Rural Development, significant progress has been made in improving barn infrastructure, including the construction of modern barns, installation of ventilation systems, provision of water supply, and the introduction of equipment for milking and milk storage.

However, the material indicates that farms with inadequate design and insufficient ventilation still exist, which may result in lower production, increased risks to animal health, and inadequate welfare. This highlights the need for continued investment, better planning, and the implementation of modern housing standards.
Natural ventilation through side openings and roof ridges, as well as mechanical ventilation using appropriately positioned fans, plays an essential role in removing heat, humidity, harmful gases, and microorganisms from the barn. Combining these systems with modern technologies, such as temperature-humidity index (THI) sensors and water-based cooling systems, can significantly improve cow comfort, particularly during hot periods.

Behavioural monitoring data, such as resting time measured using pedometers, indicate that cows living in well-designed environments rest more, are calmer, and show better welfare indicators.
Another critical component is milking hygiene and milk quality. Strict hygiene protocols before, during, and after milking, regular maintenance of equipment, and immediate cooling of milk are essential for achieving the quality standards established in Kosovo.

Incorrect milking practices, poor hygiene, or inadequate equipment maintenance may lead to increased microbial loads, elevated somatic cell counts, and, in some cases, rejection of milk on the market. Therefore, farmer training and adherence to technical guidelines are essential for the economic sustainability of farms.

Manure management and the separation of organic waste are another important element. Proper collection and storage of animal manure and plant residues help preserve nutrients, reduce environmental pollution, and improve the quality of organic fertilizer for agricultural use. This approach contributes not only to environmental protection but also to the economic efficiency of the farm.

Finally, the material emphasizes the importance of continuous monitoring of animal welfare based on the concept of the Five Freedoms. Ensuring sufficient food and water, preventing pain and disease, reducing stress, providing comfort, and allowing animals to express natural behaviours are fundamental to a functional and productive farm. A farm that invests in animal welfare, good housing, hygiene, and careful management can achieve not only higher welfare standards but also increased production, better milk quality, and greater market credibility.

Key Stakeholders and Their Roles in the Programme / Integrated Water Resources Management (IWRM) System in Kosovo

Stakeholders	Role
Ministry of Environment, Climate and Spatial Planning	Lead authority for water policy, legislation, and implementation of national water management strategies. Oversee IWRM planning and coordination among other stakeholders.
Ministry of Agriculture, Forestry and Ru-ral Development (MAFRD)	Manage water use for agriculture, irrigation, and rural development projects. Ensure sustainable water use in agricultural sectors.
Water and Wastewater Utilities (e.g., regional water companies)	Provide water supply and sanitation services, manage water distribution networks, and implement water quality standards.
Local Municipalities / Local Governments	Implement local water management plans, maintain local water infrastructure, and engage communities in water conservation initiatives.
Environmental Protection Agencies / Inspectorates	Monitor water quality, enforce regulations, and ensure compliance with environmental standards.
Civil Society Organizations (CSOs) / NGOs	Advocate for sustainable water use, raise public awareness, and support community-based water management initiatives.
Academia and Research Institutions	Provide scientific research, data collection, and analysis to support evidence-based water management decisions.
International Donors / Development Partners	Provide technical and financial support for IWRM programs, capacity building, and implementation of water-related projects.

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MATERIAL 3. FEED MANAGEMENT AND NUTRITIONAL MANAGEMENT OF DAIRY COWS

Assoc. Prof. Dr. Behlul Behluli
Associate Professor, Department of Veterinary Medicine
Faculty of Agriculture and Veterinary Medicine
University of Prishtina, Kosovo

Executive Summary

Feeding dairy cows remains one of the main challenges for farmers in Kosovo, particularly due to the poor quality of forage used on most farms. Forage forms the basis of the diet and directly affects cow health, diet digestibility, and milk production levels. Its quality is determined by cultivation practices, harvesting time, and conservation methods. Unbalanced rations and poorly preserved feed led to reduced milk production and increased manure output. Focusing on the production of high-quality forage and on proper ration balancing is essential for the sustainability of dairy farms.

Introduction

Feeding dairy cows continues to be one of the most limiting factors affecting productivity and herd health on farms in Kosovo. Even today, the quality of feed used on most farms is unsatisfactory, making feeding a structural challenge for the dairy sector.

General Situation

The main problem in feeding dairy cows is related to the quality of forage, which constitutes the basic and major component of the diet. Forage is a relatively fixed component that is used throughout the year and accounts for at least half of the total dry matter of the ration. Cow health and the efficiency of milk production depend to a large extent on the quality of this feed. At least 50% of milk production should come from forage. For this reason, its quality should be as high as possible. In practice, many farmers try to compensate for poor-quality forage by increasing the amount of concentrate; however, concentrate is not a natural feed for cows and cannot replace the nutritional value of high-quality forage.

Feed Management and Dairy Cow Feeding Management

A typical daily ration for a dairy cow contains approximately 50 kg of total feed, consisting of around 30 kg of corn silage, 10 kg of grass silage, 2 kg of dried alfalfa, and 8 kg of concentrate. After removing the water, this amount corresponds to approximately 22 kg of dry matter. Of this amount, 2.5 to 3 kg of undigested material should remain in the digestive tract, consisting mainly of lignin. This undigested material is essential for the normal functioning of the digestive system and for maintaining the cow's health. Any reduction in diet digestibility leads to reduced milk production and increased manure output.
The quality of forage depends on several key factors. High-quality crop cultivation provides healthy raw material rich in nutrients. Harvesting time is also crucial. Corn should be harvested at the dough stage, with 28–35% dry matter; wheat, barley, and triticale at the same stage, with 28–40% dry matter; rye before ear emergence; while alfalfa and mixed grasses should be harvested at the 10–15% flowering stage, with 30–35% dry matter. The younger the plant is at the time of harvest, the higher its digestibility, whereas as the plant matures, digestibility decreases significantly.
Another critical factor is feed conservation. Moldy or spoiled feed damages the rumen microflora, reduces milk production, and in severe cases can be fatal to the cow. Therefore, drying, fermentation, and storage processes must be properly controlled and carried out according to appropriate standards.
Ration balancing represents the most critical stage of feeding management. A ration that is not properly balanced in terms of energy, protein, or fiber leads to digestive problems, reduced feed efficiency, and lower milk production. In conclusion, the higher the quality of the forage, the higher its digestibility, the

greater the milk production, and the lower the amount of undigested feed. Conversely, poor-quality forage reduces digestibility, lowers milk production, and increases manure output. For this reason, farmers should focus on producing high-quality forage and selecting appropriate feed products according to the needs of their herd.

“Those who are unwilling to change and learn will eventually lose even what they are trying to preserve.”

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MATERIAL 4. COW HEALTH AND DISEASE PREVENTION (THE PRODUCTIVE POTENTIAL OF DAIRY COWS AND THE IMPACT OF DIS-EASES ON THEIR PERFORMANCE)

Assoc. Prof. Dr. Behlul Behluli
Associate Professor, Department of Veterinary
Faculty of Agriculture and Veterinary
University of Prishtina, Kosovo

Executive Summary

Cow health and a balanced diet are key prerequisites for fully utilizing the productive potential of dairy cows. Metabolic disorders, mastitis, hoof problems, and reproductive disorders reduce feed intake, milk production, and the economic efficiency of the farm. Prevention through quality feeding, proper management, and regular health care is the most effective way to maintain productivity and the sustainability of dairy farms.

Introduction

The health of the dairy cow is a fundamental prerequisite for utilizing its productive potential and ensuring the economic performance of the farm. In practice, milk production depends not only on the animal's genetic potential but, above all, on its health status and on how feeding and the daily ration are managed. Healthy cows are able to consume sufficient amounts of dry matter (DM), providing the energy required for high and sustainable milk production. In contrast, any health problem is immediately reflected in reduced appetite, lower daily feed intake and, consequently, lower milk production, while manure production may increase.

On dairy farms, diseases are not only veterinary problems but also factors that directly affect feed efficiency and production costs. If a cow cannot efficiently convert the feed it consumes into milk, the farm's daily and annual losses increase. This is particularly evident when metabolic disorders such as ketosis and acidosis, mastitis, hoof problems, and reproductive disorders occur. These conditions reduce feed intake, disrupt metabolic balance, and significantly decrease the cow's productive performance. Therefore, this chapter addresses the relationship between health, nutrition, and performance, emphasizing that disease prevention and proper ration management are among the most effective ways to maintain productivity, reduce economic losses, and ensure the long-term sustainability of dairy farms.

Genetic Potential and the Impact of Health on Production

The genetic potential of a dairy cow can only be fully utilized when the animal is healthy and fed a balanced, high-quality ration. Healthy cows consume sufficient amounts of dry matter (DM), providing the energy required for optimal milk production. In contrast, sick cows consume less feed, resulting in reduced energy availability and, consequently, a significant decline in milk production, while manure production may increase.

Feed Efficiency (DM) and Performance

Feed efficiency is a key indicator of cow performance: the more litres of milk produced per 1 kg of DM, the higher the efficiency of feed utilization. Values may range, for example, from 1.7 L/kg (high efficiency) to 1.0 L/kg (low efficiency), representing considerable differences in daily productivity.

Common Diseases in Dairy Cows and Their Impact
The main diseases that reduce milk production and feed intake on dairy farms include:

Ketosis and Acidosis
Ketosis and acidosis are metabolic disorders that may be associated with an unbalanced ration and insufficient or inappropriate energy supply.
They can reduce daily feed intake and cause a decline in milk production, particularly during critical stages of lactation.
Diagnosis and treatment should be carried out by a veterinarian, while prevention relies on providing a high-quality, balanced ration and proper management of the transition period.

Mastitis (Udder Diseases)
Mastitis is an inflammatory disease of the udder primarily associated with infections and poor hygiene, as well as deficiencies in milking management. It can occur in a clinical (visible) or subclinical (hidden) form.
Prevention requires the implementation of good milking hygiene practices, proper maintenance of milking equipment, environmental hygiene, and appropriate udder health management.

Hoof Diseases
Hooves are essential for cow movement and access to feed and water.
Cows with hoof problems move less, consume less feed, and may experience a significant decline in milk production.
Hoof trimming should be carried out regularly, generally at least twice a year, as well as immediately when clinical signs or visible problems occur.
Poor nutrition, unsuitable housing conditions, and inadequate regular hoof care can result in significant economic losses.

Reproductive Disorders
Successful reproduction is essential for maintaining production continuity on dairy farms. Without regular reproduction, the production of calves and herd replacement cannot be ensured, while milk production is negatively affected.
Cows that calve at optimal intervals can maintain a more efficient production cycle, whereas extended calving intervals may negatively affect farm productivity and profitability.
One important indicator for assessing reproductive management is the **average number of days in lactation of the herd**, which should be interpreted in relation to herd structure, calving patterns, and farm objectives.
Excessively prolonged lactation intervals may result in production and income losses. For example, two farms with 20 cows each, where one has an average of 180 days in lactation and the other 205 days, have a difference of 25 days. If a loss of 0.1 L of milk/day is assumed for each day above the reference level, this could translate into a considerable annual production loss. **However, these figures should be verified against the methodology used and actual farm data before being presented as an economic indicator.**

MATERIAL 5: INTEGRATED APPROACHES TO SUSTAINABLE MANURE MANAGEMENT, WATER RESOURCE PROTECTION, AND LONG-TERM IMPROVEMENT OF SOIL FERTILITY

Gursel Arifi, Expert

Introduction

Sustainable manure management is one of the key pillars of modern agriculture, particularly on livestock farms. When manure is properly handled, stored, and applied, it can be transformed from a farm by-product into a valuable resource for improving soil fertility, increasing agricultural yields, and protecting water resources. In contrast, poor manure management can lead to nutrient losses, contamination of surface and groundwater, greenhouse gas emissions, and long-term damage to the environment and human health.
This material has been prepared to provide an integrated and practical approach to manure management, combining technical knowledge with good agricultural practices and environmental standards. The material is structured into three main sessions, which complement one another and aim to support farmers, agricultural advisors, and rural sector stakeholders in the proper management of manure.

Session 1 focuses on the fundamentals of manure management, explaining its nutrient composition, the role of nitrogen, phosphorus, potassium, and organic matter, as well as the benefits and risks associated with the use of manure in agriculture. This session provides a solid knowledge base on the value of manure as a fertilizer and its impact on long-term soil fertility and the environment.

Session 2 addresses the practical aspects of manure handling, storage, and use on the farm. This session includes guidance on the construction and management of storage facilities, the separation of solid and liquid manure, minimization of nutrient losses, composting, and safety measures. The session aims to help farmers preserve the nutrient value of manure while simultaneously reducing environmental and health risks.

Session 3 focuses on the application of manure to improve soil fertility, emphasizing the importance of proper timing, application rates, and application techniques. This session covers good practices for preventing nutrient losses during application, protecting water resources, calibrating manure spreaders, and integrating manure with mineral fertilizers. The main objective is to ensure the most efficient use of manure in accordance with crop requirements and the principles of sustainable agriculture.

Overall, this material aims to contribute to increased awareness and practical capacity for sustainable manure management, helping to protect natural resources, improve agricultural productivity, and strengthen the long-term sustainability of farms.

SESSION 1

1. FUNDAMENTALS OF MANURE MANAGEMENT

Manure is one of the most valuable natural resources available on a dairy farm. When properly handled and applied, it provides a balanced supply of essential nutrients for plants, improves soil structure, increases organic matter content, and supports long-term soil fertility. This session explains the **importance of manure as a fertilizer**, the reasons why its nutrient content varies, and how farmers can use it efficiently while protecting the environment at the same time.

Understanding manure begins with understanding its composition and how its components behave in the soil. Every decision made by a farmer – such as how manure is stored, when it is applied, and how quickly it is incorporated into the soil (covered with soil) – affects nutrient availability, crop performance, and the potential for nutrient losses.

2. NUTRIENTS IN CATTLE MANURE

Cattle manure contains several **key plant nutrients** that are essential for crop growth and maintaining soil fertility. It is a rich source of nitrogen (N), which promotes leaf development and overall plant growth; phosphorus (P), which supports root development, flowering, and energy transfer; and potassium (K), which strengthens plants, improves drought resistance, and enhances the quality of fruits and seeds.

In addition to these major elements, cattle manure also provides other elements, such as calcium, magnesium, and sulfur, as well as trace elements such as zinc, copper, and manganese, which are important for specific physiological functions in plants. Beyond its nutrient value, the **organic matter** contained in manure improves soil structure, water-holding capacity, and microbial activity, thereby supporting long-term soil health and productivity.

Nitrogen (N)

Nitrogen (N) is one of the most important nutrients for plant growth and development, as it directly influences the formation of strong leaves with an intense green color. This element is essential for the synthesis of proteins and chlorophyll, the pigment that enables photosynthesis and normal plant growth. Without an adequate supply of nitrogen, plants grow more slowly and yields decline significantly.

In organic manure, nitrogen is found mainly in two forms. The first is **organic nitrogen**, which is released gradually and becomes available to plants only after it is decomposed by soil microorganisms. This form provides a more sustained source of nutrients for plants during the growing season. The second form is **ammonium nitrogen (NH_4^+)**, which is immediately available to plants but is also highly susceptible to losses through volatilization if manure is left on the soil surface.

For this reason, **incorporating manure into the soil or covering it after application within 12–24 hours** is an important agricultural practice. This measure helps reduce nitrogen losses by approximately 40–60%[1], increases the efficiency of nutrient use by plants, and, at the same time, protects the environment from air and water pollution.

Phosphorus (P_2O_5)

Phosphorus (P) is an essential nutrient for healthy plant development, particularly during the early stages of growth. It plays a key role in the development of strong and deep root systems, enabling plants to absorb water and nutrients from the soil more effectively. Phosphorus is also essential for the movement and transfer of energy within the plant.

In organic manure, phosphorus is relatively stable and is not lost through volatilization, as occurs with nitrogen. However, the main risk is associated with **surface runoff and leaching**, particularly when manure is applied to the soil surface or on sloping land. In such cases, phosphorus can be transported into rivers and other water bodies, causing pollution and environmental problems such as algal blooms.

Controlled use of phosphorus-containing manure is particularly suitable for crops with high phosphorus requirements, such as maize, alfalfa, and wheat[2]. When applied at the appropriate rate and time, phosphorus improves yields, strengthens the root system, and supports the sustainable development of crops.

Potassium (K_2O)

Potassium (K) is a very important nutrient for strengthening plants and maintaining their overall resilience. It plays a key role in regulating water within the plant, increasing drought resistance and helping plants better withstand climatic stress conditions. In addition, potassium improves resistance to diseases, strengthens plant tissues, and contributes to balanced crop development.

This nutrient is particularly important for crops with high potassium requirements, such as maize, forage grasses, and alfalfa, which remove considerable amounts of potassium from the soil during harvesting or frequent cutting. An adequate supply of potassium helps maintain high yields and good production quality, particularly in intensive forage production systems.

An important advantage of the potassium present in manure is that most of it is in a soluble form. This means that potassium becomes available to plants immediately after manure application, providing a rapid and efficient supply of this nutrient without requiring prolonged decomposition processes in the soil.

Lënda organike – ndërtuesja e tokës

Plehu i lopëve është një burim shumë i rëndësishëm i lëndës organike, e cila luan një rol kyç në përmirësimin e cilësisë dhe pjellorisë së tokës. Lënda organike ndihmon në përmirësimin e strukturës së tokës, duke e bërë atë më të ajrosur dhe më të lehtë për t'u punuar. Tokat me strukturë të mirë mundësojnë zhvillim më të shëndetshëm të rrënjëve dhe përthithje më efikase të ujit dhe lëndëve ushqyese.

Një tjetër përfitim i rëndësishëm i lëndës organike është rritja e kapacitetit të tokës për të mbajtur ujin, çka është veçanërisht e rëndësishme në zonat me mungesë reshjesh ose gjatë periudhave të thata. Plehu ndihmon gjithashtu në parandalimin e ngjeshjes së tokës, duke ruajtur porozitetin dhe duke përmirësuar qarkullimin e ajrit dhe ujit në profilin e tokës. Kjo krijon kushte më të favorshme për rritjen e bimëve dhe aktivitetin biologjik të tokës.

Lënda organike nga plehu ushqen mikroorganizmat e dobishëm të tokës, si bakteret, kërpudhat dhe organizmat e tjerë të tokës, të cilët janë thelbësorë për shpërbërjen e materialeve organike dhe çlirimin gradual të lëndëve ushqyese. Ky proces siguron një furnizim më të qëndrueshëm me lëndë ushqyese gjatë gjithë sezonit të rritjes. Aplikimi i rregullt i plehut rrit përmbajtjen e lëndës organike në tokë, përmirëson pjellorinë e përgjithshme dhe kontribuon në produktivitetin afatgjatë të tokës bujqësore.

Secondary Nutrients in Cattle Manure

In addition to the primary nutrients, cattle manure also contains important secondary nutrients that are essential for healthy plant development, such as sulfur (S), calcium (Ca), and magnesium (Mg). Sulfur plays a key role in improving nitrogen-use efficiency, as it helps plants use nitrogen more effectively for protein formation. Sulfur deficiency often appears as yellowing of the young leaves, a symptom that may resemble nitrogen deficiency. Manure provides a steady supply of sulfur, particularly in organic form, which is gradually released and supports continuous plant growth.

Calcium is an essential element for the formation of strong cell walls and the development of healthy roots. It also contributes to soil structure and stability, creating more favorable conditions for plant growth. With regular manure applications, calcium can also contribute to the gradual improvement of soil conditions and help create a more favorable environment for the uptake of other nutrients.
Magnesium is the central component of the chlorophyll molecule and is therefore essential for photosynthesis. It also plays an important role in the movement of sugars within the plant, contributing to energy supply and plant growth. An adequate supply of magnesium is particularly important in pasture and alfalfa production, where plant quality and productivity depend on efficient photosynthesis and balanced nutrition.

Organic Matter – The Building Block of Soil
Cattle manure is an important source of organic matter, which plays a key role in improving soil quality and fertility. Organic matter helps improve soil structure, making it better aerated and easier to work. Well-structured soils allow healthier root development and more efficient uptake of water and nutrients.
Another important benefit of organic matter is its ability to increase the soil's water-holding capacity, which is particularly important in areas with limited rainfall or during dry periods. Manure also helps prevent soil compaction by maintaining soil porosity and improving the movement of air and water through the soil profile. This creates more favorable conditions for plant growth and soil biological activity.
Organic matter from manure provides a food source for beneficial soil microorganisms, such as bacteria, fungi, and other soil organisms, which are essential for the decomposition of organic materials and the gradual release of nutrients. This process provides a more sustained supply of nutrients throughout the growing season. Regular manure application increases the organic matter content of the soil, improves overall soil fertility, and contributes to the long-term productivity of agricultural land.

Why Nutrient Content in Manure Varies
The nutrient content of manure is not always the same, as it is influenced by several key factors related to farm management. One of the most important factors is the feeding system used for dairy cows. High-protein diets generally result in higher concentrations of nitrogen in manure, while balanced diets result in more stable and predictable nutrient levels. **Total Mixed Ration (TMR)** systems, prepared using a mixer, generally provide a more uniform manure composition compared with systems based mainly on grazing.
Another important factor is the method used to store manure. Solid manure piles can result in nitrogen losses due to exposure to air, while storage tanks or pits for liquid manure, particularly when covered, help to better retain nutrients and reduce nitrogen losses. In open storage facilities or lagoons, nitrogen losses can be higher due to volatilization and dilution with water. Covers on liquid manure storage tanks can reduce nitrogen losses by up to 30–40%[3]. In lagoon systems, nutrients may also accumulate at the bottom of the storage facility; therefore, mixing the manure before pumping is essential to ensure more uniform application.
Manure composition is also affected by the bedding materials used and by the amount of water mixed with the manure. Straw and wood shavings add organic carbon and influence the carbon-to-nitrogen ratio, while sand may reduce the overall concentration of nutrients. Bedding materials absorb liquids and retain a considerable proportion of nutrients within the manure. On the other hand, dilution of manure with water, resulting from cleaning floors, milking areas, or rainfall, reduces the concentration of nutrients per tonne or per cubic metre. **The lower the water content of the manure, the more concentrated it is and the easier it is to apply accurately to the soil.**

Different manure storage systems affect the extent of nutrient losses:

Storage Method	Risk of Nutrient Losses	Notes
Solid manure piles	Moderate nitrogen (N) losses due to exposure to air	Suitable for farms using bedding materials

Pits/tanks for liquid manure	Lower nitrogen (N) losses when covered	Help retain and concentrate nutrients
Open lagoons	Higher nitrogen (N) losses due to volatilization	Nutrients are more diluted due to mixing with water

Why Manure Testing Is Important

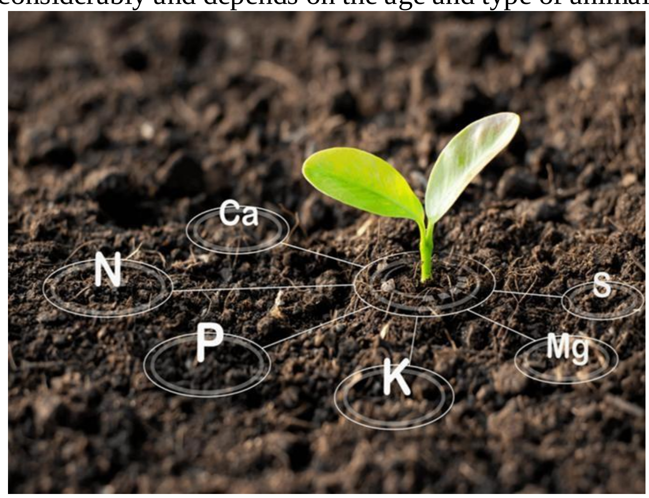
Manure testing is an important practice for the efficient management of nutrients on the farm, as nutrient content can vary significantly from one farm to another and even from one period to another. For this reason, farmers are recommended to test manure at least once a year. Laboratory analysis determines the content of key nutrients, such as nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O), enabling more accurate calculation of application rates according to crop and soil requirements.

One of the main benefits of manure testing is preventing **over-application of manure**, which can lead to nutrient losses and environmental pollution. When manure is applied in quantities greater than required, the risk of nitrogen and phosphorus leaching into rivers, lakes, and groundwater increases. Testing helps protect water bodies and supports the implementation of sustainable agricultural practices.

NUTRIENT VALUES OF CATTLE MANURE

The nutrient composition of cattle manure varies considerably and depends on the age and type of animals, the feed they consume, the way manure is handled and stored, the degree of dilution with water, and the type of bedding material used.

The nutrient content of manure varies from one farm to another. Therefore, it is important for farmers to test their manure at least once a year in order to accurately determine its nutrient content and the appropriate amount of manure to apply to the soil.



Solid Cattle Manure – Nutrient Content

Solid cattle manure contains nitrogen, phosphorus, and potassium. Its nitrogen content is approximately **5–104 kg per tonne** and includes both a slowly released fraction and a more readily available fraction. Only around **30–40% of the nitrogen** becomes available to plants during the first year[4]. Nitrogen content is also influenced by the type of bedding material used: grass or straw bedding increases the organic matter content, wood shavings may immobilize some of the nitrogen during decomposition, while manure without bedding generally has a higher nitrogen concentration.

The phosphorus content of manure is approximately **2–4 kg per tonne**[4] and is released gradually over several years. Potassium content is approximately **5–8 kg per tonne**[4], and most of it is in a soluble form, making it readily available to plants shortly after application. This type of manure is particularly beneficial for pastures and alfalfa, where plants have high potassium requirements.

The nutrient composition of manure is influenced by a range of factors, including the type and age of livestock, animal diet, manure handling and storage methods, the degree of dilution of liquid manure, and the type and amount of bedding material used. These are average values, as nutrient content can vary considerably from one farm to another. Therefore, farmers should test their manure **at least once a year** to determine the appropriate application rates accurately.

Liquid Cattle Manure – Nutrient Content

Liquid cattle manure contains nitrogen, phosphorus, and potassium, but their concentrations are generally lower than in solid manure. The nitrogen content is approximately **3–6 kg per cubic metre**[4], of which around **50–60% is present in the ammonium (NH_4^+) form** and can be immediately available to plants. If manure is not incorporated or injected into the soil shortly after application, part of the nitrogen may be lost through volatilization. Covering manure storage facilities helps reduce these losses.

The phosphorus content is approximately **1–3 kg per cubic metre**[4] and is lower compared with solid manure. Some of the phosphorus may accumulate at the bottom of the pit or lagoon; therefore, it is important to mix the manure thoroughly before pumping to ensure a more uniform distribution of nutrients.

The potassium content is approximately **3–5 kg per cubic metre**[4], and most of it is in soluble form and becomes readily available to plants. This makes liquid manure a good source of potassium, particularly for forage crops and silage maize, contributing to improved feed quality and yield.

Farmers can use average nutrient values as an initial guide for planning manure application, but it is always important to confirm these values through manure testing. This ensures that crops receive an appropriate amount of nutrients and helps reduce potential nutrient losses.

For example, if liquid manure contains **5 kg of nitrogen per cubic metre** and a farmer applies **30 cubic metres per hectare**, the total amount of nitrogen applied is:

5 × 30 = 150 kg N/ha

However, only a proportion of this nitrogen becomes available to plants. This depends on the timing of application, the method of incorporation into the soil, and whether the manure is covered after application. Therefore, planning should take into account potential nitrogen losses, as well as the specific conditions and characteristics of the farm.

NUTRIENT REQUIREMENTS OF AGRICULTURAL CROPS

Different agricultural crops have different nutrient requirements, and manure application should be adjusted to meet these requirements in order to achieve higher yields and avoid nutrient losses or soil degradation. Understanding these requirements helps farmers plan manure use more efficiently, optimize nutrient supply, and reduce the costs of mineral fertilizers.

Maize
Maize has high nitrogen requirements, typically **150–220 kg/ha**[5], particularly during periods of intensive growth. Phosphorus and potassium are also important nutrients; phosphorus supports root development and early plant establishment, while potassium strengthens the plant stem and improves drought resistance. Manure, particularly liquid or well-composted manure, can replace a significant proportion of mineral nitrogen and provide a good supply of nutrients for early plant growth.
For optimal results, manure should be applied before planting, in early spring, and incorporated into the soil or covered with soil within **12–24 hours** to reduce nitrogen losses. Maize responds well to banded manure application or manure incorporated into the soil; however, excessive application should be avoided, as excessive nitrogen can cause excessive plant growth and increase the risk of lodging.
Nutrient application should be adjusted to the specific requirements of maize to achieve high yields, minimize nutrient losses, and avoid unnecessary costs associated with mineral fertilizers.

Pastures and Forage Crops
Pastures and forage crops have high nutrient requirements throughout the growing season. Grasses use significant amounts of nitrogen for leaf growth, regrowth after cutting, and maintaining protein content. Potassium is also very important for forage quality and plant health, but it is removed from the soil in considerable amounts when grass is cut several times during the year. Phosphorus is necessary for root system development; however, excessive application should be avoided.
Liquid cattle manure is particularly beneficial for grasses because it contains nitrogen in a form that is readily available to plants, helping to promote rapid regrowth after cutting. It also supplies considerable amounts of potassium, contributing to improved forage yield and quality. Frequent applications of manure at controlled rates can match the nutrient requirements of grasses well throughout the growing season.
The most appropriate time for application is after each cutting or grazing cycle, where farm conditions allow. Manure application should be avoided on water-saturated soils, near water sources, or before heavy rainfall in order to minimize nutrient losses and the risk of environmental pollution.

Wheat and Barley
Wheat and barley have moderate nutrient requirements. Nitrogen is important at rates of 80–150 kg/ha[6] to promote plant tillering and increase protein content in the grain. Phosphorus supports root system development during germination, while potassium improves drought tolerance and resistance to diseases.
Solid manure, applied before soil preparation, provides a gradual supply of nutrients for cereals. Liquid manure can be applied before planting or in early spring to support tillering and plant growth.
Cereal crops do not require excessive amounts of nitrogen, as over-application can cause lodging, reduce grain quality, and delay maturity. Therefore, fertilization planning should be carried out carefully, taking into account the actual nutrient requirements of the crop and the characteristics of the manure being used.

Matching Manure Application to Crop Requirements
Applying manure according to the nutrient requirements of the crop helps farmers achieve higher yields, reduce the costs of mineral fertilizers, and improve soil fertility. In addition, proper manure management helps protect rivers and groundwater from pollution.
Avoiding over-application is very important. Excessive nitrogen application can cause nitrate leaching and negatively affect plant growth and development. The accumulation of phosphorus in the soil can lead to the pollution of surface water and groundwater.
Excessive potassium can also create problems by reducing magnesium uptake by forage crops, which may pose a risk to the health of cows consuming these forages. Therefore, fertilization planning should be carried out carefully, taking into account the actual nutrient requirements of the crop and the characteristics of the manure being used.

BENEFITS OF MANURE AS AN ORGANIC FERTILIZER

Cattle manure is not simply a waste product, but a valuable fertilizer that can improve crop yields, soil health, and farm profitability. When properly managed and applied, manure becomes a valuable and cost-effective source of nutrients, reducing the need for mineral fertilizers and lowering production costs. Liquid manure provides nitrogen in a form that is more readily available to plants, while solid manure provides nutrients that are released gradually over several weeks or months.

Regular manure application improves soil structure and porosity by adding organic matter, which promotes better root development, air circulation, and easier soil cultivation. Organic matter derived from manure increases soil humus content, helps retain nutrients, improves soil structure and friability, and supports beneficial microorganisms. This contributes to long-term soil fertility by ensuring that phosphorus and organic nitrogen continue to contribute to crop nutrition in subsequent years.

In addition to improving soil fertility, manure increases microbial activity in the soil, helping microorganisms decompose organic matter and gradually release nutrients for plants. Organic matter also acts like a sponge, helping the soil retain more water and increasing its resistance to drought. Manure-treated fields can retain up to 11.6% more moisture[7]. These benefits enable farmers to achieve higher yields with lower input costs, maintain healthier soils that are more resilient to adverse conditions, and use farm resources more efficiently, thereby contributing to the long-term sustainability of livestock farms.

ENVIRONMENTAL RISKS OF POOR MANURE MANAGEMENT

Improper manure handling or application at the wrong time can cause serious environmental problems, affecting soil, water, animals, and human health. Understanding these risks helps farmers protect soil and comply with environmental standards while avoiding damage to natural resources.

One of the main risks is nitrate leaching from manure nitrogen, particularly from liquid manure, into groundwater. When manure is applied in excessive amounts, on light soils, or before heavy rainfall, nitrogen can move through the soil profile and reach wells and drinking-water sources. This can result in water pollution, posing risks to people and livestock. High nitrate concentrations in drinking water can also pose health risks, particularly to infants and young children.

To reduce these risks, farmers should apply manure according to crop requirements and based on the results of soil and manure testing. It is important to avoid manure application before forecast heavy rainfall, use split and controlled applications on pastures, and avoid applying manure late in the season to bare soils. These measures help ensure safer and more efficient manure use while protecting soil and water resources.

Phosphorus Loss and Runoff (Surface Water Pollution)

Phosphorus loss and transport through surface runoff is an important environmental risk when manure is used improperly. Phosphorus contained in manure binds to soil particles and, during rainfall, surface runoff can transport it into streams, rivers, lakes, and reservoirs. When phosphorus reaches water bodies, it can contribute to algal blooms, which reduce oxygen concentrations in the water and may harm or kill fish and other aquatic organisms, damaging aquatic ecosystems.

The most vulnerable fields are those with slopes, frozen or snow-covered soils, water-saturated or compacted soils, and fields located near water sources. Even relatively small amounts of phosphorus can contribute to surface water pollution and create problems for communities, including deterioration of water quality, unpleasant odors, and loss of biodiversity.

To reduce these risks, farmers should avoid applying manure to frozen, water-saturated, or snow-covered soils, establish buffer strips near water sources, and incorporate manure into the soil as soon as possible when conditions allow. Regular testing of soil phosphorus levels helps prevent excessive accumulation, protect water resources, and ensure sustainable manure management in compliance with legal requirements.

Greenhouse Gases

Proper manure management is essential for protecting the farm, the community, and water resources. Improper handling, storage, and application of manure can cause serious environmental problems, including greenhouse gas emissions, air pollution, pathogen-related risks, and soil degradation. Understanding these issues helps farmers operate more efficiently and preserve the nutrient value of manure.

One of the main risks is greenhouse gas emissions. Methane (CH_4) is produced under anaerobic conditions, particularly in liquid manure pits and storage tanks, and has a global warming potential approximately 25 times[8] greater than that of CO_2. Nitrous oxide (N_2O), which can be generated following excessive manure application or application to wet, frozen, or compacted soils, has a global warming potential approximately 300 times[9] greater than that of CO_2 and contributes significantly to climate change. Ammonia (NH_3) is released when manure is exposed to the air and contributes to air pollution and nitrogen losses, while high concentrations can pose health risks.

To reduce these impacts, farmers should keep manure covered, mix it regularly to prevent the formation of thick layers, and consider investing in biogas production systems where appropriate. Manure should be applied according to crop nutrient requirements and during periods of active plant growth to maximize nitrogen uptake. In addition, incorporating or injecting manure into the soil as soon as possible after application, particularly within 12 hours, together with the use of low-emission application techniques, can help conserve nutrients and reduce environmental impacts.

Other Environmental Risks

Poor manure management can also create other environmental risks that directly affect farm productivity, relationships with the community, and animal health. Manure can contaminate water with pathogens such as *E. coli* and *Salmonella*, particularly when it reaches rivers, wells, or drainage channels. This risk increases during surface runoff, flooding, or manure application on wet soils. To reduce this risk, farmers should maintain buffer strips near water sources, avoid manure application before heavy rainfall, and ensure proper maintenance of manure storage lagoons and pits.

Other risks include unpleasant odours from anaerobic decomposition, soil compaction caused by the use of heavy machinery, and the spread of weed seeds through manure. Unpleasant odours can negatively affect relationships with the community; therefore, manure should be covered during storage, properly managed during composting, and incorporated into the soil as soon as possible after application. The spread of weeds can be reduced through proper composting, accurate application rates, and crop rotation.

Proper management of these risks helps farmers conserve nutrients, improve air and water quality, maintain good relationships with the community, and reduce greenhouse gas emissions. This contributes to higher soil productivity, more efficient use of farm resources, and a more sustainable farm that is safer for both animal and human health.

RULES AND STANDARDS FOR MANURE MANAGEMENT

Most countries and regions have rules and standards to ensure that manure is managed safely and responsibly. These regulations aim to protect water resources, soil health and fertility, air quality, and surrounding communities. Understanding and complying with these requirements helps farmers avoid penalties and ensure sustainable farm management.

Farmers should prevent water pollution by keeping manure away from rivers, wells, and drainage channels, and by developing management plans that link application rates to crop nutrient requirements. Managing manure storage capacity is also essential. Storage facilities should be stable and suitable for preventing leakage, while covering them can help reduce odours and emissions. Storage capacity should be sufficient to hold manure for at least 4–6 months, depending on the climate, farm system, and local requirements.

Regulations may limit the maximum application rates of nitrogen and phosphorus to prevent over-application and pollution, and may require buffer zones near rivers and wells, for example 5–15 metres, to reduce the risk of manure runoff into surface waters. In areas designated as nitrate-vulnerable zones, the EU Nitrates Directive sets a limit of **170 kg N/ha per year** from livestock manure. Specific limits and requirements may vary depending on the region and national legislation.

The application of manure to frozen, snow-covered, or water-saturated soils is restricted or prohibited under many regulatory systems, as these conditions increase the risk of surface runoff and water pollution. Complying with these restrictions helps farmers use manure more safely and sustainably.

Record-keeping is another important element of manure management. Farmers should record application dates and locations, manure quantities, nutrient content, storage capacity and conditions, equipment used, and any movement of manure between farms. These records help demonstrate compliance with legal requirements, support farm planning, and ensure responsible nutrient management. Compliance with regulations contributes to farm sustainability, reduces the risk of penalties, and strengthens the farm's reputation.

SESSION 2

MANURE HANDLING, STORAGE AND USE

Introduction

Proper handling, storage, and use of manure are very important for every dairy farm. Proper manure management helps protect soil and water resources by preventing the contamination of rivers, streams, wells, and groundwater. When manure is properly handled and stored, nutrients are retained and can be utilized by crops instead of being lost and causing environmental damage.

Manure is a valuable source of nutrients for the soil, as it contains nitrogen, phosphorus, and potassium, which are essential for crop growth. Proper manure use helps farmers reduce their need for purchased mineral fertilizers, lower production costs, and increase the yields of forage and other agricultural crops.

At the same time, applying manure at the right time and in appropriate amounts helps reduce unpleasant odours and greenhouse gas emissions, contributing to a cleaner and safer environment on the farm.

Good manure management also helps farmers comply with environmental regulations and relevant standards, reducing the risk of fines and legal problems. This material provides simple and practical guidance that dairy farmers can apply in practice to improve manure management, protect the environment, and ensure long-term sustainability and economic benefits for their farms.

MANURE MANAGEMENT ON THE FARM

Proper manure management helps prevent nutrient losses, protect the environment, and ensure that manure is safely managed and stored. Protecting water resources is a key part of sustainable agriculture. Clean water is vital for the farm, animals, and the surrounding environment.

Implementing water protection practices not only safeguards human and animal health but also contributes to improving soil and crop quality.

Keep clean water separate from contaminated water

- Construct channels and drainage systems to divert rainwater away from livestock housing and manure storage areas.
- Prevent unnecessary filling of manure pits and lagoons with clean water.
- Reduce manure and nutrient dilution, thereby lowering costs and ammonia emissions.
- Maintain sufficient storage capacity for periods when manure application is not permitted.

Maintain manure collection areas

- Regularly clean barn alleys and collection areas to remove manure.
- Reduce unpleasant odours, ammonia emissions, and the presence of insects.
- Prevent manure from mixing with water and avoid flooding of surrounding yards or fields.
- Regular and proper cleaning reduces the risk of disease transmission to animals and farm workers.

Separation of liquid and solid manure

Separating liquid manure from solid manure can improve manure management on the farm and facilitate its storage, handling, and application.

Benefits:

- **Reduces storage volume:** the solid fraction can be handled and stored more easily, making more efficient use of available space.
- **Improves application efficiency:** liquid manure can be pumped and applied to the soil more easily.
- **Provides suitable material for composting:** the solid fraction can be composted to produce a nutrient- and organic matter-rich material that can be used as a soil amendment.

CONSTRUCTION OF SUITABLE MANURE STORAGE FACILITIES

The construction of suitable manure storage facilities is essential for protecting the environment and ensuring safe farm operations. A properly designed and constructed system prevents contamination of surface water and groundwater, preserves valuable manure nutrients, and reduces unpleasant odours and harmful emissions. Proper storage enables farmers to apply manure only during suitable periods, when crops can efficiently utilize its nutrients.

Underground Manure Pits for Liquid Manure

Underground pits for liquid manure, above-ground storage tanks, and solid manure storage platforms are among the most common manure storage systems. All of these structures should be sealed with concrete or other impermeable materials to prevent leakage into the soil and groundwater. They should also be equipped with mixing systems to ensure that manure is properly mixed before pumping or application, allowing nutrients to be distributed as evenly as possible.

Covers are strongly recommended, as they help reduce nitrogen losses, limit unpleasant odours, and prevent rainwater from entering the storage facilities.

The location and size of manure storage facilities should comply with environmental standards and local requirements, ensuring sufficient storage capacity, typically for around six months, depending on the farm system and climatic conditions.

Facilities should be located at a safe distance from wells, streams, and drainage channels and constructed on stable ground. They should be regularly inspected and maintained to prevent cracks, leaks, or other damage.

Safe and proper manure storage protects the environment, preserves nutrients, and improves farm efficiency. Proper design, construction, and maintenance of storage facilities are essential for reducing nutrient losses, emissions, and the risk of pollution.

Above-Ground Manure Tanks

Above-ground manure tanks are a practical and safe solution for storing liquid manure on the farm. They are typically constructed from galvanized steel or reinforced concrete, materials that provide durability, strength, and a long service life. These tanks are suitable both for short-term storage and for flexible manure management prior to application on agricultural fields.

One of the main advantages of above-ground tanks is the possibility of expansion as the farm's capacity increases. Compared with underground structures, they can be more easily adapted or expanded to meet the farm's future needs. In addition, access for mixing, pumping, and inspection is easier, helping to ensure more uniform application of manure to the soil.

For safety reasons, tanks should be equipped with appropriate protective measures, such as fencing, covers, or barriers, to prevent accidents and falls. They should be located on stable ground and at a safe distance from water sources, in accordance with applicable environmental requirements and regulations. When properly designed, operated, and maintained, above-ground manure tanks improve farm safety, preserve the nutrient value of manure, and reduce the risk of environmental pollution.

Key points:

- Constructed from galvanized steel or reinforced concrete.
- Strong, durable, and easier to expand if the farm's storage capacity increases.
- Should include appropriate safety measures to prevent accidents.
- Particularly suitable for storing liquid manure and holding it before application to agricultural fields.

Covered Storage Systems (Highly Recommended)
Covered manure storage systems are highly recommended because they significantly improve nutrient conservation and reduce negative environmental impacts. Covers help prevent nitrogen losses, reduce unpleasant odors, and limit greenhouse gas emissions. By preventing rainwater from entering the storage facility, they help maintain the nutrient concentration of the manure and improve the efficiency of its subsequent application to agricultural land.

The use of covers can significantly reduce nitrogen losses and ammonia emissions, while also helping to control unpleasant odors. Their effectiveness depends on the type of cover used and the storage conditions.

Several types of covers can be selected according to the size, design, and budget of the farm. These include floating plastic membranes that remain on the surface of the manure; rigid roofs that provide long-term protection; and floating layers made from organic materials, such as straw, which can provide a simpler and lower-cost option for smaller farms.

To ensure the most effective operation of covered storage systems, the structures should have an appropriate base and lining to prevent leakage and contamination of water resources. Safe and easy access should also be provided for manure mixing, pumping, inspection, and maintenance.
Overall, covered storage systems help conserve nutrients, reduce emissions and odors, and improve the efficiency and sustainability of manure management on the farm.

http://crawfordswcd.org/conservation-best-management-practices/

REQUIREMENTS FOR THE CONSTRUCTION OF MANURE STORAGE FACILITIES
Proper design and construction of manure storage facilities are essential for safe manure storage, environmental protection, and the preservation of its nutrient value. The storage facility should have sufficient capacity for at least **6 months**, allowing manure to be stored during periods when land application is not permitted, such as winter or periods of heavy rainfall. This helps avoid forced or premature manure application and reduces the risk of soil and water pollution.

The storage structure should be constructed using impermeable materials, particularly for the floor and walls, to prevent leakage into the soil and groundwater. Concrete floors or suitable approved liners provide long-term protection and help retain valuable nutrients. Walls should be structurally sound, free of cracks, and constructed in accordance with applicable technical standards to prevent structural damage and unnecessary maintenance costs.
To reduce nutrient losses and environmental risks, the storage facility should be equipped with an appropriate drainage system for managing rainwater and should be located at a safe distance from water sources, in accordance with applicable legal and environmental requirements. Safety fencing and warning signs should also be installed to protect people and animals.

The combination of impermeable floors, appropriate drainage, and covered storage systems ensures safer and more sustainable manure management, reduces the risk of pollution, and helps ensure compliance with environmental requirements.

SAFETY DURING MANURE STORAGE AND HANDLING

Safety during manure storage and handling is essential to protect farm workers, animals, and visitors. Manure can release hazardous gases such as hydrogen sulfide (H_2S) and methane (CH_4). Hydrogen sulfide is highly toxic, while methane can create an explosion hazard and, at high concentrations, can displace oxygen. For this reason, entry into manure pits, tanks, or enclosed manure storage areas should be avoided. Children and animals should also be kept away from storage areas to prevent accidents.

Only trained workers should operate equipment used for manure mixing, pumping, and application. Mechanical equipment can present hazards due to technical failures, slippery surfaces, moving parts, or exposure to hazardous gases. Manure agitation can release significant amounts of gases and should therefore be carried out carefully, under appropriate ventilation conditions, and while keeping a safe distance from manure pits or tank openings. Workers should never lean over or stand directly above a manure pit during agitation.

Key safety measures include:

- keeping workers and visitors away from hazardous areas;
- installing appropriate fencing and clearly visible warning signs;
- ensuring adequate ventilation during mixing and pumping operations;
- using appropriate personal protective equipment according to the specific task and risk;
- regularly inspecting and maintaining mechanical equipment;
- preventing entry into manure pits or tanks unless specific confined-space safety procedures and appropriate equipment are in place;
- establishing clear emergency procedures and communication protocols in case of an accident.

Implementing these measures helps prevent accidents and exposure to hazardous gases, while creating a safer and more professional working environment on the farm.

MINIMIZING NUTRIENT LOSSES DURING STORAGE

Proper manure storage is key to preserving the nitrogen, phosphorus, and potassium it contains. Losses of these nutrients increase fertilizer costs and reduce crop production. To minimize nitrogen losses through ammonia volatilization, liquid manure should be kept covered with membranes, roofs, or floating covers, and agitation should be carried out slowly only when necessary for pumping or application.

Natural crusts on the surface of the liquid also act as a protective cover and help conserve nutrients.
Another factor that reduces losses is preventing rainwater from entering the storage area. For solid manure piles, use roofs and concrete platforms to collect runoff water. Divert clean water from barns, roofs, and yards away from storage areas so that the manure is not diluted and can retain its nutrient concentration. This practice preserves storage capacity and ensures that the manure is ready for application when crops need it.
Proper storage of solid manure includes the use of solid platforms with side walls, covering the manure with plastic, tarpaulins, or roofs, as well as proper management of the pile to limit nutrient losses. This method reduces odors, greenhouse gas emissions, and nitrogen losses, while improving the value of manure as an organic fertilizer. Regular inspection of storage areas for cracks, leaks, or water accumulation helps maintain manure quality and protect the farm environment.

COMPOSTING OF MANURE

Composting is an effective method for transforming solid manure into a stable and nutrient-rich fertilizer. It makes manure easier to spread, reduces odors, and makes its application safer for the soil and plants. In addition, composting improves soil structure and health while retaining the nitrogen, phosphorus, and potassium contained in the manure.
To achieve successful composting, several key factors need to be controlled. Moisture should be maintained at 50–60%, neither too dry nor too wet, so that decomposition can proceed properly. Air should reach the compost piles by turning them every 2–4 weeks to improve decomposition and reduce odors. The carbon-to-nitrogen ratio (C:N) should be approximately 25–30:1[14], by adding carbon-rich materials such as straw, dry grass, or leaves to balance manure with a high nitrogen content.

Farmers should also monitor the temperature of the piles. A temperature of 55–65°C indicates active composting. The piles should be covered during heavy rainfall to prevent nutrient losses. Well-composted manure has a dark color, a crumbly texture, and an earthy smell, rather than an ammonia odor[14]. By following these practices, farmers can ensure a high-quality and stable product that retains nutrients and protects the environment.

COMPOSTING METHODS

Different composting methods allow farmers to manage solid manure efficiently, reduce odors, and produce high-quality fertilizer. Choose the method that best suits the size of the farm, available labor, and equipment.

Windrow Composting

The first method is windrow composting, where long piles of manure mixed with carbon-rich materials are turned every 1–4 weeks to provide oxygen and promote decomposition. This method produces uniform and nutrient-rich compost within 8–12 weeks and is ideal for medium and large farms with sufficient space and machinery.

Aerated Static Piles

Aerated static piles are a composting method in which the materials remain largely in place, without frequent turning. Oxygen is supplied through air pipes or perforated pipes, ensuring aerobic decomposition and reducing unpleasant odors. This method requires less labor and is ideal for medium-sized farms that do not have the workforce or machinery needed for frequent turning. The main benefit is reduced labor costs while maintaining effective composting and the quality of the compost produced.

Deep-Bedding Composting

Deep-bedding composting is a method in which bedding materials, such as straw or wood residues, are mixed with manure and allowed to decompose directly inside the animal housing area. This method helps reduce manure volume and odors in the animal housing environment. The mixed manure can be removed periodically and applied directly to fields or further composted to improve its composition. The method is most suitable for small to medium-sized farms, particularly those where animals are housed indoors for extended periods or kept in a free-stall system. A practical tip is to monitor moisture, temperature, and ventilation to ensure effective and stable composting.

Monitoring Compost Maturity

Monitoring compost maturity is essential to ensure that the processed manure is safe and effective as a soil amendment. Properly matured compost has a temperature close to ambient temperature, a dark and crumbly structure, no unpleasant odor, and no visible pieces of straw or bedding.

The carbon-to-nitrogen ratio (C:N) typically reaches 15–20:1, indicating that decomposition has been completed and the compost has stabilized.

The main benefits of mature compost include safe application close to planting time, improved soil structure and water-holding capacity, as well as the slow release of nutrients, reducing the need for chemical fertilizers. Mature compost also reduces the risk from pathogens and weed seeds, making it safer for plants and animals.

Practical advice for farmers includes **cooling or allowing the compost temperature to decrease before application**. Use simple methods to assess compost maturity by using your hand to evaluate its structure, as well as checking its odor and visible residues. These assessments can be complemented by occasional laboratory tests to confirm stability and nutrient concentrations. This monitoring helps farmers apply high-quality compost, maximizing the benefits for soil and crops.

TECHNIQUES FOR REDUCING ODORS

Reducing odors from manure is important not only for maintaining good relationships with the community, but also for preserving nutrients and improving hygiene on the farm. During manure handling, daily cleaning of alleys and proper maintenance of animal bedding help reduce odor accumulation. Manure should not be left in the barn for long periods before being moved to the storage facility, and high-pressure water spraying should only be used when necessary to avoid ammonia volatilization.

During storage, using covers over liquid manure storage facilities helps reduce gas emissions and maintains the natural surface layers as a natural protective barrier. Compacting solid manure piles reduces exposure to oxygen and the release of ammonia, while diverting rainwater away from storage areas keeps the manure dry and maintains the concentration of nutrients. These practices also help prevent the spread of unpleasant odors.

During field application, injecting liquid manure directly into the soil is the best method for reducing volatilization. Solid manure should be incorporated within 6–12 hours after spreading to minimize odors and nutrient losses. Applying manure during cool weather and avoiding windy days also help reduce odors and improve the efficiency of manure use.

SESSION 3:

APPLICATION OF ORGANIC MANURE TO IMPROVE SOIL FERTILITY

INTRODUCTION

Field application is the final and most important step in sustainable manure management. Even when manure has been properly stored and handled, its full value is achieved only when it is applied to the soil at the right time, in the right amount, and using the right method. Proper application ensures that the nutrients in the manure feed the crop — not the air, not groundwater, and not nearby rivers or drainage channels.

This session focuses on how farmers can use manure to:

- Increase soil fertility;
- Improve crop yields;
- Reduce the costs of mineral fertilizers while minimizing environmental risks.

Manure is a powerful fertilizer, rich in nitrogen (N), phosphorus (P), potassium (K), and organic matter. However, if it is spread at the wrong time or in the wrong way, these nutrients can easily be lost through leaching, volatilization, or runoff.

This material provides practical guidance to ensure that more nutrients remain in the field and are available to plants.

IMPORTANCE OF APPLYING MANURE AT THE RIGHT RATE

Proper manure application is essential for maximizing nutrient use and improving crop yields. Manure is a valuable source of nitrogen, phosphorus, potassium, and organic matter, but its benefits can only be achieved when it is applied correctly. Applying too little may limit plant growth, while excessive application can damage plants and reduce fertilizer efficiency. The timing, amount, and method of application should match the crop's nutrient requirements and soil conditions to ensure that nutrients are available when plants can use them.

Proper manure management also protects the environment. If manure is spread at the wrong time, such as on frozen or saturated soil, nutrients can be lost through runoff or leaching into rivers, streams, and groundwater. This contributes to water pollution, algal blooms, and contamination of drinking water. By applying manure during periods of active crop growth and incorporating it into the soil where possible, farmers can reduce nutrient losses and minimize negative environmental impacts.

Finally, proper manure application supports long-term soil health and farm sustainability. Manure improves soil structure, increases organic matter, and improves moisture-holding capacity; all of these are essential for productive and resilient soils. When properly managed, manure becomes a natural fertilizer that reduces the need for synthetic inputs, lowers production costs, and promotes sustainable agriculture. Ultimately, careful attention to proper manure application benefits crops, the environment, and farm profitability.

TIMING OF APPLICATION ACCORDING TO THE PLANT GROWTH STAGE

Using manure at the right time ensures that nutrients are available when plants need them most, increasing yields and reducing environmental losses. Manure application is part of soil management that improves soil fertility and structure, providing a healthy foundation for food production and the health of dairy cows. The use of manure is often more effective than using chemical fertilizers alone because it provides gradually released nutrients and increases organic matter in the soil.

Applying manure at the right time is key to the effective use of nutrients and increasing crop yields. Manure should be applied when plants have the greatest need for nutrients, which usually coincides with active growth stages. For most crops, the ideal period is spring, when plants enter a period of rapid growth and can optimally utilize nitrogen, phosphorus, and potassium from manure. Applications in late autumn or during winter are not recommended because during these periods manure may lose its main nutrients through leaching or volatilization, increasing the risk of pollution of surface and groundwater.

It is also important to adjust the release of nitrogen and other nutrients according to the specific needs of the crop and its growth stage. Fresh manure has a faster release of nutrients and, therefore, is more suitable for plants with immediate nutrient requirements. Compost or processed manure, on the other hand, releases nutrients slowly and gradually, making it ideal for crops with a long growing season, extended growth periods, or for improving soil organic matter. This gradual release helps reduce nitrogen losses and supports long-term soil development.

To illustrate more clearly the use of manure according to different crops, several practical examples can be given. For maize, manure should be applied 2–3 weeks before planting or at the time of planting, providing the nutrients needed for the start of growth. In grasslands, manure should be applied after each cutting to support rapid grass regeneration and increase green biomass production. For cereals such as wheat and barley, it is better to avoid application in mid-winter; manure should be applied before planting or during early spring growth, when plants can fully utilize the nutrients and improve soil structure. This planned approach not only maximizes the benefits of manure but also helps manage the soil sustainably and protects the environment.

How Manure Helps Improve Soil Fertility

Manure is an important organic resource that helps improve soil fertility in many ways. It adds organic matter to the soil, creating a favorable environment for earthworms and microorganisms that process nutrients and improve soil health. In addition, manure helps improve soil structure by reducing compaction, making it easier for roots to grow and absorb water. Organic matter also increases the soil's capacity to retain moisture, protecting plants during dry periods. Another important benefit is the slow release of nutrients, such as nitrogen, phosphorus, and potassium, which supports steady and long-term plant growth. To maximize the benefits of manure, several good practices should be followed. Combining manure with crop rotation, including forage crops such as alfalfa, helps with natural nitrogen fixation and maintaining soil fertility. In addition, it is important to prevent erosion by keeping the soil covered and reducing intensive soil tillage. Balancing the use of organic manure with chemical fertilizers, based on soil analyses, helps meet the nutrient requirements of crops without excessive use of unnecessary inputs.

Proper storage and application timing are also important. Manure should be stored in a covered area and applied at the right time to maximize nutrient availability and prevent runoff. When properly managed, the use of manure provides many benefits: it increases crop yields and forage quality, reduces the need for chemical fertilizers over time, strengthens plants and pastures, and provides long-term savings, thereby increasing farm profitability.

PREVENTING NUTRIENT LOSSES DURING APPLICATION

Proper timing of manure application is a key element in ensuring that nutrients reach the plants while also protecting the environment. Application at the wrong time can cause losses of nitrogen, phosphorus, and potassium through runoff or leaching, reducing crop yields and increasing the risk of pollution of surface water and groundwater. For this reason, farmers should follow several important restrictions that maximize benefits and minimize losses.

The main restrictions include avoiding application before heavy rainfall, because water can wash nutrients away and carry them into rivers, streams, and wells. Likewise, manure should not be spread on frozen, snow-covered, or water-saturated soils, as these conditions increase surface runoff and nutrient losses. Until the time of application, manure should be kept covered and protected, maintaining the concentration of nutrients and reducing unpleasant odors.

Applying these practices provides clear benefits. Farmers can preserve the value of the fertilizer, ensuring that more nutrients reach the crops. Nitrate leaching and phosphorus runoff are reduced, protecting groundwater and surface water. In addition, the environment is protected overall, helping to maintain healthy rivers, wells, and soils while promoting sustainable and productive agriculture.

CALIBRATION OF MANURE SPREADERS

Accurate calibration of manure spreaders is a key step in ensuring that nutrients are applied at the correct rate, maximizing crop growth while minimizing negative impacts on the environment. The nutrient content of manure varies from farm to farm, from animal to animal, and from season to season. Without careful calibration, application may be insufficient, reducing yields, or excessive, causing pollution, nutrient runoff, and loss of manure's value. Calibration is particularly important for organic fertilizers such as cattle, pig, or poultry manure, where the concentrations of nitrogen, phosphorus, and potassium vary from one batch to another.

The calibration process begins by determining the nutrient content of the manure using laboratory tests or standard tables. The amount applied by the spreader per unit of area is then measured by calculating the application rate in tonnes per hectare. The equipment is adjusted by changing the spreader gate opening, the speed of the tractor, or the speed of the spreader itself to achieve the desired application rate. Calibration should be checked and repeated every season, as changes in manure composition or crop nutrient requirements may require new adjustments.

For example, if the manure contains 6 kg of nitrogen per tonne and the crop requires 120 kg of nitrogen per hectare, the amount of manure that should be applied is $120 \div 6 = 20$ tonnes of manure per hectare. This simple calculation demonstrates the importance of accurate calibration to ensure that nutrients reach the plants at the required rate, while avoiding nutrient losses and environmental pollution.

RECOMMENDED MANURE APPLICATION RATES

These rates are approximate and should be adjusted based on soil test results and the nutrient content of the manure.

Crop / Soil Type	Recommended Rate (tonnes/ha)
Maize	15–25
Grasses	20–30 after the first cut
Wheat / Barley	10–15
Vegetables	20–30
Pastures	10–15 (avoid burning the grass)

Avoiding Over-Application of Manure

Excessive manure application can have serious consequences for crops, soil, and the environment. Using the correct amount ensures that nutrients are used effectively, supporting plant growth without causing harm. One of the main risks is nitrate leaching into groundwater, which can contaminate wells and sources of drinking water. Phosphorus runoff into rivers can also cause eutrophication, increase algae growth and reducing oxygen levels for fish and aquatic life. Excess nitrogen can cause plants to lodge or become damaged, while the use of heavy machinery on wet soil increases the risk of soil compaction and deteriorates soil structure. In addition, odors and ammonia emissions can negatively affect the farm environment and may lead to complaints from neighbors.

To prevent these problems, manure should be applied based on the actual nutrient requirements of the crops, rather than simply to empty storage facilities. It is important to maintain buffer zones near rivers, streams, and wells to prevent water contamination. In addition, annual nitrogen (N) and phosphorus (P) levels should be kept within the limits established in the nutrient management plan, ensuring that the amount of manure applied is balanced and sustainable.

Proper planning and implementation of manure management practices not only protect the environment and soil quality, but also improve crop yields and the efficient use of resources. Farmers should combine laboratory measurements, soil testing, and monitoring of plant growth to determine optimal manure application rates, minimizing losses while maximizing benefits for the farm and the environment.

Protection of Rivers, Wells, and Water Sources
Proper manure management is essential for protecting water quality, maintaining farm productivity, and safeguarding the health of the surrounding community. One of the main measures is to establish buffer zones around water sources. Farmers should maintain a safe distance of 15–30 meters from streams, rivers, canals, and wells, while also using grass strips or protective vegetation as natural barriers to capture nutrients that may be transported by runoff. These areas act as natural filters, reducing surface water pollution and protecting aquatic biodiversity.
It is also important to avoid applying manure before heavy rainfall, as rainwater can carry nutrients toward rivers, streams, and wells.

Manure should not be applied on land with slopes greater than 15%, where the risk of erosion and nutrient loss is very high. Similarly, application near drainage channels or limestone areas should be avoided, as these locations are particularly vulnerable to rapid contamination and may result in damage to the aquatic environment.
Implementing these practices not only protects water resources but also helps preserve the value of manure and farm efficiency. Farmers who respect buffer distances and site conditions can minimize nutrient losses, reduce the risk of pollution, and promote sustainable and environmentally friendly agriculture.

INTEGRATION OF ORGANIC MANURE WITH MINERAL FERTILIZERS

Integrating organic manure with mineral fertilizers is an important practice for maximizing crop nutrition, improving soil health, and reducing production costs. Organic manure provides organic matter and slow-release nutrients, helping to improve soil structure, increase microbial activity, and retain moisture. On the other hand, mineral fertilizers provide measurable and fast-release nutrients that plants can absorb immediately to meet their growth and development needs. This combination ensures a stable and balanced supply of nutrients, optimizing crop yield and quality.
The most common integration strategy is to use farmyard manure as a base fertilizer to enrich the soil with organic nutrients and supplement it with mineral fertilizers only where necessary, based on soil test results. This approach helps farmers use fertilizers efficiently, avoid over-application, and maintain the nutrient balance of the soil.

For example, in the case of nitrogen, if farmyard manure provides 80 kg N/ha and maize requires 150 kg N/ha, only 70 kg N/ha of mineral fertilizer should be added to meet the requirement. In soils with high phosphorus content, manure should be applied carefully and supplemented only with nitrogen, according to the specific requirement. This method not only maximizes the benefits for plants but also supports sustainable and economically efficient agriculture.

MANURE APPLICATION TECHNIQUES

The method of manure application plays a key role in the efficient use of nutrients, minimizing odors, and protecting the environment. Choosing the appropriate technique ensures that nutrients reach plant roots at the right time, maximizing crop yield and quality. In addition, proper application helps reduce nutrient losses through nitrogen volatilization, phosphorus leaching, and contamination of surface water and groundwater.

Surface Application

Surface application is the most common method of applying manure, where the material is placed directly on the soil without further incorporation.

This technique is simple to implement, requires minimal equipment, and has a low cost, making it suitable for farmers with limited resources.

However, the method has several important disadvantages.

Manure left on the soil surface is exposed to wind, particularly ammonia losses, which can volatilize and cause unpleasant odors in the surrounding area. Nitrogen losses can be significant, often reaching 30–50%, which considerably reduces the effectiveness of manure application.

In addition, surface application increases the risk of nutrient runoff during rainfall, causing contamination of surface water and groundwater. This makes the method less efficient for retaining nutrients and maximizing benefits for plants, particularly during periods of heavy rainfall or on sloping land.

Incorporation or Mixing into the Soil

Incorporating manure into the soil is a recommended application method in which manure is mixed with the soil using equipment such as a plough, disc harrow, or rotary tiller. It is important that incorporation is carried out within 12 hours after application to maximize the benefits.

This method has many advantages compared with surface application. First, it significantly reduces unpleasant manure odors, improving working conditions and relations with neighbors. Second, it minimizes nitrogen losses, ensuring that more nutrients remain in the soil and are available to plants.

In addition, mixing manure with the soil increases contact between the nutrients and the soil, improving their uptake by plant roots. This method improves fertilizer efficiency, preserves the value of nutrients, and contributes to more sustainable and productive agriculture.

Injection of Manure into the Soil

Injection is one of the most effective methods of manure application, particularly for liquid manure, but it requires specialized equipment. With this technique, manure is placed directly into the soil, avoiding exposure on the soil surface.

This process has many benefits.

First, ammonia losses are minimal, preserving most of the nitrogen available to plants. Second, injection significantly reduces odors and the risk of surface runoff, protecting the environment and improving working conditions on the farm.

In addition, nutrients are placed precisely where plant roots can absorb them more easily, increasing fertilizer efficiency and maximizing crop growth and production. This method is considered one of the best approaches for nutrient management and for protecting soil and water quality.

Best Practices for Manure Application

Applying manure at the right time is essential to maximize nutrient uptake by plants and reduce losses. One of the main rules is to avoid application in early spring when the soil is too cold or waterlogged. In cold soil, plant growth slows down and nutrient uptake is limited, while in waterlogged soil, the risk of nutrient runoff is high, reducing fertilizer efficiency.

Practical Examples for Farmers

Example 1: Grass Field

- Mow the grass on Monday.
- Apply liquid manure on Tuesday.
- The grass begins to grow immediately and uses the nutrients efficiently.

⇒ Maximum benefit, minimum losses

Example 2: Maize Field

- Apply manure 1–3 weeks before planting.
- Incorporate it or lightly cover it with a disc harrow.
- Plants begin to use nitrogen immediately during early growth.

⇒ Higher yield + reduced fertilizer costs

Example 3: Nutrient Requirements by Crop

- Grass and maize → require high amounts of nitrogen.
- Legume crops (alfalfa, clover) → require little or no nitrogen.
- Wheat and barley → require balanced nutrients.

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MATERIAL 6: PRACTICAL IMPLICATIONS OF CLIMATE CHANGE FOR LIVESTOCK HEALTH AND PRODUCTIVITY

Bajram Imeri, Expert

Executive Summary

This document describes the main impacts of climate change on the livestock sector in Kosovo.
The focus of the work has been the analysis of climate impacts on dairy cattle, including animal productivity, health, and welfare.
It should be emphasized that climate change is already affecting agriculture and, in particular, the livestock sector; however, this issue still receives insufficient attention and commitment for proper analysis.
Since Kosovo does not have a program for recording the quantity of milk produced on farms, analyzing reductions in milk yield as a result of climate change and high temperatures presents a serious challenge.
In this document, I have attempted to identify the main mechanisms through which climate change affects livestock production. These mechanisms include heat stress and reductions in forage and pasture yields.

In the context of the undeniable challenges, this document attempts to propose several adaptation measures that are feasible at this initial stage:

- **Improving climatic conditions in livestock housing** – this means improving barn infrastructure and installing fans in a way that ensures good air circulation at all times;
- **Using natural or artificial shade** – these provide comfort for animals near barns or on pastures;
- **Ensuring access to fresh water**, particularly during periods of high temperatures;
- **Adapting feeding practices** to high-temperature conditions.

Through this document, policymakers are called upon to take action by:

- creating concrete support measures;
- developing legal measures, strategies, and action plans, including timelines and financial support.

Finally, I believe that farmers will have the opportunity to become informed, at least, about the impacts of climate change and the possibilities for taking the necessary measures on their farms.

Introduction

Livestock farming in Kosovo is an important sector of agriculture and the economy in general, providing food, household income, and employment. In terms of importance, the cattle sector is one of the most important sectors due to milk production and the importance of milk to the processing industry and overall consumption. The sector is relatively well organized and aims for further development. The small ruminant and poultry sectors are also of considerable importance for meat and egg production.
Climate change is increasingly affecting livestock systems worldwide by altering temperature patterns, water availability, and disease dynamics. Increasing heat stress, more frequent extreme weather events, and changes in the quality of feed and pastures directly affect animal health, welfare, and productivity. These pressures lead to reduced growth and milk yields, impaired reproduction, and increased disease risks, ultimately threatening farm profitability and food security. Therefore, understanding the practical implications of climate change is essential for developing effective adaptation measures that strengthen the resilience and sustainability of livestock production systems.
Although Kosovo has high-quality agricultural land, land fragmentation, outdated and insufficient agricultural equipment and machinery, weak agricultural infrastructure (e.g., irrigation systems, agricultural roads, etc.), high input costs, and difficult access to finance are resulting in lower productivity per annual work unit in agriculture compared with the EU and neighboring countries.

Dominated by small and insufficiently modernized farms, and facing open competition from EU countries and the region, the low competitiveness of Kosovo's agriculture is directly reflected in a negative trade balance, particularly with EU countries.[1]
As a signatory to the Sofia Declaration in 2020, Kosovo has committed to playing its role in efforts to make the continent climate-neutral by 2050, together with the European Union (EU), through the integration of strong climate policies and the reform of the energy and transport sectors. In 2021, Kosovo agreed to implement the Green Agenda Action Plan, which means placing sustainable development, resource efficiency, nature protection, and climate action at the center of all economic activities. To achieve this, the Ministry of Environment, Spatial Planning and Infrastructure (MESPI) requires technical and legal support to assist in the successful implementation of Kosovo's climate change agenda. The request for assistance under this capacity-sharing program is for technical support in greenhouse gas (GHG) emissions accounting, with a focus on emissions from the agricultural sector, with the aim of coordinating and supporting ongoing efforts to update the national GHG inventory.

Impacts
Climate change has significant and multifaceted impacts on livestock systems worldwide, particularly in regions experiencing rising temperatures and climate variability. It is now clear that climate change has a significant impact on livestock systems, especially in regions with variable climates. Kosovo is also a region with a highly variable climate.
The Kosovo Hydrometeorological Institute is a public institution which, among other responsibilities, is tasked with establishing and maintaining the basic network of hydrological, meteorological, and air-quality monitoring stations; organizing measurements and observations of hydrological, meteorological, and agrometeorological elements and phenomena; and monitoring environmental components, including air, water, and soil quality.

Table 1. Average Monthly Values for Prishtina

2018 V.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	VJ.
Tmax . ºC	5.9	5.4	10.7	21.6	23.7	24.2	25.9	27.5	23.8	19.6	11.7	4.6	17.1
Tmin. ºC	-3.0	-1.2	1.5	7.0	10.1	13.4	15.3	14.7	9.6	5.9	2.1	-3.4	6.0
T.mesº C	1.2	1.7	5.8	14.5	16.6	18.4	20.1	20.3	16.7	12.0	6.4	0.4	11.2
Lagsh. %	86	85	77	69	68	71	72	76	75	78	85	87	77
Resh. totale(mm)	57.1	67.0	91.8	60.6	163	225	138.4	78.6	5.6	17.7	38.1	37.4	980.3

Source: Hydrometeorological Institute of Kosovo/Meteorological Data, Monthly Averages, 2001–2019

Increase in Average Temperatures
Among the factors contributing to climate change is the increase in average temperatures, as well as maximum temperatures throughout the year. These climate changes have a significant impact on the behavior and physiology of livestock. As shown in Table 1, an increase in average temperatures can be observed during June and July, reaching its peak in August. It is believed that average temperatures after this reference year have been even higher.
Heat waves cause heat stress in dairy and beef cattle.

Prolonged droughts are becoming a reality, with increasingly lower rainfall and clearly visible periods of drought. These conditions affect the availability of feed for animals, feed quality, and pasture availability. Referring to Table 1, we can see that rainfall is minimal in September, at a time when pastures would normally be expected to be replenished with grass for grazing.

Drought – Kosovo is a country with a considerable rural area, where longer periods of high temperatures may occur during the summer season, mainly accompanied by a lack of atmospheric precipitation. These conditions can cause drought, resulting in significant water shortages.

Extreme Weather Events

Extreme weather events are becoming increasingly common in the region and beyond. Kosovo has experienced and continues to experience extreme weather events. According to the Hydrometeorological Institute, the most significant floods of the last 10 years occurred during the period of 6–12 January 2021, with approximately 200 mm of rainfall, or liters/m². Kosovo is vulnerable to flooding, which occurs frequently.

Current Situation

Flooding in Kosovo is generally caused by heavy atmospheric precipitation, which leads to high river flows and can cause significant damage to infrastructure, private property, agriculture, etc.

As a result of this natural disaster, agricultural land and meadows were flooded, and a small number of animals died. There is no doubt that extreme weather events have a negative impact on the development of the livestock sector. These negative effects can be observed in animal feed, both in terms of quantity and quality. In Kosovo, there is no monitoring system for extreme weather events in the livestock sector; however, the Ministry of Agriculture, Forestry and Rural Development has established a commission for monitoring natural disasters in agriculture in general.

Mechanisms

During climate change accompanied by high temperatures, animals may experience biological, physiological, and behavioral changes. These can be explained through heat stress.

Heat Stress

Heat stress occurs when dairy cows are no longer able to adequately regulate their body temperature. The so-called thermoneutral zone of dairy cows is approximately between -5 and 15°C. Temperatures of 20°C and above, combined with high humidity, can cause many animals to experience heat stress. Dairy cows are particularly affected due to their high energy turnover and the resulting high heat production.

The Temperature-Humidity Index (THI) is the most important tool for assessing heat stress on dairy farms. It takes into account not only temperature but also humidity, providing a much more accurate assessment than temperature alone.

Table 2. Calculation and Evaluation of THI

Effects on the dairy cow **THI**		
Below 68	**No heat stress**	
69-71	**Mild heat stress**	Seeking shade • Increased respiratory rate • Dilation of blood vessels • Initial impact on milk yield
72-79	**Moderate heat stress**	• Increased salivation • Elevated respiration rate • Increased heart rate • Reduced feed intake • Increased water consumption • Decreased milk production • Reduced fertility
80-89	**Severe heat stress**	• General discomfort due to worsening symptoms
Over 90	**Danger**	Deaths may occur

Cows already show the first signs of moderate heat stress at a THI of 72. A THI of 80 or higher is considered severe heat stress, resulting in significant performance losses and potential health problems for animals. With the help of mobile applications, for example on a smartphone, the current THI can be calculated to better assess daily heat stress in animals.

Typical formula:
THI = 0.8 × T + RH × (T − 14.4) + 46.4
Where:

- **T** = air temperature in °C
- **RH** = relative humidity expressed as a decimal (e.g., 75% = 0.75)

Calculation example
If the temperature is **32°C** and the relative humidity is **22%**:
THI = 0.8 × 32 + 0.22 × (32 − 14.4) + 46.4
THI = 25.6 + 0.22 × 17.6 + 46.4
THI = 25.6 + 3.872 + 46.4
THI = 75.9
Source: Pericoli – *Temperature Humidity Index: What You Need to Know About It*

Effects of Heat Stress on Animal Feeding

Heat stress, in most cases, has a significant impact on animal feeding. It is manifested by a reduction in feed intake, expressed as dry matter intake. Dry matter intake can decrease by 2 to 3 kg per animal per day, and this can be observed on most farms experiencing this phenomenon.

Due to increased digestive activity and heat production, animal feeding, particularly with feeds rich in crude fiber, is increasingly affected. Reduced intake of basic feed or crude fiber leads to lower rumination activity, which means that less saliva is produced to regulate the pH in the rumen. This, combined with a higher proportion of rapidly digestible carbohydrates, may negatively affect digestion processes and animal health.

Milk Production and Composition

When energy supply decreases while energy requirements continue to increase, milk production can decrease significantly. It is not uncommon for dairy farmers to report considerable reductions in milk production during periods of high temperatures.

Due to lower energy intake, less microbial protein is produced in the foregut, which may reduce the protein content of milk. In addition, amino acids from the blood, which would normally be used for milk protein synthesis, may instead be used to compensate for the energy deficit, leading to a further reduction in protein content.

During hot periods, feeds that are easier to digest and require less energy for digestion are preferred. At the same time, it is preferable to feed animals during periods when temperatures are lower, namely in the evening and early morning.

Regarding Milk Production Analyses

In Kosovo, analyses of the milk market have been conducted, including production, imports, exports, and collection prices. I consider that these analyses do not directly contribute to the study on which we have focused. These analyses address issues related to milk imports and the milk market, while climate-related issues and their impact on milk production have not been addressed.

Table 3. Cattle Population and Structure, 2018–2022

Cattle categories	2018	2019	2020	2021	2022	Change 2021/2022 (%) 2021/2022
Dairy cows	132,474	131,939	133,916	132,076	130,493	-1.2
Heifers over 2 years	9,635	8,128	8,920	8,890	8,575	-3.5

Source: KAS – Agricultural Farm Surveys (2018, 2019, 2020, 2021, 2022)

Referring to Table 3, the number of dairy cows has decreased slightly. The reasons are not provided, and even less are they linked to climate change.

The fact that the number of animals prepared for herd replacement (heifers) has decreased even more is concerning.

In recent years, Kosovo has experienced recurring droughts, resulting in reduced feed availability for animals. In many regions without irrigation systems, maize does not reach all stages of maturity, so farmers are forced to produce silage even when its quality is very poor. Some farmers have started to reduce the areas planted with maize and are looking for alternatives. Alfalfa, as a perennial crop with a well-developed root system, could provide an advantage in ensuring a nutritious feed base within the farm.

Consequences

Fertility Problems

In addition to losses in milk yield, fertility problems can lead to further economic disadvantages for dairy farmers.
Lower conception rates, as well as weight losses due to disruptions in embryonic development, can lead to problems during the summer months. Changes in estrus behavior and an increase in silent estrus make its detection even more difficult.
Follicles, which begin to develop several months before ovulation, can be permanently damaged by hyperthermia and hormonal imbalances. This can result in cycle disorders and fertility problems extending into autumn, i.e., several weeks after the actual heat period. In the case of artificial insemination (AI), it should be emphasized that high temperatures can negatively affect sperm quality and motility.

Diseases
Heat stress can weaken the animals' immune system and make them more susceptible to inflammatory diseases. In particular, cases of mastitis and increases in somatic cell counts within the herd may increase significantly. The causes are numerous and may be related to a weakened immune system and increased pathogen load (e.g., in bedding or animal housing).
Ketosis and other metabolic disorders may also increase as a result of heat stress and reduced feed intake.
An increasing number of lame animals – often caused by infectious hoof diseases such as digital dermatitis – may also be a consequence of high temperatures.[3]
[3] IAK Agrar Consulting GmbH

Adaptation Measures

Climatic Conditions
Climatic conditions inside the barn can be significantly improved through targeted cooling measures. The use of ventilation systems, such as fans, ensures continuous air circulation and can significantly reduce the temperature inside the barn. Cross-ventilation systems, which rely on natural airflow, can also provide fresh air and reduce temperatures.
Another option is the use of water-spraying systems. These systems release a fine mist of water into the barn air, which evaporates quickly and thereby lowers the ambient temperature – providing effective support for the thermoregulation of dairy cows.
Direct sunlight on barn surfaces also plays a decisive role. Exposure to direct sunlight can be effectively reduced through appropriate shading, using natural or artificial materials, which can lead to a noticeable reduction in indoor temperatures. Light-colored roofs or reflective materials can also contribute to temperature control by reflecting solar radiation and preventing excessive heat from entering the barn.

Photo 1 & Photo 2 – Fan installed at the front of the farm (photo by Bajram Imeri).

In Kosovo, it is considered that there are three types of dairy farms:

a) farms with 1–5 heads;
b) farms with 6–10 heads; and
c) farms with more than 10 heads.

The photos presented in this paper represent group **b)** of farms, which are considered suitable for infrastructure adaptation measures, as group **a)** has a smaller number of animals, making the cost of investment potentially unaffordable. Meanwhile, group **c)** has already started investing in infrastructure adaptation measures.

Shading

Natural Shade
Animals generally prefer shade provided by trees. Trees are effective at blocking incoming solar radiation, while moisture evaporating from their leaves helps cool the surrounding air. The strategic planting of trees can increase natural shade in grazing areas. Feed and water can be placed near existing or planned natural shade.

Types of Artificial Shade
Shade can be permanent or movable, while covers can be made from materials selected specifically for this purpose.

Genetic Improvement
One of the measures for adapting to climate change is adapting breeding practices or developing breeds that are more resistant to harsh climatic conditions.
However, in our country, we do not have a well-established breeding program. In such a situation, the main breeds found in Kosovo can be presented, including Holstein, Simmental, and Montbéliarde, while the majority of the population consists of mixed breeds.

Policy and Institutional Measures
Unfortunately, agriculture in Kosovo is not financed through IPARD funds. On the other hand, the livestock sector receives financial support from government programs through the Direct Payments Program, where support is provided per animal, as well as through the Rural Development Program. The measures supported by the Rural Development Program are mainly technical measures and do not directly address climate change issues.
In this regard, investments in the storage of solid and liquid manure are worth mentioning.

Renewable Energy
Renewable energy is becoming a key pillar of sustainable development in modern agriculture. Rising energy costs, climate change, and the need to reduce emissions make the use of clean energy sources an increasingly important need for farms and agricultural systems.
The importance of using renewable energy lies in:

- Reducing production costs;
- In agriculture, energy is used for:
    - water pumping;
    - ventilation, cooling, and heating of livestock buildings.

Table 1 presents the financial support for solar panels provided by the Ministry of Agriculture, Forestry and Rural Development.

Table 4 – Assessment of Capacity and Use of Renewable Energy – Solar Panels on Farms / Agricultural Enterprises

Year	No of farms	Capacity kw	Cofinancing amount/€	Public support/€	Private support/€
1	2	3	4(3x1800€)	5(4x60%)	5(4x40%)
2014	135	540.00	972,000.00	583,200.00	388,800.00
2015	156	624.00	1,123,200.00	673,920.00	449,280.00
2016	193	675.00	1,215,900.00	729,540.00	486,360.00
2017	168	588.00	1,058,400.00	635,040.00	423,360.00
2018	222	666.00	1,198,800.00	719,280.00	479,520.00
2019	199	597.00	1,074,600.00	644,760.00	429,840.00
Total	**1,073**	**3,690.50**	**6,642,900.00**	**3,985,740.00**	**2,657,160.00**

Source: MAFRD

The direct impacts on animal welfare can be seen across several dimensions and are positive.
Solar energy enables the ventilation of livestock housing, which helps reduce heat stress, ensure access to drinking water, and facilitate the cleaning of milking machines, milk cooling tanks, and other equipment. It also provides adequate lighting, while a regular water supply supports the physiological processes involved in milk production and increases the resilience of farm animals to heat waves. From an economic perspective, farmers can benefit from more affordable operating costs.

Key Stakeholders and Their Role in the Program / in the IWRM System in Kosovo

Stakeholders	Their Role in the Program
Ministry of Agriculture, Forestry and Rural Development	Provides legal and strategic support
Ministry of Environment, Spatial Planning and Infrastructure	Provides legal and strategic support
University – Faculty of Agriculture and Veterinary	Provides education and expertise
Farmers' Associations	Provide education and information
Livestock Experts and Other Agronomists	Provide technical expertise
NGOs	Cooperation in relevant areas
Media	Provides necessary information to farmers
Kosovo Hydrometeorological Institute	Provides meteorological data