

Methodological aspects of assessing the sustainability of the agricultural sector

Jolita Greblikaite

*Bioeconomy Research Institute, Vytautas Magnus University,
Lithuania*
jolita.greblikaite@vdu.lt
ORCID 0000-0001-8327-1583

Rolandas Rakstys

*Faculty of Bioeconomy Development, Vytautas Magnus University,
Lithuania*
rolandas.rakstys@vdu.lt
ORCID 0000-0003-0299-9930

Mantas Svazas

*Bioeconomy Research Institute, Vytautas Magnus University,
Lithuania*
mantas@svazas.lt
ORCID 0000-0003-1762-9617

Abstract. As the need for sustainability grows in various areas, the agricultural sector is also being turned to. This sector has pollution problems for which there are no cost-effective alternatives. However, complex actions would allow achieving a higher level of sustainability in individual agricultural disciplines. This is related to the necessary financial investments in the modernization of farms. The aim of this article – to developing a system of complex evaluation tool and a methodology for sustainability evaluation in dairy farms. A review of scientific sources was conducted revealing various methodologies for farm sustainability evaluation. A system of integrated evaluation indicators for the implementation of sustainable farming on dairy farms has been developed and verified in Lithuanian farm conditions. The developed methodology for assessing the level of sustainability in farms includes technical and economic indicators, which allow for a comprehensive evaluation of the possibilities of farms to change their activities in terms of environmental protection. The article showed that solutions related to elementary waste management and their conversion can significantly reduce greenhouse gas emissions. The developed methodology for measuring and assessing sustainability can be integrated into support schemes, with the help and use of which will be aimed at the sustainable development of dairy farms.

Received:
April, 2024
1st Revision:
March, 2025
Accepted:
May, 2025

DOI:
10.14254/2071-
8330.2025/18-2/2

Keywords: sustainability, dairy farm, rural development

JEL Classification: O13, P25, Q13

1. INTRODUCTION

There is much debate about the sustainable development of the dairy farm. The concept of sustainability covers various aspects and both the FAO (Food and Agriculture Organization of the United Nations, 2019) and the International Dairy Federation (IDF Dairy Sustainability Outlook, 2020) and other various international organizations (OECD, 2019; United Nations, 2015) uses various criteria and combinations of these criteria in relation to a sustainable farm, defining it. These criteria are economic, social, environmental, technological, animal welfare, etc. Increasingly faced with the problems caused by climate change, food security, safe food and health-friendly food supply, it is important for Lithuania to define which dairy farm is considered sustainable, i.e. what criteria define sustainability. This also relates to the Strategic Plan for Agriculture for the next financial period, where the European Commission (EC) is focusing on sustainable farms and sustainable farming methods, with financial support for sustainable production methods. In 2017, Lithuania joined the Rotterdam Dairy Declaration, committing itself to developing a sustainable dairy farm, but what actions or measures would allow it to do so is not foreseen and defined. Countries are left free to decide internally how sustainability will be achieved, what specific measures, how it will be assessed, etc.

In scientific literature, there is no unified evaluation of sustainable economy, and different authors analyze sustainable farming in different sections and present various options for interpreting the concept of sustainability and its evaluation. Parna et al. (2006) argue that the satisfaction of current needs must not reduce the possibilities for future generations to meet their own; In Bittante et al. (2015), a sustainable farm is inseparable from the evaluation of the impact of newly introduced agrarian measures on agriculture; Balaine et al. (2020) believe that a sustainable system must be based on a win-win strategy that at the same time improves agricultural efficiency and provides wider benefits for the environment and social activities. Sustainable farming must promote local consumption, make more sustainable use of water and manage wastewater responsibly; Lam et al. (2016) emphasizes the negative impact of antibiotics on the quality of milk; According to Foote (2020), modern and sustainable dairy farms should introduce digital methods for sowing and caring for crops, such as fixing nitrogen in the soil and improving the quality of cow silage.

However, there is currently a lack of methodological solutions that would allow assessing the decarbonization potential of farms. This is especially true of the livestock sector, which is complex and requires various initial analytical actions. Before specifying methodological solutions, it is necessary to delve into the reasons that prevent farms from achieving decarbonization, while creating the prerequisites for additional income. They can be obtained from biogas production, carbon credit programs, thus saving funds allocated to animals through feed production. Farms, not having the opportunity to assess their capabilities to achieve sustainability, postpone the necessary decisions. This may prevent farms from achieving a competitive advantage, since there is a possibility that polluting farms will be additionally taxed or no longer subsidized. This article attempts to reduce the negative impact created by the lack of methodological solutions. The article proposes complex solutions that combine economic and environmental interests.

Environmental evaluation of cow farms is carried out due to the growing importance of this farming method worldwide. On the one hand, the consumption of milk and its products is constantly growing in the world. On the other hand, technological progress allows for the extraction of high-quality proteins, fats, and proteins from milk, which have a high economic value on the market. With the increasing expansion of this sector, there is a need to assess the sustainability component, since unbalanced cattle breeding

contributes to the growth of environmental pollution levels. Innovations in this area are necessary, but at the same time, the development of the necessary methodology is necessary to achieve measurements of the progress achieved. Lithuanian data was chosen due to the optimal size of the country, the developing milk production and processing sector, as well as clear environmental requirements, which are likely to be applied in more and more countries of the world. Currently, methodological solutions are needed that would allow for the evaluation of both environmental and economic and social aspects. The latter aspects are important because the growth of the standard of living of society in rural areas would enable the development of new business activities and the growth of the standard of living.

The aim of this article was to develop a system of complex evaluation tool and a methodology for its application, designed to assess sustainability in dairy farms, and to test the possibilities of applying the methodology in Lithuanian dairy farms in a pilot study.

2. LITERATURE REVIEW

The European Union has been consistently on the path of decarbonization for several years. By orienting the legal framework towards a green transformation, the EU aims to significantly contribute to the improving global environmental situation. However, the decarbonization of the agricultural sector is delayed due to the lack of technology and a strong farming community. Samusevych et al. (2024) emphasize that successful implementation of environmental tax reform requires institutional readiness, which is crucial for decarbonization to take root in agriculture. According to Shcherbak et al. (2025), disruptions caused by geopolitical conflict and trade imbalances may hinder regional ecosystem sustainability and slow environmental policy implementation. Furthermore, Giyasova et al. (2025) note that environmental outcomes are strongly linked to the pace of economic growth and the quality of institutions in both developed and developing contexts. When the EU Green Deal was launched, one of the most important measures envisaged in it was the reduction of agricultural pollution. This was to be achieved by protecting perennial grass areas and changing farming habits. This was to be encouraged by additional subsidies. However, when it comes to animal husbandry, more active actions towards decarbonization are somewhat lacking. Štreimikienė et al. (2022) highlight that effective information management is essential for implementing Green Deal goals in sectors such as agriculture. A similar delay is observed in other sectors, such as automotive, where environmental transformation is highly dependent on government intervention and industrial capacity (AlSheikh, 2025).

The concept of competitiveness has many definitions in literature due to its complex and dynamic nature, which may vary depending on the industry. Authors choose the definitions they are guided by, considering their areas of interest and the available data on which competitiveness indicators could be calculated. The Organisation for Economic Co-operation and Development (OECD) is an important public sector institution that pays much attention to better understanding the factors that influence relative competitiveness. A study by Becerril Torres et al. (2025) emphasizes that economic growth does not automatically reduce CO₂ emissions unless accompanied by specific environmental policies and sectoral reforms. The competitiveness of an economy is determined by its ability to produce and supply homogeneous goods to the open market at lower or at least the same costs than competitors, thus creating higher or equal value added. As noted by Gesevičienė et al. (2025), the eco-efficiency of EU farms increases significantly when agri-environmental subsidies are properly allocated, which directly impacts both sustainability and competitiveness. According to Kriščiukaitienė (2008), “in the open market, an economy is considered competitive if it is able to offer its products at world market prices, and the compensating factors of production are at least compensated at the market level”. Latruffe (2014) defines farm competitiveness as “the ability of a farm to compete and be successful”. The competitive success of farms

is determined by their competitive capabilities. They depend on the following factors: resources, production structure, national market and related and auxiliary production. In a recent study, Bórawski et al. (2022) emphasized the importance of innovation adoption and access to credit as vital components of farm competitiveness in the EU's green transition. Amaliah (2025) suggests that knowledge sharing and performance measurement systems, even in traditional farming cultures, significantly enhance farmer output and adaptive capacity.

Meanwhile, Galnaitytė and Krisčiukaitienė (2017) distinguished two alternatives for how a farm can be competitive: ‘

a) if it can produce and sell homogeneous products cheaper than others in competitive markets and without subsidies,

b) if it can produce unique products or find exceptional features for existing products (i.e. innovative products, modifications) that other farms cannot produce.

Competitiveness is also understood as the ability to sell products that meet demand requirements (price, quality, quantity) and at the same time ensure a profit that allows the farm to prosper. Competitiveness can be assessed in the context of domestic markets (in this case, business entities or sectors in the same country are compared with each other) or in an international context (in this case, business entities from different countries are compared) (Keogh, Tomlinson, Henry, 2015). Sitenko et al. (2023) stress the role of innovative energy technologies in boosting regional competitive capacity, especially in resource-based economies. Korjonen-Kuusipuro et al. (2024) propose a shift in societal narratives toward inclusive sufficiency, which may redefine competitive benchmarks in agriculture and rural development.

Competitiveness can be described as the long-term ability of a business entity to make a profit (Michaličková et al 2014). A broad approach to this issue was proposed by Gorynia (2004), who defined competition as the ability to operate and survive in a competitive environment. In this context, the main focus is on long-term business activity in a market economy. Most authors agree that competitiveness is a relative concept that can be analyzed using a comparative method (Siudek and Zawojcka 2014). Therefore, the concept of competitiveness should be decomposed and applied to operations. The following dimensions of competitiveness are generally recognized: (1) the competitive potential of the business entity, (2) the strategy of market competitors, (3) competitive advantage (Bórawski et al., 2020). The Competitiveness Research Center defines competitiveness at the business entity level as the ability to consistently offer consumers products and services that meet social responsibility standards and for which they are willing to pay more than for competitors' products, ensuring profitable conditions for the business entity. The condition for this competitiveness is that the business entity, by consistently achieving better market competition criteria compared to its competitors, is able to notice changes in the environment and within the business entity (Gál, 2010).

Profitability and success are inseparable concepts of competitiveness, and Toth, (2012) also linked viability and livelihood to the definition of competitiveness. According to literature sources, viable are farms or agricultural enterprises that are engaged in production in sectors that have comparative advantages in both domestic and foreign markets, and which, by efficiently allocating available resources in the existing legal and economic environment, can generate socially acceptable normal profits. On this basis, competitive are those entities that can generate some additional profits exceeding the socially acceptable level in a free, open and competitive market.

At the farm or company level, the definition of competitiveness is associated not only with profitability, but also with productivity. They are often considered key performance indicators according to strategic management theory. This theory emphasizes cost leadership and product differentiation (i.e. brand identification or image and customer loyalty) to increase productivity and profitability (Thorne and Fingleton, 2006; Latruffe, 2010).

The most comprehensive definition of farm competitiveness is provided by Bachev (2010), who states that competitiveness is the ability (internal ability, potential, incentives) of an agricultural holding to maintain a sustainable competitive position in a (certain) market, which leads to high economic performance by constantly improving and adapting to the changing market, natural and institutional environment. The level of competitiveness is always characteristic of a specific market-oriented farm, considering the markets in which it sells its products and services (Bachev and Koteva, 2021). Kontautienė et al. (2024) forecast that sustainable consumption patterns will become dominant in small EU economies, reshaping demand in agricultural markets.

The insurance sector also plays a crucial role in mitigating climate-related risks. Al-Smadi (2025) reports that digital transformation readiness in insurance institutions significantly influences their ability to support sustainable investments. Dillianti et al. (2025) highlight how digital enablement and strategic alignment in life insurance can contribute to long-term sustainability goals.

Efficiency, financial provision, adaptability and sustainability are the main “pillars” of agricultural competitiveness. High competitiveness means that the farm (1) efficiently produces and sells its products and services on the market, (2) effectively manages its financing, (3) is adaptable to the changing market, institutional and natural environment and (4) is sustainable (Bachev, 2010). Conversely, insufficient competitiveness (its absence) indicates that the farm has serious financing, production and sales problems due to high production and/or transaction costs, inability to adapt to changing environmental conditions and/or insufficient sustainability over time (Bachev and Koteva, 2021).

A significant number of documents have been issued at European Union level (*European Green Deal, 2019; EIP-AGRI Report, 2018; the Johannesburg Declaration and the Sustainable Development Implementation Plan, 2002; updated EU Strategy for Sustainable Development, 2006; Rio Declaration, 2002; Conclusions of the Rio+20 conference "The Future We Want", 2012; FAO document "Climate change and the global dairy cattle sector. The role of the dairy sector in reducing carbon dioxide in the future", 2019; OECD document "Innovation, productivity and sustainability of food and agriculture", 2019*), *International Federation (IDF) document "Animal Health Report", 2019 and reports of the International Federation (IDF) "Sustainability of Dairy Farming", 2018, 2019, 2020; Report of the World Commission for The Development of the Environment (WCED), 1987; European Milk Sector References, 2018 and 2019, European Union Policies, 2014*) related to sustainable development of dairy sector, which cover three main areas – economic, social and environmental. The European dairy sector strives to be part of sustainable development and to contribute to the achievement of the objectives set, but successful implementation depends to a large extent on national regulation. Streimikiene et al. (2024) argue that sustainable finance instruments are crucial for advancing Green Deal objectives, especially in emission-intensive sectors like dairy. Fernandes et al. (2025) emphasize the need for targeted government expenditure to promote renewable energy adoption and support sector-wide green growth. Regional perspectives also matter in shaping sustainability policies. For example, Olzhebayeva et al. (2023) reveal that while Central Asia is beginning to embrace Green Deal research, interest levels are still uneven—indicating the need for more inclusive knowledge transfer in environmental policy. Document analysis (*EU dairy sector: key features, challenges and prospects, 2018; National Strategy for Sustainable Development, 2003; Updated National Strategy for Sustainable Development, 2011; in the order of the Director of the State Food and Veterinary Service on the approval of welfare requirements for farm animals (No B1-690 of 20 September 2019; Environmental requirements for manure management, 2005; Modelling of sustainable farming development of the Lithuanian agricultural sector, 2017; Rules and Tips for Smart Farming, 2007; Indicators of the National Strategy for Sustainable Development (n.d.); Methodology for optimizing the production of dairy farms, 2011; Annual Report of the Register of Farm Animals, 2020, etc.*) it turned out that Lithuania still lacks both a sustainable development strategy and a system of criteria and indicators for assessing farms in the dairy sector.

This study, based on the UN Agenda for Sustainable Development (2015), the EIP-AGRI report (2018), the FAO document (2020) the scale for assessing the MDG indicator 2.4.1., according to experts, the FAO (2019) document MOTIFS (Meul et al., 2008) methodology, the methodology of MIESMIS (López-Ridaura et al., 2002), indicators of the organization "SAI Platform" (2010), aims to single out the most significant and important criteria for assessing sustainability of dairy farms, to form their system, and then, on the basis of methodological methods, recommendations for the use of this methodology in real-world conditions. Plastun and Kozmenko (2025) stress that the disruption caused by war and climate-related stressors has intensified the need for resilient and sustainable frameworks in agricultural production. In 2015, the UN 2030 Agenda for Sustainable Development was developed, which identified three strands of sustainable development – *economic, social and environmental*; 17 Sustainable Development Goals, which have 232 indicators.

When analyzing sustainability of dairy farms, it is important to single out the measurement of the indicator 2.4.1., which is highlighted in the FAO (2020) document "MDG indicator 2.4.1. Share of agricultural land used for productive and sustainable farming", which provides for three dimensions of sustainability – *economic, social and environmental protection*.

In research various important documents are analyzed, which form the basis for methodological assumptions. One of them is the EIP-AGRI report. in which (2018) three key areas related to a strong and resilient dairy farm are analyzed. The report analyses robust and resilient resilience of dairy farms on three levels: cow, dairy farming and sector. The first part evaluates cows through the prisms of animal welfare, animal health, animal nutrition, milk quality and reproduction and their criteria. In the second part, dairy farms are evaluated from strategy to execution (dairy farm strategies, effective feeding, herd management and attitudes, skills and support). The third part assesses the dairy sector, which addresses social needs and challenges (communication and dialogue between farmers and consumers, and new parameters of milk quality). The same report identifies 4 main challenges that respond to social needs: environmental impacts (GHG, water pollution, land use intensity), animal welfare (living conditions, human intervention), health (use of antibiotics, disease outbreaks) and breed management issues (genetically modified organisms (GMOs)) (EIP-AGRI, 2018). Indicators are also provided to define a robust and resilient dairy farm. According to the authors of the EIP-AGRI report, a strong and resilient farm consists of a large number of criteria that are interrelated. Yang et al. (2023) further show how financial market volatility, influenced by carbon emission trading, can have ripple effects on investment in agricultural and energy sectors. However, farmers need simple and clearly defined indicators that are easy to measure, describe and monitor.

Another important document is the FAO's 2019 edition of "Climate Change and the Global Dairy Cattle Sector. The role of the dairy sector in reducing carbon dioxide in the future" document Climate Change and the Global Dairy Cattle Sector. The Role of the Dairy in a Low-Carbon Future), which provides guidance to the dairy sector on GHG reduction. Recommendations consist of 5 main parts: feeding and feeding management, manure management, energy consumption on the farm, animal health and cultivation, fertilizer management (manure and commercial fertilizers).

3. METHODOLOGY

The research is based and constructed on these to main methodologies and their adaptation to appropriate conditions (in this case Lithuanian dairy farms): MOTIFS (The methodology of the Monitoring Tool for Inegrated Farm Sustainability) considers the economic, ecological and social pillars, through which it analyzes the following topics: resource use, quality of natural resources, biodiversity, productivity and efficiency, profitability, internal social sustainability, external social sustainability, disposable income, entrepreneurship; MIESMIS (English: MIESMIS) Management Systems Assessment Framework

Incorporating Sustainability Indicators methodology integrates the results of the indicators with qualitative and quantitative methods and multi-criteria analysis. The methodology assumes that sustainability is defined by the NRMS (NRMS). Signs of Natural Resource Management Systems: productivity, stability, reliability, resilience, adaptability, justice and self-confidence (López-Ridaura, S., et al. 2002).

The following methods were used in the research: analysis of statistical data, interviews of experts to assess the selection and significance of sustainability indicators, synthesis and comparison of data, experimental and analytical studies for the selection of sustainability criteria and indicators, sustainability measurements on farms. Technological solutions for keeping cows are evaluated based on creating optimal conditions for keeping animals, labor costs, productivity, environmental impact and investment, as well as operating costs. In the case of this study, the sustainability methodology is designed to measure sustainability at the farm level and is most adapted to the conditions of Lithuanian farms. The sustainability methodology can be used to monitor the sustainability of farms through the introduction of certain support schemes, but the methodology is not the basis for modelling the support schemes themselves.

The purpose of developing a methodology for assessing sustainability of a dairy farm is based on assumptions about the necessity of such a methodology to encourage dairy farms to follow environmental, social and economic criteria, to identify farm sustainability problems and to solve them. Farms facing sustainability problems should also be encouraged if necessary to receive state support in investing in increasing sustainability of the economy. The need for sustainability evaluation methodology presupposes the need for the FAO, OECD, EU and other regulatory instruments governing countries to take action to promote sustainable farm development.

Sustainability measurement may include the analysis of quantitative indicators, may be based on questionnaire surveys, and mixed methods may be used. In all cases, sustainability measurement is based on a holistic approach. Sustainability evaluation must not be based solely on the determination of the current situation, it is necessary to assess trend and variability of indicators reflecting sustainability (stability, resilience, risk management), one of the most important aspects of sustainability is long-term sustainability. The assessment of the fulfilment of sustainability requirements is not possible without a wider context and comparability with the indicators of the branch (group). Not all effects/results reflecting the sustainability of farms can be measured quickly and accurately. Effects, measurement of which can be sufficiently reliable and uncomplicated, are expressed in quantitative indicators. For effects that are relatively complex and can be costly to measure, the farm's use of sustainability measures and their characteristics (technical specifications) can be judged.

Sustainability assessment methodology in this study is based on the following assumptions:

1. The essential sustainability conditions discussed in the international documents and recommendations governing the concept and assessment of sustainability are respected.
2. Three dimensions of the assessment are distinguished: environmental, social and economic
3. In each dimension, indicators or attributes are selected. Indicators (attributes) have been selected considering the possibilities of obtaining objective data in Lithuania, i.e. the possibility to use statistical information, public registers, declarations, farm accounting data. In individual cases, sustainability traits that the farms would declare were selected, but in the case of verification, they would be easy to verify.
4. Sustainability dimensions are given equal weight. The sustainability assessment methodologies examined also use the same weights of sustainability dimensions.
5. Indicators(s) that describe sustainability are given equal weight. For indicators (attributes), minimum thresholds are set. Some of the sustainability features are mandatory in accordance with the legislation in force in Lithuania. If the farm does not meet any of these attributes, it does not meet the sustainability requirement in this dimension.

6. Some of the characteristics that characterize sustainability are important, but these characteristics are difficult to identify and require studies, e.g. emissions of NH₃, H₂S, etc. In this case, sustainability is not defined by the result, but by the instrument used ((-s) (attribute) leading to compliance with the sustainability criterion.

To substantiate the significance and relevance of sustainability dimensions and indicators (attributes) that characterize them, an interview with experts was carried out, as well as a standardized questionnaire was provided to them to determine the weights of indicators (attributes). 10 experts took part in the survey: 5 scientists (the areas of research represented are animal welfare, technologies of dairy farms, agricultural economics and management), 5 persons representing the dairy business.

Based on the expressed opinion, observations and suggestions of experts, the methodology for the sustainability of dairy farms was formed based on the following basic methodological principles:

1. A 3-point scale is used. Some of the signs have only two possible expressions – "yes" and "no". For such signs, a two-point scale is used - 0 (the condition is not met) and 1 or 2 (the condition is met). 1 point applies only to the mandatory minimum criteria.
2. The environmental dimension has been supplemented with an additional feature – fixed whether the farm keeps records of the use of fertilizers and the use of plant protection products.
3. The social dimension has been supplemented with a mandatory minimum requirement, whether the farm complied with the requirements of the labor code. If the farm has received penalties in the last 12 months, then the population has not been able to do so. due to improper working conditions or illegal work, it is considered unsustainable. In the absence of hired employees, the indicator is not included in the assessment.
4. The economic dimension is supplemented with an attribute, whether cattle are prohibited on the farm. Also supplemented with a financial factor reflecting the level of EBITDA. The loan coverage rate used is $EBITDA / (\text{Loans repaid, including leasing payments} + \text{interest})$. This indicator shows whether the main (typical) activity of the farm generates enough funds to repay loans and pay off interest. Partly reflects whether the farm is able to make borrowing decisions responsibly. The economic dimension of sustainability is supplemented by an indicator reflecting the weight of grants and subsidies related to income in the revenue structure. The use of this indicator remains debatable, on the one hand it is appropriate to use this indicator in the methodology in order to more objectively determine how independent and capable the farm is economically independent and capable, on the other hand, state subsidies guarantee its economic sustainability. A larger proportion of subsidies would mean less sustainability, more dependence on state support schemes.
5. The concepts of some criteria, the signs of their determination have been clarified.

Restrictions on research. There is no unified methodology for measuring sustainability. Sustainability measurements can be of varying complexity and detail, measuring the sustainability of the dairy industry at the EU level, at the Lithuanian level. In the case of this study, the sustainability methodology is designed to measure sustainability at the farm level and is most adapted to the conditions of Lithuanian farms. The sustainability methodology can be used to monitor sustainability of farms through the introduction of certain support schemes, but the methodology is not the basis for modelling the support schemes themselves.

4. EMPIRICAL RESULTS AND DISCUSSION

Summarizing the results of the expert study, it was found that the weight of almost all the indicators submitted for assessment differed insignificantly – the weight of the indicators in the environmental dimension was from 5.95 to 8.25 per cent (the weight of one indicator was 4.18 per cent – this indicator

was rejected), in the social dimension from 8.55 to 10.24 per cent and in the economic dimension from 10.9 to 13.76 per cent (the total weight of the dimension indicators is 100 per cent). It is noteworthy that scientists approached all dimensions of sustainability and the indicators that characterize them more evenly, while some practitioners gave priority to indicators characterizing animal welfare, distinguishing a separate dimension, part - to economic indicators, giving them more than 1/3 of the total weight.

Study considers that sustainability must be ensured in every dimension of sustainability: economic, social, environmental (UN Agenda for Sustainable Development, 2015; Kebreab, 2019; Balaine, 2020; United Nations, 2015; Ndambi et al., 2020; Da Silva et al., 2020; Strezov et al., 2016; Scherer et al., 2018). Social – improving working conditions, reducing labor costs, increasing the attractiveness of work, increasing labor productivity. In economic – increasing the economic efficiency of milk production (improving the conditions of keeping animals, productivity, quality of production, etc.), reducing the cost of production. Environment – to reduce air, water and soil pollution and GHG emissions through complex measures.

The study, based on (Bai (2018), Bankuti (2020), Fogarassy et al. (2016)), concluded that the sustainability of a dairy farm is assessed in two stages: first, compliance with the mandatory minimum requirements is assessed, and if the farm meets the mandatory criteria, then the level of sustainability of the farm is determined. The sustainability of the dairy farming farm shall be determined in accordance with the criteria set out in Table 1. Annex.

Assessment of sustainability of dairy farm is:

- Sustainable: Scored more than 60% of the maximum number of points that can be scored.
- Acceptable sustainability: scored 40-60% of the maximum number of points that can be scored.
- Unsustainable: Scored less than 40% of the maximum number of points that can be scored.

The justification of the criteria for assessing the sustainability of the dairy farm is based on the analyzed methodologies (UN Agenda for Sustainable Development (2015), EIP-AGRI report (2018), the FAO document (2020) MDG indicator 2.4.1. assessment scale, the expert opinion, the FAO (2019) document MOTIFS (Meul et al., 2008) methodology, the methodology of MIESMIS (López-Ridaura et al., 2002), the indicators of the organization "SAI Platform" (2010), (Methodology for optimizing the production of dairy farms (2011)) and scientific literature (Kebreab et al. (2019), Zhou (2010), Bichisao et al. (2019), Karttunen et al. (2016)). Below the criteria are discussed in more detail.

Criteria for the social dimension.

The farm is equipped with rest / sanitary facilities. Conditions are created for employees to rest. Smart control systems are installed on the farm. This is a criterion that shows the level of technology applied on the farm, on which the working conditions, the attractiveness of work, productivity, the conditions of keeping livestock and productivity depend. Labor costs and workload are reduced, the attractiveness of work on farms is increased by mechanizing work processes and increasing the efficiency of the equipment used, labor productivity and automating work processes, employing robots in barns, installing digital systems, monitoring and analysis systems for sensor and remote work processes. This is very important for increasing the competitiveness of dairy farms and the quality of human life. This can be done by comprehensively covering all processes in the barn or in stages: first by automating milking, then by preparing and feeding feed, manure management and the entire management of technological processes.

The wages of unskilled workers are higher than the minimum wage in the country. The average salary is calculated during the calendar year. The salary of qualified specialists is not lower than the average monthly salary in the country. The average salary is calculated during the calendar year.

Compliance with the Labor Code. This is a mandatory minimum requirement. If the farm has received penalties in the last 12 months, then the population has not been able to do so due to im-proper working conditions or illegal work, it is considered unsustainable. In the absence of hired employees, the indicator is not included in the assessment.

The farm is a social patron (provides support for social community initiatives STI). Determined on the basis of the declaration of support submitted to the STI, or a certificate is submitted from the institution to which the support was granted.

Employees (farmer) annually raise their qualifications (at least 8 hours). Has a document confirming advanced training. Qualifications are raised by all employees of the farm.

He/she is a member of the cooperative(s). Has a document confirming the membership.

He/ she is a member of farmers' associations and/or rural communities. Has a document confirming the membership.

The farm has a green diploma. Has a document confirming the "green diploma".

Criteria for the economic dimension.

On the farm, the average productivity of cows is higher than the average productivity in the country (the productivity of cows is calculated in a calendar year). It is very important to increase the productivity of cattle by improving housing conditions, optimizing the behavior of animals, keeping hygiene, creating an optimal microclimate in the barn. High productivity of cows can be achieved only with well-balanced feeding, under good housing conditions, proper treatment of animals (Table 2).

Table 2. Factors for assessing animal welfare

	<i>Welfare criteria</i>		<i>Assessment method</i>
Proper nutrition	1	Freedom to hate hunger	The result of the state of the body
	2	Freedom to hate thirst	Water supply, cleanliness of water, number of animals per drinker
Storage conditions	3	Comfort during rest	Cleanliness of cattle, lying time
	4	Thermal comfort	No established assessment method
	5	Freedom of movement	The function of the enclosure depends on the live weight, access to pastures
Wellness	6	Absence of injuries	Tenderness, changes in the body
	7	Manifestation of diseases	Cough, nasal discharge, eye discharge, breathing disorder, diarrhea, swollen rumen, mortality
	8	Avoiding pain during procedures	Castration, etc.
Proper behavior	9	Social behavior	Agonistic behavior, harmonious behavior
	10	Reaction to environmental stimulation	Access to pasture
	11	The relationship of an animal with a person	Distance avoidance test
	12	Positive emotional state	Assessment of proper behavior

In the cowshed, diseases of production (abrasions, wounds, bruises, swelling of the joints, damage to the nails, injury to the tail and teats, pneumonia, inflammation of the udder, overheating) and diseases of an infectious nature must be avoided. The freedom of movement of animals shall not be restricted. The environment in the barn must meet all the physiological and ethological needs of the cow.

In the cowshed, diseases of production (abrasions, wounds, bruises, swelling of the joints, damage to the nails, injury to the tail and teats, pneumonia, inflammation of the udder, overheating) and diseases of an infectious nature must be avoided. The freedom of movement of animals shall not be restricted. The environment in the barn must meet all the physiological and ethological needs of the cow.

The effect of seasonality on the productivity of cows is not more than 15% (the average productivity of cows is calculated in the calendar year, the change in productivity is estimated by the average productivity in each quarter of the year). At all times of the year, it is important to create a good microclimate in the barn, maintain indoor hygiene, feed the cattle with full-fledged feed. In the cowsheds you need to ensure an optimal microclimate at all times of the year. It is necessary to control the most important microclimate factors in them: air temperature and humidity, which also influence other factors (the concentration of ammonia, hydrogen sulphide gas, etc.). The microclimate of the cowsheds depends on the outdoor climate, the insulation of the barn, the intensity of the livestock kept in the barn and the ventilation of the barn. The optimum air temperature for a cow is from -7 °C to 23 °C. In frosts or heat, temperatures cause less damage than high air humidity.

The factor for converting the actual milk content into the basic milk content is more than 1,10 (calculated as the average coefficient per calendar year). This is an indicator that depends on the quality of milk and greatly affects the income received for the milk sold. The coefficient for converting the milk content into the basic quantity shall be calculated using the formula:

$$k_p = 1 + (R_f - R_b) \times k_1 + (B_f - B_b) \times k_2$$

here:

k_p is the conversion of the quantity of raw milk into a basic coefficient;

R_f = fat content of milk bought in, %;

R_b = basic fat content of milk, % (3,4);

B_f = protein content of the milk bought in, %;

B_b = basic protein content of milk, % (3,0);

k_1 - coef., showing how much the amount changes with a change in fat content by 1 percent (0.178);

k_2 - coef., which shows how much the amount changes with a change in protein content by 1 percent (0.267).

In a sustainable farm, quality milk must be produced in all quarters of the year. This can be achieved when a well-planned and equipped barn is provided, good conditions for keeping cows are created, good hygiene of premises and equipment, a good microclimate in the barn, the livestock is fed with well-balanced feed.

Value added per job per year Eur/per hour. A generalized economic indicator characterizing labor productivity. Scores should be awarded in the event that the farm indicator corresponds to the average of the Lithuanian branch of agriculture or higher.

Profitability of equity in percent. Three-year average higher than the average interest rate on long-term loans. It is recommended to round the interest rate on loans to a higher integer, at the time of preparation of the report – 4 per cent.

Sales revenue in Eur / live. Data for the last 3 years are evaluated. Not a decrease in income every year, or if income has developed unevenly, the deviation of the minimum need from the average is not more than 10 percent.

Indicator of specialization. Calculation is made on the basis of gross production. Crop production accounts for at least 34% of the total value of production. Crop production accounts for at least 34% of the total value of production, or at least 50% of the feed is produced on its own farm.

Environmental dimension criteria

Measures are being taken to reduce emissions of odors (gas NH₃, H₂S, etc.) and air pollution from barns (bio-means-probiotics are used; manure is acidified; feed additives are used). Of the measures submitted, at least one measure shall be taken to reduce gas emissions.

The main source of ammonia is manure. Ammonia evaporates most intensively from the urine of livestock, breaking down the urea contained in it. Ammonia in animal husbandry accounts for more than 90 % of the total NH₃ content and its evaporation occurs at all stages of manure formation, storage and spreading. The structure of ammonia emissions in animal husbandry is as follows: on average, 37% is made up of barns, 35% is used for fertilization in the fields, 24% from manure, and 4% in pastures. Most ammonia evaporates into the environment during the keeping of bovine animals: about 50 % of the total emissions.

The modernization of cattle housing technologies must reduce air pollution, gas emissions from farms, the impact of animal husbandry on climate change. Air pollution and ammonia emissions are reduced at all stages of manure management: in barns, manure storage facilities, transportation and manure is introduced into the soil.

Ammonia emissions from manure are reduced by controlling the most important factors affecting the intensity of gas evaporation: reducing the temperature, reducing the air rate above the manure, reducing the humidity of the surface of manure, intensifying the formation of a crust on the surface of manure, reducing the protein content of manure.

Measures are in place to reduce emissions of odors (NH₃, H₂S, etc.) and air pollution from manure (maintaining the natural coating-crust of manure; artificial manure coatings are applied; the manure is covered with roofing material). Of the measures submitted, at least one measure shall be taken to reduce gas emissions.

Ammonia emissions from thick manure manure are reduced by applying the following complex measures:

- cover the manure stack with straw, peat, film, etc.;
- reducing the surface area of manure (e.g. by building manure with high walls);
- maintaining a high content of dry matter (for example, by covering the roof above the manure shed);
- if the manure stack is not covered, it is loaded in the form of a cone to run off precipitation;
- maintain a temperature below 50 oC in the manure sieve by adding more straw to the manure so that the carbon-to-nitrogen ratio is greater than 40 (C:N>40).

Ammonia emissions from liquid manure manure are reduced by the following measures:

- scalded with a layer of chopped straw, expanded clay, peat;
- cover with tarpaulin, synthetic film;
- do not destroy the natural crust on the surface of the manure, which is formed when the manure contains more than 7 % of the dry matter and when the fresh manure gets to the bottom of the reservoir;
- do not mix manure in manure (mix only before removal).

Measures are in place to reduce GHG (CO₂, CH₄, N₂O) emissions (climate-friendly rations are used).

The impact of animal husbandry on climate change is reduced by reducing GHG emissions. The main GHGs emitted are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O).

In Lithuania, GHG contains mainly carbon dioxide CO₂, which accounts for about 65.5%, methane – 15.9% (of which about 8.7% in animal husbandry), and nitrous oxide – 14.8% (of which about 0.9% in animal husbandry), fluorinated gas 3.7% of the total GHG content in CO₂ eq. In Lithuania, agriculture is the second sector in terms of GHG emissions, accounting for about 21.6% of total GHG emissions. As a

result of agricultural activities, in 2017, 4403 kt of GHG CO₂ eq. was released into the environment, of which about 44.6% of gas (1965 kt CO₂ eq.) evaporated in animal husbandry (Lithuania's Greenhouse Gas Inventory Report 2019). Total GHG in Lithuania in 2017 produced 20,417 kt of CO₂ eq.

Measures to reduce energy consumption are applied (heat recovery system, frequency converters in milking equipment, efficient lighting in the barn, natural ventilation system). Sustainable energy consumption, reducing the impact of animal husbandry on climate change

According to the summarized results of scientific research, in an average dairy farm it is possible to reduce energy costs by 32-39 percent, and these investments will pay off in 3-5 years. The best options for reducing power consumption are:

- the heat recovery system reduces up to 55% of energy consumption for water heating.
- the use of frequency converters reduces up to 70% of the cost of milking.
- efficient lighting reduces the energy consumption of lighting up to 66%.
- combining a natural and artificial ventilation system reduces energy consumption by up to 80% for the formation of an optimal microclimate.

The average energy consumption structure on a dairy farm is: 26% for milking; 32 % - for heating water; 21% - for cooling milk; 10 % for pumps for water supply and sewage disposal; 11% - for ventilation, lighting, etc. needs.

Energy costs depend on the size of the farm, the productivity of animals and the technology implemented in it. Each farm has different options for reducing energy costs, as well as GHG emissions. Knowing the energy costs required for production, GHG emissions can also be predicted. The CO₂ emission intensity (g CO₂ / kWh) is calculated as the ratio of CO₂ emissions to the amount of electricity and heating energy produced (EEA, 2018). In the production of electricity, the average intensity of greenhouse gas emissions in the EU equivalent of CO₂ is 558 g CO₂/kWh.

Water according to the norms is used for watering animals, preparing feed and maintaining cleanliness of the premises (water is not used in manure management technologies). The average amount of water consumed per cow per day is equal to 100 l. The average amount of water consumed consists of the following needs: for watering cattle, preparing feed, washing equipment, washing cattle (udders), cleaning the premises. Water must be of drinking water quality and be supplied without interruption. For washing the surface of the dung floor, dilution of manure in liquid manure removal systems, water from surface deposits should be used.

A manure shed is installed that holds 6 months of manure. The farm is equipped with a compliant manure shed. If the barn is deep and manure is accumulated in it for 6 months, it is considered that the farm has a properly equipped manure shed. If liquid manure is accumulated, a liquid manure tank is installed, if thick manure is a thick manure plant, which consists of a site for storing manure and a slurry tank next to it. A waterproofing layer must be installed in the manure shed and slurry hoard to ensure tightness throughout the entire period of operation. The manure shed and the slurry hoarder must be installed in such a way that surface and groundwater and slurry into the environment from adjacent areas cannot be introduced into them. With the help of peculiar or pumps, liquid manure (slurry) must be fed into the storage unit to a part of its bottom. The slurry hoarder must be covered. Persons holding 10 SG or more must apply measures to reduce ambient air pollution and odors in liquid manure and/or slurry hoards selectively: sealed roofing, flexible coatings (awnings), solid floating coatings (plastic sheets or granules, light bulk materials, straw, naturally occurring crusts).

Manure recovery technology is used: compost production – aerobic processing or biogas production – anaerobic processing. Manure is composted, compost is made from it, and then used to fertilize the soil. Compost is used in bulk or granules are made from it. For composting, thick manure is suitable: a mixture of droppings and straw. Liquid manure is subjected to anaerobic processing, during which biogas is produced.

A direct system of embedding liquid manure into the soil is applied or thick manure is introduced into the soil within 4 hours. For fertilizing with liquid manure, technologies of direct embedding in the soil are used. After spreading on arable land, thick manure is introduced into the soil as soon as possible, but no later than 4 hours after application. For fertilization, a special technically neat and safe technique is used. It is recommended to fertilize at the lowest possible wind speed, lower air temperature, with the wind blowing from the most populated area.

Industrial waste is recovered. Contracts have been concluded with waste management companies, the farm is equipped with containers for the accumulation and sorting of such waste.

Freedom of movement of cows is ensured (a sufficient area per head). No more cattle are kept in the barn than provided for in the project. The number of cattle is a sufficient area of the barn to ensure free movement: the total area of the cowshed / the average (maximum) number of cows, pcs. The dimensions and area of the bearing sites, the width of the paths must comply with the requirements set out in the Rules for the Technological Design of Cattle Buildings (UAA TPT 01:2009).

Cows lay 12-14 hours a day. Only with the correct installation of the bearing place for the cow, it will rest well, will be weighty, the smallest will be sick and will be productive. When the cowshed is dry and there are no drafts, and the bearing area is warm, clean and comfortable, the cows can endure very low temperatures. In the barn, a bearing room is very important. In it, the animal must rest well, without experiencing injuries and stresses. This is a very important aspect of the environment surrounding the cow. If it is not properly evaluated, the normal functioning of the cow's body is disrupted. The energy balance of the animal changes, energy losses increase significantly. At low air temperatures, heat exchange between the animal and the environment intensifies. To maintain a constant body temperature, animals need an additional source of energy that can be obtained along with feed, which will lead to an increase in feed costs. It is very important to realize that the animal needs not only to be fed satisfactorily, but also to pay great attention to its freedom of movement, cleanliness of the bearing area, comfort, warmth, etc.

There is a good microclimate in the cowshed, water vapor does not condense on the building structures. The most common cause of a bad microclimate is the high humidity of the air, as a result of which water vapor condenses on the building structures, later mold appears. The ventilation system is obliged to maintain a good microclimate in the barn: remove excess moisture (in summer and excess heat) and control condensation. Barns need intensive ventilation. Only in extreme cases, when the air temperature outside is very low and the wind speed is high, the ducts need to be made, but they cannot be completely closed. The high humidity of the air in hot weather causes a feeling of stuffiness, the livestock does not emit a sufficient amount of heat, since in too humid air it is difficult to evaporate body moisture. The minimum permissible relative humidity of the air in the cattle housing room is 40% and the maximum is 88% (at a temperature of 5 °C) (TPT 01:2009). With increasing temperature, the recommended humidity of the air decreases to 80% (at a temperature of 10 °C), and when the temperature rises to 20 °C, the air should be no more humid than 65%.

In summary, the sustainability of dairy farming must be achieved in every dimension: economic, social, environmental.

- In the social dimension, the sustainability of the farm is achieved by improving the working and rest conditions on farms, raising the qualifications and motivation of employees to work well, effectively mechanizing or automating production processes and reducing labor costs, increasing the attractiveness of work, increasing labor productivity.
- In the economic dimension, the sustainability of the farm is achieved by improving the conditions of keeping animals, productivity, quality of production and increasing the economic efficiency of milk production, reducing the cost of production.

- In the environmental dimension, the sustainability of the farm is achieved by introducing environmentally and animal-friendly housing technologies and technical solutions in cowsheds, sustain-able use of water and energy resources, creating good conditions for keeping livestock and reducing air pollution and the impact on climate change – GHG emissions.

It is recommended to link the methodology for assessing the sustainability of dairy farms with support schemes used for farm development, with a view to achieving not only quantitative but also qualitative changes. Investment support to dairy farms must be assessed in a holistic manner, not limited to the identification of compliance with the priorities, objectives and areas of activity of the support measure. For example, the methodology of economic viability used in Lithuania only in a very small part, more formally, evaluates the economic dimension of sustainability, calculates net profitability, debt, loan coverage indicators partially reflect the financial condition of farms, but does not assess the impact of investments in reducing the volatility of economic indicators. Social aspects in general are hardly appreciated. Environmental and animal welfare criteria only require the farm to meet the minimum requirements, but the aim is not to bring about qualitative changes in farm activities that allow a larger number of sustainability criteria to be met and/or the level of sustainability improves qualitatively. The recommended methodology may be used or adapted, in its entirety or to a lesser extent, to provide investment support for dairy farms. With the help of this methodology, annual monitoring of farms can be carried out. If it is found that a farm only partially meets the sustainability criteria, such a farm should be offered consultative, educational - educational support.

5. CONCLUSION

A review of the research carried out revealed that there is a strong emphasis in the scientific literature on sustainability research in agriculture. Recent research does not discuss the need for sustainability, but is characterized by much deeper insights into the object under consideration, a number of measurement methodologies have been developed, with various combinations of criteria and indicators, weights, etc. It is important to stress that the main dimensions of sustainability in theoretical works are the same – economic, environmental and social.

The methodology developed in the study for assessing the sustainability of dairy farms is based on the basic principles of the FAO methodology (dimensions, indicators, indicators, weight measurement), and also corresponds to the basic principles of other sustainability assessment methodologies used, which were studied in this work. However, the choice of criteria and indicators is related to the specifics of the Lithuanian dairy sector, available data, the possibilities for farmers to assess the level of sustainability themselves (three levels – green, yellow, red). The methodology is prepared for evaluation at the farm level. It is possible to apply it both to the farmer himself, to the consultants, and to the granting of a sustainability certificate or support. The developed methodology for measuring and assessing sustainability can be integrated in-to support schemes, with the help and use of which will be aimed at the sustainable development of dairy farms. The methodology can also be used to monitor sustainability.

Recommendations have been developed for the assessment of sustainable farming systems on dairy farms. Recommendations not only on how to measure sustainability on farms, but also on how to implement sustainability principles on farms in order to achieve a higher level of sustainability. Based on the recommendations, a complex assessment methodology has been developed and tested to measure sustainability on dairy farms. The methodology pays equal attention to all dimensions of sustainability: economic, social and environmental. Animal welfare indicators are integrated into these three groups.

REFERENCES

- Al-Smadi, M. O. (2025). Insurance sector readiness for digital transformation: Empirical evidence from Jordan. *Insurance Markets and Companies*, 16(1), 33–41. [https://doi.org/10.21511/ins.16\(1\).2025.03](https://doi.org/10.21511/ins.16(1).2025.03)
- AlSheikh, M. (2025). Toward a cleaner road: Environmental transformation in Hungary's automotive sector. *Environmental Economics*, 16(2), 1–14. [https://doi.org/10.21511/ee.16\(2\).2025.01](https://doi.org/10.21511/ee.16(2).2025.01)
- Amaliah, T. H. (2025). Impact of knowledge management, knowledge sharing, and mental accounting on farmer performance. *Knowledge and Performance Management*, 9(1), 62–75. [https://doi.org/10.21511/kpm.09\(1\).2025.05](https://doi.org/10.21511/kpm.09(1).2025.05)
- Bachev, H. (2010). Management of Farm Contracts and Competitiveness, VDM Verlag Dr. Muller, Germany.
- Bachev, H., Koteva, N. (2021). Assessment of the competitiveness of agricultural holdings in Bulgaria. MPRA Paper No. 106341.
- Bai, Z., Lee, M. R. F., Ma, L., Ledgard, S., Oenema, O., Velthof, G. L., Ma, W., Guo, M., Zhao, Z., Wei, S., Li, S., Liu, X., Havlik, P., Luo, J., Hu, C., Zhang, F. (2018). Global Environmental Costs of China's Thirst for Milk. *Global Change Biology*, 24(5), 2198-2211.
- Balaine, L., Dillon, E., J., Lapple, D., Lynch, J. (2020). Can technology help achieve sustainable intensification? Evidence from milk recording on Irish dairy farms. *Land Use Policy*. 92, 104437.
- Bánkuti, F. I., Prizon, R. C., Damasceno, J. C., De Brito, M. M., Pozza, M. S. S., & Lima, P. G. L. (2020). Farmers' actions toward sustainability: A typology of dairy farms according to sustainability indicators. *Animal*, 14(S2), s417-s423.
- Becerril Torres, O. U., Becerril-Tinoco, C. A., Wieloch, J., & Munguía Vázquez, G. (2025). Does economic growth influence the reduction of carbon dioxide emissions? *Economics and Sociology*, 18(1), 27–46. <https://doi.org/10.14254/2071-789X.2025/18-1/2>
- Bichisao, G., Diaz, M., M., Pizzi, E. (2019). Horizon 2030. Looking ahead to challenges and opportunities. https://www.eib.org/attachments/strategies/horizon_2030_en.pdf
- Bittante, G., Cipolat-Gotet, C., Malchiodi, F., Sturaro, E., Tagliapietra, F., Schiavon, S., & Cecchinato, A. (2015). Effect of dairy farming system, herd, season, parity, and days in milk on modeling of the coagulation, curd firming, and syneresis of bovine milk. *Journal of Dairy Science*, 98(4), 2759-2774.
- Bittante, G., et al. 2015. Effect of dairy farming system, herd, season, parity, and days in milk on modeling of the coagulation, curd firming, and syneresis of bovine milk. *J. Dairy Sci.* 98 :2759–2774. Online access: <https://reader.elsevier.com/reader/sd/pii/S0022030215001009?token=E786C41516C5EC03F77890DD1152CA52417E1A876563D65EE00BA17B73A44EFE66CA811BA62E2BBFC337B3CEB13AC74B>
- Borawski, P., Pawlewicz, A., Parzonko, A., Harper, J., K., Holden, L. (2020). Factors Shaping Cow's Milk Production in the EU. *Sustainability*, 12(1), 420.
- Da Silva, J., et al. 2020. Sustainable development assessment from a capitals perspective: Analytical structure and indicator selection criteria. *Journal of Environmental Management*. Volume 260, 110147. Internet access <https://www.sciencedirect.com/science/article/pii/S0301479720300840>
- Dillianti, R., Prabowo, H., Rahim, R. K., & Kurniawan, Y. (2025). Bridging market orientation and leadership through digital enablement. *Insurance Markets and Companies*, 16(1), 42–53. [https://doi.org/10.21511/ins.16\(1\).2025.04](https://doi.org/10.21511/ins.16(1).2025.04)
- EIP-AGRI (2018). Focus Group: Robust & Resilient Dairy Production Systems. Final Report. https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_fg_robust_resilient_dairy_farming_final_report_2018_en.pdf
- Euromilk (2018). The European Dairy Sector & the Sustainable Development Goals. (2018). EDA fact sheet. Internet access http://eda.euromilk.org/fileadmin/user_upload/Public_Documents/EDA_Position_papers_-_Fact_Sheets/Sustainability/EDA_factsheet_Dairy_the_SDGs_Update_Sept_2018.pdf
- Euromilk (2019). The Dairy sector & the Green Deal. EDA. Internet access http://eda.euromilk.org/fileadmin/user_upload/Public_Documents/EDA_Position_papers_-_Fact_Sheets/Sustainability/EDA_Paper_-_Green_Deal_communication_-_Dec_2019.pdf
- European Commission (2014). Guide to Cost-Benefit Analysis of Investment Projects for Cohesion Policy 2014-2020. ISBN 978-92-79-41399-5.
- European Environmental Agency. Overview of the electricity production. <https://www.eea.europa.eu/data-and-maps/indicators/overview-of-the-electricity-production-1/assessment>

- European Green Deal (2019). Communication from the Commission to the European Parliament, the European Council and the European Economic and Social Committee. European Commission. Internet access https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0011.02/DOC_1&format=PDF
- Fernandes, K., Marathe, S. R., Parab, S., Amonkar, V., Vernekar, G., & Pandhre, S. S. (2025). Evaluating the role of government expenditure in promoting renewable energy and economic growth in India. *Environmental Economics*, 16(2), 162–172. [https://doi.org/10.21511/ee.16\(2\).2025.12](https://doi.org/10.21511/ee.16(2).2025.12)
- Fogarassy, C., Orosz, S., Ozsvári, L. (2016). Evaluating system development options in circular economies for the milk sector-development options for production systems in the Netherlands and Hungary. *Hungarian Agricultural Engineering*, 30, 62-74.
- Food and Agriculture Organization of the United Nations (FAO) (2020). SDG Indicator 2.4.1. Proportion of Agricultural Area under Productive and Sustainable Agriculture. Methodological Note. Internet access: <http://www.fao.org/3/ca7154en/ca7154en.pdf>
- Food and Agriculture Organization of the United Nations (FAO) (2019). Climate Change and the Global Dairy Cattle Sector. The Role of the Dairy in a Low-Carbon Future. Internet access: <http://www.fao.org/3/CA2929EN/ca2929en.pdf>
- Foote, N. (2020). Collaborative initiative aims to improve sustainability of EU dairy farming. Internet access <https://www.euractiv.com/section/agriculture-food/news/collaborative-initiative-aims-to-improve-sustainability-of-eu-dairy-farming/>
- Gal, A. N. (2010). Competitiveness of small and medium sized enterprises-a possible analytical framework. *Hungarian Electronic Journal of Science, HEJ: ECO-100115-A*, 1-14.
- Galnaitytė, A., Krisčiukaitienė, I. (2017). Modelling of the development of sustainable farming in the Lithuanian agricultural sector. *Public policy and administration*, 16(2), 264–278.
- Gesevičienė, K., Miceikienė, A., & Niskanen, V. A. (2025). Investigating eco-efficiency of EU field crop farms – a neural network approach. *Economics and Sociology*, 18(2), 158–183. <https://doi.org/10.14254/2071-789X.2025/18-2/9>
- Giyasova, Z., Guliyeva, S., Azizova, R., Smiech, L., & Nabiyeva, I. (2025). Relationships between human development, economic growth, and environmental condition: The case of South Korea. *Environmental Economics*, 16(2), 73–83. [https://doi.org/10.21511/ee.16\(2\).2025.06](https://doi.org/10.21511/ee.16(2).2025.06)
- Gorynia, M. (2004). Competitiveness of Polish firms and the European Union enlargement. *Competitiveness Review: An International Business Journal*, 14(1/2), 1-11.
- IDF Animal Health Report. Research Progress. Global Insights. Expert Opinion. (2019). Internet access: <https://store.fil-idf.org/product/idf-animal-health-report-n-13/>
- IDF Dairy Sustainability Outlook. Research Progress. Global Insights. Expert Opinion. (2018). Issue 1. Internet access: <https://store.fil-idf.org/product/report-163-idf-dairy-sustainability-outlook-no-1/>
- IDF Dairy Sustainability Outlook. Research Progress. Global Insights. Expert Opinion. (2019). Issue 2. Internet access: <https://store.fil-idf.org/product/issue-2-idf-dairy-sustainability-outlook/>
- IDF Dairy Sustainability Outlook. Research Progress. Global Insights. Expert Opinion. (2020). Issue 3. Internet access: <https://store.fil-idf.org/product/issue-3-idf-dairy-sustainability-outlook/>
- IDF Dairy Sustainability Outlook. Research Progress. Global Insights. Expert Opinion. (2020). Issue3. Internet access: <https://store.fil-idf.org/product/issue-3-idf-dairy-sustainability-outlook>
- IDF Dairy Sustainability Outlook. Research Progress. Global Insights. Expert Opinion. (2020). Issue3. Internet access: <https://store.fil-idf.org/product/issue-3-idf-dairy-sustainability-outlook/>
- Karttunen, J. P., Rautiainen, R. H., & Lunner-Kolstrup, C. (2016). Occupational health and safety of Finnish dairy farmers using automatic milking systems. *Frontiers in public health*, 4, 147.
- Kebreab, E., Reed, K. F., Cabrera, V. E., Vadas, P. A., Thoma, G., & Tricarico, J. M. (2019). A new modeling environment for integrated dairy system management. *Animal Frontiers*, 9(2), 25-32.
- Keogh, M., Tomlinson, A., & Henry, M. (2015). Assessing the competitiveness of Australian agriculture. *Rural Industries Research and Development Corporation*.

- Kontautienė, R., Stravinskas, T., & Barkauskas, V. (2024). Forecasts of sustainable consumption in small economies. *Journal of International Studies*, 17(2), 9–37. <https://doi.org/10.14254/2071-8330.2024.17-2/1>
- Korjonen-Kuusipuro, K., Koskimäki, T., Wojciechowski, A., & Neuvonen, A. (2024). Towards an inclusive sufficiency narrative. *Human Technology*, 20(1), 1–5. <https://doi.org/10.14254/1795-6889.2024.20-1.0>
- Kriščiukaitienė, I. (2008). Lietuvos ūkių konkurencingumas ir ES paramos įtaka. *Vadybos mokslas ir studijos-kaime verslų ir jų infrastruktūros plėtrai*, (2), 85-92.
- Lam, T. J. G. M., Wessels, R. J., & Jansen, J. (2016, July). RESET the mindset on antibiotic usage in dairy cows. In *Proceedings of the World Buiatrics Congress, Dublin, Ireland* (pp. 3-8).
- Läpple, D., & Thorne, F. (2019). The role of innovation in farm economic sustainability: Generalised propensity score evidence from Irish dairy farms. *Journal of agricultural economics*, 70(1), 178-197.
- Latruffe, L. (2010), Competitiveness, Productivity and Efficiency in the Agricultural and Agri-Food Sectors, OECD Food, Agriculture and Fisheries Papers, No. 30, OECD Publishing, Paris.
- Latruffe, L. (2010), Competitiveness, Productivity and Efficiency in the Agricultural and Agri-Food Sectors, OECD Food, Agriculture and Fisheries Papers, No. 30, OECD Publishing, Paris.
- Lithuania's Greenhouse Gas Inventory Report 2019. Vilnius, 2019, p. 565.
- López-Ridaura, S., Masera, O., & Astier, M. (2002). Evaluating the sustainability of complex socio-environmental systems. The MESMIS framework. *Ecological indicators*, 2(1-2), 135-148.
- Methodology for optimizing the production of farms of the dairy direction. 2011. Optimization of agricultural production on farmers' farms.
- Meul, M., Van Passel, S., Nevens, F., Dessein, J., Rogge, E., Mulier, A., & Van Hauwermeiren, A. (2008). MOTIFS: a monitoring tool for integrated farm sustainability. *Agronomy for sustainable development*, 28, 321-332.
- Michalíková, M., Krupova, Z., Polak, P., Hetenyi, L., & Krupa, E. (2014). Development of competitiveness and its determinants in Slovak dairy farms. *Agricultural Economics/Zemědělská Ekonomika*, 60(2).
- Ndambi, A., Pishgar Komleh, H., van der Lee, J. 2020. An overview and analysis of integral tools to monitor people, planet and profit sustainability dimensions of dairy development in East Africa. Wageningen Livestock Research, Report 1277. Internet access <https://edepot.wur.nl/533370>
- O'Mahony, N., Campbell, S., Carvalho, A., Krpalkova, L., Riordan, D., & Walsh, J. (2019). 3D vision for precision dairy farming. *IFAC-PapersOnLine*, 52(30), 312-317.
- OECD (2019). Innovation, Productivity and Sustainability in Food and Agriculture. Internet access: <https://www.oecd.org/publications/innovation-productivity-and-sustainability-in-food-and-agriculture-c9c4ec1d-en.htm>
- Olzhebayeva, G., Buldybayev, T., Pavalkis, D., Kireyeva, A., & Micekiene, A. (2023). Is there interest in green deal research in Central Asia?. *Economics and Sociology*, 16(3), 302–322. <https://doi.org/10.14254/2071-789X.2023/16-3/16>
- Pärna, E., Kiiman, H., & Saveli, O. (2006). Sustainability aspects in estonian cattle breeding. *Veterinarija ir zootechnika*, 33(55).
- Plastun, A., & Kozmenko, S. (2025). Stolen Ukrainian universities: An invisible russian weapon. *Problems and Perspectives in Management*, 23(2-si), 151–175. [https://doi.org/10.21511/ppm.23\(2-si\).2025.11](https://doi.org/10.21511/ppm.23(2-si).2025.11)
- Poteko, J., Záhner, M., & Schrade, S. (2019). Effects of housing system, floor type and temperature on ammonia and methane emissions from dairy farming: A meta-analysis. *biosystems engineering*, 182, 16-28.
- Renewed EU strategy for Sustainable Development (2006). Internet access: <https://register.consilium.europa.eu/doc/srv?l=EN&f=ST%2010917%202006%20INIT>
- Rio Declaration on Environment and Development (1992). Internet access: https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_CONF.151_26_Vol.I_Declaration.pdf
- Rules and tips for smart farming. Ministry of Agriculture of Lithuania. Villains. 2007. 38 p.
- SAI Platform (2010). Discussion paper: Measuring dairy farms' overall sustainability. Internet access <https://saiplatform.org/uploads/Library/SAI%20Platform%20Discussion%20paper%20-%20Measuring%20dairy%20farms%20overall%20sustainability%20-%20nov%202010.pdf>

- Samusevych, Y., Račka, I., Vasylieva, T., & Tóth, A. (2024). Environmental tax reform efficiency: Prerequisites and consequences. *Journal of International Studies*, 17(4), 90–108. <https://doi.org/10.14254/2071-8330.2024/17-4/6>
- Scherer, L., Behrens, P., De Koning, A., Heijungs, R., Sprecher, B., & Tukker, A. (2018). Trade-offs between social and environmental Sustainable Development Goals. *Environmental science & policy*, 90, 65-72.
- Shcherbak, V., Kolodiziev, O., Krupka, I., Vzhytynska, K., Androshchuk, I., Kolodizieva, T., & Berehovi, V. (2025). Impact of international trade on regional ecosystem sustainability: Evidence from Ukraine amid war. *Problems and Perspectives in Management*, 23(1), 364–378. [https://doi.org/10.21511/ppm.23\(1\).2025.27](https://doi.org/10.21511/ppm.23(1).2025.27)
- Sitenko, D., Gordeyeva, Y., Sabyrzhan, A., & Syzdykova, E. (2023). Implementation of innovative technologies in Kazakhstan: A case of the energy sector. *Problems and Perspectives in Management*, 21(4), 179–188. [https://doi.org/10.21511/ppm.21\(4\).2023.14](https://doi.org/10.21511/ppm.21(4).2023.14)
- Siudek, T., & Zawojcka, A. (2014). Competitiveness in the economic concepts, theories and empirical research. *Acta Scientiarum Polonorum. Oeconomia*, 13(1), 91-108.
- Speksnijder, D. C., Graveland, H., Eijck, I. A., Schepers, R. W., Heederik, D. J., Verheij, T. J., & Wagenaar, J. A. (2017). Effect of structural animal health planning on antimicrobial use and animal health variables in conventional dairy farming in the Netherlands. *Journal of Dairy Science*, 100(6), 4903-4913.
- Streimikiene, D., Mikalauskas, I., Lėckienė, V., Pisula, T., & Mikalauskiene, A. (2024). The role of sustainable finance in the context of the European green course. *Economics and Sociology*, 17(1), 54–79. <https://doi.org/10.14254/2071-789X.2024/17-2/3>
- Štreimikienė, D., Mikalauskiene, A., & Macijauskaitė – Daunaravičienė, U. (2022). Role of information management in implementing the Green Deal in the EU and the US. *Journal of International Studies*, 15(4), 9–27. <https://doi.org/10.14254/2071-8330.2022/15-4/1>
- Strezov, V., Evans, A., & Evans, T. J. (2017). Assessment of the economic, social and environmental dimensions of the indicators for sustainable development. *Sustainable development*, 25(3), 242-253.
- Teisės aktų registras (2019). Order of the Director of the State Food and Veterinary Service on the approval of welfare requirements for farm animals (No. B1-690 of 20 September 2019). Internet access: <https://www.e-tar.lt/portal/lt/legalAct/e426f910ddd611e99681cd81dcdca52c>
- The European Parliament (2018). EU Dairy Sector: Main Features, Challenges and Prospects. Internet access: [https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/630345/EPRS_BRI\(2018\)630345_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/630345/EPRS_BRI(2018)630345_EN.pdf)
- Thorne, F.S. Fingleton, W. (2006). “Examining the relative competitiveness of milk production: an Irish case study (1996 – 2004)”. *Journal of International Farm Management*, 3(4), 1-13.
- Toth, O. (2012). Farm structure and competitiveness in agriculture. Paper presented at the 132nd Seminar of the EAAE (European Association of Agricultural Economists), Is Transition in European Agriculture Really Over?, Skopje, 25-27 October. (No. 709-2016-48460).
- United Nations (2012). The Future We Want – Outcome Document of the United Nations Conference on Sustainable Development. Rio+20 United Nations Conference on Sustainable Development. Internet access: <https://sustainabledevelopment.un.org/content/documents/733FutureWeWant.pdf>
- United Nations (2015). Transforming our World: the 2030 Agenda for Sustainable Development. Internet access: <https://sdgs.un.org/2030agenda>
- Verslo informacijos centras (2020). Annual report of the Register of Farm Animals. (2020). Department of Accounting of Animal and Feed Entities. Online access: https://www.vic.lt/gpsas-apskaita/wp-content/uploads/sites/6/2020/03/2019m_GPSAS_metine_ataskaita_20200320.pdf
- World Commission on Environment and Development (WCED) (1987). Our common future. Report of the World Commission on Environment and Development.
- Yang, X., Zhu, J., Xie, H., & Zhang, J. (2023). Liquidity spillover from carbon emission trading markets to stock markets in China. *Investment Management and Financial Innovations*, 20(4), 227–241. [https://doi.org/10.21511/imfi.20\(4\).2023.19](https://doi.org/10.21511/imfi.20(4).2023.19)
- Zhou, Y., Zwahlen, F., Wang, Y., Li, Y. (2010). Impact of climate change on irrigation requirements in terms of groundwater resources. *Journal of Hydrogeology*, 18(7), 1571-1582.

ANNEX

Table 1. Criteria for assessing the sustainability of the dairy farm

Yy. No.	Criteria for assessing the sustainability of a dairy farm	Mandatory requirement	Scoring scale			Notes
			0 points	1 point	2 points	
Environmental dimension						
1.	Measures are being taken to reduce the emission of odors (gas NH ₃ , H ₂ S, etc.) and air pollution from the barns (bio-remedies are used - probiotics; manure is acidified; feed additives are used)	Not	Not		So	Not applicable or subject to at least one measure
2.	Measures are in place to reduce emissions of odors (gas NH ₃ , H ₂ S, etc.) and air pollution from manure (maintaining the natural coating-crust of manure; artificial manure coatings are applied)	Not	Not		So	Not applicable or subject to at least one measure
3.	Measures to reduce GHG (CO ₂ , CH ₄ , N ₂ O) emissions (feeding supplements used)	Not	Not		So	Feeding supplements used or not used
4.	Cattle are fed according to an individual ration in groups	Not	Not		So	Fed in one ration or fed in groups with different rations
5.	A manure shed is installed that holds 6 months of manure (in deep barns the manure shed is located in the barn)	So	Not	So		there is a manure shed (or a deep barn) or there is no
6.	Applied manure recovery technology: compost production – aerobic processing or biogas production – anaerobic processing	Not	Not		So	
7.	A direct system of embedding liquid manure into the soil is applied or thick manure is introduced into the soil within 4 hours.	Not	Not		So	
8.	Recoverable industrial waste	So	Not	So		Concluded disposal contracts; no penalties for the last 12 months.
9.	Freedom of movement of cows is ensured (sufficient area per head)	So	Not	So		Calculated indicator: the ratio of the design area of the barn to the maximum number of livestock per year
10.	Antibiotics are used only for the treatment of cattle, but not for prophylaxis	Not	Not		So	
11.	A good microclimate in the cowshed (water vapor does not condense on the building structures)	Not	Not		So	
12.	Milk quality indicator: the total number of bacteria, not more than, thousand. CFU/ml	So	no more than 100 thousand CFU/ml	no more than 90 thousand. CFU/ml	no more than 70 thousand CFU/ml	Calculated annual geometric mean

Yy. No.	Criteria for assessing the sustainability of a dairy farm	Mandatory requirement	Scoring scale			Notes
			0 points	1 point	2 points	
13.	Milk quality indicator: the number of somatic cells not more than 400 thousand /ml	So	not more than 400 thousand /ml	not more than 360 thousand/ml	not more than 280 thousand /ml	Calculated annual geometric mean
14.	Energy consumption reduction measures are applied (heat recovery system, frequency converters in milking equipment, efficient lighting in the barn, natural ventilation system)	Not	Not applicable	measure 1 applies	2 or more measures applied	
15.	Water according to the norms is used for watering animals, preparing feed and maintaining cleanliness of the premises (water is not used in manure management technologies)	Not	Not		So	
16.	Compilation of records of fertiliser use and use of plant protection products	So	Not	So		
Social dimension						
1.	The cost of working time per cow	Not	more than 70 hours.	less than 70 hours.	less than 35 hours.	Less than 70 human working hours per cow per year; There are at least 29 cows per 1 full-time position; Annual number of hours of work of 1 full-time - 2018 hours.
2.	The farm is equipped with rest / sanitary facilities	Not	Not		So	
3.	The farm is equipped with smart control systems	Not	Not		So	
4.	Wages of unskilled workers are higher than the minimum wage in the country	Not	up to 5%	from 5 to 20 percent.	more than 20 percent.	
5.	The salary of qualified specialists is not lower than the average monthly salary in the country	Not	below average	higher to 15 percent.	more than 15 percent.	
6.	Compliance with the Labor Code	So	Not	So		If the farm has received penalties in the last 12 months, then the population has not been able to do so. due to improper working conditions or illegal work, it is considered unsustainable. In the absence of hired employees, the indicator is not included in the assessment.

Yy. No.	Criteria for assessing the sustainability of a dairy farm	Mandatory requirement	Scoring scale			Notes
			0 points	1 point	2 points	
7.	The farm is a social patron (provides support for social community initiatives)	Not	Not		So	It shall be determined on the basis of the declaration of assistance or shall be accompanied by a certificate from the institution to which the assistance was granted.
8.	Qualified workers (farmer) annually raise their qualifications	Not	up to 40%	from 40 to 60 percent.	60% or more	The share of qualified specialists (incl. farmer) who have trained at least 8 academic hours.
9.	Is a member of the cooperative	Not	Not		So	
10.	Is a member of the association	Not	Not		So	
11.	The farm has a green diploma	Not	Not		So	
Economic dimension						
1.	The average productivity of cows on the farm	Not	Less	up to 20%	more than 20 percent.	According to the data of statistics department; higher than the average productivity in the country
2.	Monitoring of the productivity of cows is carried out	Not	Not		So	
3.	The effect of seasonality on the productivity of cows	Not	more than 15 percent.	from 10 to 15 percent.	up to 10%	
4.	The factor for converting the actual milk content into the basic milk content shall be equal to	Not	less than 1.1	from 1.1 to 1.35	1.35 and over	
5.	Value added per job per year eur/d.v.	Not	Less than 10000 Eur	10000 - 20000 Eur	20000 Eur and more	Gross value added / Number of jobs; Gross value added = net profit + depreciation costs + wage costs + taxes
6.	Profitability of equity in percent.	Not	Less than 0	More than 0	More than the interest rate on loans (3.5 per cent)	Three-year average above average interest rate on long-term loans
7.	Sales revenue in Eur / live.	Not	Income volatility about the average by more	Income volatility about the average up to 10 percent.	Incomes stable or increasing	The dynamics of the indicator for the last 3 years is evaluated; annual increase in income, or income

Yy. No.	Criteria for assessing the sustainability of a dairy farm	Mandatory requirement	Scoring scale			Notes
			0 points	1 point	2 points	
			than 10 percent.			fluctuation of no more than 10 percent.
8.	Specialization indicator	Not	100% dairy farming	Crop production up to 34 percent.	Crop production is more than 34 percent.	Calculation is made on the basis of gross production. Crop production accounts for at least 34% of the total value of production. Sustainability aspect: biodiversity, diversification.
9.	Share of grants and subsidies in farm revenue	Not	More than 30%	from 10 to 30 percent.	Less than 10%	
10.	Forbidden cattle	Not	Not		So	
11.	EBITDA / (Loans repaid, including leasing payments + interest)	Not	less than 1	from 1 to 1.25	1.25 and above	
12.	Net profit / 12	Not	less than the minimum monthly wage	more than the minimum wage, but less than the average salary in Lithuania	more than the average salary in Lithuania	Applies only to farmers; compared to after tax wages