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Environmental sustainability and economic viability of the Compost Barn system in Brazilian dairy farming

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Abstract

Dairy farming has great socioeconomic importance in Brazil, and the last decades have registered a constant evolution of the production chain, seeking to increase quality and production efficiency. In this context, the production systems have intensified and adopted new technologies. The Compost Barn system has stood out as a confinement option for dairy cattle, for its lower implementation cost than other confinement systems and the possibility of giving an adequate destination to the animals' waste. Besides the search for greater production efficiency, the environmental sustainability of agricultural systems has been increasingly discussed, and dairy cattle farming is associated with many potential environmental impacts. It is essential to identify and mitigate them for the consolidation of a production chain socially fair, economically viable and environmentally correct. Thus, this literature review aims to evaluate the economic and environmental feasibility of the Compost barn system within the national dairy farming scenario.

keywords: Life cycle assessment. Milk production. Environmental impacts. Greenhouse gasses.

Sustentabilidade ambiental e viabilidade econômica do sistema Compost Barn na pecuária leiteira brasileira

Resumo

A pecuária leiteira tem grande importância socioeconômica no Brasil e as últimas décadas tem registrado uma constante evolução da cadeia produtiva, buscando aumentar a qualidade e a eficiência produtiva. Nesse contexto, os sistemas de produção têm se intensificado e adotado novas tecnologias e o sistema Compost Barn tem se destacado como opção de confinamento para bovinos leiteiros, por seu menor custo de implantação em relação a outros sistemas estabulados e a possibilidade de dar um destino adequado aos dejetos dos animais. Além da busca por maior eficiência produtiva, a sustentabilidade ambiental dos sistemas agropecuários tem sido cada vez mais discutida, e a bovinocultura leiteira é associada à uma série de potenciais impactos ambientais, sendo imprescindível a identificação e mitigação dos mesmos para a consolidação de uma cadeia produtiva socialmente justa, economicamente viável e

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ambientalmente correta. Sendo assim, o objetivo com essa revisão bibliográfica é avaliar a viabilidade econômica e ambiental do sistema Compost barn dentro do panorama da pecuária leiteira nacional.

Palavras Chave: Avaliação do ciclo de vida. Produção de leite. Impactos ambientais. Gases de efeito estufa.

INTRODUCTION

Dairy farming and its production chain are of great national socioeconomic importance, generating employment and income in the countryside and the city (Rocha et al., 2020). Currently, Brazil stands out as one of the world's largest producers of milk volume, and its production chain has been undergoing decades of improvements in search of higher production, productivity, and quality (Maia et al., 2013).

The adoption of new technologies and the optimization of production systems have been a constant in the development process of national dairy farming. The transition from extensive to intensive production systems is gaining more and more space since intensive systems can provide gains in productivity. Recent researches indicate that intensive production systems tend to have a lower environmental impact because these are diluted in a greater volume of production and concentrated in a smaller area. In this context, the Compost Barn has been gaining space in the national scenario, offering lower implementation cost compared to other confined systems and gains in the environment, welfare and productivity (Basaia, 2020; Caldato, 2019; Krüger et al., 2021; Silva, 2022; Tomazi; Gai, 2022).

Despite its socioeconomic relevance, dairy cattle farming is also an activity that can cause environmental pollution from untreated animal waste and the emission of greenhouse gases; for example, and therefore the analysis and mitigation of environmental impacts are necessary, seeking the consolidation of sustainable dairy farming (Amaral et al., 2012). The circular economy and regenerative agriculture are concepts still little explored that preach sustainable practices, which can be adopted to mitigate environmental impacts attributed to the dairy supply chain. Life cycle assessment (LCA) has presented itself as an alternative for the evaluation of production chains and the identification of critical points to be improved, and recent studies have made use of this tool to assess the environmental sustainability of farming systems (Basaia, 2020; Seó et al., 2017; Silva, 2022).

Considering the socioeconomic importance and the environmental impacts attributed to dairy farming, the search for production techniques and technologies that maximize productivity and resource use associated with the least possible environmental impact is of paramount importance.

DEPLYOMENT

Overview of dairy cattle breeding in Brazil and in Minas Gerais

The milk production chain, one of the main economic activities in Brazil, is responsible for positive numbers in the economy, besides generating millions of jobs in the countryside and the city (Rocha et al, 2020). According to data from the Municipal Livestock Survey (PPM) of 2021, released by the Brazilian Institute of Geography and Statistics (IBGE, 2022) the, milk production was 35.3 billion liters, similar to the 35.4 billion recorded in the year 2020 (IBGE, 2021).

According to data from the Food and Agriculture Organization (FAO, 2019), Brazil is the third largest milk producer in the world, preceded by the United States and China, respectively. According to Maia and collaborators (2013), milk production has grown relatively steadily in Brazil since 1974, rising from 7.1 billion liters to 32 billion in 2011, a growth of almost 350%. More specifically, in the last two decades, production has increased by approximately 80%, while the number of milked cows has decreased due to increased herd productivity (Rocha et al., 2020).

The Municipal Cattle Survey identified a reduction in the milked herd in Brazil in 2020 compared to the previous year, with a discrete decrease of 0.8%, along with an increase of 1.5% in production, despite the challenges that 2020 brought to the milk production chain, such as the closing of production flow channels and the escalating prices of inputs such as corn and soy meal (IBGE, 2021). The decrease in establishments and milked animals and the increase in production indicate productivity improvements, with the average going from 1.6 thousand liters per cow/year in 2006 to 2.6 thousand liters per cow/year in 2017 (Ferrazza; Castellani, 2022).

Historically, Minas Gerais is the largest dairy basin in Brazil. According to IBGE data, in 2018, the state recorded a volume of more than 9.4 billion liters of milk, 27.1% of the national production. According to census surveys, from 2006 to 2017, the number of farms involved in dairy cattle farming in Minas Gerais fell by 2.96% and the number of milked animals dropped by 6.58%, while the state's total production increased by 52.9% in the same period, with productivity jumping from 1.8 thousand liters per cow/year in 2006 to 2.9 thousand liters per cow/year in 2017, a growth of 63.67% (Ferrazza; Castellani, 2022). In 2021, the average productivity in the state was 3,114 liters/cow/year, an increase of 7.4% compared to 2017 (IBGE, 2021; SEAPA-MG, 2022).

Ximenes (2020) points out that despite Brazil presenting favorable characteristics for efficient production, the dairy chain lacks greater organization of the sectors, and the heterogeneity of the production systems requires the adoption of local development policies to encourage greater organization and access to technical assistance. The adoption of new technologies is necessary for production systems to become more efficient, sustainable and competitive, being increasingly necessary the dissemination of knowledge and technical training (Zoccal et al., 2011).

Sustainability in dairy cattle farming

Dairy farming, undeniably an activity of great economic importance in Brazil and worldwide, is also potentially polluting the environment, likely to cause adverse environmental impacts such as soil degradation, indiscriminate use and/or contamination of water resources, reduction of biodiversity, and emission of greenhouse gases. Animal waste, fertilizers, antibiotic residues, and other veterinary medicines and pesticides are pointed out as the main sources of pollution of activity (Wüst et al., 2015).

The activity is responsible for producing a considerable amount of waste, about 317 million tons per year (Instituto de Pesquisa Econômica Aplicada - IPEA, 2012). In general, Brazil accounts for high production of waste from animal production, waste that can contribute to environmental pollution. However, with a cyclical vision of the systems and the proper disposal of waste, these can stop being environmental problems, and becoming sources of nutrients for the soil and / or energy sources (Albuquerque et al., 2022; Maciel et al., 2019).

Sustainability can be understood as the development that meets the demands of the Present without compromising the ability of future generations to meet theirs (WCED, 1987). When applied to livestock farming, sustainability should simultaneously contemplate environmental, productive, and socioeconomic aspects to meet the present population's food demands without exhausting environmental resources and compromising the producer's and community's quality of life. Therefore, sustainable livestock farming should be based on the rational use of soil, water, and energy, the preservation of biodiversity, productivity and respect for human health (Alvez, 2011).

The emissions of greenhouse gases (GHG) associated with agricultural production are mainly related to the expansion of agricultural boundaries and deforestation, change in land use, use of chemical fertilizers, enteric fermentation of ruminant animals and fermentation of animal waste. It is estimated that 46% of the dairy farming GHG emissions come from the production of pollutant gases, such as methane, and the waste produced by the animals; 36% are attributed to animal feed and food procurement; 21% to the fertilization of crop areas and 5% of emissions are attributed to dairy products, and the intensity of emissions varies according to the type of property and the production system adopted (Basaia, 2020).

Life Cycle Assessment

Life Cycle Assessment (LCA) is a widely used technique for evaluating and quantifying the sustainability profile of products, analyzing and measuring the impacts generated both in the manufacturing processes and in their use, in order to consider the entire production chain and its relationships with the environment. In this context, LCA allows a complete understanding of the environmental impacts, enabling the search for improvement at different points of the production process and optimizing environmental management and the reduction of impacts associated with the production chain (Basaia, 2020; Brandalise; Bertolini, 2015; Seó et al., 2017; Silva, 2022).

According to the NBR ISO 14044 of the Brazilian Association of Technical Standards (ABNT, 2009), LCA allows the assessment of points of potential improvement in the environmental performance of products at various points in their life cycle and the selection of relevant environmental performance indicators. LCA encompasses the environmental aspects and potential environmental impacts of the entire life cycle of a product, from raw material sourcing, production process, use, post-use treatment, recycling, and final disposal, and is referred to as "cradle to grave" assessment. The delimitation of the boundaries of an LCA study will depend on the product being evaluated and the objective of the study. However, in general, the study will consist of the phases of defining the objective and scope, inventory analysis, impact assessment, and finally, the interpretation phase.

The life cycle inventory analysis (LCI) phase, the second phase of LCA, is the formation of the inventory of input and output data associated with the system studied, then involves the collection of the necessary data. In the third phase, the life cycle impact assessment (LCA) phase, the goal is to provide additional information that helps in the LCI assessment, aiming for a better understanding of its environmental significance. Finally, in the interpretation phase, the results of the LCI and/or the LCIA will be summarized and discussed as a basis for conclusions and decision-making, according to the objectives set for the study (ABNT, 2009).

The life cycle can be understood as the consecutive and interconnected stages of the production system of a given product, from the acquisition of raw materials or its procurement through natural resources to its final disposal (ABNT, 2009). Thus, LCA is defined as the compilation and evaluation of inputs, outputs and potential environmental impacts of a production system throughout its life cycle.

In a systematic review on the use of LCA in the dairy supply chain, Seó et al. (2017) found that primary production accounted for the majority of greenhouse gas emissions. Enteric fermentation, production and use of synthetic fertilizers, manure use, production and transport of concentrates, low animal productivity, and the low nutritional quality and yields of pastures are the main critical control points for the activity.

Circular economy

The circular economy (CE) has been presented as a counterpoint to traditional production systems and the current production/consumption model, called linear or closed-system economy. The linear economy follows a pattern of extract-produce-dispose in a closed cycle that repeats itself indefinitely and can produce a large amount of waste. With population growth and the concentration of populations in urban areas, the demand for consumer goods and consequently the production of waste increases. The disposal of this waste can pollute the soil, water, and air, being a threat to the earth's ecosystems (Abdalla; Sampaio, 2018).

In an attempt to minimize waste production and the environmental impacts involved, the principles, currently called "5R's", have been disseminated: rethink, refuse, reduce, reuse, and recycle. However, according to McDonough and Braungart (2002), cited by Abdalla and Sampaio (2018), focusing only on strategies to minimize these impacts leads society in the same direction, only reducing the speed of environmental degradation.

The circular economy, in turn, proposes to revolutionize society's current production and consumption patterns. According to the Ellen MacArthur Foundation, created to propagate the ideas of the CE, this model is based on three principles: eliminate waste and pollution, circulate products and materials, and regenerate nature by adopting renewable materials and energy sources. The adoption of CE starts from the search to preserve and improve natural resources, optimize resource yield, and recirculate inputs and products (Abdalla; Sampaio, 2018; Maia et al., 2013). According to Abdalla and Sampaio (2018), one can summarize the concept of CE into three fundamental principles: waste is nutrients, use of solar energy or other renewable sources, and celebration of diversity.

Waste is nutrients: each product must be thought of from its conception, prioritizing the use of healthy inputs for humans and the biosphere, and that can have their value recovered after each use. Thus, we seek to replace harmful and/or unwanted substances by others that can be used later as nutrients or raw materials;

Use of renewable energy: the use of solar energy or other renewable energy sources should always be preferred over non-renewable sources such as fossil fuels;

Celebration of diversity: advocates harmony between manufactured and natural spaces, the stimulation of biodiversity, and the premise that there is no single solution for any problem, proposing the search for potential answers on a case-by-case basis, aiming at the best use of resources and processes in different situations.

These principles are applied to production in two distinct cycles: biological and technical (figure 1). The biological cycle includes natural processes and the premise is to mimic the logic of the cycles that occur in nature, where the input is used and regenerated, with or without human interference, and returns to the biosphere as a nutrient. In the technical cycle, in turn, it seeks the maintenance of materials in industrial circulation so that they can be recovered in whole or in part after use and reconverted into raw materials and/or products for new uses instead of becoming waste (Abdalla; Sampaio, 2018; Maia et al., 2013).

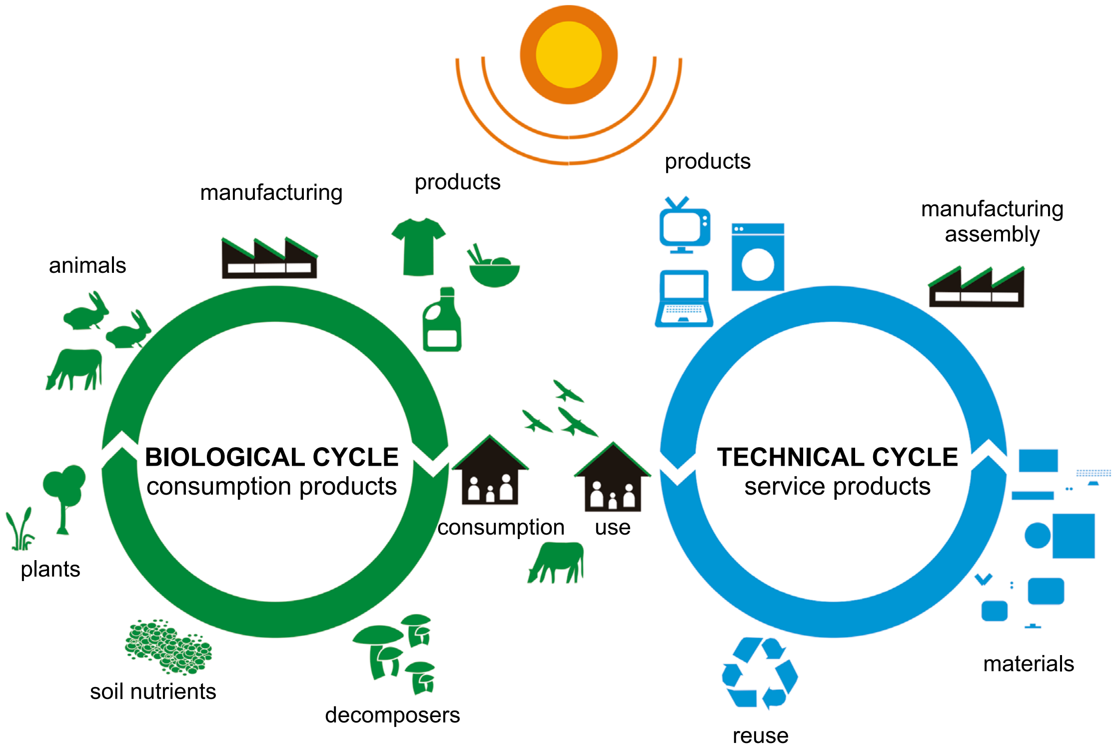
Countries in the European Union and China have been pioneers in adopting circular economy concepts and in the search for sustainable production. In Denmark, the concept of "industrial symbiosis" has emerged, where industrial parks are diversified, and one industry is installed near another, from which it can work with waste as raw material. China not only adopted the industrial symbiosis but added a new level, the industrial eco-parks, which besides the symbiosis by the flow of materials, counts on the sharing of structures and resources. In Brazil and South America in general, except for Chile, the advances of the circular economy are still incipient and walk slowly, but there is a movement for the adoption of this concept from universities, public agencies, and private initiative (Abdalla; Sampaio, 2018; Maia et al., 2013).

Regenerative Agriculture

Regenerative Organic Agriculture was idealized and defined in the 1980s by Robert Rodale. It can be understood as a set of practices aimed at the rational use of soil and the recovery of degraded soils, building its structure and fertility, and allowing productivity sustainably. Besides positively altering the soil's chemical, physical, and biological attributes, it can contribute to reducing greenhouse gas emissions and reducing agriculture's dependence on chemical inputs and fossil fuels (Rhodes, 2017; Gazola et al., 2017; Tavares; Borschiver, 2019).

The Rodale Institute defines Regenerative Agriculture as "a type of agriculture that goes beyond sustainable" because it contributes to the improvement of available resources, rather than just preserving them, being concerned with the health of the food system as a whole, from the health of crops and humans to the prospects of future generations (Rodale institute, 2021). In addition, this model of agriculture encourages constant innovation and improvement in environmental, economic, and social measures, being guided not only by being environmentally sustainable but also by the social and economic sustainability of the entire system (Ehlers, 1994).

Figure 1 – Schematic of the biological and technical cycles.



Source: McDonough; Braungart, 2002.

According to Perez Casar (2021), the traditional production model was based mainly on modifying the environment to allow crops to express their genetic potential to the maximum, which brought us many benefits, but also caused environmental impacts that we have to deal with. Now, the premise would be to adapt crops and technologies so that the environment can express its productive potential with minimal disturbance. Regenerative Agriculture seeks to harmonize agricultural production processes with natural dynamics, producing and promoting biodiversity simultaneously through techniques such as crop rotation, ground cover, no-till or reduced tillage, and the use of organic compost for fertilization. The rational use of water and the biological control of pests are also among the proposals contemplated by this system (Gazola et al., 2017; Tavares; Borschiver, 2019).

Compost Barn

In search of production and productivity improvements, the intensification of production systems is a growing trend in dairy cattle farming. Despite the higher initial investment in facilities and machinery, confined systems are associated with gains in animal welfare and productivity (Caldato, 2019; Krüger et al., 2021; Tomazi; Gai, 2022).

Created as an adaptation to the Free Stall, the Compost Barn is a confinement system for dairy cows that has been gaining space in Brazil. Compared to the Free Stall, the Compost Barn demands less initial investment and can favor greater animal welfare, besides minimizing the risk of hoof or hock problems, favored by the time the animals spend on concrete floors in the Free Stall (Caldato, 2019). The Compost Barn comprises a concrete feeding lane and an area of free circulation for the animals, consisting of a collective bed, usually formed with an organic material rich in carbon such as shavings, sawdust, and rice husk, among other similar materials. The premise is the aerobic composting of the bedding material plus animal excreta (Caldato, 2019; Janni et al., 2007; Tomazi; Gai, 2022).

To provide the expected gains in ambience and productivity, the project must be prepared by qualified professionals and take into consideration a number of criteria, including the orientation of the house, the type of ventilation to be used, the microclimate of the region, the number of animals housed and the availability of bedding material. One can work with 7.4 to 15 m^2 of bedding area per animal, and it should be considered that the smaller the area per animal, the greater the frequency of bedding replacement should be. In addition, the microclimate of the region directly influences the drying of the litter; colder and more humid regions demand a larger area per animal so that the litter is maintained at the appropriate humidity (Caldato, 2019).

The bed should be formed with a depth of 40 to 50 cm, with the addition of layers of 10 to 20 cm every five weeks, and typically maintained for periods of 6 to 12 months. For the composting process to occur correctly, at 30 cm depth, the bed temperature should vary between 40 and 50 C°, enabling the degradation of cellulose and the inactivation of pathogens, and the humidity should be kept between 40 and 60%. The carbon/nitrogen ratio of the bedding must be adequate for the desired stabilization of the manure to occur, and a carbon/nitrogen ratio of 25:1 to 30:1 is recommended (Caldato, 2019; Janni et al., 2007).

If the bed presents excess organic matter, low temperature or high humidity, it is necessary to add a new layer of the material that composes it, renewing the carbon source consumed during composting. In a bed formed of fine ground particles or dust the compaction is favored, hindering aeration, reducing microbial activity, and may provide the formation of clods and areas of anaerobiosis. On the other hand, a bed of coarsely ground particles favors the entry of air and can accelerate the composting process, reducing the bed's replacement time. Thus, using materials in different granulometries to form the bed is interesting. Proper bed management is crucial to the Compost Barn's success and consists of making the bed stirring and incorporating animal waste into the bed material. This revolving should be done from 25 to 30 cm deep at least twice a day and usually happens while the cows are in the milking parlor (Caldato, 2019; Janni et al., 2007).

Despite being a relatively new system, the Compost Barn has shown promise for dairy cattle farming. Besides the benefits involving production, animal welfare, and the advantages it presents concerning the free stall system, another positive point can be attributed to the system regarding environmental sustainability. The waste from cattle farming is a major concern regarding the potential polluter of the activity, and with the Compost Barn, most of the waste is incorporated into the bed and then used as organic fertilizer, providing then rational management of waste and replacing part of the mineral fertilization (Caldato, 2019).

Tomazi and Gai (2022) observed that the use of compost from the Compost Barn litter contributed to the diameter of the stalk and number of leaves in a corn crop, as well as improving the chemical parameters of the soil in terms of phosphorus, calcium, organic matter, base sum, cation exchange capacity, and base saturation percentage, about the control treatment, which received only mineral fertilization.

Therefore, the Compost Barn can provide, in addition to improvements in production and animal welfare, the improvement of soil quality and the reduction of waste production, aligning then to premises of regenerative agriculture, which aims at rational use and building soil fertility, and circular economy, which proposes the cyclicality of materials within a productive system (Abdalla; Sampaio, 2018; Rhodes, 2017).

Financial viability of dairy cattle farming

As one of the leading agricultural activities in Brazil, dairy cattle farming is an important source of income. Therefore, the financial management of farms is of utmost importance as a managerial tool, allowing properties to be considered as companies and for them to evolve along with the sector. Applying accounting in the rural sector is indispensable for proper property management and assertive decision-making to make the activity more efficient (Neves et al., 2017).

Rural accounting is focused on studying properties and/or companies focused on vegetable or animal production or agro-industrial activities. It is a tool that is still little used by producers, considered complex and of low practical return, which can be attributed to the deficiency of accounting systems that are reliable to the characteristics of agricultural activities and the lack of trained professionals to transmit adequate administrative strategies to rural producers (Krüger et al., 2021; Neves et al., 2017).

An analysis of its feasibility should precede the implementation of a project. The discounted cash flow presents itself as the most used method for assessing the feasibility of a project by determining through calculations the fair value and the risks inherent in the investment, discounting a rate of cash flows expected for the future (Basaia, 2020; Farina et al., 2015). According to Basaia (2020), to perform these analyses, it is necessary to define cash flow, gross revenue, net revenue, costs and expenses, depreciation and amortization, opportunity cost, minimum rate of attractiveness (TMA), inflation, net present value (NPV), internal rate of return (IRR), discounted payback, profitability index and benefit-cost ratio. According to this methodology, he concluded that an intensive dairy farm, adept of the Compost Barn system, was economically viable, also concluding that the intensification of production systems favors its financial viability.

Krüger and collaborators (2021), in a study based on documentary research and interviews with the producer, observed that despite the necessary investment, the implementation of a Compost Barn System was economically feasible in the property studied, because even implying an increase in production costs, it allowed the reduction of the area used with dairy cattle and gains related to increases in production, productivity, and milk quality. The main indexes used to evaluate economic viability in the previously mentioned bibliography are described below.

Cash flow: This is understood as the behavior (inflows and outflows) of money in the cash of a particular company or enterprise over some time, even allowing to estimate the cash flow for the future and it is possible to evaluate periods in daily, monthly, semiannual or annual intervals, depending on the purpose (Basaia, 2020; Farina et al., 2015);

Gross revenue: Monetary value that comes into the company's cash flow from selling products, animals, or services in a certain period. It is obtained by multiplying the total produced by the amount received (liters of milk sold per month x amount paid per liter, for example);

Net Revenue: It is calculated employing the difference between the Gross Revenue and the expenses implied in the production process;

Costs and expenses: Costs can be understood as the monetary value of inputs consumed directly or indirectly in the production process and marketing of a particular product or service, such as the amount spent on fuel and labor, while expenses are the spending or decrease of resources during a period of company activities and that are necessary to obtain revenue (Farina et al., 2015);

Depreciation and amortization: Depreciation aims to account for the loss of value of fixed assets in the production process, which occurs through the action of nature, physical wear, and tear, or obsolescence. In short, it is the difference between the purchase value of an asset and its value at the end of its useful life (Farina et al., 2015). The amortization covers the reduction of some debt through partial or total discharge between the parties involved and can be considered as a cost;

Opportunity Cost: represents how much is renounced in remuneration when choosing to apply its resources in a particular activity instead of applying these same resources in another, that is, it evaluates the possibility of alternative use of resources (Basaia, 2020; Farina et al., 2015);

Minimum Rate of Attractiveness (TMA): represents the minimum interest rate that an investor proposes to earn when investing his resources in a given project or the maximum that he is willing to pay when financing a given amount (Farina et al., 2015). To be considered attractive, an investment must yield at least the interest rate equivalent to the profitability offered by low-risk investments, such as the Selic rate;

Net Present Value (NPV): is the sum of the variations of the expected cash flow for the expected years of investment for each period, updated year by year and brought to zero period values (present value, in which the analysis is made), applying an interest rate that is equivalent to the Minimum Rate of Attractiveness (TMA) of the market subtracted from the amount initially invested, in period zero, i.e., in simplified form, it is the amount that the investor will receive in the future, discounting the amount invested. The higher the NPV, the more attractive is considered the investment, and the NPV must be greater than zero to be considered viable (Guiducci et al., 2012);

The Internal Rate of Return (IRR): is the rate of return that a project offers to its investor, and if the IRR is higher than the opportunity cost rate, it is viable for the investor to invest in that project (Guiducci et al., 2012). The IRR shows precisely what is the periodic rate at which the investment is remunerated and serves as a basis for comparison with other investments;

Discounted Payback: allows you to calculate the time (in days, months or years) required for an investment to pay off, i.e., the time required for the net profit to equal the amount invested, recovering the initial capital invested. This period is calculated by adjusting the amounts invested at a given interest rate compared to the maximum period defined as the parameter of attractiveness, and if the Payback period is longer than the time defined as the parameter of attractiveness, the investment must be rejected (Farina et al., 2015; Guiducci et al., 2012);

Profitability Index: is an indicator of the investment's capacity to generate profits from the project developed, showing what proportion of the gross revenue consists of available resources after covering the total operating costs, calculated from the present value of the disbursements, in percentage terms, allowing us to define whether the project is viable or not;

Benefit-cost ratio: This is the relationship between the present value of the revenues to be obtained and the present value of the costs.

CONCLUSION

The bibliography consulted shows the dairy production chain's importance and the possible challenges and environmental impacts it can cause. It becomes clear, therefore, the need for further studies that identify and quantify these environmental impacts, so that it is possible to define the critical points to be worked on and plausible alternatives to be adopted for this.

Author contributions

FGS, FC, OSPN, SP: Conceptualization, Supervision, Writing original draft preparation, writing, eviewing and editing. ARC, BNC, FRS: Writing original draft preparation and editing. All authors gave their final approval and agree with all aspects of the work.

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