SUSTAINABLE AGRIBUSINESS IN BRAZIL: LEVERAGING ENVIRONMENTAL EDUCATION TO EMPOWER LOCAL PRODUCERS

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Abstract: This study investigates small-scale agro-livestock producers' perceptions of integrated agro-livestock systems (IALS) in Mato Grosso do Sul, Brazil, and their alignment with SDGs 2, 4, 12, and 15. Using a tailored questionnaire and socio-environmental analysis, the research reveals that although IALS offer clear economic and environmental benefits, adoption remains limited due to financial constraints and lack of information. The findings underscore the vital role of targeted environmental education and strategic institutional support in promoting sustainable practices such as crop-livestock integration and silvopasture, which can enhance both productivity and ecological resilience.

Keywords: Integrated Agro-Livestock Systems (IALS); Environmental Education; Sustainable Agriculture; Rural Development; Socio-Environmental Analysis.

Resumo: Este estudo analisa as percepções de pequenos produtores sobre os sistemas integrados de produção agropecuária (SIPA) em Mato Grosso do Sul e sua contribuição para os ODS 2, 4, 12 e 15. Com base em questionário adaptado e análise socioambiental, revela-se que, apesar dos benefícios econômicos e ambientais dos SIPA, sua adoção é limitada por barreiras financeiras e falta de informação. Os resultados destacam a importância da Educação Ambiental direcionada e do apoio institucional para promover práticas sustentáveis, como a integração lavoura-pecuária e o sistema silvipastoril, que fortalecem a produtividade e a conservação ambiental.

Palavras-chave: Sistemas Integrados de Produção Agropecuária (SIPA); Educação Ambiental; Agricultura Sustentável; Desenvolvimento Rural; Análise Socioambiental.

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Introduction

The United Nations' 2030 Agenda for Sustainable Development highlights 17 goals, four of which are directly relevant to this study: Goal 2 (Zero Hunger, Food Security, Improved Nutrition, and Sustainable Agriculture), Goal 4 (Inclusive, Equitable, and Quality Education), Goal 12 (Responsible Consumption and Production), and Goal 15 (Life on Land). This research aligns these goals with robust environmental education methodologies, drawing inspiration from David Ausubel's (1982) concept of meaningful learning and Paulo Freire's (2017) approach to inclusive education. These educational frameworks can foster responsible agricultural practices based on integrated systems that enhance environmental conservation, resource optimization, and productivity. This is particularly crucial in Brazil, where there is a significant demand for sustainable practices due to the vast areas of degraded pastureland.

Education must be democratic and enduring, making sense to learners by building on prior knowledge. This approach counters reductionist views and fosters complex thinking about environmental issues, as proposed by Enrique Leff's (2003) concept of environmental complexity and the socio-ecological systems framework by Fazey (2010). The systemic view encourages understanding interrelations and interdependencies, positioning humans as central actors responsible for the consequences of their actions on the environment (Fazey, 2010; Fischer et al., 2009; Krazny et al., 2010).

Sustainable production and consumption, as defined by Prof. Adisa Azapagic[4], involve producing and using products in a socially beneficial, economically viable, and environmentally benign manner throughout their life cycle. However, studies in southern Minas Gerais show that farmers often prioritize immediate economic benefits over environmental considerations, such as herbicide efficiency (Freitas et al., 2015a). This short-term focus can lead to long-term negative impacts, including soil degradation, water pollution, and reduced biodiversity, ultimately affecting economic and environmental sustainability.

In animal husbandry, Gamborg and Sandoe's (2005) review highlighted the need for clear sustainability criteria. Their concern-criteria-indicators method offers a structured approach to sustainability, focusing on animal welfare and production efficiency. However, there's a noticeable gap in addressing environmental concerns within this framework. Potential solutions include reducing environmental degradation through intensive production and using animal genetic improvement to minimize environmental impacts (Richardson et al., 2023; Torp-Donner and Juga, 1997). For instance, intensive grazing in dairy farming is more sustainable than total confinement methods, as it reduces greenhouse gas emissions and maintains ecological balance (Aguirre-Villegas

[4] https://www.sciencedirect.com/journal/sustainable-production-and-consumption/about/aims-and-scope

et al., 2017; Meul et al., 2012). Integrated systems, such as crop-livestock-forestry, enhance sustainability by combining agricultural practices with environmental conservation (Gasparini et al., 2017; Ikerd, 1993). Thus, there is no inherent conflict between the ecological and economic elements of pasture systems; however, financial literacy, knowledge of pasture ecology, and practical and intellectual management skills are essential (Walsh and Holmes, 2023).

The Brazilian Federal Government's pasture recovery program, launched in anticipation of COP-28, exemplifies national efforts to promote sustainable agribusiness. This program aims to regenerate up to 40 million hectares of pasture, emphasizing the importance of environmental education in achieving these goals. Educational practices for management will generate methodologies, materials, and strategies for extension workers and small to medium-sized producers, focusing on the positive financial impacts of pro-environmental measures.

Simple management practices, such as carbon sequestration and soil health improvement, can significantly reduce greenhouse gas emissions and create carbon credits. These credits can be traded, providing economic benefits while supporting environmental sustainability. Crop genetics can also enhance soil carbon sequestration, contributing to a reduced carbon footprint.

In summary, integrating inclusive and continuous education with sustainable agricultural practices is essential for achieving the goals of the 2030 Agenda. An environmental education program that demonstrates the complementarity of economic and environmental sustainability is crucial. This proposal aims to assess economic and environmental perceptions through a questionnaire, develop a pro-sustainability environmental education program, and address misguided social representations. By doing so, it seeks to generate strategies that support both the rural economy and environmental sustainability, ultimately fostering a more sustainable future for agricultural communities.

Materials and Methods

Study Design and Participants

The study aimed to assess producers' perceptions of the agro-livestock integration system and to subsidize policies that support its implementation. A group of 18 producers, each situated on properties of up to 22 hectares - most of which ranged between 0 and 4 hectares - participated in the study. This group included 4 livestock farmers and 14 agro-livestock farmers. These participants were selected based on their willingness to provide insights into their knowledge and adoption of integration system techniques. The initial status analysis on the concept of sustainability was conducted through socio-economic and socio-environmental questionnaires, which addressed issues related to productivity, profitability, means of production, and, implicitly, environmental conservation measures. The main target audience consisted of

several families in the agricultural community of Mato Grosso do Sul, Brazil, particularly those in rural settlements. Data collection involved administering questionnaires through face-to-face interviews, enabling detailed responses and the clarification of any ambiguous questions. This approach facilitated the collection of both quantitative and qualitative data. The quantitative data were analyzed using descriptive statistics, while the semi-structured questions were categorized through triple-blind content analysis.

Environmental Education Design

Environmental education was designed using everyday examples from an inclusive, systemic, and complex perspective. The development of sustainable environmental thinking followed hierarchical graduations: sensitivity, understanding, responsibility, competence, and citizenship (Abreu et al., 2008; Freitas et al., 2015b). Subsequently, methodologies, didactic materials, and strategies on how to economically benefit from pro-environmental actions, particularly crop integration, were designed using a dialectical approach (Lefebvre, 1991). Various teaching methods should be employed to plan environmental education activities (Macedo et al., 2011). According to Ronca and Terzi (1995, 1996), discussion moments were designed to promote the development of mental operations such as analysis, comparison, synthesis, classification, seriation, and knowledge transfer. The ability to transfer environmental knowledge to everyday situations should be emphasized as a skill that could trigger sustainable actions (Moreira, 1999; Moreira and Masini, 2006).

Expected Technical Products

The products of this environmental education stage include support materials that guide agricultural practices, such as: guidance scripts for extension workers, conceptual maps, sequences of illustrations for brochures and lectures, manuals, and other materials that incorporate sustainable reasoning into the activities of agricultural producers.

Results and Discussion

Gamborg and Sandoe (2005), in their review on sustainability in animal husbandry, highlight that little had been studied about the requirements for sustainable animal farming. Since then, there has been an exponential increase in the scientific community's interest in the topic of sustainability and animal husbandry (Figure 1), but it is still imperative to construct a clear definition of sustainability, as an unequivocal concept can effectively be used to organize and facilitate dialogue among stakeholders, including the animal production industry and society as a whole. In this vein, SEFABAR (Sustainable European Farm Animal Breeding and Reproduction) proposes the concern-criteria-

indicators method to define sustainability (Gamborg and Sandoe, 2005). According to the authors, concern refers to animal welfare and production efficiency; criteria correspond to coupling the concern with a direction of change, such as, to maintain productivity, one should seek to reduce resource use or increase animal welfare; indicators are empirically verified states of cases that can be used to determine if, and to what extent, a criterion is met, meaning they allow for the measurement of the satisfaction criterion and thus determine the extent to which the concern has been addressed. However, in the examples above, there is a noticeable lack of concern for environmental issues, mitigation criteria, and indicators for assessment in the context of animal production.

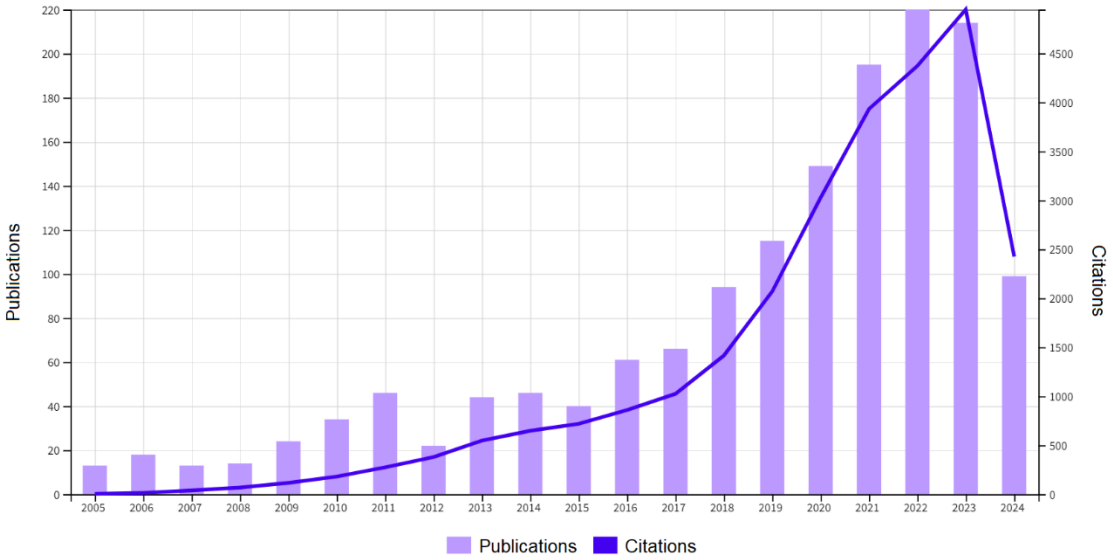

Figure 1: Publications and citations using the search terms "SUSTAINABILITY AND ANIMAL BREEDING" in the Web of Science database between the years 2005 and 2024 (accessed on July 2, 2024).

Although still on an upward trajectory from 2005 to 2023, the inclusion of "environmental" in the search terms "sustainability AND animal breeding" in the Web of Science database causes a marked decline in the absolute numbers of publications and citations (Figure 2), indicating a certain neglect of environmental sustainability in the context of animal production. Therefore, it remains necessary to identify and analyze the origin of a problem in sustainable agricultural production, as well as to evaluate ways to mitigate it through educational practices based on the systemic concept of the environment and guided by an environmental education methodology.

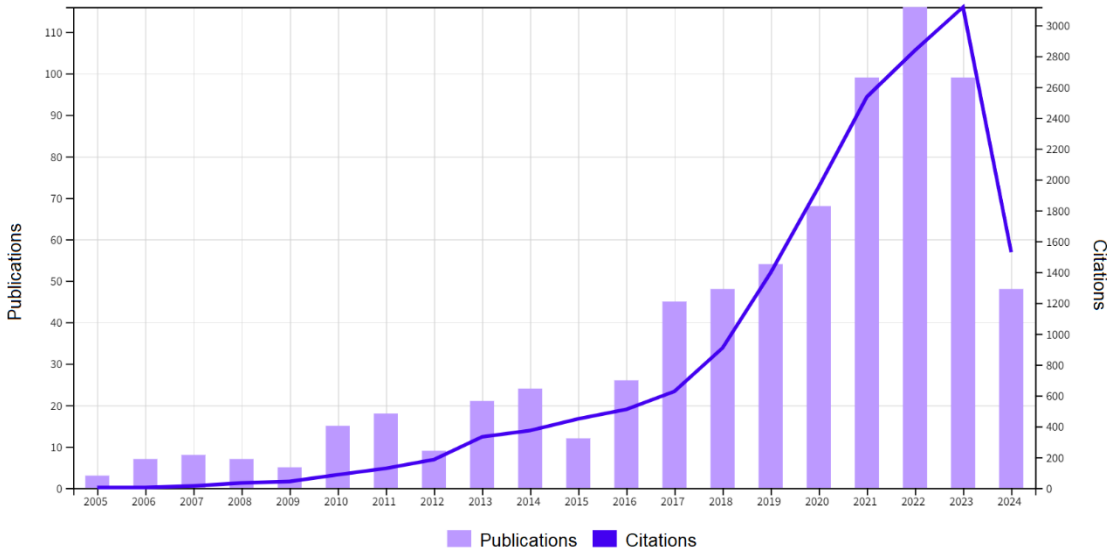

Figure 2: Publications and citations using the search terms "SUSTAINABILITY AND ANIMAL BREEDING AND ENVIRONMENTAL" in the Web of Science database between the years 2005 and 2024 (accessed on July 2, 2024).

The first step to promoting policies that support the agro-livestock integration system is to conduct a perception study of producers on this subject. Based on this premise, a group of 18 producers with profiles as livestock farmers (4) and agro-livestock farmers (14) was examined regarding their knowledge of integration system techniques and the reasons that led them to adopt or not adopt such techniques. It is noteworthy that 50% of the interviewees are unaware of the integration system as a technique aimed at minimizing the use of external inputs by implementing a variety of production enterprises, long and diversified crop rotations, and the restitution of crop residue or animal excreta to the soil. Therefore, the level of sensitivity and understanding toward environmental thinking was assessed, as pro-environmental actions can only be effectively planned and implemented if the stakeholders are fully aware of the issue at hand. Those producers who are familiar with the technique primarily learned about it through the internet. Even so, many do not adopt integration systems (14 out of 18 producers) due to a lack of knowledge (6), financial resources (3), or the size of the cultivated area (3). Among those who know the technique, a significant portion (7) cite the high cost of implementation and emphasize that financial resources and technical assistance are necessary to encourage its use.

From the analysis, it is observed that the major concern of the producers lies in the lack of financial incentives to adopt the technique and the need for professional advice to make it known and implement it. Furthermore, a large portion is unaware of the economic and especially environmental benefits that the implementation of the integrated agro-livestock system can offer. Therefore, an environmental education program detailing the economic benefits of

implementing integration system techniques, while also preserving the environment—which can generate resources for new investments—seems urgent for the population under study.

Based on the diagnosis presented above, some actions can be implemented within the scope of specialized advisory services to promote economic and social benefits while respecting environmental ethics and the interests of the producers. Implementing an integrated agro-livestock system (IALS) program involves a series of strategic actions and best practices designed to promote the coexistence of agricultural and livestock activities in a manner that enhances productivity, improves soil health, and preserves the environment. Below is a detailed description of how to implement such a program:

Assessment and Planning

Recognizing the public's profile is essential for proposing targeted solutions that address specific needs. Therefore, certain guidelines are proposed.

A. Baseline Assessment:

- **Conduct Surveys or Semi-Structured Questionnaires:** Begin with a detailed survey or semi-structured questionnaire of the farm to understand the current agricultural and livestock practices, soil health, water resources, and biodiversity. This will help identify areas of improvement and existing challenges.
- **Stakeholder Engagement:** Engage with farmers, agricultural experts, local authorities, and other stakeholders to gather insights and establish a participatory approach.

B. Develop a Comprehensive Plan:

- **Set Goals:** Define clear sustainability and productivity goals that align with environmental ethics, such as reducing chemical inputs, enhancing biodiversity, and improving soil fertility.
- **Design System Layout:** Plan the spatial arrangement of crops, pastures, and livestock areas to maximize resource efficiency and minimize environmental impact.

Training and Capacity Building

For first-stage producers considering engagement in integrated systems, it is essential to develop a plan that builds on their existing and everyday knowledge. This approach should then advance towards meaningful learning that fosters both pro-economic and pro-environmental changes, utilizing a dialectical and inclusive language.

A. Educate Farmers:

- **Workshops and Seminars:** Conduct workshops and seminars to educate farmers about the benefits and techniques of IALS. Topics should include crop rotation, agroforestry, organic farming, and sustainable livestock management.
- **Field Demonstrations:** Organize field demonstrations to show practical examples of successful IALS implementations.

B. Technical Assistance:

- **Advisory Services:** Provide ongoing technical assistance through agronomists, veterinarians, zootechnician, and environmental specialists who can guide farmers in adopting new practices.
- **Resource Materials:** Develop and distribute manuals, guides, and other educational materials that outline best practices for integrated farming.

Implementation of Practices

Once the objectives are set and the planning is organized and grounded in sustainability, the target audience will be prepared to put them into practice. An example of such a plan is outlined below.

A. Sustainable Crop Management:

- **Crop Rotation and Diversification:** Implement crop rotation and diversification strategies to improve soil health and reduce pest and disease incidence.
- **Agroforestry:** Integrate trees and shrubs into agricultural lands to enhance biodiversity, provide shade and windbreaks, and improve soil structure.

B. Livestock Management:

- **Rotational Grazing:** Use pasture management according to recommended technical criteria to prevent overgrazing, promote pasture regeneration, and distribute manure evenly.
- **Manure Management:** Implement systems for collecting and composting livestock manure to use as organic fertilizer for crops.

C. Soil and Water Conservation:

- **Cover Cropping:** Use cover crops to prevent soil erosion, enhance soil fertility, and retain soil moisture.
- **Water Management:** Implement efficient irrigation systems such as drip irrigation and construct water harvesting structures to ensure sustainable water use.

Monitoring and Evaluation

There is a need for continuous monitoring to assess whether the actions are being effectively transformed into sustainable practices. If not, reformulation and adaptation of the plan may be necessary.

A. Performance Monitoring:

- **Regular Assessments:** Conduct regular assessments to monitor soil health, crop yields, livestock productivity, and environmental impact.
- **Data Collection:** Use technology such as remote sensing, GIS mapping, and mobile apps to collect and analyze data on farm performance.

B. Continuous Improvement:

- **Feedback Mechanisms:** Establish feedback mechanisms to gather input from farmers and other stakeholders to continuously improve the system.
- **Adaptation:** Adjust practices and strategies based on monitoring results and feedback to enhance system effectiveness and sustainability.

Community and Market Integration

Beyond learning and managing their own resources, it would be an act of competence and citizenship to share the acquired knowledge to optimize the resources of the socio-environmental system within the microregion covered by the rural producers.

A. Community Involvement:

- **Cooperative Models:** Encourage the formation of cooperatives or farmer groups to facilitate knowledge sharing, resource pooling, and collective marketing.
- **Community Outreach:** Conduct community outreach programs to raise awareness about the environmental and economic benefits of IALS.

B. Market Access:

- **Value-Added Products:** Support farmers in developing value-added products such as organic produce and sustainably raised livestock, which can fetch higher market prices.
- **Certification Programs:** Assist farmers in obtaining certifications such as organic or fair trade to enhance marketability and consumer trust.

Examples of Integrated Agro-Livestock Practices

Crop-Livestock Integration:

A farm growing maize and soybean can use crop residues as livestock feed, while manure from livestock is composted and returned to the fields as organic fertilizer. This reduces reliance on chemical inputs and improves soil fertility.

Silvopasture:

Implementing silvopasture by integrating trees with pasturelands where cattle graze. Trees provide shade and wind protection for livestock, sequester carbon, and improve biodiversity. The livestock help in controlling underbrush and fertilizing the soil.

Aquaponics:

Combining fish farming with hydroponic crop production. Fish waste provides nutrients for plants, and plants help filter and clean the water for the fish. This closed-loop system minimizes waste and maximizes resource use.

Conclusions

This study sheds light on the knowledge and adoption challenges faced by small-scale agro-livestock producers regarding integrated agro-livestock systems (IALS) in Mato Grosso do Sul, Brazil. Despite the growing interest in sustainability and animal husbandry, our findings reveal significant gaps in both awareness and practice, particularly concerning the environmental aspects of sustainability. Half of the surveyed producers were unfamiliar with IALS, while those who had some knowledge of the system cited financial constraints and technical limitations as major barriers to adoption. The study underscores the importance of developing and implementing targeted environmental education programs that emphasize the economic and environmental benefits of IALS. Such programs, alongside strategic financial and technical support, are crucial to overcoming the barriers identified by producers. By integrating practices like crop-livestock rotation and silvopasture, IALS can not only enhance agricultural productivity but also contribute to long-term environmental conservation. Moreover, the study highlights the need for more comprehensive sustainability frameworks that fully integrate environmental concerns within animal husbandry. Current research trends suggest that environmental sustainability is often overlooked in favor of production efficiency and animal welfare. Addressing this gap is essential for the holistic development of sustainable agricultural systems that balance economic viability with ecological responsibility. In conclusion, promoting IALS through education, financial incentives, and technical assistance can significantly improve the sustainability of small-scale agro-livestock operations. This research contributes to the broader understanding of how environmental education can facilitate the transition to sustainable agricultural practices and provides a foundation for future policies aimed at supporting both the economic and environmental goals of small-scale producers.

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