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Environment

Sustainability assessment of pig production: a study in Santa Catarina, Brazil

Avaliação da sustentabilidade da suinocultura: um estudo em Santa Catarina, Brasil

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ABSTRACT

This study aimed to identify the sustainability practices of pig creation on rural properties in the West region of the state of Santa Catarina, Brazil. The analysis included the system of sustainability indicators in pig farming. Although managers comply with the regulations and legislation, there are practical difficulties related to the destination of production waste, water use, expenditure controls, and social interaction. The analysis comprised 30 rural properties and a scale of 0-10 points, related to organizational, social, and environmental practices. Nine rural properties had a general performance, indicating characteristics of in search for sustainability, while 21 obtained a performance between 2.5 and 5.0 points, indicating fragilities in organizational, environmental, and social practices. It highlights the importance of analyzing sustainability indicators as a mechanism to control and implement better practices to assist in the search for sustainable development.

Keywords: Sustainability indicators; Sustainability assessment; Environmental management; Pig farming; Brazilian agribusiness

RESUMO

O objetivo deste estudo foi identificar práticas sustentáveis de produção de suínos em áreas rurais da região Oeste do estado de Santa Catarina no Brasil. Foi analisado o sistema de indicadores de sustentabilidade na suinocultura. Embora os gestores rurais cumpram regras e regulamentos, há dificuldades práticas com a alocação de resíduos de produção, consumo de água, controle de gastos e interações sociais. A análise compreendeu 30 propriedades rurais e uma escala de 0 a 10 pontos para

avaliar fatores relacionados a práticas organizacionais, sociais e ambientais. Nove propriedades rurais obtiveram pontuação geral indicando as características de busca do desenvolvimento sustentável, enquanto 21 pontuaram entre 2,5 e 5,0, indicando a fragilidade das práticas organizacionais, ambientais e sociais. Salienta-se a importância da análise de indicadores de sustentabilidade como mecanismo de controle e implementação de melhores práticas para moderar o desenvolvimento sustentável.

Palavras-chave: Indicadores de sustentabilidade; Avaliação de sustentabilidade; Gestão ambiental; Suinocultura; Agronegócio brasileiro

1 INTRODUCTION

Agribusiness plays an important role in the world economy and is responsible for the food supply and raw materials to industrialize the world's population. Brazilian agribusiness is one of the most productive globally compared to other nations' output. Among the characteristics of Brazilian agribusiness, it stands out as particularly strong when it comes to the generation of jobs and income, especially in the context of the development of family agriculture (Süptitzüptitz, Wobeto & Hofer, 2011; Castro, Barros, Almeida, Gilio & Morais, 2020).

The participation in the international market depends fundamentally on the scale of production (Macohon, Scarpin & Zittei , 2015). Machado and Moraes (2012) note that the professional management of rural businesses combined with investments in technology has transformed Brazil into one of the most competitive nations in agribusiness.

Among the activities of Brazilian agribusiness, it is worth highlighting pig farming, with emphasis on productivity in the southern region of Brazil, particularly on family farms. According to the Ministry of Agriculture (Brazil), Brazil ranks fourth in the world ranking of production and export of pork. Swine activity is represented by approximately 7.8 million heads of pigs, accounting for about 20.0% of the gross domestic product of Santa Catarina (IBGE, 2020). According to the Catarinense Association of Pig Breeders (ACCS, 2019), the activity has approximately 8.000 swine farmers in commercial-scale production, accounting for the export of 55.65% of Brazil's pig production.

Arêdes, Santos and Gomes (2012) show that, until recently, swine farming primarily was operated for the subsistence of the family group, with the possibility of limited commercialization from surpluses due to most of the production being performed with little modern technology. However, the insertion of new technologies has allowed for the extension of production, increasing the scale of production, the generation of value for producers and animal welfare (Benjamin & Yik, 2019).

Concurrent with the growth of agricultural enterprises, there is a need for efficient management, which is made possible with information and controls in rural entities. Besides the efficiency and productive quality, it is necessary to emphasize the importance of the administrative management of rural properties that aims to identify the results and evaluate the performance of the developed activities (Süptitz et al., 2011). Rural properties have sought to add value to their products, increase profits and compete on the world stage; however, it is the need to use adequate accounting tools to properly manage and evaluate the results of economic activities is evident as these property owners try to scale their operations (Macohon et al., 2015).

In contrast, swine farming is considered one of the most polluting agricultural activities, causing environmental degradation, due to the volume of waste produced and the intrinsic aspects such as air degradation, water resources, and soil (Soerger, Oliveira & Moraes, 2016). Until the 1970s, the pig production was not concentrated, and the soil had a greater capacity to absorb organic loads; however, with the intensification of production and adoption of the confinement regime, the need for treatment and environmental control of production is necessary nowadays (Souza, Moreira, Ferreira & Matos, 2009).

Besides the need for economic and financial income, pig production needs to be cognizant of its environmental and social effects (Rauw et al., 2020). These are related to the context of global concerns about sustainability. Sustainability advocates worry about the availability of natural resources for future generations, without compromising the continuity of the various forms of life (WCED, 1987). Sustainability can be understood by three main approaches: (a) economic aspect: related to human well-being about the

cost-benefit of activities, from the generation of revenues and of the result obtained; (b) environmental aspect: it is concerned with the use and minimization of the impacts of the natural resources used; (c) social aspect: it aims to reduce social problems and promote the well-being of people who relate to the entity (Elkington, 2012).

According to Lassaletta et al. (2019), global pig production is expected to continue growing during the next three decades. Pig farming is carried out in different systems, with different levels of technical development and different feed sources, from local products to internationally traded feed products (Macleod et al., 2013). The increase in pig production has implications for the use of natural resources.

There are several environmental issues related to swine production along the production and supply chain (Winkler, Schopf, Aschemann & Winiwarter, 2016). Several compounds are released into the air and soil, and during feed production, swine production, and manure management (Uwizeye, Gerber, Schulte & Boer , 2016). Another issue concerns the use of agricultural land, which is growing around the world, in part to produce feed needed by the livestock sector (Doelman et al., 2018). Recent research by Wu, Cheng and CHang, (2020), concerns manure management scenarios in intensive swine farming in terms of materials, transport, energy, and emissions. This perspective describes scenarios to improve the sustainability of swine production systems.

Sustainability highlights the concern with the preservation of natural resources and with waste generated, aiming to mitigate the resources waste and seek alternatives so that the entities carry out their social function while doing so in an ecologically correct and socially just manner (Santiago & Dias, 2012). Studies, such as Souza et al. (2009), Santiago and Dias (2012), Carvalho, Melo and Soto (2015), and Soerger et al. (2016), emphasize aspects related to production costs, environmental practices of pig production, and concern with the destination of generated waste. Callado, Callado and Machado (2007) show the importance of the use of performance indicators for the measurement and evaluation of the performance of rural entities (Sangha, Russell-Smith, Evans & Edwards, 2020).

In this context, the problem research emerges: What are the sustainability practices of pig production on rural properties in the West region of Santa Catarina, Brazil? In this regard, this research aims to identify the sustainability practices of pig production in rural properties in the West region of Santa Catarina. The relevance of this research is justified by considering the need to evaluate the economic, financial, social, and environmental performances of the pig farming activity, aiming to understand sustainability as a requirement for the continuity of rural entities.

1.1 Context of sustainability in rural areas

1.1.1 Sustainability

The Brundtland Report (1987) recognizes the emergence of the concept of sustainable development, which is a development that meets the needs of the present without compromising future generations to meet their own needs. The concept broadly refers to preserving the quality of ecological systems or natural resources, the need to balance economic growth to meet social needs, and equity between present and future generations (Sachs, 2009).

From the world discussions and the initiatives promoted by the conferences of the United Nations, such as one held in Rio de Janeiro, Brazil, in 1992 (Rio-92), sustainable development goals are established. Rio-92 Conference promoted discussions and advances among the environmental, social, and economic sectors that challenged the existing world discourse in favor of concrete initiatives for sustainable development, to guarantee the continuity of human life that is dependent on natural resources (Van Bellen, 2005).

The sustainability approach has three main dimensions: economic, social, and environmental; together, these are considered the tripod of sustainability. Under the economic focus, the performance and return of investments, which consider the economic and financial viability of the business, are observed about environmental requirements and regulations, that seek to minimize the impact on, and promote

the appropriate use of, natural resources (Bastas, 2021). Social aspects related to the activity developed should be addressed, including the social well-being of both employees and the community in the short and long terms. In this way, sustainability is based on practices that ensure environmentally correct, socially just, and economically viable actions (Elkington, 2012; Borges, 2013).

An understanding of the sustainability principles is necessary for the organizations to plan their continuity and activities with a focus on the preservation of natural resources, mitigating the waste resources and the waste generation, and acting responsibly in the community where they operate (Santiago & Dias, 2012).

There is a need to develop performance evaluation indicators, which can help in the measurement and insertion of improvements in organizational practices, in favor of sustainable development. The observation of performance measurement indicators is thereby essential when it comes to sustainability, as these make it possible to measure, compare and implement improvements in social and environmental practices, necessary to meet the goals defined worldwide by agreements between nations (Veleva & Ellenbecker, 2001).

In this sense, the construction and analysis of sustainability indicators can help in the decision-making process, guiding managers in the search for better economic, social, and environmental practices (Santiago-Brown, Matcalfe, Jerram & Collins , 2015). Indicators allow us to measure, communicate ideals, and provide alert information, which can prevent social and environmental impacts in the short and long term (Tanzil & Beloff, 2006).

Kruger, Petri, Ensslin and Matos (2015) emphasize the need to evaluate sustainability in the rural area, aiming to construct indicators to evaluate the performance of the activities, considering the economic relevance, employment generation, and income of these activities, especially in the context of pig farming. In this context and from the sustainability perspective, it is relevant to consider the economic, social, and environmental factors related to the production aspects, to add improvements for sustainability given the high pollutant (Masera, Astier & López-Ridaura , 1999).

1.1.2 Pig Production

The understanding of the long-term transformation process in agri-food systems provided a new scenario that initially produced mainly lard for the domestic market, for a scenario integrated with global production chains. The boundary infrastructure has influenced the evolution of the Brazilian swine system to follow international standards and guide the direction of innovation to support sustainability transitions in agri-food systems (Vilas-Boas, Klerkx & LIe, 2022).

When we consider pig production, Brazil ranks fourth in the world ranking of pork production and exports, according to the Ministry of Agriculture. For the state of Santa Catarina, swine production represents significant participation in the generation of employment and income, with economic participation of approximately 20.0% of the gross domestic product (IBGE, 2020), approximately 8.000 swine farmers in commercial-scale production represent it, with and labor is predominantly family-owned.

However, according to environmental agencies, pork production is one of the agricultural activities with the greatest potential for pollution due to the volume of manure produced, and the degradation aspects of water resources, soil, and air (Soerger et al., 2016). With the intensification of production, through the confinement regime, there is an increase in the volume of waste produced and the reduction of the absorption capacity of the effluents in the soil, reflecting the concern with the environmental impacts of pig production (Souza et al., 2009).

According to Secco et al. (2020), a model for measuring the activity in the pig production chain facilitates decision-making on environmental and social aspects and property costs, contributing to environmental preservation and the practice of swine farming. The form of waste management adopted by pig farmers can contribute to the reduction of environmental impacts. The management of pig manure and pollution generated is analyzed from the perspective of costs and benefits, the role of legislation and environmental agreements, and the perspective of business strategies.

The destination of swine production waste is an environmental and social impact factor, which distances it from the economic relevance of this activity (Hollas et al., 2021). Among the bottlenecks for pig production are the inadequate handling and treatment of generated waste, which affect the natural resources and cause damage to human health (Avaci et al., 2013). Although there are alternatives for the reuse of waste (e.g. biodigesters), it is possible to increase the production of bioenergy and biogas, to minimize the negative impacts of the activity in rural areas. However, the initial capital investment is high, and the use of biodigesters is restricted to a few rural properties (Rocha Júnior, Shikida, Souza & Zanella , 2013).

In the context of rural properties that develop pig production, studies indicate fragilities in the management of waste or residues generated by the activity and the lack of use of control and information to support the management of rural entities. The study developed by Gomes, Peruzatto, Santos and Sellitto (2014) analyzes sustainability practices in pig farms, highlighting the importance of using sustainability indicators as an alternative to economic, social, environmental, and political-spatial practices as well as the need for joint actions between rural producers and members of the entire supply chain, so that the pig industry can become sustainable.

Marchesan and Fraga (2014) emphasize that pig farmers do not have the strength, economic power, or political organization to solve the environmental problems of the activity. Many are decapitalized and discouraged by the activity and the conditions established by the market. Carvalho et al. (2015) demonstrate the need to create programs to manage the residues generated in pig farms, to minimize the environmental impacts.

Süptitz et al. (2009) show that the lack of reliable accounting tools and data makes it difficult to manage a business, particularly in rural properties. The study of Kruger, Glustak, Mazzioni, and Zanin (2014) indicates the fragility of accounting as a management tool in rural properties. The rural producers surveyed do not make use of controls and reports, and consequently do not separate the personal expenses of the different

aspects of the enterprise. Zanin, Oenning, Tres, Kruger and Gubiani (2014) indicate the lack of use of accounting for the analysis of costs and results of activities, evidencing the fragility of the management of rural properties in the West of Santa Catarina.

The assessment of sustainability in the rural areas allows considering environmental, social, and economic aspects of the production developed on rural properties. In pig farming, the sustainability indicators allow for observing the management of animals, the treatment of manure, the labor, and aim to establish criteria to improve production processes and the minimization of social and environmental impacts (Gomes et al., 2014).

2 METHODOLOGICAL PROCEDURES

This research was characterized as a descriptive investigation carried out through the application of a structured questionnaire. It was carried out in 30 rural properties in the West region of the State of Santa Catarina, Brazil. The proposed questionnaire was developed to compose quantitative analyses.

Data collection was carried out through a structured questionnaire, proposed by the Sustainability Indicators in Pig Farming (SISS), adapted from Gomes et al. (2014), including economic, social, environmental and political-spatial data indicators. The sample was obtained due to the accessibility and availability of the rural managers in contributing to the research. The answer's composition considered the municipalities of Chapecó, Seara, and São Carlos.

Table 1 summarizes the questioning carried out under the economic, social, environmental, and political-spatial dimensions. Each response is defined as 0, 1, 2, or 3, according to the characteristics of the management and production of each rural entity.

It was possible to obtain the questionnaire's economic, social, environmental, and political-spatial indicators. The SISS method points out that the score obtained between 0.0 and 5.1 points indicates entities classified as unsustainable; between 5.2 and 7.5 points are rural properties classified as in search of sustainability. Operations

are classified as sustainable when the score reaches 7.6 to 10.0 points. The results obtained are compared between the dimensions and the rural entities of the sample, aiming to identify aspects and characteristics of the sustainability of pig production in the West region of the state of Santa Catarina. Data analysis focused on descriptive statistics.

Table 1– Sustainability indicators in pig production: a structured questionnaire

(Continue..)

Dimension	Indicators
The score of the indicators for the criterion of efficiency in the economic and social dimensions	**E1**: Organizational development - Does the property have a management system that executes and controls the administrative and operational routines of the farm?
	E2: Facilities costs (Brazilian real/swine) - Is there a control of facility costs over the installed capacity on the farm? Are there records of construction and maintenance costs?
	E3: Costs of the treatment system (Brazilian real/swine) - Is there a control of the costs of the treatment systems on the installed capacity in the farm? Are there records of the construction and maintenance of installations, biodigesters or composters?
	E4: Profitability - Is there control over the profitability of the farm?
	E5: Aggregation of value by the treatment system - Are the fertilizers/by products generated on the farm used and/or marketed on the farm?
	E6: Food conversion - Is farm productivity within the animal's expectations of development? (Ratio of feed/weight gain).
	E7: Economic seasonality - Does the property not suffer retaliation due to the commercial difficulties of the segment? For example, restrictions on exports.
	S1: Participation in class entities - Is it participatory in associations and unions?
	S2: Accident and disease prevention programs - Do you have prevention programs? Do you have internal commission of accident prevention (CIPA)? Do you train with all the staff on the property?
	S3: Training and professional development - Do you invest in internal and external professional and educational training for employees?
	S4: Social Projects - Do you donate, promote events or participate in social activities?
	S5: Socially accepted work system - Registered employees, do not contract minors, pay charges such as insalubrity and dangerousness?
	S6: Employee Benefits - Do you offer employees benefits such as education, transportation, food, profit sharing, and others?

Table 1– Sustainability indicators in pig production: a structured questionnaire

(Conclusion..)

Dimension	Indicators
The score of the indicators for the criterion of efficiency in the environmental dimension	**A1**: Environmental licensing - Do you have an operating permit before the environmental agencies?
	A2: Environmental impact assessment - Identified aspects and impacts of the activity?
	A3: Environmental management system - Is there an environmental management system implemented (planning for improvements, application of new technologies, nonconformities, corrective and preventive actions)?
	A4: Physicochemical analyses of the feed - Are physico-chemical analyses of the feed consumed by pigs?
	A5: Physico-chemical analyzes of effluents/wastes - Are physico-chemical analyses of effluents/wastes?
	A6: Water consumption - Is there a control of water consumption in pig rearing (hydrometer)? Do you comply with published parameters?
	A7: Waste production - Is there waste production control? (volume)
	A8: Proper disposal area - Is the waste disposal area suitable? If not, how many properties are involved in this process?
	A9: Average distance from the disposal area - Average distance from waste disposal area is less than three kilometers.
	A10: Physical-chemical analyzes of the soil - Are physical-chemical analyses of the soil receiving the swine manures?
	A11: Air contamination - Was there any record/complaint about air contamination?
	A12: Water reuse - Is there any installation or technology for reuse of rainwater?
The score of the indicators for the criterion of efficiency in the political-spatial dimension	**Q1**: Integrator invests in environmental management policies - Does the integrator finance or invest in the farm in new environmental management, treatment and monitoring technologies?
	Q2: Municipality has strategic planning - Does the municipality where the farm is headquartered have norms and legislation in the master plan for the economic activity of swine farming?
	Q3: Water resources management - Is there a river basin management committee?
	Q4: Availability of water resources - Is there a baseline for the availability of water resources in the region, including water needs for the maintenance of existing and projected pig farms?
	P5: Compliance with legal requirements - Are the requirements and restrictions attributed by the operating license fully met?
	S1: Participation in class entities - Is it participatory in associations and unions?
	S2: Accident and disease prevention programs - Do you have prevention programs? Do you have internal commission of accident prevention? Do you train with all the staff on the property?
	S3: Training and professional development - Do you invest in internal and external professional and educational training for employees?
	S4: Social projects - Do you donate, promote events or participate in social activities?
	S5: Socially accepted work system - Registered employees, do not contract minors, pay charges such as insalubrity and dangerousness?
	S6: Employee benefits - Do you offer employees benefits such as education, transportation, food, and profit sharing?

Source: Gomes et al. (2014

3. RESULTS

After the visits made to the rural properties that develop swine activity, and through the structured questionnaire, pig production information and indicators were collected. Table 2 indicates the main characteristics of the entities studied such as the size of hectares, the number of people that work and contribute to the activity, the capacity of animals in the rural property, and the production system used.

Table 2 – Rural properties under investigation

Property	Size of the entities (hectares)	Labour (family members working in the activity)	Housing capacity (pigs/ animals)	Production system
Property 1	50.0	3	700	Termination
Property 2	50.0	5	1.000	Pig Production Unit
Property 3	37.5	4	1.500	Pig Production Unit
Property 4	62.5	7	3.700	Pig Production Unit
Property 5	45.0	5	2.600	Pig Production Unit
Property 6	30.0	4	900	Pig Production Unit
Property 7	9.9	3	350	Complete cycle
Property 8	30.1	1	400	Termination
Property 9	25.6	5	3.630	Early segregated weaning
Property 10	40.0	3	300	Complete cycle to
Property 11	30.8	2	600	Termination
Property 12	31.5	2	2.000	Early segregated weaning
Property 13	40.0	2	2.000	Early segregated weaning
Property 14	18.1	2	250	Pig Production Unit
Property 15	8.5	2	150	Pig Production Unit
Property 16	20.0	1	400	Complete cycle
Property 17	75.0	5	3.700	Termination
Property 18	50.0	4	1.900	Termination
Property 19	37.5	3	1.500	Complete cycle
Property 20	35.0	4	1.000	Pig Production Unit
Property 21	25.0	4	1.500	Termination
Property 22	45.0	3	1.400	Pig Production Unit
Property 23	28.0	2	700	Complete cycle
Property 24	32.0	3	1.900	Complete cycle
Property 25	64.0	4	2.600	Termination
Property 26	49.0	3	700	Complete cycle
Property 27	50.0	4	950	Termination
Property 28	72.0	5	3.100	Complete cycle
Property 29	53.0	3	1.400	Termination
Property 30	29.0	2	400	Termination

Source: Author (Year)

According to Kruger Pissaia, Zanin, Bagatini and Mazzioni (2012) and Miranda and Miele (2009), the Pig Production Unit (UPL) system consists of the management of matrices for breeding and rearing of piglets up to 22 kg and approximately 65 days of life; while the segregated early weaning system (DPS) consists of management of matrices and rearing pigs until weaning (usually 21 days of life). On the other hand, the rural properties that use the termination system receive the pigs with an average of 22 kg, a period that includes fattening until slaughter. In comparison, the units with a complete cycle have maternity, daycare, and finish, or the complete cycle from birth to slaughter.

It can be observed that when the number of animals is representative, the size or area in hectares is characterized by small entities, the majority (83.0%) has up to 50 hectares. Another perceived aspect is the presence of the family workforce in swine activity in the rural properties surveyed. The answers were classified according to the SISS method of observing sustainability by assessing the economic, social, environmental, and political-spatial dimensions based on the structured script.

Table 3 shows the results of each rural property in the analyzed dimensions. In this, we present the individual score of each rural entity and the general sum of the points obtained in each dimension, considering the 100 possible points and the maximum value of each dimension.

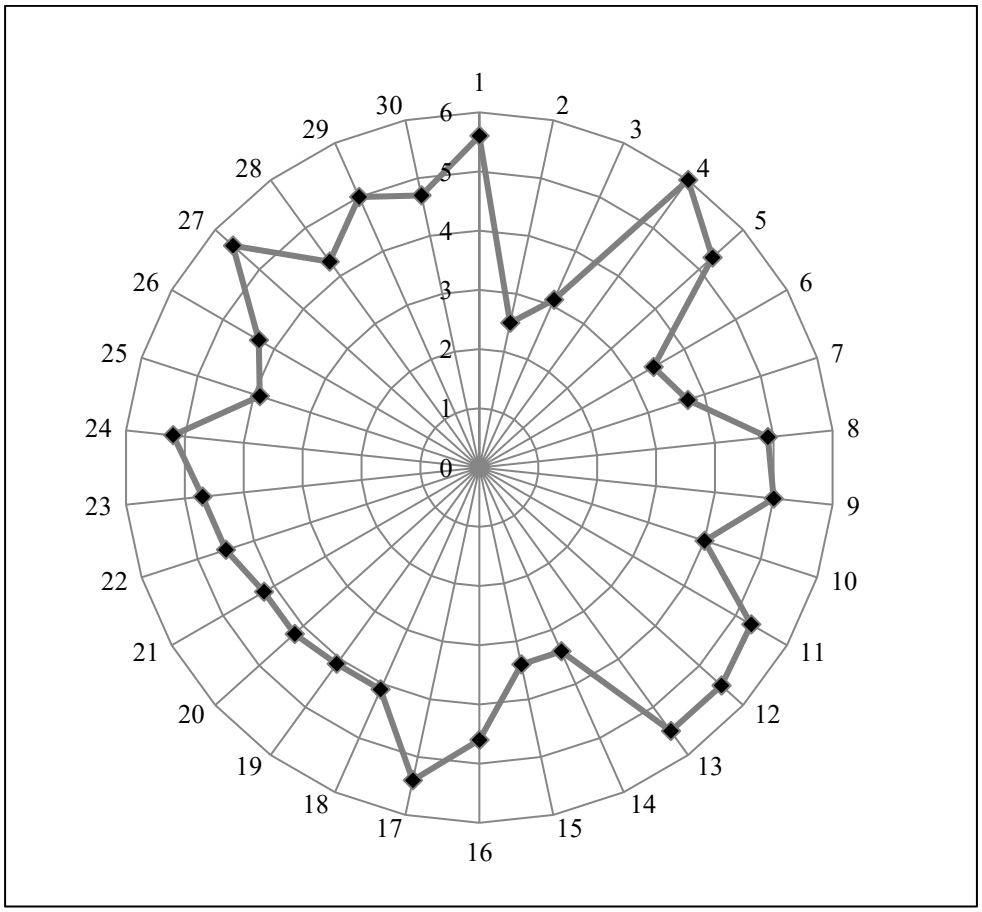
Based on Table 3, the score between 0.0 and 5.1 points shows entities classified as unsustainable; between 5.2 and 7.5 points are rural properties classified as in search of sustainability; when the score reaches 7.6 to 10.0 points entities can be classified as sustainable, which was not verified in this research. In this sense, rural entities were reorganized in order of scoring, with 70.0% of the sample having unsustainable characteristics, while nine (30.0%) are rural properties classified as in search of sustainability.

Table 3 – Results of sustainability indicators in pig production

Farm	Political-spatial indicator	Economic and social indicator	Environ-mental indicator	Maximum score	Total performance	Overall average	
Property 4	17	18	24	100	60	6.0	In search of sustainability
Property 1	17	16	22	100	56	5.6	
Property 27	12	14	29	100	56	5.6	
Property 12	9	15	30	100	55	5.5	
Property 13	9	15	30	100	55	5.5	
Property 17	10	18	25	100	54	5.4	
Property 5	11	13	28	100	53	5.3	
Property 11	9	15	28	100	53	5.3	
Property 24	11	14	26	100	52	5.2	
Property 9	16	7	26	100	50	5.0	Unsustainable
Property 29	11	13	25	100	50	5.0	
Property 8	16	7	25	100	49	4.9	
Property 23	9	11	26	100	47	4.7	
Property 30	9	11	26	100	47	4.7	
Property 16	12	16	17	100	46	4.6	
Property 22	12	7	25	100	45	4.5	
Property 26	9	8	25	100	43	4.3	
Property 28	7	10	25	100	43	4.3	
Property 20	4	13	24	100	42	4.2	
Property 21	4	13	24	100	42	4.2	
Property 18	4	12	24	100	41	4.1	
Property 19	4	12	24	100	41	4.1	
Property 10	7	9	23	100	40	4.0	
Property 25	6	13	19	100	39	3.9	
Property 7	7	9	20	100	37	3.7	
Property 6	4	11	18	100	34	3.4	
Property 14	7	9	17	100	34	3.4	
Property 15	7	9	17	100	34	3.4	
Property 3	4	13	13	100	31	3.1	
Property 2	6	3	15	100	25	2.5	

Source: Research data (2023)

Figure 1 – shows the general classification of sustainability obtained in each rural property surveyed



Source: Research data (2023)

The rural entities 1, 4, 5, 11, 12, 13, 17, 24, and 27 reach a score “in search of sustainability”, while the other properties reach scores with unsustainable characteristics. The results demonstrate the importance of the use of sustainability indicators as a mechanism for measuring and monitoring the performance of organizational practices and environmental management. This context reinforces the need for improvements in the organizational practices of pig production, specifically aimed at minimizing the impacts caused by activity in rural areas about economic, social, environmental, and political-spatial criteria and achieving sustainable levels of development in the long term.

4 FINAL CONSIDERATIONS

This research analyzed the level of sustainability of pig production in rural properties in the West region of the State of Santa Catarina, Brazil. The SISS method allows for comparing the sustainability indicators and to verify the need for improvements in economic, social, environmental, and political-spatial aspects in pig production.

The analysis points out weaknesses related to the productive practices of swine breeding to meet the sustainability criteria proposed for the pig production based on the SISS method. Among the suggestions for environmental improvement are the need to increase the distance between facilities and natural resources, reuse of rainwater, minimize the use of natural resources, greater waste control (use of biodigesters, rigor in time of decomposition of waste for use as biofertilizer), and physical-chemical control of soil. Concerning social and political-spatial dimensions, the following aspects are highlighted: participation in associations and unions, interaction in the community, and control of accounting records (production costs, labor routines).

Although all rural properties have a regular and valid environmental license, the survey showed that there are restrictions on the land available for disposal of waste, especially if the relationship between the available land area and the quantity of pigs housed is analyzed. This becomes worrying if one considers the soil's ability to absorb waste over time.

The general analysis of the indicators showed that rural property 4 reached the highest score in the sustainability assessment (6.0 points), which has 3.700 pigs housed and 62.5 hectares of available area. Rural property 2, which had the lowest overall score (2.5 points), has 50 hectares of available area and 1.000 animals housed. The SISS method demonstrates alternatives for improvements to be implemented, in search of scores ranging from 7.6 to 10.0 points, considering the sustainability characteristics.

This research shows that in line with the values raised in the results, farms are more concerned with the environmental and political dimensions, while producers

comply with environmental legislation and standards. This analysis allows us to observe the fragility of political-spatial, economic, social, and environmental aspects, and to identify the need for improvements in production practices aimed not only at complying with legal aspects, but also guiding criteria for the continuity of production and seeking better practices for the developed production.

By analyzing and assessing criteria in the social, environmental, and economic dimensions, adapted to the methodology, instruments were created that enable the visualization and classification of pig production systems in integration for: unsustainable, in search of sustainability, and sustainable. Although this methodology is based on regional references, it can be adapted to new regions or periods for different analyzes

In general, the results obtained allow for additional improvements in the support process for the analysis and evaluation of the sustainability of pig production, aiming to assure better organizational practices. It highlights the importance of using sustainability indicators as a measurement alternative to guide change processes and minimize the social and environmental impacts caused by swine activity.

The need to develop realistic and accessible methods to measure and subsequently assess the sector's sustainability is the first step in diagnosing and implementing public or private policies and actions. By analyzing and evaluating criteria in the social, environmental, and economic dimensions, adapted to methodologies that allow the visualization and classification of pig production systems.

For future research, we suggest the analysis of production practices in different production systems, observing the context of public policies and production practices required by agro-industrial companies (cooperatives, slaughterhouses), as stages in the production chain and co-responsible for the impacts of the activity.

It is suggested for future studies the approval of public policies for the environmental monitoring and future environmental recovery projects for pig production waste.

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