CIÊNCIA e NATURA

UFSM

Ci. e Nat., Santa Maria v.42, e72, p. 1-27, 2020
DOI:10.5902/2179460X40427
ISSN 2179-460X

Environment Submissão 09/10/19 Aprovação 20/02/20 Publicação 09/09/20

Environmental sustainability in milk-producing family farms in the micro-region of Carazinho-RS

Sustentabilidade ambiental na agricultura familiar leiteira da microrregião de Carazinho-RS

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ABSTRACT

Milk production in the northwestern region of Rio Grande do Sul has been particularly prominent among family farmers. Given the need to diversify production in their small farms, family farmers consider dairy farming a potential alternative to increase family income. However, the environmental dimension is often sidelined when implementing or maintaining this agricultural activity. Therefore, the aim of the present study was to evaluate the environmental sustainability of milk-producing family farms in the microregion of Carazinho-RS in order to identify the environmental reality in these properties. A total of 167 properties were sampled from the ten municipalities that have the most significant dairy production in the microregion. The environmental sustainability index of the properties was identified by applying a questionnaire. Research results showed that the microregion studied has a regular environmental sustainability index. This indicates the need for some adjustments, mainly in the indicators 'land use' and 'legal reserve', which were the ones that most compromised their environmental sustainability index.

Keywords: Milk production; Environmental indicators; Agroecology; Land use; Legal reserve

RESUMO

A produção leiteira na região noroeste do Rio Grande do Sul vem se destacando principalmente entre os agricultores familiares. Diante da necessidade de diversificação da produção em suas pequenas propriedades, os agricultores familiares veem, na pecuária leiteira, uma possibilidade de ampliar a renda familiar. No entanto, percebe-se que a dimensão ambiental muitas vezes fica relegada para um segundo plano, quando se decide pela implementação ou manutenção da referida atividade agrícola. Nesse sentido, o objetivo do presente trabalho foi avaliar a sustentabilidade ambiental em propriedades de agricultura familiar produtoras de leite na microrregião de Carazinho-RS, para identificar qual a realidade ambiental das referidas propriedades. Foram coletados dados junto a 167 propriedades dos dez municípios que mais se destacam na produção leiteira da microrregião, junto às quais se buscaram, com a aplicação de um questionário, identificar o índice de sustentabilidade ambiental das propriedades. O resultado da pesquisa demonstrou que a microrregião estudada apresenta um índice de sustentabilidade ambiental regular. Esse índice mostra a necessidade de algumas adequações, principalmente nos indicadores uso da terra e reserva legal, que foram os que mais comprometeram o índice de sustentabilidade ambiental.

Palavras-chave: Produção leiteira; Indicadores ambientais; Agroecologia; Uso da terra; Reserva legal

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1 INTRODUCTION

Milk production has had an eminent position in countries such as the European Union and the United States. It has not been considered a marginal activity for a long time, since it has been perceived as playing an essential role in economic and social issues. In 2016, for instance, the European Union accounted for a production of 152 billion liters of milk, and the United States produced 96.3 billion liters (FAGUNDES, 2017).

In the Brazilian context, the southern region has significantly contributed to increase milk yield over the last years, according to data from Instituto Brasileiro de Geografia e Estatística (BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS - IBGE, 2015). According to this survey, Brazilian production was 35 billion liters in 2015, and the southern region was responsible for 35.2% of national production, occupying the first place in the milk production ranking. Rio Grande do Sul ranks third place among the Brazilian states, and is only behind Minas Gerais, major producer in the country with 9.14 billion liters, and Paraná (IBGE, 2015).

In Rio Grande do Sul, the northwestern mesoregion has a prominent position as it is responsible for the largest amount of milk produced in the state, and its most striking characteristic is the fact that family farms are responsible for the majority of milk production. Moreover, 85% of the milk produced in the state in 2006 derived from family farming, according to the agricultural census conducted by IBGE (FEIX; LEUSIN, 2015).

Although milk production is not the main agricultural activity in Rio Grande do Sul, it plays an important role in the state's economy and in the economic sustainability of family farming. According to a survey carried out by Fundação de Economia e Estatística (FEE - Foundation of Economy and Statistics), soy crops predominate in the agricultural production of Rio Grande do Sul, and this crop accounted for a gross production value (GPV) of BRL 14 billion in 2015. The second and third largest agricultural productions in the state in the same year were rice and milk, with a GPV of BRL 6 million and BRL 4 billion, respectively (FEIX; LEUSIN, 2015). The same survey indicated that family farming accounted for only 35.7% of the soy

production and 10.7% of rice production in Rio Grande do Sul. It did, however, account for 84.7% of milk production (FEIX; LEUSIN, 2015). The importance of family farming in milk production can be proved by analyzing data from 2017, derived from the survey on milk productive chain developed by Empresa de Assistência Técnica e Extensão Rural do Rio Grande do Sul (Technical Assistance and Rural Extension Company of Rio Grande do Sul), which concluded that the mean milk yield/day produced by each property was 70.6 liters (EMATER, 2017).

Based on the data shown, we propose to check whether these small rural properties are capable of developing a milk-producing activity in an environmentally sustainable manner. According to Nascimento (2012), environmental sustainability is attained when both production and consumption occur in a way that ensures that ecosystems can maintain their self-repair, not compromising the life quality of future generations. In order to establish environmental sustainability indices, the following aspects were evaluated: water quality, biodiversity present in the properties, compliance with current environmental legislation, and basic sanitation conditions.

Therefore, the present study, titled "Environmental sustainability in milk-producing family farms in the micro-region of Carazinho-RS", proposes to evaluate the environmental sustainability indices of family farms that work with milk production. Importantly, this study was conducted with this group of farmers bearing in mind that family farming plays an important role in the economic, social, and environmental context of the state. It is also the aim of this study to characterize the properties of the microregion studied, identifying what perception farmers have about production along agroecological lines, which is a practice with potential to ensure environmental sustainability in rural properties.

According to what was mentioned above, we intend to answer the following questions: How environmentally sustainable are milk-producing family farms in the microregion of Carazinho? How are the milk-producing family farms in the micro-region of Carazinho characterized? What is the perception of agroecological production that milk-producing family farmers have in the microregion of Carazinho?

Based on these questions, we hypothesized that most of the properties studied have a satisfactory environmental sustainability index. Family farming properties that are milk producers in the microregion of Carazinho have, on average, 20 hectares (ha), and a rugged terrain, which hampers mechanization. In addition, we believe that actually few family farmers carry out agroecological production.

In face of these initial considerations, which indicate that milk activity in the referred microregion is an economically sustainable activity, the importance of the present study to the environmental sustainability of this economic activity becomes evident. According to Rempel et al. (2012), this study might make rural producers aware of strengths and weaknesses in their properties, and therefore, start to manage their farming practices in a sustainable manner.

2. THEORETICAL REVISION

2.1 Environmental sustainability

The concept of environmental sustainability might be compared to that of resilience. This means that the ecosystem analyzed is environmentally sustainable when it has the potential to recover and adapt after any intervention, either natural or anthropogenic (human activity that has negative impact on the ecosystem). Thus, we must bear in mind that the ability of an ecosystem to be resilient must be ensured, and therefore, production and consumption must be studied to check if the environmental aspect is being overlooked because only the economic aspect is being considered (NASCIMENTO, 2012).

Souza Filho (2014) also addresses the concept of resilience when studying environmental sustainability. In the author's opinion, the ability of an ecosystem to recover is shown in face of two forces: stress and shock. Stress is characterized by being a short-term force that affects a system. Erosion and salinization are examples used by the author to emphasize the fact that a long-term cumulative action of this force might have high impact. Shock, on the other hand, refers to an unpredictable and transitory change, such as a new pest that attacks a certain plantation or drought.

A sustainable environment could overcome problems derived from these forces, since yield (production of any product in a given area), stability (maintaining that yield even in face of setbacks), and equity (fair compensation for all those involved in the process) would have a harmonious relationship. Meticulous care must be taken with each of these elements for environmental sustainability not to be compromised. However, what frequently happens is that the farmer uses pesticides/insecticides in order to obtain higher yield, for instance. This is what occurred when the 'green revolution' was disseminated and used as a tool to increase yield by almost all farmers (SOUZA FILHO, 2014).

It is also important to point out the contributions by Sachs (2010), who suggests a solution regarding the 'double-green revolution' in the field. In the author's opinion, unlike the green revolution and its purpose of exclusively reaching high yield levels, the ideal would be to envision an increased yield per hectare, without overlooking ecological limitations. This is only possible if the real importance of the small-sized farmer is acknowledged, as they are 'the silent majority in the rural world' that provides for humanity's subsistence (SACHS, 2010).

Sharing the same opinion, Stofell, Colognese e Silva (2014) state that environmental sustainability is directly related to the social conditions of rural producers. These authors believe that the much-awaited sustainable development in the properties necessarily relies on their understanding that both the preservation of the environment and higher life standards for the farmer must be sought simultaneously in a long term perspective.

This appreciation of the farmer is an ecological imperative, since they are currently the main providers of essential environmental services regarding landscape and natural resources, on which everyone depends. Therefore, there is an urgent need to think of ways to keep these people in the countryside, e.g. paying them adequately (SACHS, 2010).

Family-farm milk production has been shown to be effective when observed from the perspective of improved life conditions (life standards). Nevertheless, the environmental impacts of this activity must be studied in specific cases, e.g. in the

microregion of Carazinho, which is the focus of this study. Due to the elements shown so far, the concept of ecodevelopment shown by Jacobi (1999) is convenient, as it refers to the idea that we must make improved life quality of stakeholders compatible with rural production and environmental preservation.

This is clear when the author states that “ecodevelopment rose as an alternative strategy to international economic order, thus emphasizing the importance of local models based on suitable technologies” (English translation by the authors) (JACOBI, 1999, p. 175). In his approach, the author emphasizes how important it is for technical assistance to observe the particularities of each region and to appreciate knowledges that farmers have inherited from their ancestors.

2.2 Family farming and environmental context

Data shown by the Ministry of Rural Development (MDA) indicate the current importance of this category. Although family farming occupies only 24.3% of the total agricultural area, it is estimated not only to house 84% of rural establishments, but also to employ 70% of the rural workforce and produce 70% of the food that reaches Brazilians' tables (DELGADO; BERGAMASCO, 2017).

In the scope of the present study, it is worth mentioning the alert made by Buainain (2006) as to the 'indiscriminate' use of the concept of family farming, since this label bears political value. For this author, the particularities must be observed to identify a given activity as family farming, so that it is not confused with activities developed by farmers who have a smallholding in the northeastern Brazilian hinterland, or small farmers integrated to larger agroindustries. Although both situations involve a family core, some of their characteristics, e.g. the extension of the properties, as mentioned previously, are different from family farming.

Therefore, it is important to emphasize that data from INCRA (BRASIL, 2013) indicate that the municipalities involved in the present study fall into tax modules that range from 16 to 20 ha. Hence, the maximum extension of family farms shall be 80 ha.

Specific aspects must be taken into consideration regarding the establishment of family farming in Rio Grande do Sul, especially in its northern half, as this location, unlike most of the other Brazilian states, was colonized by immigrants who wished to work the land in order to defend their territory and frontiers from countries of La Plata Basin. Large monocultures (e.g. São Paulo and the coffee production) were not interested in employing immigrant workforce; therefore, these families settled down in small plots and started to exploit them (CORADINI; FREDERICO, 2009).

However, the municipalities in the microregion of Carazinho were affected by the second colonization phase in the state, when new regions both in Rio Grande do Sul and in neighboring states (e.g. the western part of Santa Catarina and Paraná) were occupied by a population surplus generated from the colonies of the first phase. This expansion, now not with immigrants anymore, but with their descendants, kept the same structure when establishing these properties, i.e., small areas that could employ family workforce. In such context, it made no sense to consider the cultivation of large areas, as access to technology was limited and the new colonies were distant from commercial centers. Thus, since its establishment, the small farm would play a complementary role to the activities of landholdings, which were concentrated mostly in the southern part of the state, of the so-called ranchers, to whom a diversified production of food was not interesting from an economic perspective (CORADINI; FREDERICO, 2009).

That is why family farming is one of the elements that comprise the microregion of Carazinho. This activity is part of the genesis of the city. Since its birth, in the late 19th century, family farming has gone through a series of changes in an attempt to adapt this agricultural production model to new realities, both estimated and experienced over time. Such renovation proves the fact that family farming is not endangered, at least not because of its production form (SILVA, 1999). However, the evident aging of this population is cause for concern, since it compromises family succession in the countryside.

2.3 Family farming and agroecology

Agroecology is responsible for an effective sustainability of family farms. Fernandes e Pascual (2015), who conducted a study with two groups of family farmers, agroecological and non-agroecological, in southern Rio Grande do Sul showed that family farmers whose production was agroecological had higher environmental and social sustainability indices than those whose production was not agroecological.

Vargas, Fontoura e Wizniewsky (2013) corroborate this importance of agroecological production. The referred authors even state that agricultural production is the only means to reverse socio-environmental unsustainability. Unsustainability, which characterizes the current scenario, marked by the experience of capitalism and its consequent tendency towards consumerism, leads to a much higher extraction from the environment than the latter is capable of restoring.

However, agroecology requires workforce availability, which is a limiting factor for this activity. This is because, many times, some family members have income source outside the scope of the farm. Therefore, in order to implement agroecology, the activities of family members have to be restricted to the property, which might harm the economic sustainability of these families.

Another limiting factor is the low amount paid for agroecological products. Although they have a higher market value, compared to non-organic produce, their production cost is also higher. This factor also compromises the economic base of the activity and discourages farmers to choose this production form (FERNANDES; PASCUAL, 2015).

It is also important to highlight the reflection by Borsatto e Carmo (2012), who refer to agroecology as a scientific subfield that questions many of the dominant paradigms, thus causing a differentiated attitude in face of the existing socio-environmental crisis in the rural world. Therefore, agroecology allows for thinking the 'development model' from another perspective, focused on rational energy consumption and on ensuring the life of future generations (VARGAS; FONTOURA; WIZNIEWSKY, 2013).

From this perspective, considering that agroecology has the potential to reverse the current situation, in which the bases of agricultural production are visibly harming environmental sustainability (VARGAS; FONTOURA; WIZNIEWSKY, 2013), the activities developed in each property cannot be separated from each other. Therefore, milk production, one of the focuses of this study, cannot be considered separately. For this activity to be sustainable from an environmental standpoint, it must be integrated and considered inside the total context of the property.

The perspective mentioned above is corroborated by Almeida (2002). Addressing the paradigms involved in the concept of agroecology, this author mentions that agroecology is an heterogeneous system of interventions that, when applied in a given production or breeding system, allows for realizing that this system is comprised by multiple variables that although are impossible to reach all at the same time, are yet intertwined; and when one variable is interfered with, the entire system is affected. Similarly, agroecology is perceived by the author as an input-optimizing system, with lower impact on the environment. Sustainability in agriculture cannot be considered without agroecology postulates, although the market does not encourage this perception.

Another aspect to be observed when tackling environmental sustainability in family farming is its compliance with the Brazilian Forestry Code, as the land must fulfill simultaneously a social and an environmental role. In other words, aside from ensuring the well-being of their owners and maintain satisfactory levels of yield, rural properties must ensure the preservation of natural resources, which are essential to life in our planet and to which everyone is entitled (NINO; ANJOS, 2015).

2.4 Microregion of Carazinho-RS

Territorial division in microregions was defined by the 1988 Constitution in article 25, paragraph 3:

The States might, upon a supplementary law, institute metropolitan regions, urban agglomerations, and microregions, comprised of groups of neighboring

municipalities, to integrate the organization, planning, and performance of public roles of common interest (BRASIL, 1988).

Therefore, the microregion of Carazinho-RS was comprised of eighteen municipalities, belonging to the northwestern mesoregion of Rio Grande do Sul. According to Rovani, Werlang & Cassol (2008), in a study concerning the characteristics of the geographical microregions of Rio Grande do Sul, the service sector predominates in the economic structure of the microregion of Carazinho, followed by agriculture and manufacturing.

However, analyzing IBGE data (BRASIL, 2013) regarding the municipalities' revenues and separating the service sector from the private sector and from public administration and service, it becomes clear that out of the eighteen municipalities that comprise the microregion of Carazinho, fourteen have agriculture as their major revenue source.

The referred microregion is comprised basically of small municipalities with an essentially agricultural vocation. Therefore, as observed by Castanho e Rosa (2007), it is evident that the major activity in municipalities with larger extensions in the microregion of Carazinho-RS is the production of grains, in terms of agriculture, while the territorially smaller municipalities are focused on dairy farming.

Schumacher (2013) highlighted that the microregions that comprise the northwestern mesoregion of Rio Grande do Sul (composed by thirteen microregions) are much more specialized in dairy production than the other microregions. This became evident by the 128 municipalities specialized in dairy production indicated by the author, with nearly all of them situated in this mesoregion. Five of them belong to the microregion of Carazinho: Jaboticaba, Nova Boa Vista, Novo Barreiro, Pinhal, and Sagrada Família. All these municipalities have a small territorial area and population lower than five thousand inhabitants. Additionally, dairy farming is the major source of income of most family farmers in this region.

3. METHODOLOGICAL PROCEDURES

3.1 Type of research

This is characterized as applied research, as it proposes to answer a problem, whether confirming or not the hypothesis set for this problem. Additionally, its focus is the practical application of its results. Regarding the approach method, this study is classified as qualiquantitative, as it was possible to establish an interpretation of the quantitative data collected using a questionnaire. Based on that questionnaire, the environmental sustainability index of the properties was generated, and the properties were then classified as either environmentally sustainable or not. Based on conversations with the farmers and in loco observation, it was possible to establish a qualitative analysis regarding the environmental sustainability of the property, since some aspects that had not been captured by the questionnaire could be thus tackled (CHEMIN, 2015).

Regarding its objective, this study is classified as a descriptive study, with an exploratory nature, conducted through fieldwork that used cross-sectional data collection as its technical procedure.

3.2 Data collection

Data were collected using an assessment questionnaire concerning the environmental sustainability of dairy family farms belonging to the microregion of Carazinho-RS. This questionnaire was adapted from the model proposed by Rempel et al. (2012). To identify environmental sustainability, the nine parameters listed in "Data analysis" were checked in loco. In order to do that, properties were selected after they were identified using the geographical coordinates of farmers' houses.

The properties that participated in the study were selected with the help of EMATER offices and of Sindicatos dos Trabalhadores Rurais na Agricultura Familiar (SINTRAFs - Union of Rural Workers in Family Farming). A total of 167 questionnaires were applied in ten municipalities of the microregion of Carazinho, and the criterion to define in which municipalities farms would be sampled was that of higher representative milk production. The number of farms that work with milk production

in each municipality served as a parameter to define how many properties would be selected to participate in the survey conducted in each municipality.

The questionnaire is comprised of 26 questions, most of which are multiple-choice. This document also has a few open questions, intended to characterize particularities of each property, which are subjective. Questionnaires were applied in the properties of the selected farmers, who were previously informed of the details of the research. While farmers answered the questions in the assessment form, they were asked other pertinent questions in an informal manner. Hence, some particularities of the properties could thus be observed, which were extremely relevant to the development of this study.

3.3 Data analysis

The sustainability index of the properties was shown by using a score that was attributed according to the nine parameters (Table 3) comprising the questionnaire: water, permanent preservation area (PPA), legal reserve, waste, agricultural chemicals and fertilizers, land slope, erosion, burns, and several land uses.

The maximum environmental sustainability index is attributed 100 points. This score was determined according to the methodology shown by Rempel et al. (2012). According to the authors, measuring the environmental sustainability of milk-producing properties in the microregion of Carazinho-RS provides a diagnosis of either the sustainability or unsustainability of these farmers' practices.

Table 3 shows how the nine parameters and their corresponding subparameters were scored. That is how the levels of environmental sustainability were determined in the properties.

Table 3 – Parameters, subparameters, and assessment scores of environmental sustainability

Parameter	Score	Subparameter	Score
Waste	20	Storage of solid waste	10
		Storage of liquid waste	5
		Disposal of animal waste	5

PPA	15	Percentage of use of PPAs Predominant use in PPA	10 5
Pesticides and Fertilizers	15	Use of chemical fertilizers and pesticides Storage of pesticide packages	10 5
Legal Reserve	10	Percentage of native vegetation for registration in legal reserve	10
Water	10	Water source	10
Slope	10	Land slope	10
Erosion	5	Evidence of eroded soil	5
Burns	5	Evidence of burns	5
Land use	10	Diversity of covers	10
Total	-	-	100

Source: Adapted from Verona (2008) and Rempel et al. (2012)

Chart 1 shows the scores that comprise each one of the subparameters. The highest score corresponds to the situation considered ideal, and the lowest score corresponds to the situation that indicates environmental unsustainability of the corresponding subparameter.

Chart 1 – Subparameters analyzed, with corresponding scores and grades

1. Subparameter 'solid waste storage'	**Score**	**Grade**
Closed and covered manure pits	10	Excellent
Closed and uncovered manure pits	7	Good
No manure pits	3	Regular
Release of waste near water course	0	Bad
2. Subparameter 'liquid waste storage'	**Score**	**Grade**
Total treatment of the effluent generated and subsequent release in water course	10	Excellent
Closed and covered manure pits	7.5	Good
Closed and uncovered manure pits	5	Regular
No manure pits	2.5	Bad
Release of effluents near water course	0	Very bad
3. Subparameter 'disposal of animal waste'	**Score**	**Grade**
Balanced application and far from water resources	10	Excellent
Application according to availability of waste	5	Regular
Uncontrolled application of waste	0	Very bad
4. Subparameter 'percentage of use of PPAs'	**Score**	**Grade**
0%	10	Excellent
1 to 30%	7.5	Good
31 to 55%	5	Regular
56 to 80%	2.5	Poor
81 to 100%	0	Very bad
5. Subparameter 'predominant use in PPA'	**Score**	**Grade**
Native Forest	5	Excellent
Perennial crops and exotic vegetation	4	Good

Pastureland	3	Regular
Agriculture	2	Bad
Betterments	1	Very bad
6. Subparameter 'use of chemical fertilizers and pesticides'	**Score**	**Grade**
No use	10	Excellent
Controlled application	7.5	Good
Application throughout the property except near wells, creeks, and betterments	5	Regular
Uncontrolled application throughout the property	2.5	Bad
Uncontrolled application and near water courses	0	Very bad
7. Subparameter 'storage of pesticide packages'	**Score**	**Grade**
In a special covered warehouse, separated from any medication, food, animal, and moist-free	10	Excellent
In a covered warehouse	7	Good
In any place inside the property	4	Regular
Carelessly discarded	0	Very bad
8. Subparameter 'percentage of native vegetation for registration in legal reserve'	**Score**	**Grade**
Legal reserve area larger than 20%	10	Excellent
15 to 20% of legal reserve area	7.5	Good
10 to 15% of legal reserve area	3	Regular
5 to 10% of legal reserve area	2	Bad
0 to 5% of legal reserve area	1	Very bad
9. Subparameter 'water source'	**Score**	**Grade**
Water of external source with treatment	10	Excellent
Water from shallow well isolated from contamination	7.5	Good
Water from shallow well not isolated from contamination	5	Regular
Stream water	2.5	Bad
10. Subparameter 'land slope'	**Score**	**Grade**
Flat	10	Excellent
Smooth undulation	7.5	Good
Moderate undulation	5	Regular
Strong undulation	2.5	Bad
Mountainous	0	Very bad
11. Subparameter 'eroded soil'	**Score**	**Grade**
Not evident	4	Adequate
Evident	0	Inadequate
12. Subparameter 'Burns'	**Score**	**Grade**
Not evident	4	Adequate
Evident	0	Inadequate
13. Subparameter 'diversity of covers'	**Score**	**Grade**
More than 6 uses and covers	2	High diversity
From 4 to 6 uses and covers	1	Medium diversity
Less than 4 covers	0	Low diversity

Source: Rempel et al. (2012, p. 51)

Finally, Chart 2 shows the index and grade attributed to the properties. The environmental sustainability of these properties was classified as inadequate, bad, regular, good, and excellent.

Chart 2 – Qualitative grade of the environmental sustainability condition

Environmental Sustainability Index	Grade
Score equal to or higher than 0.9	Excellent
Score equal to or higher than 0.7	Good
Score equal to or higher than 0.5	Regular
Score equal to or higher than 0.2	Bad
Score lower than 0.2	Inadequate

Source: Rempel et al. (2012, p. 52).

The questionnaire also had some questions referring to agroecology, as shown in Appendix A. The analysis of these data was descriptive and percentage was also used.

4 RESULTS AND DISCUSSION

The size of the properties studied (Table 4) varied from 6 ha to 76 ha, and their overall mean value was 21.6 ha, slightly higher than the mean size of milk-producing farms shown in a survey conducted by EMATER (2017), which was 19.1 ha. In most properties, the area is intended for pasture or crops. However, there were also orchards and vegetable gardens, which are mostly intended for family consumption.

On average, these properties have 21 milking cows, with predominance of Holstein and Jersey breeds. Mean production is 483 liters of milk daily, which were almost entirely type 'B' milk. Mean daily production per cow is 23 liters/cow, an amount quite higher than the Brazilian mean value, which is 5.8 liters according to O Anuário Leite 2018 (2018 MILK YEAR BOOK -EMBRAPA, 2018). However, the fact that the municipalities selected had the highest dairy production must be taken into consideration, as most of the properties visited are consequently highly specialized in the referred production.

Livestock in all properties visited had other bovine animals aside from milking cows. In general, they were cows out of their lactation period, calves, heifers, draft

animals, and breeding animals. At the end, these animals reached a mean number of 37 animals per property, thus generating a waste production equivalent to 1,342 kg per property/day. Waste generation was one of the parameters analyzed subsequently in the assessment of the properties' environmental sustainability.

Table 4 - Data for the general characterization of dairy farms in the microregion of Carazinho-RS

Data	Mean values of dairy properties
No. of animals	37
Milking cows	21
Daily milk production (L)	483
Mean yield (L/cow)	23
Total area (ha)	21.6
Daily waste production (Kg)	1342

Source: By the author

As pointed out throughout this study, dairy production in family farms plays a determining role in their economic sustainability, which is corroborated by Dalcin et al. (2009). This importance is more evident in the northwestern region of Rio Grande do Sul, where the microregion of Carazinho is located. However, the scenario projected by the questionnaire applied to family farmers in this microregion indicates that their environmental sustainability is graded as *regular*, as shown in Table 5.

Table 5 - Mean score for each environmental indicator in the dairy farms analyzed in the microregion of Carazinho

Environmental indicator (maximum score)	Mean values of properties in the microregion In Carazinho-RS
Waste (30)	14.9
Water source (10)	8.5
PPA (15)	7.4
Legal reserve (10)	4.8
Pesticides and fertilizers (15)	10.9
Slope (10)	5.8
Land use (2)	0.7
Erosion (4)	3.0

Burns (4)	4
TOTAL	60.1
Quantitative index	0.6
Quantitative index	Regular

Source: By the author

This regular environmental sustainability of the microregion of Carazinho corroborates the findings by Roloff, Rempel e Eckhardt (2014), Bortoli, Rempel e Bica (2014), and Marangon e Rempel (2014). These studies also observed an environmental sustainability level classified as regular or bad in the overall average of municipalities of the Taquari Valley. Nevertheless, it is important to emphasize that the problems identified as responsible for this grade vary according to each study. Therefore, quantitative data would serve as a base to reach an objective measurement unit, thus allowing for identifying and discussing the bottlenecks that prevent a satisfactory environmental sustainability and suggesting solutions for such problems (REMPEL et al., 2012).

The percentage adequacy for each environmental indicator shown in Table 6 helps to understand which indicators are considered positive and those that somehow compromise the environmental sustainability of milk cattle breeding in the microregion of Carazinho. Importantly, the general mean adequacy of the parameters analyzed was 63.84%.

Table 6– Mean percentage adequacy of each parameter in the farms of the microregion of Carazinho-RS

Environmental Indicator	**Mean percentage of parameters analyzed**
Waste	49.8%
Water source	85.5%
PPA	49.3%
Legal Reserve	48%
Pesticides and fertilizers	73%
Slope	58%
Land use	35%
Erosion	76%
Burns	100%
TOTAL MEAN	**63.8%**

Source: By the author

Two indicators deserve special attention for their high percentage of adequacy in the properties: there was no evidence of burns in any properties visited, thus indicating that this practice is falling out of use in family rural properties. Oderich e Miguel (2017), in their study on “História e situação da agricultura e do desenvolvimento rural em quatro municípios do noroeste do Rio Grande do Sul” (“History and status of agriculture and rural development in four municipalities of northwestern Rio Grande do Sul” – translation by the authors), emphasize that the evolutionary process of agricultural systems in this region of Rio Grande do Sul has gone through four distinct periods, classified as follows: indigenous system, caboclo system, colonial system, and current system. In the first three systems, the use of burns was recurring and necessary; however, from the 1970's onwards, the process of modernization of agriculture caused this technique to be ceased.

Surveying the INPE Burn Database (2019), no burns were identified throughout the state between March 2018 and March 2019, thus confirming, at least theoretically, the result attained in our study. It is worth of note that the satellites used to comprise this database are capable of capturing burns of at least 30 meters of extension per 1 m width.

Another parameter that can be highlighted is water, as this indicator affects social well-being, because it is directly related with health. Nearly 86% of farmers said they had access to treated water in their properties. Thus, the studied microregion is different from those in the studies conducted by Roloff, Rempel e Eckhardt (2014) and Marangon e Rempel (2014), who found 37% and 70% of adequacy for this indicator, respectively.

The environmental indicator erosion had a mean adequacy percentage of 76%. Observations by farmers corroborate the findings of Dias e Thomaz (2009), who characterize bovines as the animal species with the highest impact in geomorphological processes, as trampling by these animals excessively compacts pasture soils, thus hampering the infiltration of rain waters. With that, water runs over the surface, thus leading to the erosive process. Another issue is that bovine livestock

usually moves through tracks in different directions and areas, and this repeated path trampling also causes ground sinking.

The use of pesticides and chemical fertilizers is the fourth most important parameter, considering its high environmental impact on the properties. According to Spadotto et al. (2004), the correct use and storage of pesticides mitigates their potential to change soil biochemistry, and consequently, ecosystem function. The maximum score that could be reached with both subparameters that comprised this parameter, namely, use and storage of pesticides and fertilizers, was fifteen points, and the overall mean value was 10.9 points, which is equal to 73% of adequacy. However, the result of the analysis of this parameter must be compared with question number 24, which asked whether farmers considered their properties agroecological. As stated by Fernandes e Pascoal (2015), agroecology is a way for rural properties to reach environmental sustainability. Among the answers to this question, 17 farmers (10.2%) considered their farms agroecological, yet only 3 farmers (1.8%) said they did not use pesticides and chemical fertilizers.

Similarly, 83 interviewees (49.7%) said they had knowledge of organic production, while the other 84 interviewees (50.3%) showed no knowledge of this type of agricultural production. However, as discussed previously, it seems that the knowledge of organic production does not correspond to the indices found, as many farmers understood their properties were organic-producing farms just because they controlled their use pesticides and chemical fertilizers.

The five remaining parameters, slope, waste, PPA, legal reserve, and soil coverage, were those that most contributed with the final regular grade in the microregion of Carazinho, as all of them obtained an index lower than 0.6. The indicator slope reached only 58% of adequacy, mainly due to the predominant topographic conditions throughout the microregion. This region is situated in a transition area from an altitude of approximately 600 meters to an altitude of approximately 200 meters, which characterizes this land as gently sloping and moderately steep.

This parameter is ultimately directly related with the occurrence of erosion in 33 of the properties visited (19.8%), since the use of Regions with steeper slope for agricultural activities, many times with no adequate care for suitable soil cover, affects and changes natural systems, thus contributing with the erosion process, as emphasized by Zamberlan et al. (2014).

Waste storage and disposal were the two subparameters measured to evaluate the parameter waste. The adequacy of these indicators was 49.8%, thus totaling 14.94 points in the possible total of 30 points for this parameter. A first analysis allows for identifying that the lack of manure pits, for solid and for liquid waste, had a negative impact in the score of the referred parameter. Regarding solid waste, only 6.6% of the properties stored it properly, with manure pits adequately closed and covered. The scenario is even more concerning when it comes to liquid waste, as no property treated effluents before releasing them, and only 10.2% had closed and covered manure pits. Therefore, those two situations were, in that order, the ones that primarily comprised the score for this parameter.

This problem indentified in solid and liquid waste storage directly affects environmental sustainability considering the high polluting potential of waste. Souza, Tonin e Carvalho (2012), conducting studies regarding environmental impacts of milk cattle-raising waste, observed that problems derived from storage compromise environmental sustainability as they enable the proliferation of flies and other vectors, increasing the potential for soil and water contamination. This is due to the fact that the water used to wash equipment can change physical and chemical characteristics of the soil on which it is discharged, as well as contaminate groundwaters. Similarly, manure that is not treated adequately can contain a high amount of pathogens.

As to waste disposal, 24% of farmers said they applied waste in the plantation, with no type of control. These properties did not score in this subparameter. The percentage of properties that reached the maximum score in this subparameter was 29.9%. These farmers disposed of waste in a balanced manner (after letting it rest for an adequate period) and far from water resources.

When asked if the waste produced in the farm meets the farm's need for fertilization, 72.4% answered no, which means more waste is required. Therefore, if on one hand they are aware of the importance of waste to farm dynamics, on the other hand, it is not stored adequately; it is either done inadequately or simply not done at all.

With an adequacy of 49.3%, parameter 'PPA' has issues both in its percentage of use and in the predominat use in PPA's. Thus, only 13.2% of the properties did not have PPA's in their rural activity, and in the overall average, the percentage of use was higher than 55%. The predominant use in these PPA's is perennial crops, exotic vegetation, and pasture. As mentioned previously, livestock trampling causes considerable impact on the soil, and when this area is located inside a PPA, the level of harm is enhanced.

Nevertheless, the two indicators that most compromised the sustainability indices in the microregion of Carazinho were land use and legal reserve. Of the 167 farms that participated in the study, 117 (70%) indicated that they adopted less than four covers, whereas 37 (22.2%) properties used 4 to 6 covers, and only 13 (7.8%) properties reached the ideal condition, i.e., more than 6 covers.

These data show that the low diversity of organisms in an agricultural system might compromise environmental sustainability, since low cover diversity causes soil to be more exposed, with consequent loss of water and yield. Low diversity also favors outbreaks of pests, diseases, and spreading of invasive plants (SAMBUICHI et al., 2012). The fact that most farmers use less than four covers is due to their focus on production of pastures and fodder, especially maize, and they do not introduce other cultivars for fear of economic loss derived from the lack of suitable feed for livestock. Although the maximum score for this parameter is 2 points, it is possible to establish a direct relation with another parameter, erosion; if the farmer observes and maintains an adequate soil cover diversity, soil loss is mitigated. Therefore, the parameter land uses reached an adequacy of only 35%, quite below the parameter legal reserve, identified as the second indicator that most compromised the

environmental sustainability index of the microregion of Carazinho, with an adequacy of 48%.

Law n° 12.651/2012 provides for adequacy of PPAs and legal reserves in rural properties at a national level. However, it addresses rural farmers who fall within the condition of family farmers in a specific manner, flexibilizing the rules that set forth a minimum percentage of area with native vegetation intended for legal reserve, and that varies according to the biome in which the property is inserted. This somehow exempts farmers to keep 20% of the total area of their farms intended for legal reserves, and on the other hand, allows for including areas with fruit plants and other exotic plants cultivated in agroforestry systems, combined with native species.

The maximum possible score in this parameter was 10 points, and the mean score was 4.8 points, which shows there is loss of environmental biodiversity, since the native cover of these farms is reduced. As a counter-argument, farmers explain that, as their properties are small, maintaining these non-productive areas is economically unfeasible.

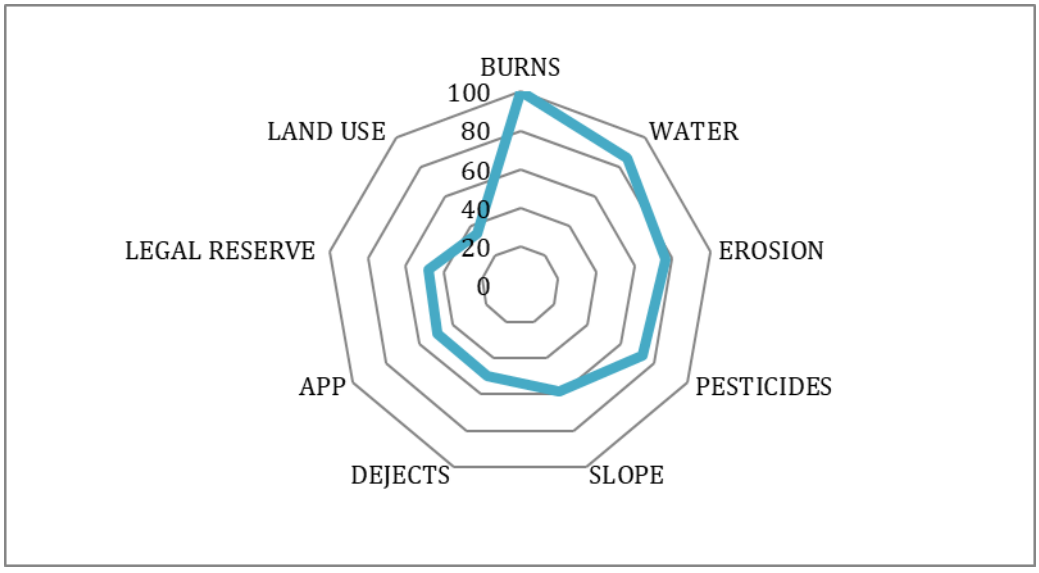
Our study also proposed to observe if agroecology is currently a sustainable option for farmers, in economic, social, and environmental terms. However, as already mentioned previously, this agricultural production method is far from their realities even regarding livestock management, as only 3 farmers (1.8%) said they did not use chemical treatments for tick control, for instance, or antibiotics, and used only homeopathic medications. Another 6% of the interviewees said they used both homeopathic and conventional chemical treatments, 78.4% said they used chemical products and antibiotics monitored by a veterinarian, and 13.8% of the farmers used these supplies with no supervision.

Farmers were asked about their non-compliance with agroecology to try to understand why they are unfamiliar with this production method, even though it represents the best perspective of sustainability for family farming (SANTOS et al., 2014). Among the farmers, 43% answered they did not consider feasible to organize their production in a new way, 11.3% indicated that the lack of technical assistance

was a limiting factor for this production, and 47% indicated lack of knowledge regarding agroecological production.

The radar graph (Graph 2) illustrates the overall panorama regarding the percentage reached by each assessment parameter of environmental sustainability. It is thus evident that the indicators providing the best score for the microregion of Carazinho are burns, water, erosion, and pesticides. These indicators had the highest scores due to factors that involve a range of activities, from technical monitoring of the farms, explaining how burns are harmful to soils, to campaigns regarding the adequate disposal and storage of pesticide packages. Community treated water supply, quite disseminated in this region, significantly helped them to have quality access to water. Finally, although located in a region with slope and soil cover issues, erosion has been mitigated due to the adoption of techniques focused on minimizing the negative effect of rainwater drainage.

Graph 2 - Mean percentage of the nine parameters of environmental sustainability in the milk-producing family farms in the microregion of Carazinho



Source: By the author

Legal reserve and land use are among the indicators that decreased the grade of the microregion of Carazinho. Focus on economic issue in the properties causes farmers to seek to maximize production. Consequently, they use the largest possible proportion of land, and thus, do not maintain native vegetation on a portion of the

property. On the other hand, the indicator with the lowest score was land use. Once again, farmers end up compromising environmental quality as they attempt to maximize production, and they do not realize that they are impoverishing the soil by focusing on pasture and maize production for silage, and are not aware of the future costs this shall cause.

5 CONCLUSION

Revisiting the aim of the present study, which is to evaluate the environmental sustainability of the milk-producing family farms in the microregion of Carazinho, a mean quantitative index of 0.6 was found, which represents 60% of the maximum score. Hence, the environmental sustainability obtained was graded 'regular'. Therefore, our initial hypothesis, according to which there would be a satisfactory environmental sustainability, was not confirmed as it should have been identified by a qualitative index of either 'good' or 'excellent'.

It is important to emphasize that no element indicating a worsening of this concept was observed, either in the short or in the medium term. Quite the opposite, opportunities were identified for improving the quantitative index, and consequently, the grade. This conclusion is feasible because the indicators that most compromise the microregion of Carazinho are related to property organization method, which does not depend on external conditions, e.g. relief. One single change in property management, with the help of technical assistance, and indicators such as cover diversity, legal reserve, and waste might reach higher scores.

Finally, the economic sustainability aspect many times causes farmers to disregard the environmental aspect. The importance of educating farmers and raising their awareness must be stressed. As the culture of burns has been gradually overcome, a new and more ecological base culture can and must be built up, and thus, agroecology might start to gain more space in family farming.

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