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Technological profile of ranchers in the Pirajibu-Mirim river watershed

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Abstract

Objective: To analyze the technological profile of ranchers in a watershed located in Sorocaba-SP (Brazil) using technological and socioeconomic indicators.
Method: Sorocaba city and São Paulo State census data, as well as interview data, were used in this study to verify the profile of ranchers in the watershed under study.
Uniqueness/Significance: Even though different agricultural production systems have similarities; each farm has its limitations in available resources. In this sense, technologies must be implemented on these farms for their long-term maintenance. However, smallholder farmers usually hesitate to incorporate new technologies. Thus, public policies that support investment in human, technological, and infrastructural capital should be developed to ensure higher productivity, income generation, and competitiveness among producers.
Results: Cattle ranchers in the study region lack access to infrastructure and agricultural training.
Social contributions: Obtaining and making data available can improve the understanding of parameters that allow decision-making in public policies to improve the social, technological, and economic conditions of ranchers in the area under study.

Keywords: Technology. Training. Infrastructure.

Perfil tecnológico dos pecuaristas da bacia hidrográfica do rio Pirajibu-Mirim

Resumo

Objetivo: Analisar o perfil tecnológico de pecuaristas em uma bacia hidrográfica de Sorocaba-SP através de indicadores tecnológicos e socioeconômicos.
Metodologia: Informações censitárias do município de Sorocaba, do Estado de São Paulo e dados obtidos através de entrevistas foram utilizados nesse estudo, a fim de se verificar os perfis dos pecuaristas da bacia hidrográfica estudada.
Originalidade/Relevância: Mesmo que diferentes sistemas de produção agropecuária apresentem semelhanças, cada propriedade rural possui limitações quanto aos recursos disponíveis para si. A implementação de tecnologias nessas propriedades é um elemento primordial para a manutenção desses sistemas ao longo do tempo. Contudo, é comum que pequenos produtores rurais não incorporem facilmente essas tecnologias. Dessa forma, o desenvolvimento de políticas públicas que auxiliem no investimento em capital humano, tecnológico e infraestrutural, é importante para garantir maiores níveis de produtividade, geração de renda e competividade entre os produtores rurais.
Resultados: Verificou-se uma carência, quanto aos pecuaristas na região em estudo, em relação ao acesso a infraestrutura e capacitação agropecuária.
Contribuições sociais: A obtenção e disponibilização dos dados apresentados, podem ser utilizados para a compreensão de parâmetros que permitem a tomada de decisões em políticas públicas voltadas para a melhoria das condições sociais, tecnológicas e econômicas dos pecuaristas presentes na área em estudo.

Palavras-chave: Tecnologia. Capacitação. Infraestrutura.

Perfil tecnológico de los ganaderos de la cuenca hidrográfica del río Pirajibu-Mirim

Resumen
Objetivo: Analizar el perfil tecnológico de ganaderos en una cuenca hidrográfica de Sorocaba-SP utilizando indicadores tecnológicos y socioeconómicos.
Metodología: Informaciones censitarias, del municipio de Sorocaba, del Estado de São Paulo y datos obtenidos a través de entrevistas, fueron utilizados en ese estudio fueron utilizados para verificar los perfiles de los ganaderos de la cuenca hidrográfica.
Originalidad/Relevancia: Aunque diferentes sistemas de producción agropecuaria presenten similitudes, cada propiedad rural posee limitaciones en cuanto a los recursos disponibles para sí. La implementación de tecnologías en estas propiedades es un elemento primordial para el mantenimiento de estos sistemas a lo largo del tiempo. Sin embargo, es común que los pequeños productores rurales no incorporen fácilmente estas tecnologías. De esta forma, el desarrollo de políticas públicas que ayuden en la inversión en capital humano, tecnológico e infraestructural, es importante para garantizar mayores niveles de productividad, generación de renta y competitividad entre los productores rurales.
Resultados: Se verificó una carencia, en cuanto a los ganaderos en la región en estudio, con relación al acceso a infraestructura y capacitación agropecuaria.
Cotizaciones sociales: La obtención y puesta a disposición de los datos presentados, pueden ser utilizados para la comprensión de parámetros que permiten la toma de decisiones en políticas públicas orientadas a la mejora de condiciones sociales, tecnológicas y económicas de los ganaderos presentes en el área en estudio.

Palabras clave: Tecnología. Capacitación. Infraestructura

Introduction

From the mid-20th century onwards, several countries have experienced intense changes in their agricultural activities, because of the substantial increase in food production to meet the growing demand of the world population (Alves et al., 2017; Pretty et al., 2018). However, even with a significant agribusiness transformation, especially from the 1970s onwards (Vilela et al., 2012), differences between social and economic conditions among farmers have not been reduced. On the contrary, in some regions, heterogeneity has become more intense (Vieira et al., 2016; Dawson et al., 2016; Harwood, 2020).

In the 1990s, society experienced an intense innovation burst due to the rise of numerous technological paths, with strong integration of technical-scientific factors in agriculture, especially through the Green Revolution, allowing advances in some technological models that contributed to increased agricultural productivity. However, throughout that period, social contradictions also intensified and were marked by rural exodus, unbalanced land structure, and income disparity. In this context, the adoption of new technologies by rural producers has been a constant challenge (Dawson et al., 2016; Vieira et al., 2016; Gonzaga et al., 2019; Harwood, 2020).

In the context of technological advances in agriculture and livestock, "technology" can be perceived as what is not natural, which was invented and can be reinvented by people (Carrol, 2017). However, by considering that knowledge and logical methods, on certain occasions, cannot be represented physically, but result in benefits for society and organizations, technology can be better defined as a complex system developed to satisfy needs, solve problems, and generate benefits from its use (Carrol, 2017; Coccia, 2019).

Accordingly, the technological profile of a certain group of people, systems, or institutions will be related to their access to technology and knowledge. In the first sector, this profile can be characterized by sources of labor, type of implements, and used machinery (Philip & Itodo, 2012). However, by understanding that skilled professionals are essential for suitable technical solutions (Barros et al., 2020), one can also infer that technological profile will be characterized by their level of access to information and knowledge.

Despite the cultural similarities between agricultural production systems, each producer has its limitations in terms of available resources (Meira et al., 2016; Cortner et al., 2019). In this sense, smallholder farmers tend not to incorporate new technologies easily because of their low schooling background. Therefore, small farms have been managed intuitively (Gil et al., 2015) and have had frequent problems with technical and educational assistance (Gonzaga et al., 2019).

In this sense, the Brazilian Agricultural Research Corporation (EMBRAPA in portuguese) was created in 1973 by the Brazilian government to lead innovation policies and strengthen agricultural development in the country (Silva et al., 2019). However, the Campinas Agronomic Institute (IAC in portuguese) had been performing studies in inner São Paulo State since 1887 (Fuck & Bonacelli, 2009). Moreover, in 2001, the São Paulo State Agency for Agribusiness Technology (APTA in portuguese) began to coordinate the IAC and other five institutes in São Paulo, which are focused on agricultural research, thus making APTA the second largest Brazilian institution for agricultural technology research (Estado de São Paulo [São Paulo], 2000; São Paulo, 2001; Agência Paulista de Tecnologia dos Agronegócios [APTA], 2021a).

In addition to these research institutes, the "S" system through National Rural Learning Service (SENAR in portuguese), which was created in 1991, also organizes, manages, and executes professional training of rural producers throughout the country in partnership with Rural employers' unions (República Federativa do Brasil FBrasil], 1991; Serviço Nacional de Aprendizagem Rural do Estado de São Paulo [SENAR-SP], 2020).

Technical Assistance and Rural Extension ("Assistência Técnica e Extensão Rural" – ATER) also provides rural producers with access to knowledge and information. Originated from the Association of Credit and Rural Assistance ("Associação de Crédito e Assistência Rural" - ACAR) in 1948, in the State of Minas Gerais, through Nelson Rockefeller's recommendations to the government to improve the socioeconomic conditions of ranchers in the region (Castro & Pereira, 2017).

Technical assistance and rural extension provided by ATER have changed over time, adopting a collaborative and inclusive model that values local knowledge, and promoting a constructivist dialogue between ATER agents and farmers (Amaral, 2020). It has made the agricultural technology transfer a dynamic process since small and medium holder farmers are more sensitive to opportunity costs and risks associated with changes in their farms, showing certain differences between small and large properties (Chandra et al., 2018; Cortner et al., 2019).

Therefore, technologies must be implemented on different farms to maintain production systems (Gonzaga et al., 2019). Investment in human, technological and infrastructure capital, as well as public policies, are foundations of innovative processes that achieve productivity, profitability, and competitiveness (Simões et al., 2020; Sampaio & Fredo, 2021).

New technologies and innovations in agriculture must be dimensioned regarding social, biotic, abiotic, and economic factors (Wigboldus et al., 2016). Thus, due to changes in the fields of agricultural science, understanding the heterogeneous profiles of farmers becomes relevant for planning better practices for agricultural production (Lisboa et al., 2020).

Moreover, the conditions of farmers must be known to understand the resources available on their properties (Cortner et al., 2019), as technological development requires the availability of resources for agricultural innovation (Chandra et al., 2018).

Given this background, to develop public policies able to meet their goals, detailed surveys and diagnoses should be prepared to identify the demands and shortcomings of a given population. Therefore, a good diagnosis must contain indicators of population characteristics, and an understanding of the social conditions in which producers find themselves, such as strengths and weaknesses (Jannuzzi, 2016, 2018). Census surveys can be included as tools to provide statistical data and support the development of public policies.

Considering this scenario, statistics involving social indicators are fundamental to direct a government agenda that focuses on actions to meet the real demands of society and that reduce social disparities. This is because censuses allow collecting data on socioeconomic factors that help in thematic diagnoses for comparisons over time, with details at territorial levels, which in turn, help in understanding social deficits (Jannuzzi, 2017, 2018).

Statistics have improved research and improved investigation parameters, allowing decision-making in socio-economic policies. Thus, statistical data provided through censuses can meet different territorial levels, providing data at regional, federal, and municipal levels or by the census sector (Jannuzzi, 2018).

Such diversity in census data scale contributes to public programs with different degrees of detail and scope. On the other hand, these data can also serve as a source of information to assess the effectiveness of government actions in different spheres due to their thematic scope, coverage, and disaggregation capacity (Jannuzzi, 2018).

The formulation and implementation of public policies depend on different factors, whether institutional or operational. However, statistical data availability enables characterizing social demands, which may not be well clarified or visible to public management (Jannuzzi, 2018). Therefore, given its relevance, the State should not ignore information from censuses, as they can guide political agendas, qualify public debates, and support technical-political decisions (Jannuzzi, 2018).

Agricultural censuses can gather sound quantitative and statistical data on agricultural production units. This way, they can be used to indicate technical-production foundations, as well as socio-productive conditions. These data are, therefore, capable of indicating whether rural occupations have evolved and how (Mitidiero et al., 2017).

Given the financial, commercial, and assistance issues (Danso-Abbeam et al., 2018) and the essential use of family labor, smallholders may often have trouble meeting production demands, and the farm management compromised (Oliveira, 2019). Accordingly, studies to characterize farmer technological profiles and farms become relevant to help producers elaborate methods to transfer suitable technologies so that social, environmental, and economic improvements could be achieved.

Several approaches have included agricultural census and statistical data to understand actual production conditions. Williams et al. (2017) evaluated national census data from Timor-Leste to define agricultural typology and propose a new zoning system for production systems. Michel et al. (2019) explored and evaluated how national agricultural census data are used as a policy approach in the agricultural development of Argentina.

In Brazil, farming census data can be analyzed at the national level or by state surveys, such as the Survey of Agricultural Production Units (LUPA in portuguese) of the state of São Paulo for 10-year intervals in 1995/96, 2007/08, and 2016/17 crop seasons (Sampaio & Fredo, 2021). Soares and Spolador (2019) used data from LUPA 2007/08 to analyze the technical efficiency of corn production in the state of São Paulo. Sampaio and Fredo (2021) analyzed the evolution of peanut production in São Paulo State from a socioeconomic and technological point of view, taking as reference information consolidated in LUPA for the 2007/08 and 2016/17 crop seasons.

In this diversified universe, agricultural census information constitutes a relevant object of study to understand different realities and themes associated with agricultural and livestock production (Sampaio & Fredo, 2021).

Therefore, this study aimed to analyze the technological profile of ranchers in a watershed in the city of Sorocaba-SP (Brazil), using as support technological and socioeconomic indicators of census information from the municipality of Sorocaba and the state of São Paulo, comparing them with the profile of other rural producers.

Such an approach is justified due to the need to understand the profiles of producers in the region under study. Thereby, by identifying disparities and similarities with other rural producers at the municipal and state levels, one can establish references to help governmental planning to improve the socio-productive and technological conditions of ranchers.

We found that the ranchers in the studied watershed have a low-tech profile, given their limited access to infrastructure and technical training. When compared to rural producers in São Paulo State and Sorocaba city, we found that the producers in the watershed have less access to agricultural machinery. Nonetheless, cattle ranchers in the watershed and other rural producers in the city of Sorocaba have the same difficulty in accessing technical training.

Thus, we conclude that the region under study has simpler production systems, which need support from different institutional actors to value production activities and the ranchers. Public management action must be oriented towards the training of these producers, stimulating sustainable development in the watershed.

Methods

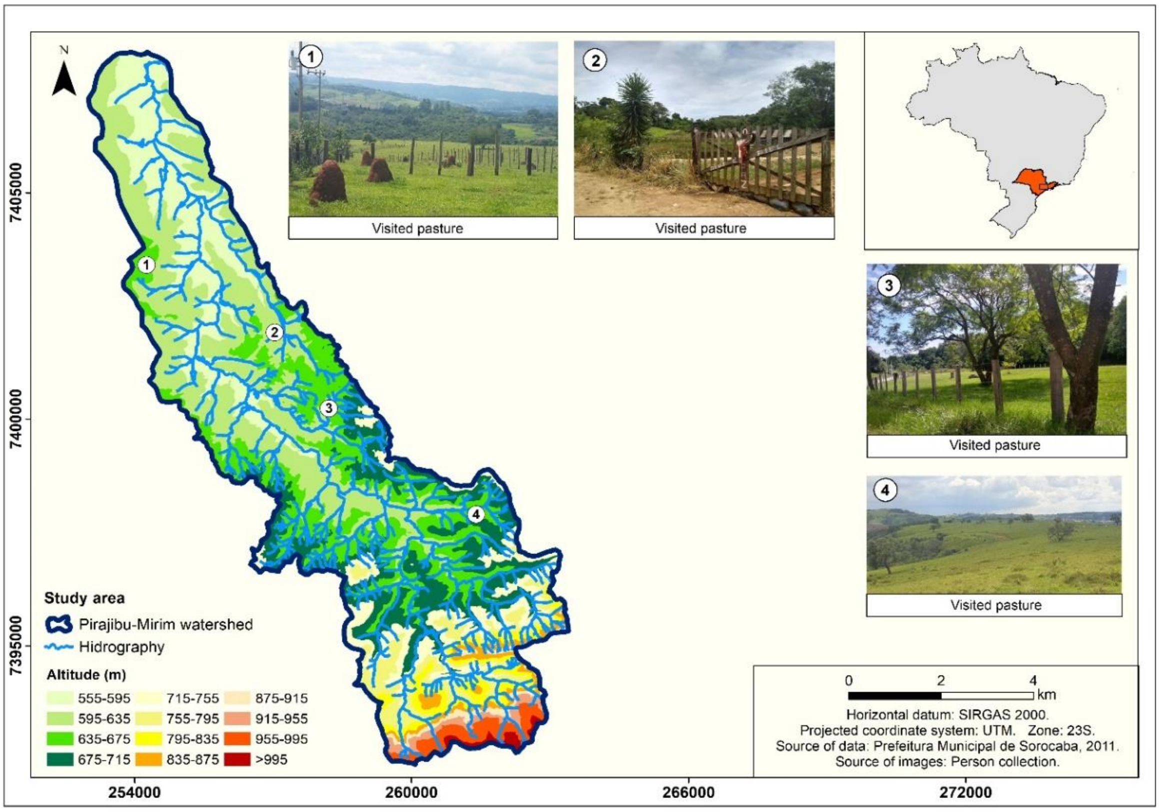
Study area characterization

The study region refers to the Pirajibu-Mirim River watershed (Figure 1), which is fully located at the Water Resources Management Unit (UGRHI in portuguese) of the Sorocaba and Médio Tietê rivers (UGRHI–10–Sorocaba / Médio Tietê, in the city of Sorocaba) (Nery, 2021). Minimum and maximum altitudes range from 555 to 1,028 meters, respectively, and its area has about 55.35 km². The Pirajibu-Mirim River watershed can be considered a priority area for integrative studies, as it contributes to 10% of the surface water catchment of the municipality, through the Ferraz dam that lies within the limits of the watershed (Serviço Autônomo de Água e Esgoto [SAAE], 2016).

The city of Sorocaba has an estimated population of 679,378 inhabitants (Instituto Brasileiro de Geografia e Estatística [IBGE], 2019). Its urban area has grown due to an industrial production decentralization in São Paulo State. Such growth has favored commercial activities and the provision of services, especially in central parts of the city (Prefeitura Municipal de Sorocaba [PMS], 2011). The municipality is in a privileged region, given its proximity to the Metropolitan Region of São Paulo, which can be accessed through Castelo Branco (SP-280), Raposo Tavares (SP-270), and José Ermírio de Moraes (SP-79) highways (PMS, 2011). The city is the most economically relevant within the Metropolitan Region of Sorocaba (RMS) (Silva et al., 2021).

Figure 1

Location of the study area



Source: Authors.

The Pirajibu-Mirim River watershed lies within an ecotone region between Dense Ombrophilous Forest (Atlantic Forest) and Cerrado. The latter is characterized by savanna-like vegetations (Simonetti et al., 2022). Moreover, land cover and use are characterized by pastures and planted forests to the south of the watershed (Nery, 2021; Simonetti et al., 2022). The local climate is classified as a hot subtropical climate (Cwa), with dry winters and rainy summers. Annual averages of rainfall and temperature are 1,311 mm (Corrêa et al., 2016) and 20ºC (Lourenço et al., 2014), respectively.

The local relief is predominantly undulating, with slopes between 5 and 45%. The steepest slopes are located to the south of the watershed (Nery et al., 2019; Nery, 2021). The soils in the region are classified as Red-Yellow Argisol (PVA) and Haplic Cambisol (CX) (Nery et al., 2019; Nery, 2021).

Survey of livestock production units in the study area

Livestock production units in the Pirajibu-Mirim river watershed were identified by synthesizing the land use and land cover map of the region, manual rectification of the “Map of vegetation, land use and occupation of Sorocaba city" (PMS, 2011), and identification of pastures using the Google Earth Pro 2020 imagery (Nery, 2021).

On-site visits were also made on Jan/16/21, Jan/31/21, Feb/18/21, and Feb/19/21 to confirm land covers and uses, and the pasture areas previously mapped. On these same dates, to identify the technological profile of ranchers and livestock production units, those responsible for pastures were evaluated using a form (Table 1). The form had questions aimed at identifying the educational profile of ranchers, as well as their access to infrastructure, and training, in addition to identifying livestock production systems developed, according to the agricultural census of IBGE (2017) (Nery, 2021).

Not all pastures identified had their responsible interviewed; therefore, they were disregarded in the study as livestock production units due to a lack of data. These data could not be gathered due to difficulty in accessing and locating the ranchers, and because some ranchers did not accept to participate in the research.

Table 1

Research form used to identify the technological profile of ranchers in the Pirajibu-Mirim River watershed

SEARCH FORM:		
LOCATION		
Coordinates UTM (N): UTM (E): DATUM:		
IDENTIFICATION	**ANSWERS**	**POINTS**
Level of education of the rural producer:		
Never attended school		N.A.
Incomplete elementary school		N.A.
Complete elementary school		N.A.
Complete high school		N.A.
Full technical education		N.A.
Incomplete higher education		N.A.
Full higher education		N.A.
Legal condition of the rural producer:		
Individual producer		N.A.
Union of persons or consortium		N.A.
Cooperative		N.A.
Legal person		N.A.
Institution of public utility		N.A.
Government		N.A.
Another condition		N.A.
What is the purpose of the production of the property?		
Own consumption		N.A.
Commercialization		N.A.

INFRASTRUCTURE	ANSWERS	POINTS
Does the establishment use electricity?		
Yes		1
No		0
Type of livestock production:		N.A.
Are there other types of activities that are developed in the property?		
No		0
Horticulture		1
Permanent crop		1
Temporary crop		1
Flower production		1
Forestry		1
Are these activities carried out in an integrated way?		
Yes		1
No		0
Is there irrigation in the property?		
Yes		1
No		0
Are there any grain storage units?		
Yes		1
No		0
Are there tractors, implements, machinery and vehicles in the property?		
Yes		1
No		0
Are products processed or processed in the property?		
Yes		1
No		0
What kind of facility did you use for processing?		
Proper		1
Public community		1
Private community		1
Third-party		0
TRAINING	**ANSWERS**	**POINTS**
Is the rural producer associated with a cooperative or class entity?		
Yes		1
No		0
If yes, what type of entity is the rural producer associated with?		
Cooperative		1
Syndicate		1
Associations		1
Does the rural producer receive guidance and assistance?		
Yes		1
No		0
If yes, what are the sources of technical assistance received?		
Government		1
Cooperatives		1

Syndicate		1
NGO		1
System S		1
Private company		1
Other:		1
How does the rural producer obtain technical information?		
Consultancies		1
Seminars and technical meetings		1
Courses and training		1
Media		1
Does not obtain technical information		0

Subtitle: N.A.: Not Applicable.
Source: Elaboration based on IBGE, 2017.

The form questions were scored from 0 to 1 to rank the levels of access to agricultural training or infrastructure (Nery, 2021). The more affirmative the answer, the higher the score. For infrastructure access, scores from 0 to 5 indicate low levels, and between 6 and 12 high levels. As for access to training, scores from 0 to 7 indicate low level, and scores from 8 to 16 high level.

Survey of agricultural production units (LUPA) 2016/17

Data obtained during the LUPA in the 2016/17 crop season were used to verify disparities and similarities between the profiles of ranchers interviewed in the region under study and other rural producers in Sorocaba city and São Paulo State (São Paulo, 2019).

According to Sampaio and Fredo (2021), Agricultural Production Units (UPAs) refer to farms that can be represented by contiguous properties if they belong to the same owner or group of owners, are in the same municipality, and have a total area greater than 0.1 hectares.

After obtaining, data were exported and processed in Excel software. According to data available in the LUPA 2016/17, we could characterize livestock production in Sorocaba city and São Paulo State regarding access to agricultural machinery, and the presence of irrigation systems and grain storage units or silos.

Social aspects in which ranchers are inserted were also verified, as well as access to training and information. For that purpose, formal education levels of ranchers were verified. However, the LUPA 2016/17 data do not include formal education levels for rural producers of São Paulo State, making such data available only at the municipal level. Therefore, only schooling data from rural producers in Sorocaba were compared with interviewed ranchers.

We also verified participation with cooperatives, unions, and access to technical assistance, both for rural producers in Sorocaba city and São Paulo State.

In this study, data on access to agricultural machinery, irrigation, and grain storage units or silos were considered as access to agricultural infrastructure and technology (Garret et al., 2017; Souza et al., 2021). Data on educational levels and participation with entities were considered as technological profiles of ranchers, as well as levels of access to training, information, and technological innovation (Gil et al., 2015; Bendahan et al., 2018; Sampaio & Fredo, 2021).

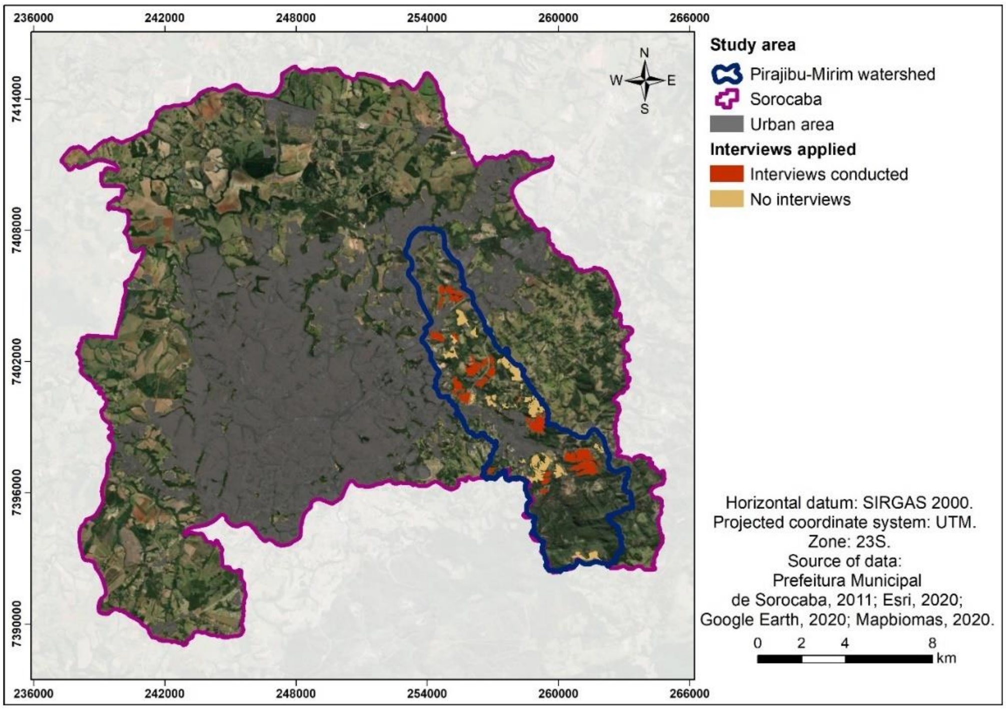
Results and discussion

An area of 6.72 km² of pastures was identified by the cover and land use mapping, this area represents 12.14% of the total area of the Pirajibu-Mirim river watershed. In São Paulo State, 31.37% of the agricultural production areas refer to pastures, representing 227,088 UPAs and an area of about 63,793.31 km². In Sorocaba, 390 UPAs are represented by pastures, with a total area of 69.98 km², representing 76.77% of the total identified production units (São Paulo, 2019).

3,63 km² of pasture areas were mapped in the Pirajibu-Mirim River watershed, about 54% of the mapped pastures were identified as livestock production units, and 17 ranchers were interviewed (Figure 2).

Figure 2

Identified pasture areas where respondents were interviewed

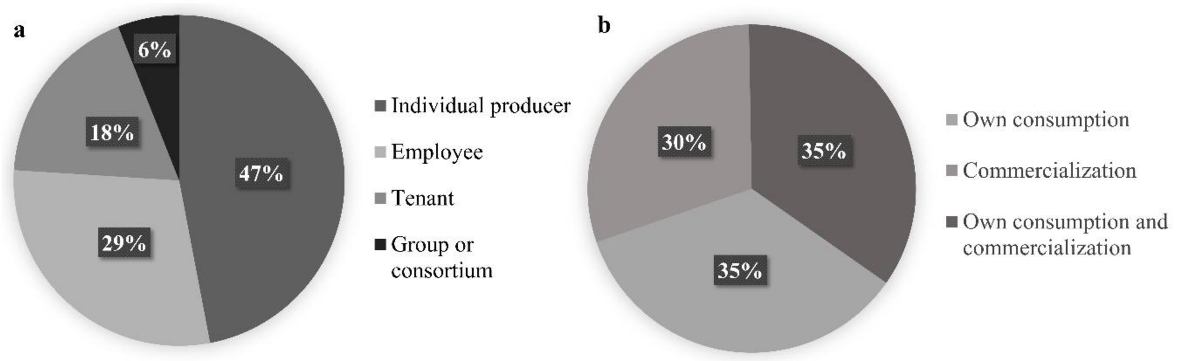


Source: Authors.

Our survey showed that most of the ranchers interviewed are individual producers, 29% are employees or caretakers who managed and/or took care of the farms and production, 18% lease the land for livestock production, and a minority represents a group of people who are responsible for the same area. Thirty-five% of the ranchers stated that they use livestock production both for marketing and for their consumption. Producers who use production only for commercialization or only for their consumption were also verified (Figure 3).

Figure 3

Characterization of livestock production units in the study area: a) interviewed ranchers; b) the intended use of livestock production



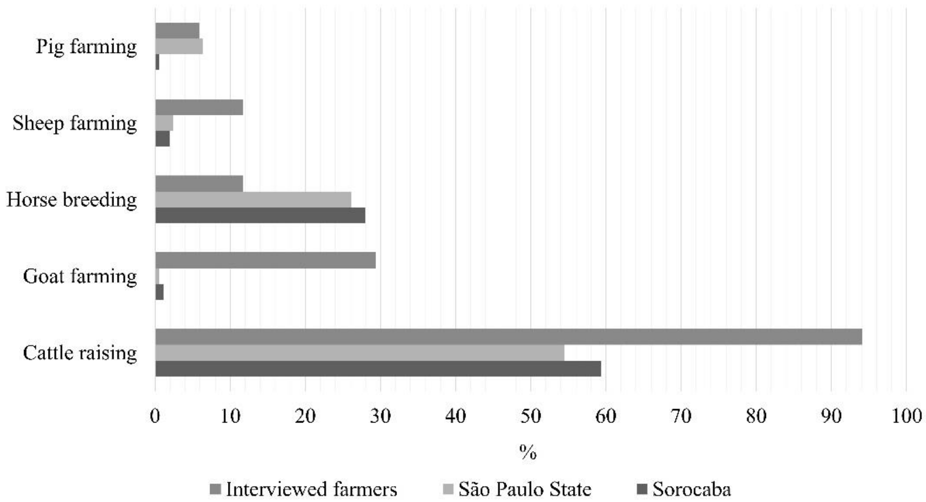
Source: Authors.

Forty-one% of the ranchers interviewed grew some plant, which represents most of the livestock production in the watershed under study. Cattle farming is the most common type of production among the ranchers interviewed (94.11%), unlike what was observed for Sorocaba city and São Paulo State.

As seen in Figure 4, the second most frequent type of animal production among ranchers in the Pirajibu-Mirim River watershed was goat farming (29.41%), followed by horse farming (11.76%), sheep farming (11.76 %), and pig farming (5.88%). Census data revealed equine production as the second most relevant in Sorocaba and São Paulo State (São Paulo, 2019).

Figure 4

Comparison among the interviewed ranchers, rural producers in São Paulo State, and Sorocaba city regarding livestock production types



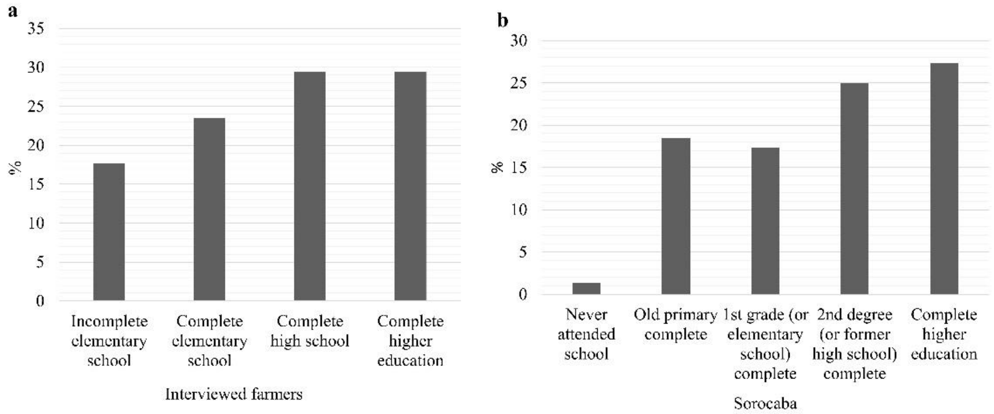
Source: Authors.

According to Lima et al. (2009), it is common for small animals to be raised in family farming, even if in small numbers, as a way of subsistence. Since rural producers act according to the social and economic conditions in which they are inserted (Cortner et al., 2019), ranchers in the river watershed studied may have some difficulty in diversifying practice and production techniques, due to the predominance of individual producers in the region, 70% of the interviewees use their products for consumption or consumption and commercialization, while only 30% of the interviewees use what is produced only for commercialization.

Regarding schooling, the ranchers interviewed showed similarities with LUPA 2016/17 data for Sorocaba city (Figure 5). About 23.53% of the ranchers interviewed finished elementary school, 29.41% high school, and 29.41% higher education. In the LUPA 2016/17, 17.32% of the rural producers in Sorocaba claimed to have finished elementary school, 27.36% higher education, and 25% high school.

Figure 5

Comparison between a) interviewed ranchers and; b) rural producers in Sorocaba in terms of schooling



Source: Authors.

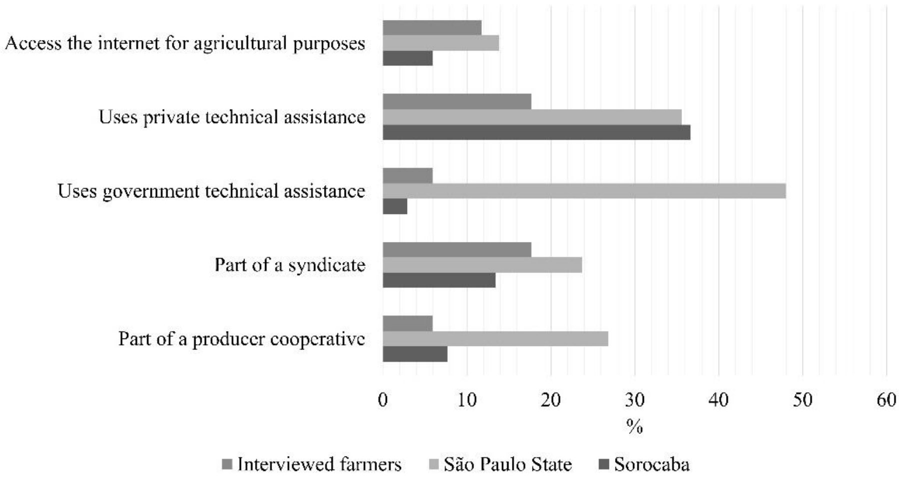
Among the ranchers interviewed, 17.65% revealed that they had not completed elementary school. When compared to the LUPA 2016/17 data for Sorocaba, we observed that only 1.38% of the interviewed producers in the UPAs claimed to have no education or incomplete education. However, regarding the number of producers who attended only the first years of elementary school, which is equivalent to the former primary education, 18.50% of the rural producers from Sorocaba interviewed during the LUPA 2016/17 were under this condition.

Low-skilled and low-education producers are more prone to leave rural areas, leading to the marginalization of the region, with significant urban expansion and devaluation of rural work. Due to its consequences for society, rural exodus must be present in public management guidelines, considering incentives aimed at technical assistance and commercialization to encourage people to stay in the countryside (Silva et al., 2019).

Despite the differences in educational levels, we observed difficulties for ranchers in the studied watershed to have access to technical training. Among those interviewed, 53% do not receive any type of agricultural technical assistance or have access to technical information. However, there are similarities between ranchers in the study area and rural producers in the city of Sorocaba. This similar behavior reflects a lack of access to information and training by producers, especially from government programs (Figure 6).

Figure 6

Comparison between interviewed ranchers and rural producers in Sorocaba city in terms of access to technical assistance, training, and qualification



Source: Authors.

During the survey, we found that 65% of the ranchers interviewed are not associated with any class entity, 18% are associated with a rural union, 6% are members of cooperatives, and 12% are associated with both unions and cooperatives. Active participation in all agricultural production links is essential to meet the needs and demands of rural producers (Bassi & Silva, 2019). Those entities can share knowledge and information, promoting learning (Queiroz et al., 2020) and solving the day-to-day problems of rural producers.

When comparing the survey and LUPA 2016/17 data, both interviewed ranchers and rural producers in Sorocaba city use private technical assistance as the major source of technical assistance. The situation is different when comparing the respondents with the rural producers in São Paulo State. Moreover, the interviewed ranchers and rural producers in Sorocaba are more commonly associated with unions than with cooperatives. Among the ranchers interviewed, 18% depend on private initiatives to have access to assistance, 12% receive assistance from rural unions, and 12% receive assistance from cooperatives or government institutions. As for access to information, 36% of respondents participate in courses, seminars, training, technical meetings, or consultancies, while 12% use social media and the Internet to obtain such information.

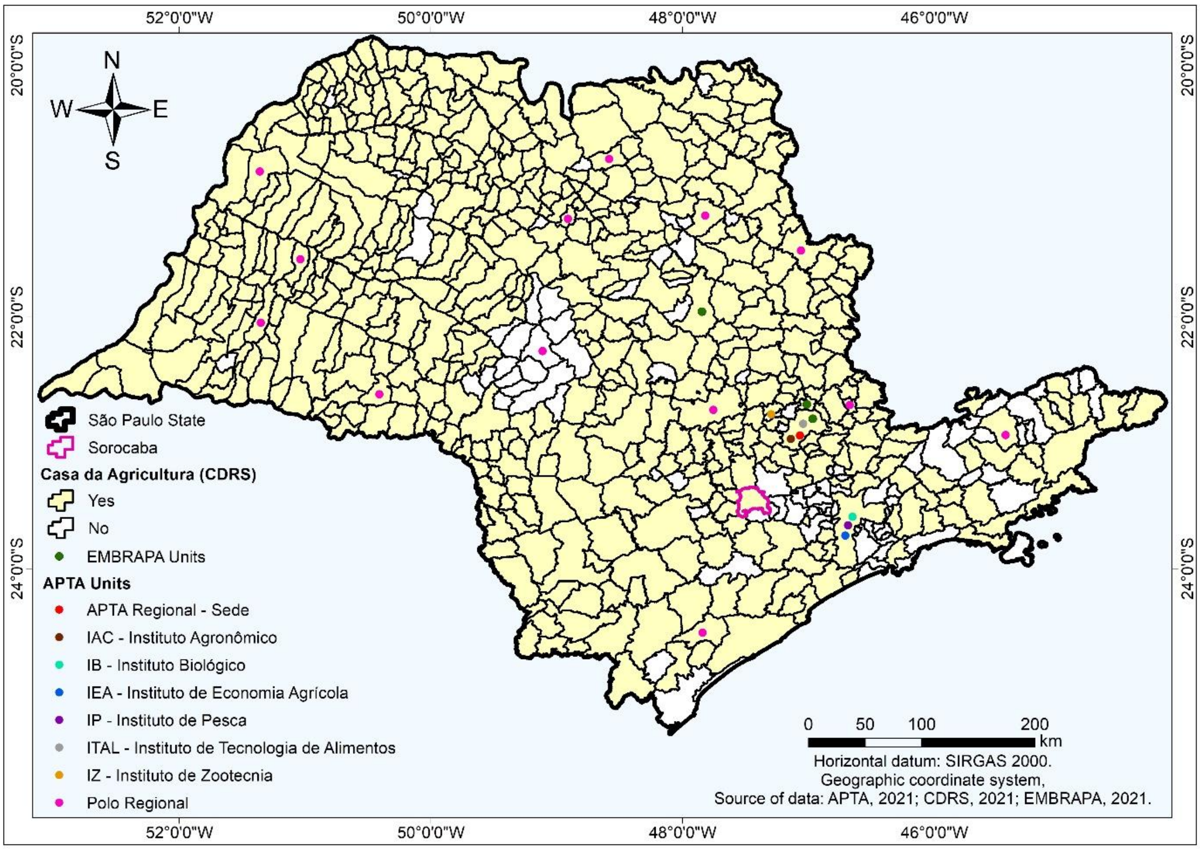
Training and technical assistance are crucial to ensure production chain sustainability (Oliveira, 2019). In this way, suitable methods for technology, knowledge, and information transfer may improve the sector (Bassi & Silva, 2019; Maciel et al., 2019); therefore, different institutions can assist in this process.

EMBRAPA, for example, has subsidiaries throughout Brazil in a strategic way (Crespi et al., 2019). Five of them are in São Paulo State (Figure 7), namely *Embrapa Informática Agropecuária*, *Embrapa Instrumentação*, *Embrapa Meio Ambiente*, *Embrapa Pecuária Sudeste*, and *Embrapa Territorial* (Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2021). In addition to APTA-linked institutions, São Paulo State has 11 regional centers (Figure 7) focused on meeting regional technological demands of agricultural production systems, generating, and transferring knowledge for a sustainable development (São Paulo, 2018; APTA, 2021b; Nery, 2021).

Furthermore, *Casas da Agricultura* (Houses of Agriculture) distributed throughout the state and linked to the Coordination of Sustainable Rural Development promotes actions to increase access of rural producers to public policies (Coordenadoria de Desenvolvimento Rural Sustentável [CDRS], 2021). Therefore, the aforementioned institutions promote technical and formal training of researchers, technicians, and rural producers, in addition to spreading information through publications, farm field day events, demonstration units, technical visits, consultations, courses, speeches, and other events (Nery, 2021).

Figure 7

Location of EMBRAPA, APTA, and Casas da Agricultura units in the state of São Paulo



Source: Authors.

However, even with the offer of different activities, mechanisms, and institutional actors involved in technical-scientific development, research, and dissemination, according to the LUPA 2016/17 data and the interviews, we found a gap between the communication of these institutional actors with rural producers in the studied region, and need to increase the exchange of knowledge, assistance, and qualification of rural labor.

In addition to the institutional actors already mentioned, other entities present in Sorocaba city are also relevant to the local and regional agriculture (Nery et al., 2021), such as the Sorocaba employers' union, which works jointly with SENAR, local cooperatives, the Sorocaba Technological Park, and universities (Nery, 2021). However, these institutions need to understand the need to transfer a certain technology "with" the producer and not only "to" the producer, overcoming barriers that prevent access to qualification and directly impacting how this technology will be accepted and interpreted by rural producers (Silva et al., 2019).

As for access to agricultural infrastructure, Table 2 shows that only 5.88% of the ranchers interviewed have an irrigation system because they grow vegetables together with livestock activity. Moreover, 5.88% have a place for grain storage or a silo, and 35.29% have agricultural equipment or tractors.

Table 2

Access of interviewed ranchers to agricultural infrastructure

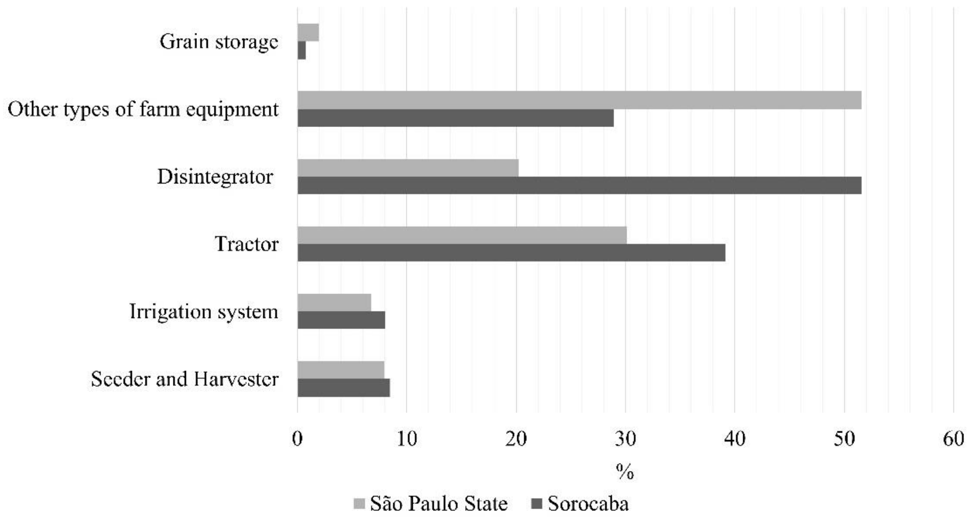
	%
Have agricultural equipment or tractor	35,29
Have some type of irrigation system	5,88
Grain storage units	5,88

Source: Authors.

Comparing the LUPA 2016/17 data between producers of Sorocaba and São Paulo State (Figure 8), we found that only, respectively, 8% and 6.72% have irrigation systems, like what was observed for the interviewed ranchers. Additionally, both interviewed ranchers and rural producers in Sorocaba city and São Paulo State have some difficulty in storing grains. As for tractors and other agricultural equipment, the ranchers interviewed have difficulty accessing agricultural machinery.

Figure 8

Comparison between rural producers in Sorocaba and São Paulo State in terms of access to agricultural infrastructure



Source: Authors.

Socioeconomic factors, such as the availability of infrastructure and training for producers, are understood to be associated with producers' ability to collect and optimize financial, technological, and environmental resources (Gil et al., 2015; Cortner et al., 2019; Garret et al., 2020; Reis et al., 2021; Vinholis et al., 2021). In this case, creating a network of relationships to help ranchers in the region can be very useful to reduce difficulties related to lack of access to infrastructure and training.

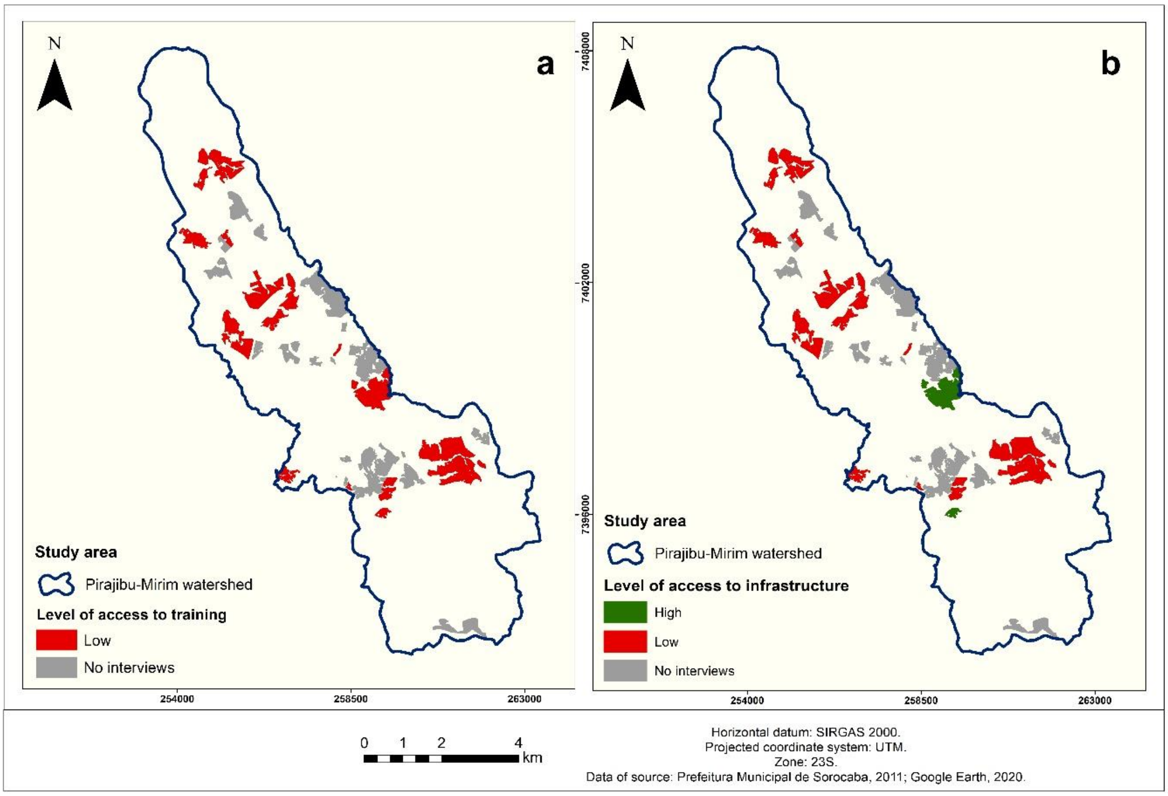
Infrastructure limitations also include access to different production chain links (traders, suppliers, agribusiness), inserted in a well-structured production chain (Garrett et al., 2019). Therefore, actions toward economic incentives can favor the spread of some technologies (Vinholis et al., 2021).

Cooperatives can also minimize limitations on access to infrastructure, such as silos and grain storage capacity (Garrett et al., 2019). An inter-institutional relationship involving teaching and research entities with cooperatives, unions, and producer associations can more effectively meet production chain demands (Hirakuri et al., 2017).

No livestock production unit was classified as having high access to training (Figure 9a). Among the interviewed ranchers, 12% reached the maximum score of 6 points, 18% 5 points, 12% 2 points, and 58% from 0 to 1 point. As for access to infrastructure (Figure 9b), only 12% were classified as high level, 65% between 1 and 2 points, and 24% between 3 and 4 points. The method and graphic representation used for pasture mapping highlight the difficulty of ranchers to reach agricultural and livestock infrastructure, in addition to training.

Figure 9

Classification of the identified pasture areas where respondents were interviewed regarding: a) the level access to training and; b) infrastructure



Source: Authors.

Furthermore, a common complaint among interviewed ranchers was difficulty in getting help and keeping in touch with institutional actors who could help them with qualifications. These producers feel abandoned by the government and have the perception that Sorocaba urban sprawling has encouraged constant devaluation of rural work (Nery, 2021). In this sense, qualified professionals are essential to promote ideal technical solutions in agriculture, whether for more sustainable production, strategic land-use planning, environmental compliance, or adjustments and economic improvements (Antônio, 2019).

Sorocaba has a Municipal Council for Sustainable Rural Development, which was created by Law nº 11.814, on October 15, 2018. This council has the following competencies: elaboration of proposals and actions to encourage agricultural development and improve rural activity in the city; foster integration of different segments of the agricultural sector; and monitor and propose municipal public policies related to sustainable rural development (PMS, 2018). In this context, the Municipal Master Plan has reduced rural areas and environmental conservation zones in the city (Corrêa *et al.*, 2017). These changes have an impact on landscape dynamics due to territorial planning, but also on the production of environmental services (Corrêa et al., 2017), as urban occupation expansion towards strategic areas for production and water conservation, such as the Pirajibu-Mirim river watershed, can compromise water quality and soil sealing, in addition to impacting the daily lives of smallholders socioeconomically, weakening agrarian activities in the region (Nery, 2021).

Smallholder farmers, who develop activities under a family economy regime, have more difficulty in reaching a minimum scale of production, mainly due to factors such as limited investment capacity, lack of technical assistance, and difficulty in accessing new technologies that can help increase productivity (Oliveira, 2019).

Producers with little technical knowledge and difficulty in acquiring resources for investment perceive that technical assistance services, as well as rural extension, are important to offer, less expensively and practically, solutions to daily difficulties (Fernandes, 2019). Thereby, the support provided by technical assistance and rural extension allows rural producers to have productivity, profitability, and product quality gains, in addition to improving the efficiency in the use of natural resources in the production process (Fernandes, 2019).

Therefore, the low access to training and infrastructure observed in this study indicates that the livestock production units in the Pirajibu-Mirim River watershed must establish an assertive dialogue with institutional actors to resolve qualification difficulties, such as access to technology, information, and training, which are essential for their subsistence and sustainability over time.

Thus, the technical training level of rural producers is related to job creation and income generation and affects long-term relationships of technical-scientific development, technology supply, technology transfer, and technical assistance with rural producers and their productive activities (Firetti et al., 2012). Innovation management in the agricultural sphere is directly linked to an institutional structure capable of generating knowledge, information, and opportunities, in addition to ensuring that the target audience can accumulate such knowledge and information in the long term (Vieira, 2010).

Farmer networks are useful for marketing, supply acquisition, assistance with occasional services, animal health services, and technology incorporation, as well as better rural training programs (Bendahan et al., 2018; Cortner et al., 2019). Moreover, several institutional actors have played important roles in technology dissemination (Vinholis et al., 2021). Therefore, increased participation of rural producers in professional associations increases exposure to the latest innovations. Allied to that, these environments promote frequent technical meetings, training, and other opportunities to provide technical support to producers (Gil et al., 2015).

New technologies and innovations contribute socially (Millar et al., 2018; Si & Chen, 2020) to the economic growth of a country (Calcagnini & Favaretto, 2016; Agustinho & Garcia, 2018; Salam et al., 2019; Ozkaya et al., 2021). Allied to this, valuing more sustainable production activities has contributed to the development and adoption of technologies aimed at production means and systems (Dereti, 2009; Cortner et al., 2019). Therefore, agricultural systems deficient in access to infrastructure and training are poor in terms of their economic, social, and environmental sustainability. In this context, public policies that support the technological development of rural properties, especially sustainable innovations, will certainly contribute to the social development of rural areas.

Furthermore, innovation in agriculture depends on an institutional framework that can generate public knowledge and technological opportunities, as well as ensure knowledge accumulation by productive agents (Vieira, 2010). Since this innovation strengthens competitiveness in several production chain links and has multiplier effects on non-agricultural sectors (Vieira et al., 2016), institutions should thus increase exchanges of knowledge between producers, in addition to working together with them to develop and disseminate the technologies (Garrett et al., 2020).

Conclusions

In this study, we sought to understand technological profile differences and similarities between the ranchers in the Pirajibu-Mirim River watershed and rural producers in Sorocaba city and São Paulo State by comparing data from Agricultural Production Units of São Paulo State (LUPA) in the 2016/17 crop season with the responses to the questionnaire applied to ranchers in the study area.

Access to agricultural infrastructure, e.g., irrigation and grain storage, is similar between the ranchers interviewed and rural producers in Sorocaba and São Paulo State. Otherwise, the ranchers interviewed have less access to tractors and other agricultural machinery than the others. Still, interviewed ranchers and rural producers in Sorocaba city have a similarity in terms of education level, association with institutions, and access to technical assistance.

Although similarities between ranchers in the region under study and other rural producers in Sorocaba and São Paulo State are predominant, the technological profile in the hydrographic basin is less developed. Based on the responses from interviewed ranchers, there is limited access to infrastructure and technical training in the studied watershed. Therefore, we understand that ranchers in the region are inserted in a simpler context and should strengthen relationships with different institutional actors (unions, cooperatives, universities, and associations, among others), aiming at sustainable development.

Public management actions should aim to train producers and generate local technical references to propagate the acquired knowledge. Also, increasing access to infrastructure, training, and adequate technical assistance may increase productivity and profitability, in addition to reducing risks associated with externalities on rural properties.

Therefore, this study can work as a guide for public managers, teaching and research institutes, and other interested parties involved in the agricultural production chain, in order to (1) develop more effective public policies for smallholder producers, which foster partnerships between different institutions and stakeholders, promoting sustainable development in the region; (2) create a local technical and institutional support network that works expressively together with cattle ranchers for dissemination of knowledge and information; (3) understand the demands of ranchers to develop technologies that meet their expectations and respect their conditions.

Our research did not seek to evaluate physical and environmental parameters in the farms, nor analyze the market, local and regional commerce, or human and financial capital. Accordingly, further studies should seek to understand such a broader context, in a comprehensive approach, to guide technology transfer methods according to the local conditions, making the process synergistic and spotted on the reality of the ranchers.

By considering the social, environmental, and physical factors in the studied pastures, an integrative view of the productive systems will be allowed, considering their strengths and weaknesses to solve problems and demands, besides promoting social, economic, and environmental sustainability.

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