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Pathways to Rural Sustainability: Opportunities and Challenges in the Creation of an Agrotechnological District in Ingaí City, Brazil

Caroline Mendonça Nogueira Paiva [1,2,*], Derick David Quintino [1,3], Thacyo Bruno Custódio de Morais [1], Elisa Guimarães Cozadi [1], Jaqueline Severino da Costa [4], Paulo Henrique Montagnana Vicente Leme [1] and José Roberto Soares Scolforo [5]

[1] Faculty of Applied Social Sciences, Federal University of Lavras, Lavras 37203-202, MG, Brazil; derickdq@alumni.usp.br (D.D.Q.); thacyomorais@gmail.com (T.B.C.d.M.); elisa.rguimaraes@ufla.br (E.G.C.); paulo.leme@ufla.br (P.H.M.V.L.)
[2] Gammon Presbyterian Faculty, Gammon Presbyterian Institute, Lavras 37200-154, MG, Brazil
[3] VALORIZA—Research Center for Endogenous Resource Valorization, 7300-555 Portalegre, Portugal
[4] Department of Agribusiness Management, Federal University of Lavras, Lavras 37203-202, MG, Brazil; jaqueline.s.costa@ufla.br
[5] Department of Forest Science, Federal University of Lavras, Lavras 37200-000, MG, Brazil; josescolforo@ufla.br
* Correspondence: carolmn_be@yahoo.com.br

Abstract: An agrotechnological district (ATD) integrates sustainable agricultural practices and technologies, aiming to transform rural communities by stimulating socioeconomic development and addressing the UN Sustainable Development Goals. Ingaí, a dairy-producing municipality in Minas Gerais, Brazil, stands to benefit from the implementation of an ATD. This study aimed to identify the opportunities and challenges for the implementation of an ATD in the municipality, considering its socioeconomic characteristics, the level of producers' technological adoption, connectivity infrastructure, support networks, and rural and market management. The method was based on an exploratory case study, using semi-structured group interviews for data collection, conducted in March 2024, with agricultural stakeholders. As a result, key challenges emerged: limited connectivity infrastructure; ineffective property management; rural family succession problems; barriers in accessing credit; resistance to the adoption of technologies; and dependence on the local government. Opportunities included the strengthening of support networks among the agents of rural productive activity; the promotion of technology adoption by producers; and creating training and rural extension programs. The adoption of these initiatives can stimulate Ingaí's economic and social development, generate multiplier effects in its region of influence, and serve as a model for other initiatives in the state of Minas Gerais, the main dairy hub in the country, and one of the primary drivers of Brazilian agribusiness.

Keywords: sustainable communities; rural development; digital agriculture; technification; local infrastructure; support networks

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1. Introduction

The development of sustainable communities transforms rural areas, improving socioeconomic conditions and ensuring environmental preservation and the efficient use of natural resources. In addition, the implementation of digital technologies can be seen as a milestone in this development [1], since digitalization acts as a catalyst for agricultural development, offering a new path to more sustainable practices [2].

Despite small- and medium-scale producers being a key to ensuring food security and income generation in rural areas, they face challenges such as climate change, limited access to credit, poor infrastructure, and policy constraints. While there are numerous digital

solutions to serve the agricultural sector and minimize these challenges, these solutions are out of reach of many smallholder farmers, due to the excessive cost and gaps in digital literacy and digital skills, as well as the lack of digital infrastructure such as connectivity and mobile network infrastructure [3].

In this context, the 'Semear Digital' project has emerged, where Semear means "Sowing", developed by the Science Centre for Development in Digital Agriculture (SCDDA), a consortium between the following institutions: the Brazilian Agricultural Research Corporation—EMBRAPA, Telecommunications Research and Development Centre—CPQD, Institute of Agricultural Economics—IEA, "Luiz de Queiroz" College of Agriculture, University of São Paulo—Esalq/USP, Agronomic Institute of Campinas—IAC, National Institute of Telecommunications—INATEL, and Federal University of Lavras—UFLA. The project is funded by the São Paulo Research Foundation—FAPESP. The objective of this consortium is to overcome inequalities in the countryside by encouraging the adoption of digital technologies among small and medium-sized rural producers, through the implementation of agrotechnological districts (ATDs), in Brazil. The eligibility of the municipalities to be transformed into ATDs was based on a methodology developed by the Institute of Agricultural Economics of the state of São Paulo, which relied on the following indicators: level of technical assistance, economy, education, land structure, infrastructure, social organizations, population, and social development. Based on these indicators, ten municipalities with the potential to become an ATDs were selected, and Ingaí was chosen as the representative of the dairy basin in the state of Minas Gerais (MG). Another nine municipalities, distributed in the main regions of Brazil, make up the scope of the project, namely, Caconde, SP; São Miguel Arcanjo, SP; Alto Alegre, SP; Jacupiranga, SP; Lagoinha, SP (five from São Paulo State, Southeast Region); Vacaria, RS (Rio Grande do Sul State, South Region); Guia Lopes da Laguna, MS (Mato Grosso do Sul State, Central West Region); Breves, PA (Pará State, North Region); and Boa Vista do Tupim, BA (Bahia State, Northeast Region) [4].

Agribusiness is one of the most dynamic and important sectors of the Brazilian economy [5], and Brazil is one of the main milk producers in the world. Dairy farming has great relevance for the local economy [6], especially in Minas Gerais, an important center of Brazilian agribusiness. In 2022, the state was the largest milk producer in the country, producing 9.4 billion liters, which corresponded to 27.1% of the national production (and 80.6% considering the Southeast region), an amount considerably higher than that of the state in second place, the state of Paraná, which corresponded to 12.9% of the Brazilian production in the same period [7]. In Ingaí, the focus of this study, 60% of the total agricultural establishments are milk producers [8], demonstrating the relevance of this activity for the municipality.

Despite Brazil being a major world producer of milk, with Minas Gerais leading the supply and municipalities such as Ingaí relying heavily on dairy farming, Brazilian productivity is still not satisfactory. This limitation could be minimized through the adoption of technologies that promote efficiency in production management, including the implementation of digital solutions for milk quality monitoring, the automation of milking processes, and product traceability. These technologies would help small and medium-sized producers improve productivity, reduce losses, and access markets that value sustainable practices and certified products.

Considering the context of milk production and the adoption of digital technologies in dairy farming, this article aims to identify opportunities and difficulties for the transformation of Ingaí, MG, into an ATD.

The innovative character of this study lies in the analysis of the transformation of Ingaí, MG, into an agrotechnological district (ATD), promoting the sustainable development of the dairy basin of Minas Gerais through the promotion of the adoption of technologies, especially digital ones. This is achieved through the identification of specific challenges faced by local farmers and the assessment of existing market solutions that can address these issues effectively. Thus, this study stands out for addressing the digitalization of production as a catalyst for greater efficiency, better animal welfare, and more efficient and

accurate management. In addition, by focusing on a representative municipality of the milk production chain in Brazil, in the context of small- and medium-scale farmers, the study offers a regional perspective on how these technologies can reduce socioeconomic disparities, foster innovation in rural areas, and contribute to food security and sustainability.

The present article is structured in six sections: after this introduction, Section 2 shows a description of sustainable rural development and agrotechnological districts (ATDs). Next, Section 3 shows the methodological approach and data collection, and, in sequence, the results are presented in Section 4. After this, Section 5 presents a discussion of results, and, finally, Section 6 presents the final considerations.

2. Theoretical Framework: Sustainable Rural Development and ATDs

Stimulating sustainable communities is fundamental for the development of a country, since sustainability encompasses the resolution of social, political, cultural, economic, and environmental problems [9]. In this sense, the United Nations (UN) presents, in its 2030 agenda, the Sustainable Development Goals (SDGs) 2—Zero Hunger and Sustainable Agriculture and 11—Sustainable Cities and Communities, which aim to make communities safer and resilient, and ensure sustainable food production systems that meet present and future demands [10].

The term sustainable community refers to groups of people who live for long periods in an environment that is interconnected with other environments and have access to both endogenous and exogenous resources, such as "time, finance, devices, people, institutional knowledge, networks and the built and physical environment" [11] (p. 4). In this way, the sustainable development of a community permeates to "protect and improve the environment, answer the social needs and promote the economic success" [12] (p. 1), contributing to the life quality of those who participate in it.

Development theories have emphasized territorial systems, relating geographic concentration and local conditions to the promotion, attraction, and growth of activities that are developed within these contexts. The concentration of activities generates economies of scale, reduces transportation costs, and facilitates access to new knowledge [13].

Rural communities are complex systems shaped by unique natural, cultural, and geographical factors, and can be conceived as functional units integrated by a system of relationships with a strong dependence on the context. The attitude toward innovation is a condition that quietly facilitates, blocks, or aborts community development initiatives. In rural communities, territory refers to the inhabited geographic space that has been appropriated in socio-historical processes to satisfy inhabitants' material and social needs. These spaces include biophysical characteristics (which condition rural life and agricultural activities), spatial relations (which establish restrictions and opportunities in the territory to develop productive and social practices, including knowledge information networks and access to markets), and human security (food, economic, and water security, and protection from violence, among others), which are factors to be considered to advance the community's development trajectories [14].

The adoption of technology can be a driver for development, as it facilitates the overcoming of challenges associated with territorial limitations and the variability in natural and social conditions in rural communities. The term agricultural technology is used to describe equipment, genetic material, agricultural techniques, and inputs that have been developed to improve the effectiveness of agriculture and can be divided into four categories: (i) Natural Resource Management; (ii) Improved Varieties; (iii) Chemical Inputs; and (iv) Mechanization and Infrastructure [15] (p. 2).

Digital agriculture emerges as a strand within the technological spectrum, focused on the integration of information and communication technologies (ICT) into agricultural processes to promote greater precision and efficiency. There are different levels of technological complexity that can be adopted by producers to boost productivity and sustainability [16]. More advanced technologies involving artificial intelligence, such as the internet of things, big data, and blockchain, tend to be adopted on a smaller scale [16]. On the other hand,

more accessible and practical tools, such as communication applications on smartphones, digital management platforms, GPS systems, and remote sensing technologies, are the most used in digital agriculture [16].

In the specific case of milk production, the adoption of digital technologies has the potential to further develop this practice, as they impact production efficiency, animal welfare, and the efficiency of the management of the property [6]. These technologies can also improve management processes, increase production efficiency, and enable better decision-making by the producer, as these devices and sensors collect real-time data, such as herd behavior, health, milk production, and food consumption [17]. This monitoring helps producers to outline preventive actions for early intervention and "enables the promotion of the health and welfare of the entire life cycle of dairy cattle and the creation of better value for producers" [17] (p. 2).

The adoption of technology in agriculture is a complex issue that evokes a range of factors that can influence the decision to adopt technology or not [18]. Studies on technology adoption assume that producers are rational actors who seek to maximize a utility function, and point to the existence of three paradigms to explain the factors that influence this adoption [15]: (i) the innovation-diffusion paradigm; (ii) the economic constraints paradigm; and (iii) the adopter-perception paradigm. From these paradigms, it is possible to analyze the propensity to adopt technologies as a function of producer elements, such as socioeconomic, personal, and environmental, and property, such as financial, management, and external factors, here called the market [15].

The implementation of a rural development model that includes the integration of agricultural practices and the adoption of digital technologies can transform rural communities into innovation centers, as in the concept of the agrotechnological district (ATD). The term 'technological district' refers to a territorial system composed of relational components, infrastructures, and cognitive and technological learning processes, requiring qualified labor, a strong network of cooperation between actors, and the support of a series of innovation-oriented institutions [13].

The transformation of a rural community into an ATD aims to improve its productive efficiency in addition to local sustainability by providing several benefits, such as reducing excessive working hours, saving resources, and increasing transparency across value chains while reducing regional disparities in the development of digital agriculture [1,2].

To Prosperi et al. [19], the transformation of a region into an ATD involves a process of socio-technical transition, which means that in addition to the adoption of technologies by producers, it includes changes in institutional and cultural practices and structures, which results in the conceptualization of new products, services, and business models, among others, reshaping the market in which the actors are inserted. Some factors that influence the formation of an ATD are the characteristics of the district (infrastructure and institutional, political, and technological environment), chain relationships and support networks (consortia, production associations, and other organizations, and informal contracts) and the features of the companies themselves—in the specific case of this study, of producers (gender, age group, propensity for risk, and adoption of technologies) and rural properties (size, establishment age, governance and management, and availability of resources and capital) [19].

Gumbi, Gumbi, and Twinomurinzi [3] affirm that the successful adoption of digital agriculture by smallholder farmers depends on the existence of a functioning digital agriculture ecosystem within their context and environment. They also state that the development of a digital agriculture ecosystem depends on elements such as the availability of digital platforms to access agricultural information, markets, finance, agricultural inputs, supply chain management, consulting and business intelligence services, innovations in business models, digital literacy, digital infrastructure, 4IR (artificial intelligence, big data, internet of things, and smart and remote sensors), and accessibility.

Meng Zhao, Song, and Lin [2] point out that the level of development of digital agriculture in a region can be measured through five indicators: (1) digital agriculture

infrastructure (rural delivery routes, total reservoir capacity, road mileage, rural electricity consumption, length of optical fiber cables); (2) digital agriculture talent resources (average years of education in rural areas, education expenditure, science and technology expenditure, average number of students enrolled in higher education); (3) agricultural informatization level (density of cell phone base stations, number of internet domain names, rural broadband access); (4) the digitalization of agricultural production processes (effective irrigated area, total power of agricultural machinery, large and medium-sized tractors for agricultural use); and (5) agricultural production efficiency (e-commerce sales, per capita disposable income of rural households, total input value of agriculture, forestry, animal husbandry, and fisheries). The authors point out that promoting the digitalization of agriculture aims to achieve high-quality and sustainable agricultural development, with the benefits reflected in production efficiency.

Silva et al. [6] argue that there are gaps in the literature on the digital transformation of livestock in Brazil, making it difficult to obtain a national overview of this sector. Thus, the realization of a diagnosis of the municipality in question allows the identification of its potential and challenges for the transition to an agrotechnological district.

It is understood that the diagnosis needs to consider four dimensions which advance from the micro to the macro level and include the producer´s characteristics; the rural property´s characteristics; the local community´s characteristics; and the market characteristics. Figure 1 demonstrates the main attributes found in these dimensions.

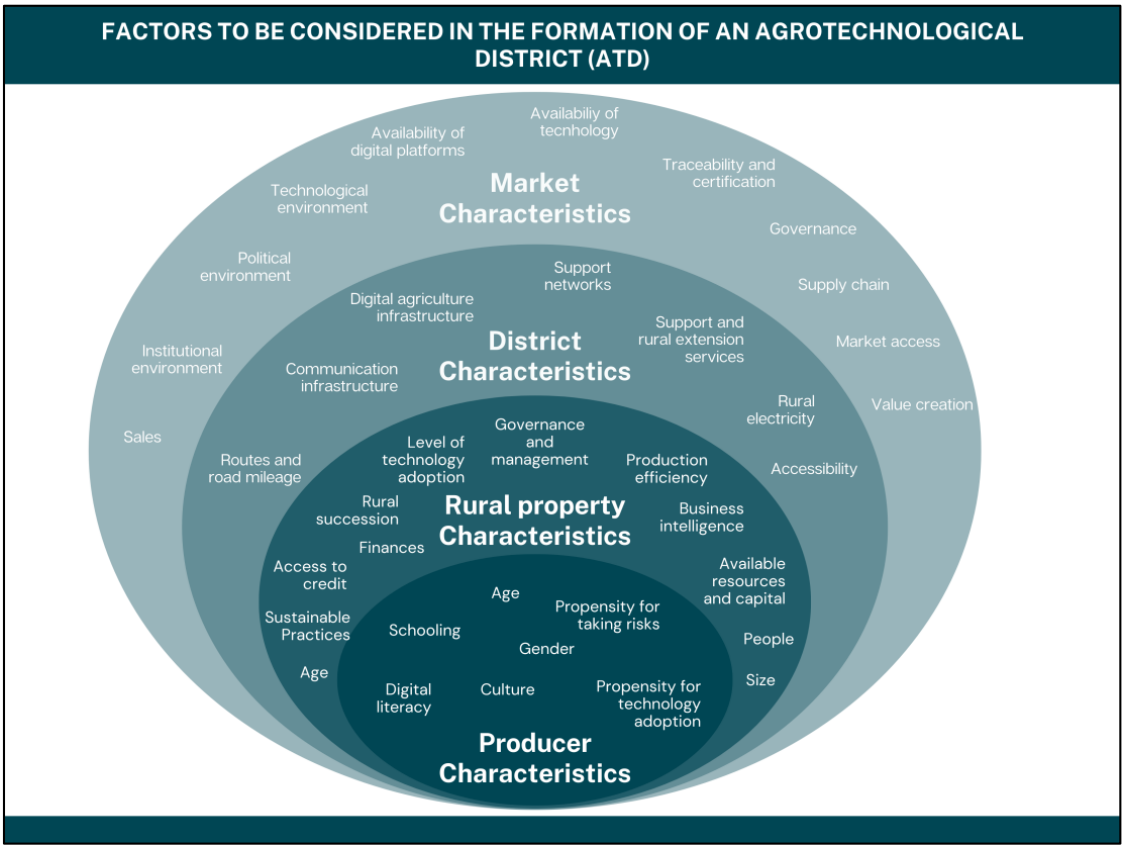

Figure 1. Dimensions to be considered in the formation of an agrotechnological district (ATD). Source: The figure was designed by the authors using Canva software, version number 1.99.0.0.

Based on the literature presented earlier about the transformation of a rural community into an ATD, an analysis framework was built. The following analytical categories were included: the socioeconomic characteristics of the municipality; the producers' level of technification; the local connectivity infrastructure; the existing support networks; the characteristics of the property; and property and market management [2,3,19]. Figure 2

illustrates the dynamic and interconnected nature of these analysis categories. It is understood that the local socioeconomic characteristics form the basis of this transformation, influencing the ability of farmers to adopt technologies and the feasibility of implementing an ATD. Local connectivity infrastructure acts as a catalyst, boosting producers' level of technification by enabling access to information, digital platforms, and agricultural technologies. Existing support networks, such as associations, cooperatives, and research institutions, play a role in providing technical support, capacity building, and access to new practices, tools, and resources. Finally, the incorporation of new technologies enables better management of both the property and the market, as they allow for more strategic and assertive decision-making. It is important to emphasize that these elements do not act in isolation, but influence each other, creating a complex ecosystem where the success of the ATD depends on the synergy between its components.

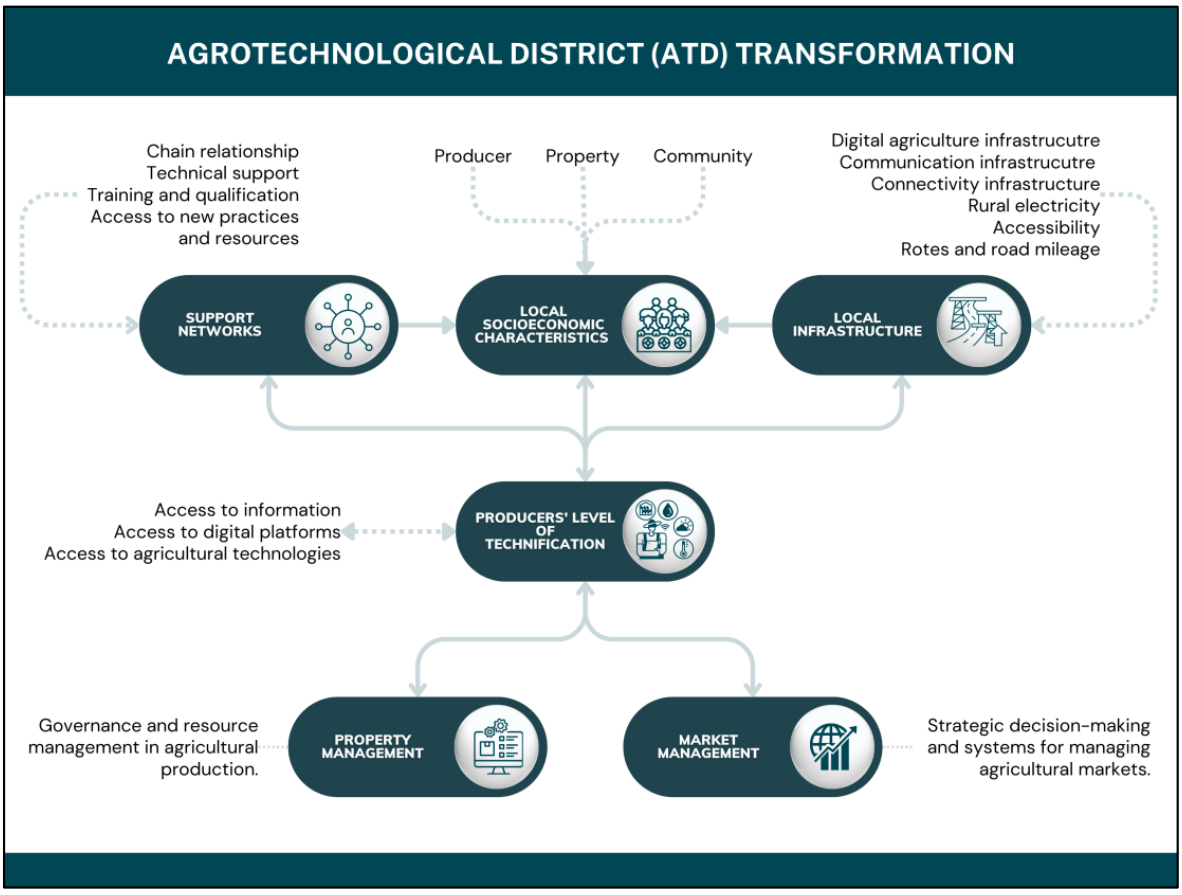

Figure 2. Analysis framework for an agrotechnological district (ATD) transformation. Source: The figure was designed by the authors using Canva software, version number 1.99.0.0, based on Prosperi, Sisto, Lopolito, and Materia [19], Gumbi, Gumbi, and Twinomurinzi [3], and Meng, Zhao, Song, and Lin [2].

Taking these relations into account, from this diagnosis, it is possible to propose strategies for the implementation of solutions that promote digital inclusion, improve infrastructure, and strengthen support networks for small- and medium-scale farmers, promoting sustainable development that not only respects the principles of the SDGs, but also contributes to a more prosperous and sustainable future for rural communities in Ingaí, MG, Brazil. In addition, the adoption of these initiatives can stimulate the economic and social development of the municipality, generate multiplier effects in its region of influence, and establish a benchmark for other initiatives in the state of Minas Gerais, the main dairy hub in the country, and one of the main driving states of Brazilian agribusiness.

3. Materials and Methods

An exploratory case study was conducted, with a qualitative methodology, supported by semi-structured group interviews [20]. A case study "consists of an in-depth and exhaustive study of one or a few subjects, allowing for broad and detailed understanding" [21] (p. 54). This method is useful for understanding social processes within a specific context and exploring the situation's meaning for its participants [22].

Interviews, while they do not represent absolute truths, are co-constructed by the interviewer and interviewee, and shaped by cultural and situational contexts [23]. This makes interviews a valuable tool for capturing participants' perspectives in qualitative research, whether as a personal narrative of lived experience or as a reflection of broader social influences and the dynamics within the interview itself.

The justification for sample size in qualitative research can be grounded in the concept of saturation [24–26]. This principle refers to the point at which the researcher, during data collection, ceases to identify added information and the responses begin to repeat, indicating that the data gathered have reached a sufficient level of consistency to represent the phenomenon under study [24–26].

The interviews took place between 20 and 22 March 2024, when researchers from the Centre of Science for Development in Digital Agriculture (CSD-DA) made their first visit to the municipality. This visit aimed to bring together different stakeholders and introduce the project to local leaders and producers. It was also important to establish a period for the beginning of the research regarding the implementation of the ATD in the municipality to understand the nuances of the region and its inhabitants.

The interview script included questions related to producers' socioeconomic profiles; the level of technification of producers; local infrastructure; and existing support networks in the municipality, and was adapted to different audiences. The interviews lasted around 90 min and pertained to milk production, as Ingaí had been selected as an ATD representative of the dairy basin in the state of Minas Gerais. The contact with and selection of the interviewees were carried out with the help of technicians from Emater, Ingaí, MG, Brazil (Technical Assistance and Rural Extension Company of the State of Minas Gerais). The process of selecting rural producers through recommendations from Emater agents in the municipality is similar to the approach adopted by Diederen et al. [26], who used sources such as agronomists, specialists, specialized magazines, and government contact lists to identify innovative producers in their study on the adoption of agricultural innovations.

Table 1 shows the groups of local actors who were submitted to the interview.

Table 1. Groups of interviewees.

Group of Interviewees	Number of Participants
Technicians and extension workers (Emater, Ingaí City Hall, Sebrae Lavras, MG, Brazil, and Company X, Lavras, MG, Brazil)	4
Representatives of the local government	6
Producers belonging to the association of producers of Ingaí and credit cooperatives operating in the municipality	8
Representatives of the local agribusiness	2
Local internet service providers	4
Commercial representatives of agricultural input companies	6

Source: research data. Number of participants interviewed in each category during study, based on interviews conducted with agricultural stakeholders in Ingaí, MG.

The information collected during the interviews was recorded in a field diary by the researchers and was later subjected to a closed-grid content analysis that consisted of the preliminary definition of categories aligned with the research objective, followed by identifying elements within the selected material that would be organized into the previously established categories [27].

The analytical categories were based on the studies of Prosperi, Sisto, Lopolito, and Materia [19], Gumbi, Gumbi, and Twinomurinzi [3], and Meng, Zhao, Song, and Lin [2], and contemplated the following: the socioeconomic characteristics of the municipality; the producers' level of technification; the local connectivity infrastructure; the existing support networks; property management; and market management (as shown in Figure 2). The results are presented in the next section.

Socioeconomic Characteristics of Municipality of Ingaí, MG, Brazil

Ingaí is a Brazilian municipality belonging to the state of Minas Gerais, in the mesoregion of Campo das Vertentes, and whose region of influence is the municipality of Lavras, MG, with which it borders (Figure 3). According to the IBGE Cities portal, the municipality of 305,591 km^2 has a resident population of 2580 inhabitants, indicating a region with low population density [7]. As for the labor market, 23.2% of the municipality's population are employed, with an average salary of 1.8 minimum wages, suggesting low participation of the population in the formal labor market, which may be related to its rural and informal characteristics. From an economic aspect, the Gross Domestic Product (GDP) per capita of the municipality was BRL 41,544.77 (about USD 8308.954, as explained in Table 2) in 2021; despite seeming high for a small municipality, when analyzed alone, the GDP per capita does not reflect the distribution of income, which can be concentrated. The Human Development Index (HDI) of 0.697 places the municipality in the "medium human development" range, according to the classification of the United Nations Development Program [28]. Although it is not one of the lowest, there are still challenges in terms of quality of life, education, health, economic development, job opportunities and social inclusion.

Figure 3. A map of the location of Ingaí, Minas Gerais, Brazil. In the top left corner, the state of Minas Gerais in Brazil is highlighted. In the larger figure, the municipality of Ingaí, Minas Gerais, is highlighted [29].

Agribusiness is the main economic activity of the municipality, with 236 agricultural establishments, with an area of 21,908 hectares [8]. Of the total number of producers, 88.55% are male, 79.66% are over 45 years old, and 57.2% have schooling up to Elementary School level. At the time, 960 people were employed in these establishments, and 49.68% were related to the producer [8].

Regarding livestock, 191 establishments had herds, of which 145 were milk producers. The herd number was 16,331 heads, of which 4382 were milked cows, which produced 20,647 thousand liters of milk, and the production value was BRL 23,710,067 (about USD 4,742,013.4), with this activity being of great representativeness for the municipality [8].

The main agricultural products of Ingaí, MG, are described in Table 2.

Table 2. Main agricultural products in Ingaí, MG, Brazil.

Product	Establishments	Harvested Area (Hectares)	Quantity Produced	Production Value (×1000 USD)
Milk	145	Not applicable	20,647 thousand liters	4742
Corn (grain)	97	2270	14,944 tons	1545
Corn (forage)	121	1571	60,163 tons	1146
Coffee	30	416	524 tons	840
Soy	11	939	3,387 tons	747
Beans (color)	18	639	937 tons	542

Source: Brazilian Agricultural Census [8], available at IBGE Cities Portal. We consider the average BRL/USD exchange rate of 2023 for currency conversion, available at https://anuario.ibge.gov.br/images/aeb/2023/s7/2_pdf/s7t4301.pdf (accessed on 21 November 2024).

The first technical visit to the municipality of Ingaí, MG, allowed us to gain an initial understanding of the socioeconomic profile of the region. According to data collected in this study, Ingaí has a total of 33 rural communities. According to the interviewees, the southwest region of the municipality "is more agribusiness", that is, in their perception, it comprises larger-scale agriculture.

Ingaí, MG, reveals a community predominantly composed of family farmers, in which the production of milk, coffee, and grains plays a central role. According to the interview with the technicians and extension workers, the typical producers in the municipality consist of small milk producers who are also farmers, planting for their own consumption and selling the surplus or using it for animal consumption (corn). The meeting with representatives of a company that supplies inputs pointed out that the socioeconomic profile of milk producers in Ingaí, MG, reflects a heterogeneous reality, in which small producers, a group predominantly composed of men over 45 years of age, constitute the majority (keeping in line with the data of the Agricultural Census [8]), with average production of 200 to 300 L per day.

As pointed out by Bánkuti, Bánkuti, and Souza Filho [30], the milk market in Brazil has undergone intense transformations, related to public policies and changes in the market, such as the need to intensify production, an increase in the consumption of dairy products, and greater competition from imported products. For the authors, producers need a larger scale of production, greater regularity of supply, and a higher standard of quality, which can be achieved through the adoption of productive technologies. The authors add that these transformations have resulted in overflows, such as the following:

"The expansion of competition to a more systemic level; greater dispersion (differences) of prices paid to the producer, mainly due to volume; quality and bargaining power; stricter selection of market participants and expulsion of producers from the activity or to informality; severer negotiations between suppliers and customers; and changes in the relationships between agents" [30] (p. 45).

Along these lines, Martins et al. [31] pointed out that one of the changes that occurred in the structure of milk production in Brazil over the last two decades was the reduction in the number of producers and the intensification of production systems. Although the

municipality of Ingaí, MG, has a tradition in dairy activity, the interviews indicated that, over the last few years, this activity has faced a decline due to the increasingly challenging economic viability of the sector, with many producers migrating to more profitable crops, such as grains (corn, soybeans, beans) and eucalyptus.

According to the interview with members of the producers' association, milk production has declined in recent years in the municipality, since "milk has stopped being profitable". For them, the cost of production is extremely high, and labor is difficult to find, in addition to milk production being an activity that requires great dedication from the producer. The representatives of the local agribusiness add that "rural work is difficult, heavy. The workload is difficult, you need to work on the weekend and holidays. The cow does not stop producing milk; It is 24 h, 365 days a year". In addition, the interviewees point out that the new generation is no longer interested in staying in the countryside, corroborating the literature that states that dairy farming, especially in family systems, does not offer attractive and desirable working conditions, as it is hard work which can be exhausting and unprofitable, depending on its management [5,32]. Therefore, in some cases, family members choose to work outside the property. It was identified that the main employers in the region are the municipal government, the local agroindustry, and some companies in the municipality of Lavras, MG.

Considering all these challenges, many producers have opted for land lease to obtain income. According to one of the producers, "nothing pays the producer better than renting the land", especially in those properties that are not technified. This result is in line with Novo, Jansen, and Slingerland [33], who stated that dairy production in the context of family farming still survives in the Southeast of Brazil, although land leasing has become a more profitable alternative. In Ingaí, the land is leased to produce eucalyptus, grains, tomatoes, coffee, soybeans, and corn. Although leasing is an option, it was pointed out that leasing is only viable for larger properties. It is valid to say that, although milk production is declining, the interview with members of the local agribusiness points out that there is still potential for dairy in the region.

4. Results

The results of this study are organized into five subsections to address the key aspects investigated: Section 4.1. Producers' Level of Technification; Section 4.2. Local Connectivity Infrastructure; Section 4.3. Existing Support Networks; Section 4.4. Property Management; and Section 4.5. Market Management. Throughout the presentation of our results, we sought to identify the groups of respondents that addressed each theme, highlighting their specific perspectives. In cases where no specific respondents are mentioned, it indicates that the understanding on the topic was consensual among all groups of interviewees, ensuring a comprehensive and balanced analysis.

4.1. Producers' Level of Technification

"The level of agricultural informatization is a critical dimension that mirrors the state of digital agriculture development" [2] (p. 4). In the context of Ingaí, MG, this development faces challenges, since the adoption of technologies is restricted among small producers due to high implementation costs and cultural resistance. This scenario is in line with the observations of Bánkuti, Bánkuti, and Souza Filho [30], which highlight that the adoption of information technologies is considered low due to economic issues, the lack of knowledge of farmers about these technologies, and the data they generate. Gumbi, Gumbi, and Twinomurinzi [3] add to this discussion by stating that the challenges related to digital literacy in small and medium-sized producers include inadequate information about digital solutions, a lack of perceived value, language barriers, and a lack of knowledge about digital solutions.

Resistance to change is observed among producers in Ingaí, MG, influenced by distrust and local traditions. According to one of the interviewees, "The resident of Minas Gerais is suspicious, but the small producer from Minas Gerais is even more [suspicious]". Thus, it

is necessary to create approach strategies that are sensitive to the needs and interests of producers, especially through practical examples and references.

According to technicians and extension workers, small-scale farmers are very dependent on third-party machines or machines from the city government. These facts show a scenario of limited capitalization in which few producers have machinery to meet the needs of their own activity. Rather, they have "simpler" machinery, mostly tractors, silage harvesters, and trailers for transporting material and preparing the soil.

In the case of milk production operations, most have some level of technology, since without it, the producer cannot continue with this activity. In Ingaí, MG, milking is all mechanized and expansion tanks are used. The dairy firm, at times, requires the producer to use technology, for example, providing producers with management and financing applications and sending the analysis of milk quality through digital platforms.

The restriction on the use of technologies by small and medium-sized producers in Ingaí, MG, can be noted when compared to other contexts, such as in the production chain in Santa Catarina, as presented by Bonamigo, Ferenhof, and Forcellini [34]. According to the authors, low technification occurs due to the supply of technology itself (lack of incentives, lack of interest from developers and manufacturers) and is related to the producer's profile (income limitation, lack of cooperation with other producers, and low education). In addition, the complexity of agroecosystems is a complicating factor for the use of digital technologies [1].

For members of the agribusiness, there is a tendency for young people to show more willingness to adopt technologies. It was reported that many times, these young people are the ones who follow up, request the password to check the analysis of the quality of the milk, and control the herd, while the most experienced producers, often, do not even consult the digital reports sent by the industry. It was also pointed out that the active participation of women has been effective in promoting the adoption of technologies in the field. Thus, an opportunity for the digitalization of livestock in Ingaí, MG, is to promote specific training aimed at young people and women, encouraging their role as agents of digital transformation on properties. By fostering this participation, the digitalization of livestock can be accelerated, taking advantage of young people's interest in innovative technologies and the growing leadership of women in the management of rural activities, ensuring greater productive efficiency and modernization of the sector.

Despite the presence of young producers seeking to modernize this industry, the excessive costs of digital technologies impose barriers to their adoption, relegating most farmers to low-complexity technification device usage. It was pointed out in the various interviews that the internet is used for GPS, meteorology (weather forecast), monitoring the property, reading veterinary medicine leaflets and using them to determine dosage, making quotes and purchases ("looking for a cheaper product"), sales ("taking a picture of a cow to sell to the neighbour"), communication via social networks ("talk", "say hi to the group", "look at TikTok"), and entertainment ("watching movies"). These results corroborate the study by Gumbi, Gumbi, and Twinomurinzi [3], which identified that small farmers use digital solutions for accessing agricultural information, monitoring and tracking, the marketing of products (purchase and sale), production, fertilization, communication, the purchase of inputs, banking/economics, the control of agricultural equipment, forecasting, and credit evaluation. According to Bassotto et al. [35], "it is possible that internet access contributes to dairy farms improving their technical efficiencies by allowing searches for new information" [35] (p. 4).

The introduction of digital technologies is seen as a possible solution by producers themselves, who recognize that it can help improve productivity. Also, "increasing production volumes leads to better prices per litter and the dilution of fixed costs" [31] (p. 3). But excessive costs and a lack of knowledge pose barriers to their adoption, as can be seen in the Section 4.2. The use of technologies becomes attractive to producers because, in addition to improving crop production and productivity, they result in less environmental impact [31,34]. For representatives of the local agribusiness, to remain in this industry, it is necessary to be

technified: "No matter what, being small or large, those who are efficient and technified will remain. This is regardless of whether it is in milk, soybeans, oranges, corn, etc. It is a global movement. You must have financial, productive, professional, and personal efficiency". In addition, the same interviewees pointed out that producers feel the need for technification and are looking for it. However, it is necessary to provide support and training for the use of technology to be effective: "When you simplify, facilitate and empower him to do this, to use technology, he uses" (interview with representatives of the agribusiness).

4.2. Local Connectivity Infrastructure

Mellet and Beauvisage [36] describe infrastructure as a series of objects that are invisible to market actors and that are necessary to support human activities, such as collective equipment and materials (bridges, energy, and communication networks), as well as protocols and standards that create the scenarios in which social life takes place. The authors argue that, when analyzing market infrastructures, it is important to analyze the activities that these infrastructures support and not only how these infrastructures are built [36].

In its study, Gumbi, Gumbi, and Twinomurinzi [3] identified that research on digital infrastructure focuses on information and communication technology (ICT) and mobile phone and broadband connection. To Meng, Zhao, Song, and Lin [2], the infrastructure needed for the development of digital agriculture covers five aspects: rural delivery routes and road mileage (transport infrastructure, "essential for the movement of agricultural production, materials and products"); total reservoir capacity and rural electricity consumption ("resources for the digitalization of the agricultural production process"); and the length of optical fiber cables ("hardware foundation underpinning the advancement of agricultural informatization and digitization") [2] (p. 3).

During the interviews, it was possible to identify that the infrastructure in Ingaí, MG, faces significant challenges, with most rural communities having only single-phase electricity available to use, which is frequently interrupted. These oscillations affect milk production and milk quality, as energy is needed for milking (mechanical, in almost all properties) and expansion tanks. According to technicians and extension workers, some larger producers already have photovoltaic energy on their properties and see its benefits, although they still depend on the network of the Energy Company of Minas Gerais (CEMIG) due to the costs of investments in batteries to store the energy generated. According to the interview with members of the local government, about 40 families do not have access to electricity because the land was irregularly established and cannot be registered.

Regarding the transport infrastructure, the roads that connect the region are dirt and their quality worsens in rainy seasons, which hinders the flow of production and access to properties. In addition, in relation to road mileage, it was identified that there are dairy industries 200 km away that look for milk in Ingaí, MG, while the local dairy industry looks for milk within a radius of 150 km from the municipality.

Building connectivity infrastructure and promoting network coverage in rural areas are key to the development of digital agriculture [2]. In Ingaí, MG, it was found that the connectivity infrastructure is underdeveloped, with internet access being limited and primarily radio-based. The mountainous terrain also contributes to unstable communication signals in some areas, exacerbating the challenges of accessing information and technologies. According to representatives of internet service providers, even in regions where fiber-optic internet is available, it is received via radio and then distributed via fiber. It was noted that in some areas, the antenna signal does not reach the property. The region of Mato Sem Pau was identified as the most difficult area in which to obtain internet access.

According to the same group of interviewees, there is a challenge in bringing fiber-optic internet to rural areas, due to the excessive costs and low population density making investment unjustified. In addition, the producer's culture is another obstacle, since "if he is already sure to use the radio-based internet access that works, he will not want to change it". In this way, producers do not even request a viability analysis to bring fiber-optic internet to the region. Another point addressed by the representatives was that they often

carry out studies to improve radio connectivity in the region and determine strategic points to install the antennas. The cost of these antennas is about BRL 30 to 40 thousand, and companies are interested in installing them. However, producers do not allow antennas to be installed on their properties, as they take up too much rural area and also serve as lightning rods, which can kill animals that are around them, in cases of electrical discharge.

Rural mobile telephony is an important means of communication for rural workers, who often remain away from urban areas [37]. In Brazil, the main operators of mobile phone services are Vivo, Tim, Claro, and Oi. In the region of Ingaí, the connection of mobile phones is of variable quality, with a predominance of the Vivo and Tim service providers. Starlink technology has been pointed out as a solution, but it is still too costly for most producers.

An example reported by representatives of the agroindustry about the need for connectivity in the field is that the clinical laboratory sends milk quality analyses to the producer by telephone signal, via message. If the producer is outside of the coverage area, they do not receive the message. Thus, the producer must access the system over the internet, which is often unstable on the property.

The interviewees also observed that the lack of connectivity is a problem that hinders not only the work, but also the permanence, of the producer in the field, especially when family demands arise. Some examples highlighted were the education of children and young people in the pandemic, the difficulty of communication, and the lack of entertainment. According to one of the producers, "my boys, if the internet connection goes out, they get in the car and leave".

While there is interest in the establishment of fiber-optic internet infrastructure by enterprises, excessive costs and geographic challenges pose significant barriers. The interview with local internet providers indicated that the companies are interested in the project and willing to carry out partnerships and studies in the area to improve connectivity in the region. Respondents emphasized that producer's need for connectivity is increasing with the emergence of "smart homes, security cameras, and smart farms". So, local internet providers state that "the producers themselves will need a better connectivity infrastructure and will demand the availability of this service".

4.3. Existing Support Networks

Prosperi et al. [19] express that in the process of transforming a region into a technological district, cohesion among all stakeholders is necessary. For the authors, support networks influence innovation capacities through the sharing of information and knowledge, thus creating a favorable environment and ensuring learning for the promotion of innovative technologies among local actors.

Regarding producer support networks, it was reported that the Association of Rural Producers of Ingaí, MG, was created in 2005, with the aim of commercializing production jointly, but has lost its strength in recent years. This information contrasts with Bassotto et al. [35], who state that "in Minas Gerais, milk farmers are likely motivated to participate in collective organizations" [35] (p. 4). One of the difficulties pointed out by the producers in relation to participation in the association was the milk producer's own routine, as they are unable to leave the farm to participate in meetings and collective decisions. The lack of effective management was also highlighted, with cooperatives and associations unable to deliver tangible benefits to their members. In addition, market prices have become more attractive than collective selling via association, corroborating Prosperi et al. [19], who state that insertion in these support networks can generate lock-in problems, regarding the lack of openness and flexibility. We also identified a lack of knowledge about the importance of associative/cooperativism for collective strengthening.

In addition to the producers' association, other actors emerge as a support network for rural producers in Ingaí, MG. The local agribusiness itself assists in the execution of operational and financial processes, in the organization of documents for requesting financing, and in the provision of training and qualifications. In addition, partnerships

with startups and initiatives such as app development show the dairy sector's potential to help producers modernize and remain competitive.

"Given the diversity and complexity of milk production systems in the country, technical assistance plays a vital role in providing increased production and factor productivity, which enables the growth of the producer's income" [38] (p. 80). The role of Emater-MG technicians, IMA (Minas Gerais Institute of Agriculture) technicians, and commercial representatives goes beyond simple marketing, offering technical support and production evaluations to local producers. The presence of Emater-MG and partnerships with financial cooperatives demonstrates a collective effort to overcome barriers to access to rural credit. Also, in relation to the support network, there is veterinarian support on some farms.

4.4. Property Management

Prosperi et al. [19] emphasized the relevance of management in the transition process to a technological configuration. In Ingaí, MG, some of the elements related to property management mentioned by the interviewees were labor, female leadership, of the rise in production costs, and family succession.

According to Meng, Zhao, Song, and Lin [2], people play an indispensable role in the development of digital agriculture in a region, and the shortage of skilled personnel remains a challenge in this process. In Ingaí, MG, this scenario is evident, with the workforce being predominantly family-based. Also, it is difficult to find people willing to work in the dairy sector. Although "the average salary of a retiree is around R$4500.00 (about USD 900, as explained in Table 2) per month, they still cannot find people willing to work," as one of the producers points out. In addition, the issue of employee training was addressed as a hindrance, since each property has its specificities, such as "the way to express milk, the place where the cow stays, how to give feed, water, etc.". Bánkuti et al. [5], in their study carried out with small producers in Paraná, identified that there is a tacit knowledge in the dairy industry that is irreplaceable, which can both be a source of benefits and better performance, and create a situation of imprisonment and dependence for the owners.

According to technicians and extension workers, although there are many women in the field, in most properties, they are not paid for production, and female leadership is still incipient. Despite this, the commercial representatives pointed out that the growing role that women have assumed in the management of properties is notable, as they are increasingly engaging in the adoption of technologies, the execution of payments, purchases, controls, and cleaning. In this way, the woman is no longer an assistant and is perceived as a producer, being responsible for initiating the decision-making process, while the man will carry out the validation. Thus, an opportunity found in Ingaí, MG, is to improve female representation in the countryside, establishing women as a target audience for training and qualifications and creating job opportunities for them, such as the promotion of initiatives such as family agribusiness and rural tourism.

As for the raising of production costs, it was pointed out that most producers do not have these records in a formal way, and this, associated with the difficulties of managing the working capital of the milk producer, becomes a hindering factor. This is because, according to producers, although the costs of the activity remain daily, there are occasions when dairy industries delay payment, and others pay less than agreed. "The cow doesn't stop eating because the dairy industry didn't pay me", reports one of the interviewees.

Family succession is a bottleneck in property management. Bánkuti et al. [5] pointed out that the family decision on whether to remain in the dairy activity must consider material and immaterial elements, such as the characteristics of the farm, its structural aspects, its technical characteristics, the socioeconomic characteristics of the family, the degree of experience with the activity, and the availability of labor, among others.

In Ingaí, according to the interviewees, the income from agriculture is insufficient and, as a result, young people seek work and study opportunities in larger cities. In addition, young people realize the difficulties their parents face with agricultural activities. According to the producers, 'there is no substitute for the farmer'. The children see their

parents' difficulties and say 'This is not for me!'. Regarding family succession, when a producer has many children, the division of the rural property often leads to even lower profitability. Consequently, farms tend to transform into small leisure farms.

According to local commercial representatives, when family succession occurs, some young people continue the activity in the same way their parents did (tradition), while others are more technologically advanced, have more information, and are more open to changes in the production process. "More modern places are those with young people. (. . .) A property that has young people, they are looking to study more, to train, they are graduates in agronomy, animal science, veterinary. This results in more selected cattle, with a better genetic structure, a better-quality feed. (. . .) And parents accept it when they see that it works", say the commercial representatives.

4.5. Market Management

The potential of the municipality refers to the presence of large stakeholders in the milk market, who may be interested in the transfer of technology to producers, with a view to improving productivity and product quality. According to data from the Dairy Industry Union of the State of Minas Gerais, there are 226 associated dairies, of which 65 are within a radius of 200 km from the city [39]. In addition, the municipality is relatively close (275 km) to Juiz de Fora, a city that is home to Embrapa Dairy Cattle, an important player in the development of dairy farming in the country. Figure 4 shows the location of the dairy products in relation to Ingaí, MG.

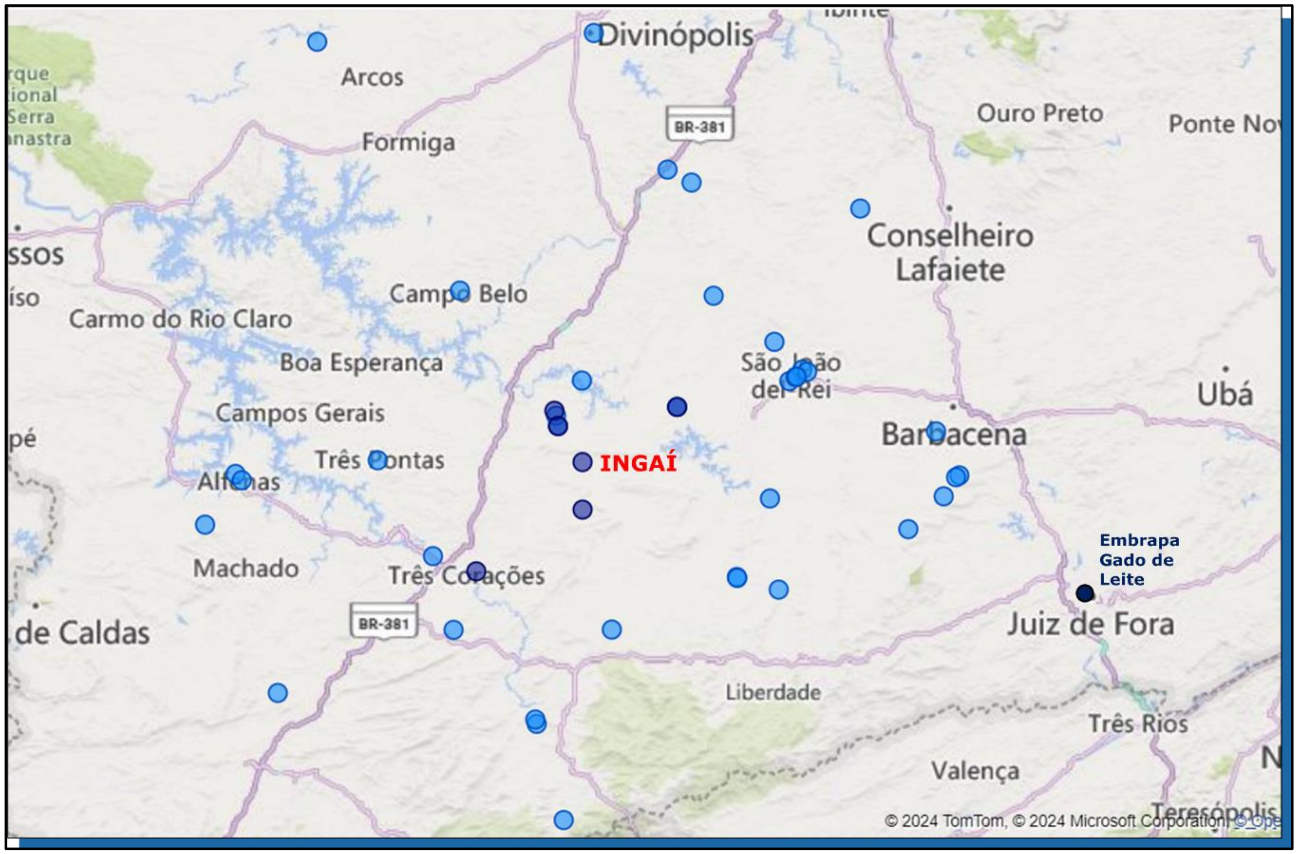

Figure 4. Dairy industry within a radius of 200 km from municipality of Ingaí, MG. Source: Map built in PowerBi software, version number 2.138.1004.0 64-bit, based on data from Dairy Industry Union of state of Minas Gerais [39].

The commercialization of the production of Ingaí, MG, takes place directly with three cooperatives and seven dairy industry factories that operate in the region, of which three

are large and two medium-sized, with commercialization throughout the country. The existence of these major players is understood as an opportunity for the municipality, since they may be interested in assisting in the transfer of technology to the producer, since an improvement in productivity and quality of milk directly impacts the quality of the products offered by them.

A challenge pointed out by producers is related to the sale value of raw milk. The interviewees stated that the sale price of milk is low, and the production costs are high, due to investments in machinery. In addition, the market itself defines the price of milk, due to the quality and productivity premiums. There is a requirement that the dairy industry carry out periodic analyses of the quality of milk, which is carried out through sampling, and this analysis will determine whether the producer will receive a quality award or not. Due to this quality test, the producer can receive a premium of BRL 0.20 to R$0.50 (about USD 0.04 to USD 0.1, as explained in Table 2) per liter. Although there is a minimum value for the sale of milk, due to this productivity premium, the producer cannot be sure about the value of the milk that will be received. With these price variations, there is difficulty in producing and selling profitably, especially for small producers, due to the lower production volumes. Therefore, producers change dairy industries very easily, always going towards those who pay better. These results corroborate the considerations of Bánkuti et al. [5], who pointed out that the volume of milk is an important variable in defining the price paid per liter and that those who produce more tend to have better economic efficiency, due to the economy of scale (dilution of fixed costs and reduction in unit costs of production) and, consequently, generate better income.

In this context, the technification of production becomes an opportunity for producers to improve their production and, thus, achieve better prices for their product, since the adoption of technologies allows the improvement of milk quality.

An example of this application can be found in Rocha, Silva, and Silveira, who advocate the implementation of blockchain technology in the milk supply chain in Brazil [40]. They say that this technology has a positive impact on the quality of the milk, since, among other factors, it can offer support in the management of inputs, such as feed, vaccines, and medicines, directly affecting the health and well-being of the animal. The authors conclude by stating that this improvement benefits both the industry, since it receives the milk in better condition, resulting in higher-quality products, and the producers, who will receive a higher price for the milk supplied.

The incorporation of technologies in the production process involves investments, but in Ingaí, MG, access to credit is still a barrier for milk producers. "Producers of other crops (for example, coffee, which they only receive during the harvest) have learned to work with credit, but the milk producer, he receives every month for production (because he produces every month), so he prefers to work with the resource he already has." In this way, the producer often works with difficulties, afraid to look for a bank branch and incur a debt that compromises their income. Thus, stability is essential for the producer to decide to make a large investment in technology.

In the city, there are few family agribusinesses, which limits the opportunities to add value to local production and greater profitability. In this way, the promotion of initiatives such as the creation of family agribusinesses and rural ecotourism, become opportunities for the more sustainable development of the municipality. These initiatives can make it possible to diversify the sources of family income (reducing dependence on the dairy industry), generate income in a more distributed way, keep the rural population economically active, promote social inclusion, especially for women, and boost the local economy with new opportunities, respecting the natural resources present in the region. Additionally, they can help to preserve and enhance the cultural and natural heritage of the region, which can include traditions, typical cuisine, and sustainable farming practices. This appreciation not only attracts visitors, but also strengthens the sense of local identity and the pride of belonging to the community.

5. Discussion

The results of this study are in line with the findings of Bonamigo, Ferenhof, and Forcellini [34], who made a diagnosis of milk production in the state of Santa Catarina, Brazil. The authors identified 19 bottlenecks that are limiting to milk production, within four main constructs: the lack of cooperation between local actors; the deficiency in milk quality; the rural exodus; and productivity limitations [34]. They indicate that cooperation between local ecosystem actors allows support for the development or financing of the adoption of technologies and/or better agricultural practices [34]. Regarding the rural exodus, it was pointed out that young people in Santa Catarina go to urban centers in search of better living conditions (study, employment, an increase in income) and rarely return to the countryside, in the same way as in Ingaí, MG [34].

Regarding the quality of milk, in Santa Catarina, the price of the product is also associated with its quality, with the producer being the most vulnerable link in the production chain. Finally, regarding the limitation of productivity, the authors suggest an agenda that encourages the adoption of technologies and best practices that promote efficiency on the property.

Overcoming these challenges requires an approach not only to technological and structural issues, but also to socioeconomic and cultural aspects. The engagement of producers, government support, and partnerships between local institutions can boost the sustainable development of the agricultural sector in Ingaí, MG, encouraging innovation, training, and the search for solutions that promote the well-being of the agricultural community.

Meng, Zhao, Song, and Lin [2] point out that the development of digital agriculture is a gradual process and influenced by many factors. Thus, they present a series of recommendations to improve the level of development of digital agriculture, considering the real conditions of each location, such as improving public policies related to digital agriculture, improving the development of local infrastructure, and training people so that they can work in digital agriculture (investments in training and qualification). Gumbi, Gumbi, and Twinomurinzi [3] point out that there is a limitation in research on literacy or digital skills, accessibility, and innovation of the business model focused on digital agriculture. Therefore, some opportunities for the digital transformation of Ingaí, MG, are the strengthening of support networks, the increase in the technification of producers, training and rural extension, and the growth potential of the rural community in the municipality, through the promotion of the creation of family agro-industries and rural tourism.

Finally, as reported by representatives of the local agribusiness, "the dairy basin in Ingaí will not be exhausted. It will change. But the little ones who do not become technified, will be impacted, and will be swallowed up". The creation of an ATD in Ingaí, MG, can be a strategic solution to the challenges in dairy production. By promoting partnerships between dairy industries, cooperatives, and agribusinesses, the ATD strengthens support networks, reducing the vulnerability of smallholders. Technological infrastructure and training programs would facilitate the adoption of more efficient practices, raising the quality and profitability of milk. In addition, by giving women a voice, retaining young people in the countryside, and encouraging innovation, the ATD would contribute to sustainable socioeconomic development, making the local dairy basin more resilient and competitive.

Figures 5 and 6 demonstrate the opportunities and challenges for the transformation of Ingaí into an ATD, related to the following categories: the socioeconomic characteristics of the municipality; producers' level of technification; the local connectivity infrastructure; the existing support networks; property management; and market management.

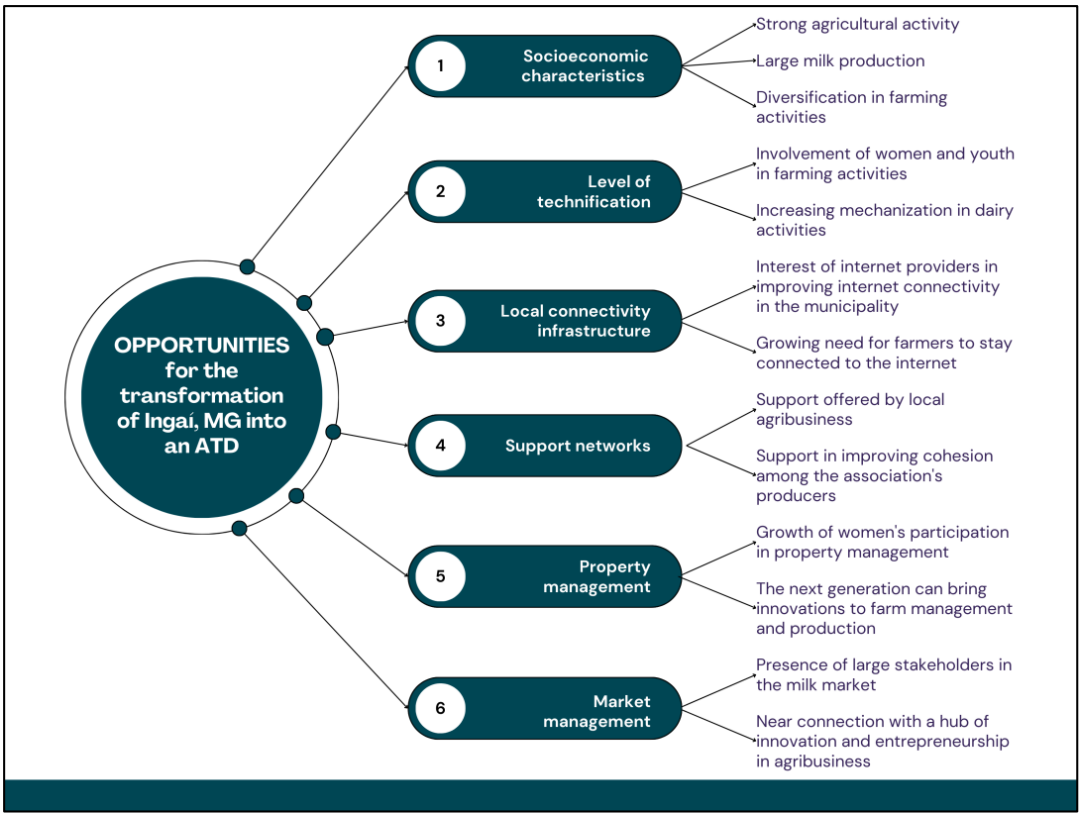

Figure 5. Opportunities for the transformation of Ingaí, MG, into an ATD. Source: The figure was designed by the authors using Canva software, version number 1.99.0.0.

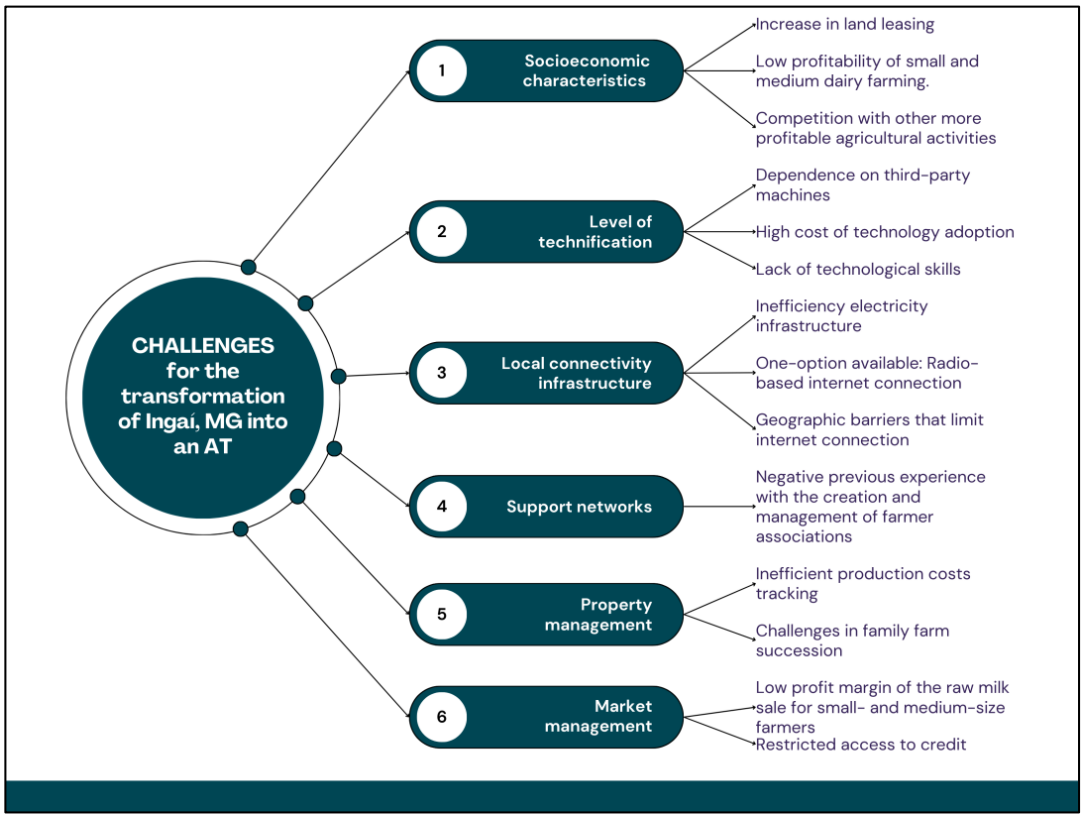

Figure 6. Challenges for the transformation of Ingaí into an ATD. Source: The figure was designed by the authors using Canva software, version number 1.99.0.0.

6. Conclusions

This study aimed to identify difficulties and opportunities for the transformation of Ingaí, MG, into an agro-technological district, using semi-structured group interviews as a method of data collection. The results allowed the identification of information about the municipality and offer insights for decision-making on the strategy for its transformation into an agrotechnological district.

In Ingaí, MG, socioeconomic development is linked to overcoming the limitations of technification, access to credit, connectivity infrastructure, the management and succession of properties, and access to support networks. There is potential for growth in the rural community of the municipality, based on the collaboration between the various actors involved, aiming at the implementation of solutions that promote digital inclusion, improve local infrastructure, and strengthen support networks for family farmers. The importance of rural extension actions is highlighted, offering training and qualification aimed at the adoption of technologies, property management, and the creation of new markets. These actions will enable the development of sustainable agriculture in the region, as they promote increased production efficiency, optimization of the use of natural resources, and a reduction in waste.

Finally, the transformation of Ingaí into an agrotechnological district will allow dairy farmers to monitor herd performance, improve milk quality, and reduce operating costs. In addition, digital inclusion will facilitate access to market data and information, opening new opportunities for marketing and adding value to local products. By strengthening support networks and providing continuous training, it will be possible to increase the competitiveness and resilience of small properties, promoting a cycle of sustainable regional development that will benefit the rural community, especially the new generations of producers.

In this sense, public policies to support agricultural activity are necessary. Municipal and state governments can act to improve connectivity infrastructure, such as financing the installation and maintenance of internet and mobile phone antennas and collaborating in discussions on the most suitable locations for installation. At the federal level, the government could contribute to providing access to credit for small- and medium-scale farmers, via public banks, to boost activity. Universities and development agencies can train farmers to use digital technologies, both in production and in property management, emphasizing financial education, to stimulate the viability of small and medium-sized enterprises.

This exploratory study has some limitations that should be considered when interpreting the results. First, the qualitative nature of the group interviews, although rich in details and insights, may not capture all the relevant variables or completely generalize the realities faced by dairy farmers in Ingaí, MG. In addition, the focus on a single municipality limits the applicability of our findings to other regions with different socioeconomic, cultural, and structural contexts. The absence of quantitative data also prevents a more in-depth analysis of the correlations between the identified factors and the socioeconomic performance of producers. Finally, the influence of external factors, such as public policies and changes in the global dairy market, was not fully considered, which may impact the sustainability of the proposed solutions.

An additional limitation of this study is the exclusive focus on milk production, influenced by the scope of the SEMEAR Digital project in the locality of Ingaí, MG. Although milk is a relevant agricultural activity, other activities also play a significant role in the rural economy of the region and have not been explored. This concentration in a single sector may have excluded opportunities and challenges present in other agricultural areas, limiting the scope of the conclusions and recommendations offered by this study.

As a research agenda, future studies can address the limitations mentioned above, such as considering other production chains in the analysis of the construction of an ATD; seeking a larger sample, by increasing the number of interviews and/or covering other municipalities, in order to test hypotheses with quantitative methods; and examining the municipalities that are candidates for ATDs in the institutional context, in order to cover sectoral industrial policies, especially those related to the dairy market, macroeconomic

and international, referring to the foreign trade of such products. These suggestions are proposed for the future work in the context of the theme addressed here.

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Institutional Review Board Statement: Ethical review and approval were waived for this study, considering CNS Resolution No. 510/2016, which provides the rules applicable to research in the Human and Social Sciences whose methodological procedures involve the use of data directly obtained from participants or identifiable information, or that may entail greater risks than those existing in everyday life. This resolution establishes that research with the aim of the theoretical deepening of situations that emerge spontaneously and contingently in professional practice will not be registered or evaluated by the CEP/CONEP system, if they do not reveal data that can identify the subject. More information about research that does not require evaluation by the ethics committee can be obtained at the link http://www.cep.propesq.ufrn.br/noticias/pesquisas-que-nao-necessitam-de-registro-no-sistema-cep-conep-resolucao-no-510-2016-cns/28749886 (accessed on 10 October 2024).

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