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Strategic Territorial Intelligence for Family Farming in the Cuiabá River Valley and Surroundings

Inteligência Territorial Estratégica para a Agricultura Familiar do Vale do Rio Cuiabá e Entorno

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Abstract

Family farming is a cornerstone of Brazil's economic and social structure. It accounts for a significant portion of the national food production and plays a crucial role in promoting food security in the country. In the Metropolitan Region of the Cuiabá River Valley and Surroundings, this segment encompasses approximately 28,000 families residing in rural areas, organized into 10,547 agricultural establishments. The strengthening of family farming depends on its support by public policies which are capable of understanding regional specificities and creating effective mechanisms for the development and consolidation of the sector. In this context, a partnership was established between the Mato Grosso Company of Rural Research, Assistance, and Extension (EMPAER) and Embrapa, to develop a digital platform that integrates data across different territorial dimensions, aiming to characterize the region and, above all, provide analytical tools to support public policy and local investment decisions. This solution was based on the strategic territorial intelligence concept, which thematically organizes spatial data into five major frameworks: natural, agrarian, agricultural, infrastructural, and socioeconomic. We expect the platform to support territorial management efforts by public and private organizations by classifying the region's municipalities according to their environmental and production potential. This, in turn, will assist research institutions and organizations responsible for rural planning, management, and technical assistance.

Keywords:
Rural development, Spatial analysis, Public policies.

Resumo

A agricultura familiar representa um pilar fundamental da estrutura econômica e social do Brasil, sendo responsável por uma parte significativa da produção nacional de alimentos e

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desempenhando um papel crucial na promoção da segurança alimentar no País. Na Região Metropolitana do Vale do Rio Cuiabá e Entorno, este segmento é representado por cerca de 28.000 famílias residentes no meio rural, organizadas em 10.547 estabelecimentos agropecuários. Seu fortalecimento depende do apoio de políticas públicas capazes de compreender especificidades regionais e criar mecanismos eficientes de desenvolvimento e consolidação do setor. Neste contexto, a Empresa Mato-Grossense de Pesquisa, Assistência e Extensão Rural (EMPAER) e a Embrapa estabeleceram uma parceria para desenvolver uma plataforma digital capaz de integrar dados de diversas dimensões territoriais. O objetivo foi caracterizar a região de forma abrangente e, principalmente, disponibilizar ferramentas de análise inteligente que auxiliem na formulação de políticas públicas e na orientação de investimentos locais. A solução foi estruturada a partir do conceito de inteligência territorial estratégica, que prevê a organização temática de dados espaciais em cinco grandes quadros: natural, agrário, agrícola, de infraestrutura e socioeconômico. Espera-se que a plataforma possa ser utilizada para subsidiar ações de gestão territorial de organizações públicas e privadas por meio da tipificação dos municípios da região em função dos seus potenciais ambientais e produtivos, apoiando instituições de pesquisa, órgãos de planejamento, gestão e de assistência técnica rural.

Palavras-chave:
Desenvolvimento rural, Análise espacial, Políticas públicas.

I. INTRODUÇÃO

Family farming is a cornerstone of Brazil's economic and social structure. It accounts for a significant portion of the national food production. According to the 2017 Agricultural Census, 3.8 million agricultural establishments in Brazil are family farms, 77% of the total agricultural establishments in the country (IBGE, 2019). Additionally, family farming employs 67% of the agricultural workforce, engaging over 10.1 million people in distinct productive activities. This segment is responsible for a diversified food production, and accounts for high national shares of several products: 70% of cassava, 51% of pigs, 64% of cow's milk, 46% of poultry, and 38% of coffee (EMBRAPA, 2022).

This scenario of productive diversity is observed, with some regional particularities, across Brazilian regions and biomes. In Mato Grosso State, the Metropolitan Region of the Cuiabá River Valley and Surrounding Area (RMVRCE) is home to over 1 million inhabitants, and almost 50 thousand people are employed in agricultural establishments (IBGE, 2019). The majority of this population are family farmers and members of traditional communities, such as quilombolas and indigenous peoples, who typically have small areas available for agriculture (on average, less than 80 ha per property) (MDA, 2015). These farmers generally work under a family-collaboration system (approximately 28 thousand families) and account for nearly 80% of rurais establishments that ensure the production of significant amounts of fruit and vegetable products

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consumed in the region, especially gherkins, cassava, okra, zucchini, green beans, tomatoes, citrus fruits, among dozens of other fruit and vegetable products (Ferro; Vechi, 2014).

One of the major challenges faced by these farmers is ensuring consistency, quantity and quality of "in natura" or "processed" products for sale (Dallemole et al., 2017). A study made for the 2014 World Cup shows that approximately 53% of fruit products, 42% of dairy products and 21% of vegetables and greens consumed in Mato Grosso State are supplied by retailers and wholesalers from other Brazilian States (mainly São Paulo, Paraná and Rio Grande do Sul), given the mismatch between demand and low production (Dallemole et al., 2013). Dependence on in natura and minimally processed foods from other states produces a constant vulnerability, given the high risk of local shortages, food insecurity and increasing costs passed on to consumers. A strategic priority for this sector would be: to increase the productivity of family farming's vocational production chains in Mato Grosso State by adopting good agricultural practices, and improving climate-intelligent agricultural technologies, as well as logistics and other important factors.

As in other developed and developing countries, the migration of the rural population to urban areas is a Brazilian problem, particularly among young people (Morais et al., 2017, Foguesatto et al., 2020). The lack of adequate public policies aimed at generating income and encouraging young people to stay in their communities contributes to their loss of interest in continuing family farming, and pushes them to urban centers in their search for opportunities. This causes an aging of the agricultural workforce, which is a structural factor that takes away the dynamism of family farming and produces uncertainty regarding the succession of these businesses (Matte; Machado, 2016; Cavicchioli et al., 2018, Guanziroli et al., 2020). As a sector that heavily relies on family labor, its scarcity is a prognosis of family farming involution (Guanziroli et al., 2020). Therefore, encouraging young people's interest through new technologies and agricultural practices applied to projects they coordinate with their families is also extremely important to sustain family farming in the region.

Both challenges will only be mitigated by converging efforts between funding, planning and implementing agencies. In this context, the Mato Grosso Rural Research, Assistance and Extension Company (Empaer-MT) has established a partnership with Embrapa Territorial to foster the development of family farming in RMVRCE, through joint initiatives to collect primary and secondary data and collaboratively carry out structured diagnoses at the regional level. This cooperation has the André and Lúcia Maggi Foundation (FALM) as sponsor and facilitator.

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The objective of this paper is to present the results obtained by this partnership when structuring a digital platform aimed to support prioritary actions within the scope of a family farming development plan in the RMVRCE region. The platform integrates secondary data about multiple themes which are relevant to characterize the region, thus enabling detailed analyses for each dimension. In addition to data selection, the process of structuring the platform includes curation, aggregation, spatial representation, and data modeling stages. The platform is expected to contribute to the classification of municipalities according to their productive and socio-environmental inclusion potential, and additionally support the elaboration of territorial development plans aimed to retain young people in the countryside, among other regional development actions.

II. Material and Methods

Study area

The Metropolitan Region of the Cuiabá River Valley was established in 2009 by the state complementary law Nr. 359, amended by the complementary laws Nr. 577/2016 and Nr. 796/2024 (Mato Grosso, 2024). The region encompasses the municipalities of Cuiabá, Várzea Grande, Nossa Senhora do Livramento, Santo Antônio de Leverger, Acorizal, Chapada dos Guimarães and Campo Verde, and its surroundings area, formed by the municipalities of Barão de Melgaço, Jangada, Nobres, Nova Brasilândia, Planalto da Serra, Poconé and Rosário Oeste. The whole territorial delimitation comprises 14 municipalities, totaling 7,850,373 ha (8.7% of the Mato Grosso State area), and is the study area of the project. As shown in Figure 1, the RMVRCE is located between the Cerrado (58%) and Pantanal (42%) biomes. Despite its lower insertion into the Pantanal biome, all municipalities are fully (9 municipalities) or partially (5 municipalities) located within the Upper Paraguay River Basin, which covers 88% of the area. The higher altitude plateaus (not subject to flooding) house most of the Pantanal rivers' tributaries and headwaters (ANA, 2015). Most environmental problems affecting Pantanal originate on the Plateau and the Depression (Irigaray et al., 2020).

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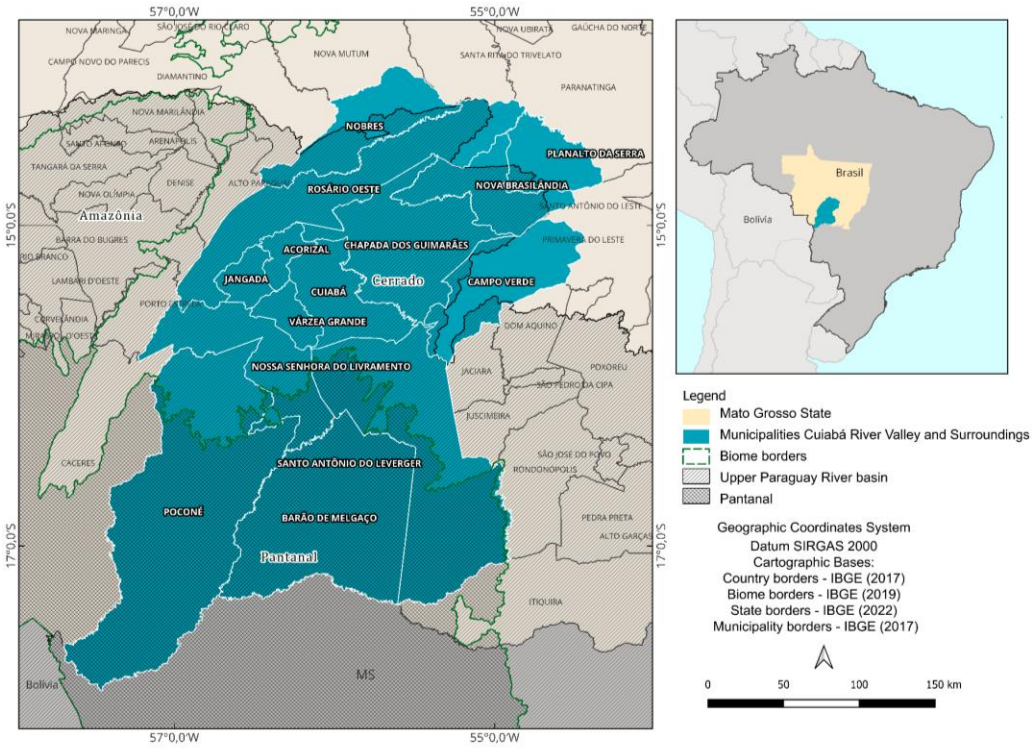

Figure 1 – Study area – Metropolitan Region of the Cuiabá River Valley and surroundings (RMVRCE).

Systems for Strategic Territorial Intelligence

A major challenge in territorial management is effectively planning and monitoring public policies while also guiding private initiatives. This requires integrating multiple knowledge areas and fostering collaboration among various society actors. The main tasks involve organizing territorial data for up-to-date analyses, which effectively enable strategic planning aimed at improving the region's social, economic and environmental conditions.

Strategic Territorial intelligence (STI, henceforth ITE, in Portuguese) is a tool that gathers geographic data, geospatial technologies, and territorial analysis to understand and make decisions related to the geographic space (Locatel, 2023). STI has been used collaboratively by several society actors and within a more comprehensive perspective. The integrated analysis of spatial data across natural, agrarian, agricultural, infrastructural, and socioeconomic frameworks is the basis of Embrapa's Strategic Territorial Intelligence Systems (Magalhães et al., 2021). This concept was adopted to structure the RMVRC's platform, with the aim of improving family farming. A Strategic Territorial Intelligence System (SITE) makes land-use governance more efficient by considering the particularities of each area and promoting sustainable planning (Rodrigues et al., 2023).

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ITE is configured as a continuous and collective process of production, integration and leveraging of territorial knowledge. Guided by sustainability and democratic governance principles, it aims to convert information into strategic actions to foster local development (García-Madurga et al., 2020). Previous territorial-policy experiences in Brazil, such as the Sustainable Development Program for Rural Territories (PRONAT) and the Territories of Citizenship Program (PTC), have already highlighted the relevance of articulation between social actors and the State to promote development strategies, often anchored in socially constructed territorial units (Delgado; Grisa, 2014). These experiences show that more than a physical space, territory is a social and political construction that requires multidimensional and integrated analysis structures, both available in the method proposed by SITE. Initiatives such as the Territorial Plan of the Bean Production Network, within the scope of the Productive Territories Program in the Pernambuco State, reinforce the importance of territorial planning as an instrument for connecting different government levels and civil society sectors and promoting governance based on production networks and participatory processes to strengthen family farming (Melo; Sousa, 2017). Such evidence demonstrates that territorial planning, when structured on collaboration and integration, is an essential instrument to promote sustainable rural development, especially for family farming.

III. RESULTS AND DISCUSSION

The platform was developed using a broad set of spatial data, and structured as a single data management mechanism, a spatial relational database (PostgreSQL + PostGIS). Due to its nature, the spatial component was considered the element that integrates the themes. Figure 2 offers an overview of the data diagram built for the platform, aiming at the normalization, consistency and integrity of the qualifying attributes. The municipality was placed as the central entity, acting as the link for cross-referencing data across multiple thematic tables. It is also the spatial element where most relationships occur, that is, several themes are spatialized by the geometry of the municipalities. The diagram also shows how the relationships between different themes are organized within each of the tables that make up the SITE. In this representation, conventional and spatial relationships are distinguished by a symbol indicating the type of spatial geometry (point, line, polygon) on the left side of their labels.

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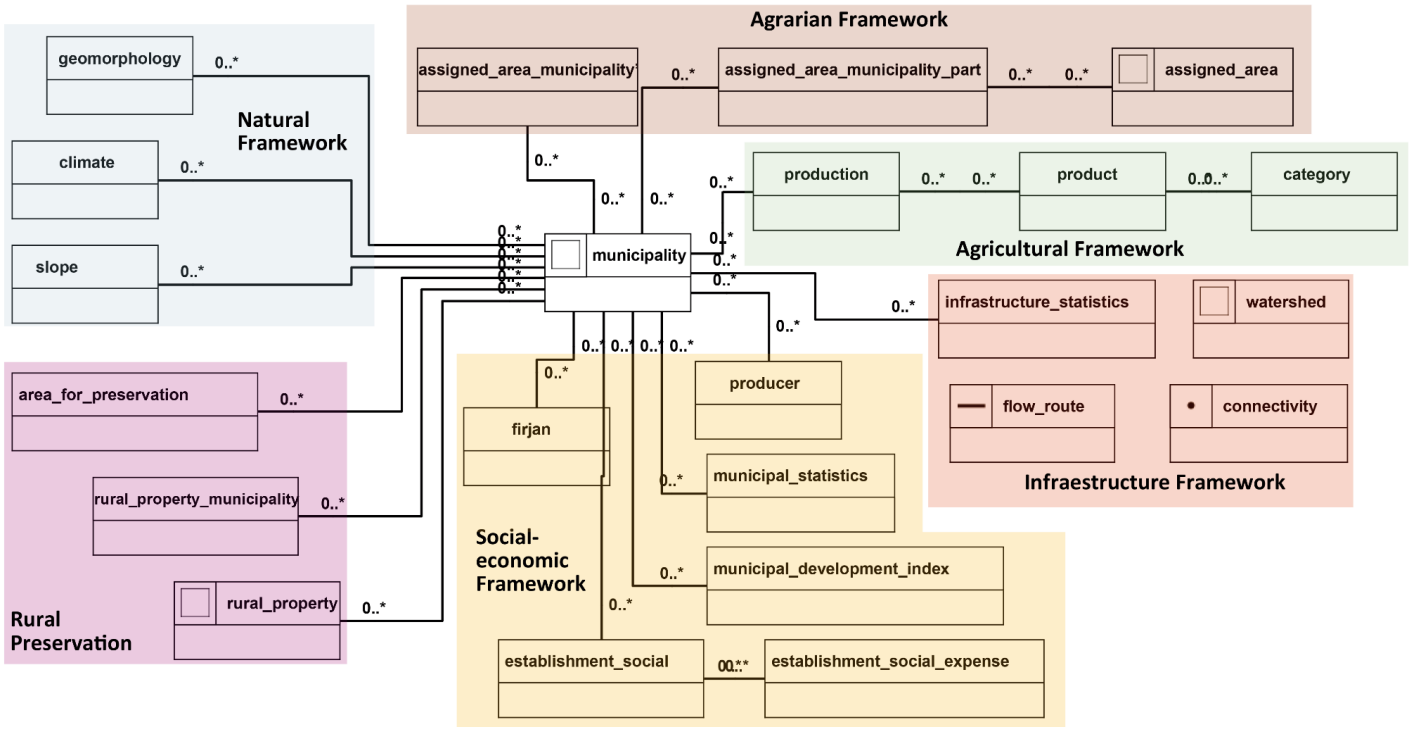

Figure 2 – Data model of the platform and its organization by thematic frames.

Figure 2's Natural Framework aggregates temperature, potential evapotranspiration and precipitation (climate) data and SRTM (Shuttle Radar Topography Mission) data (slope and geomorphology). The Agrarian Framework contains data from multiple categories of legally assigned areas: preservation units, indigenous lands, agrarian reform settlements and *quilombola* communities. These datasets and their qualifiers are compatible and integrated into a single spatial relationship that contains these areas' delimiting polygons. From this relationship, municipal consolidations on topics of interest were produced, and are portrayed in the other relationships that make up the framework.

The Agricultural Framework gathers production and harvested area data obtained from the 2017 Agricultural Census organized into products and their categories (vegetables, fruits or livestock, for example). The Infrastructure Framework portrays connectivity antennas as point geometries, flow routes as line geometries, and micro-basin limits as polygon geometries. This framework also contains additional statistics from the Agricultural Census about the establishments' access to infrastructure.

Other statistics from the Agricultural Census were systematized to compose the Social-Economic Framework, which contains detailed characteristics of rural producers and establishments, in addition to data from the municipal development indicator proposed by Firjan (2018). Data from the Rural Environmental

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Registry (CAR) complete these original databases and were organized under the Rural Preservation theme, which includes spatial delimitations (polygon geometry) of rural properties in the region and municipal consolidations on the areas dedicated to preservation within these properties.

The first step to materialize this diagram was selecting the temporal frame for the municipal grid. Seven of the municipalities of the RMVRCE experienced changes to their territorial boundaries between 2017 and 2022 (IBGE, 2022), when the last municipal grid was released by IBGE. These changes involved both losses and additions of areas. The biggest changes in terms of area were observed in the municipalities of Cuiabá and Santo Antônio de Leverger, which in 2017 included a portion a portion of what became part of the Jaciara municipality in 2022. Despite these recent changes, we decided to consider the 2017 IBGE municipal boundaries for compatibility with the 2017 Agricultural Census, which was one of our main data sources, given its number of qualifiers on agricultural establishments, producers, economic and employment indicators in rural areas, livestock, agriculture and agribusiness. Since these data are broken down by municipality, using compatible municipal boundaries from the same year was essential.

After organizing the data, we began to develop and structure the platform for hosting and visualizing information by constructing an interactive set of panels. These panels were developed using the Tableau tool, a data visualization software that enables the creation of interactive components based on the combination of structured data sources. In Tableau, the available attributes are categorized either as dimensions or measures. Dimensions are qualitative values used to categorize or segment data. Measures are numerical, quantitative values that can be aggregated (e.g. minimum/maximum, count, sum or average). For each table, measures associated with spatial features originated thematic maps. Strategic qualifiers were accommodated in other graphical visual representations considering the behavior of the data and the number of classes, such as bar/pie charts, or tree maps and tables, in some cases.

The dashboards were published on the open-access Tableau public cloud[1], where it is possible to view and explore the dashboards via browser by applying queries/filters and downloading the data. The platform content was structured using a combination of web elements, incorporating published dashboards, supporting explanatory texts and references, and organized within the Liferay content manager (Embrapa's corporate content hosting environment). Figure 3 offers an overview of the platform's organization, which is publicly available on Embrapa's portal[2]. The platform was organized into thematic pages, dedicated to each framework

[1] https://public.tableau.com/
[2] www.embrapa.br/baixada-cuiabana

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and to the rural preservation theme. The main information included in each page and the main analytical results are presented below.

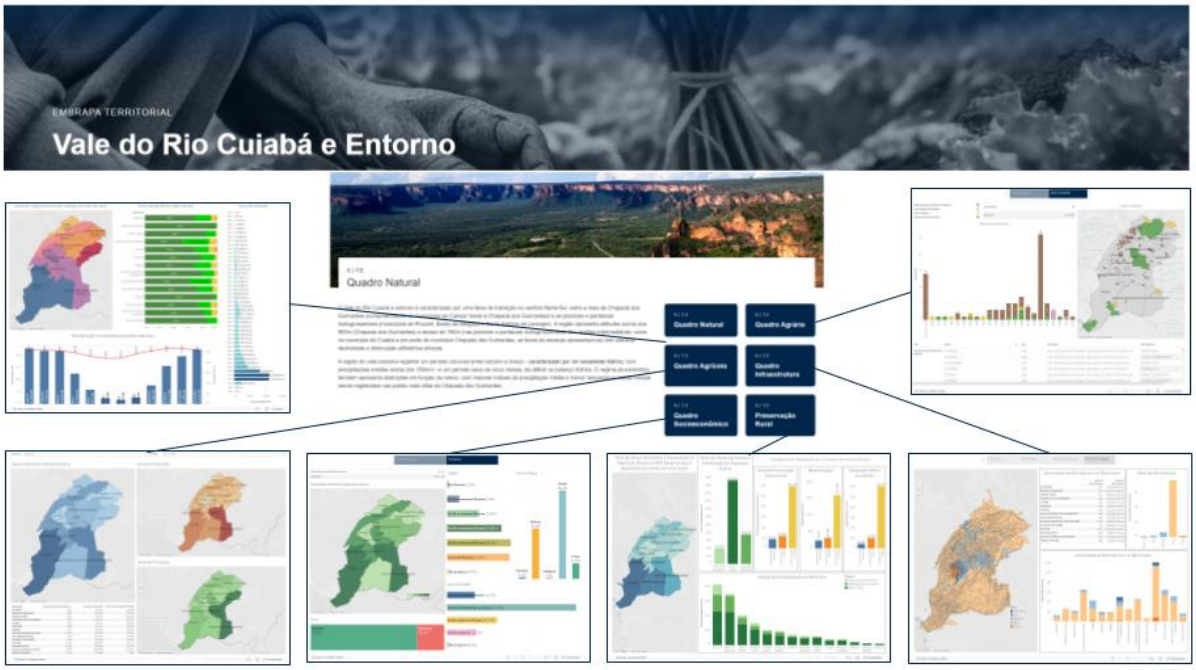

Figure 3 – Overview of the platform.

Natural framework

The natural framework presents precipitation and temperature data, variables that directly influence the water balance and, consequently, the climatic suitability for the various crops in the RMVRCE (Alvares et al., 2015). Furthermore, the framework aggregates altitude data collected by the SRTM (Shuttle Radar Topography Mission) mission and processed by the Brazilian Geomorphometry Database, which is also responsible for calculating slope metrics according to Embrapa's suitability classes (Valeriano, 2005). Geographically, the RMVRCE corresponds to a transition strip in the North-South direction, between the highest and most humid area of Chapada dos Guimarães and the floodplains and wetlands of Mato Grosso State, that are lower and drier. The region has altitudes above 900 m (Chapada dos Guimarães) and below 150 m. In intermediate regions, such as the municipality of Cuiabá and, in part of the municipality Chapada dos Guimarães, the faces of the escarpment present a high slope and abrupt altimetry variation (Prado et al., 2014). As a result, the higher and flatter areas are better suited to annual crops using techniques, while the lower ones, with rugged terrain, are home to agriculture at a lower management level.

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From a climatic point of view, the valley region usually experiences a rainy season between October and March, characterized by a water surplus, with average rainfall above 150 mm, also concentrating the main harvest, in addition to a five-month dry season with a deficit in the water balance.

The natural climate and topography conditions impose restrictions and opportunities for the development of agriculture in the region. Steep slopes limit the use of machinery and require greater care to erosion control, while the rainfall and temperature regime determine the agricultural calendars and the critical periods for the various stages of crop development (Ramalho Filho; Beek, 1995).

In addition to the problems related to low agricultural productivity, rural planning is important to reduce the environmental impact of inadequate management. Problems of soil erosion in degraded pastures and the natural susceptibility to erosion of plateau soils are a worrying factor regarding the deposition of sediments in the Pantanal floodplain and consequent silting of rivers in these lower altitude areas.

Agrarian framework

The agrarian framework presents the legally assigned areas composed of Conservation Units (UC) for full protection or sustainable use (Ministry of the Environment - MMA; Chico Mendes Institute for Biodiversity Conservation - ICMBio), Indigenous Lands (National Foundation for Indigenous Peoples - FUNAI), Agrarian Reform Settlements and Quilombola Communities (National Institute for Colonization and Agrarian Reform - INCRA). These areas were officially decreed by Mato Grosso State in the 55 years, by deliberations, decrees and acts of various bodies and administrative instances of the Federation.

The RMVRCE has 96 legally assigned areas, totaling more than 1.4 million hectares, for the base year 2023, discounting already the overlaps, which represents a territorial extension corresponding to approximately 18% of the study area. The municipality of Rosário Oeste, at the north of the study area, encompasses at least a quarter of these areas, with emphasis on the Environmental Protection Area (APA) of the Headwaters of the Cuiabá River and numerous settlements located in the central part of its territory. Regarding the agrarian structure, the UCs are the most representative category in terms of area (70%), followed by Settlements (22%), which have around 6 thousand families settled in the 14 municipalities analyzed.

The subsistence farming, with the sale of surplus products, is the basis of the economy of rural settlements and Quilombola communities. So the data from the agrarian framework available on the platform, is analyzed together with data from other frameworks, serving as a support to identify priority locations to

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promote food security, access to credit, rural assistance, and dissemination of good agricultural and environmental practices. These are locations where government programs such as the National Program to Strengthen Family Farming (PRONAF) and the Food Acquisition Program (PAA) benefit families and the local and regional economy. Despite some benefits guaranteed by the agrarian reform program, many settlers don't receive these benefits (Quintão Braga et al., 2023), which leads to a needed investigation of the living conditions from these families, as a priority for action.

Agricultural framework

The agricultural sector represents the diversity of producers and products, ranging from intensive and extensive agriculture to family farming and traditional community practices. Although agricultural production in the region represents a modest share of Mato Grosso's trade balance (approximately 5%, according to the 2017 Agricultural Census), its relevance is notable, considering the food security and economic sustainability of local families.

The most significant products in the region, both in terms of volume produced and production value, include corn, cassava, bananas and beans, among other essential foods for the population's supply. The data presented in this framework were selected to highlight the products of greatest relevance to family farming, excluding those produced on a large scale, aimed primarily at the foreign market.

The region's agricultural diversity is expressed through the cultivation of 96 different products, distributed across nine thematic categories: vegetables (fruits or parts of it), vegetables (leaves, flowers and stems), vegetables (roots, bulbs and tubers), fruit growing, grains, livestock, livestock products, other crops and extractive activities. This breadth of products allows a detailed assessment of the agricultural vocation from each municipality related to RMVRCE, promoting an improved understanding of local specificities. This diversity is materialized in local terms, and each municipality has its own particular production structure.

Regarding livestock farming, poultry is the most common activity in the region, present in 10,770 agricultural establishments out of a total from 16,115, followed by cattle and pig raising. These figures highlight the importance of livestock farming, especially poultry farming, for the local economy and in the livelihood of families in the region. In terms of production value, cattle farming stands out, taking the largest share, with R$735 million.

Despite the existence of data on agricultural and livestock production on a municipal scale, with annual and more recent periodicity (IBGE Annual Surveys PAM/PPM and PEVS), the choice of Census data is justified

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for several reasons. The most important is related to the products that are essential for the characterization of the region - the PAM list of temporary and permanent crop products does not include fruit-type vegetables such as cucumber, pumpkin, zucchini, chayote, and ten other products grown in the RMVRCE, as well as leafy vegetables such as lettuce, cabbage, arugula, and twenty other products also grown in the region (IBGE, 2018). Considering livestock, the Census allowed the stratification of data between cattle establishments with up to 50 head and larger establishments with more than 50 head, which is not possible for the PPM. Finally, the Census also systematizes several other data about the producer and establishments (Buainain; Souza Filho, 2020) that are systematized to compose other tables on the platform.

Infrastructure framework

The infrastructure framework includes information characterizing the physical infrastructure resources available in the rural areas of the region, such as electrification, access and use of irrigation, and rural connectivity coverage. In the RMVRCE, the distance from the farm headquarters of agricultural establishments to a road (road, street, or highway) varies significantly between municipalities. In Nova Brasilândia, 50% of these headquarters are more than 1 km distant from a road, while in Poconé, only 3% of the headquarters are in this condition. Due to the location of the CEASA in Cuiabá, located on the BR-364 highway, access problems are intensified due to traffic, the solution for which involves the construction of auxiliary roads, with its own challenges (Nora; Lima, 2018). This difficulty aspect to access CEASA is added to other market problems (Rodrigues Pires; Ribeiro, 2020). A great variability was observed in relation to mobile Internet coverage in areas of rural properties (SiCAR, 2021). In Acorizal, only 28% of properties do not have a mobile Internet coverage, while in Barão de Melgaço, 95% of them don't have this coverage.

Regarding the use of irrigation, it was found that the most widely used system is drip irrigation, with Cuiabá, Poconé and Campo Verde presenting most rural properties with this type of irrigation. In addition, in the study area, the wetting technique is used, which involves the utilization of hoses or other systems not provided for in the other categories, for the irrigation horticultural beds, predominantly in the municipalities of Santo Antônio do Leverger, Várzea Grande and Cuiabá. Considering the potential for the expansion of irrigated areas, Barão de Melgaço and Poconé present more than 100 hectares of watershed areas with a high availability of water captured directly from watercourses.

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Social-economic framework

The social-economic framework is responsible for gathering social and economic indicators to represent the different regional realities, with an emphasis on family farming. For this purpose, it presents an interactive panel segmented into two main sections: 'The establishment', where the available variables are associated with the profile of the agricultural establishments present in the RMVRCE; and 'The producer', where the information is dedicated exclusively to the characterization of the producers in the region.

In the 'The establishment' section, the agricultural establishments are represented in relation to the main variables characterizing them: a) classification to family and non-family farming; b) size of the establishment; c) land use of the establishments; d) identification and measurement of financial expenses incurred on the establishments; e) purpose of production, whether for marketing or own consumption. Based on this analytical set of information on family farming, it is possible to distinguish different profiles of municipalities in relation to agricultural activities, which can promote different policies for each type and condition (Buainain; Souza Filho, 2020; Guanziroli; Sabbato; Buainain, 2020).

Regarding RMVRCE, the establishments are mostly family farms (65%), ranging from a participation level of 54% in Cuiabá to 76% in Campo Verde and Barão de Melgaço. There are, however, important internal differences in the analysis of the other available variables. While municipalities such as Planalto da Serra, Nova Brasilândia and Poconé have their own/family consumption as the preferred purpose of the establishments, which indicates family farming with low capacity for commercial exploitation, other municipalities such as Nobres and Campo Verde have its production aimed mainly for commercialization, which demonstrates a higher capacity of producers to enter the markets. This differentiation is also found when considering land use: in Nobres and Campo Verde, the area used for temporary crops is representative in relation to different uses, which is not the case in other municipalities of the region, whose main characteristic of use is represented by the pasture area, whether planted or native. This heterogeneity reflects the complexity of rural development in Brazil which, as pointed out by Schneider et al. (2010), is a multifaceted process that includes diverse realities and grants rural actors an active role in the construction of their ways of life.

In the section 'The Producer', information is dedicated to characterize the universe of producers in the region. To this end, information on age and education level is presented, segmented into different categories, and identification of gender (male or female), in addition to color or race. In this region, 80% of producers responsible for agricultural establishments are men, a percentage close to the national average of 81.3%. In

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this regard, there are no significant differences between the municipalities in the region, but Barão de Melgaço and Planalto da Serra reach percentages above 90% of men managing the establishments. Research indicates that the strong male presence in the management of rural properties is probably associated with historical issues of succession and concentration of land in male figures. In addition to that, many models of family organization underestimate or make invisible the female contribution (Gonçalves; Teixeira, 2021; Silva; Lima, 2018). This male predominance in management, as pointed out by Gonçalves and Teixeira (2021) and Silva and Lima (2018), may be intrinsically related to the devaluation and invisibility of female work in family farming, where women play a fundamental role, but are often not recognized as the main decision-makers.

Regarding color or race, the region's producers are mostly brown, with percentages ranging from 60% to 75%. However, it is worth highlighting the difference recorded in the municipalities of Campo Verde and Nobres, where producers declared themselves as white are the majority, in the case of the former, and very close to the majority, in the case of the latter. Regarding education and age data, all municipalities in the region register significant bottlenecks. In the case of education, the vast majority of producers (more than 50%) have only elementary education, with high school accounting for a share between 15% and 25% in most municipalities. The low level of education observed among rural producers in the RMVRCE is similar to other regions in Brazil, which can limit access to more efficient technologies and agricultural practices, as well as create significant obstacles to access credit and technical assistance (Cruz et al., 2021). Regarding the age profile, all municipalities reveal a chronic and emerging problem of family succession: more than half of the producers are over 55 years old. This situation, combined with possible conditions of economic stagnation, can generate a significant decrease in family farming at the regional level, making commercial activity unviable in some locations. The lack of successors on rural properties compromises the continuity of agricultural activities, the transmission of family assets (Spanevello et al., 2017) and the social reproduction of family farming itself.

Rural preservation

Territorial analyses based on data from the Rural Environmental Registry System (SICAR) provide insight into the territorial dimension of rural properties and the scope of areas designated for the preservation of native vegetation in the region (Ferreira et al., 2019; Miranda et al., 2020). In the processing of data and consolidation of the number of areas dedicated to the preservation of native vegetation by municipality, presented in this work, overlaps between vegetation categories were removed following the priority:

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hydrography overlaps permanent preservation area (APP); permanent preservation areas overlap legal reserve; legal reserve overlaps additional native vegetation area.

At RMVRCE there are 14,545 rural properties registered in the 2023 SICAR, occupying an area of 5,750,502 ha (73.3% of the region). These rural properties dedicate 3,378,925 ha of their areas to the preservation and conservation of native vegetation (43% of the RMVRCE). The region is located in the Cerrado of the Legal Amazon (requirement of 35% legal reserve in the 2012 Forest Code) and in the Pantanal (requirement of 20% in the 2012 Forest Code). On average, a rural property dedicates 58.8% for such purposes. In the RMVRCE, 11,167 rural properties are small, with up to 4 tax modules (77.4% of the total), while medium-sized rural properties are 1,906 (13.2%) and large rural properties 1,363 (9.4%). In terms of area occupied by rural properties, the situation is reversed: large properties occupy 3,992,615 hectares (70.0% of the total area of rural properties), while small properties occupy 719,613 hectares (12.6%). The largest registered properties are in the municipalities of Poconé, Barão de Melgaço and Santo Antônio do Leverger, located in the Pantanal Biome. One of the platform's features is the individualized visualization of areas designated for preservation within municipalities, which allows to observe the size of these areas according to the size of the properties. Two divergent examples are the municipalities of Jangada and Acorizal. While in Jangada, more than 60% of the legal reserve (67%) and excess native vegetation (61%) are in large rural properties, in Acorizal the legal reserve is mainly in small (33%) and medium (34%) properties, and native vegetation predominantly in small properties (56%). It is worth noting, however, that the rural area of Jangada has 61% of the area occupied by large properties, while in Acorizal, large properties correspond to 31% of the total rural area.

IV. CONCLUSIONS

The territorial intelligence platform for the Metropolitan Region of the Cuiabá River Valley and Surrounding Area (RMVRCE) is a significant advance in the integration of spatial and thematic data, allowing a comprehensive analysis of regional realities. It provides detailed information on natural, agrarian, agricultural, infrastructure and social-economic aspects, within the concept of the Strategic Territorial Intelligence System. The platform is a strategic tool to support the sustainable development of family farming in the region. The classification of municipalities based on their environmental and productive characteristics enables the formulation of more assertive public policies that meet local specificities and promote productive inclusion and social-environmental sustainability.

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Additionally, the platform demonstrates the capacity of inter-institutional cooperation between Embrapa, Empaer-MT and FALM to generate innovative and effective solutions to complex challenges, such as retain young people in the countryside and preserve natural resources. The experience acquired at RMVRCE could be a model for other regions, encouraging the use of territorial intelligence technologies to strengthen family farming and sustainable territorial management for different contexts in Brazil.

Potential next steps to continue the research include collecting, registering and integrating primary data through collaborations with different public and private institutions and social organizations (e.g. associations, cooperatives, agribusinesses). Primary data from production chains, access roads to production areas, institutional and private markets could be aggregated, contributing to policies supporting and promoting family farming.

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