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Paths of the landscape: changes in land use and the perception of stakeholders in the landscape of Leme–SP

Caminhos da terra: transformações no uso do solo e percepção de sujeitos na paisagem de Leme-SP

Mariane de Cassia Gallo[*], Renata Evangelista de Oliveira[**], Adriana Cavalieri Sais[***], Eliana Cardoso Leite[****]

[*] Programa de Pós-Graduação em Desastres Naturais - Instituto de Ciência e Tecnologia (ICT), Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP) e Centro Nacional de Monitoramento e Alertas de Desastres Naturais (CEMADEN), mariane.gallo@gmail.com
[**] Departamento de Desenvolvimento Rural na Universidade Federal de São Carlos (UFSCar), reolivei@ufscar.br
[***] Departamento de Desenvolvimento Rural na Universidade Federal de São Carlos (UFSCar, acsais@ufscar.br
[****] Departamento de Ciências Ambientais na Universidade Federal de São Carlos (UFSCar), eliana.leite@ufscar.br

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Abstract

This study investigated the relationships between land use and cover changes, territorial dynamics, and perceptions regarding water availability in the municipality of Leme-SP, located within the UGRHI-09 region. The objective was to analyze how farmers and non-farmers perceive changes in the landscape and water availability, linking these perceptions to technical data and spatial analyses. Secondary data were used to characterize rural properties and landowners, including the 2017 Agricultural Census, LUPA Project, and SICAR-SP. Water use rights were identified through DAEE-SP and the River Basin Plan (SIGRHi), while land use changes between 2000 and 2021 were obtained from the MapBiomas project. Fieldwork involved 32 semi-structured interviews (16 farmers and 16 non-farmers), analyzed through descriptive statistics and categorical content analysis. The results indicate that local perceptions largely align with public data and technical analyses: predominance of sugarcane monoculture, urban expansion, a reduction in native vegetation cover (12.6%), and increased pressure on water resources (47% of water grants for irrigation and aquaculture). Most respondents (90.63%) associated forests with improved water quality and quantity, and 84% advocated for forest expansion. Regional climate and hydrological data corroborated perceptions regarding rainfall changes and reduced water availability. The findings reveal affective and productive ties to the territory, critical awareness of landscape changes, and the complexities related to deterritorialized exploitation. The study highlights the importance of considering social, cultural, and subjective dimensions in the design of public policies and territorial planning.

Keywords:
Family Farming, Belonging, Water resources, Monoculture, Climate Change.

Resumo

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Este trabalho investigou as relações entre transformações no uso e cobertura do solo, dinâmicas territoriais e percepções sobre disponibilidade hídrica no município de Leme-SP, inserido na UGRHI-09. O objetivo foi analisar como agricultores e não agricultores percebem mudanças na paisagem e na água, articulando essas percepções com dados técnicos e análises espaciais. Foram utilizados dados secundários do Censo Agropecuário (2017), Projeto LUPA e SICAR-SP para caracterização dos imóveis rurais, além de informações sobre outorgas (DAEE-SP, Plano de Bacias/SIGRHi) e uso do solo (MapBiomas, 2000 e 2021). Realizou-se levantamento de campo com 32 entrevistas semiestruturadas (16 agricultores e 16 não agricultores), analisadas por estatística descritiva e análise de conteúdo. Os resultados indicam que as percepções locais coincidem, em grande parte, com dados públicos e análises técnicas: predominância da monocultura da cana-de-açúcar, aumento da urbanização, redução da vegetação nativa (12,6%) e pressões sobre os recursos hídricos (47% das outorgas para irrigação/aquicultura). A maioria dos entrevistados (90,63%) relacionou florestas à melhoria da água, e 84% defenderam o aumento da cobertura florestal. As análises climáticas e hidrológicas regionais corroboram as percepções sobre alterações nas chuvas e na disponibilidade hídrica. Evidenciaram-se vínculos afetivos e produtivos com o território, percepção crítica sobre mudanças na paisagem e complexidades associadas à exploração desterritorializada. Reforça-se, assim, a importância de considerar dimensões sociais, culturais e subjetivas na formulação de políticas públicas e no planejamento territorial.
Palavras-chave:
Agricultura Familiar, Pertencimento, Recursos Hídricos, Monoculturas, Mudanças Climáticas.

I. INTRODUCTION

Historically, the concept of development has been linked to economic expansion and increased productivity, understood as the ability to produce more goods and services with fewer resources (Anwarya, 2022). This perspective enabled significant advances, such as the increase of food supply, the mechanization of agriculture, and the dissemination of technologies in rural areas. On the other hand, the same logic has also promoted intense transformations in rural landscapes, such as changes in land use and methods of agricultural production, intensifying the pressure on natural resources. As a result, there was an increase in the vulnerability of ecosystems and agroecosystems, with negative effects on soil, water, and biodiversity. Environmental degradation, in turn, compromises ecosystem services, directly affecting human well-being (Adla et al., 2022).

Several studies indicate that extreme events related to water security, such as droughts, floods, and forest fires, have intensified in different regions of the planet (Ferreira; Almeida, 2021; Jones et al., 2022). In Brazil, such phenomena make it more challenging to achieve the Millennium Development Goals and, consequently, the Sustainable Development Goals (Barbado; Leal, 2021), especially in areas where the burden

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on natural resources is increasing. The degradation of ecosystem services, coupled with the intensification of socioeconomic demands, compromises the resilience of territories (Weiskopf et al., 2020). Anthropogenic activities continue to push the regenerative capacities of these natural systems, while relying on them to ensure quality of life (Shah, 2022). In this scenario, the discussion on approaches to environmental governance that consider ecological limits and social participation in resource management becomes relevant**.**

In Brazil, the model of intensive resource use is reflected in water management. The country has approximately 12% of the freshwater available on the planet (FAO, 2020). However, the observation of the scale of analysis is once again necessary, as studies on a national scale can mask regional and local inequalities. According to the report "*Conjuntura dos RecursosHídricos*" (Water Resources Environment) of the Agência Nacional de Águas (National Water Agency – ANA), annual rainfall variations are commonly greater in some states and regions than in others; however, in 2019, more pronounced droughts were observed in all four states of the southeast region, compared to other regions of the country (ANA, 2020). In this context, the effects of climate change tend to magnify the impacts of this pattern of land occupation and use. The Intergovernmental Panel on Climate Change (IPCC, 2023) warns that changes in land cover directly affect the hydrological cycle, contributing to the intensification of extreme events and the loss of ecosystem resilience. As Blanchy and collaborators (2023) highlight, inadequate agricultural practices compromise the water regulation of territories, increasing the challenges related to environmental sustainability and water security.

International scientific production has highlighted that the effectiveness of climate adaptation policies depends not only on technical solutions, but also on the integration of social, cultural, and psychological aspects in their formulation and implementation (Hügel; Davies, 2020; RusmayadiI et al., 2024; Noll et al., 2022). Studies show that factors such as risk perception, self-efficacy, social norms, and emotional concerns significantly influence the engagement of populations in adaptive actions, revealing that motivation for adaptation varies according to the social and institutional context (Noll et al., 2022; Houser et al., 2022; Puig et al., 2025). This perspective converges with the proposal for a re-connection between society and the biosphere as a way to overcome the fragmentation of environmental policies (Falkenmark, 2020), and is supported by approaches that propose a governance sensitive to the needs of future generations, based on intergenerational equity and on learning with the mistakes and successes of the past (RusmayadiI et al., 2024). In this sense, understanding how local stakeholders perceive the transformations of the landscape and natural resources becomes essential for creating effective public policies, adapted to specific realities. Studies that

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value the local knowledge of farmers and urban residents can reveal socio-environmental dynamics that often escape the technical approaches to planning.

This work aims to analyze the perception of family farmers and residents of the municipality of Leme-SP about the transformations in landscape and water availability, intertwining these perceptions with official data on land use and cover and water grants. Its starting point is the hypothesis that the meanings attributed by the stakeholders to the territory express not only a sensitive and local interpretation of the local environmental reality, but also reveal tensions and contradictions between productive models, daily practices, and public policies. By combining different sources of information, spatial analysis, and social discourses, we seek to contribute to the debate on environmental planning based on integrated and territorialized approaches.

As highlighted by Landrigan and collaborators (2024), problems such as pollution, climate change, and biodiversity loss have direct and adverse impacts on human health. Therefore, investigating different existing perspectives is essential to effectively create and implement public policies aimed at sustainability, human well-being, and fostering the culture of resilience (Wu, 2013; Ciccotti, 2020).

Authors such as Vygotsky (1991) and Leontiev (2021) highlight the dialectical unity between the practical action of subjects in the world and the development of the psyche, i.e., there is no separation between the individual and the social environment in which they live. For these authors, awarenessis structured from concrete activity, at the same time that it reorganizes it, mediating social relations. This relationship is dialectical because it is not one-way: activity produces awareness, but awareness, once formed, reorganizes and guides new ways of acting, mediating social relations. Thus, all action is simultaneously determined by historical social and cultural conditions and, at the same time, it constitutes a possibility of transformation of these same conditions. Human awareness, in this sense, is not only a reflection of the world but an active element in its transformation. Marx, as a fundamental theoretical reference for the cited authors, highlights, in his *Economic and Philosophic Manuscripts* (Marx, 2004), the centrality of work as a vital activity, through which human beings transform nature and, simultaneously, constitute themselves as social and historical beings. This transformation is not only material, but also symbolic: by acting on nature, individuals imprint meaning to the world, establishing a relationship mediated by culture. This perspective is essential to understand that the meanings attributed to the use of natural resources and practices related to environmental preservation are not natural data, but socially and historically constructed, resulting from collective processes and, therefore, permanent objects of dispute. The daily actions related to resource

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management, such as decisions on land or water use, are part of networks of activities that, in their genesis, are collective and cannot be understood in isolation. Thus, analyzing the perceptions of stakeholders about local environmental transformations requires considering these social, historical, and cultural interactions that shape both consciousness and action.

II. Materials and Methods

Characterization of the area of study: Municipality of Leme - SP

The area of study, presented in Figure 1, is located in the Peripheral Depression of São Paulo, where hills with wide tops and straight to convex slopes predominate. According to the Soil Map of the State of São Paulo, the soils that prevail in the region are Red and Red-Yellow Latosols, among others found less frequently, such as Quartzarenic Neosols (Oliveira et al., 1999). They are soils in an advanced intemperization state, occurring in an area with low drainage density that demonstrate agricultural aptitude. The climate falls into the Cwa type according to the Köppen classification, that is, it presents a warm season with summer showers and dry winters. The native forest cover is predominantly composed of the Seasonal Semidecidual Forest (Silva; Souza, 2020), with traces of Cerrado vegetation (Oliveira et al., 1999; Costa et al., 2015).

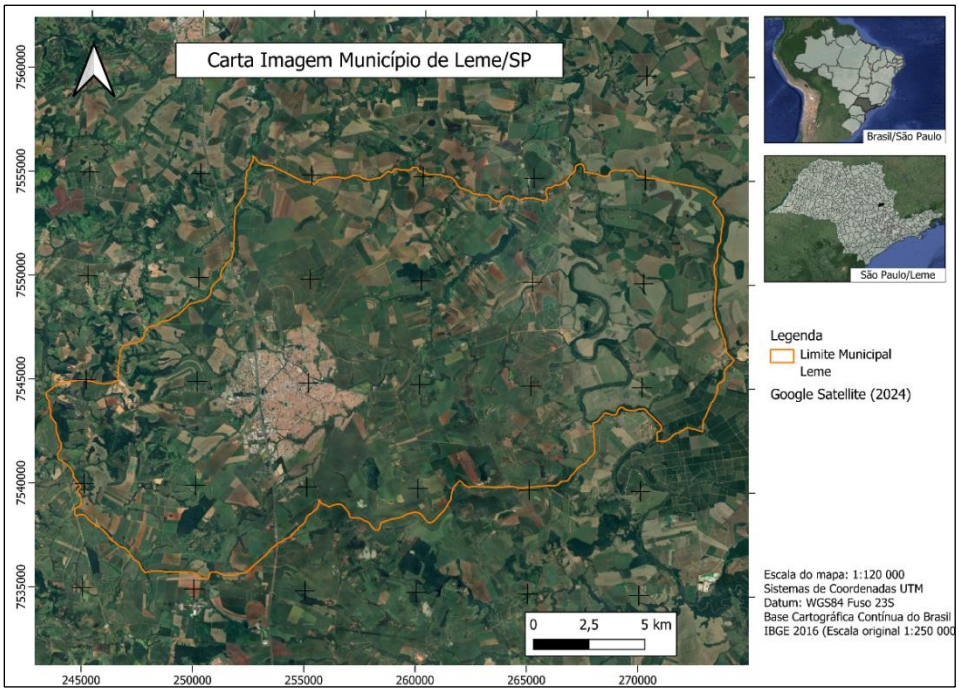

Figure 1 – Location of Leme-SP.

The municipality of Leme has a mostly urban population, with 101,316 inhabitants estimated in 2024, compared to the 98,161 registered in the 2022 Census (IBGE). It is part of the Urban agglomeration of

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Piracicaba, considered one of the most dynamic in the interior of São Paulo (Braga, 2018), and holds the 235th position in the state ranking of GDP per capita (IBGE, 2023). Its economy is historically linked to the agricultural sector, with emphasis on the production of sugarcane, which occupies an extensive cultivated area and supports the production chain of the regional sugar-alcohol industry (Souza Sardinha et al., 2010). This culture, already responsible for more than 50% of agricultural production in 2005 (Moraes et al., 2009), contributes to the homogenization of the rural landscape and puts pressure on natural resources, especially in contexts of land concentration and expansion of monoculture (Tscharntke et al., 2005). According to data from the MapBiomas Project (2021), 84.81% of the municipal territory is occupied by agricultural activities, with 7.29% of forest cover remaining. Leme is located in the Alto Mogi section of UGRHI-09, whose economic base, according to the Water Resources Status Report (CBH-Mogi Guaçu, 2023), is marked by agriculture, livestock, and agro-industries focused on the production of orange, corn, sugarcane, sugar, alcohol, and beverages.

Data collection and analysis

General characterization: Profile of farmers, land use, and occupation in Leme-SP

In the first stage, the general characterization of the profile of the farmers in the municipality was carried out, based on data from the Agricultural Census of 2017 (IBGE) and the LUPA Project (SAA-SP, 2016/2017). Information on age range, gender, and formal education of farmers was collected. The classification of properties by size followed the criteria defined by the Rural Environmental Register (CAR), and data on the size of the production units were obtained from the National System of Rural Environmental Registration (SICAR), a public platform created by Federal Decree No. 7.830/2012. To ensure greater reliability of the information, only properties with active registration, valid coordinates, and location compatible with the city limits were considered. Records with missing, duplicate, or incompatible data were discarded.

The information on grants for water collection (domestic, industrial, and agricultural use) was obtained from the records of the Department of Water and Electric Power of the State of São Paulo (DAEE) and the Basins Plan available in SIGRHi. For this purpose, data with "current" status for 2021 and clearly specified use were prioritized, seeking to ensure consistency with the objectives of the study.

Characterization of the profile of the interviewees

The second stage sought to characterize the profile of the stakeholders who participated in this research beyond the census data, from a qualitative approach. The semi-structured interview approach (Box

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1) was chosen with the objective of identifying feelings, thoughts, opinions, values, perceptions, and attitudes of the interviewees (Moré, 2015) in relation to landscape transformation and effects on water resources.

To define the sample, we combined the snowball sampling and time-space sampling techniques, both considered appropriate in studies with populations of difficult access or territorially dispersed (Dewes, 2013). The methodological choice took into account, especially, the context of the COVID-19 pandemic, still present at the beginning of data collection, which required additional ethical, logistical, and sanitary care, and demanded greater flexibility in approaching the interviewees. Among family farmers, the spatial dispersion of properties and full-time work on the farms made the *snowball technique* effective to ensure access to the farmers' network, and, in this case, the formation of a relatively homogeneous group regarding professional activity, that is, the "bubble" that we intended to access was intentional. For the non-farmers group, the strategy was reversed: a randomness criterion was adopted in the choice of contact points. The combination with time-space sampling helped reduce the risk of excessive homogeneity of responses, avoiding the formation of very restricted or niche subgroups. Thus, we sought to ensure amplitude and contrast between the perceptions of those who live and work directly with the land and those of individuals who predominantly occupy the urban space. The final sample was composed of 32 participants, 16 farmers (all linked to the Rural Producers Association of Leme – APRUL, responsible for the Producer Market) and 16 non-farmers. The interviews were carried out between February and July 2022. The end of the collection process followed the saturation criterion, that is, when new participants stopped adding relevant information to the data set (Dewes, 2013). It is important to emphasize that the results obtained from the interviews are not meant as a statistical representation of the whole population of the city, given the intentional and qualitative character of the sample. The main objective was to identify patterns and meanings in participants' perceptions, which could be contrasted with the secondary data available for Leme-SP, in order to enrich the understanding of local socio-environmental dynamics. This triangulation sought to prevent hasty conclusions, allowing us to recognize approximations, contrasts, and gaps between official records and the daily perception of the stakeholders.

The analytical approach considered several geographic scales: national (from data such as the Agricultural Census and the Forest Inventory of the State of São Paulo), state (projects such as the LUPA and data from UGRHI-09), municipal (Leme data and maps), and intra-municipal (local perceptions). This multiscale perspective allowed us to integrate the structural dimensions of the territory into the daily experience of

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those interviewed, valuing both the technical interpretation of the space and the local knowledge obtained from the interviews.

All research participants signed the Free and Informed Consent Form (TCLE), approved by the Research Ethics Committee under number 52928121.1.0000.5504. The interview script (Box 1) included closed questions, with alternatives formulated based on the Likert scale, widely used in exploratory research to investigate perceptions and attitudes, including in qualitative studies (Martins; Theóphilo, 2009), and open questions, without inducing answers. The data obtained from the closed questions were systematized through descriptive statistical analysis, with the support of the R software (version 4.2.1). Since this was a small and qualitative sample, the internal consistency test (Cronbach's alpha) was not applied, because the closed variables acted as interpretative support, not as a measuring instrument.

The open answers were processed using the content analysis technique, more specifically, the categorical approach proposed by Bardin (1977), following three stages: (i) pre-analysis, with organization and skimming of the transcripts; (ii) material exploration, identifying and grouping the units of record into categories; and (iii) processing of the results, using inference and interpreting the text based on the literature and secondary data.

The interfacing between the content of the interviews and the spatial data on land use and cover was carried out through thematic confrontation with secondary data from MapBiomas (years 2000 and 2021). Two maps were developed in a SIG environment (QGIS, version 3.22.2) to represent and quantify territorial changes in the municipality of Leme. These cartographic representations allowed us to identify patterns such as the advancement of monoculture, urban expansion, and the reduction of vegetation areas, which were compared to the recurrent perceptions recorded in the interviews, thus enriching the analysis of local socio-environmental transformations.

III. RESULTS AND DISCUSSION

General Characterization

According to the data from the 2017 Agricultural Census, 267 establishments with valid records were identified in the municipality of Leme-SP, which constitutes the sample used in this analysis, and not an estimate of the total municipal land structure. Based on that, Figure 2 was created, using the information declared in the Rural Environmental Register (SICAR) regarding the size of rural properties. Of the properties registered in the Census, only 19 had one woman as the person in charge, while 236 (88%) were run by men.

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Although the Census data reflects the person legally in charge of the property, which in many cases corresponds to the traditional family structure, the literature points out that this pattern reveals persistent gender inequalities in the Brazilian rural environment. Such asymmetries do not arise from the family structure itself, but from the way in which the sexual division of labor still makes unviable or subordinates the role of women in agriculture (Bueno; Silva, 2020; Silveira et al., 2021; Lawrence; Hensly, 2023). Women farmers often face difficulties in accessing land, credit, technology, and public policies, which compromises not only their autonomy, but also the sustainability of productive activities, as evidenced by several studies (Manta, 2019; Nascimento et al., 2024; Nascimento Siqueira et al., 2024). The data also indicate a small presence of younger producers: less than 5% of those responsible for the properties are under 35 years old. This aging of farmers is a challenge pointed out both by national studies and the interviews conducted in the present work, and has important implications for the continuity of family farming and generational succession in the countryside (Breitenbach; Dallagnol; Troian, 2023).

According to data from the interviews conducted in this study, most participants declared themselves to be white, while only 1.5% declared themselves to be brown, indicating a low degree of racial diversity in the sample. This data is consistent with the socio-racial composition of the Southeast region and, more specifically, the municipality of Leme, where the presence of self-declared black or brown farmers is notably lower than the national average. According to the 2017 Agricultural Census, in Brazil, 78.5% of rural producers declare themselves to be white, 18.2% brown, and 2.9% black. However, the North and Northeast regions have significantly higher proportions of black and brown workers, revealing an unequal distribution that goes back to historical, socioeconomic, and structural factors related to land occupation and access to agricultural policies (Carvalho, 2021). In the context of Leme-SP, the prevalence of white farmers reinforces this asymmetry and indicates a more pronounced excluding pattern. As discussed by Milton Santos (2006), geographic space is the product of historically constructed social relations and, therefore, reflects the power structures that organize it. Recognizing these disparities at the local level is fundamental to proposing approaches to promote greater inclusion and social justice in rural areas (Nascimento et al., 2024).

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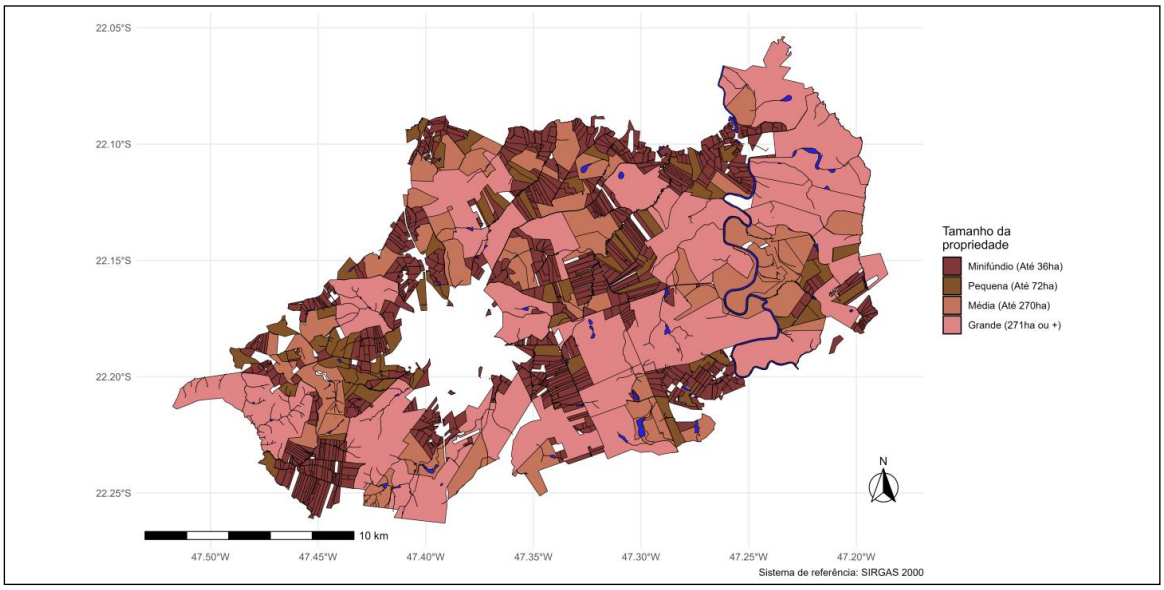

Figure 2 – Classification of properties according to their size (Source: SICAR, 2022).

In Leme-SP, based on the data obtained from SICAR (2022), compared to the criteria of land classification of the Rural Environmental Register (CAR), most of the rural properties analyzed fall into the category of small property (up to four fiscal modules, in the case of the municipality, 96 hectares). For this analysis, only properties with active records and valid geographic coordinates were considered. Although the sample analyzed does not represent the totality of the existing registrations, it faithfully reflects the structural trends of the local land distribution. When the occupied area is observed, it is noticeable that the large properties occupy about 47% of the rural territory, evidencing a structure marked by inequality, in line with the national conjuncture (Maués, 2022). Despite initiatives such as the National Agrarian Reform Program (PNRA), which aims to promote a fairer distribution of land, issues such as land titling and regularization still face bureaucratic obstacles and institutional fragility (Marchetti, 2020). In addition, the reduction of investments in agrarian reform policies has weakened instruments of democratization of access to land, accentuating inequalities in rural areas (Matheus; Feliciano, 2021).

By examining the main crops in the municipality according to the cultivated area, sugarcane stands out as the dominant one. Data from the Agricultural Census (2017) indicate about 25k hectares occupied with sugarcane, while corn occupies 3.8k hectares, orange 1.7k hectares, and soybean 1.5k hectares (Figure 3). The predominance of sugarcane is directly related to the process of land concentration, since its production is strongly linked to large properties and requires infrastructure, mechanization, and logistics that go beyond the capacity of family agriculture (Baccarin et al., 2020).

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The concentration of production in a few crops, especially in a single commodity, contributes to the homogenization of the rural landscape, the reduction of productive diversity, and the increase of socio-environmental vulnerability, central topics of this work (FAO, 2019). In addition, this scenario was identified in the interviews, in which family farmers expressed concern about the expansion of sugarcane and its relationship with water scarcity, the loss of productive territory, and the decrease of agricultural variety. Thus, the land and productive analysis is directly linked to the perception of the stakeholders, revealing how hegemonic models of land use impact both the territorial structure and the daily experience of those who inhabit and cultivate these spaces.

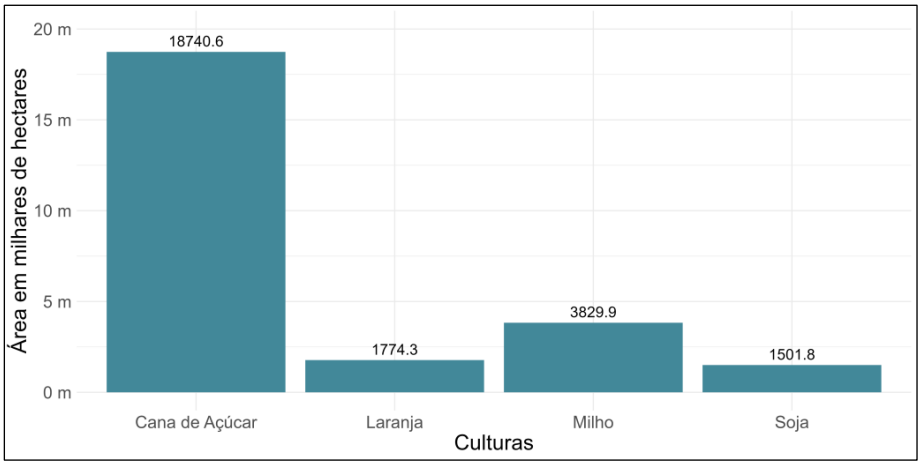

Figure 3 – Area of agricultural properties in Leme-SP regarding the main cultivated crops (Source: Agricultural census, 2017).

Figure 3 shows the predominance of sugarcane in land use in Leme-SP, with 18,740.6 hectares cultivated, an area much larger than that of other crops such as corn, orange, and soybean. This predominance reflects the strength of the regional sugar-alcohol chain and is associated with large properties, intensive mechanization, and high levels of water demand (Baccarin et al., 2020; Rudke et al., 2022). Data from the Department of Water and Electric Power (DAEE) indicate that 28.38% of the grants in the municipality are destined for irrigation, which corroborates the pressure exerted by this productive model on water resources. In contexts of recurrent droughts, as alerted by IPCC (2023), this scenario reinforces the urgency of integrated strategies of territorial and water management (Tsakiris; Loucks, 2023), especially in view of the challenges faced by family agriculture and the reduction of productive diversity.

In summary, it is possible to observe that the general profile of farmers in the municipality reflects the national context identified by the Agricultural Census (IBGE, 2017; Abonízio; França; Nunes et al., 2023). Municipal information shows the predominance of sugarcane, following the trend observed in the state of São

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Paulo, the national leader in agricultural production (IBGE, 2022). The primary sector was responsible for most of the total water demand granted in 2021. Regarding the vegetation cover, Leme presents only 12.6% of native vegetation remaining, an index lower than the state average of 22.9%, according to the last Forest Inventory of the State of São Paulo (SIFESP, 2020). This reality confirms patterns already pointed out in previous studies, such as that by Souza Sardinha and collaborators (2010), which analyzed the environmental impacts associated with land use in the rural area of the municipality and identified deforestation for sugarcane and livestock expansion as central factors in the degradation of vegetation cover and loss of biodiversity. The persistence of these aspects over time, more than a decade later, reinforces the importance of integrating the results generated by academic research with the formulation of public policies. The absence of vegetation cover, the predominance of monocultures, and the increasing pressure on water resources indicate the urgency of initiatives aimed at restructuring the ecological landscape, based on the dialogue between academia, environmental management, and territorial planning.

Perception of the Landscape – Interviews

Based on the answers to questions 1 and 2 (Box 1), two categories of analysis were obtained*: transformed space* and *untransformed space*.

Box 1 – Semi-structured Interview Guide.

1)	Do you think the rural landscape of the municipality has changed over the past twenty years? Yes ( ) No ( ) If yes, how?
2)	Do you think the urban landscape of the municipality has changed over the past twenty years? Yes ( ) No ( ) If yes, how?
3)	Do you think agriculture influences water availability? Strongly agree / Agree / Neutral / Disagree / Strongly disagree – Why?
4)	Do you believe that the presence of native vegetation/forest influences the quantity and quality of water? Strongly agree / Agree / Neutral / Disagree / Strongly disagree – Why?
5)	Do you think we should plant more forests in the municipality? Strongly agree / Agree / Neutral / Disagree / Strongly disagree – Why?
6)	Are there noticeable changes in the occurrence of rainfall and periods of drought over time (last 20 years)? Strongly agree / Agree / Neutral / Disagree / Strongly disagree – Why?
7)	Have you noticed changes in water availability over time (last 20 years)? Decreased significantly / Decreased / Remained stable / Increased / Increased significantly

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Only one farmer said he believed that the rural landscape had not changed in the last 20 years, and two other people (non-farmers) did not know how to respond. Most of the sample recognized changes in the rural landscape, listing some of the possible reasons for that. To better identify the perception of the interviewees, three subcategories were created, related to the causes of this transformation: agriculture, industry and trade, and urban expansion. It was possible to pinpoint how people interpret the advance and prevalence of sugarcane monoculture in the area. The statements, once again, show an agreement with the information obtained through official sources, but, above all, show the subjective meanings that individuals attribute to these transformations:

> "Agriculture **is a strength** of the city, **orange and cane**" (Interviewee 1).
>
> "It has changed natural vegetation, **large sugarcane crops took the place of subsistence crops**, there was a change in the water quality of rivers, roads, and rural communities changed" (Interviewee 25).
>
> "With the expansion of paved roads and the **predominance of sugarcane crops**" (Interviewee 31).
>
> "**It's the sugarcane, you know.** But, how can I say, people who are small farmers have more like, in my case, cassava, pumpkin, those are the things we plant. But in the larger area it is sugarcane" (Interviewee 8).
>
> "The wetlands dried, lakes decreased, deforestation in industrial areas is getting very close to the river" (Interviewee 15).

Going back to the contributions of historical-cultural psychology, authors such as Leontiev (2021) and Vygotsky (1991) emphasize that awareness is not formed in an isolated way but emerges from the social practices of the subject in interaction with the environment. From this perspective, a practical activity is not only a means of adaptation, but also a process through which individuals attribute meanings and reorganize their relationship with the world. Thus, the answers of the interviewees show how they perceive the expansion of monoculture not only as an objective change in land use, but as a transformation that directly affects their practices, identities, and types of relationship with the territory. The answers of the interviewees, which associate the expansion of monoculture and the reduction of vegetation to the worsening of water quality and the reduction of productive diversity, are in line with the findings of Zhang et al. (2021), who identified, in a chinese context, the importance of local perceptions on ecosystem services as indicative of social demands for environmental sustainability. For the authors, the greater the importance attributed to certain services, the greater the social demand for their preservation, showing that such perceptions should guide territorial planning and public policies.

According to the historical-cultural approach, awareness is simultaneously a product and mediator of the activity: after perceiving the retraction of vegetation, decreased rainfall, or reduced subsistence practices,

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participants reorient their actions, adjust, or resist the new spatial configurations, and reinterpret the socio-environmental dynamics around them. This process is especially evident in the answers that mention the replacement of small crops by monoculture or the loss of wetlands, demonstrating how collective practices of land and water management are affected by disputes of meanings and subjective reconfigurations. As authors Wu (2013) and Ciccotti (2020) highlight, the meanings attributed to the environment profoundly influence the daily practices and resilience of communities in the face of socio-ecological changes. Thus, the perceptions of the interviewees, at the same time, express the objective reality of the expansion of the monoculture and constitute socially mediated interpretations that guide their actions and resistances.

This interaction between perception, practice, and awareness reinforces the importance of understanding environmental transformations not only in terms of physical changes or land use policies, but also as processes that affect subjectivity and shape the possibilities of collective action in the territory. Similarly, a study by Ahammad and collaborators (2019) revealed that rural residents build their understanding of environmental transformations from everyday experience, with perceptions that, in many cases, coincide with technical data and satellite images. This convergence reinforces the analytical potential of local perceptions as diagnostic tools and points to the importance of incorporating them into environmental management strategies. Thus, the present work contributes by demonstrating how the perception of environmental changes is inseparable from the historicity of local practices and culture, mobilizing knowledge and affections that transform the relation of individuals with the landscape. The impacts of changes on land use and occupation are significant for a greater sustainability of agricultural practices (Viola; Mendes, 2022). From the perspective of the interviewees, such changes have negatively impacted the availability of water and the variety of crops. According to Araújo e Araújo (2020), the intensive production of sugarcane around the industries hinders agricultural diversification, which results in a uniform landscape.

When asked about the changes in the urban area, only two farmers said they did not notice changes, while the others declared noticing the transformation of urban space over the years; there was no relevant difference between the perspective of farmers and non-farmers:

> "With the visible **expansion of the urban area, construction of land plots** for the poorer and **gated communities** for the richer" (interviewed 30).
>
> "The **city grew** a lot, the **peripheral area increased** a lot, forming new neighborhoods. The central region was seized by commerce, with **great destruction of historic buildings**. There was the construction of new schools and institutions for health care and social well-being. Also, the huge growth of **gated communities** presents us with a separatist view of social classes." (Interviewee 25)

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> "The **city spread out**, the periphery increased. The city grew a lot, and the city center became busy." (Interviewee 15)
>
> **"It expanded a lot**; there was no asphalt everywhere." (Interviewee 10)
>
> "The spaces near my house, for example, have fewer trees. **The number of buildings in the city has increased** as well." (Interviewee 26)

Although urban expansion toward rural areas is a common phenomenon in several regions, little is known about how local stakeholders perceive and deal with this transformation. The results show that, regardless of the characteristics of each group, there are shared concerns regarding the spread of the urban fabric. David Harvey (2014) highlights the dynamics of capital reproduction throughout the urban space and the importance of active participation of the population in the management of cities. In Leme-SP, the interviewees described horizontal growth, with peripheral neighborhoods to the east and gated communities to the west and northwest, a pattern also identified in the analysis of Figure 4. This configuration expresses an excluding urbanization model, marked by strong socio-spatial segregation (Calixto, 2021; Santos Cunha; Luz Conceição, 2023). Orsi (2014) adds that the housing policy of the municipality, by being dissociated from urban planning, reinforces this logic, consolidating peripheral properties with low urban and environmental quality. Thus, the perceptions raised reveal that the participants recognize and attribute meanings to the urban transformations they experience daily, expressing them through terms such as "the city spread out", "grew a lot" and "formed new neighborhoods", or even when referring to the "destruction of historical buildings" and the "separatist view of social classes". These statements demonstrate that the interpretations about urban expansion are built in social practice, from the direct experience of individuals in the changing space, which, in turn, influence the ways in which they relate to the city, shaping everyday practices and affections. The sharing of these perceptions reinforces the idea that urban expansion is not only a spatial or demographic phenomenon, but a socially mediated process, loaded with meanings, that impacts identities and expectations about the future of the city.

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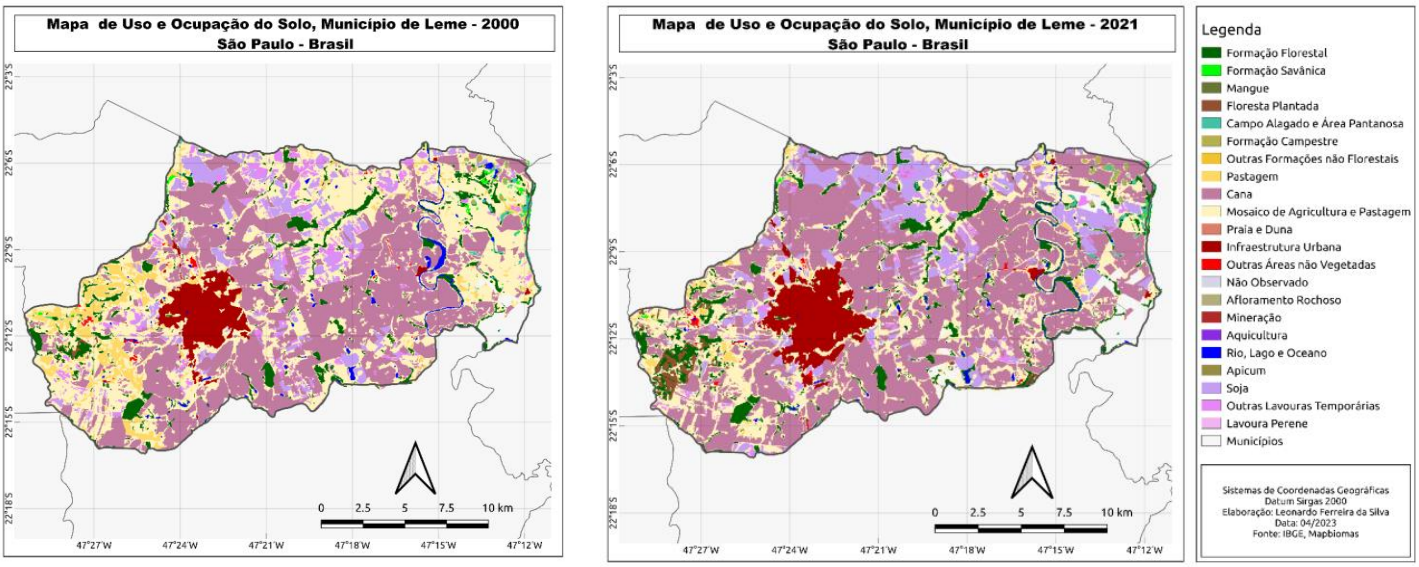

Figure 4 – Map of land use and occupation in Leme – SP in the years 2000 and 2021. (Source: IBGE, Mapbiomas, 2022).

When comparing the information and geographic data collected, which are spatially represented in Figure 4, we can see a clear example of how, even in the face of difficulties of access to academic or institutional knowledge, local communities, in this case, family farmers, demonstrate a practical knowledge deeply rooted in their experience with the landscape (Sandim et al., 2021). This finding is in line with the international literature on traditional ecological knowledge, which highlights the relevance of local knowledge in perceiving environmental transformations and building sustainable strategies for managing natural resources (Vinyeta; Lynn, 2013; Berkes, 2017; Brondízio et al., 2021). Recent studies show that local knowledge, socially constructed and continuously updated by daily experience, is fundamental to community resilience in the face of climate change (Reyes-García et al., 2019; Nakamura; Kanemazu, 2020). Traditional ecological knowledge contributes to the monitoring of ecosystems and the adoption of culturally rooted adaptive strategies, as evidenced by Kupika et al. (2025) in riparian communities in Zimbabwe affected by water scarcity. In this sense, recognizing the ability of family farmers to perceive and interpret changes in the landscape not only legitimizes their experiences but highlights the importance of integrating their knowledge into environmental conservation policies and participatory territorial planning (UNESCO, 2017; Brondízio et al., 2021; Fenetiruma; Kamakaula, 2023). According to Sele and Mukundi (2024), by incorporating local knowledge into socio-cultural practices, community accountability is reinforced, increasing environmental and socioeconomic resilience. It is important to note that the authors admit that, despite the advances promoted by community-based conservation approaches (CBC), challenges such as resource scarcity, land-use conflicts, and limited political-institutional support still persist. Therefore, they advocate for the adoption of robust

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political interventions, training programs, and ongoing financing mechanisms as essential strategies to strengthen local governance and ensure the effectiveness of conservation actions over time.

Water resources and vegetation cover

When asked about the influence of agriculture on water availability (Figure 5), 66% of respondents said they believed there is a relationship between water availability and agricultural activities, 16% were indifferent, while 19% disagreed.

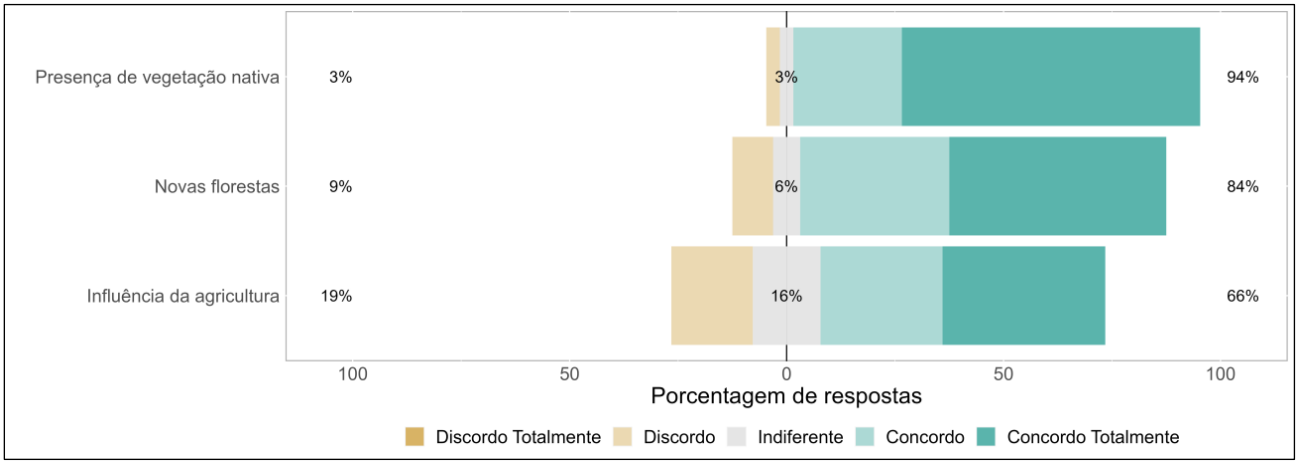

Figure 5 – Percentage of answers to questions about the influence of native vegetation/forest cover and water quality; whether we should plant more forests in the municipality, and on the impact of agriculture on water availability.

In Figure 6, we can notice a perception difference between the groups: a higher proportion of non-farmers (73.3%) state that agricultural activity influences water supply, compared to farmers (64.7%). Although this difference was not submitted to a statistical significance test, due to the qualitative and exploratory nature of the sample, it suggests a relevant trend that reinforces the need to consider different perceptions about the impacts of agriculture on water availability. Reflecting on the positioning of the groups on this issue, we can note that 23.5% of farmers said they did not believe agriculture affects water availability, whereas only 6.7% of non-farmers manifested the same view. The distinction between the perceptions of farmers and non-farmers observed in this research is also reported by Suškevičs and collaborators (2023), who demonstrated that different social groups attribute different values to ecosystem services based on their roles, experiences, and daily practices. These heterogeneous perceptions reinforce the need for territorial policies that consider multiple points of view regarding the environment, avoiding homogeneous solutions in diverse socio-environmental contexts.

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The specialized literature points out that, in many agricultural regions, the intensive use of soil for monocultures, especially sugarcane, tends to reduce water infiltration, increase erosion, and decrease water quality, which may be associated with the use of agrochemicals (Guarenghi; Walter, 2016; Tomasella, 2022). On the other hand, studies indicate that the effects vary according to the type of management adopted, the type of soil, and the conservation practices implemented, revealing a complex and sometimes contradictory picture (Bordonalet al., 2018; Milindiet al., 2024). Thus, this perceptive divergence between the groups can be interpreted as a reflection both of direct experiences with the territory and of differences in the circulation of information about the effects of agriculture on water systems. Combining local perceptions and technical data can contribute to qualifying water policies and management practices in the municipality.

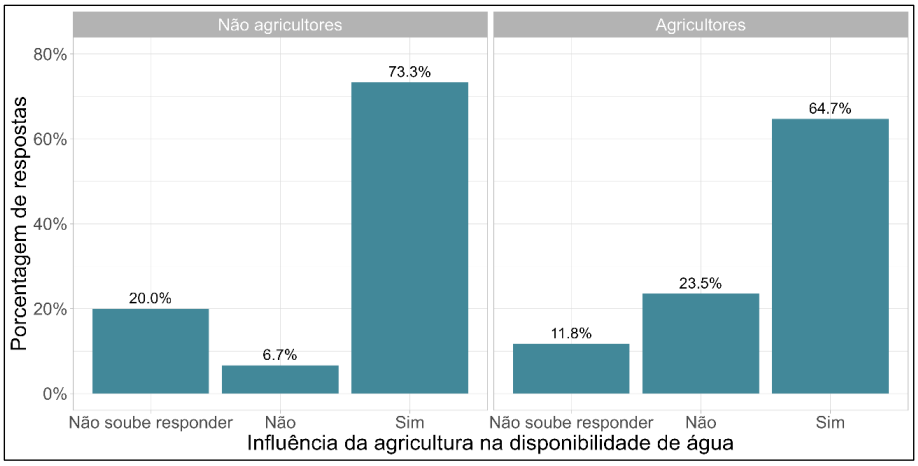

Figure 6 – Answers on the impact of agriculture on water availability compared between farmers and non-farmers groups.

The "*RelatórioSíntese do Sexto Ciclo de Avaliação do IPCC*" (IPCC Sixth Assessment Cycle Summary Report – AR6) highlights that unsustainable agricultural expansion intensifies the vulnerability of ecosystems and human populations and the competition for land and water resources. The document points out that extreme weather events have exposed millions of people to food and water insecurity, with especially severe effects in vulnerable countries and communities, such as those located in South America, the region where this study was conducted, as well as among small producers, low-income families, and indigenous peoples around the world (IPCC, 2023).

According to Yu and Leng (2022), much of the impact on global temperature is related to the transitions of forested/non-forested secondary lands, urban areas, and agricultural land. Therefore, it is essential to include strategies that address these transitions and land use practices, aiming to reduce the effects of global warming and mitigate climate change in different regions of the planet (Artaxo, 2022). In Leme, these transitions are evident, as demonstrated in the cartographic analysis created based on

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MapBiomas data (2000 and 2021) and represented in Figure 4. There is a reduction in native vegetation cover to 12.6% of the territory, a percentage lower than the state average, accompanied by the expansion of agricultural areas, especially those destined for sugarcane, and by the growth of urban areas. These processes reflect, on a local scale, the transformations pointed out at a global level (IPCC, 2023) and reinforce the importance of integrating strategies for vegetation conservation and territorial planning aimed at mitigating environmental impacts in the region.

The testimonies obtained in question 4 demonstrate what participants think about the importance of native forest and vegetation in the quantity and quality of water. Three categories of analysis were created: *positive perception*, *negative perception*, *and non*-perception (Cardoso, 2021). The *negative perception* category was excluded after the process of inference and interpretation, because none of the participants' answers had elements against the forests. That being said, the following result was found: 90.63% perceive a positive impact, while 9.38% did not notice anything or did not know how to answer. This perception can be related to both daily practical experiences and the circulation of broader environmental discourses, present in the media, in schools, or in state and national policies. However, such positive awareness does not necessarily translate into effective changes in the pattern of land use and occupation, since factors such as economic interests, land structure, and lack of technical and financial support make it difficult to adopt more conservationist practices (Altieri, 2012). Thus, although the recognition of the importance of vegetation is present, it is accompanied by the persistence of productive models that promote landscape fragmentation and pressure on water resources.

Among the participants who attributed a positive impact to the vegetation (Figure 7), 58.6% mentioned provision services; 20.7%, regulation services; 13.8%, support services; and 10.3% expressed positive value without giving any details. Farmers emphasized regulatory services more, while non-farmers highlighted support functions. These results contrast with the findings of Consorti and collaborators (2021), in a study on environmental perception conducted in the city of Boituva-SP. In the aforementioned work, a greater emphasis was identified for cultural services among urban and rural populations, followed by regulatory services. Research on environmental perception often identifies variations in the ways different social groups recognize and value ecosystem services. These differences are expected because perceptions are shaped by factors such as occupation, connection with the territory, access to information, and life experiences (Balta-Ozkan; Le Gallo, 2018; Zanni et al., 2021; Thiemann et al., 2022).

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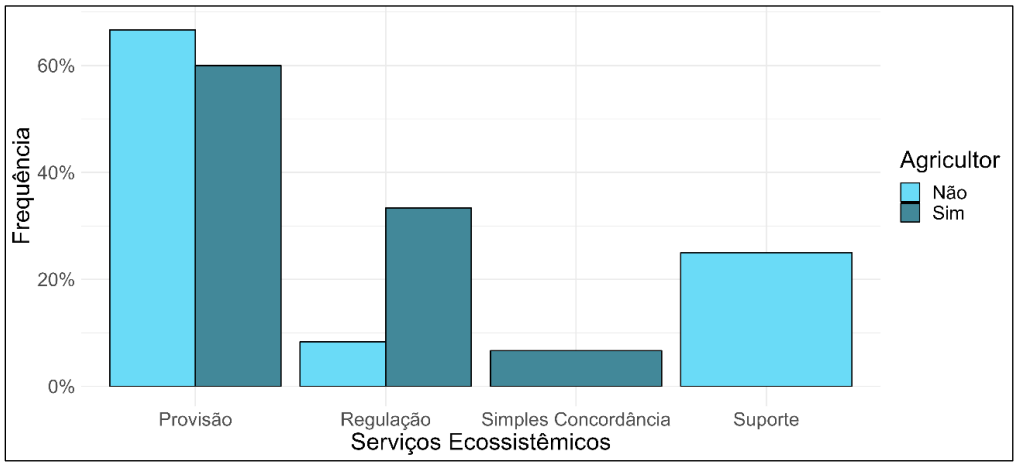

Figure 7 – Comparison of answers (Q4 – Box 1) between groups of farmers and non-farmers (Source: author).

Regarding the awareness about the value of vegetation, the following is highlighted:

> "Of course. Suppose I was born in Taquari Ponte and I now live in Taquari Bairro. Where I used to live, it was all muddy, there were all those ponds' people used to talk about, ditches, as people used to call them. Now, they planted sugarcane and drained everything, so there is no water, and where are the bushes? There is no vegetation. We need vegetation to make water, to keep water in the soil. I can say that because I remember when I was little, where I was born... We planted rice, and there was water... We harvested the rice with water up to our waists, and now, there is nothing, nada. There isn't a drop of water. Even the tanks there used to be there aren't there anymore, because they drained everything and cut the vegetation, because it was vegetation before, right? Nowadays, if you plant rice, like they used to do back then, in the water, there is no more, you can't" (Interviewee 8).

A total of 84% of participants agree with the need to increase the forest areas in the municipality, although there is divergence in relation to the location where this would be necessary and its reasons:

> "It depends, actually, people should take better care of what we still have" (Interviewee 18).
>
> "It depends where. Not in Leme, it has to be where the springs are and in the spring that supplies Leme. Planting in Leme won't do much" (Interviewee 5).
>
> "I believe that the streets, the urban area, have a great need; it would have to have many more trees" (Interviewee 6)
>
> "We must provide the cultivation of trees that are native to the region, with a view to restoring climate conditions" (Interviewee 25).

These answers demonstrate not only the value given to the vegetation, but also the local perception about the limitations and practical possibilities of expanding the forest cover in the municipality. As Pinto et al. (2010) indicate, ecological restoration faces challenges such as the availability of appropriate areas, conflicts with consolidated productive uses, high economic costs, and the need for interinstitutional articulation. In addition, the success of restoration initiatives strongly depends on the clear definition of their goals — how to protect springs, improve ecological connectivity, or mitigate the effects of climate change — and territorial allocation strategies that consider both ecological function and the local socioeconomic reality (Wohl et al., 2015; Shimamoto et al., 2018; Edwards; Cerullo, 2024).

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In the case of Leme, the predominance of intensive agricultural areas and land concentration may hinder the allocation of new forest areas, especially in regions with higher productive value. On the other hand, the suggestions of the interviewees, such as prioritizing areas of springs and urban areas in need of afforestation, point to the need for integrated territorial planning, which considers not only the quantitative expansion of the vegetation cover but also its ecological and social function.

All participants, when asked about changes in rainfall patterns and periods of drought over the last 20 years (Figure 8), said they noticed changes in the rain and drought periods. However, there was a difference when comparing the answers between the groups: the mention of the decreased rainfall was more frequent in the responses of farmers compared to non-farmers. When comparing the perceptions of participants with the climatological data referring to the southeast region, where the municipality of Leme is located, we found an important convergence with trends identified in recent studies. Cunha et al. (2023) demonstrated that the Brazilian Southeast experienced extreme drought events, especially between 2014 and 2015, whose impacts significantly compromised water supply and agricultural production, highlighting the socio-environmental vulnerability of the territory in the face of climate change. In addition to the intensification of droughts, historical series analyses indicate a growing irregularity in the distribution of rainfall, a phenomenon that increases water instability and affects food security, with effects already widely documented in the literature (Nobre et al., 2016; Nunes et al., 2023). In the Alto Mogi section of UGRHI-09, where the municipality of Leme is located, the pressure on water resources has increased, with a reduction of the per capita availability and the water balance in a critical situation, requiring actions such as reforestation and recomposition of APPs (CBH-Mogi Guaçu, 2023). The data reinforce the perceptions of farmers on water reduction and prolonged droughts, aligning local experience with technical diagnoses. Pressures such as population growth, intensive land use, and the decrease in rainfall aggravate the scenario, highlighting the urgency of integrated public policies for conservation and adaptive water management.

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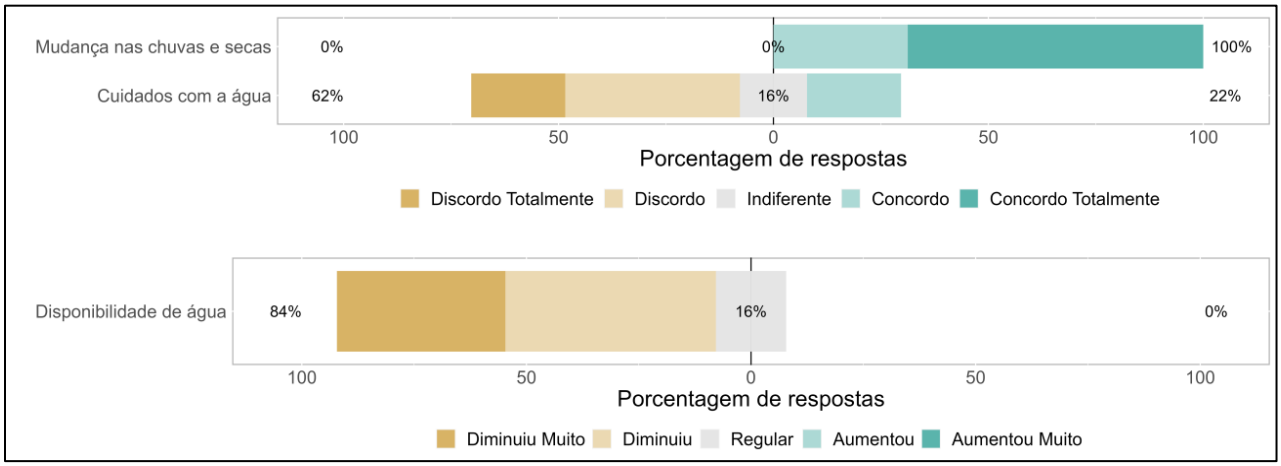

Figure 8 – Percentage of answers to questions 6 and 7 (Source: Author).

Individuals who mentioned cause and effect relations had their answers combined in the following subcategories: less rainfall, long droughts, and climate change (9). This classification was instituted based on the meanings inferred, taking into account the phrases and words used by the participants (Castro, 2011).

Individuals who mentioned cause and effect relations had their answers combined in the following subcategories: less rainfall, long droughts, and climate change (Figure 9). This classification was created based on the meanings inferred from recurrent expressions and terms used by the participants, following the recommendations of Castro (2011), by emphasizing that environmental perception is a social construction, mediated by values, knowledge, and experiences lived.

The identification of these subcategories suggests that the participants articulate their experiences with broader processes, such as climate change, although often intuitively or based on experiences accumulated over the years. This result reinforces the importance of considering environmental perception as a qualified indicator of local socio-environmental transformations, not only as a reproduction of scientific information, but as a situated elaboration, anchored in practice and direct observation of the environment.

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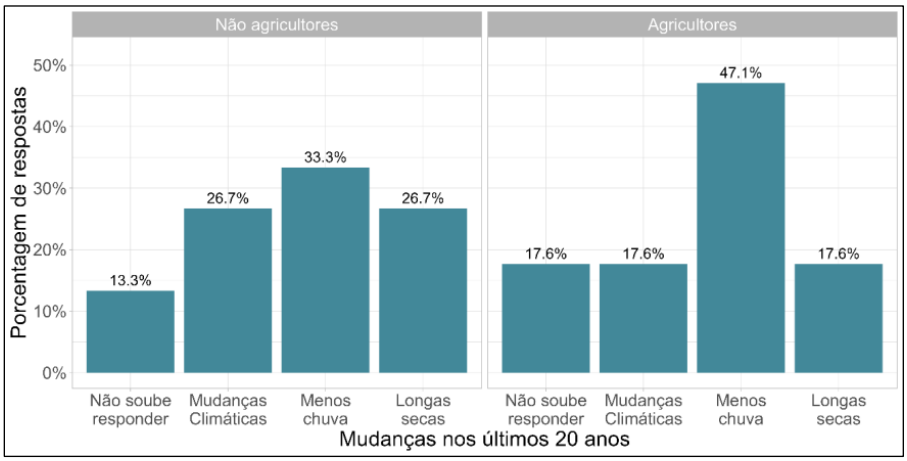

Figure 9 – Comparison of answers (Q.6 – Box 1) of the farmers and non-farmers groups (Source: Author).

It is important to note the existence of answers that pointed to the context of climate change. The following passages are highlighted:

> "[...] everything is kind of *out of control* [...]." (Interviewee 10)
>
> "Yes. There was more regularity before. It is raining less and less and in an *irregular* way." (Interviewee 13)
>
> "The weather *used to be more predictable*, the heat increased, and the cold decreased." (Interviewee 27)

Regarding changes in water availability over time (last 20 years), 84% of the participants noticed a decrease (37% indicating that availability decreased a lot, and 47% responding that availability decreased), 16% said they did not notice changes (indifferent), and no participants indicated an increase in water availability over the last few years. The participants noticed changes in the rainfall pattern and water availability in the last 20 years, mainly in the farmers' group, linking the presence of water to the existence of forest cover, that is, demonstrating an understanding of the interdependence between the different systems. The identification of the relationship between water and forests more often in the answers of farmers shows the role of personal experience, in line with Falkenmark (2020), who stresses that it is imperative to adopt a perspective that acknowledges people and nature as interdependent systems, paying special attention to water management for socioecological sustainability and resilience.

IV. CONCLUSIONS

The analysis of the answers of the 32 participants revealed that the family farmers and interviewees not connected to agriculture recognize significant transformations in rural and urban landscapes over the past

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two decades in the city of Leme-SP. These perceptions express a moving territory, affected by external pressures that reconfigure soil use, vegetation cover, and water availability.

The aging of those responsible for rural properties and the low presence of young people, observed both in census data and in the sample of family farmers, reflect a national trend and may compromise the continuity of traditional practices and local management of common assets. The interviews also highlighted the complexity of the processes of deterritorialized exploitation, in which family farmers remain physically in the territories but lose decision-making power and the symbolic link to the dynamics that affect them. This finding points to the need to expand the analysis of environmental transformations beyond physical aspects, incorporating the social, cultural, and subjective dimensions that shape the ways of living and giving meaning to spaces. The convergence between the perception of the stakeholders and the technical diagnoses shows that their narratives are not mere impressions, but consistent reflections of concrete processes of space transformation.

Finally, the findings of this research reveal that environmental perception, when anchored to official data and interpreted in the light of critical theoretical references, becomes a powerful, methodological, and political tool for local socio-environmental diagnosis. By giving visibility to the ways in which individuals experience, describe, and signify the changes in the landscape, we pave the way for building more sensitive public policies that recognize the multiple perspectives that coexist in the territory. This careful reading allows not only to map contradictions and tensions, but also to glimpse possibilities. Possibilities of fairer territorial planning, conservation actions that respect the memory of places, and strategies that restore the vital role of water, soil, and vegetation in the fabric of life. By articulating reason and affection, technique and experience, the study reaffirms the urgency of policies that arise from the ground and dialogue with those who inhabit it.

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