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“AMTR-MS E A TRANSIÇÃO AGROECOLÓGICA NO CERRADO: EXPERIÊNCIAS PRODUTIVAS E SOCIOBIODIVERSIDADE NO ASSENTAMENTO NAZARETH”

“AMTR-MS AND THE AGROECOLOGICAL TRANSITION IN THE CERRADO: PRODUCTIVE EXPERIENCES AND SOCIOBIODIVERSITY IN THE NAZARETH SETTLEMENT”

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ABSTRACT

This article presents a case study on the process of agroecological transition in the Nazareth Settlement, located in Sidrolândia/MS, based on a Technical Assistance and Rural Extension (ATER) initiative conducted by the Association of Rural Women Workers of Mato Grosso do Sul (AMTR-MS), in partnership with the Sustainable Rural Cerrado Project. Between November 2022 and April 2023, 22 families were monitored through interviews, technical visits, and georeferenced photographic records. The collected data allowed for the characterization of the initial production conditions, with emphasis on mixed cattle farming (meat and milk) and the significant presence of marolo (Annona crassiflora) as a native species with economic potential. The analysis showed that livestock stocking rates ranged from 0.8 to 1.7 head per hectare, generating net margins of R$ 300.00 to R$ 600.00 per animal, but with strong dependence on external inputs during the dry season. Land use between 2014 and 2022 revealed a reduction in the dominance of pastures (from 70% to 50%) and significant growth of agroforestry systems (from 5% to 20%), reflecting ongoing productive diversification. Meanwhile, marolo production, estimated at 150 to 300 kg annually per family, proved comparable to the income obtained from a dairy cow, but with lower input demand and greater contribution to ecosystem services. It is concluded that ATER plays a fundamental role in structuring more resilient agroecological systems, capable of articulating environmental conservation, food security, and income generation, highlighting the relevance of AMTR-MS as an agent of socio-environmental transformation in the Cerrado.

Keywords: *Agroforestry systems; Rural women's organizations; Technical Assistance and Rural Extension (ATER); Annona crassiflora (marolo); Sustainable livelihoods.*

INTRODUCTION

Observed in the daily routines of family farmers' production units are elements and guidelines capable of orienting structural conditions for the sustainability of development within the Cerrado landscape. In this context, the recording of characteristics related to the functionality of productive area management, production and income potential, and the dialogue between production and conservation of the biome's sociobiodiversity begins.

In a landscape marked by the ancient soils of the savanna, with its complex flora and fauna, the challenge falls on a recent Agrarian Reform settlement, established between 2015 and 2018 for different families. From the outset, two features became evident: the presence of cattle ranching, with a focus on dairy production, and the coexistence with the fruit-bearing species *marolo* (Cerrado araticum, genus *Annona*), still little explored in botanical studies of the Annonaceae family.

The current context includes the recent trajectory of the Association of Rural Women Workers of Mato Grosso do Sul (AMTR-MS), which operates within a regional social geography. For the Nazareth Settlement, located in the municipality of Sidrolândia/MS, AMTR-MS stands out as the main actor leading a project in its early stages. This demands from farming families an adaptation to local and regional ecological conditions, as well as facing the first structural steps: building houses, establishing productive facilities, and attempting to access supportive public policies. Along this path, AMTR-MS assumes a strategic role in shaping an agriculture with an agroecological profile, especially through the implementation of agroforestry systems (AFS), already adopted by several families.

Among the initial steps of institutional support, different projects were directed towards soil fertility restoration, environmental care, the establishment of productive systems with the acquisition of animals, the encouragement of handicrafts, and Technical Assistance and Rural Extension (ATER). In this scenario, special attention is given to the ATER process initiated at the end of 2022, in its diagnostic phase between November 2022 and April 2023, whose guiding focus was to support agroecological farming through the establishment of AFS.

Some basic characteristics define the profile of the ongoing project:
(1) the settlement is in an initial stage, with farming families accumulating between 4 and 6 harvests up to 2023, in relatively homogeneous conditions;
(2) plots of approximately 10 to 13 hectares per family, encompassing about 175 families;
(3) predominantly sandy soils, imposing specific restrictions on the emerging agriculture;
(4) cattle ranching as the predominant initial activity, especially dairy production;
(5) families tending toward mixed production (meat and milk), with sales varying according to herd conditions and the dry season;
(6) limited support from public policies, characterizing the production units as still in the early stages of structuring a development project.

This article thus presents a case study developed during the implementation of an ATER initiative carried out by AMTR-MS, in partnership with the Sustainable Rural Cerrado Project, with 22 families from the Nazareth Settlement, in Sidrolândia/MS. The central objective was to highlight the role of ATER with a critical and constructive

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character, which collects data, performs analyses, and demonstrates, with concrete evidence, how sociobiodiversity is directly linked to well-being, food abundance, environmental restoration, and the viability of agroecological production systems capable of reconciling environmental recovery with income generation.

The results obtained in this study are in dialogue with the literature. For example, Silva et al. (2024) demonstrate that the Rural Agent Program contributed to the adoption of environmentally sustainable technologies and to significant increases in income and employment generation among family farmers in Ceará. Such evidence corroborates the data presented in this article, reinforcing that high-quality ATER processes are fundamental to consolidating sustainable productive practices and strengthening the resilience of family farming in the Cerrado.

GENERAL OBJECTIVE

To analyze the process of agroecological transition in the Nazareth Settlement (Sidrolândia/MS), highlighting the role of AMTR-MS in valuing the sociobiodiversity of the Cerrado and in the productive reconfiguration of family units, integrating cattle ranching, agroforestry systems, and native species such as *marolo* (*Annona crassiflora*).

SPECIFIC OBJECTIVES

1. To characterize the productive, social, and environmental conditions of the Nazareth Settlement in its initial structuring phase.
2. To evaluate cattle ranching practiced by the families, identifying stocking rates, net margins, and main management challenges.
3. To compare land-use changes between 2014 and 2022, with emphasis on the expansion of agroforestry systems and productive diversification.
4. To quantify the population of *marolo* trees present in family plots and estimate their potential contribution in terms of production and income.
5. To integrate qualitative data (images, interviews, and field records) and quantitative data (tables and graphs) to discuss the pathways of agroecological sustainability.
6. To highlight the strategic role of AMTR-MS as an organizing agent and promoter of ATER policies, articulating practices of environmental conservation, food security, and income generation.

GUIDING PRINCIPLES AND METHODOLOGICAL ELEMENTS

Guided by the perspective of agroecological agriculture, the principles—elements under construction and defined in this proposal for sustainability within a development project—are presented with a focus on the recent ATER (Technical Assistance and Rural Extension) process, while continuously dialoguing with the strategic projects of AMTR – Association of Rural Women Workers of MS.

We first present a synthesis of the guiding principles—elements that orient various activities by thematic groups.

A – Group of principles for the planning and management of productive structures and services

- Planning of adequate infrastructure adapted to the reality of the recently established settlement project and to the production systems grounded in agroecological farming through the implementation of agroforestry systems.
- Evaluation of the implementation conditions for a macro management plan enabling access to an effective Development Project (this plan is a prerequisite for self-managed activities by farming families, requiring records, data organization, evaluation, and goal setting).

B – Management of agroforestry systems with emphasis on homegardens and animal husbandry in the regeneration of native Cerrado tree elements

- Food security through diversity and surplus sales.
- Citizenship through the recognition of complex, integral environmental services.
- The relationship between animal production and agroforestry environments exposes a clear technological challenge.

Research Context

The research was conducted at the Nazareth Settlement, located in the municipality of Sidrolândia/MS, between November 2022 and April 2023, as part of the Technical Assistance and Rural Extension (ATER) activities in partnership with the Association of Rural Women Workers of Mato Grosso do Sul (AMTR-MS). The study adopted a participatory approach, involving interviews with farming families, technical field visits, and georeferenced photographic records.

Data Collection

Information was collected on:

- Stocking rates (number of cattle heads per hectare), obtained through farmer interviews and direct observation of pasture areas;
- Weeding days per hectare, estimated based on family reports and monitoring of pasture management practices;

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- Population of *marolo* (*Annona crassiflora*) trees in each plot, counted during field visits and confirmed by georeferencing and photographic records;
- Land use in 2014 and 2022, analyzed through satellite imagery and compared with farmers' accounts.

Data Processing and Systematization

The data collected were organized into electronic spreadsheets (Microsoft Excel®, version XX), enabling tabulation and the calculation of frequencies, proportions, and estimated means. This systematization allowed for the construction of comparative indicators, such as net margins per animal, land-use proportions, and production and income estimates for *marolo*.

Graph Development

To represent the collected data, scatter plots were created in Microsoft Excel® to visualize:

- The relationship between stocking rates and weeding days per hectare;
- The population of *marolo* trees per plot/family;
- The relationship between *marolo* populations and stocking rates.

These graphs were chosen for their ability to highlight trends and variability among farming families within the same settlement, facilitating visual interpretation of correlations.

Table Construction

From the same dataset used for the graphs, comparative tables were organized (in Excel®), aimed at systematically quantifying:

- Average stocking rates and net margins observed;
- The evolution of land use between 2014 and 2022;
- Estimated *marolo* production and income across different groups of families.

The tables complement the graphs, offering a clearer quantitative view and allowing direct comparisons between variables.

RESULTS

1. Guidelines – elements: respecting the initial phase of an agrarian reform settlement Project.

The recent history of the settlement, with between 2 and 6 annual harvests, access to initial support policies for food and housing, restricted access to production support, and homogeneous ecological conditions shaped by the strong presence of sandy soils and a dry season (limited rainfall) typical of the Cerrado environment, requires the definition of the profile and the specific timeline for the implementation of the development project.

From this perspective, for example, investment in dairy cows requires adequate genetic profiles and prior conditions; otherwise, it may result in high mortality rates and/or a reduced productive lifespan.

2. Guidelines – elements: preparation for records, controls, and decision-making analysis in a scenario of different proposed projects

Training for decision-making is a fundamental element and must be conceived not as a long formal training process detached from reality and/or prior to experiencing it. Instead, it must be part of daily life, integrated into the everyday experiences of farming families and their representative organizations.

The management of dairy production during the Cerrado dry season may be oriented—or effectively constrained—by the increased selling price caused by the high cost of concentrated feed (rations, hay), demanding immediate and objective decisions. At the Nazareth Settlement, some families created practical alternatives, such as selling milk directly to consumers or focusing exclusively on meat production during this period.

3. Guidelines – elements: the place of the settlement in the landscape

To the west lies the Pantanal Biome; moving eastward, through the Cerrado Biome where the settlement is located, one reaches the ecotone zone with the Atlantic Forest Biome, in the ecological complex of conservation units of Ilha Grande do Rio Paraná. This record seeks not only to locate but also to broaden the understanding of a geographical environment capable of encompassing possible complex environmental services to be found in family productive units (Figure 1, Mato Grosso do Sul).

In the center of the image, outlined in black, is the municipality of Sidrolândia, and in its eastern/northeastern part, a white dot indicates the location of the Nazareth Settlement (Figure 2).

Figure 1. State of Mato Grosso do Sul.

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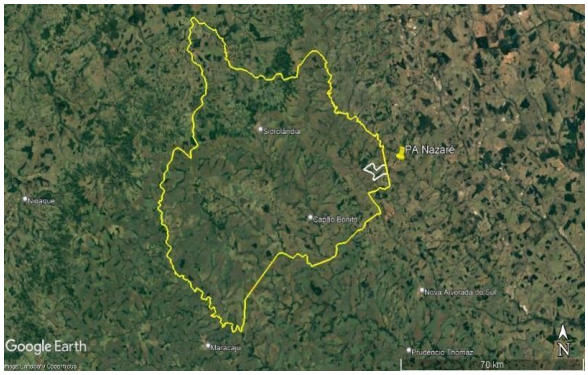
Source: Google Earth, 2023.
Figure 2. The Nazareth Settlement highlighted within the Municipality of Sidrolândia-MS.



Source: Google Earth, 2023.

Figure 3. Forest fragments connected to the Legal Reserve of the Nazareth Settlement.

Source: Google Earth, 2023.

Figure 4. Forest fragments connected to the Legal Reserve of the Nazareth Settlement, showing the visibility of areas comprising the Legal Reserve of more than 500 hectares.

Source: Google Earth, 2023.

A mosaic of forest fragments connected to the Legal Reserve of the Nazareth Settlement (Figures 3 and 4) highlights the presence, to some extent, of environmental indicators that emerged from the testimonies of families interviewed during the diagnostic phase, with emphasis on the significant presence of tapir (*Tapirus terrestris*) populations within the settlement, suggesting details about the potential habitat conditions for this threatened species.

An example of this condition is the strategies for animal husbandry, which reveal at least three management strategies identified so far: community herd management involving 2 to 3 families; outsourcing of pastures through various forms of financial and non-financial agreements. These diagnostic indicators may point to different grazing capacities, reflected in diverse stocking rates (heads per hectare or livestock units adjusted to weight per hectare), which vary significantly according to the seasonality of the Cerrado's productive year—particularly between the dry and rainy periods. The extent of this diagnostic (data included in the survey) allowed observation of two productive strategies within the same agricultural year: alternating between milk production for commercialization (rainy season) and meat production for commercialization, associated with milk production for self-consumption (dry season).

The stocking rates currently practiced by 15 families in the Nazareth Settlement, ranging from 0.8 to 1.7 heads per hectare in different areas containing tree cover (as seen in the following land-use images), indicate preliminary economic productivity indicators, with net margins ranging from R$ 300 to R$ 600 per animal producing milk and/or beef. However, scenarios of higher costs than selling prices are also present—especially under conditions of low pasture availability, recurrent dry seasons, and intensive use of feed concentrates. This poses a management challenge. Nevertheless, alternatives are emerging, as outlined in the diagnostic phase below.

Differences in productive practices among families (even in a scenario of relatively homogeneous structural conditions) already prove highly relevant. During the diagnostic phase, it was observed that diverse management practices are underway, resulting in different stocking rates per hectare, which in turn determine different impacts on the forage availability of pastures. These were described for each family unit in the diagnostic and reinforced among the strategic actions of the management plan under development. The use matrix distinguished three groups of pasture-use proportions (%): arboreal/shrub strata, herbaceous *Brachiaria* cover, and clumped *Brachiaria*. This indicator of pasture-use groups is associated with greater or lesser demand for weeding and the time of labor required throughout the year, ranging from 20 days to over 100 workdays annually, to be carried out in 3 to 4 stages (as justified and included in each family unit's implementation plan).

At this initial stage, based on diagnostic content, another structural characteristic can also be identified: the restricted access to public policies

supporting production. So far, support has been directed toward house construction, emergency

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aid for non-productive periods, and acquisition of dairy cows. This indicates strong homogeneity in production organization among families, with differences perhaps arising from private investment resources and from historical trajectories of agricultural knowledge.

1. Guidelines – elements: the production landscape in settlement family lots, before and after a period of 2 to 6 annual harvests

Examining land-use areas at two points in time—2014 (before the settlement) and 2022 (after establishment)—through satellite images, enables progress in perceiving the organizational process underway, significantly strengthening the diagnostic and orienting ATER actions/activities.

Emphasis is placed on the homogeneity of land use in family lots, even though differences in the images must be relativized due to variations between years and different periods within the agricultural cycle. The presence of tree elements within pasture areas indicates an adaptation process to ecological conditions as well as to the investment capacities of settled families.

It should be emphasized that the observation of the grouped images below (Figure 5) must take into account that similarities in productive areas, family production units, land use, and production systems may indicate similar access to technologies—and, in cases of low investment costs, to low-impact technologies and productive organization—resulting in limited ecological changes in family lots, particularly when the ecological conditions of the families observed are comparable.

It was observed that, in the previous images, the infrastructure generally consisted of one house and one shed and/or a small structure for animal management. It was also observed, as a rule, that there were two large sections around the house, with the remaining area consisting of pastures containing tree elements in varying densities. For all families (plots), a broad pattern of homogeneity was evident.

5. Guidelines – elements: a new income perspective with environmental assets, including the sociobiodiversity of the Cerrado

An economic perspective focused on income must be considered in order to understand the profile of the agrarian reform settlement and its farming families. It is possible to state that most families in this group, studied and monitored within the ATER project, rely on off-farm income sources to make a living. These sources are diverse non-agricultural activities, and partially agricultural, through wage labor.

Considering that this diagnostic is consolidated, it places proposals for productive organization and even direct management technologies at high risk of non-adoption. In this regard, when it comes to adopting propositions and activities, it is common—out of respect and consideration—that families do not directly refuse them, but over time do not adopt them. In this context, it becomes relevant to guide the analysis of these propositions and activities, as well as their inclusion in implementation plans, emphasizing their direct impacts on non-monetary income, such as the self-consumption of food from family production, which can reduce direct monetary expenses.

Labor and workforce. For this project, the theme highlights certain characteristics present among families: the advanced age of many family members, the absence of children—which restricts the availability of labor—and health conditions.

This labor situation makes access to resources capable of expanding the workforce not only important but a necessary condition.

A new perspective under experimentation seems to be emerging (perhaps new to those who have not known, tested, noticed, or studied it). The comparative analysis between the economic productivity capacity of cattle production (for different purposes) and Cerrado fruit production has become a pedagogical and methodological tool of interest to farming families. In the case of the Nazareth Settlement, structural characteristics and the monetary and non-monetary income potential of extractivism—strongly based on fruit collection in Cerrado areas—are becoming increasingly evident.

Below are image s of the effective presence and potential of the development project, building the foundation for discussion, observing technological references, and systematizing indicators. The initial hypothesis guiding the observation and study of this project perspective suggests that around 10 to 15 producing *marolo* trees could be equivalent to the annual production of one dairy cow, with a potential labor reduction of more than 60%.

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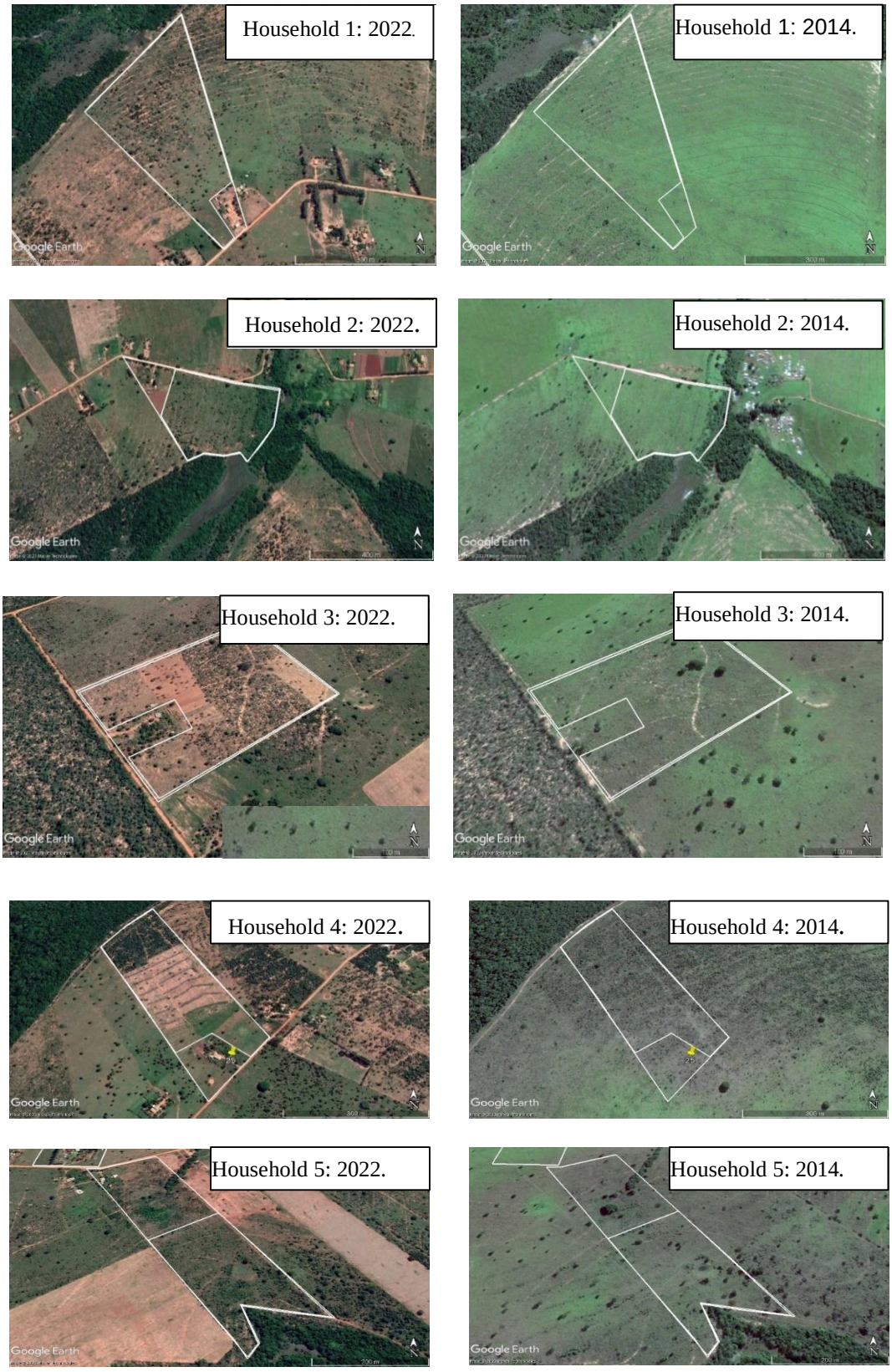
Figure 5. Aerial images collected via Google Earth, from 2014, when the settlers received their properties, and from 2022, eight years after the settlement was established.



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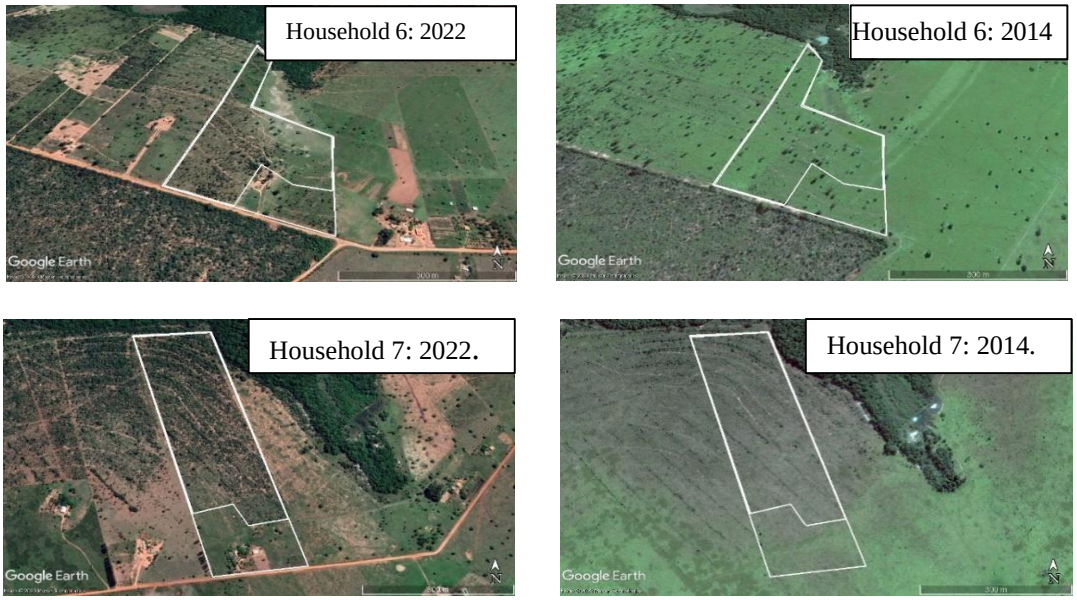

Marolo juice (*Araticum do Cerrado*), Figure 6, served in the home of a farming family.

Figure 6. Araticum (Cerrado) juice.

Source: AMTR-MS, 2023.

The fruit, the tree, the woman farmer from another family (Figure 7), establishing networked references. The fruit can weigh more than 2 kg, and pulp yield can exceed 65% (experimentation, research, strategic orientation, and farming families as protagonists).

The footprint of Cerrado forest animals, recorded by one of th e farming families already discussing sustainable alternatives (Figure 8), near *marolo* fruit trees, likely from a species that feeds on and disperses the seeds.

Figure 7. Collecting economic data in the field.

Source: AMTR-MS, 2023.

Figure 8. Record of wild animal footprints in family farm areas.

Source: Mrs. Ecirlene – AMTR-MS, 2023.

Another sighting (Figure 9), the “three-toed” footprint, evidence of environmental services. Another family recorded it, with the tool visible in the shadow of the image.

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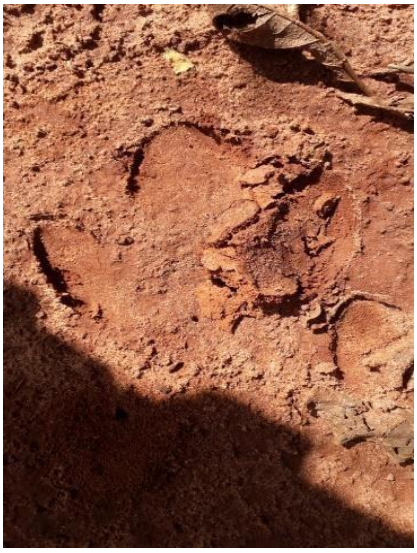
Figure 9. Record of wild animal footprints in family farm areas.



Source: Mrs. Débora – AMTR-MS, 2023.

The fruit on the ground, the color of the pulp, and the debate initiated by the farmer with the technician about whether it is possible to mow/prune in that spot (within the family plot) for *Brachiaria* to grow again (Figure 10).

Figure 10. Records of field dialogue.

Source: AMTR-MS, 2023.

Another family, with thawed pulp ready to eat (Figure 11).

Figure 11. Reception of the technician at the farmer's home, showing the frozen pulp she preserves throughout the year for family consumption.

Source: AMTR-MS, 2023.

During field georeferencing, experimentation (research) was also carried out, counting the population of fruit trees. The *marolo* trees already larger than one meter, almost producing or already producing (Figure 12).

Figure 12. Georeferencing activity of *marolo* trees on family properties.

Source: AMTR-MS, 2023.

Another tree, and the planning of actions to assess fruit production capacity by the families, a new experimental phase (counting fruits on the tree and fallen to the ground, not to forget). In another family, a *marolo* tree in a *Brachiaria* area used by cattle, where the clumped growth no longer provides forage (Figure 13).

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Figure 13. A *marolo* tree in a pasture área.

Source: AMTR-MS, 2023.

Another family, with a *marolo* tree over 20 years old and annual production in 2022/2023 exceeding 20 kg. Why is *marolo* important? (Figure 14).

Figure 14. A *marolo* tree in the farmer's backyard.

Source: AMTR-MS, 2023.

The use of *marolo* (Cerrado araticum) as a basis for planning arises from its significant presence in the Nazareth Settlement landscape and from the productive potential identified during evaluations and planning with families. Another family: during the technical visit, the task was to record the number of trees in the plot (Figure 15**).**

Figure 15. Field georeferencing of *marolo* on family properties.

Source: AMTR-MS, 2023.

Other fruits identified in areas needing light management to strengthen *Brachiaria* (Figure 16).

Figure 16. Identification of other fruit species in the field.

Source: AMTR-MS, 2023.

Reference family: in the following image, the good condition of *Brachiaria* with the presence of shrub/tree elements (fruits and other potential resources), and little need for clearing. Strategies of community stocking—herds shared by more than one family with common-use agreements—reveal distinct seasonal stocking rates, technologically adapted.

Three layers of landscape use and the presence of *marolo* coexisting with cattle (Figure 17).

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Figure 17. Pasture area: integration of Cerrado shrub system with grass.

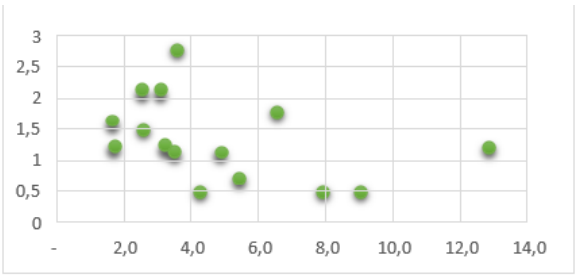
Source: AMTR-MS, 2023.

DISCUSSION

The results obtained from the ATER process carried out in the Nazareth Settlement (Sidrolândia/MS) make it possible to understand the productive dynamics in its early stage and the strategies adopted by farming families in response to the edaphoclimatic conditions of the Cerrado. The analyses combine qualitative data—observed in satellite images, field photographs, and participatory records—with quantitative information systematized in tables of land use, stocking rates, and *marolo* production. The integration of these elements strengthens the scientific discussion, as it links visual evidence to the numerical organization of indicators.

The selective pruning practices, maintaining the shrub/tree component, form the basis for livestock management. In Figure 18 below, references are built on the labor requirements to carry out this task and the relationship between stocking rates and the indicator of workdays per hectare of pasture used for livestock.

Figure 18. Correlation between stocking rate (Y-axis) and weeding days per hectare (X-axis).



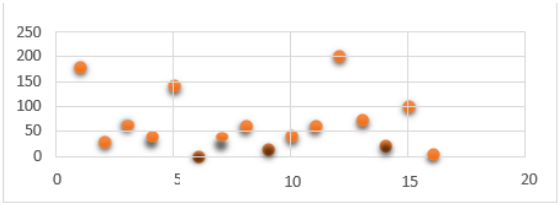
Source: Prepared by AMTR-MS, 2023.

The analyzed images reveal that the relationship between stocking rate (heads/hectare) and weeding requirements varies significantly among families. Areas with higher cattle density tend to require less weeding effort, while areas with lower stocking rates show greater shrub presence and clumped *Brachiaria*. This pattern suggests a trade-off between animal carrying capacity and manual labor, highlighting the importance of technological adjustments in production systems.

Seed collection and planting of native species in pasture areas for various purposes are part of the development project under construction—as are fruit collection and processing. The subdivision of pasture areas also includes the perspective of allocating plots for fruit species such as *guavira*.

In Figure 19, NEW GUIDING ELEMENTS: the population of *marolo* trees already in production or possibly starting their first yield per family. The research and development process is building reference points to guide practices.

Figure 19. Relationship between the population of *marolo* trees (Y-axis) per family (X-axis).

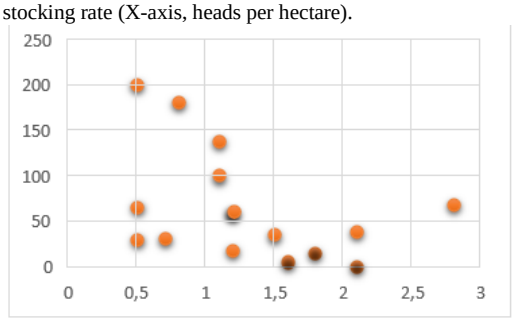


Source: Prepared by AMTR-MS, 2023.

In the comparison between 2014 and 2022, satellite images demonstrate a reduction in land-use homogeneity, with increased tree cover and the introduction of agroforestry systems. This process confirms the ongoing agroecological transition, encouraged by community organization and technical assistance.

In Figure 20, an initial visible relationship: population of *marolo* trees and stocking rate (heads per hectare) for each family currently under study**.**

Figure 20. Population of *marolo* trees (Y-axis) and stocking rate (X-axis, heads per hectare).



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Field photographs further highlight the socioeconomic potential of *marolo* (*Annona crassiflora*), both through direct family consumption and through the possibility of fruit and pulp commercialization. The presence of wildlife footprints and biodiversity records reinforces the environmental dimension of the settlement, linking agricultural production to conservation.

The *marolo* fruit can weigh over 2 kg, and measured pulp yield can exceed 65%. So far, dialogues with farming families indicate an average of 0.5 kg per fruit, with approximately 4 to 7 fruits produced per tree per year. References are being developed on productive cycles, indicating good harvests and more restrictive ones over time. The density of *marolo* trees per unit area is another challenge under evaluation, necessary to strengthen planning capacity.

The elements highlighted in this document are presented to give visibility to the process of building development projects and the organizational efforts within an agrarian reform settlement seeking alternatives.

Table 1 presents the stocking rates practiced by different families, ranging from 0.8 to 1.7 heads per hectare, with net margins varying from R$ 300.00 to R$ 600.00 per animal. These values reflect both the influence of pasture management and the dependence on external inputs during the dry season. Intensification can generate higher economic returns, but at the cost of greater environmental and productive risks.

Table 2 shows the transition in land use between 2014 and 2022. Pasture areas decreased from 70% to 50%, while agroforestry systems increased from 5% to 20%. This change indicates a process of productive diversification, strengthening the economic and ecological resilience of families. The maintenance of preserved areas at 10% demonstrates that, even in the initial structuring phase, the settlement remains committed to environmental conservation.

Table 3 highlights the production and estimated income from marolo. Families with 10 to 20 fruiting trees reach between 150 and 300 kg/year, with income ranging from R$ 1,500.00 to R$ 3,000.00 annually. A comparison with cattle ranching shows that 10 to 15 trees can be economically equivalent to a dairy cow, but with lower labor and input requirements. Beyond the economic aspect, marolo also contributes to ecosystem services such as shading, seed dispersal, and attraction of native fauna.

Table 1 highlights the variation in livestock stocking rates among families in the Nazareth Settlement, ranging from 0.8 to 1.7 heads per hectare. This interval is consistent with extensive livestock systems typical of the Cerrado, where pasture availability is conditioned by strong climatic seasonality. The results show that net margins per animal range from R$ 300.00 to R$ 600.00, directly related to stocking intensity and the use of external inputs. Families with lower stocking rates (0.8–1.0 heads/ha) achieve lower margins but maintain greater balance with the natural capacity of the pasture. Those with higher stocking rates (1.7 heads/ha), on the other hand, achieve higher net margins but face a greater risk of ecological imbalance and dependence on feed and hay during the dry season.

This analysis demonstrates the need for an adaptive management strategy that reconciles economic productivity with the resilience of agroecological systems.

Table 2 shows the significant transformation in land use between 2014 and 2022. Initially, the production matrix was strongly dependent on livestock, with 70% of the area dedicated to pasture. After the settlement process and technical support, a reduction in pasture area (50%) and a substantial increase in agroforestry systems (20%) were observed. This result is indicative of the ongoing agroecological transition, driven by rural extension policies (ATER) and community organization. The increase in agricultural crops (from 15% to 20%) and the maintenance of preserved areas (10%) reinforce the multifunctionality of production units, combining food production, income diversification, and environmental conservation. The analysis confirms that agrarian reform settlements can become living laboratories of agroecological experimentation, with the potential to generate replicable models in other Cerrado territories.

Table 3 highlights the strategic role of marolo (Annona crassiflora) as an emerging source of income and food security. Families with 10 to 12 fruiting trees reach yields of 150 to 180 kg/year, with estimated income between R$ 1,500.00 and R$ 1,800.00. In cases where families have 20 mature trees, production can reach 300 kg/year, equivalent to R$ 3,000.00 annually, solely from selling fresh fruit or pulp. This equivalence is relevant when compared to cattle ranching: while a dairy cow requires significant input and daily labor, 10 to 15 marolo trees can generate an equivalent income with lower labor demand. In addition, marolo contributes environmental services such as shading, attracting disperser fauna, and maintaining Cerrado biodiversity. Thus, its valorization as a socioeconomic asset expands income alternatives for families, reducing exclusive dependence on livestock.

After carrying out this research in partnership with the field technician, and following the technical assistance that families received, and understanding that these analyses on the valorization of local biodiversity can greatly impact the lives of these rural families, the importance of adequate technical assistance for family farming becomes evident. Caporal (2020), in his article *Agroecological Transition and the Role of Rural Extension*, also brings

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this reflection, showing that, as agroecological practices deepen, the role of rural extension becomes even more important. Navakoski et al. (2019) also emphasize the urgent need to "redesign" current agroecosystems so that, in light of the new environmental perspective we are experiencing, "rural development that achieves sustainability" becomes possible.

Table 1 – Stocking rate and net margins observed in the Nazareth Settlement.

Family/Group	Stocking rate (heads/ha)	Net margin (R$/animal)	Observations
Families 1–5	0.8 – 1.0	300 – 400	Mixed meat and milk production, greater weeding effort
Families 6–10	1.3 – 1.5	400 – 500	Meat commercialization during the dry season
Families 11–15	1.7	600	Greater dependence on inputs during the dry season

Table 2 – Land use in the plots (comparison 2014 and 2022).

Category	2014 (%)	2022 (%)	Observations
Pasture	70	50	Reduction with increase of trees and agroforestry systems
Agroforestry/SAFs	5	20	Recent implementation of homegardens and fruit tree areas
Agricultural crops	15	20	Increase in the diversity of annual crops
Preserved area	10	10	Legal reserve and Permanent Preservation Areas maintained

Table 3 – Estimated production and income from marolo (*Annona crassiflora*)

Family/Group	Fruiting trees	Estimated production (kg/year)	Estimated income (R$/year)*	Observations
Families 1–5	10–12	150–180	1,500–1,800	Family consumption and small sales
Families 6–10	15	220	2,200	Production already organized for pulp
Families 11–15	20	300	3,000	Adult trees, higher income potential

*Estimate: R$ 10.00/kg of pulp/fruit at local market values (2023).

CONCLUSION

The integrated analysis of data obtained at the Nazareth Settlement reveals a dynamic process of productive reconfiguration, in which cattle ranching, although still central, increasingly shares space with land-use diversification and the valorization of native Cerrado species. This movement indicates an agroecological transition under construction, capable of articulating economic, social, and environmental sustainability in agrarian reform territories.

The tables presented show that extensive cattle ranching, while ensuring net margins in certain contexts, faces structural limitations related to low resilience during dry periods and dependence on external inputs. On the other hand, the inclusion of *marolo* (*Annona crassiflora*) as a productive asset points to an economic potential comparable to livestock, but with lower labor demand and greater contribution to ecosystem services. Meanwhile, the temporal comparison of land use demonstrates that, in less than a decade, there has been a significant reduction in the dominance of pastures and an expansion of agroforestry systems, reflecting the families' capacity for innovation and the strategic role of participatory ATER.

The images and graphs complement the tables by visually and contextually translating the complexity of family farming in the Cerrado. Together, these elements provide scientific robustness to the analysis, showing that sustainability in the settlement does not depend exclusively on livestock intensification, but rather on the balanced integration of livestock, agroforestry systems, and sociobiodiversity.

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