RURAL SETTLEMENT AS AN AGENT OF AGRICULTURAL DEVELOPMENT IN BRAZIL: PORTRAIT AND CHALLENGES IN THE CONTEXT OF THE BRAZILIAN AMAZON

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ABSTRACT

Objective: Study carried out in the Padre Josimo Tavares settlement project, located in the Brazilian Amazon, to portray the social reality, productivity and agricultural spatial distribution, as well as its implications for the preservation of the Amazon biome.

Theoretical framework: The developmental measures adopted in the Amazon region, which include the creation of numerous settlement projects, did not consider the need to conserve natural resources. Currently, it is necessary to boost agricultural productivity combined with strategies that contribute to plant recovery and curb deforestation.

Method: Data were collected in the field, and also spatial data were obtained, which were synthesized and analyzed using spatial, statistical and multicriteria analysis to verify the distribution and environmental suitability of agricultural activities.

Results and conclusion: The settlers grow various plant products and most of them produce species strongly adapted to the region, which offers a productive advantage. Beef cattle farming is widely practiced; however, it is widely identified as the main cause of deforestation in the Amazon biome. To overcome this environmental obstacle, the recommended and discussed approaches were the implementation of agroforestry systems and zero deforestation commitment policies.

Research implications: Knowing the socioeconomic and environmental reality of settlement projects is essential to identify strategies that increase, in an integrated manner, social, economic and environmental sustainability.

Originality/value: Use of unpublished data obtained through field collections of the RADIS-UFV Project, the result of a partnership between the National Institute of Colonization and Agrarian Reform and the Federal University of Viçosa.

Keywords: Rural Settlement, Agrarian Reform, Family Farming, Livestock, Brazilian Amazon.

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ASSENTAMENTO RURAL COMO AGENTE DE DESENVOLVIMENTO AGROPECUÁRIO NO BRASIL: RETRATO E DESAFIOS NO CONTEXTO DA AMAZÔNIA BRASILEIRA

RESUMO

Objetivo: Estudo realizado no projeto de assentamento Padre Josimo Tavares, localizado na Amazônia brasileira, para retratar a realidade social, produtividade e distribuição espacial agropecuária, bem como suas implicações para preservação do bioma amazônico.

Referencial teórico: As medidas desenvolvimentistas adotadas na região amazônica, que incluem a criação de inúmeros projetos de assentamento, não consideravam a necessidade de conservação de recursos naturais. Atualmente, torna-se necessário impulsionar a produtividade agrária aliada a estratégias que contribuam para recomposição vegetal e freie o desmatamento.

Método: Foi realizada coleta de dados em campo e obtidos outros dados espaciais, que foram sintetizados e analisados por meio de análises espacial e de multicritério para verificar a distribuição e adequabilidade ambiental de atividades agropecuárias, respectivamente.

Resultados e conclusão: Os assentados cultivam vários produtos vegetais e a maior parte deles produzem espécies fortemente adaptadas a região, o que oferece uma vantagem produtiva. A bovinocultura de corte é muito praticada, contudo, é amplamente apontada como a principal responsável pelo desmatamento do bioma amazônico. Para superar este entrave ambiental, as abordagens recomendadas e discutidas foram a implementação de sistemas agroflorestais e de políticas de compromisso de desmatamento zero.

Implicações da pesquisa: Conhecer a realidade socioeconômica e ambiental dos projetos de assentamento é essencial para identificar estratégias que aumentem, de forma integrada, a sustentabilidade social, econômica e ambiental.

Originalidade/valor: Uso de dados inéditos obtidos por meio de coletas de campo do Projeto RADIS-UFV, fruto da parceria entre o Instituto Nacional de Colonização e Reforma Agrária e a Universidade Federal de Viçosa.

Palavras-chave: Assentamento Rural, Reforma Agrária, Agricultura Familiar, Amazônia Brasileira, Bovinocultura.

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1 INTRODUCTION

Over the years, many public policies have been created to boost economic activities and develop the northern region of Brazil. In the mid-nineteenth century, the Amazon region was understood by the government as a territory of low social and economic development, still little explored, which needed to be integrated into the rest of the country, which resulted in incentives for agricultural projects, colonization and mining (NASCIMENTO; SILVA; FERREIRA, 2015). Thus, from 1970 onwards, a more accelerated process of occupation began, resulting in the creation of pastures, colonization projects and the application of agrarian reform (NASCIMENTO; SILVA; FERREIRA, 2015).

Settlement Projects (PAs) are areas created or recognized by the National Institute of Colonization and Agrarian Reform (INCRA) consisting of a set of agricultural units, independent of each other, called parcels (PEREIRA et al., 2022) or lots. Thus, the PAs are instruments used for individual regularization, installed from land collected, expropriated or purchased by the Union (ARRAZ; MARQUES; RIBEIRO, 2022). Through them, INCRA implements Agrarian Reform policies in Brazil, in order to redistribute land to small producers.
and rural workers. As established in the Land Statute, “Agrarian Reform aims to establish a relation between man, rural property and land use, capable of promoting social justice, progress and well-being of rural workers and development economy of the country” (BRASIL, 1964, p. 1). Thus, it is up to the State to analyze and implement agrarian and food security policies, considering aspects such as the presence of unproductive areas, land occupation processes, demography, culture and population movements (SANGALLI; SCHLINDWEIN; CAMILO, 2014).

The creation of PAs in the Amazon region was understood, at first by the public authorities, as an alternative to repair existing land conflicts in other regions, which represented a social problem, as well as to act in the face of pressures and the need for a Brazilian agrarian reform (NASCIMENTO; SILVA; FERREIRA, 2015). Currently, around 87% of the territory of PAs created or recognized by INCRA in Brazil are located within the Legal Amazon (PEREIRA et al., 2022). Pará is the state that has the most Agrarian Reform PAs, with emphasis on the Southeast of Pará, where a large number of rural farmers live dedicated to the production of food for their own consumption and for commercialization with nearby urban centers, which makes clear the social and economic role of PAs for this region (AMORIM et al., 2020).

Currently, rural activities, in general, play an important role in the economy and income generation in the North region, representing a strong regional economic support base (LOBÃO, 2023).

PAs emerged as a strategy to avoid conflicts over land (ARRAZ; MARQUES; RIBEIRO, 2022) and offer space for family farmers to produce, generate income and ensure food security for their families. The internal management of parceling out lots and access to infrastructure is important for the social, cultural and economic development within the settlements. To boost it, INCRA has some lines of financing, such as housing credit, which is aimed at financing the construction of homes for families benefited by the Agrarian Reform Policy.

Monitoring the productive performance of PAs is, for INCRA, a challenging activity, given the great demand from the autarchy and the high number of settlements and settlers that need to be assisted. Currently, the effective staff is not enough in the face of numerous demands and, therefore, the Decentralized Execution Terms (TED) can represent important allies for the autarchy to fulfill its objectives.

Considering that reconciling interests between agribusiness and conservation of natural resources is one of the main challenges in Brazil (MAGALHÃES et al., 2020), the monitoring of PAs in relation to legislation and environmental regularization is also challenging. Above all, for the Amazon region, environmental monitoring linked to economic activities is necessary, since INCRA and its PAs have been identified as one of the main actors that drive deforestation in the Brazilian Amazon (PEREIRA et al., 2022). This biome attracts global attention, since it is understood as an essential natural heritage to ensure global climate stability. Studies that aim to discuss possible sustainable actions applied to the region have been carried out, and research that addresses agribusiness segments has been recommended (MOURA et al., 2023). It is widely accepted that its development must occur in a sustainable and inclusive manner. Therefore, monitoring and supporting the development of PAs can reconcile the economic and environmental expectations expected for this region. It is believed that if there is a present and operational land regularization, it is possible to combat land grabbing and promote sustainable agricultural development.

Therefore, this study aims to present a picture of the socioeconomic reality of PA Padre Josimo Tavares, highlighting its agricultural and livestock activities and their possible implications for the environmental sustainability of the Amazon region. One of the study's differentials was the use of unpublished data obtained through face-to-face work in the field,
carried out indirectly by INCRA, through a TED celebrated between the autarchy and the Federal University of Viçosa (UFV).

2 THEORETICAL FRAMEWORK

The developmental measures adopted in the last century for the Amazon region, which include the creation of numerous settlement projects, were not compatible with the preservation of this biome. Faced with a strong environmental debate, studies and measures are necessary to reconcile the demands of the settlers, agricultural production and conservation of natural resources. This research employs content focused on agriculture and the environment, as well as geographic information system concepts to understand the analyzes carried out.

3 METHODOLOGY

The study area was characterized in Section 3.1. In order to portray the socio-productive reality of the study area, this paper was conducted through the following stages: (i) data acquisition; (ii) spatial statistical analysis, and (iii) multicriteria analysis. The methodological approach used in each step is described in Sections 3.2, 3.3 and 3.4.

3.1 Study Area Characterization

The PA Padre Josimo Tavares is located in the State of Pará, in the rural area of the municipality of Conceição do Araguaia, and is entirely inserted in the Legal Amazon (Figure 1). The population of the municipality, according to the 2022 demographic census, was 44,617 people (IBGE, 2023). The municipality has stood out as an area of expansion of agribusiness in the Amazon region, which is facilitated by the presence of strategic access roads that allow the production flow (ARRAZ; MARQUES; RIBEIRO, 2022).

Figure 1. Location map of the Padre Josimo Tavares Settlement Project. Source: The authors
The natural characteristics of the study area are marked by a climate classified as Aw, by the Köppen classification, and it has an average annual temperature of 26.3°C, while the annual maximum and minimum are 30°C and 22.7°C, respectively. The municipality is located within the Araguaia-Tocantins watershed, with the Araguaia river being the closest main watercourse and standing out as one of the main Brazilian rivers and one of the main tributaries of the Tocantins river.

3.2 Data Acquisition

To carry out this study, primary data were collected, obtained by the RADIS-UFV Project, and secondary data, made available by INCRA. The data used were described in sections 3.2.1 and 3.2.2.

3.2.1 RADIS-UFV project, field data collection and validation

Data from the PA Padre Josimo Tavares were obtained from the development of the RADIS-UFV Project. The RADIS-UFV Project – Agro-environmental Systems in rural settlements: from environmental regularization to economic development – emerged as an initiative of the INCRA. INCRA is a federal autarchy responsible for implementing the agrarian reform policy and carrying out the national land order to contribute to sustainable rural development (Decree nº. 1,110,1970). Thus, in view of INCRA's need to promote environmental regularization, in accordance with Law nº. 12,651 of May 25, 2012, in rural properties located in settlements of the Agrarian Reform Program and to give capillarity to its demands, TED nº. 06 /2017 (Process 54000.030333/2017-49) was agreed at the end of 2017, establishing a partnership between INCRA and the Federal University of Viçosa (Viçosa, Minas Gerais, Brazil). Among the specific objectives of the project are: (i) evaluation of existing production systems through the application of the agrarian systems diagnosis, providing information for analysis of the existing reality and projecting the strengthening of the productive base; (ii) survey of socio-environmental information; and, (iii) survey and diagnosis of the demand for access to settlement development policies.

Therefore, one of the main purposes of the project is the data collection that portray the socioeconomic and environmental reality of rural settlements. For this, a collection instrument (the form) was produced together and approved by INCRA. The form addresses social, economic and environmental issues and visits are made with beneficiaries and occupants. Beneficiary is understood to be the person who was contemplated by the National Agrarian Reform Program and received the right to use the land of a lot present in Settlement Projects created or recognized by INCRA. On the other hand, the occupant is the one who exploits a lot within the boundaries of PAs, which has not yet been regularized before INCRA and received the right to use the land.

Among the information collected, those used in the present study are summarized in Table 1. The data collection period was between December 2018 and February 2019. In addition to quantitative and qualitative data, spatial data were obtained from this information.

<table>
<thead>
<tr>
<th>Table 1. Qualitative and quantitative data obtained through the RADIS-UFV Project.</th>
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<tbody>
<tr>
<td><strong>Thematic</strong></td>
</tr>
<tr>
<td>Social</td>
</tr>
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<td></td>
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</tbody>
</table>
Basic Services
- Access to water for human consumption
- Access to electrification
- Destination of domestic sewage
- Rural communication

Economic
- Income sources
- Annual gross income
- Access to the Government Social Program

Commercial production (animal and vegetable)
- Type of agricultural activity carried out on the lot
- Values of production and marketing of agricultural products

Source: The authors.

Within the project, some key activities are essential for data collection. After authorization to carry out a certain number of collections through INCRA's Board of Development and Consolidation of Settlement Projects, the project team meets with the Regional Superintendence of the state that will be contemplated in order to present the methodology of the work to be carried out, and get to know the dynamics and reality of the PA that will be visited. Next, the other activities necessary to fulfill the field data collection are conducted.

The main steps directly aimed at collecting data in the field were summarized in Figure 2. The importance of the Mobilization Seminars stage is highlighted, which are held to awaken the interest of the settler in participating in the work. Direct dialogue with the local population is valued, so this stage is essential, since the participation of each settler is voluntary.

**Figure 2.** Description of the main stages of the RADIS-UFV Project for carrying out the data collection of the Settlement Projects.

Source: The authors.

The project team prides itself on training field technicians, responsible for visits and collections. The training consists of theoretical and practical content and is carried out in PAs contemplated by the project. Field collection procedures include the form application, where part of the interview is documentary and carried out with the resident in their home and another part is carried out directly on the plot, where the information declared during the interview is validated. In addition, to confirm that the data collection was carried out in loco, there is a record of the geographic coordinates of each lot, as well as the signature of the person responsible for the lot.
The forms prepared in the field are sent to an online system that allows the editing and validation of the information. The validation stage confers credibility and assertiveness to the data collected in the field. In order to verify the data consistency of the form, a team was organized into three groups to assess (i) questions about the land tenure situation and family nucleus documentation; (ii) issues related to income, life quality and aspects related to the CAR; and, (iii) questions about agrarian property and production.

After the initial validation, the list of possible backlogs is evaluated and organized by a second group of analysts. Then, the forms marked as pending are returned to the field technicians, in an automated way, and, as soon as the technicians attend to the pending issues, the validation team checks the form again. Once the pending issue is resolved, the form is validated. All photographic information collected in the field by the technician is georeferenced. Thus, the consistency of spatial data is also checked in a geographic information systems environment.

3.2.2 Data provided by INCRA

With regard to the settlements spatial database, in addition to the records of geographical coordinates of agricultural activities collected through the RADIS-UFV Project, described in Section 4.1.1, the installment of the PA was obtained from INCRA. In this context, INCRA was responsible for defining the PA, which was then vectorized, georeferenced and superimposed on satellite images to identify its real location.

3.3 Statistical Analysis

As a way of identifying the main crops grown in the PA Padre Josimo Tavares, a statistical cluster analysis was carried out. This analysis, also called cluster analysis, consists of a method that aims to group elements, components and objects (CRISPIM et al., 2019), as well as locations (GONÇALVES et al., 2016), based on characteristics or attributes linked to them (HAIR et al., 2009), allowing the generation of similar and homogeneous elements within the group, however distinct from elements of other groups (RODRIGUES; FACHEL; PASSUELLO, 2012).

To carry out the cluster analysis, ArcMap 10.5 software, provided by ESRI, was used. More precisely, the Grouping Analysis and Directional Distribution tools were used. They allowed the separation of attributes into different homogeneous groups, as well as the zoning of regions with the closest spatial characteristics among the studied data, respectively.

Another statistical analysis performed was the Hot Spot. This tool allows the location of the incidence of a certain variable by determining if there is any statistically significant clustering in the data spatial model (MARQUES et al., 2021). The Hot Spot made it possible to identify, in a spatial way, the incidence of agricultural and livestock activities, more precisely cattle raising, contributing to the verification of the occurrence zones and how they are related within the PA studied.

3.4 Agricultural Suitability Zoning

This step aimed to identify the suitability of the region for the cultivation of species most commonly produced in the PA, according to the data obtained in the RADIS-UFV Project. For this, Multicriteria Evaluation (MCE) was used through the TerrSet 2020 software. MCE assists in decision making by evaluating all the requirements (factors and restrictions) to be considered during the choice and identification of the best places to implement a certain activity, the objective (EASTMAN, 2016). According to PINTO et al. (2014), the MCE seeks to
prioritize the biological aspects, the heterogeneity of the study area, and the socioeconomic aspirations of the population. This is applied to meet a specific objective where several criteria need to be evaluated.

In this context, databases relevant to the development of agricultural activities were used, without the presence of development inducers, such as irrigation, production flow, processing, among others, considering only the natural conditions of the study area, such as pluviometry, temperature, slope and soil type (Table 2).

**Table 2. Environmental factors considered in the Multicriteria Evaluation to assess the suitability of the Padre Josimo Tavares Settlement Project for growing pineapple (*Ananas comosus*), banana (*Musa spp*), maize (*Zea mays*) and manioc (*Manihot esculenta*).**

<table>
<thead>
<tr>
<th>Types</th>
<th>Cultivation Characteristics</th>
<th>Pluviometry (mm)</th>
<th>Temperature (°C)</th>
<th>Soil Type</th>
<th>Slope (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pineapple</td>
<td></td>
<td>1000 - 1500</td>
<td>22 - 33</td>
<td>Gleissol</td>
<td>≤ 05</td>
</tr>
<tr>
<td>Banana</td>
<td></td>
<td>1500 - 1900</td>
<td>27 - 30</td>
<td>Neosol</td>
<td>≤ 10</td>
</tr>
<tr>
<td>Manioc</td>
<td></td>
<td>1000 - 1500</td>
<td>27 - 29</td>
<td>Latosol</td>
<td>≤ 08</td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td>1200 - 1500</td>
<td>24 - 30</td>
<td>Latosol</td>
<td>≤ 05</td>
</tr>
</tbody>
</table>

Source: [https://www.embrapa.br/cultivares](https://www.embrapa.br/cultivares)

All maps used were obtained free of charge, on a 30x30m resolution. Pluviometry and temperature were acquired through the Global Land Data Assimilation System available at NASA Goddard Earth Sciences Data and Information Services Center. The digital elevation model was obtained from the Shuttle Radar Topography Mission (STRM) provided by the Brazilian Agricultural Research Corporation (EMBRAPA). Finally, soil type data were acquired from the *Instituto Brasileiro Geográfica e Estatístico* (IBGE).

**4 RESULTS**

The results were divided into 3 steps as seen below.

**4.1 Socioeconomic Profile of PA Settlers Padre Josimo Tavares**

Some data compiled from the forms obtained through visits and field data collection at PA Padre Josimo Tavares were summarized and presented in Figure 3. In 2019, there were an estimated 1,800 residents in the PA. Some of the families declared to have been in the PA since before 1990, however, most of the beneficiary families (91.8% in relation to the total number of beneficiaries) were covered by the National Agrarian Reform Program and started to explore the lots between 1990 and 2009, while most occupants (80.6% of the total number of occupants) began to explore the lots from 2010 onwards.

The RADIS-UFV Project reached 775 families settled in PA Padre Josimo Tavares and it was found that 476 and 299 lots were exploited by beneficiaries and occupants, respectively. Most of those responsible for the lots are from another state (72.4%) and only 15.4% were born in the city of Conceição do Araguaia. About half of those responsible for the lots are between 41 and 60 years old (51.4%) and the settled families are composed mainly of two members (36.8%). The occupants' schooling is mostly incomplete Elementary School (45.8%).

With regard to access basic services for these families, especially infrastructure, it was found that 87.1% have electrification, 83.5% have access to water for human consumption and the domestic sewage generated in 537 lots is destined for pit/sink. More than half of the families (69.2%) have some form of communication (mainly via cell phone). The availability, throughout the year, of access to water for carrying out agricultural activities was recorded in 58.6% of the lots.
The vast majority of those responsible for the lots declared that they are fully dedicated to the agricultural activities carried out on their lots (80.5%). The settlers' main source of income comes from agriculture and livestock (31.6%), agriculture (27.9%) and retirement (20.6%). Although 28.4% of the settlers declared themselves retired (around 66 of them), they continue to be engaged in the productive activities of the lot. In addition, 9.3% of the settlers declared themselves dedicated to agriculture and household activities. The challenges for batch production pointed out were the difficulty in accessing credit, the high cost of production and lack of technical assistance.

Although clearly dedicated to field activities, there are 117 people responsible for the lot who perform some type of extra-lot service (15.1%), thus having an extra source of income. Sources of income obtained outside the lot play an important role in the lives of 27.6% of families, whose income is mostly (> 80%) coming from these external sources, which can be extra lot service, retirement and even program benefits government social security program, since around 174 people have Bolsa Familia. The annual gross income of 65.4% of families varies up to R$ 20,999.00, however, there were those (24.6%) who had annual gross income ranging from R$ 21,000.00 to R$ 40,999.00.

4.2 Agriculture in the Context of the Settlement Project

Concerning to livestock data collected in the field with the settlers of PA Padre Josimo Tavares, beef cattle farming is the most common activity, being carried out by 381 families,
approximately 49.0% of the registered (Figure 4). This is followed by dairy cattle, poultry and pig farming, which are activities practiced by 133 (17.1%), 64 (8.3%) and 45 (5.8%) families, respectively. The other livestock activities such as beekeeping, goat farming, sheep farming and fish farming are little carried out or even non-existent in this region.

![Figure 4](image)

*Figure 4. Survey of the number of settlers who carry out livestock activities in the Padre Josimo Tavares Settlement Project.*

*Source: The authors.*

In the settlement, the annual sale of 4,041 heads of cattle was recorded, which resulted in revenue of R$ 3,767,183.00. Dairy farming, in turn, contributed with a total annual production of 5,605.98 L of milk sold, generating gross revenue of R$ 7,628.55.

Beef cattle farming stands out as one of the activities that contributes to higher revenues. However, the financial return can vary greatly between producers, as the annual gross income obtained from this activity can vary from R$ 1,800.00 to 40,000.00, as can be seen in Figure 5. On the other hand, beef pigs and poultry, although they provide a high profit value, are individually related to producers with better structural conditions. In this context, it was identified that cattle raising is more prominent than other livestock activities, whether for trade or consumption.

As for its spatial statistical distribution within the PA, based on the Hot Spot analysis, it was found that the eastern region has the highest concentration of cattle raising (Figure 6), with such activity being focused on the border between the states of Pará and Tocantins. On the other hand, cattle raising is less expressive in the west and south, where vegetable production is more prominent.
4.3 Agricultural Production in Padre Josimo and its Spatial Characteristics

Agriculture in PA has contributed to the production of different crops, with 20 different varieties registered. In 2019, an annual total of 217,000 kilograms of plant products was sold. The largest number of settlers dedicate themselves to the production of manioc (203 producers), followed by maize (40 producers) and soybeans (35 producers).
Among the crops with the highest annual production, corn (1,664,430 kg), manioc (1,255,477 kg), soybean (885,000 kg), pineapple (347,140 kg) and sugar cane (73,000 kg) stand out, considering the amount equivalent to the entire PA. Despite this, most of the manioc (75.0%) and all the sugarcane produced are consumed within the lot, either as food for the families or for use as animal feed. Thus, the largest commercialized productions are: corn (1,606,950 kg), soybeans (863,000 kg), pineapple (337,580 kg) and manioc (314,320 kg). Considering the commercial value of these crops, the highest income comes from soy (R$996,000.00), corn (R$406,882.00), pineapple (R$185,180.00) and manioc (R$100,058.00).

Based on the spatial distribution of agricultural production in PA Padre Josimo, as shown in Figure 6, there is a greater number of settlers dedicated to agriculture in the southern and western regions of the settlement project. From a grouping statistical analysis, more precisely the Grouping Analysis, a spatial statistics tool, the results referring to the spatial distribution of the crops present in the study area were obtained. In this way, it was verified that among the activities practiced in the region, the cultivation of bananas, corn, manioc and pineapple are the most common, that is, with a greater number of producers. Furthermore, using the Directional Distribution tool, standard deviation ellipses were produced to summarize the spatial characteristics of geographic features of central tendency, dispersion, and directional trends (Figure 7).

As can be seen in Figure 7, the trend regions are located mainly where the ellipses intersect, a region where the Hot Spot analysis of agriculture showed the highest concentration of producers of each crop type (Figure 6). In addition, it is possible to conclude, according to the size of the generated ellipses, that manioc cultivation is the most prominent, followed by banana, corn and pineapple plantations.

Based on the crops that have the largest number of producers in the PA, a Multicriteria Evaluation was also carried out with the objective of identifying, based on a zoning by the natural characteristics of the region, the best places for the insertion of these cultivars (Figure 7).

![Figure 7. Spatial characteristics of the cultivation of plant species produced by a greater number of settlers in the Padre Josimo Tavares Settlement project.](image_url)

**Source.** The authors.
The Multicriteria Evaluation showed high suitability values for maize (238 to 249), manioc (204 to 250), banana (223 to 255) and pineapple (222 to 249). Banana cultivation reached the highest suitability values. As shown in Figure 8, based on the suitability values achieved for each of the crops, it is possible to see that the PA Padre Josimo Tavares is inserted in an ideal area for the development of the cultures inserted in it. Knowing that the suitability scale ranges from 0 to 255, where 0 indicates low suitability and 255 refers to high suitability, it is concluded that all four crops have high natural suitability in the region, since they are all in ranges above 80% suitable for cultivation.

5 DISCUSSION

The guarantee of the right of access to land for the exercise of family agriculture is an achievement signed by law. Through the Agrarian Reform Policy, a better distribution of land is promoted in order to meet the principles of social justice combined with the number reduction of unproductive lands in the Brazilian territory (BRASIL,1964). In this way, Law nº 4,504, of November 30, 1964, guarantees everyone the opportunity to access land ownership, subject to the commitment to maintain its social function, which boils down to favoring the well-being of owners and workers and their families; maintain satisfactory levels of agricultural productivity; ensure the conservation of natural resources; and, exercise fair labor relations between those who own and cultivate the land (BRASIL,1964).

The Agrarian Reform Policy has been applied throughout Brazil and Pará has been the stage for the creation of several settlements (INCRA, 2023). In southeastern Pará, settlements were populated by small producers, squatters and members of the Landless Rural Workers Movement, who migrated to the region in search of better living conditions and to get rid of the social exclusion suffered in other regions of the country (AMORIM et al., 2020).
Possibly, these same social actors were responsible for the exploitation of PA Padre Josimo Tavares, given that, as mentioned in Section 5.1., the vast majority of settlers are not natives of Conceição do Araguaia and migrated to the settlement from other states. Thus, the creation of the PA contributed with new opportunities and attracted farmers from other regions.

Added to the fact that those responsible for the lot are between 41 and 60 years old and the PA is around 30 years old, possibly the lots, in 2019, were still explored by the original settlers, which demonstrates that there was a bond and commitment to the development of the batches from them. As the main activity and sources of income of the settlers are linked to agricultural activities, it is believed that a large part of them are dedicated to guaranteeing the lots’ social function, seeking to keep them productive and to support their families.

It was observed that 299 lots were exploited by occupants, that is, about 37% of the PA lots observed in the field. The inspections, during the activities of the RADIS-UFV Project, revealed that part of the lots were occupied by beneficiaries of other lots in the PA. It is common practice to occupy a lot close or adjacent to the benefited lot to meet the demands, especially of cattle raising, favoring land requirements and the rotation of animals to allow pasture renewal. Therefore, INCRA needs to devise a strategy for land tenure regularization in these cases. After all, does the stipulated size for the lots not meet the demand of small and medium-sized livestock? In this case, regulation of these occupants would be justified. As it was observed that, among the occupants, the most common level of education is incomplete primary education, offering the necessary conditions to keep them connected to the land is a socioeconomic strategy, as long as they meet the requirements and have the profile to be contemplated by the National Policy for Agrarian Reform.

On the other hand, it is worth questioning whether allowing beneficiaries to explore double, or even triple, the area initially fractioned to serve each settler mischaracterizes the socio-productive profile encouraged by the agrarian reform policy. Thus, this is a first question, a result of the agreed TED, which should be better understood by the municipality.

Regarding agricultural activities, in the municipality of Conceição do Araguaia, there are larger areas destined for livestock practices (pasture areas = 231,547 hectares) than agriculture (permanent and temporary crops area = 14,304 hectares) (IBGE, 2017). Within the PA, the same trend follows, given that livestock farming proved to be the most prominent activity, although a large part of the settlers carries out, simultaneously, livestock farming and agriculture. Among permanent crops, the municipality is dedicated mainly to banana and coconut (IBGE, 2022). With regard to the production of cereals, legumes and oilseeds, the most prominent crops in the municipality are rice, beans, corn and soybeans (IBGE, 2008). In this way, the activities carried out in the PA follow, in part, the trend of the municipality, since bananas, corn and soybeans are the crops with the largest number of producers or with relevant production. It is noteworthy that, although the cultivation of corn has greater production, the main source of income comes from soybeans.

The municipality of Conceição do Araguaia borders Tocantins, which is inserted in the region known as MATOPIBA, in which soy production is one of the main activities. Although the soy moratorium aims to prevent large producers from settling in the Brazilian Amazon, which resulted in advances in this activity for the Cerrado biome (MAGALHÃES et al., 2020), there are recent reports of pressure from agribusiness capital, mainly with advances of soy production, in settlements located in the municipality of Conceição do Araguaia. With regard to the PA Padre Josimo Tavares, the occurrence of irregular transfers of ownership of lots to soy producers in the region was pointed out, justified by financial difficulties suffered by the settlers (ARRAZ; MARQUES; RIBEIRO, 2022). In this sense, the financial return arising from soybeans in the PA is questioned, which is possibly not favoring small producers and family farmers benefited by the agrarian reform. In order for the PA not to lose its social function, an
autarky approach is needed to remedy the situation and even contain the advance of soy cultivation, under landowning conditions, to the territory of the Amazon biome.

Through spatial analysis, considering the crops produced by a greater number of settlers, it was observed that there is a good distribution between the evaluated crops in the PA, being more oriented to the west. Comparing Figures 7 and 8, it is observed that these cultures were planted in areas with good suitability for their development, according to the natural aspects of the region. This offers advantages, as the use of traditional cultivation techniques, which is characteristic of family farming, may be sufficient for farming in the PA. Thus, even if state-of-the-art technologies are not applied in agriculture, which requires greater financial resources, the cultivars develop more easily, given their adaptability to local edaphoclimatic conditions.

Beef cattle breeders, in turn, are more concentrated in the northeast. Livestock is the predominant activity in the Amazon region and is attractive because it demands low initial investments and labor, financial returns in a shorter period and is an easily tradable form of liquid capital (NASCIMENTO; SILVA; PEDREIRA, 2015). In addition, the activity becomes profitable considering the low land prices in the Amazon (NASCIMENTO; SILVA; PEDREIRA, 2015).

Among the family farmers in southeastern Pará, cattle raising is also a very recurrent activity, since it is not demanding in terms of labor and has a stable and logistical market for its production (AMORIM et al., 2020). On the other hand, it is the agricultural activity identified as responsible for most of the deforestation in the region, which occurs due to its demand for large extensions of land and because small farmers consider it economically viable to replace the forest and the old agricultural crops for pasture implantation (AMORIM et al., 2020). The environmental conditions in the region also contribute to the implementation of livestock, since the distribution of rainfall (between 1600 mm/year and 2200 mm/year) and the absence of frost are favorable for the maintenance of pastures (NASCIMENTO; SILVA; PEDREIRA, 2015).

There is criticism of livestock farming in the Amazon region, since, although there are several actors who have contributed and continue to contribute to deforestation in the region, this economic activity is identified as one of the main causes and which has been advancing (NASCIMENTO; SILVA; PEDREIRA, 2015). The reversal of this reality requires time and strategies through actions and public policies. This is because, initially, rural settlements were created with the premise, coming from the government, that lots should be deforested to be used in agricultural activities, so that lots that contained standing forest were understood as unproductive and suffered penalties (MACHADO et al., 2019). Thus, it is necessary to establish a new paradigm that reconciles agricultural productivity and plant conservation.

An alternative to make environmental conditions applicable to the PA Padre Josimo Tavares, as well as to other PAs, is livestock-forest integration, such as the well-known agroforestry system. In this practice, there is a combination of pasture and trees to compose the vegetation cover. These systems can be implemented with different plant species (including trees and shrubs), which provide shade for livestock, reduce soil erosion and increase carbon sequestration. This production approach is more sustainable and has been increasing around the world, as well as increased, between 2006 and 2017, in the Amazon. Among the plant species used, the main ones observed were açai, Brazil nuts and babassu, native to the region (SABINO et al., 2022). This alternative can be applied with species for commercial purposes, with the extraction of non-timber products, which would increase the productivity and profitability of the lots. In addition, the adaptation of pastures to compose agroforestry systems could, for example, be adopted as a compensatory measure for companies that intend to comply with the environmental regulations. In this way, existing problems are intertwined with necessary solutions.

Regarding to economic policy, those focused on the commitment to zero deforestation should be encouraged. These policies aim to ensure that, within the production chain, the
products purchased by suppliers were obtained through production free of deforestation and/or illegal deforestation (LEVY et al., 2023). For example, the Conduct Adjustment Term, created by the Federal Public Ministry of the state of Pará in 2009, which was signed by slaughterhouses directly targeted by the ministry due to historical knowledge with high levels of illegal deforestation in the Legal Amazon (LEVY et al., 2023). Policy strategies in this sense need and must be shaped to be applied to small and medium-sized producers located in rural settlements.

Finally, due to the importance of some factors, such as improved investment in technology, higher capital formation, the opening of better market channels, improved processing sector efficiency, better cropping systems, extension activities, adequate focus on post-harvest management, pest and disease control to boost the agricultural sector (Lalengkima et al., 2023), the importance of offering adequate technical support to settlers is reinforced.

6 CONCLUSION

The present study contributes to understand how some aspects of the social function of the land are being taken care of in the Padre Josimo Tavares Settlement Project. Through the data obtained in the RADIS-UFV Project, it was observed that most of the settlers cultivate species that are suitable for the region, which favors the lot productivity. Beef cattle was the main economic activity that reflects the characteristics of the region in which the settlement project is located, as well as one of the main current concerns for the environmental preservation of the legal Amazon.

Thus, in order to contribute to the development of the studied settlement project, jointly in the social, economic and environmental spheres, it is important to implement actions and programs in order to promote technical solutions, such as the installation of agroforestry systems, and economic policies that favor and regulate the small and medium-sized producer inserted in the context of rural settlement.

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