



TERRITORY, TECHNIFICATION, AND AGRICULTURE IN THE AMAZONAS STATE: AN APPROACH

**TERRITÓRIO, TECNIFICAÇÃO E AGROPECUÁRIA NO AMAZONAS:
UMA APROXIMAÇÃO**

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ABSTRACT

This article aims to analyze the processes of agricultural modernization in Amazonas, linking them to land tenure structures and territorial dynamics, from the perspective of the Philosophy of Techniques proposed by Milton Santos (2006, 2008). The methodology is based on the analysis of secondary data from the 2017 Agricultural Census (IBGE), organized in Excel for tabulation and QGIS for mapping, examining indicators such as the presence of tractors, access to electricity, and technical guidance in establishments of different sizes. The results reveal a concentrated land tenure structure, with properties larger than 1,000 ha occupying 37.27% of the total agricultural area despite having the smallest number of farms; technical diffusion is asymmetrical, concentrated in the southern part of the state by pioneer fronts and around the Manaus metropolitan area, benefiting large estates integrated into global commodity markets, while small producers account for only 1.22% of those with tractors and receive limited assistance and rural extension services (ATER). In regional terms, the process of agricultural modernization has benefited agricultural sectors with the greatest potential for productivity and technological gains, promoting varying levels of intra- and interregional modernization.

Keywords: agribusiness; modernization; public policies; agriculture.

RESUMO

Este artigo objetiva analisar os processos de tecnificação da agropecuária no Amazonas, articulando-os à estrutura fundiária e às dinâmicas territoriais, sob a ótica da Filosofia das Técnicas proposta por Milton Santos (2006, 2008). A metodologia baseia-se na análise de dados secundários do Censo Agropecuário 2017 (IBGE), sistematizados no Excel para tabulação e QGIS para cartografia, examinando indicadores como presença de tratores, acesso a energia elétrica e orientação técnica em estabelecimentos de diferentes portes. Os resultados revelam uma estrutura fundiária concentrada, com imóveis acima de 1.000 ha ocupando 37,27% da área agropecuária total apesar de apresentarem o menor número de estabelecimentos; a difusão técnica é assimétrica, polarizada no sul do estado por frentes pioneiras e no entorno da metrópole Manaus, beneficiando latifúndios integrados a *commodities* globais, enquanto pequenos produtores apresentam apenas 1,22% com tratores e baixa assistência e extensão rural (ATER). Em termos regionais, o processo de modernização agrícola beneficiou setores da agricultura com maior potencial em produtividade e ganhos tecnológicos promovendo distintos níveis da modernização intra e interregional.

Palavras-chave: agronegócio; modernização; políticas públicas; agricultura.

INTRODUCTION

The process known as “agricultural modernization”, underway since the mid-twentieth century, has profoundly affected Brazil’s agrarian space, triggering a series of dynamics linked to the technification of the territory. As Paulino (2006) points out, technification does not equate to social progress. This is especially true in the countryside, where the idea of “modernity” is often invoked to justify the monopolization of land access and, primarily, land ownership.

Locatel (2012) states that techniques in Brazilian rural areas were adopted unevenly and selectively. State efforts mainly drove technification — more machinery, inputs, and technical resources — through policies aimed at modernizing agriculture. This process varied by land structure and farm size, primarily benefiting larger properties. Instead of equalizing productivity, modernization widened gaps among producers and regions.

This research analyzes the technification processes of agriculture and ranching in the state of Amazonas using secondary data. Specifically, It examines how the reach of the electrical grid and the incorporation of machinery and technical services materialize in the Amazonian rural territory, while considering land ownership as a critical backdrop.

Two main aspects justify this study. First, Amazonas, Brazil’s largest federal unit, faces infrastructure deficits and low population density, which challenge technification, especially in rural areas. Second, technification is not spontaneous but driven by the interests of hegemonic agents like the State and capital, which can worsen territorial disparities. These factors call for empirical dialogue on technological innovation, public policy, and sustainable regional development, focusing on how techniques relate to territorial and socioeconomic dynamics.

This research is divided into two parts: the first briefly explains technification and links it to current land access trends; the second uses variables such as machinery, electricity, and guidance to analyze technification in Amazonas. It highlights a national development model that unevenly benefits regions through agricultural modernization.



METHODOLOGICAL PROCEDURES

The methodological procedures adopted in this study rely on secondary data analysis, using the key concept of technification to understand its manifestations and disparities within the agro-pastoral territory of the state of Amazonas.

While this work focuses on territorial technification in Amazonas, we identified a need to deepen our analysis of the state's current land-ownership framework within the broader Brazilian context. Thus, the study proposes an essentially empirical analysis of the land structure and, primarily, the degree of technification among agro-pastoral establishments in the territory. We adopt the concept of technique through the lens of the Philosophy of Techniques proposed by Milton Santos (2006, 2008) as our conceptual foundation. This reflection recognizes that regional inequalities in countries like Brazil are deep and recurrent, shaped by territorial formation (Furtado, 2007; Santos e Silveira, 2008; Santos, 2003). The modernization process, driven by agrarian and non-agrarian capital, aimed at capitalist, monocultural agriculture, which intensified land concentration and inequality due to production selectivity—such as incentives for specific crops, beneficiary farmers, and access to public funding and innovation (Delgado, 2012; Gonçalves Neto, 1997).

To grasp the variables of land concentration and technification, we utilize graphs and maps that compare the number and area occupied by agro-pastoral establishments of different sizes (notably those under 100 ha and those over 1,000 ha), as well as technical diffusion indicators such as the presence of tractors, access to technical guidance, and access to electricity. In this phase, the research primarily uses information from the Agricultural Census conducted by the Brazilian Institute of Geography and Statistics (IBGE, 2017), which serves as the foundation for the empirical framework. We selected the three aforementioned variables based on the understanding that, when considered together, they serve as indicators of the state of technification.

We collected secondary data through the IBGE Automatic Recovery System (SIDRA). It became evident that the most recent data regarding this theme refers to the 2017 Agricultural Census. We performed data processing and graph production in *Excel*, where information was systematized and, when necessary, converted from absolute values to percentages. Cartographic products were generated in open-source software (QGIS 3.33).



TECHNIFICATION AND LAND CHARACTERIZATION: INITIAL NOTIONS ON BRAZIL AND AMAZONAS

Since the 1970s, a prominent process of technification has shaped Brazil's agrarian space, driven by capitalist expansion and the growing role of science and technology in production. To understand these transformations, I adopt the concept of technique as a mediator between society and the environment. This concept denotes a set of instruments and social practices through which individuals organize their lives, produce goods, and, in the process, construct space (Santos, 2006).

Santos (2006) states that techniques have improved and integrated into various activities, especially during the twentieth century, replacing the technical milieu with a broader technical-scientific milieu called the "technical-scientific-informational milieu". Historically, this development was centered in the South and Southeast, known as the "Concentrated Region" (Santos; Silveira, 2008).

In agro-pastoral activities, particularly soybean production, it is important to emphasize that technification involves more than mere quantitative measures, such as increased cultivated area or rising productivity. Rather, it is a qualitative process of territorial reconfiguration. This process involves the actions of capital and the State, as well as the introduction of sophisticated machinery, inputs, infrastructure, and technical knowledge that alter socio-spatial relations in the countryside.

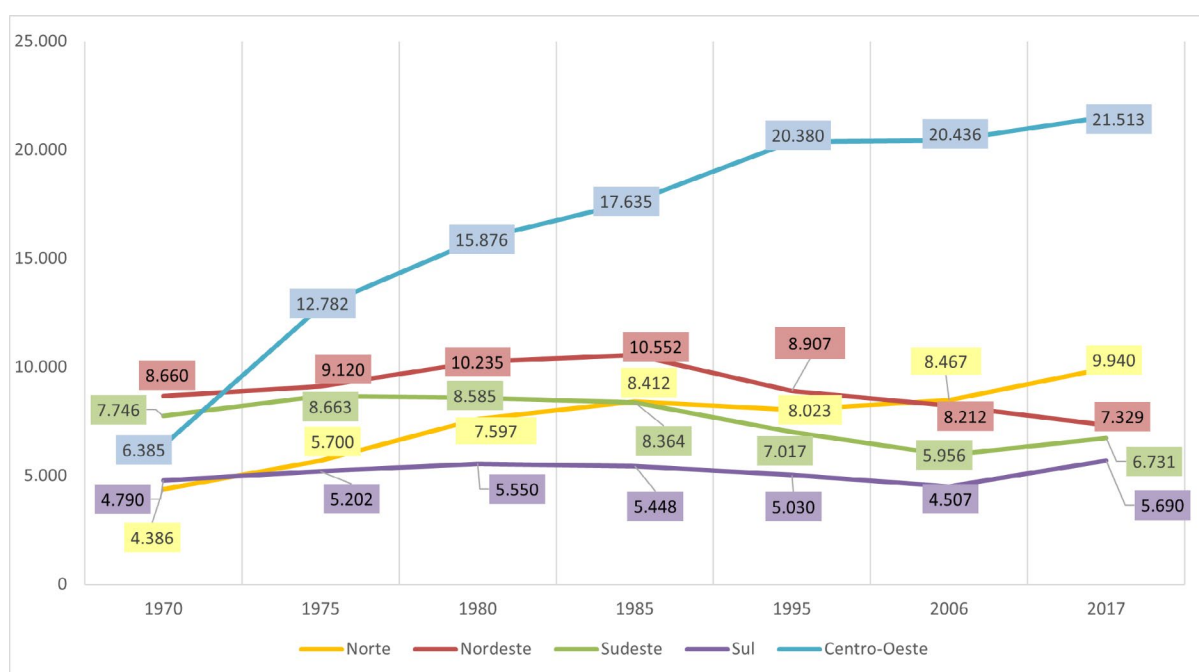
Drawing on Campos (2011) and Vidal (2024), the technification of Brazilian agriculture, especially soybean dissemination, solidified in the Southern region during the 1970s. This modernization lagged behind developed nations. In the 1980s and 1990s, the Center-West became a key area for agro-pastoral activity and is now Brazil's main technical hub for globalized production. By the 2000s, this technical-agricultural shift extended into the Northeast, particularly in MATOPIBA (Maranhão, Tocantins, Piauí, Bahia), driven by policies promoting rural production and by infrastructure improvements, such as highways and ports.

Currently, there is an intensification of technical agro-pastoral development in the Northern region. However, this dynamic accentuates social inequalities and environmental degradation, as evidenced by the region's consistent leadership in annual deforestation. These processes can only materialize on such a broad scale through access to credit.



The Center-West's command as a territory of agro-pastoral capital over other regions (Graphic 01) rests heavily on research. Specifically, universities and the Brazilian Agricultural Research Corporation (EMBRAPA, 2025) — institutions with strong state ties — play a vital role. Consequently, technique does not spread uniformly across space; its diffusion depends directly on the interests of society's hegemonic agents. In the agro-pastoral sector, these agents are primarily the State and large landowners. The former acts via technical base and innovation, while the latter, driven by surplus value, practices spatial selectivity, turning territorial fractions into sub-spaces reflecting globalization (Santos, 2008).

Graphic 01 | Agro-pastoral establishments with more than 1,000 hectares by region



Organization: The Authorship. Source: IBGE (2017).

The latifundia serve as a sign of this spatial arrangement, as the Brazilian land structure remains essentially concentrated. Despite recent public policies, as Cosme and Pereira (2020) demonstrate for the state of Alagoas, land concentration accompanies monoculture dynamics. These often show high technification and fuel rural violence. Thus, the continuation of latifundia as a dominant landform in Brazil can be seen as a “counter-agrarian reform”, even without official status.

Therefore, the articulation between technification and a concentrated land structure indicates that technical advancement in the Brazilian countryside primarily benefited large landowners, thereby fostering territorial inequalities. These properties used mechanization, agrochemicals, and biotechnology to boost exports of crops such as soybeans, corn, beef, and oranges, mainly to international markets. This reinforces Brazil's role as a global agro-pastoral power but limits its ability to produce advanced inputs for modern life or to support its domestic industry.

The State supported this process extensively, primarily through rural credit policies. The creation of the National Rural Credit System (SNCR) in 1965, established by Law 4,829 and regulated by Decree 58,380, aimed to finance agriculture through the participation of public and private financial institutions. This encouraged technological modernization and expansion of production (Leite, 2001). In this context, the State became the primary agent of agricultural modernization through public credit policies, consolidating a development pattern oriented toward medium and large producers.

The number of agro-pastoral establishments exceeding 1,000 hectares is increasing primarily in the Center-West and Northern regions. These regions show the strongest growth trends for this typology between 1970 and 2017 (Graphic 01).

Pioneer fronts are most visible in these two regions. In the Center-West, they appear in a consolidated form; in the North, they manifest actively and expansively, though they interact asymmetrically. For instance, consolidated pioneer fronts in Mato Grosso, south-central Rondônia, and southwestern Pará now command capitals and actions that progressively extend economic activation into northern Rondônia, much of Acre, and southern Amazonas (Castro de Jesus, Oliveira Neto, Silva, 2023).

As previously suggested, this process also relates to the agrarian-export productive model focused on commodity production for the global market, which demands vast tracts of land for monocultures, such as soybeans. In this context, the need for constant productive improvement implies greater investments in the technification and digitalization of the agro-pastoral productive mode, aiming to ensure quality and quantity control (Silva *et al.*, 2025).

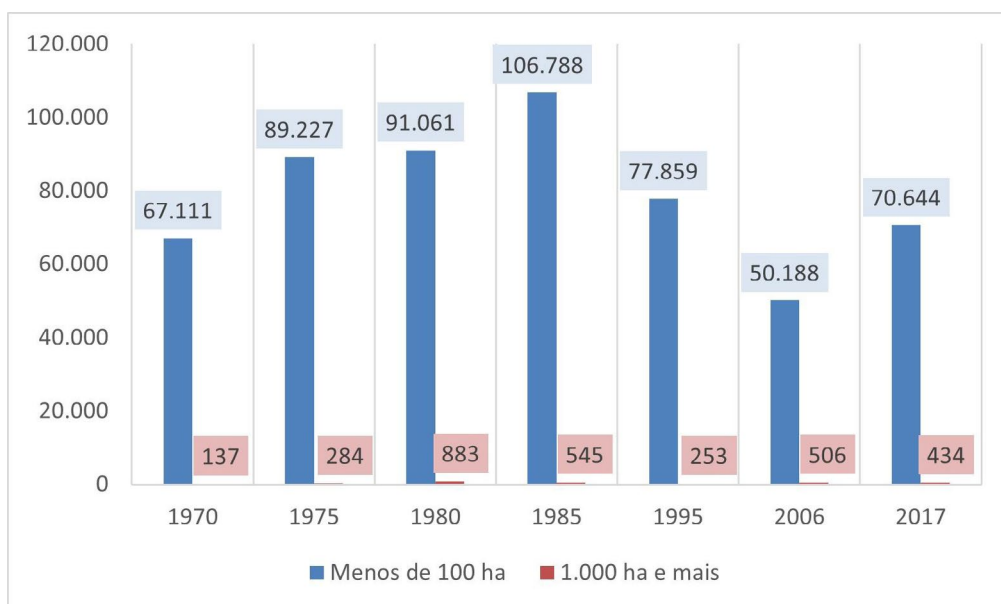


In Graphic 02, we compare the number of agro-pastoral establishments with less than 100 ha and those with more than 1,000 ha in Amazonas. Establishments with less than 100 ha are numerically dominant. They are characterized by low levels of capitalization, diversified or subsistence production, strong ties to local markets, and extractive practices typical of traditional Amazonian populations. Conversely, establishments exceeding 1,000 ha, though few in number, occupy a disproportionate share of the territory (Table 01), concentrate investments in mechanization, inputs, and logistics, and orient their production toward larger-scale value chains.

Within the Amazonian space, this duality translates into distinct land-use patterns. Small properties often lack the legal support needed to sustain traditional lifestyles, such as those of the ribeirinhos (river-dwellers), and to maintain uses with low environmental impact. By contrast, large properties maintain strong links to active pioneer fronts, highway axes, and practices that cause severe environmental degradation, especially in the state’s south.

The practical consequences for workers’ social and economic lives are broad. When subjected to the second type of duality, consequences include the precariousness of labor regimes, land conflicts, and territorial pressure on forest and water resources.

Graphic 02 | Agro-pastoral establishments with less than 100 ha and more than 1,000 hectares in the state of Amazonas



Organization: The authorship. Source: IBGE (2006;2017).



Until the mid-1960s, a large share of Amazonian land was owned by the Union and the states. Vast forest areas, formally unoccupied, stood out; caboclos and river-dwellers used them for extraction, while only a small portion was occupied by old cattle ranches. Crops covered less than 2% of the land, and public lands occupied by small squatters (*posseiros*) made up much of the territory (Loureiro; Pinto, 2005).

During the Military Dictatorship (1964–1985), the Brazilian State adopted policies aimed at the region's economic integration, offering incentives to attract national and foreign capital and to stimulate capitalist production in the territory. In this context, the creation of the Superintendency for the Development of the Amazon (SUDAM) in 1966, established by Decree-Law No. 5,173, is a relevant public agency for understanding transformations in Amazonas during this period. The institution aimed to coordinate and promote federal action in the Legal Amazon, using fiscal incentives to attract private investment, similar to the SUDENE model in the Northeast.

Between the 1970s and 1980s, SUDAM received significant investments to stimulate settlement and economic development in the region (Léon *et al.*, 2015). This also affected the state of Amazonas, particularly through the Manaus Free Trade Zone, mineral extraction projects, increased hydroelectric power production, and the expansion of the highway network — the latter three have operated in the municipality of Presidente Figueiredo since then.

In practice, a portion of these resources was not directed toward creating new productive activities in the region. Many entrepreneurs used them to purchase land for speculative purposes, for investments in other parts of the country, or even to create fictitious companies. In other cases, large firms promoted the deforestation of vast forest areas to convert them into pastures for cattle. Consequently, these initiatives produced significant environmental impacts, generated few jobs, and failed to promote the promised regional development, although this model has largely remained unchanged (Loureiro and Pinto, 2005).

An emblematic case of this process is highlighted in Schwade's (2019) thesis, which analyzes the so-called "São Paulo land-grabbing" (*grilagem paulista*) and reveals the speculative nature of land titling in the region. Many title beneficiaries never effectively occupied the areas, as their primary interest lay in the indemnities resulting from the construction of the Balbina Hydroelectric Plant on



the Uatumã River, in the municipality of Presidente Figueiredo (AM). Later, realized and estimated at hundreds of millions of reais, these lands, not affected by the reservoir, were incorporated into the land market and acquired by entrepreneurs, primarily from the timber sector, reinforcing the capitalist appropriation of land. In this context, conflicts between social classes intensified, marked by the actions of rentiers, capitalists, and peasants, as well as by recurrent land-grabbing practices and episodes of violence in property disputes (Schwade, 2019).

Furthermore, the incentive policy contributed to income concentration by primarily benefiting large economic groups, but its strongest effects occurred regarding the land issue. Starting in the 1970s and 1980s, vast areas of public land occupied by local populations were sold to investors in large lots. This process was frequently accompanied by land-grabbing practices, such as the falsification of titles, the irregular resale of public lands, and the illegal expansion of property boundaries (Loureiro; Pinto, 2005).

One can observe the reproduction of these dynamics in Graphic 02. In 2006, the number of properties of up to 100 ha in Amazonas decreased, possibly associated with the incorporation of small units by larger establishments within the context of agro-pastoral expansion and the restructuring of the agrarian space. During the same period, the expansion of soybean cultivation in the Amazon intensified debates over its link to deforestation, generating pressure for greater control over land and for the regularization of rural properties and their environmental impacts. This likely also contributed to the process, as small farmers may have faced greater difficulties in having their properties recognized under the new parameters imposed (Cardoso, 2008).

As previously observed, the Northern region exhibits growth in the number of agro-pastoral establishments exceeding 1,000 hectares (Graphic 01). In the state of Amazonas, although establishments under 100 hectares are far more numerous, properties over 1,000 hectares concentrate significantly larger land expanses (Graphic 02). Thus, despite their smaller numbers, large properties hold a substantial share of total land occupancy, revealing the persistence of a land structure characterized by concentration, as observed in Table 01.



Table 01 | Small and large-scale agro-pastoral establishments relative to the total occupied area in Amazonas (2017)

Establishment Profile	Number of Establishments	Total Occupied Area (ha)	Proportional Area of Agro-pastoral Establishments in Amazonas (%)
100 ha or less	70,644	1,060,562.834	26.39
Between 100 and 1,000 ha	9,881	1,460,743.611	36.34
Above 1,000 ha	434	1,497,271.389	37.27
Total	80,959	4,018,577.834	-

Organization: The authorship (Feb.2026). Source: IBGE (2017).

In Amazonas, while the combined area of establishments equal to or smaller than 100 hectares reached 1,060,562.834 hectares, agro-pastoral establishments with an area of 1,000 hectares or more totaled 1,497,271.389 hectares. This represents an area approximately 41.17% larger than that occupied by small-scale establishments (IBGE, 2017), underscoring a deeply unequal land structure. In other words, large landowners (latifundiários) control the majority of the land — 37.27% of the area identified as agro-pastoral establishments in Amazonas.

Amazonas’ concentrated land structure reflects a “counter-agrarian reform’ similar to trends noted by Cosme and Pereira (2020). Its land, mainly in a latifundia form, results from territorial policies that favor exchange value over land use, as Loureiro and Pinto (2005) describe.

Deepening the analysis of technification in Amazonas’ agro-pastoral production enables examination of several variables to understand its progression. One element that draws particular attention is the presence of tractors in agro-pastoral establishments, a context I will address in the following section.

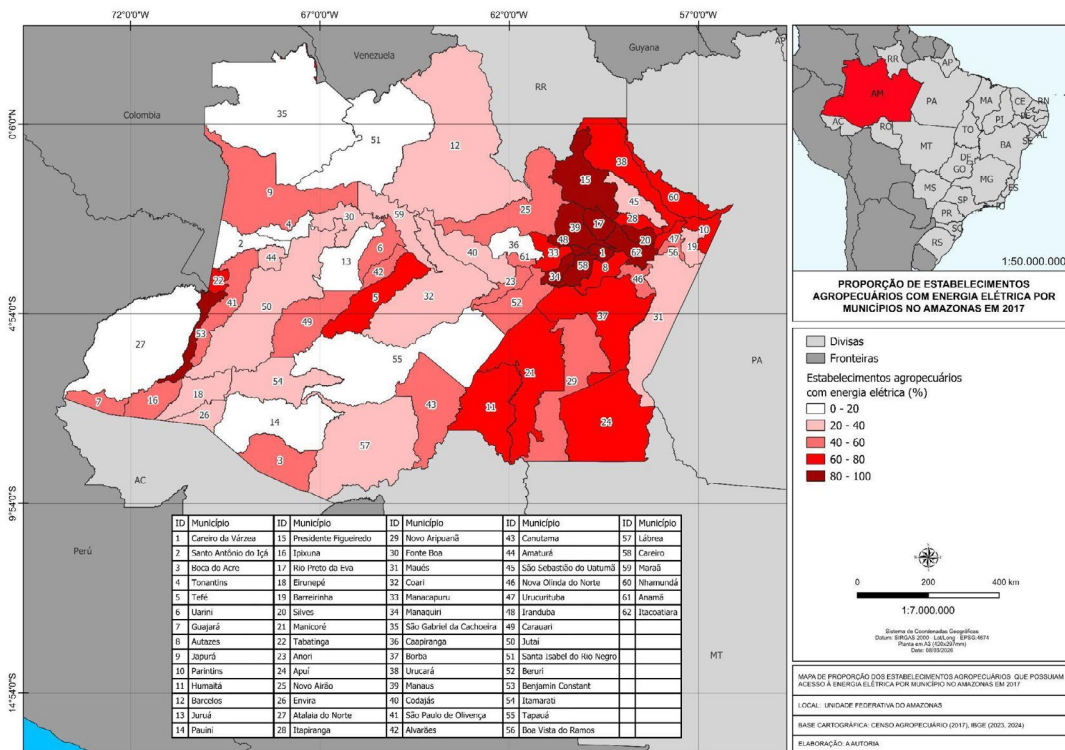
THE PATHWAYS OF TECHNIFICATION IN AMAZONAS' AGRO-PASTORAL SECTOR

We can conceive of technification, in terms of spatial form, as the introduction of machinery, inputs, and bureaucracies — in the sense of routine and procedural control — within the category of the technical milieu. From the perspective of the spatial structure (content), we emphasize the nature of operational, organizational, and command transformations within the geographic milieu. These factors affect modes of production and labor relations, among other elements (Santos, 2006).

For instance, the reach of the electrical power grid represents a substantial expansion of productive capacity and well-being in contemporary life. In rural areas, the presence of electricity enables other technical objects associated with technification, such as irrigation, refrigeration (storage), and related processing activities powered by electronic machinery (Figure 01).

The power supply network is a sensitive infrastructure; it serves as an indicator of the degree of technification — not necessarily of technical sophistication itself, but rather, in its absence, of the technical precarity within agro-pastoral establishments.

Figure 01 | Map of electricity presence in the rural space of Amazonas



Elaboration: The authorship (2026). Source: IBGE (2017).



One observes an evident intra-state spatial differentiation: the eastern portion of the state, particularly near the capital, Manaus, possesses better-qualified infrastructure regarding this variable. This fact contrasts sharply with the central and western portions of the federal unit. This internal disparity likely intertwines with the concentration of the road network in the east. Even if precarious, this network directly supports increased physical integration of the territory, thereby enhancing territorial fluidity and overall logistics.

Based on this understanding, nine municipalities in Amazonas — namely, São Gabriel da Cachoeira (3.98%), Atalaia do Norte (6.63%), Tapauá (6.93%), Tonantins (12.42%), Santo Antônio do Içá (16.66%), Caapiranga (17.08%), Pauini (17.73%), Santa Isabel do Rio Negro (18.66%), and Juruá (18.87%) — have the lowest electricity coverage rates among agro-pastoral establishments. This situation demonstrates that public policies remain insufficient to resolve this territorial problem.

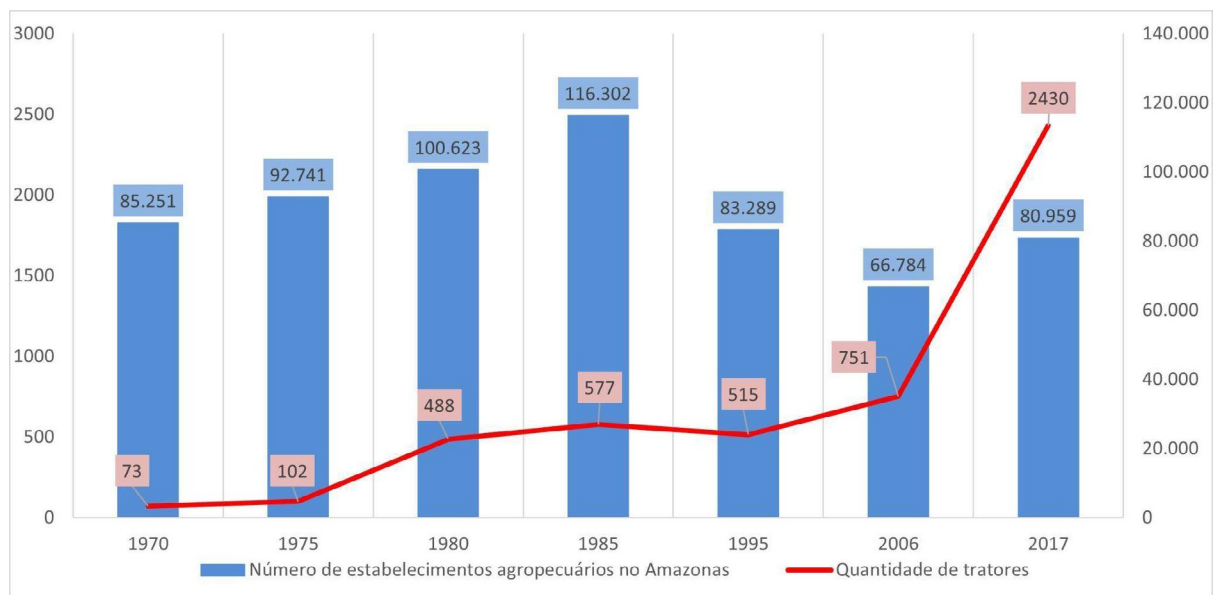
At least discursively, government agencies — primarily federal ones — treat the expansion of the electrical grid as a priority. For example, the Ministry of Mines and Energy (MME, 2026) indicates that the “Light for All Program” (Programa Luz para Todos), the main national initiative for electrical expansion, aims to achieve universal access for “the rural population and residents of remote regions in the Legal Amazon who lack access to public service”. Thus, it seeks to combat “energy poverty”.

However, a central issue in Amazonas deserves to be highlighted: most of the state, including its cities, is not even connected to the National Interconnected System (SIN). Instead, they rely on isolated systems, such as fossil-fuel-based thermoelectric plants, which have a high potential for atmospheric pollution. For riverine communities, the situation is even graver due to logistical challenges in electrical integration. In these areas, other types of isolated systems, such as photovoltaic panels, prove more viable — a form of technification promoted by the state government through the State Secretariat of Energy, Mining, and Gas (SEMIG, 2024).

When we consider tractors as an indicator of technological development, the overall picture reveals an ongoing process of productive technological development in the Amazonas agro-pastoral sector. Likely due to factors related to the consolidation of Manaus as a technical hub driven by industry, we observe a decrease in the number of agro-pastoral establishments between 1985 and 2006. This was followed by significant growth in 2017, which, in our hypothesis, associates with the emergence of pioneer fronts in the state (Graphic 03).

Despite the increase-decrease-increase pattern in the number of establishments, a steady growth trend in tractor acquisition persists. We highlight: i) a 378.4% increase in the number of tractors between 1975 and 1980; ii) a 45.8% increase between 1995 and 2006, even during a period when the total number of establishments declined; and iii) a 223.5% increase in the total number of tractors between 2006 and 2017, indicating a new dynamic of intensifying agro-pastoral technification.

Graphic 03 | Evolution of the number of agro-pastoral establishments versus the number of tractors in Amazonas



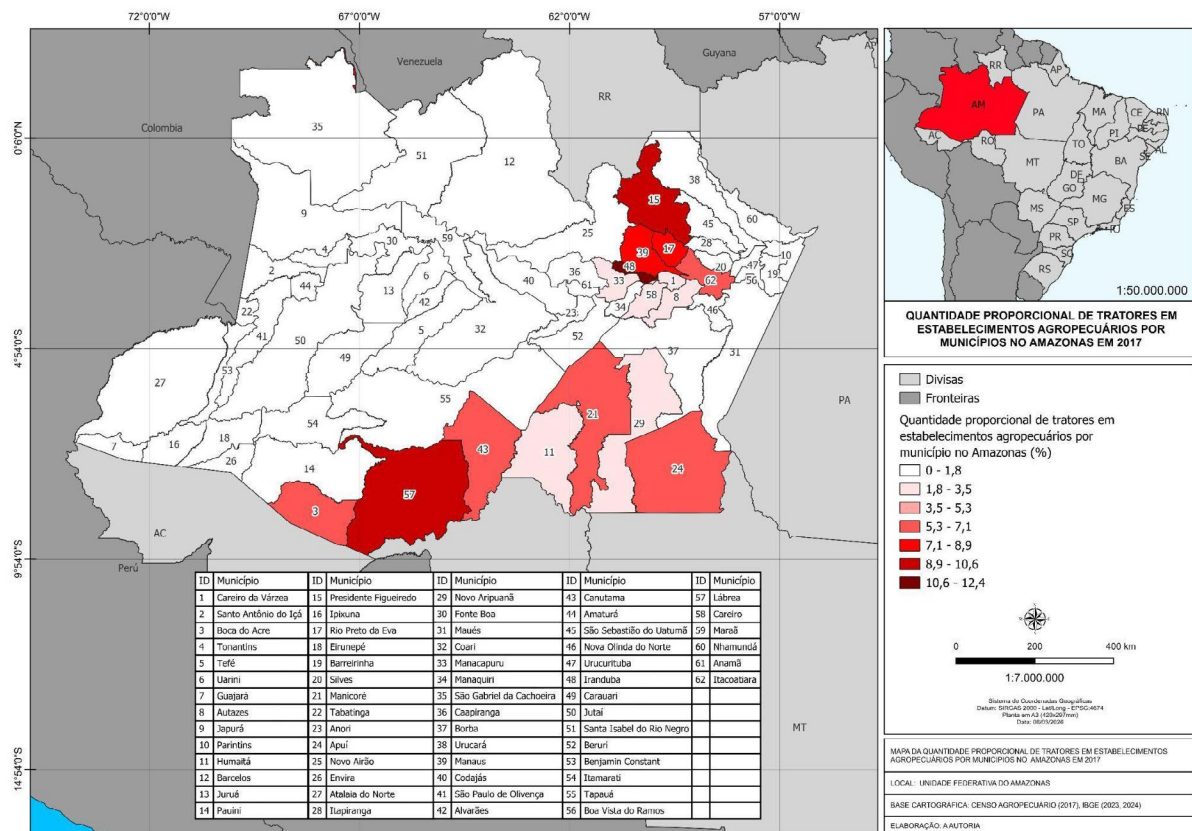
Organization: The Authorship. Source: IBGE (2017).

We consider it important to address establishments with tractors. Recent data (IBGE, 2017) show 865 small establishments (<100 ha) with tractors and 224 large ones (>1,000 ha). Although more small establishments have tractors, they make up only 1.22% of their size category, while the 224 large ones account for 51.61% of theirs.

One should question whether incentive policies, geopolitical changes, or global market shifts explain the two tractor acquisition peaks — either in the 1980s or starting in 2006. The likely cause is the transformations from the Regional Infrastructure Integration in South America (IIRSA) in the 2000s, which boosted pioneer fronts by improving highways and colonization projects along the southern BR-319, especially in southern Amazonas (Castro de Jesus et al., 2023).

Access to machinery, especially tractors, differs greatly between small and large agro-pastoral farms due to financing difficulties faced by small producers, whereas agribusinesses meet the criteria more easily. Figure 02 shows the distribution of tractors per municipality in Amazonas. There are 27 fewer tractors in the municipal total than the 2017 Agricultural Census data at the state level, requiring IBGE adjustments. The map uses municipal values.

Figure 02 | Map of the proportional distribution of tractors per municipality in Amazonas



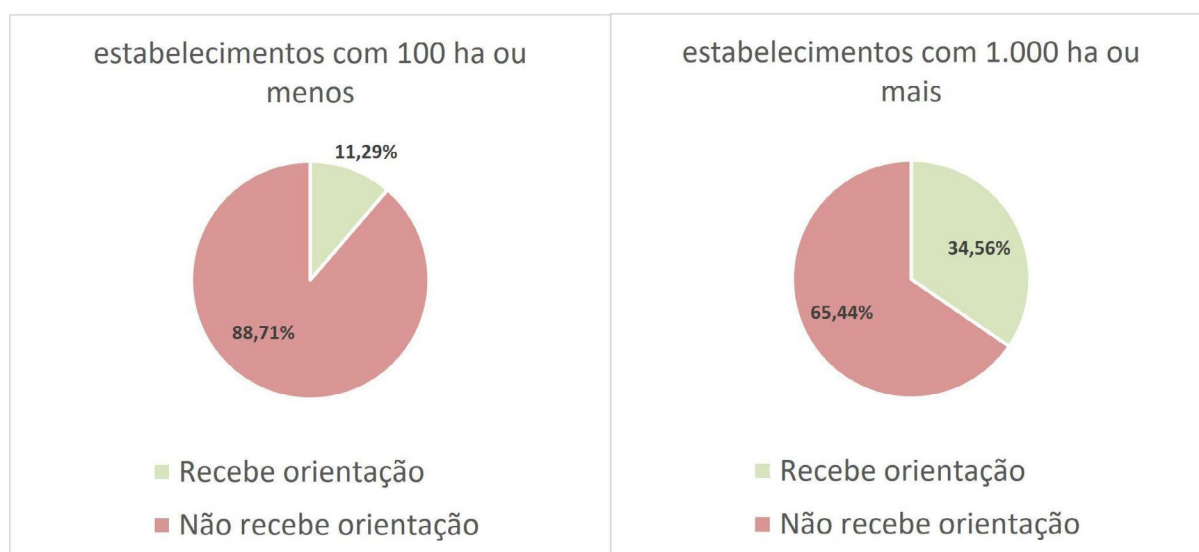
Elaboration: The authorship (2026). Source: IBGE (2017)

An analysis of the data from a spatial perspective highlights the significance of pioneer fronts in southern Amazonas in explaining the state’s high tractor density. In this regard, we reaffirm that the pioneer fronts in the Center-West region are consolidating, acting as a command center for capital and actions shifting toward the North. This triggers economic development in new territories, as seen in southern Amazonas (Castro de Jesus *et al.*, 2023). This may manifest, for instance, in the acquisition of new machinery, such as tractors, as well as other improvements.

Furthermore, technical guidance is crucial for enhancing a farmer's productive capacity and for improving and maintaining soil fertility. In Brazil, as previously stated, EMBRAPA (2025) plays a central role in innovation and technical guidance. It provides what we might consider "upper tertiary services" due to its high degree of specialization for Brazilian agribusiness, both domestically and internationally.

According to the Agricultural Census (IBGE, 2017), technical guidance is directly related to the professional articulation of agro-pastoral activities through guidance and technical assistance. Graphic 04 evaluates the presence of technical guidance among small- and large-scale agro-pastoral establishments in Amazonas.

Graphic 04 | Small and Large-scale Establishments by Presence of Technical Guidance (2017) in Amazonas



Organization: The Authorship. Source: IBGE (2017).

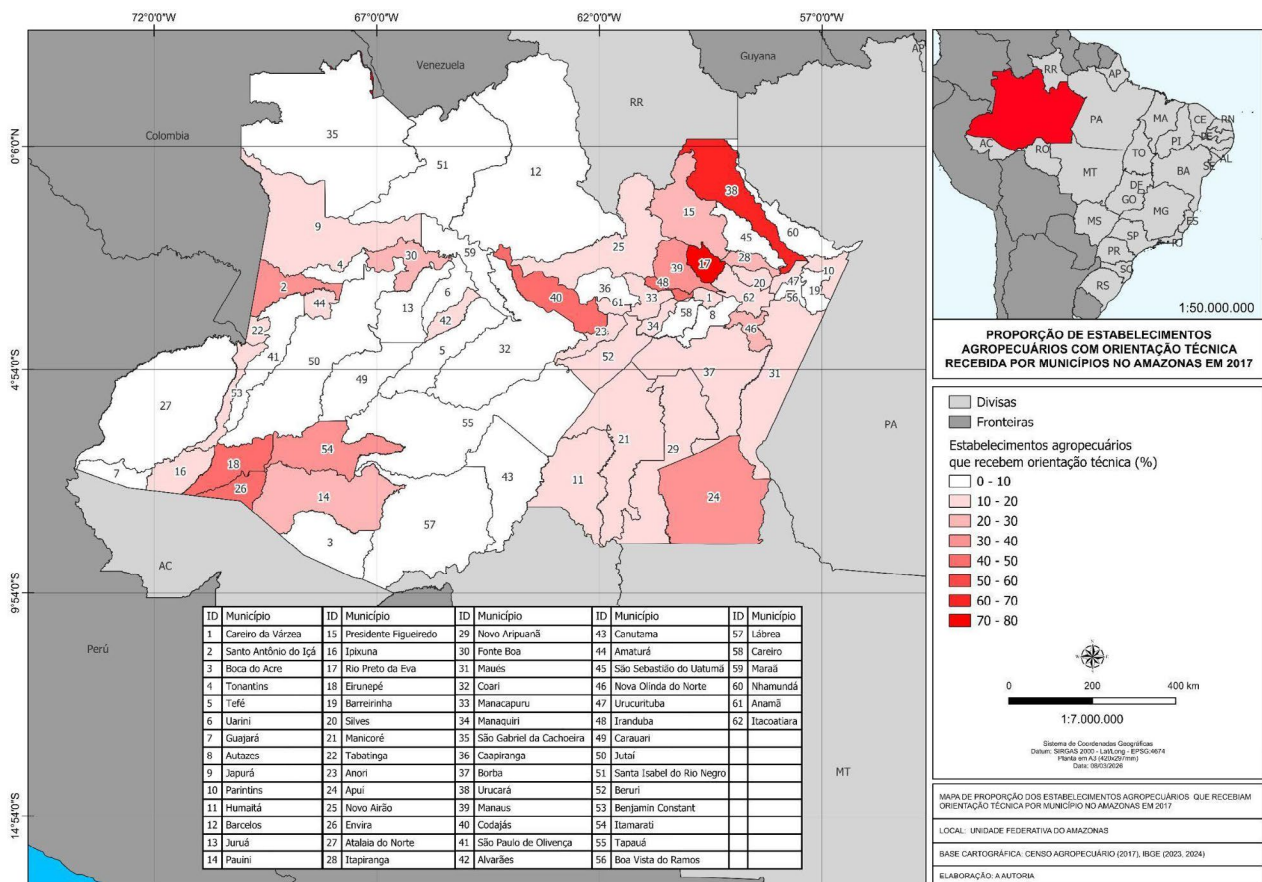
The chart indicates that technical guidance is a limiting factor for technical agricultural development in Amazonas, particularly for small-scale producers. This is significant given the presence of public research and rural extension institutions, such as EMBRAPA. This scenario shows that institutional presence alone does not ensure the effective diffusion of innovations throughout the territory. It reveals ongoing gaps between agro-technical knowledge production and its practical use on rural, mainly small, properties. Despite advances in innovation —especially in Brazilian agriculture — inequities in the geographic distribution of technological innovation persist at different scales (Tunes, 2020).

As Pereira and Castro (2021) highlight, the modernization of the countryside depends not only on generating technical knowledge but also on the institutional and organizational conditions that enable its development, circulation, and large-scale adoption across regions and across small and large establishments.

Data show that in Amazonas (Graphic 04), large-scale establishments (1,000 ha or more) exhibit a higher prevalence of technical guidance (34.56%) than small-scale establishments (11.29%).

From a spatial perspective, technical guidance is mostly limited in Amazonas, mainly due to: i) the influence of Manaus; ii) the southern region linked to pioneers. While guidance is weak in these areas, it is even scarcer elsewhere in the state (Figure 03).

Figure 03 | Map of the Proportion of Agro-pastoral Establishments with



Access to Technical Guidance in Amazonas Organization: The Authorship. Source: IBGE (2017).

This difference can be understood through Castro's (2015) analysis, which shows that small producers' access to Technical Assistance and Rural Extension (ATER) services has historically been marginalized. Even during the 1970s — a period of heightened state investment in public rural extension and the creation of the Brazilian Technical Assistance and Rural Extension Company (EMBRATER) — actions were predominantly directed toward medium and large farmers, especially those integrated into the external market, with production concentrated in crops such as soy and corn. The dissolution of EMBRATER in the late 1970s, due to a severe fiscal crisis, worsened the situation, further limiting family farmers' access to technical assistance programs (Castro, 2015). The evidence (Graphic 04 and Figure 03) shows a continued pattern of favoring larger producers in ATER policies.

Complementarily, from a regional perspective, Pereira and Castro (2021) observe that, according to the 2017 Agricultural Census, the supply of technical guidance across Brazilian regions is also quite unequal, especially in the North and Northeast. While nearly half of establishments in the South (48.6%) receive some form of assistance, in the Southeast and the Center-West, this percentage drops to 28.6% and 23.6%, respectively. The situation is even more concerning in the North and Northeast, where only 10.4% and 8.2% of establishments, respectively, have technical guidance, indicating that assistance services still fail to address the diversity and extent of the national territory adequately.

We highlight how agro-pastoral expansion influences technification by densifying productive circuits, services, and infrastructure, while favoring capital-advantaged actors. This increases territorial concentration, environmental pressures, and inequalities in access to new technologies. Map variables such as electricity, tractors, and technical guidance indicate the metropolis as a central source of technical influence in regional areas. Both socio-spatial processes referenced — the shifting pioneer fringe and metropolization — are also articulated through the established road infrastructure and other technical objects that serve as mediators and as instances of society's drive toward technification in Amazonas.

CONCLUDING REMARKS

This article has analyzed specific aspects of the Brazilian regional question through the processes of agro-pastoral modernization and technification, using the state of Amazonas as a case study. Through this analysis, we sought to reveal persistent patterns of regional inequality across the Brazilian territory. In agriculture, these inequalities remain tied to a national-developmental model grounded in an agrarian-export pattern that prioritizes export crops.

In this scenario, agro-pastoral modernization featured prominently in regional development policies that transformed the Amazon into an agricultural “frontier.” The regional development policies of the 1970s and 1980s privileged sectors with higher productivity potential and technological gains. State intervention involved selective investment in infrastructure, energy, agriculture, and industry, fundamentally altering the region’s socioeconomic and spatial configuration. Generally, the funding for this modernization (rural credit) supported large agro-pastoral firms deemed more efficient and competitive.

The variables selected for this study reveal distinct patterns in the reach of both intra- and inter-regional modernization. In the agricultural sector, technical and organizational innovations (public and private), the diffusion of chemical inputs, and the adoption of selective credit policies contributed to natural resource exploitation, increased environmental degradation, and rural violence.

Regional modernization deepened Brazilian disparities. Much of the Amazon missed out on technological advances, leading to extensive, mixed farming like family farming. In contrast, high-productivity, tech-driven agriculture is common in the Center-West and in regional areas such as MATOPIBA in the Northeast, Southern Amazonas, and parts of Roraima.

It is crucial to note that while agro-pastoral expansion has facilitated the growth of soybean and cattle production in the region, it has simultaneously jeopardized the preservation and maintenance of the Amazon biome. Furthermore, it has promoted intense land conflicts and reduced rural labor participation. This reality necessitates a reevaluation of regional development through the lens of agricultural development, with a focus on public policies and the promotion of alternative, ecologically based agricultural models.



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REFERENCES

CAMPOS, Margarida Cássia. Modernização da agricultura, expansão da soja no Brasil e as transformações socioespaciais no Paraná. **Revista Geografar**, v. 6, n. 1, p. 161-191, 2011.

CASTRO, César Nunes. Desafios da agricultura familiar: o caso da assistência técnica e extensão rural. **Boletim Regional, Urbano e Ambiental**, n. 12, p. 49-59, 2015.

CASTRO DE JESUS, Ana Beatriz; OLIVEIRA NETO, Thiago; SILVA, Fredson Bernardino Araújo. Periodização da rede urbana na faixa pioneira amazônica: os casos do sul do Amazonas e no oeste do Acre. **Boletim de Conjuntura**. Vol. 15, n. 44, 2023.

CARDOSO, Fátima Cristina. **Do confronto à governança ambiental: uma perspectiva institucional para a Moratória da soja na Amazônia**. Dissertação (Mestrado) – Universidade de São Paulo, São Paulo, 2008.

COSME, Claudemir Martins; PEREIRA, Monica Cox Britto. A concentração fundiária como uma das faces da contrarreforma agrária no Brasil: a reprodução do latifúndio e do minifúndio no campo alagoano. **GEOgraphia**, Niterói, v. 22, n. 48, 2020.

DELGADO, Guilherme Costa. **Do “capital financeiro na agricultura” à economia do agronegócio: mudanças cíclicas em meio século (1965-2012)**. Porto Alegre: UFRGS, 2012, 142p.

EMBRAPA - EMPRESA BRASILEIRA DE PESQUISA E AGROPECUÁRIA. **Embrapa conta trajetória da soja no Brasil Central a partir de variedades históricas**. 4 abr. 2025. Disponível em: <https://www.embrapa.br/busca-de-noticias/-/noticia/99579446/embrapa-countra-jetoria-da-soja-no-brasil-central-a-partir-de-variedades-historicas>. Acesso em: 8 de março de 2026.

FURTADO, C. **Formação econômica do Brasil**. 34. ed. São Paulo: Companhia das Letras, 2007.

GONÇALVES NETO, Wenceslau. **Estado e agricultura no Brasil**. Política agrícola e a modernização econômica brasileira 1960-1980. São Paulo: Hucitec, 1997. 245p.

LOCATEL, Celso. Tecnicificação dos territórios rurais no Brasil: políticas públicas e pobreza. **Revista Scripta Nova**, Barcelona, v. 16, n. 418, 2012.

LOUREIRO, Violeta Refkalefsky; PINTO, Jax Nildo Aragão. A questão fundiária na Amazônia. **Estudos Avançados**, São Paulo, Brasil, v. 19, n. 54, p. 77-98, 2005. Disponível em: <https://revistas.usp.br/eav/article/view/10071>. Acesso em: 8 de março de 2026.

LEITE, Sérgio. **Políticas públicas e agricultura no Brasil**. Porto Alegre: Ed. UFRS, 2001.

LEÓN, Ana Cevalyn; ARAÚJO, Itamar; REZENDE, Giulliano; ARAÚJO SOBRINHO, Fernando Luiz. Planejamento regional no Brasil: a experiência da Sudam. **Observatorio: Revista Eletrônica de Geografia**, v. 7, n. 18, p. 02-21, set. 2015.

MME - MINISTÉRIO DE MINAS E ENERGIA. **Programa Luz para Todos**. 2026. Disponível: <https://www.gov.br/mme/pt-br/destaques/Programa%20Luz%20para%20Todos?utm_source=copilot.com>. Acesso em 5 fev. 2026.



PAULINO, Eliane Tomiasi. Agricultura e tecnificação: notas para um debate. **Agrária (São Paulo. Online)**, n. 4, p. 3–19, 2006.

PEREIRA, Caroline Nascimento; CASTRO, César Nunes. Assistência técnica na agricultura brasileira: uma análise sobre a origem da orientação técnica por meio do Censo Agropecuário de 2017. **Texto para Discussão**, n. 2704. Rio de Janeiro: Ipea, 2021. p. 6–49.

SANTOS, Milton. **A natureza do espaço: técnica e tempo, razão e emoção**. 4. ed. São Paulo: Editora da Universidade de São Paulo, 2006.

SANTOS, Milton. **Por uma outra globalização: do pensamento único à consciência universal**. 15. ed. Rio de Janeiro: Record, 2008.

SANTOS, Milton; SILVEIRA, María Laura. **O Brasil: território e sociedade no início do século XXI**. Rio de Janeiro: Record, 2008.

SANTOS, Milton. **Economia espacial: críticas e alternativas**. 2a. ed. São Paulo: EDUSP, 2003.

SCHWADE, Tiago Maiká Muller. **A formação da propriedade capitalista no Amazonas**. Tese (Doutorado em Geografia Humana) - Universidade de São Paulo, 2019.

SEMIG - SECRETARIA DE ESTADO DE ENERGIA, MINERAÇÃO E GÁS. **Governo do Amazonas instala placas solares em comunidade ribeirinha de Parintins**. 2024. Disponível: <<https://www.semig.am.gov.br/governo-do-amazonas-instala-placas-solares-em-comunidade-ribeirinha-de-parintins/>>. Acesso em 05 fev. 2026.

SILVA, Vitória Clarice Alves da; LIMA, Maria do Socorro Bezerra; SILVA, Fredson Bernardino Araújo; VIDAL, Bruno Sarkis. Notas sobre a produção de soja e a dinâmica territorial em Roraima. **Revista Geonorte**, v. 16, p. 142–163, 2025.

TUNES, Regina. **Geografia da inovação: território e inovação no Brasil no século XXI** [recurso eletrônico]1. ed. Rio de Janeiro: Letra Capital: Observatório das metrópoles, 2020, 509p. VIDAL, Bruno Sarkis. **A expansão da soja na Amazônia Setentrional: mudanças ambientais em Roraima**. Dissertação (Mestrado em Geografia) - Universidade Federal do Amazonas, Manaus (AM), 2024.



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