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AGRIBUSINESS SACRIFICE ZONE: DEFORESTATION AND SOCIO-ENVIRONMENTAL RECONFIGURATION IN BALSAS (MA) IN THE MATOPIBA ARC

Zona de sacrifício do agronegócio: desmatamento e reconfiguração socioambiental em Balsas (MA) no arco do MATOPIBA

Zona de sacrificio del agronegocio: Deforestación y reconfiguración socioambiental en Balsas (MA) en el arco del MATOPIBA



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ABSTRACT

This article analyzes the transformation of the municipality of Balsas (MA) into a sacrifice zone for globalized agribusiness, integrating data from the Municipal Agricultural Production (PAM/IBGE), MapBiomas Collection 10, and MapBiomas Alerta between 2000 and 2024. The research problem addresses the spatial and temporal dynamics of soybean expansion and its impacts on the Cerrado biome, considering that Balsas leads deforestation in Maranhão. The thesis argued is that soybean expansion operates through the direct replacement of savanna and grassland formations, configuring a sacrifice zone where accumulation by dispossession (Harvey, 2004) is functionally articulated to global capital accumulation. The theoretical framework mobilizes the concepts of verticalities (Santos, 1996), selective modernization (Alves, 2022; Elias, 2024), and green grabbing (Silva et al., 2023) to demonstrate how the functionalization of the territory to global capital simultaneously produces environmental expropriation and social exclusion. The methodology, based on Evolutionary Landscape Analysis, employed geospatial processing in QGIS and statistical tabulation. Results indicate a 239.1% increase in soybean planted area (PAM) and a 290.4% expansion of the Soybean class (MapBiomas), with a net loss of 345,069.9 ha of savanna formation (−35.3%), evidencing the materiality of the conversion of the Cerrado into a financial asset. Balsas deforested 145,184.53 ha between 2019 and 2025, consolidating itself as the epicenter of vegetation suppression in the state. It is concluded that the prevailing agrarian model subordinates food production and turns the Cerrado into a financial asset, generating wealth at the cost of ecosystem degradation and socio-environmental injustice.

Keywords: Soy expansion; Cerrado; MATOPIBA; Accumulation by dispossession; Deforestation; Agrarian Geography.

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RESUMO

Este artigo analisa o processo de transformação do município de Balsas (MA) em uma zona de sacrifício do agronegócio globalizado, a partir da integração de dados da Produção Agrícola Municipal (PAM/IBGE), da Coleção 10 do MAPBIOMAS e do MAPBIOMAS Alerta entre 2000 e 2024. O problema investigado é a dinâmica espacial e temporal da sojização e seus impactos sobre o Cerrado, considerando que Balsas lidera o desmatamento no Maranhão. A tese defendida é que a sojização opera mediante substituição direta de formações savânicas e campestres, configurando uma zona de sacrifício onde a acumulação por espoliação (Harvey, 2004) se realiza funcionalmente à acumulação global de capital. O referencial teórico mobiliza os conceitos de verticalidades (Santos, 1996), modernização seletiva (Alves, 2022; Elias, 2024) e green grabbing (Silva et al., 2023) para demonstrar como a funcionalização do território ao capital global produz, simultaneamente, expropriação ambiental e exclusão social. A metodologia, baseada na Análise Evolutiva da Paisagem, utilizou processamento geoespacial em QGIS e tabulação estatística. Os resultados indicam crescimento de 239,1% da área plantada de soja (PAM) e de 290,4% da classe Soja (MAPBIOMAS), com perda de 345.069,9 ha de formação savânica (-35,3%), evidenciando a materialidade da conversão do Cerrado em ativo financeiro. Balsas desmatou 145.184,53 ha entre 2019 e 2025, consolidando-se como epicentro da supressão vegetal no estado. Conclui-se que o modelo agrário vigente subordina a produção de alimentos e converte o Cerrado em ativo financeiro, gerando riqueza à custa da degradação ecossistêmica e da injustiça socioambiental.

Palavras-chave: Sojização; Cerrado; MATOPIBA; Acumulação por espoliação; Desmatamento; Geografia Agrária.

RESUMEN

Este artículo analiza el proceso de transformación del municipio de Balsas (Maranhão, Brasil) en una zona de sacrificio del agronegocio globalizado, a partir de la integración de datos de la Producción Agrícola Municipal (PAM/IBGE), de la Colección 10 del MapBiomas y del MapBiomas Alerta entre 2000 y 2024. El problema investigado es la dinámica espacial y temporal de la sojización y sus impactos sobre el Cerrado, considerando que Balsas lidera la deforestación en Maranhão. La tesis defendida es que la sojización opera mediante la sustitución directa de formaciones sabaneras y campestres, configurando una zona de sacrificio donde la acumulación por desposesión (Harvey, 2004) se realiza funcionalmente a la acumulación global de capital. El marco teórico moviliza los conceptos de verticalidades (Santos, 1996), modernización selectiva (Alves, 2022; Elias, 2024) y *green grabbing* (Silva et al., 2023) para demostrar cómo la funcionalización del territorio al capital global produce, simultáneamente, expropiación ambiental y exclusión social. La metodología, basada en el Análisis Evolutivo del Paisaje, utilizó procesamiento geoespacial en QGIS y tabulación estadística. Los resultados indican un crecimiento del 239,1% del área plantada de soja (PAM) y del 290,4% de la clase Soja (MapBiomas), con una pérdida de 345.069,9 ha de formación sabanera (−35,3%), evidenciando la materialidad de la conversión del Cerrado en activo financiero. Balsas deforestó 145.184,53 ha entre 2019 y 2025, consolidándose como epicentro de la supresión vegetal en el estado. Se concluye que el modelo agrario vigente subordina la producción de alimentos y convierte el Cerrado en activo financiero, generando riqueza a costa de la degradación ecosistémica y la injusticia socioambiental.

Palabras clave: Sojización; Cerrado; MATOPIBA; Acumulación por desposesión; Deforestación; Geografía Agraria.

1 INTRODUCTION

The expansion of the Brazilian agricultural frontier into regions historically occupied by Cerrado biome formations constitutes one of the most significant processes of transformation of the national rural space over the past five decades (Miranda, 2025). In this context, the region known as MATOPIBA (an acronym formed by the initials of the states of Maranhão, Tocantins, Piauí, and Bahia) has emerged as the newest and most dynamic frontier for agricultural commodity production in the country, accounting for approximately 10% of Brazilian grain and fiber production, with a predominance of soybean, corn, and cotton cultivation (Miranda, 2025). As pointed out by Araújo and Sobrinho (2025), soybean production in southern Maranhão is part of the selective modernization model of agriculture, ensuring privileges for large producers to the detriment of other social segments in the countryside.

The territorialization of this new agricultural frontier, however, does not occur without tensions: it proceeds through the accelerated conversion of native vegetation areas into mechanized crops, promoting profound socio-environmental reconfigurations that, according to Alves (2022), result in the deterritorialization of peasants and traditional communities. The materialization of verticalities in the territory of Balsas (Santos, 1996) operates as the driving mechanism of selective modernization (Alves, 2022), functionalizing space for globalized capital.

The relevance of this study stems from the need to understand, with spatial and temporal precision, the impacts of soybean expansion on the landscapes of the Maranhão Cerrado, particularly in the municipality of Balsas. As demonstrated by MAPBIOMAS Alerta data (2019–2025), Balsas leads the deforestation ranking in Maranhão, with 145,184.53 hectares of suppressed area, a volume 20 times greater than the second-placed municipality. This dynamic, although it has boosted local economic indicators (such as GDP growth and the rise of the Human Development Index), occurs at the expense of the suppression of savanna and forest formations and the fragmentation of native ecosystems. As Elias (2024) points out, productive specialization in Balsas follows the exclusionary modernization pattern observed in other agricultural frontiers of the Cerrado. Furthermore, Silva et al. (2023) identify in this process what they call "green grabbing," in which the appropriation of land and natural resources is legitimized through discourses of sustainable development and productive efficiency.

This analysis reveals that the concept of sacrifice zones encompasses territories where systemic environmental degradation, expropriation of natural resources, and marginalization of traditional populations are justified and legitimized in the name of economic growth and wealth generation (Bullard, 1990; Lerner, 2010). In the context of Brazilian agrarian geography, this category is mobilized to describe the Cerrado biome and, specifically, the MATOPIBA frontier, where the advance of the agricultural frontier converts native ecosystems into areas of intensive monoculture aimed at commodity exports (Hecht, 2010; Oliveira, Hecht, 2016). From this perspective, such zones are configured as spaces where practically everything is permitted, from the fraudulent appropriation of land and water to the destruction of socio-biodiversity, consolidating a scenario of environmental and social injustice (Acselrad, 2015; Svampa, 2013).

The theoretical bases that support the analysis of sacrifice zones are articulated around four fundamental axes. The first is accumulation by dispossession, formulated by David Harvey (2004), according to which the expansion of capital requires the continuous capture of new territories, using violence, deforestation, and the suppression of collective rights as mechanisms to overcome overaccumulation crises. The second axis is neo-extractivism and the commodity consensus, as proposed by Maristella Svampa (2013), for whom sacrifice zones are byproducts of a model that reduces territory to a reservoir of exploitable resources—land, minerals, and water—in which the horizontalities of local life are subordinated to the verticalities of the global financial market (Santos, 1996). The third axis mobilizes the concept of necropolitics, by Achille Mbembe (2018), demonstrating that in these territories there operates a management of who should live or die, intentionally exposing vulnerable populations—such as indigenous and quilombola communities—to social and physical death to enable the reproduction of the agricultural frontier. The fourth axis is grounded in environmental injustice, according to Acselrad (2015), evidencing that the environmental risks and costs of territorial modernization are unequally shifted to social groups least protected by the State and by the legal system.

Beyond the articulation of these four theoretical axes, the concept of sacrifice zone finds concrete application in the recent history of the Brazilian Cerrado. The term was applied to the biome by authors such as Hecht (2010) and Oliveira and Hecht (2016), who diagnosed the Cerrado as a sacrifice zone to sustain the trade balance through agrarian extractivism. This condition is not accidental but results from a technical and political rationality that disconnects land from its social function to elevate it to the status of a highly liquid financial asset (Harvey, 2004; Alves, 2022), reproducing in the Brazilian agrarian

space the same pattern of environmental expropriation and subordination of local horizontalities to the verticalities of capital that characterizes sacrifice zones on a global scale.

Given this scenario, this article starts from the following question: how does the spatial and temporal dynamics of deforestation and landscape transformations occur in the municipality of Balsas (MA) between 2000 and 2024, and how does the expansion of soybean cultivation contribute to the reconfiguration of land use and occupation in this territory? Answering this question requires the articulation of quantitative data on agricultural production (PAM/IBGE), land cover and use (MAPBIOMAS Collection 10), and deforestation (MAPBIOMAS Alerta), in order to highlight the contradictions between the economic growth promoted by agribusiness and the environmental degradation of the Cerrado.

The hypothesis is that the accelerated expansion of soybean cultivation in Balsas is directly correlated with the reduction of savanna and grassland areas of the Cerrado, configuring a process of substitution of native ecosystems by export-oriented monocultures that intensified after 2010. This dynamic, according to Harvey (2004) and Alves (2022), expresses a process of accumulation by dispossession, in which native vegetation is converted into a highly liquid financial asset. Additionally, it is assumed that the municipality concentrates disproportionate volumes of deforestation compared to other municipalities in Maranhão, reflecting its hegemonic position in the regional agribusiness production chain, which Santos (1996) interprets as the formation of verticalities densified by systems of objects and actions aimed at financial capital interests.

The general objective of this article is to analyze deforestation and landscape transformations in the municipality of Balsas (MA) in the period from 2000 to 2024, based on the integration of data from the Municipal Agricultural Production (PAM/IBGE), the MAPBIOMAS platform, and MAPBIOMAS Alerta, in order to characterize the spatial and temporal dynamics of soybean expansion and its impacts on the Cerrado biome.

To this end, the following specific objectives are established: (i) to quantify the evolution of the planted area of soybeans and other temporary crops in the municipality between 2000 and 2024, based on official IBGE data; (ii) to map and quantify changes in land use and occupation between 2000 and 2024, with emphasis on the conversion of natural formations into agricultural areas; (iii) to analyze the temporal evolution of deforestation in Balsas in the period from 2019 to 2025, according to MAPBIOMAS Alerta data; and (iv) to position the municipality in the context of the deforestation ranking of the

state of Maranhão, discussing the socio-environmental implications of this dynamic in light of the concepts of accumulation by dispossession and selective modernization.

2 METHODOLOGY

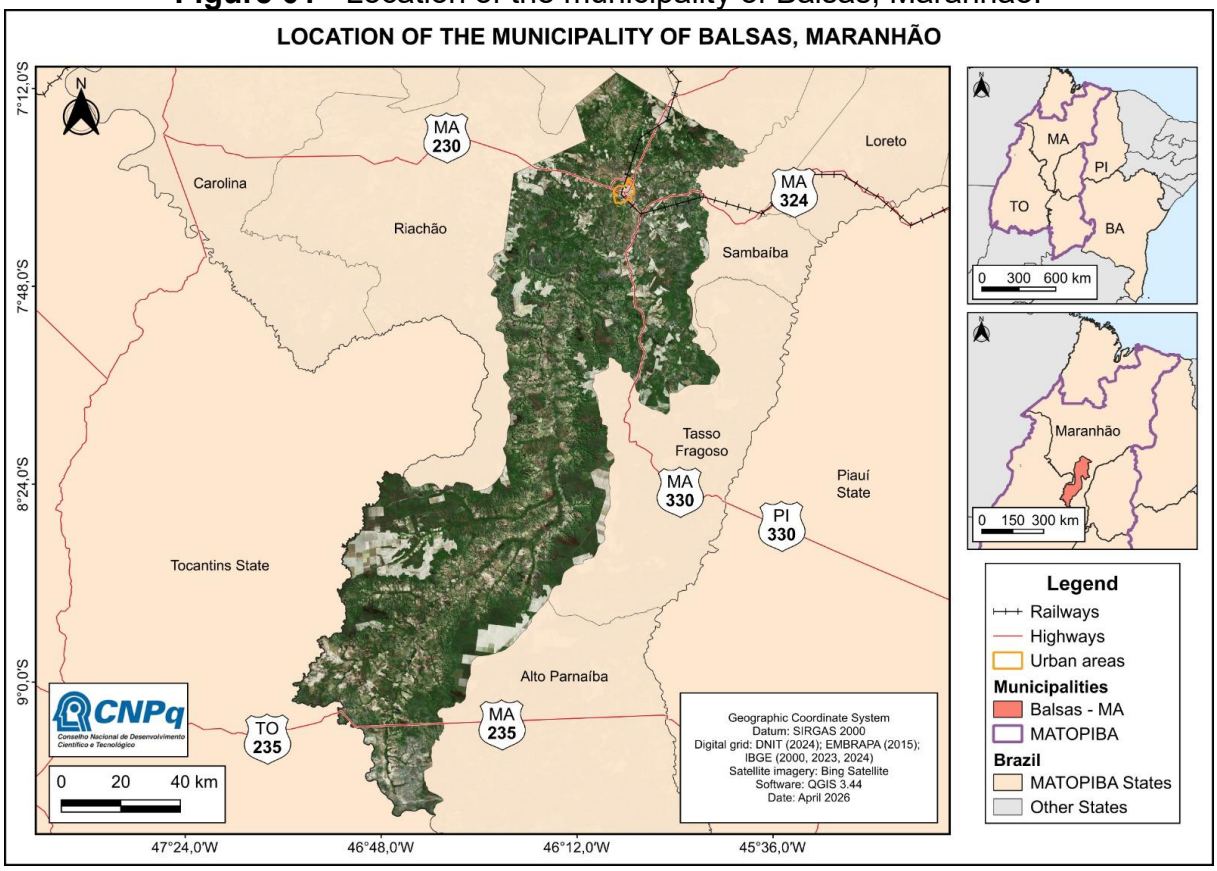
a. Location and characterization of the study area

The location and boundaries of the municipality of Balsas, as represented in Figure 1, place it in the Southern Maranhão mesoregion, between coordinates 07°31'57" south latitude and 46°02'08" west longitude, occupying a total area of 13,141.64 km², which makes it the largest municipality in territorial extension in Maranhão and the 91st in Brazil (IBGE, 2022, 2025). Approximately 814 km from the capital São Luís, the Balsas territory borders to the north with Nova Colinas, Fortaleza dos Nogueiras, and São Raimundo das Mangabeiras; to the south, with Alto Parnaíba; to the east, with Sambaíba and Tasso Fragoso; and to the west, with Riachão, Campos Lindos, Recursolândia, and Lizarda, the latter belonging to Tocantins (Santos; Vieira; Silva, 2023).

The strategic geographical position of the municipality, evidenced in Figure 01, is reinforced by the presence of federal highways such as BR-230 (Transamazônica), in addition to BR-330, BR-324, and BR-235, which integrate it into the agricultural production outflow corridors to the ports of the North and Northeast. This aspect is pointed out by Terra (2019) as determinant for the insertion of Balsas into the international commodity market.

From a biophysical point of view, Balsas presents as its predominant characteristic the occurrence of the Cerrado biome, with a hot and humid tropical climate, relief consisting of plateaus and depressions, and soils predominantly classified as Yellow Latosol, Concretionary Red-Yellow Podzolic, Quartz Sands, and Litholic soils (Mingoti; Holler; Spadotto, 2014). According to Brito, Ribeiro, and Feitosa (2006), such soils are sandy, well-drained, erodible, with low natural fertility, low moisture retention associated with acidity, and high porosity, presenting a degree of fragility to erodibility ranging from medium to strong. The local physiography comprises a sedimentary geological structure of the Parnaíba basin, conditioning a transitional landscape between the typical savanna formations of the Cerrado and areas of Amazonian influence. This context gives the territory edaphoclimatic characteristics favorable to the expansion of agricultural mechanization, although it also makes it ecologically vulnerable to processes of intensive soil degradation (Santos; Vieira; Silva, 2023; Sousa *et al*., 2025).

Figure 01 - Location of the municipality of Balsas, Maranhão.



Source: Araújo (2026).

The insertion of Balsas into the great national agricultural frontier called MATOPIBA (acronym formed by the initials of the states of Maranhão, Tocantins, Piauí, and Bahia) constitutes the defining element of its contemporary socioeconomic dynamics. This region, delimited by the Strategic Territorial Intelligence Group (GITE) of EMBRAPA, encompasses 337 municipalities in 31 geographical micro-regions, in an area of about 73 million hectares, where approximately 324 thousand agricultural establishments are found, in addition to agrarian reform settlements, indigenous lands, quilombola communities, and conservation units (Terra, 2020). The success of the agricultural project in the region can be measured by data from the National Supply Company (CONAB). In the 2014/2015 harvest, MATOPIBA was responsible for 19.7 million tons of cotton lint, soybeans, rice, and corn, in an area of 5.7 million hectares. Specifically regarding soybeans, the region reached 10.5 million tons in the 2014/2015 harvest, which is equivalent to 11% of national production (Terra, 2020). In this context, Balsas emerges as the third largest grain producer in MATOPIBA, surpassed only by the Bahian municipalities of Formosa do Rio Preto and São Desidério (Sindbalsas, 2016).

The demographic and economic transformation of Balsas is directly linked to the territorialization of the soybean agribusiness, a process initiated in the 1970s and intensified from the 1990s onwards with the implementation of Phase III of the Brazil-Japan Cooperation Program for the Development of the Cerrados (PRODECER). This program encouraged colonization by medium-sized family farmers and the installation of large grain sector companies, such as Agroserra, Varig Agropecuária, Cutrale, Cargill, and Ceval (Terra, 2019). The municipality's population grew from 41,648 inhabitants in 1991 to 96,951 inhabitants in 2022, with 83% of the population concentrated in the urban area and only 17% in the rural area, which reflects the process of rural exodus and urbanization induced by agricultural mechanization (IBGE, 2022). The municipal seat concentrates the largest number of agribusiness chain enterprises in the south of the state, including machinery dealerships, warehouses and silos, commercialization offices, and technical assistance. This configures Balsas as a national space of international economy (Santos, 1996), whose development, however, proceeds through profound socio-environmental contradictions that this article proposes to analyze.

3 METHODOLOGICAL PROCEDURES

This research is configured as a documentary study of secondary data analysis, with a quantitative-descriptive approach (Gil, 2008), based on the method of Evolutionary Landscape Analysis (Rodriguez; Silva; Cavalcanti, 2022), which allows mapping and quantifying changes in land cover over time series. The systematized bibliographic review guided the identification of gaps and the articulation between agrarian geography, land use, and remote sensing.

Data on planted area of temporary crops in Balsas were obtained from the Municipal Agricultural Production (PAM/IBGE) for the years 2000, 2004, 2008, 2012, 2016, 2020, and 2024, with four-year intervals that capture phases of acceleration and consolidation of soybean expansion, allowing comparative analysis between crops and identification of substitution patterns in the agrarian space.

For mapping land use and occupation, data from MAPBIOMAS Collection 10 (2000 and 2024) were used, obtained via Google Earth Engine (Gorelick et al., 2017). In QGIS 3.44, the raster files were converted to vector, reprojected to SIRGAS 2000/22S, and their areas were calculated in hectares. Values by class were consolidated in tables in LibreOffice Calc and integrated into the spatial base through joins.

Cartographic representation adopted the natural breaks classification method (Jenks), a deliberate methodological choice that deserves explanation. The Jenks algorithm (1967) minimizes intra-class variance and maximizes inter-class variance, being especially suitable for positively asymmetric distributions—such as those that characterize municipal deforestation data, with few extreme values and many low values. Unlike methods such as equal intervals or quantiles, which would tend to dilute or artificially fragment clusters of intense deforestation, Jenks preserves the natural structure of groupings, highlighting spatial contrasts and visually emphasizing the epicenters of vegetation suppression (Slocum et al., 2009).

It is recognized, however, that all classification implies an interpretive bias: by emphasizing differences between groups, the method may attenuate the perception of subtle variations within classes of lower values. This limitation was mitigated by the simultaneous presentation of raw data in tables, providing transparency and allowing the reader to access values without the mediation of cartographic classification.

Deforestation data were extracted from MAPBIOMAS Alerta, covering the municipal ranking for Maranhão (2019–2025) and the annual evolution of deforested area in Balsas in the same period, with emphasis on the peak of 39,737.75 ha in 2023 (2025 data considered partial). These data allowed identifying cycles of acceleration and deceleration and discussing their conditioning factors.

The integrated analysis of the three data sets—PAM/IBGE, MAPBIOMAS Collection 10, and MAPBIOMAS Alerta—was carried out through statistical tabulation, calculation of absolute and percentage variations, and construction of time series, organized in tables and figures. The overall accuracy of MAPBIOMAS is recognized without independent field validation, assuming the margins of uncertainty inherent to automated satellite image classification, especially in Cerrado-Amazon ecotone areas. This limitation is attenuated by triangulation with IBGE census data, which function as cross-validation. Methodological triangulation ensures robustness and replicability, articulating official agricultural production, land cover, and deforestation alerts at the municipal scale.

4 RESULTS AND DISCUSSION

The analysis of the evolution of temporary crop planted area in Balsas (MA) between 2000 and 2024, synthesized in Table 01, reveals an accelerated process of agrarian space reconfiguration. This movement is guided by the growing hegemony of soybeans to the

detriment of traditional crops, as pointed out by Araújo and Sobrinho (2026) and Miranda (2025). According to data from the Municipal Agricultural Production (PAM/IBGE), the area destined for the oilseed expanded from 60,040 hectares in 2000 to 203,577 hectares in 2024, which corresponds to a growth of 239.1% over 24 years (IBGE, 2024). This increase, however, did not occur linearly. Distinct phases of expansion are identified, with more significant jumps between 2008 and 2012 (+23.4%) and between 2016 and 2020 (+19.5%), periods that coincide with the international appreciation of commodities and the consolidation of MATOPIBA's logistical infrastructure (Egger, 2023). The absence of cotton planting records in 2000 (zero value in the PAM database) and the low levels of sugarcane (always below 30 hectares) reinforce the selective character of agricultural modernization in the region (Elias, 2024).

Table 01. Planted area (hectares) of temporary crops in the municipality of Balsas (MA), 2000–2024

Year	Cotton (ha)	Rice (ha)	Sugarcane (ha)	Corn (ha)	Soybean (ha)
2000	--	19,713	4	3,765	60,040
2004	3,065	8,600	3	2,810	97,400
2008	6,343	4,246	15	2,592	110,505
2012	9,726	3,265	14	42,768	136,381
2016	7,027	1,228	16	44,308	180,116
2020	10,900	1,720	15	107,670	195,161
2024	14,127	1,697	28	109,489	203,577

Source: IBGE – Municipal Agricultural Production (PAM). Own elaboration (2026).

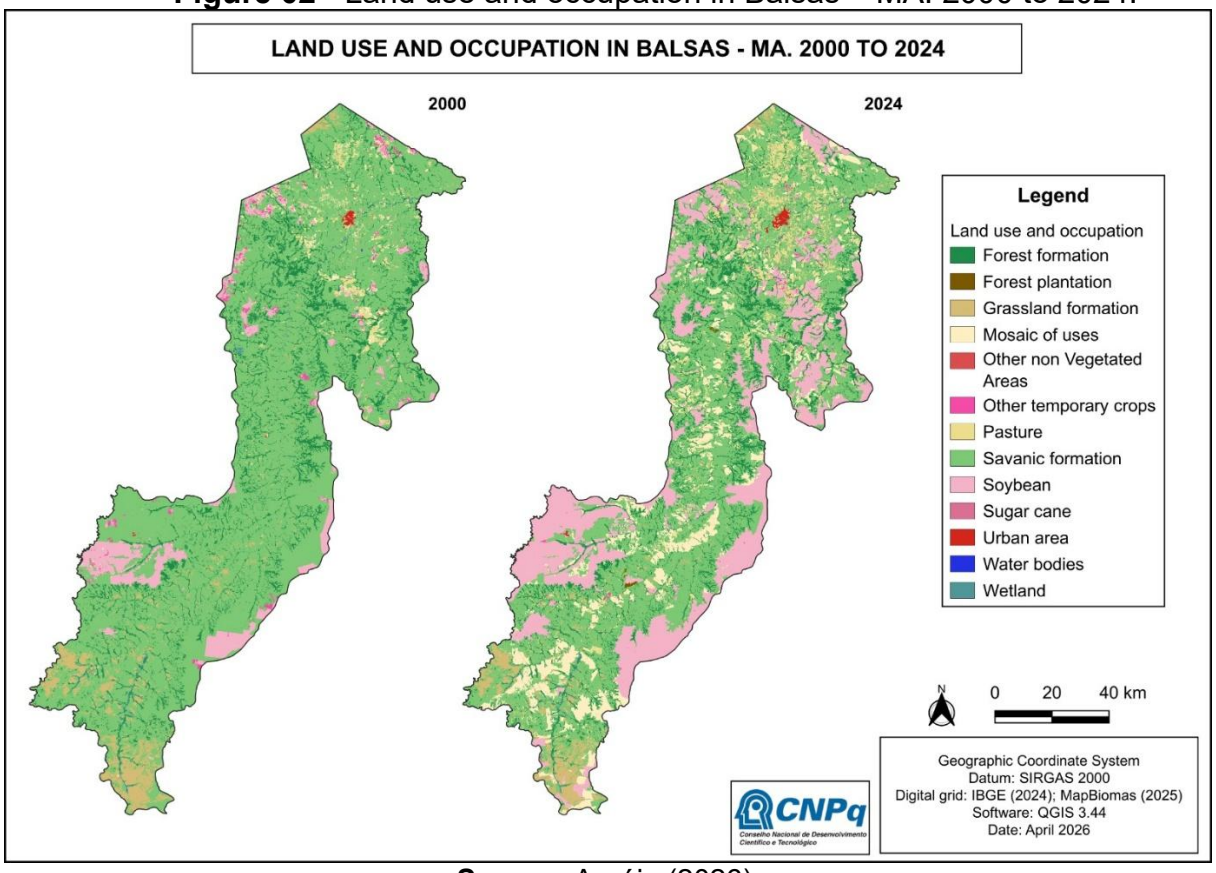
On the other hand, crops historically associated with family farming and regional subsistence evidence a process of productive substitution that favors export-oriented monoculture (Alves, 2022). Rice, for example, fell from 19,713 hectares in 2000 to only 1,697 hectares in 2024, a reduction of 91.4%. Corn, meanwhile, presented oscillations and did not recover the level prior to the 2010s, although it reached an expressive area in 2020 (107,670 ha) and in 2024 (109,489 ha), according to IBGE data (2024).

This dynamic corroborates the analyses of Araújo and Sobrinho (2025) on the selective modernization of agriculture in southern Maranhão. In addition to this, there is the recent finding that MATOPIBA lost 142 thousand hectares of rice, 23 thousand of beans, and 75 thousand of cassava since the decree of the agricultural frontier in 2015, configuring a food transition that subordinates food production to the logic of commodities. The consistency of sources and clarity in data presentation (Table 1) allow affirming that productive specialization in Balsas follows the exclusionary modernization pattern observed in other agricultural frontiers of the Cerrado (Elias, 2024).

Land use and occupation data, derived from MAPBIOMAS Collection 10 for the years 2000 and 2024 (synthesized in Table 2 and spatialized in Figure 2), quantify the landscape transformations resulting from this productive reconfiguration. The Soybean class presented the greatest absolute and relative expansion, jumping from 70,916.5 hectares to 276,870.7 hectares (+290.4%), which represents the conversion of approximately 205,954 hectares of other coverages into monoculture. Equally significant, the Use mosaic class (which encompasses areas with alternation between agriculture and pasture) grew 715.0%, from 15,343.3 to 125,047.1 hectares, indicating intensification of productive diversification processes subordinated to the logic of land commodification. The expansion of Pasture (+210.5%) and Silviculture (+10,672%, although from a tiny base of 8.6 hectares) completes the picture of accelerated anthropic occupation.

This multisectoral expansion pattern signals the accelerated insertion of the Balsas territory into globalized productive spatial circuits, linked to grain, meat, and cellulose chains. Such transformation materializes what Harvey (2004) defines as accumulation by dispossession: a large-scale privatization process of formerly common natural goods, which ceases to be a basis for community and subsistence uses to become a store of value and income for hegemonic actors. As a consequence, a territory used (Santos, 1996) by verticalities is consolidated, whose exogenous norms and demands impose themselves on the local landscape, reorganizing land use according to a strictly mercantile and expropriatory rationality.

Figure 02 - Land use and occupation in Balsas – MA. 2000 to 2024.



Source: Araújo (2026).

The ecological counterpart of this productive expansion materializes in the expressive suppression of native vegetation cover, a process that, in light of the concept of sacrifice zone discussed in the introduction of this article, transforms the Cerrado into a territory functionalized to globalized agribusiness. The data in Table 02 operationalize this concept by revealing, in absolute and relative terms, the materiality of accumulation by dispossession: Savanna formation retreated from 978,023.1 hectares in 2000 to 632,953.2 hectares in 2024, a net loss of 345,069.9 hectares representing a 35.3% reduction, consolidating itself as the most impacted class and evidencing the neo-extractivist pattern of conversion of native ecosystems into financial assets for the global market. Grassland formation, equally vulnerable to agricultural frontier pressure, suffered a 25.3% decline, while Forest formation showed relative stability with a retreat of only 0.8%—a datum that, although it may reflect the complexities of remote sensing classification in ecotone areas between Cerrado and Amazon, also indicates the spatial selectivity of deforestation, which falls primarily on phytophysiognomies more directly convertible into mechanized crops, thus revealing the dimension of environmental injustice that characterizes sacrifice zones: the

ecological costs of territorial modernization are unequally shifted to ecosystems and populations least protected by the legal system and by command and control policies.

This local large-scale conversion dynamic aligns with regional trends identified by MAPBIOMAS (2025): between 1985 and 2024, the biome lost approximately 28% of its native vegetation, equivalent to 40.5 million hectares, with savanna physiognomy being the most vulnerable to land commodification. In the specific context of MATOPIBA—a region responsible for about 73% of deforestation in the biome between 2015 and 2024, totaling 4.7 million hectares—the municipality of Balsas stands out as the epicenter of this advance, concentrating a disproportionate share of vegetation suppression and synthesizing, at the municipal scale, the expropriatory logic that characterizes the contemporary agricultural frontier.

Table 02 - Classes and quantification of areas related to land use and occupation in Balsas, Maranhão, Brazil.

lass	Area 2000 (ha)	Area 2024 (ha)	Variation (ha)	Variation (%)
Soybean	70,916.5	276,870.7	+205,954.2	+290.4%
Use mosaic	15,343.3	125,047.1	+109,703.8	+715.0%
Pasture	24,807.9	77,023.0	+52,215.1	+210.5%
Savanna formation (Cerrado)	978,023.1	632,953.2	−345,069.9	−35.3%
Forest formation	143,741.1	142,546.6	−1,194.5	−0.8%
Grassland formation	61,150.2	45,679.7	−15,470.5	−25.3%
Other temporary crops	11,375.3	4,649.4	−6,725.9	−59.1%
Silviculture	8.6	926.5	+917.9	+10,672%
Urbanized area	1,530.3	2,749.4	+1,219.1	+79.7%

Source: IBGE, 2025; MAPBIOMAS, 2025. Prepared by the authors (2026).

The analysis of the deforestation ranking by municipality in Maranhão between 2019 and 2025, based on MAPBIOMAS Alerta data synthesized in Table 03, places Balsas in an isolated leadership: 145,184.53 hectares suppressed (MAPBIOMAS, 2025). This volume is 20 times higher than that of Tasso Fragoso (7,150.55 ha) and 47 times higher than that of Riachão (3,066.86 ha), a disproportion that is not explained only by the territorial extension of the municipality (13,141.64 km²), but rather by the consolidation of Balsas as a strategic node functional to global accumulation. From the perspective of Santos (1996), this dynamic expresses the formation of verticalities, in which the territory is densified by systems of objects and actions aimed at external interests, converting the municipality into a pole of the technical-scientific-informational milieu. As Alves (2022) points out, this process of capital territorialization reconfigures the agrarian space through productive specialization and the transformation of the Cerrado into a sacrifice zone to enable commodity profitability.

According to IPAM (2025), MATOPIBA concentrates the largest volume of native vegetation on private properties subject to legal suppression, which intensifies pressure on Cerrado remnants. Balsas' hegemony in the state ranking reflects its insertion in the selective and exclusionary modernization model, in which logistical infrastructure (including federal highways, silos, and transnational trading companies) acts as a catalyst for land conversion by reducing transaction costs. Together, the data show that deforestation is concentrated in "agribusiness cities" of high technical density, where consolidated infrastructure and incentive policies transform the territory into a highly liquid financial asset.

The annual evolution of deforested area in Balsas between 2019 and 2025, presented in Table 4, reveals a cyclical pattern of acceleration and deceleration, which well expresses the dynamics of capital reterritorialization in southern Maranhão. After a peak of 31,435.32 hectares in 2020 (a variation of +226.0% compared to 2019), a drop was observed in 2021 (−39.2%), followed by a new rise in 2022 (+54.7%) and in 2023, when the maximum value of the series was recorded: 39,737.75 hectares (+34.5%) (MAPBIOMAS, 2025). In 2024, there was a reduction of 57.4% (16,912.28 hectares), a level that remained similar in 2025 (15,273.87 hectares, partial data). This behavior indicates that deforestation responds both to conjunctural factors (such as commodity price volatility and credit availability) and to structural processes of accumulation by dispossession (Harvey, 2004).

Table 03 - Deforestation Ranking by Municipality (2019–2025).

Position	Municipality	Total deforested area (ha)	Highlight
1st	Balsas (MA)	145,184.53	Largest soybean hub in Maranhão
2nd	Tasso Fragoso (MA)	7,150.55	Recent soybean expansion
3rd	Riachão (MA)	3,066.86	Agricultural transition area
4th	Alto Parnaíba (MA)	2,313.92	MATOPIBA frontier
5th	Sambaíba (MA)	1,096.92	Pressure on the Cerrado

Source: MapBiomas Alerta – Deforestation ranking by municipality (2019–2025). Own elaboration, 2026.

The analysis of the time series reveals that deforestation in Balsas does not follow a linear trajectory, but rather surges dictated by spatial adjustments of capital, aimed at circumventing barriers to profitability through the accelerated conversion of nature into productive land (Harvey, 2004). This cyclical pattern, however, cannot be understood only by conjunctural economic factors; it forcefully reflects oscillations in environmental public policies and legal frameworks that regulate land use in the Cerrado biome. The deforestation peak recorded in 2023 (39,737.75 ha) coincides with the moment when deforestation alerts in the Cerrado reached the highest index in the Deter historical series, with a 43% increase compared to the previous year (INPE, 2024), with estimates that more than half of the suppression was legal. This scenario was aggravated by the revocation of the Action Plan for Prevention and Control of Deforestation in the Cerrado (PPCerrado) in 2019 (Decree No. 10,142/2019), which left the biome without a structured command and control policy, allowing deforestation to reach almost 10.7 thousand km² (INPE/PRODES, 2020). The MATOPIBA region concentrated 75% of the biome's deforestation in 2023, with Balsas being one of its epicenters (MapBiomas, 2024; IPAM, 2024).

The expressive reduction observed in 2024 (−57.4%) and the deceleration in 2025 (−9.7%), in turn, must be largely attributed to the resumption of stricter public policies. With the publication of Decree No. 11,367 of 2023, the PPCerrado was reactivated in its 4th

phase (2023-2027), accompanied by the intensification of inspection actions conducted by Ibama and ICMBio (Decree No. 11,367/2023; MMA, 2025). Official PRODES data confirm that, between August 2023 and July 2024, the Cerrado registered a 25.7% drop in deforestation, the first reduction in four years, with the lowest rate since 2019 (INPE/PRODES, 2024). Furthermore, the update of the list of priority municipalities for deforestation monitoring and control actions in the Cerrado (Ordinance GM/MMA No. 1,224/2024) directed inspection efforts to the most critical territories, such as Balsas, contributing to the observed deceleration (Ordinance GM/MMA No. 1,224/2024; MMA, 2025). These data show that, although the structural pressure of agribusiness on the Cerrado persists, command and control public policies have the capacity to significantly influence the deforestation trajectory.

According to SAD Cerrado/IPAM data (2025), in 2024 deforestation in the biome reached 712 thousand hectares, with 82% concentrated in MATOPIBA; Balsas led the municipal ranking with 17.6 thousand hectares deforested, reaffirming its condition as an agribusiness city functional to financial accumulation. This panorama shows that pressure on the Cerrado in Balsas persists at ecologically unsustainable levels, configuring the territory as a sacrifice zone for the global market—a space where systemic environmental degradation, expropriation of natural resources, and marginalization of traditional populations are legitimized in the name of economic growth (Bullard, 1990; Lerner, 2010). In this zone, native vegetation is converted into a highly liquid asset under the logic of agrarian-financial capitalism, reproducing the pattern of environmental expropriation and subordination of local horizontalities to the verticalities of capital (Santos, 1996; Harvey, 2004; Svampa, 2013). The time series, in turn, reinforces that deforestation does not follow a linear trajectory, but rather surges dictated by spatial adjustments of capital aimed at circumventing barriers to profitability through the accelerated conversion of nature into productive land, revealing the simultaneous operation of accumulation by dispossession mechanisms (Harvey, 2004) and a necropolitical regime (Mbembe, 2018) that, by exposing vulnerable populations to social death and deterritorialization, enables the expanded reproduction of the agricultural frontier in MATOPIBA.

Table 04 - Evolution of deforested area in Balsas (2019–2025).

Year	Deforested area (ha)	Annual variation (%)
2019	9,642.23	--
2020	31,435.32	+226.0%
2021	19,097.26	−39.2%
2022	29,537.08	+54.7%
2023	39,737.75	+34.5%
2024	16,912.28	−57.4%
2025*	15,273.87	−9.7%

*Partial or estimated data (year still ongoing at the time of collection).
Source: MAPBIOMAS, 2025. Prepared by the authors (2026).

The results analyzed throughout this section consistently demonstrate that the municipality of Balsas has consolidated, over the last two decades, as the epicenter of productive reconfiguration in southern Maranhão and, more broadly, in the MATOPIBA expansion arc. The articulation between PAM/IBGE data, MAPBIOMAS Collection 10, and MAPBIOMAS Alerta revealed a structural movement of substitution of traditional crops (notably rice) by soybean monoculture, a process that not only redefined the use of temporary crops but also promoted a profound transformation in the landscape, with the suppression of more than 345 thousand hectares of savanna formation between 2000 and 2024. This loss of native vegetation, added to the simultaneous expansion of the use mosaic, pasture, and silviculture, evidences what the literature (Harvey, 2004; Alves, 2022; Silva et al., 2023) conceptualizes as accumulation by dispossession and selective and exclusionary modernization, in which the territory is functionalized to the interests of globalized capital.

Balsas' protagonism in the state deforestation ranking (with suppressed area 20 times greater than the second-placed municipality) and the cyclical pattern of acceleration and deceleration of deforestation between 2019 and 2025 reinforce the thesis that the municipality has consolidated itself as a strategic node or an agribusiness city, where verticalities (Santos, 1996) and logistical infrastructure catalyze the conversion of the

Cerrado into a financial asset. In view of this, the empirical data not only corroborate regional analyses on the expansion of soybean cultivation but also qualify Balsas as a paradigmatic case of the contradictions inherent to the agrarian development model in the Brazilian agricultural frontier: at the same time as it generates wealth and international insertion, it subordinates food production, deterritorializes traditional populations, and sacrifices the ecosystem integrity of one of the most threatened biomes on the planet.

5 FINAL CONSIDERATIONS

The objectives proposed for this research were fully achieved, since the integrated analysis of data from the Municipal Agricultural Production, MAPBIOMAS Collection 10, and MAPBIOMAS Alerta allowed precise characterization of the spatial and temporal dynamics of deforestation and landscape transformations in Balsas between 2000 and 2024, confirming the central hypothesis that the accelerated expansion of soybean cultivation is directly correlated with the reduction of savanna and grassland formations of the Cerrado. What is confirmed, in light of the adopted theoretical framework, is that soybean expansion in Balsas operates as a structural process of substitution of native ecosystems by export-oriented monocultures, configuring what Harvey (2004) defines as accumulation by dispossession and what Santos (1996) identifies as the imposition of verticalities over the territory, in which logistical infrastructure and systems of objects aimed at global agribusiness convert native vegetation into a highly liquid financial asset, while simultaneously promoting the deterritorialization of peasants and traditional communities through a selective and exclusionary modernization model.

The contribution of this study lies in the articulation of three official data sources at the municipal scale, quantitatively and geospatially demonstrating that Balsas not only leads the deforestation ranking in Maranhão with 145,184.53 hectares suppressed between 2019 and 2025, but also concentrates a net loss of 345,069.9 hectares of savanna formation between 2000 and 2024, a value that corresponds in order of magnitude to the joint expansion of soybeans and the use mosaic in the same period. This finding fills a relevant gap in the literature on the MATOPIBA agricultural frontier, which until then lacked a detailed analysis integrating the evolution of agricultural production, land cover changes, and deforestation alerts in a single municipal scope, offering the scientific community a faithful portrait of the contradictions inherent to the agrarian development model in the region and

challenging narratives that present economic growth as intrinsically compatible with environmental preservation.

The theoretical and practical implications of the results achieved are profound and multifaceted. From a theoretical point of view, the research empirically demonstrates that the concept of accumulation by dispossession is not restricted to a generic phenomenon of contemporary capitalism, but materializes concretely and measurably in the conversion of 345 thousand hectares of Cerrado into productive land for the global market, revealing that the functionalization of the Balsas territory to financial capital interests operates through a process of "green grabbing" in which the appropriation of land and natural resources is legitimized through discourses of sustainable development and productive efficiency, while traditional populations and family farming are systematically excluded from the agricultural modernization process. From a practical point of view, the data show that deforestation does not follow a linear trajectory, but rather surges dictated by spatial adjustments of capital aimed at circumventing barriers to profitability, being profoundly influenced by oscillations in environmental public policies, as demonstrated by the deforestation peak in 2023 coinciding with the revocation of the PPCerrado and the expressive reduction in 2024 associated with the resumption of inspection actions and the update of the list of priority municipalities for monitoring and control.

It is recognized as a methodological limitation of this study the dependence on the overall accuracy of MAPBIOMAS classifications, without independent field validation, which may underestimate or overestimate certain vegetation cover transitions, especially in ecotone areas between Cerrado and Amazon where remote sensing classification faces greater interpretive challenges, as well as the use of Municipal Agricultural Production data, which, being a sample-based survey, may underestimate areas in municipalities with a large presence of non-formalized family farming or crops on small properties. These limitations, however, do not compromise the robustness of the conclusions but point to the need for future research that conducts field validation and qualitative analyses of socio-territorial conflicts in Balsas, investigating the narratives and resistance strategies of peasant and traditional communities in the face of agribusiness expansion. Prospective scenario modeling that integrates climate change, water availability in the Parnaíba basin, and different trajectories of agricultural frontier expansion is also proposed, in order to support alternatives to the current selective modernization model, as well as comparative studies with other MATOPIBA municipalities that allow identifying regional patterns and local specificities in the soybean expansion process and its socio-environmental impacts.

The study presented here delivers to the academic community and public policy formulators a rigorous diagnosis and a critical analysis of the process of transformation of the Cerrado into a sacrifice zone for global agribusiness—a territory where systemic environmental degradation, expropriation of natural resources, and marginalization of traditional populations are justified in the name of economic growth, reproducing the pattern of accumulation by dispossession (Harvey, 2004), neo-extractivism (Svampa, 2013), and environmental injustice (Acselrad, 2015) that characterizes contemporary agricultural frontiers.

It is concluded, therefore, that the improvement of territorial planning in the region requires not only the maintenance of at least 35% native vegetation per property with effective inspection, as provided for in the Forest Code, but also the implementation of mechanisms for the recovery of degraded areas, the formal recognition of peasant territories and traditional communities as strategic elements for food sovereignty and water resilience of the Parnaíba basin, and the creation of fiscal incentives for food production and for low-environmental-impact agricultural practices, under penalty of the advance of soybean expansion in MATOPIBA becoming irreversible and making unfeasible not only the Cerrado biome but also the very future of Brazilian agriculture in the face of climate change and growing international pressure for deforestation-free commodities.

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