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Chaco biome in Brazil: land use, vegetation cover and socio-economics

Bioma Chaco no Brasil: uso da terra, cobertura vegetal e socioeconomia

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Abstract

The *Chaco* in Brazil, characterized by wood steppe-savanna vegetation in transition to the *Cerrado*, exhibits distinct ecological and socio-economic characteristics compared to other Brazilian biomes. However, this fragment is administratively included within the Pantanal, lacking independent legal recognition. To address this gap, public databases and research projects assist in monitoring and analyzing the region, providing support for its management and conservation. Thus, this study aims to analyze land cover change and the socio-economic scenario in the Brazilian Chaco. For this purpose, land use and vegetation cover were examined in the period from 1985 to 2022, while socio-economic data were obtained from the 2017 Agricultural Census. The results indicate a significant replacement of natural vegetation by pasture, totaling approximately 4,832.6 km² of consolidated area, which accounts for 32% of the Brazilian Chaco's territory. The deforested area is primarily associated with livestock farming, the region's dominant economic activity. An inventory of available tractors was recorded, along with a limited number of agricultural machines, such as seeders and harvesters, highlighting the low intensity of agricultural land use. It is important to highlight that, in addition to the economic significance of livestock farming, the region, particularly the municipality of Porto Murtinho, also exhibits considerable potential for tourism. The availability of spatial databases, pre-classified land cover datasets, and research projects plays a significant role to understand land use and cover dynamics, contributing to develop a public policy for the Brazilian Chaco.

Keywords:
Spatial analysis, Livestock activity, Public policies, Geo-technology, Environmental planning.

Resumo

O Chaco no Brasil, caracterizado pela vegetação de Savana Estépica em transição com o Cerrado, possui particularidades ecológicas e socioeconômicas distintas dos demais biomas brasileiros. Contudo, esse fragmento está inserido nos limites do Pantanal, sem reconhecimento legal próprio.

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Para suprir essa lacuna, bancos de dados públicos e projetos de pesquisa auxiliam no monitoramento e análise da região, fornecendo subsídios para sua gestão e conservação. Dessa forma, o estudo tem como objetivo analisar a alteração da cobertura do solo e o cenário socioeconômico no Chaco brasileiro. Para isso, foi realizado um recorte temporal no período de 1985 a 2022 para analisar o uso do solo e cobertura vegetal, enquanto para os dados socioeconômicos foi utilizado Censo Agropecuário de 2017. Os resultados obtidos possibilitaram visualizar a substituição da cobertura de vegetação natural por pastagem, totalizando aproximadamente 4.832,6 km² de área consolidada, o que equivale a 32% do território chaquenho brasileiro. Essa área desmatada está relacionada à atividade econômica majoritariamente associada à pecuária. Entretando, observou-se ainda, um acervo de tratores disponível e pouco maquinário agrícola, como semeadoras e colhedoras, destacando o baixo uso agrícola do solo. Vale ressaltar que para além da importância da pecuária para economia, bem como a aptidão ao turismo no município de Porto Murtinho e região. A disponibilização de bancos de dados espaciais, classes pré-classificadas e projetos de pesquisa contribuem de maneira significativa para o entendimento da dinâmica de uso e cobertura da terra e subsidiar políticas públicas para o Chaco brasileiro.
Palavras-chave:
Análise espacial, Atividade pecuária, Políticas públicas, Geotecnologias, Planejamento ambiental.

I. INTRODUCTION

The *Gran Chaco* biome is an environment located exclusively in South America, with approximately 1,141,000 km² covering partial areas in Argentina, Paraguay, Bolivia and a small portion in Brazil. Due to its scope, its climatic characteristics vary according to the socio-economic influence, the relief and the physical and chemical properties of the soil in the region (Hueck et al., 1972; Naumann, 2006). Located in the SW of Mato Grosso do Sul State, within the limits of the *Pantanal* biome (IBGE, 2019), the Brazilian *Chaco* is connected to the Paraguayan and Bolivian Humid *Chaco*. The vegetation is characterized by the Steppe Savanna (*Chaco*) with a transition zone to *Cerrado*, which contributes to the diversity of flora, fauna and the particularities of the morphology from the soils in the region (Prado, 1993; Prado; GIBBS, 1993; Coutinho, 2016).

In Brazil, there are 6 biomes recognized by law: Amazon, *Cerrado*, *Caatinga*, Atlantic Forest, *Pampa* and *Pantanal* (IBGE 2019). Because its size is not as significant as that of other Brazilian biomes, the *Chaco* in Brazil still suffers from the lack of legal recognition as its own biome (IBGE, 2004; IBGE, 2019). Therefore, it is incorporated into the phyto-physiognomies of the *Pantanal* and *Cerrado* biomes (Carvalho; Sartori, 2015; Lima et al., 2017). The Brazilian *Chaco*, unlike its extensions of the biome in neighboring countries, had its land use consolidated predominantly by livestock farming, established in the region between 1985 and 1990. This change in vegetation cover to pasture and crops converted 21% of the Forest and Savanna Formations into pasture between 1990 and 2019 (Baumann et al., 2016; Fidalgo et al., 2023).

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The lack of a legal definition and generalization of its characteristics in other biomes incorporates a concern related to the conservation of this biome in Brazil, both due to the non-contemplation as a legal reserve with a specific percentage, and the lack of public policies directed to the environmental and socio-economic aspects of the region (Silva et al., 2008; Ratter et al., 1978; Ratter et al., 1988).

In addition to the importance of its legal recognition, the development of studies, monitoring, and spatial analyses of the Brazilian *Chaco* is possible and supported by databases and products generated by more comprehensive projects dedicated to other biomes. Currently, free web platforms and databases play an essential role to qualify land use, monitoring deforestation, vegetation cover, fires, and water bodies, among other aspects. Projects such as MapBiomas, the IBGE Agricultural and Demographic Census, and other studies and research projects provide collections and/or products for qualifying and quantifying land use and socio-economic aspects at the state, federal, and biome levels, providing support for scientific research, environmental studies, and public policy formulation (Souza et al., 2020; Antunes et al., 2019; IBGE, 2017a; Macário et al., 2020).

In the current scenario, the Brazilian *Chaco* is included in the project to consolidate the bi-oceanic corridor route that is being planned and financed by the Federal Government and the Government of the Mato Grosso do Sul State, in Brazil. This route will connect Brazil to the Pacific Ocean, passing through Paraguay, Argentina and Chile, to the seaports of Iquique and Antofagasta. On the Brazilian side, the plan is to repair and adapt 104 kilometers of pavement from the BR-267/MS, build 13.1 kilometers of ring road on this highway, up to the Paraguay River, in addition to the bi-oceanic bridge with approximately 1,300 meters length. It also foresees the construction of a customs center for border control in the municipality of Porto Murtinho, in front of Carmelo Peralta, in Paraguay. The implementation of the connection between countries can generate changes in social and economic dynamics, as well as an increase in anthropogenic pressures that increase the suppression of the region's ecosystem (Mamede et al., 2019; Asato et al., 2019).

Thus, studies and databases dedicated to the region and particularities of the Brazilian *Chaco* on platforms such as MapBiomas and information made available by IBGE, can contribute and support research projects, public policies and financing focused on the biome. In this sense, the objective of this study is to analyze the change of land use/land cover in the Brazilian Chaco, and to present an overview of the region's socio-economic scenario and propose a discussion regarding the importance of analysis tools, data provision and research dedicated to the Chaco in Brazil.

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II. Material and Methods

Study area

The Brazilian *Chaco* at the extreme SW of Mato Grosso do Sul State, in the southern section of the *Pantanal*, bordering Bolivia and Paraguay. The processing and creation of maps were developed in QGIS 3.22 and the project was defined in Datum Sirgas 2000 UTM 21 South.

The study area is dominated by Steppe Savannah vegetation, corresponding to the remnants of the *Gran Chaco*, a unique complex of landscapes that extends across eastern Bolivia and northeastern Paraguay and is influenced by marginal vegetation, such as the *Cerrado*. In Brazil, the *Chaco* province covers an area of 22,488.6 km², equivalent to 0.26% of the country (Silva et al., in press) and comprises the "dry chaco", with fertile and well-drained soils, and the "humid chaco", characterized by *Quebracho* forests (*Schinopsis balansae*) and *Caranda* savannas (*Copernicia alba*) in clayey and poorly drained areas (Pott; Pott, 2003; Mato Grosso do Sul, 2009; Pott; Silva, 2015).

It is also worth noting that the region has a predominant land use associated with livestock farming, and therefore an abundance of exotic pasture. The legal delimitation and protection of Conservation Units has also been established: the *Cachoeira do Rio Apa Municipal Natural Park* (PNM), the *Rio Apa River Sub-basin Environmental Protection Area* (APA) and the *Kadiwéu Indigenous Land* (TI), partly in the *Chaco* and partly in the *Cerrado*.

The boundary of the *Chaco* biome in Brazil used in this study was based on Silva et al. (2024), delimited from an assessment of land use class mapping projects in the region and fieldwork in 2021 and 2023 (Figure 1).

Land cover / land use mapping

The land cover /land use maps of the study region were obtained from MapBiomas Collection 8 and 4 (MAPBIOMAS, 2024). The Google Earth Engine tool was used to prepare the data in three stages. Initially, the 19 MapBiomas classes present in the region, for the two collections, were grouped into just 9, considering the needs of this study.

The original class “Flooded Field and Marshland” was aggregated into the “Grassland Formation” class; the original classes “Temporary Crops”, “Sugarcane”, “Mosaic of Uses”, “Perennial Crops”, “Soybeans”, “Rice” and “Other Temporary Crops” were aggregated into the “Agriculture” class; the classes “Urbanized Area” and “Other Non-Vegetated Areas” were aggregated into the “Non-Vegetated Area” class; and the “River, Lake and Ocean” class was aggregated to the “Body of Water” class. Afterwards, the spatial data set was selected

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considering the years analyzed in the study: 1985, 1995, 2005, 2015 and 2022. Finally, a mosaic was created between the two reclassified collections and with the selected years aiming to produce a spatially continuous collection.

To create the deforestation map, the classes "Pasture", "Agriculture", and "Non-vegetated area" were added together to form the "Deforested and/or consolidated area" class. Meanwhile, to form the "Natural vegetation" class, the classes "Forest Formation", "Savanna Formation", "Grassland Formation" and "Natural floodplain area – Woody" were combined.

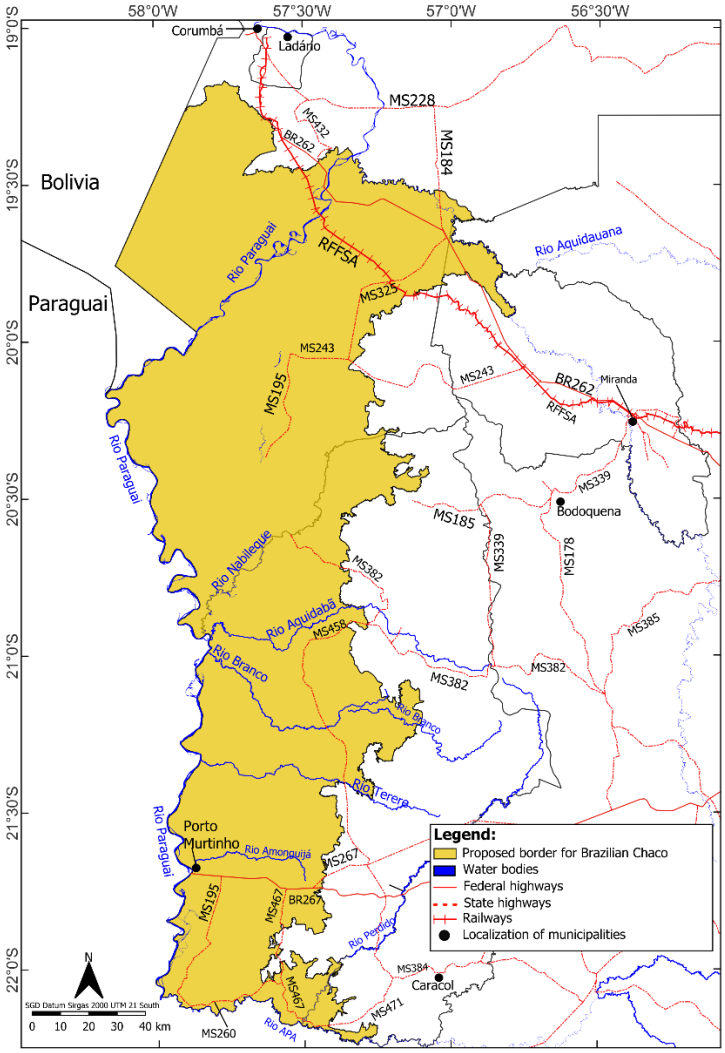

Figure 1 – Brazilian *Chaco* boundary used in the study.
Source: Silva et al. in press.

Socio-economic data

The production of the socio-economic maps was based on data published in the 2017 Agricultural Census, which were declared by producers about their properties. These data were acquired at the census tract

238
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RA'EGA, Curitiba, PR, V.63, n.2, p. 233 – 252, 8/2025
https://doi.org/10.5380/raega.v63i2.99681

level, allowing the creation of thematic maps on a more detailed scale and with visualization details beyond the municipal limits from the region of interest.

To acquire this information, it was necessary to survey the codes of the census tracts that were partially or totally within the limits of the Brazilian *Chaco*, according to the Shapefile of the Census Sector Mesh, available at IBGE (2017b). Together with the indication from the Sectors of interest, the variables used to produce the socio-economic thematic maps were detailed. Table 1 presents in detail each of the required sectors, totaling 971 establishments in the municipalities of Caracol, Corumbá and Porto Murtinho.

Table 1 – List of Census Sectors, selected for requirement

FU	Municipalities	Districts	Census sectors	Number of establishments
Mato Grosso do Sul	5003207 – Corumbá	500320705 - Corumbá	500320705000098	24
		500320705 - Corumbá	500320705000099	23
		500320710 - Albuquerque	500320710000001	4
		500320710 - Albuquerque	500320710000002	22
		500320710 - Albuquerque	500320710000004	22
		500320710 - Albuquerque	500320710000005	36
		500320720 – Coimbra	500320720000003	15
		500320720 – Coimbra	500320720000004	32
		500320720 – Coimbra	500320720000005	19
		500320735 - Porto Esperança	500320735000002	10
		500320735 - Porto Esperança	500320735000003	88
		500320735 - Porto Esperança	500320735000004	4
		500320735 - Nhecolândia	500320725000005	27
	5005608 – Miranda	500560805 - Miranda	500560805000031	9
	5006903 - Porto Murtinho	500690305 – Porto Murtinho	500690305000011	27
			500690305000012	24
			500690305000013	37
			500690305000014	6
			500690305000015	23
			500690305000016	59
			500690305000017	19
			500690305000018	20
			500690305000019	41
			500690305000020	33
			500690305000021	12
			500690305000022	14
			500690305000023	27
			500690305000024	75
			500690305000025	24
			500690305000030	37
	5002803 – Caracol	500280305 – Caracol	500280305000007	129
			500280305000008	29

Source: Adapted from IBGE (2017b)

Together with the description from the sectors of interest, it was necessary to attach the codes of the desired variables to the request for census data. Given the already known characteristics of the region, the request sought to provide a cutout of the current *Chaco* state of the actual socioeconomic characteristics and

239
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RA'EGA, Curitiba, PR, V.63, n.2, p. 233 – 252, 8/2025
https://doi.org/10.5380/raega.v63i2.99681

to understand the intensity of use in the region. To this end, information was obtained related to pasture and livestock, the use of machinery for property management, the density of agricultural establishments and the adoption or not of agricultural practices for conservation and/or crop control (Table 2).

Based on this data, thematic maps were created using the following variables per sector available by the Agricultural Census: Total Establishments, Establishments with livestock activity, Establishments with planted pasture, Total heads of cattle, Total machinery (including tractors, harvesters and Total Seeders and/or Planters).

Table 2 – Variables selected for database request

Code	Identification of variable
VW01170300	Variable derived from total area of establishment in hectares
VW04020000	Permanent crop area (ha)
VW04030000	Temporary crop area (ha)
VW04050000	Natural pasture area (ha)
VW04060000	Planted pasture area (ha)
VW04070000	Degraded pasture area or in poor conditions (ha)
VW04080000	Area of natural woods and/or forests intended for permanent preservation or legal reserve (ha)
V05130100	Variables selected for database request
V05130700	Agricultural practice used in the establishment - protection and/or conservation of slopes
V05131100	Agricultural practice used in the establishment – gully stabilization
V05180100	Uses pesticides (phyto-sanitary products) to control pests and/or diseases in vegetables
V07020101	Total number of tractors
V07020501	Number of planters and/or seeders
V07020601	Number of harvesters
V14010101	Total number of cattle heads
V15010101	Total number of buffaloes existing on the reference date

Source: Adapted from IBGE (2017c).

It is important to note that some data could not be accessed due to the low density of establishments in the census sector, which, for confidentiality reasons, were not provided by the institution. This limitation may result in the generation of maps with missing information for certain sectors.

III. RESULTS AND DISCUSSION

The acquired maps allowed reading the use and occupation classes of the Brazilian *Chaco* in the period from 1985 to 2022. During the analysis of the current soil cover from this region, the main changes were verified in the classes of Water Bodies and effective areas of Livestock and Grassland Formation (Figure 2).

The volume of water bodies identified in 1985 and 1995 (Figure 2) in the humid sector is located in a region with characteristics of the Humid *Chaco*, therefore being a flood-prone area due to its low drainage capacity (Pennington et al., 2000). From 2005 onwards, a reduction in the volume of water was observed, reflecting the decrease in the average floods and ebbs, a pattern that continues to this day (SGB, 2020). The

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reduction in flooding shows that the Pantanal is in a cycle with a lower water table. In 2025, the accumulated volume of precipitation was 18% lower than the annual average recorded between 2020 and 2025. However, the hydrological levels in Porto Murtinho remain within normal limits for the period, while in the Miranda region the levels are approaching the historical minimum for this period (SGB, 2025).

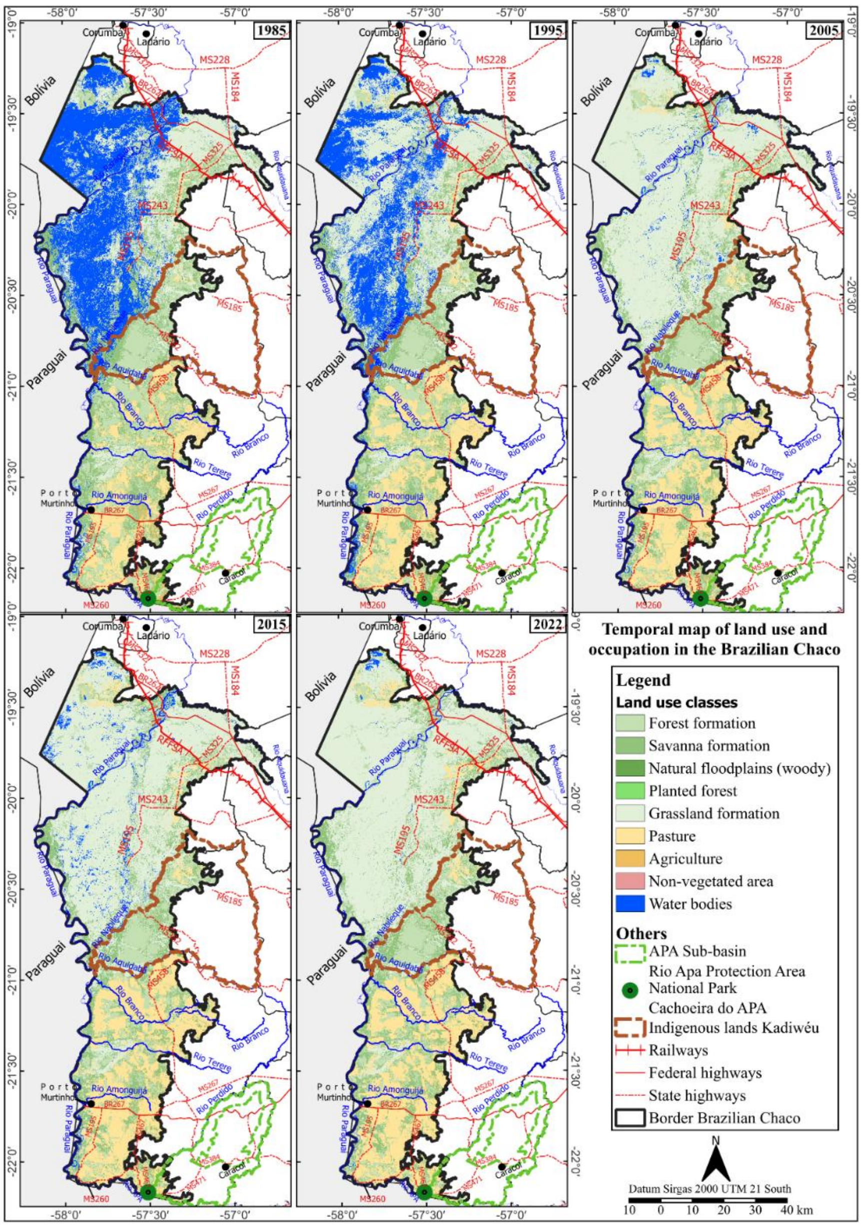

Figure 2 – Temporal map of land use and occupation in the Brazilian Chaco
Source: Adapted from MapBiomas (2024), based on the limits of Silva et al. in press.

The Brazilian Humid *Chaco* presents typical grassland floristic, characterized by species from families *Leguminosae, Malvaceae, Cactaceae, Asteraceae* and *Bromeliaceae* (Freitas et al., 2013). The herbaceous species, together with sub-shrubs, exhibit a floristic that favors the efficiency in water use. Furthermore, under

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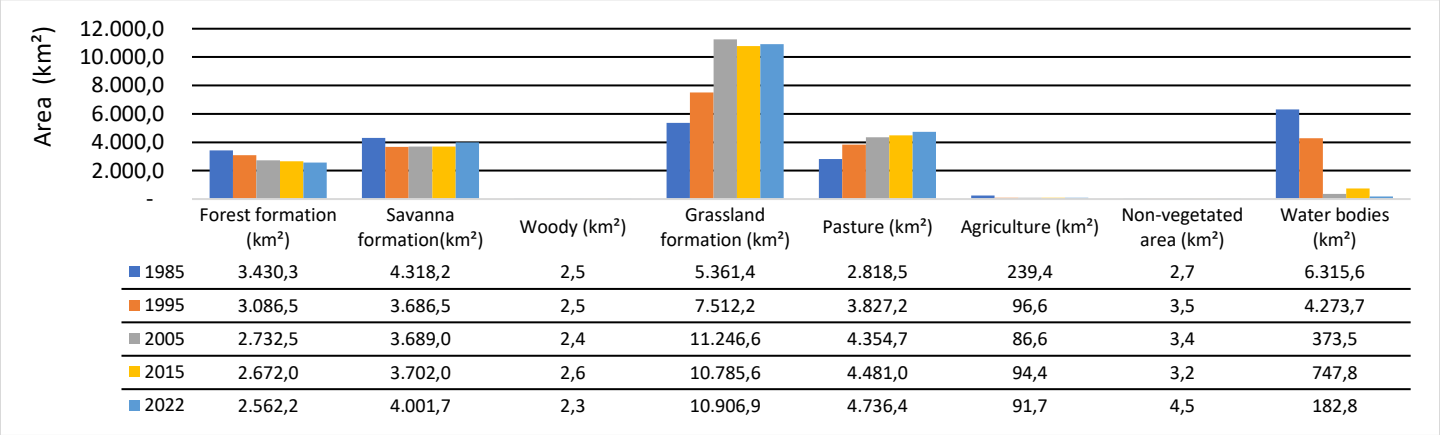
high temperature conditions, these species optimize the photosynthesis process (Monasterio; Sarmiento, 1976). Thus, all these dynamics occurs in plains associated with the Grassland Formation area.

In the south of the *Chaco*, in Porto Murtinho, there is an active and predominant economic activity of exotic pasture planted as a result of the management, dedicated to livestock farming with greater intensity. The natural vegetation is classified as Steppe Savanna and sub-group, generally with shrubby plants, spaced trees and without galleries formation (Silva et al., 2021). According to Noguchi et al. (2009), the main families are legumes and *Binociaceae*, and contact with the species of *Anacardiaceae, Myrtaceae* and *Sapindaceae*. On Figures 3 and 4 one observes that the vegetation to the south has been under anthropic pressure since before 1985, and it is still increasing.

Figure 3 shows the graphical behavior and area (km²) of the classes in the Brazilian *Chaco*. An inversely proportional relation can be seen between the reduction of Water Bodies and the increase in Grassland Formation, and the consolidation of pastures to the north, close to BR-262 highway, as an anthropic pressure (Figure 2).



	Forest formation (km²)	Savanna formation(km²)	Woody (km²)	Grassland formation (km²)	Pasture (km²)	Agriculture (km²)	Non-vegetated area (km²)	Water bodies (km²)
1985	3.430,3	4.318,2	2,5	5.361,4	2.818,5	239,4	2,7	6.315,6
1995	3.086,5	3.686,5	2,5	7.512,2	3.827,2	96,6	3,5	4.273,7
2005	2.732,5	3.689,0	2,4	11.246,6	4.354,7	86,6	3,4	373,5
2015	2.672,0	3.702,0	2,6	10.785,6	4.481,0	94,4	3,2	747,8
2022	2.562,2	4.001,7	2,3	10.906,9	4.736,4	91,7	4,5	182,8

Figure 3 – Temporal dynamics of land use classes
Source: Adapted from MapBiomas (2024).

A decline in both Forest and Savanna Formations (Figure 3) was observed, located in the south, east and a small portion in the north of the Brazilian *Chaco*. This transition was possibly a change in land cover. The effective pasture area increased from 2,818.5 km² to 4,736.3 km², totaling an increase of 1,917.8 km² in the analyzed period, while the levels of natural vegetation were reduced by approximately 1,184.6 km² in the same period. Between 1985 and 2005, consolidated deforestation was observed in the Brazilian *Chaco*, resulting from the conversion of approximately one-third of its natural vegetation cover between 1977 and 2017 (Silva et al., 2008; Dias et al., 2021). The consolidation of land use occurred predominantly in the southern region, with a

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progressive expansion from the SE to the SW of the biome. This process continued between 2015 and 2022, also advancing to the northeastern and northern portions of the region (Figure 3: 2015 and 2022).

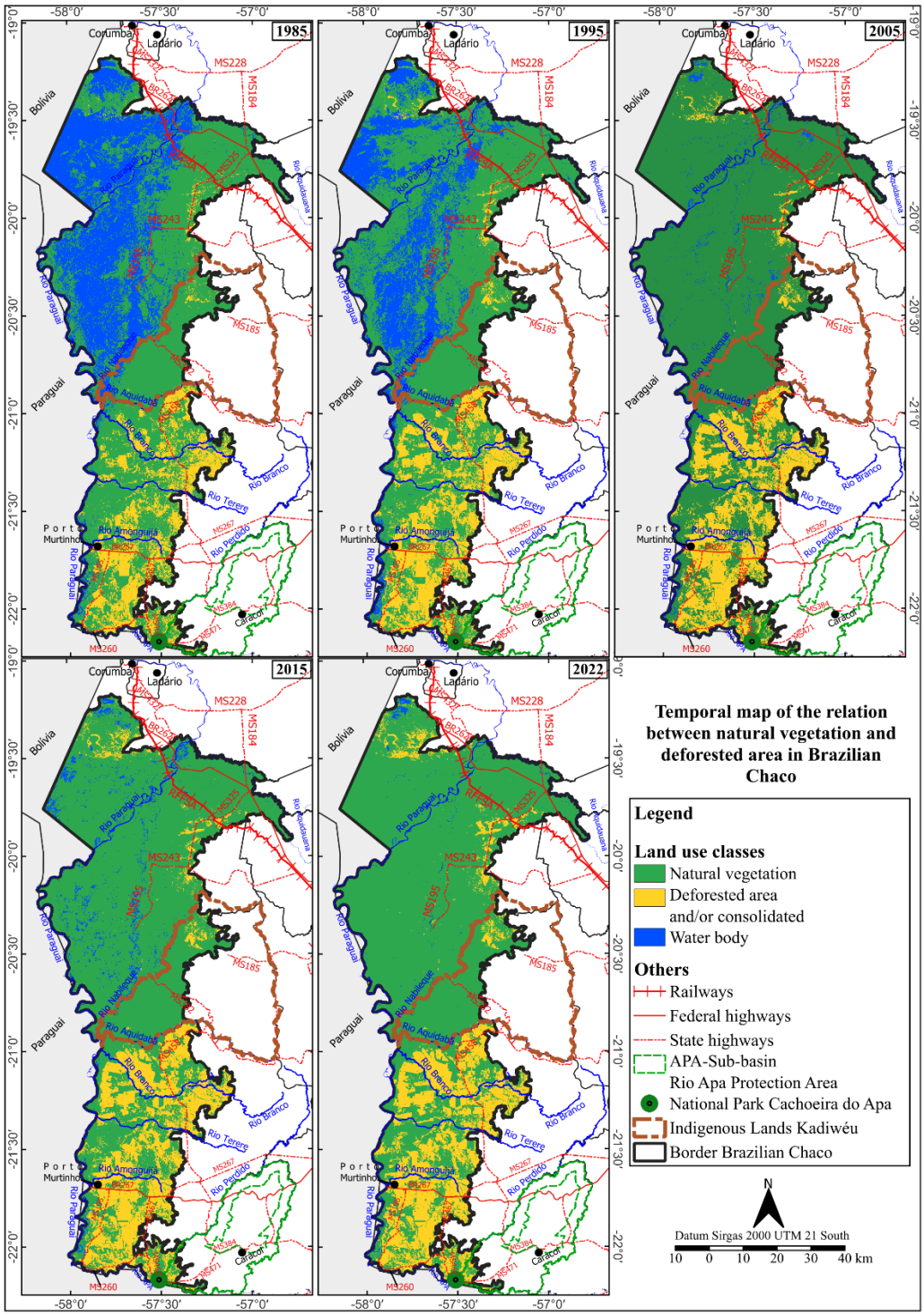

Figure 4 – Temporal map of natural vegetation and deforested area in the Brazilian *Chaco*.
Source: Adapted from MapBiomas (2024), based on the limit of Silva et al. in press.

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Livestock farming is the main economic activity in the Brazilian *Chaco*, according to data obtained from the 2017 Agricultural Census (IBGE, 2017a). Figure 5 illustrates a breakdown of the use and occupation classes, highlighting that most of the census sectors analyzed contain properties with livestock activities.

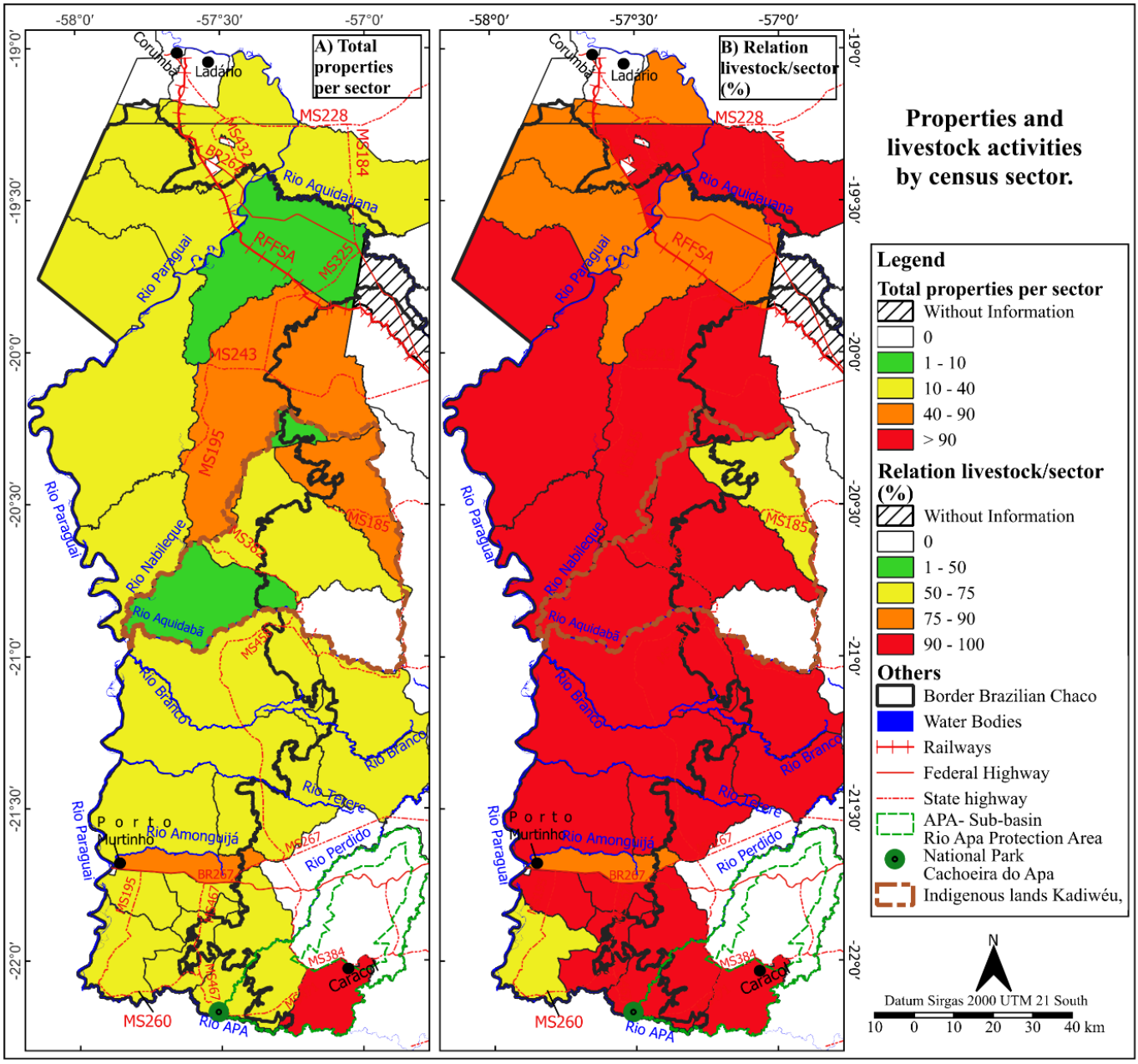

Figure 5 – Properties and livestock activities by census sector.
Source: Adapted from IBGE (2017a), based on the limit of Silva et al. in press.

Although the occurrence of properties with livestock activity is the majority, its intensity does not act in the same way and with a homogeneous proportion of cattle heads throughout the Brazilian *Chaco*. In this sense, it is clear that there is no great intensity, as illustrated by the cattle heads in Figure 6. However, it is worth noting

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that the Pantanal plain there is an increase in cattle heads on the plain, which does not rule out the *Chaco* zone (IBGE, 2017d; Alho et al., 2019a).

In the center-east, there is a greater intensity of use, reaching a total of 162,254 cattle heads, corroborating the information that the region has shown an increase in pastures since 2015 (Figures 2 and 3). Immediately below, in orange color, there are two sectors with ranges between 85 and 90 thousand cattle heads, the second portion with active economic activity and which is also located in the region with significant deforestation. The distribution of green and yellow colors was identified in the NW and SW of the Brazilian *Chaco*, with quantities ranging from 25 to 45 thousand heads of cattle.

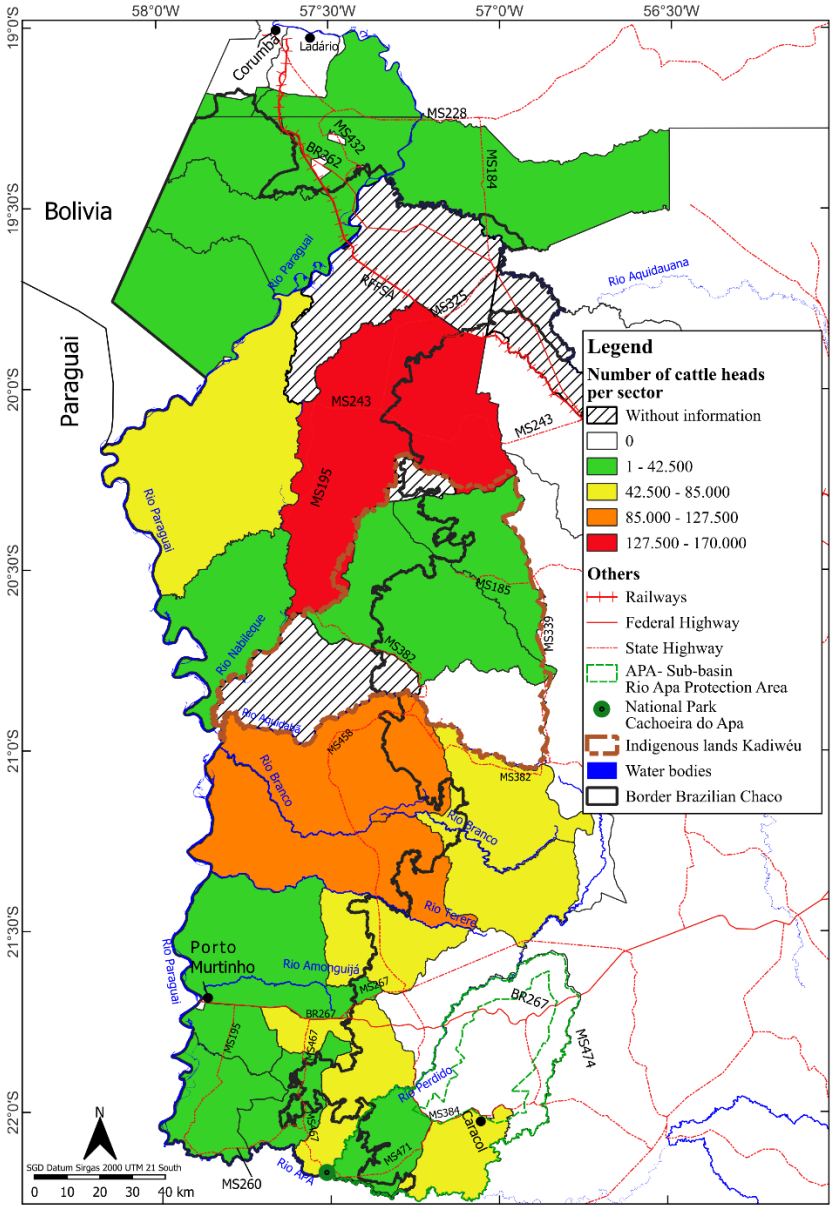

Figure 6 – Heads of cattle per census sector.
Source: Adapted from IBGE (2017a), based on the limit of Silva et al. in press.

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Given the productive capacity of the site, there is a need to use machinery to develop productive areas and *equipment to support soil management, but it can also be used for deforestation. Currently, the use of* tractors is the most significant, as shown in Figure 7A (IBGE, 2017a). Thus, the importance of tractors to support livestock farming is highlighted due to the distribution of cattle, tractors and management of planted pasture (Figures 6, 7A and 7C, respectively), which together reaffirm the main sectors with economic activities.

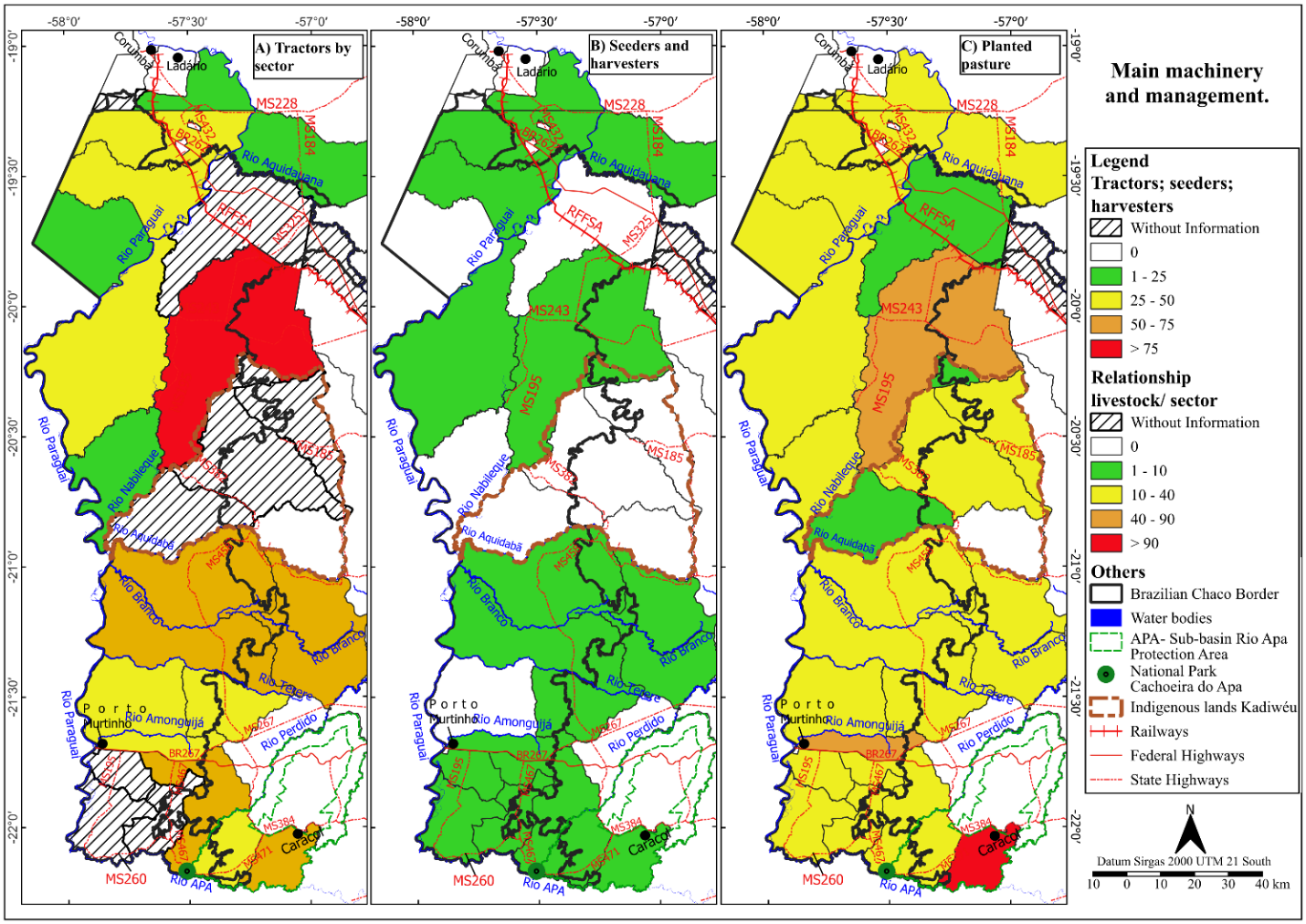

Figure 7 – Main machinery and management in the Brazilian *Chaco.*
Source: Adapted from IBGE (2017a); Silva et al. 2024.

As expected, the southern region showed a greater availability of sectors with tractors. However, the sector with the largest volume is located to the east, as illustrated by the red sector (Figure 7A), which increased in deforested area according to the latest update in 2022 (Figure 4). It is important to highlight that the area near the MS-184 highway has not yet been deforested, however, expeditions have identified anthropic pressures, such as the introduction of exotic species, the presence of fences, corrals, solid waste, cemeteries and logging along this road (Alho et al., 2019a).

ISSN eletrônico 2177-2738
RA'EGA, Curitiba, PR, V.63, n.2, p. 233 – 252, 8/2025
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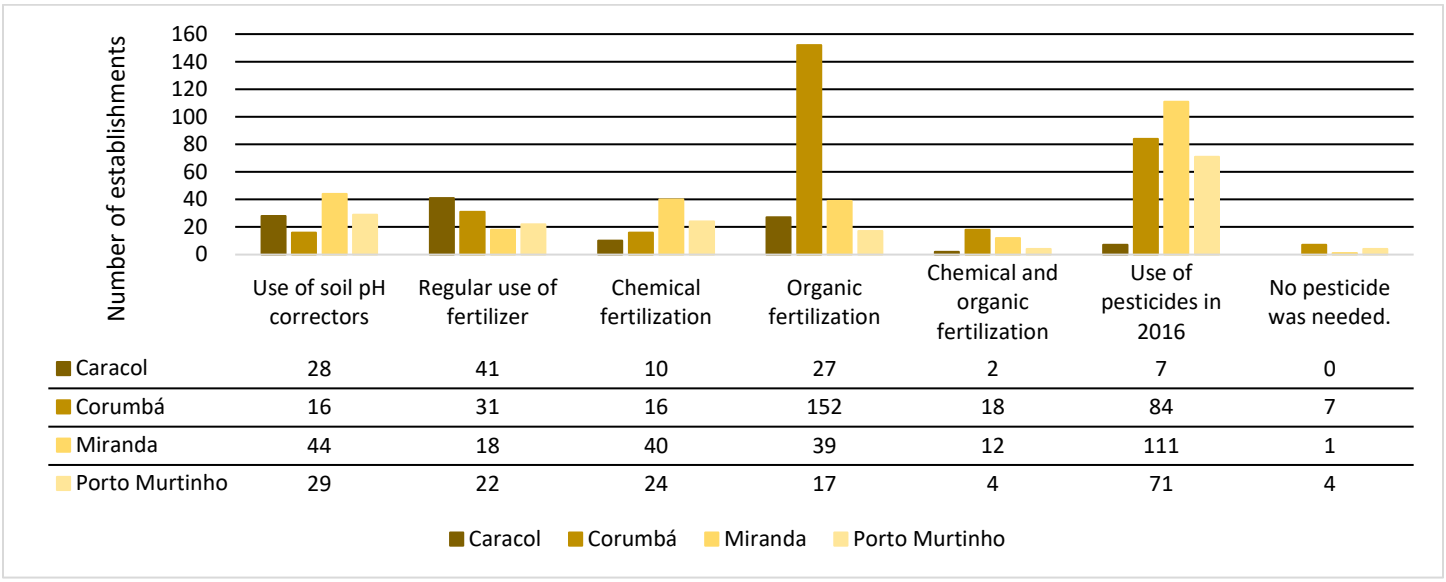
The use of agricultural machinery presented a similar conformity in the sectors. However, there is little agricultural machinery such as seeders, planters and harvesters in the sectors, which generally shows the low support and little dependence on agriculture (Figures 7A and 7B). Despite this scenario, one observe the implementation of practices that can support both livestock farming and agriculture, such as the application of fertilizers and pesticides in soil management, in addition to the use of techniques aimed at soil conservation and protection of slopes, springs and riparian forests (Figures 8 and 9).

Regarding the application of fertilizers, pesticides and soil conditioners, a small number of establishments adopt these inputs in their management. According to the Agricultural Census, the use of organic fertilization stands out, especially in the municipality of Corumbá, which registered 152 properties using this practice. It is the largest representative among the 235 establishments that adopted this technique (Figure 8). Regarding the use of pesticides, in 2016, it was identified that 273 establishments used this input in the agricultural management, which corresponds to approximately 28% of the 971 establishments analyzed.



	Use of soil pH correctors	Regular use of fertilizer	Chemical fertilization	Organic fertilization	Chemical and organic fertilization	Use of pesticides in 2016	No pesticide was needed.
Caracol	28	41	10	27	2	7	0
Corumbá	16	31	16	152	18	84	7
Miranda	44	18	40	39	12	111	1
Porto Murtinho	29	22	24	17	4	71	4

Figure 8 – Soil conditioners graph.
Source: Adapted from IBGE (2017a).

Regarding agricultural practices, a low adoption of sustainable management techniques was observed in the municipalities analyzed, with measures dedicated to properties with agricultural activity, such as crop rotation and contour planting, being the most used. However, there is little or no practice dedicated to environmental recovery actions, such as stabilization of gullies and protection of water bodies from riparian forests and reforestation of springs (Figure 9).

With the information on the current state of land use and land cover, as well as the consolidation of the main economic activities in the Brazilian Chaco region, it is possible to see thriving livestock farming in the

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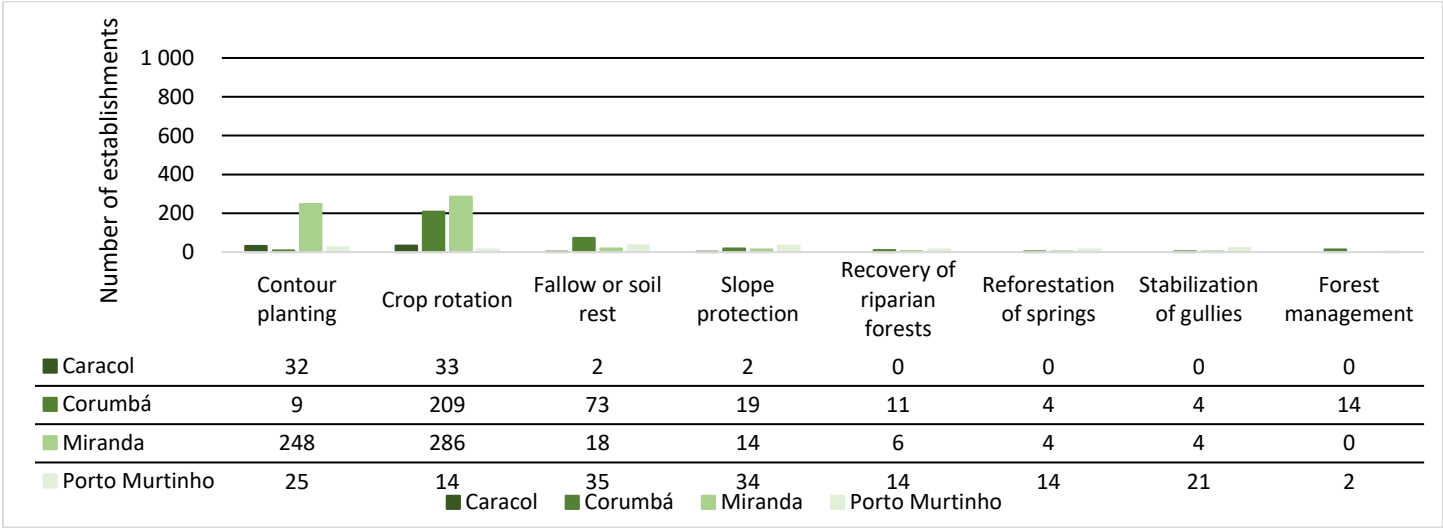
planted pasture area and a low number of establishments with agricultural management. In this sense, the information presented so far allows us to corroborate a panorama that reaffirms the characteristics highlighted by the Agro-ecological Zoning and Ecological Economic Zoning of Mato Grosso do Sul, both from 2009, especially in the municipalities of Porto Murtinho and Corumbá; it presents recommendations for land use for pasture and livestock farming purposes due to the characteristics of the soil, relief and climate of the region (Pereira et al., 2009a; Carvalho Junior et al., 2009; Pereira et al., 2009, Mato Grosso do Sul, 2009).



	Contour planting	Crop rotation	Fallow or soil rest	Slope protection	Recovery of riparian forests	Reforestation of springs	Stabilization of gullies	Forest management
Caracol	32	33	2	2	0	0	0	0
Corumbá	9	209	73	19	11	4	4	14
Miranda	248	286	18	14	6	4	4	0
Porto Murtinho	25	14	35	34	14	14	21	2

Figure 9 – Soil management practices graph.
Source: Adapted from IBGE (2017a).

Although there has been an increase in the consolidation of agricultural activities, as well as the low implementation of agricultural practices that can support the conservation of soils, forest remnants and the protection of natural resources, the *Chaco* region has shown lower annual averages of carbon dioxide (CO_2) emissions from 1990 to 2019 than the averages of the Pantanal (Fidalgo et al., 2023). However, it is worth clarifying that there has been a significant loss of savanna formation, especially in the south, but that according to the data acquired in this study, the expansion has also extended to the north and northeast of the Brazilian Chaco.

It is important to highlight that, in the Pantanal, studies indicate difficulties to implement conservation and management plans in the region, for example, the lack of political and institutional measures sensitive to environmental issues, as well as the absence of decision-makers committed to the conservation of biodiversity and ecosystem services (Alho et al., 2019a). As for the Brazilian *Chaco*, the lack of formalization of its area and legal definitions further aggravates these difficulties, especially in the feasibility and implementation of public

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RA'EGA, Curitiba, PR, V.63, n.2, p. 233 – 252, 8/2025
https://doi.org/10.5380/raega.v63i2.99681

policies, action plans and conservation strategies, mainly due to the scarcity of specific information about the region (IBGE, 2004; IBGE, 2019).

Although livestock farming is the main economic activity and the one that best adapted to the region, especially in Porto Murtinho, where human occupation and livestock farming are consolidated, it is important to consider the municipality's tourism potential and its prospects for growth and economic development (Mamede et al., 2019). The BR-267 highway, which crosses the municipality of Porto Murtinho, is planned to be part of the Bi-oceanic Corridor, linking the Atlantic and Pacific oceans. The route will connect the cities of Iquique and Antofagasta, in Chile, to the port of Santos, in Brazil. The connection between the municipalities of Porto Murtinho and Carmelo Peralta was made by ferries and it is difficult for buses and trucks to travel, but a bridge is currently under construction and will facilitate the connection between the countries and the interconnection of the Bi-oceanic Corridor (Asato et al., 2019; SEMADESC, 2024).

Just like livestock farming, the completion of the Bi-oceanic Corridor will have major economic, social, and environmental impacts on the region, boosting the flow of tourists and transport trucks and, consequently, fostering local commerce. In the case of the Pantanal, Alho et al. (2019b) highlight that both tourism and livestock farming play fundamental roles in the economic development and social progress of the region. However, it is emphasized that these activities should not override environmental conservation, since ecosystem services are essential for municipalities and their respective production chains. In addition, the study points out structural challenges in the Pantanal, such as the lack of infrastructure, the lack of training for the local population, and the difficulty to implement legislation and public policies aimed at the sustainable development of the region, which may apply to the Brazilian *Chaco* region.

Nevertheless, this transition in socio-economic aspects can bring benefits to the community and surrounding municipalities through the development of Porto Murtinho, since there will be positive externalities due to the dynamism that will occur in the municipality, which would connect Paraguay and the entire corridor to cultural tourism and scientific tourism in Bonito and the Pantanal, as well as the export and import route between Brazil and Paraguay (Asato et al., 2019; Mamede et al., 2019).

It is worth highlighting the importance of preservation and the contribution to the annual carbon balance of the *Chaco*, the *PNM Cachoeira do Rio Apa* conservation unit and the Kadiwéu TI, which are important for conservation, but are also close to a region with historical wealth, especially the conservation unit and the stretch that connects the *Rio Paraguay* River with the *Rio Apa*. This section has historical, cultural, scientific and

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educational tourist potential for the region, and could substantially contribute to the development of new economic potential in Porto Murtinho (Mamede et al., 2019; Fidalgo et al., 2023).

IV. CONCLUSIONS

The elaboration of temporal maps and socio-economic clippings allows elucidate the main classes of land use and land cover, as well as the importance of livestock farming in already consolidated areas, as well as the representation of the advance of the consolidation from exotic pasture for livestock farming as the main economic activity in the Brazilian *Chaco*.

Data from the Agricultural Census available at IBGE allows us to visualize the distribution of establishments and the main economic activities in each census sector analyzed. In addition, they made it possible to identify the regions with the highest concentration of livestock activity, number of cattle heads and the main machinery used in management. As expected, agricultural activity is not very significant, resulting in a low use of machinery aimed at agriculture. However, the use of tractors stands out, mainly for soil management in areas intended for livestock farming. Furthermore, there is a low adoption of agricultural practices aimed at soil conservation and reforestation.

The municipality of Porto Murtinho plays a strategic role in the socio-economic development of the region, not only because it concentrates a large part of the livestock activity, but also because of its position on the border with Paraguay and its integration into the Bi-oceanic Corridor. This connection will enable an increase in the flow of transport, with direct impacts on trade and tourism in Mato Grosso do Sul.

In this sense, the importance of detailed and targeted studies of the Brazilian Chaco region is highlighted, whether with the support of remote sensing tools and spatial data processing, but also with research projects. It is also important to point out the intrinsic difficulties to the development of the region by not considering the Brazilian Chaco as a biome, whether in the formulation of public policies or conservation and preservation plans.

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