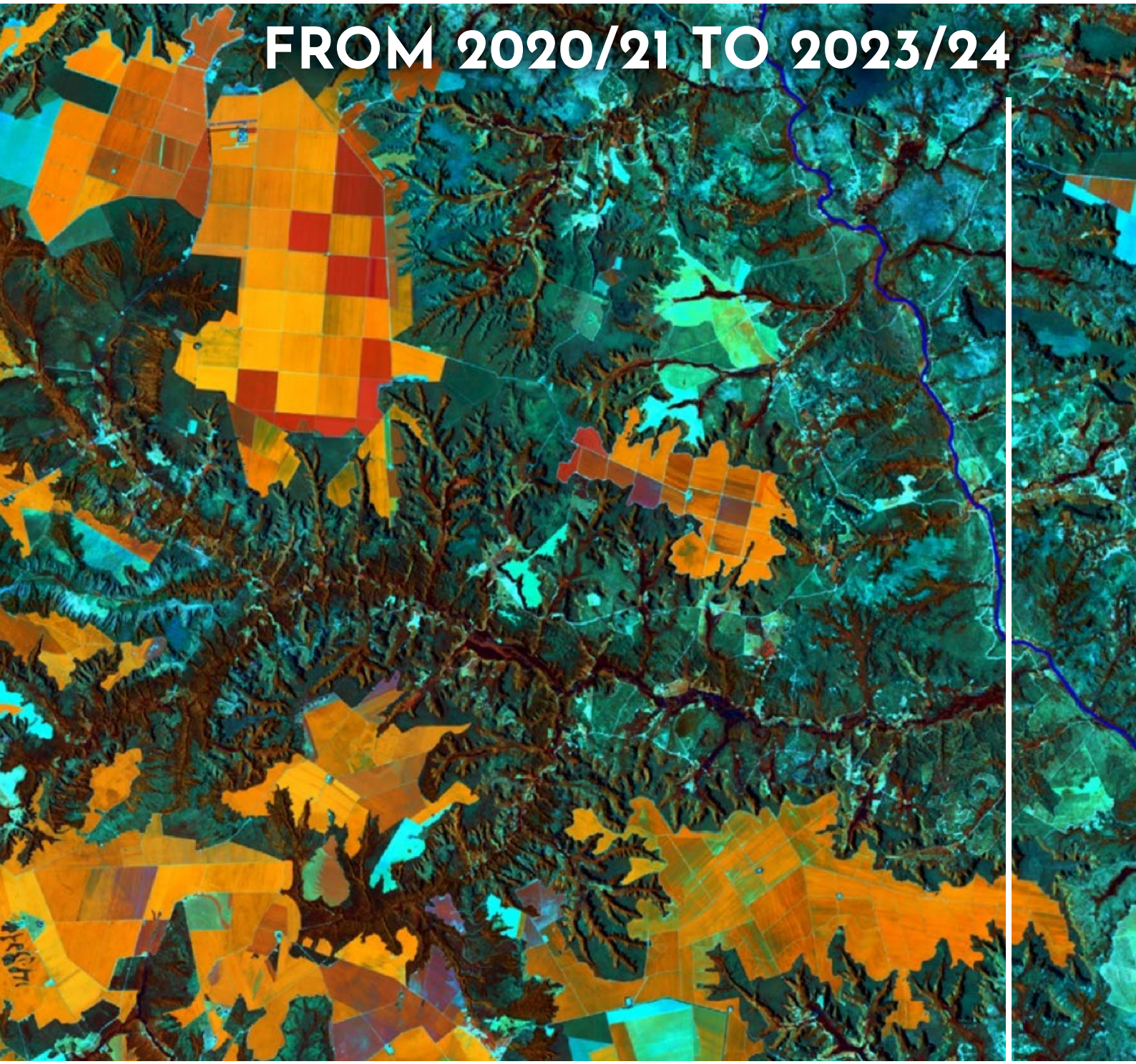
SOY EXPANSION DYNAMICS IN THE CERRADO BIOME

FROM 2020/21 TO 2023/24



GRANTEE

ABIOVE

EXECUTION

serasa experian

General Coordination
Bernardo Rudorff
Daniel Alves de Aguiar
Joel Risso

Coordination of Geoprocessing and Remote Sensing
Daniel de Oliveira Machado | **Geoprocessing**
Lucas Kreutzfeld | **Remote Sensing Soy Mapping**
Nildson França e Silva | **Analysis of changes in land use and special areas**
Rafael Cardão | **Analysis of deforestation associated with soy**
Rafael Dalla Betta | **Analysis of soy in rural properties**

Team of Geoprocessing and Remote Sensing Analysts
Alex Heck Bonfanti
Andre Fischer Silva
Anluizi Cejara Carvalho da Costa
Arthur de Souza Azevedo
Bernardo Campos Nunes
Bianca Regina Redante Scheidt
Bruno Jalowski
Caio Filippini
Cleiton Bueno Peffer
Eden Lima De Nardi
Gabriel Fioravante Ferro
Gabriel Torresilha De Oliveira
Mariana Vanz Dos Santos
Giorgia Hack Barreto Dariva
Helder Junior Michielin Filho
Janine Da Silva Falco
Julia Eliane Klock
Lucas Ariel Cunha Bortoluzzi
Lucas De Camargo Neves Stella
Luciano Dos Santos Cardoso Junior
Maria Luiza Dalsenter Souza
Maria Luiza Martins
Maria Vitoria Dos Guimarães Vidal
Matheus Julio Pereira
Matheus Oliveira Della Nina
Michele Tatsch
Pedro Nando De Souza
Raphael Viani Santos Cabral
Senoel Rodrigo da Costa
Tamires Maria Ribeiro
Thayane Muller Vieira
Thiago De Andrade Guimarães Toledo
Vile Rodrigues Malm

Technical Review
Bernardo Pires and Pedro Garcia, ABIOVE

Editorial Production and Desktop Publishing
W5

AG281a

Serasa Experian S.A. - Agribusiness. Soy expansion dynamics in the Cerrado Biome from 2020/21 to 2023/24 – Florianópolis, Santa Catarina, Brazil, 2024
24 p. : il

ISBN: 978-65-982986-1-6

1. Soy mapping, crop year 2023/24. 2. Cerrado Biome. 3. Satellite images. I. 4. Deforestation. I. Rudorff, Bernardo. II. Risso, Joel. III. Title.
CDD: 550
CDU: 550

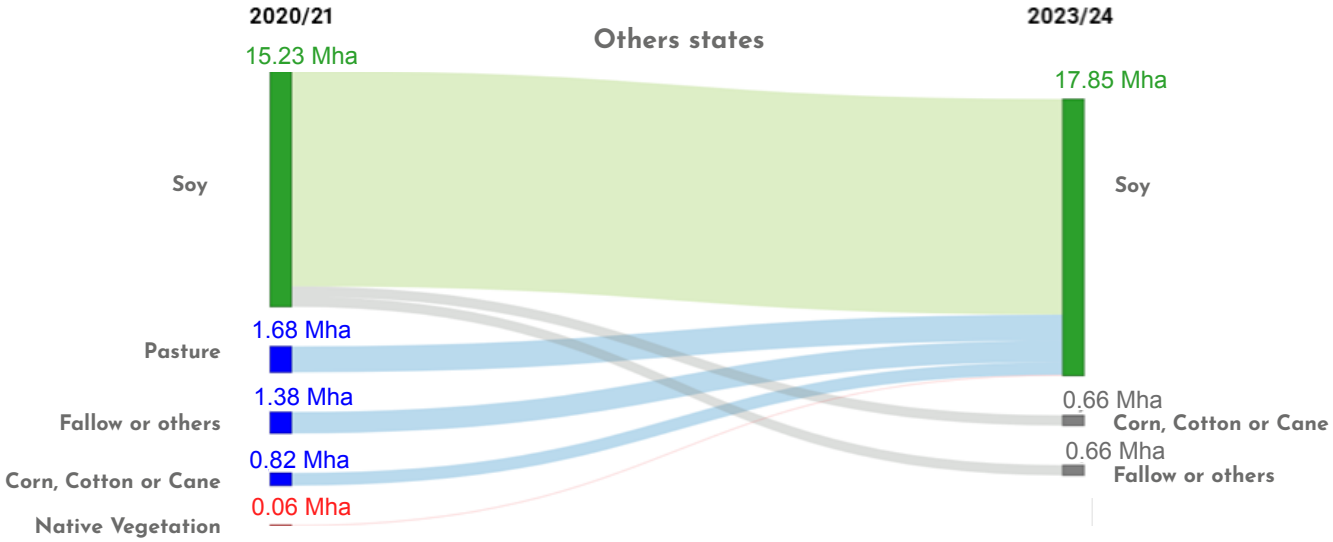
Executive Summary

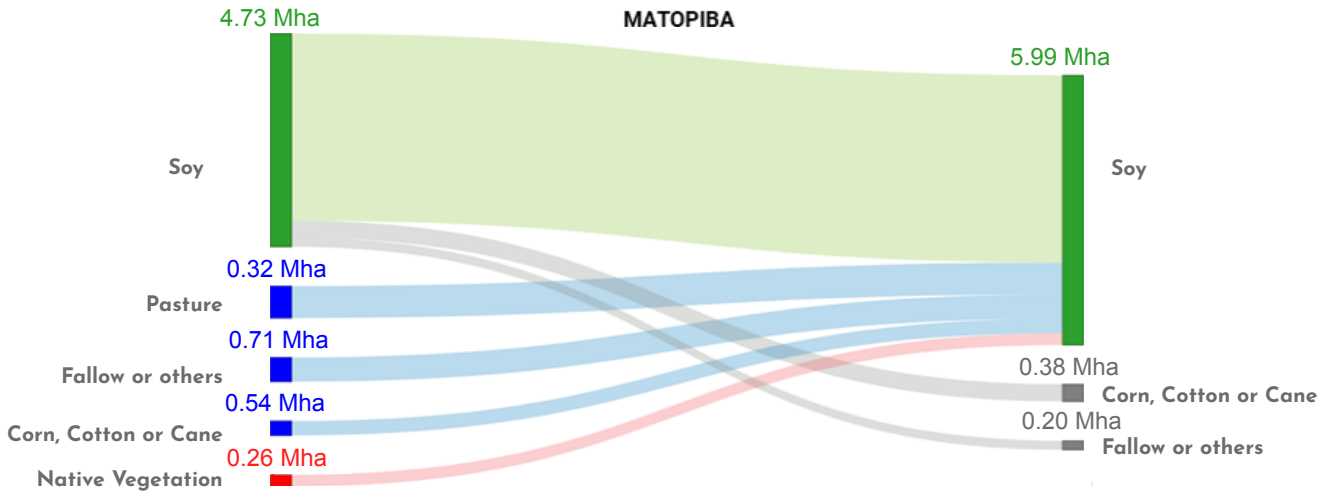
This study continues the series of mappings made to analyse the land use and land cover changes associated with the expansion of soy, with and without deforestation, in the Cerrado Biome. The analysis of the soy expansion dynamics covers the period from crop year 2020/21 to crop year 2023/24, highlighting the agricultural frontier region known as MATOPIBA and the more consolidated region comprising the remaining states of the Biome (Other States). This period of analysis was chosen to be aligned with the European Union Regulation for Deforestation-Free Products (EUDR), evaluating de soy area of crop year 2023/24 on post-2020 deforestations.

In crop year 2023/24, 23.84 million hectares of soy were planted, equal to 12% of the Cerrado Biome's and 50.2% of Brazil's soy area (47.44 million hectares), according to the survey carried out by Serasa using satellite images. Over the last three crop years, the soy area in the Biome has increased by 3.87 million hectares (19.4%), of which 2.62 million hectares were in Other States and 1.25 million hectares were in MATOPIBA. Soy expansion in the Cerrado has accelerated significantly in recent years, with 1.470 million hectares in 2021/22 and a record 1.721 million hectares in 2022/23; however, in crop year 2023/24, soy expansion was reduced to 683,000 hectares, very close to the average annual rate over the last 23 crop years (713,000 hectares).

In the Cerrado Biome, annual deforestation rates increased gradually from 791,000 hectares in 2020 to 1.101 million hectares in 2023. This increase was mostly due to the MATOPIBA region that, although it represents only 36% of the Biome's area, was responsible for 75% of the 2023 deforestation. Conversion of this deforestation into soy in the post-2020 period took place on 316,900 hectares (1.33% of the Biome's soy), with 59,300 hectares in Other States and 257,600 hectares in MATOPIBA, confirming the significant difference between the two regions in terms of soy's deforestation footprint.

A detailed analysis of the dynamics of the land use and land cover changes associated to the net soy expansion of 3.87 million hectares in the 2020/21 to 2023/24 period, as shown below in the Sankey diagram, shows that the main factors responsible for these dynamics were: (a) incorporation of new areas from conversion of native vegetation, mainly in MATOPIBA; (b) intensification of land use through conversion of pastures; and (c) agricultural management practices of crop rotation and fallow land. In the Other States region, 1.68 million hectares expanded onto pastures (intensification) and just 0.06 million hectares expanded onto deforestation. In MATOPIBA, 0.32 million hectares expanded onto pastures, while 0.26 million hectares expanded onto deforestation. It should be noted that a significant portion of the 2.09 million hectares of this expansion occurred onto crop areas that were fallow in crop year 2020/21, of which 1.38 million hectares were in Other States and 0.71 million hectares were in MATOPIBA. An area of 1.9 million hectares of soy in 2020/21 was converted into other uses in 2023/24 (retraction).


2020/21
Others states
2023/24
15.23 Mha
17.85 Mha
Soy
Soy
1.68 Mha
Pasture
1.38 Mha
Fallow or others
0.82 Mha
Corn, Cotton or Cane
0.06 Mha
Native Vegetation
0.66 Mha
Corn, Cotton or Cane
0.66 Mha
Fallow or others


4.73 Mha
MATOPIBA
5.99 Mha
Soy
Soy
0.32 Mha
Pasture
0.71 Mha
Fallow or others
0.54 Mha
Corn, Cotton or Cane
0.26 Mha
Native Vegetation
0.38 Mha
Corn, Cotton or Cane
0.20 Mha
Fallow or others

Index

1. Introduction

Of the Brazilian biomes, the Cerrado is the most relevant as regards soy production as it has been responsible for about 50% of the domestic soy area[1] for over two decades. In crop year 2023/24, 23.84 million hectares were planted with soy, an increase of 19.4% (3.87 million hectares) compared to crop year 2020/21. The soy area occupies 12% of the Biome's 198.45 million hectares, with native vegetation preserved on about 50% of its territory.

Objective information extracted from satellite images enables the mapping of the soy crop's spatial distribution and provides data on land use changes associated with soy expansion, with and without conversion of native vegetation. Knowledge of land stocks suitable for soy production provides the key elements needed to reach a balance between environmental preservation and increased soy production. In this sense, the images reveal what has happened in the territory as a result of the expansion of soy, as well as providing territorial intelligence for the proper planning of the sustainable development of agribusiness in the Cerrado Biome.

Two regions of the Cerrado Biome (Figure 1) deserve to be highlighted for their relevance in terms of land use changes associated with the dynamics of soy expansion: (1) the MATOPIBA region[2], an important agricultural frontier in process of consolidation, where soy expansion with conversion of native vegetation is still pronounced due to the ample stocks of land with agricultural aptitude still covered with native vegetation; and (2) the Other States region, more consolidated, where there are large stocks of cleared land with agricultural aptitude, allowing soy expansion through land use intensification. In crop year 2023/24, 5.98 million hectares (25%) and 17.85 million hectares (75%) of soy were grown respectively in MATOPIBA and Other States.

1. IBGE: https://sidra.ibge.gov.br/tabela/1612 and CONAB - Companhia Nacional de Abastecimento. Acompanhamento da safra brasileira de grãos, Brasília, DF, v.11 – Safra 2023/24, n.12 - Décimo segundo levantamento, pg. 1-116, September 2024. ISSN 2318 6852.
2. The MATOPIBA region consists of the states of Maranhão-MA, Tocantins-TO, Piauí-PI and Bahia-BA, primarily their areas that lie within the Cerrado Biome and their transitions with the Amazon Biome, where there has been an intense transformation in their landscape caused by the expansion of annual high-tech agriculture. The small area of MATOPIBA located in the Amazon Biome is not part of this study.

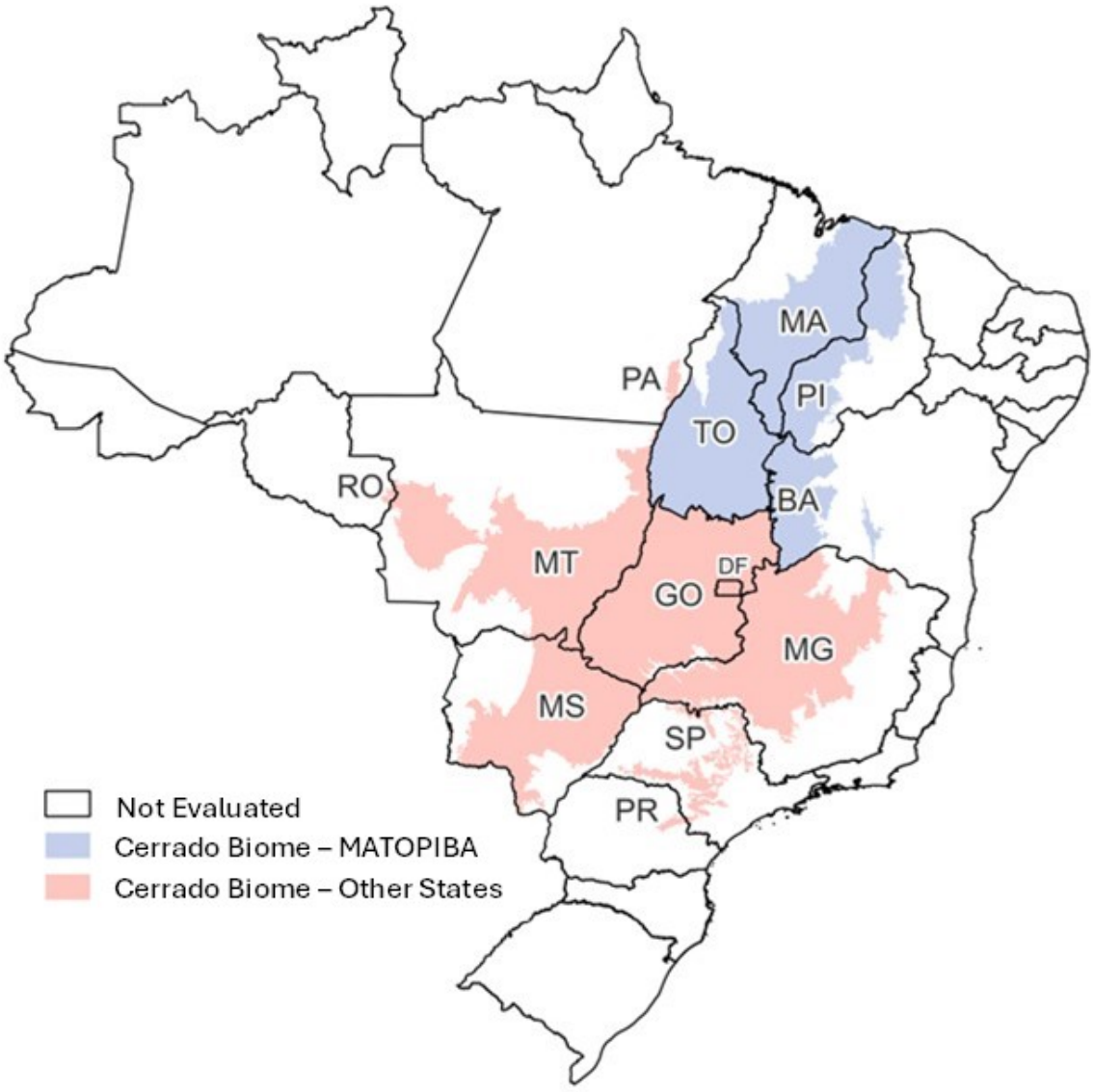


Figure 1. Highlighting the Other States and MATOPIBA regions in the Cerrado Biome.

1.1 Evolution of the soy area

Based on a detailed analysis of the satellite images[3], it was possible to assess both the gradual increase in the Cerrado's soy area, and to detail the transitions that occurred in terms of land use and land cover changes, in the period from 2020/21 to 2023/24.

3. This study used images acquired from the Landsat and Sentinel-2 satellites in the visible, near-infrared and mid-infrared wavelengths of the electromagnetic spectrum, with a spatial resolution between 10 and 30 metres (~100 to 10 pixels per hectare). The joint operation of these satellites allows the same location to be revisited at intervals of 2 to 5 days, enabling the acquisition of cloud-free images during the favourable period to identify soy plantations. About 3,000 images were available to accurately identify soy crops in the Cerrado Biome in crop year 2023/24 using visual image interpretation procedures. The starting point was the soy map of crop year 2022/23. The following RGB colour compositions of the images were used: 4-5-3 bands for the OLI/Landsat sensor and 8a-11-4 bands for the Sentinel-2 MSI sensor. The visual interpretation procedure also took into consideration an analysis of the temporal series of images obtained by the MODIS sensor, transformed into the Enhanced Vegetation Index (EVI) in the form of temporal 16-day compositions by consulting EMBRAPA's on-line SatVeg project (www.satveg.cnptia.embrapa.br).

In this study, carried out with ABIOVE's support, the analyses were based on the soy mapping of crop year 2023/24 and on the mapping in similar studies made in prior years. Based on the spatial distribution of the soy fields, it was possible to obtain the planted area, from the level of rural properties, passing through municipalities and states, to the Cerrado Biome as a whole[4]. The objective of the analysis of the historical sequence of mappings is to increase the understanding of the recent dynamics of soy expansion in the Cerrado Biome, highlighting the MATOPIBA and Other States regions.

Figures 2 to 5 illustrate the four soy maps available for the Cerrado Biome that were used in this study. Each figure highlights four sections where soy is being consolidated and gaining relevance. Section I, the Paranatinga municipality in Mato Grosso state, shows that the soy area in that part of the Cerrado Biome has increased significantly. The areas surrounding Balsas, in Maranhão state, and Baixa Grande do Ribeiro, in Piauí state (both in Section II), the areas surrounding Barreiras, in Bahia state (Section III), and the areas surrounding Porto Nacional, in Tocantins state (Section IV), also stand out for their expansion of soy. All these areas are in MATOPIBA.

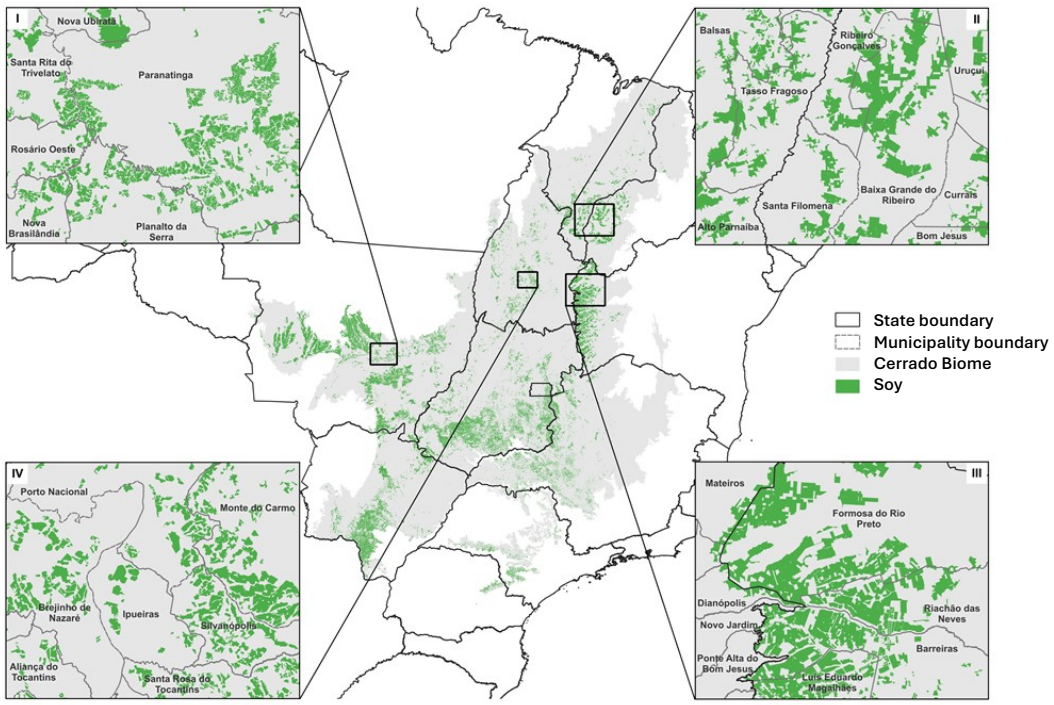


Figure 2. The Cerrado soy map for crop year 2020/21, highlighting the sections showing significant soy expansion.

4. The Cerrado Biome boundary used in this study is the one determined by IBGE in 2019 on a scale of 1:250,000, available on: https://www.ibge.gov.br/geociencias/cartas-e-mapas/informacoes-ambientais/15842-biomas.html?edicao=25799&t=acesso-ao-produto.

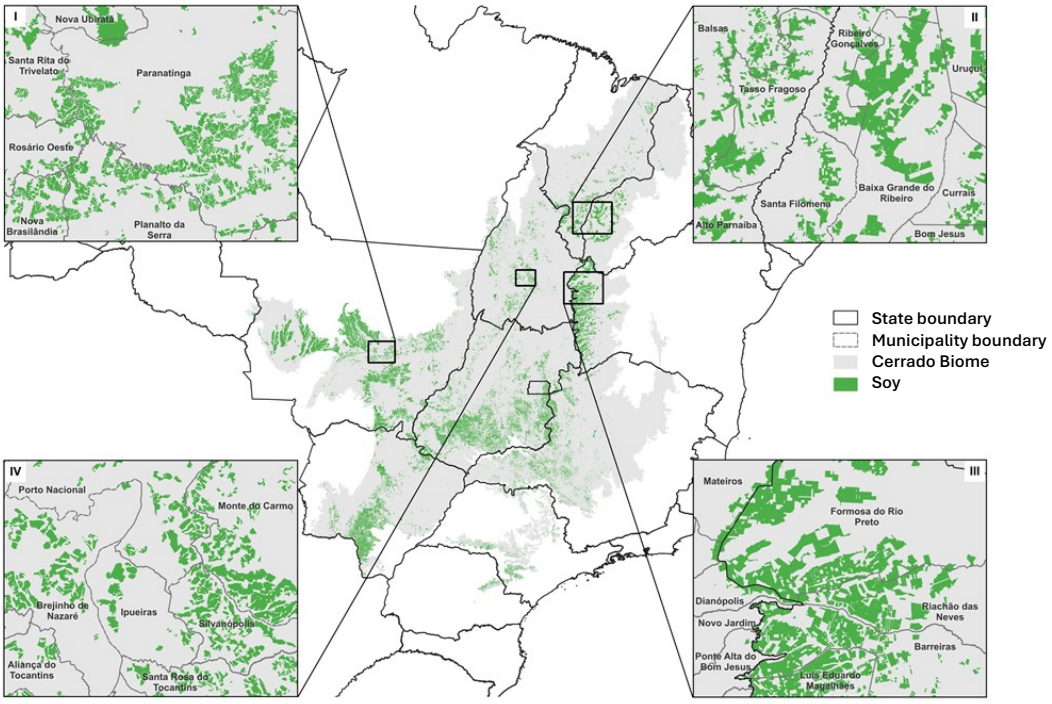


Figure 3. The Cerrado soy map for the 2021/22 crop year, highlighting the sections showing significant soy expansion.

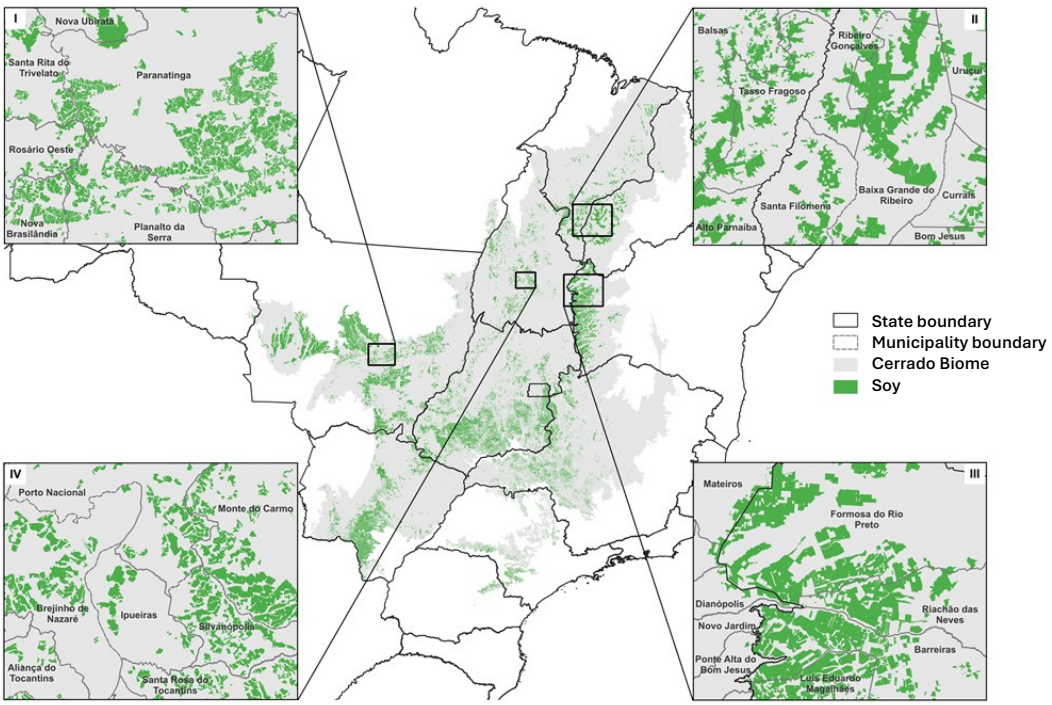


Figure 4. The Cerrado soy map for the 2022/23 crop year, highlighting the sections showing significant soy expansion.

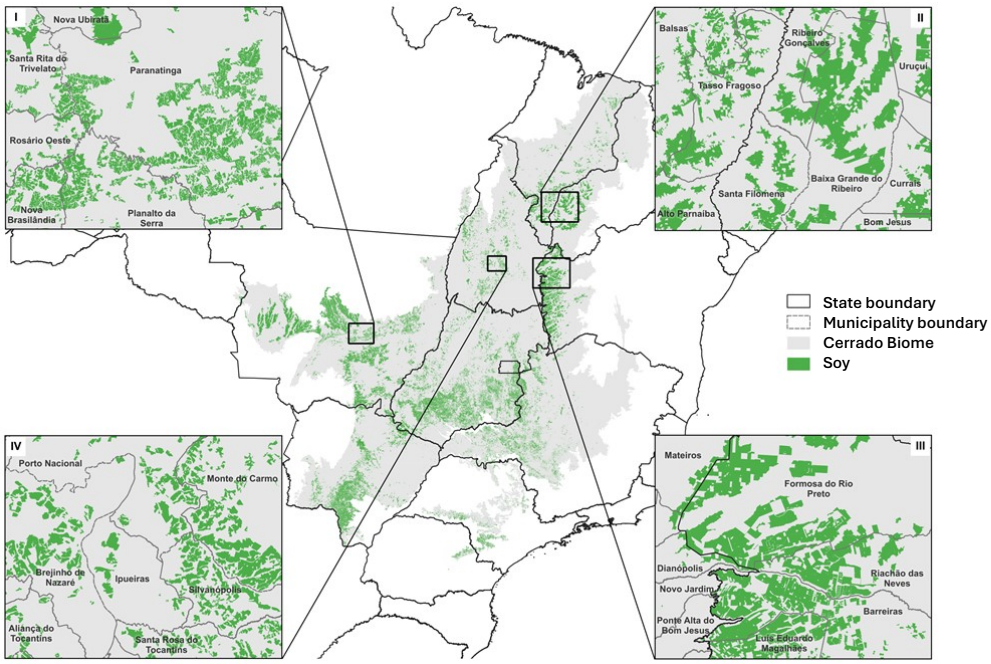


Figure 5. The Cerrado soy map for crop year 2023/24, highlighting the sections showing significant soy expansion.

Table 1 presents the results of the soy mapping in the Cerrado Biome, by state and for the Other States and MATOPIBA regions, obtained from satellite images in the same four crop years shown in Figures 2 to 5.

Table 1. Evolution of the soy area in the Cerrado Biome, in hectares, by state and for the Other States and MATOPIBA regions.

States	2020/21	2021/22	2022/23	2023/24
	ha	ha	ha	ha
Distrito Federal	84,867	101,636	102,860	106,049
Goiás	4,445,196	4,958,919	5,390,252	5,561,664
Minas Gerais	1,867,793	2,014,220	2,318,198	2,396,421
Mato Grosso Sul	2,582,202	2,678,239	2,929,638	3,038,479
Mato Grosso	5,599,613	5,898,078	6,045,772	6,005,432
Paraná	91,147	87,777	90,567	93,623
São Paulo	502,472	539,119	579,924	555,009
Rondônia	23,301	23,435	24,632	24,854
Pará	33,493	46,574	62,947	70,584
Other States	**15,230,085**	**16,347,996**	**17,544,790**	**17,852,115**
Maranhão	904,794	1,006,071	1,130,406	1,259,971
Tocantins	1,171,838	1,284,372	1,424,778	1,483,286
Piauí	819,459	867,573	970,406	1,124,311
Bahia	1,837,307	1,927,707	2,084,096	2,117,725
MATOPIBA	**4,733,398**	**5,085,723**	**5,609,685**	**5,985,293**
TOTAL	**19,963,483**	**21,433,719**	**23,154,475**	**23,837,408**

Over the last four years, the soy area in the Cerrado Biome went from 19.96 million hectares in 2020/21 to 23.84 million hectares in 2023/24, an increase of 19.4% (3.87 million hectares). In the same period, soy in the MATOPIBA region grew 26.4% (1.25 million hectares), going from 4.74 million hectares to 5.98 million hectares, representing 25% of the Cerrado's soy area. Still considering the same period, the Other States region grew 17.2% (2.62 million hectares), going from 15.23 million hectares to 17.85 million hectares, representing 75% of the Biome's soy area (Table 1 and Figure 6).

Driven by the favourable price of soy, there was significant expansion in the soy area, with 1.470 million hectares in crop year 2021/22 and a record 1.721 million hectares in crop year 2022/23. In crop year 2023/24, however, expansion fell to 683,000 hectares – very close to the average annual rate over the last 23 crop years (713,000 hectares). This reduction in the expansion rate was, in part, due to unfavourable weather conditions and the lower price for the commodity in the previous year.

Figure 6 graphically shows the soy area, by crop year, in Other States and MATOPIBA (Table 1), including the annual expansion rate.

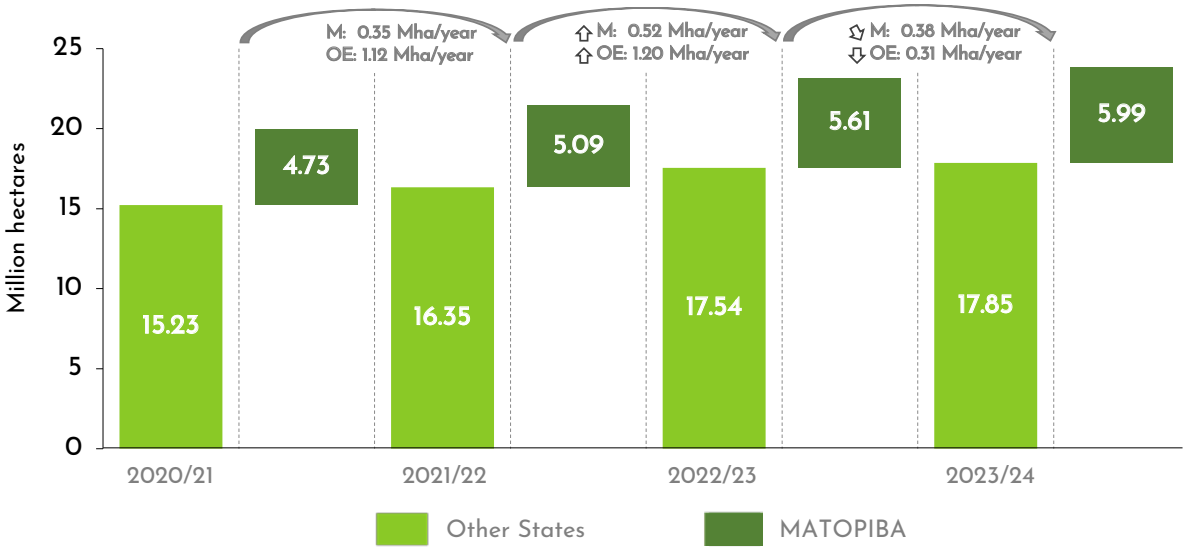


Figure 6. Evolution of the soy area between crop years 2020/21 and 2023/24 in Other States and MATOPIBA, and the annual increases in the soy area.

Table 2 shows the percentage change in the soy area, comparing crop year 2023/24 with the prior crop year. The most significant increases in soy area were seen in the states of Goiás (171,400 hectares), Piauí (153,900 hectares), Maranhão (129,600 hectares) and Mato Grosso do Sul (108,800 hectares), representing 83% of the expansion in 2023/24.

Table 2. Changes in the Cerrado Biome's soy area, in hectares and as a percentage, by state and for the Other States and MATOPIBA regions, comparing the crop years 2022/23 and 2023/24.

States	2022/23	2023/24	Var. %
	(a)	(b)	(b*100/a)-100
Distrito Federal	102,860	106,049	3.1
Goiás	5,390,252	5,561,664	3.2
Minas Gerais	2,318,198	2,396,421	3.4
Mato Grosso Sul	2,929,638	3,038,479	3.7
Mato Grosso	6,045,772	6,005,432	-0.7
Paraná	90,567	93,623	3.4
São Paulo	579,924	555,009	-4.3
Rondônia	24,632	24,854	0.9
Pará	62,947	70,584	12.1
Other States	**17,544,790**	**17,852,115**	**1.8**
Maranhão	1,130,406	1,259,971	11.5
Tocantins	1,424,778	1,483,286	4.1
Piauí	970,406	1,124,311	15.9
Bahia	2,084,096	2,117,725	1.6
MATOPIBA	**5,609,685**	**5,985,293**	**6.7**
TOTAL	**23,154,475**	**23,837,408**	**2.9**

In the process of analysing the remote sensing satellite images, the team of analysts had access to an enormous collection of images, supporting a careful analysis for the correct identification and precise mapping of the soy fields in crop year 2023/24. The soy area estimate drawn from this mapping shows higher values than those published by CONAB. For example, for the states of Goiás and Bahia, which have nearly all its soy area within the Cerrado Biome's, an area over 770,000 hectares and 123,000 hectares, respectively, was estimated. However, based on the vast experience of image analysis, on the availability of favourable images for soy mapping and on the field-visit held during the 2024 Soy Rally expedition, we are confident that the result of the estimated soy area in the Cerrado Biome, as shown in this report, is a reliable representation of the territorial extension occupied by the soy fields.

1.2 Analysis of the soy area in CAR and INCRA rural properties

By using the Rural Environmental Registry (CAR) database obtained from the National System for Rural Environmental Registry (SICAR)[5], this study gives an overall view of the land ownership situation of the rural properties in the Cerrado Biome as regards their size and soy area. Not included in this analysis were properties with less than ten hectares of soy and the properties without a CAR, which respectively represent 0.5% (0.12 million hectares) and 2.8% (0.65 million hectares) of the soy area. There are many overlapping properties in the CAR, especially properties with over 100 hectares, so that the number of CAR properties with soy is overestimated by about 20,000 properties. Because of this overlapping of properties in the CAR database, an additional analysis was made using the database of properties registered with INCRA. In this database, the overlaps are much smaller, although the properties previously certified in the former National Property Certification System (SNCI) have also had their areas registered in the current Rural Land Management System (SIGEF), resulting in the duplication of some property boundaries. Procedures related to land regularisation, such as dismemberment, aggregation, administrative rectification, among others, also contribute to the overlapping of properties.

1.2.1 Analysis based on CAR rural properties

An analysis of the CAR database revealed that 96.2% (22.93 million hectares) of the soy area in crop year 2023/24 was grown on 117,474 properties with an average soy area of 217 hectares per property.

Figure 7 shows a breakdown of the number of CAR properties by size of property with soy, in addition to the percentage of the soy area in the Cerrado Biome in each category. As can be seen, the three categories of smaller properties (10 hectares to 250 hectares) cover 75,000 properties (64%), where 17% of the Biome's soy is grown. At the other end of the spectrum, the big properties with over 2,500 hectares, corresponding to 3.1% of the properties with soy (3,700 properties), concentrate the same percentage of soy area (17%). Figure 7 also shows that 10.5% of soy properties have an area of over 1,000 hectares and are responsible for 52% of the Biome's soy.

5. https://www.car.gov.br/publico/imoveis/index.

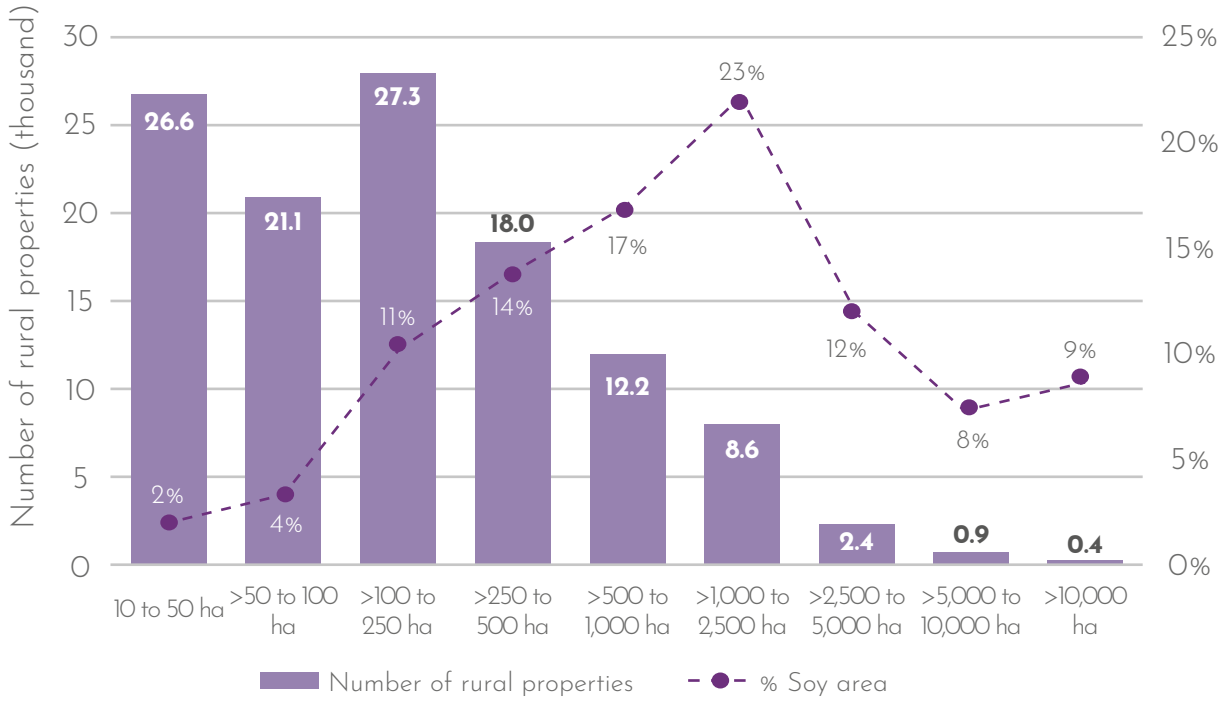


Figure 7. Number of CAR properties classified by size of property with soy and the percentage of the soy area in the Cerrado Biome, by category of property size.

1.2.2 Analysis based on INCRA properties

An analysis of the database of rural properties registered with INCRA (SIGEF and SNCI) revealed that 83.7% (19.96 million hectares) of soy in crop year 2023/24 was grown on 91,616 properties with an average of 226 hectares of soy per property[6]. This second analysis supports the observation that the number of CAR properties with soy is overestimated because of the overlaps, something not as common among the rural properties registered with INCRA, indicating that the true number of properties growing soy should be closer to 100,000.

Similarly to Figure 7 for CAR properties, Figure 8 shows a breakdown of the number of SIGEF properties by size of property with soy, in addition to the percentage of the soy area in the Cerrado Biome in each category. As can be seen, the three categories of smaller properties (10 hectares to 250 hectares) cover 54,000 properties (59%), where 18% of the Biome's soy is grown. At the other end of the spectrum, the big properties with over 2,500 hectares, corresponding to 2.7% of the properties with soy (2,500 properties), concentrate 23% of the soy area. Figure 8 also shows that 10.5% of soy properties have an area of over 1,000 hectares and are responsible for 46% of the Biome's soy.

6. INCRA properties with less than 10 hectares of soy represent only 0.32% (0.07 million hectares) of the total soy area.

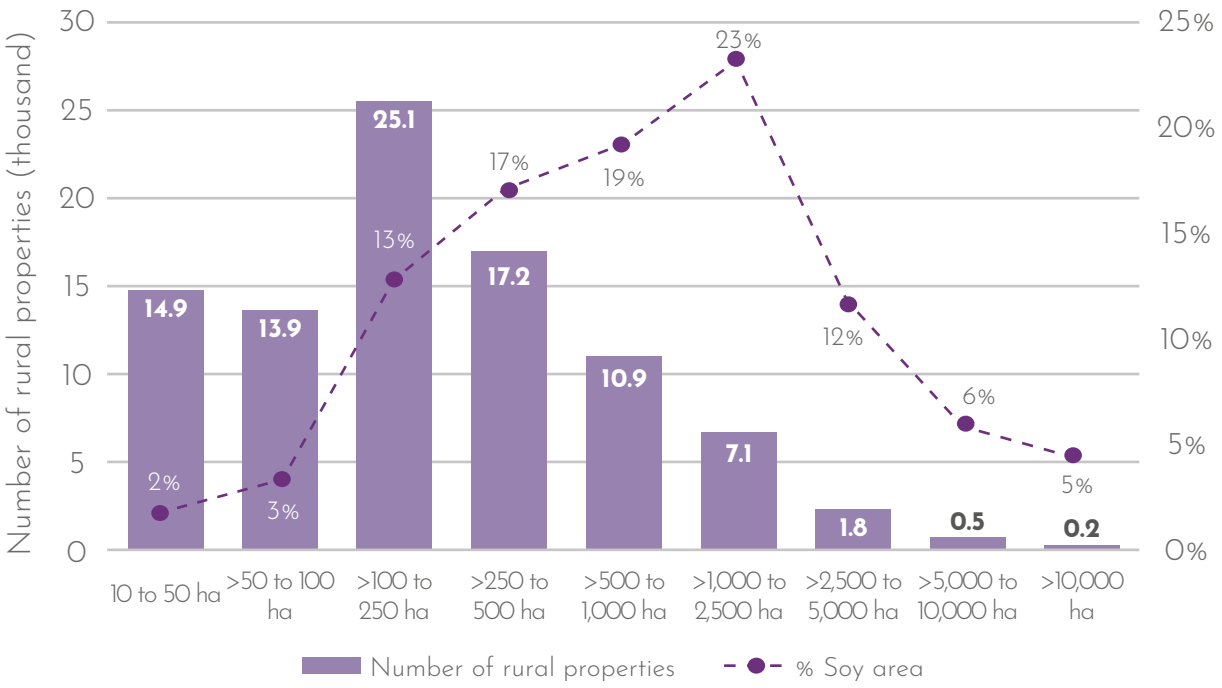


Figure 8. Number of INCRA properties classified by size of property with soy and the percentage of the soy area in the Cerrado Biome, by category of property size.

1.3 Analysis of soy area in Special Areas

Table 3 shows the results of the analysis of soy areas in crop year 2023/24, within and outside of the Special Areas: TI – Indigenous Lands; QUIL – Quilombola Territories; UC_PI – Full Protection Conservation Units; UC_US – Sustainable Use Conservation Units, except APA; Sobrep. TI-QUIL-UC_PI-UC_US – Overlaps involving these Special Areas; APP_RL-CAR – Areas of Permanent Protection and Legal Reserves, declared in the Rural Environmental Registry (CAR); UC_APA – Sustainable Use Conservation Units of the Environmental Protection Areas (APA) type; ASS – Settlements; Sobrep. ASS-UC_APA – Overlaps just of these Special Areas.

As can be seen, 92.1% of the Cerrado Biome's soy area is outside these Special Areas. Subtracting the Environmental Protection Areas (APA) and the settlements (ASS), where agricultural activity is permitted, the area outside Special Areas reaches 97.5%.

Soy grown in APA is the most significant, with 608,700 hectares in MATOPIBA and 402,500 hectares in Other States, corresponding to 4.2% of the Biome's soy. In second place is the soy grown in the Legal Reserves (RL) and Areas of Permanent Protection

(APP) declared in CAR[7], with 493,000 hectares (2.1%) – this category is more significant in Other States where there is a greater degree of anthropisation. In general, these cases are Legal Reserves that have been declared, but most of which still must be validated by the State Environmental Secretariats in order to implement Environmental Recovery Plans (PRA) and recover or compensate these areas. Soy in settlements is almost entirely in Other States, concentrated in a few settlements. In the other Special Areas that make up the Protected Areas (Indigenous Lands, Quilombola Territories, Full Protection Conservation Units, Sustainable Use Conservation Units, except APA, and the overlaps among them), where the rules for growing soy are restrictive, the area is less than 0.4% (99,400 hectares), with 60% of this area concentrated in Indigenous Lands.

Table 3. Soy area in crop year 2023/24, outside and within the Special Areas in Other States, in MATOPIBA and in the Cerrado Biome.

Category		Other states		MATOPIBA		Cerrado Biome	
		ha	%	ha	%	ha	%
SOY OUTSIDE SPECIAL AREAS		16,758,787	93.9	5,192,800	86.8	21,951,586	92.1
SOY INSIDE SPECIAL AREAS	TI	51,938	0.3	13,350	0.2	65,288	0.3
	QUIL	3,560	0.0	2,890	0.0	6,450	0.0
	UC_PI	9,160	0.1	9,135	0.2	18,295	0.1
	UC_US	1,929	0.0	7,411	0.1	9,340	0.0
	Sobrep. TI--QUIL-UC_PI-UC_US	0	0.0	1	0.0	1	0.0
	APP_RL-CAR	355,019	2.0	138,144	2.3	493,163	2.1
	UC_APA	402,478	2.3	608,705	10.2	1,011,183	4.2
	ASS	266,757	1.5	11,463	0.2	278,221	1.2
	Sobrep. ASS-UC_APA	2,488	0.0	1,394	0.0	3,882	0.0
TOTAL		**17,852,115**	**100.0**	**5,985,293**	**100.0**	**23,837,408**	**100.0**

7. Agricultural crops such as soy are not restricted in the APA, even though these areas are part of SNUC's Sustainable Use Conservation Units. Agricultural activities, however, must follow the precautions and guidelines in the management plan for each APA.

2. Deforestation in the Cerrado

Figure 9 illustrates the deforestation rates estimated by PRODES-Cerrado from 2001 to 2023 for the Cerrado Biome, by the MATOPIBA and Other States regions, as well as highlighting the annual deforestation converted to soy in crop year 2023/24.

The annual deforestation rates, which were about 2.8 million hectares per year at the beginning of the first decade of this millennium, showed a downward trend between 2005 and 2019, averaging 1.1 million hectares per year and reaching the lowest point of 632,000 hectares in 2019. Since then, however, there has been a gradual increase, reaching 1.1 million in 2023. The increase in deforestation in the Cerrado Biome over the last four years basically occurred in the MATOPIBA region that, although it represents only 36% of the Biome's area, was responsible for 75% of the 2023 deforestation (Figure 9).

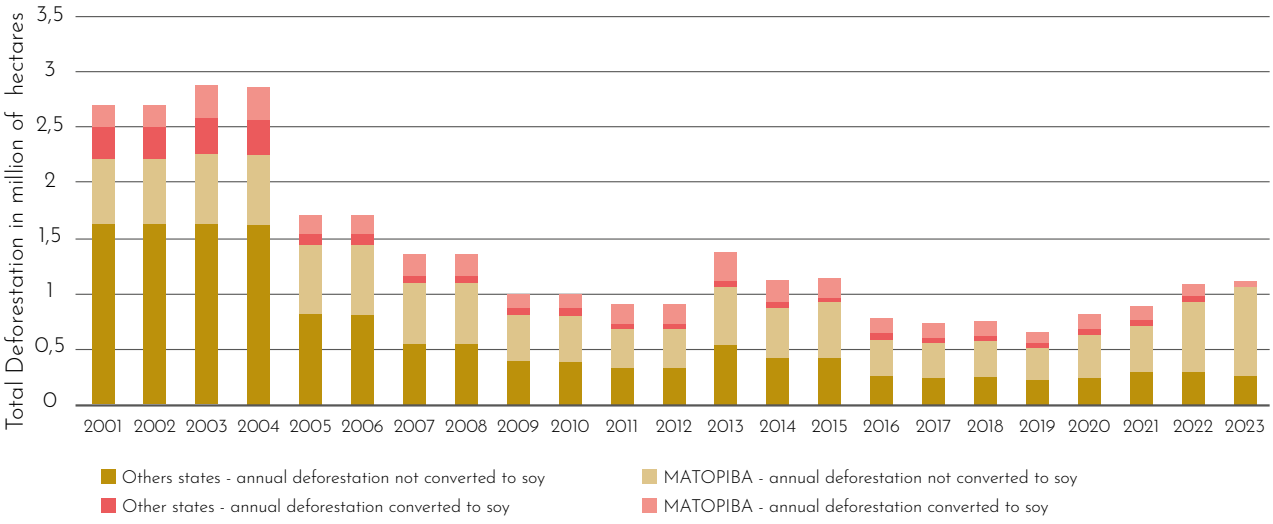


Figure 9. Annual deforestation rates in the Cerrado Biome from 2001 to 2023, highlighting the portion annually deforested and converted to soy, based on crop year 2023/24.

2.1 Deforestation converted into soy

Figure 10 illustrates the same information shown in Figure 9, highlighting the areas deforested annually between 2001 and 2023 that were used to grow soy in crop year 2022/23. Figure 9 shows that, from 2001 to 2023, the deforested area in the Cerrado Biome was 31.14 million hectares (15.7% of the Cerrado), of which 5.53 million hectares (Figure 9) had soy in crop year 2023/24, i.e., 17.8% of the area deforested in the last 23 years. In other words, 82.2% (25.61 million hectares) of the deforestation in that period was not converted to soy but destined for other uses. Furthermore, this also means that 76.8% of the 2023/24 soy area in the Cerrado Biome – equivalent to 18.31 million hectares of soy – is free of deforestation occurring after 2000.

Considering only the deforestation occurring after 22nd July 2008 (2009 to 2023), the date that defines the consolidated areas under Brazil's 2012 Forest Code, the conversion of native vegetation to soy in crop year 2023/24 occurred on 2.46 million hectares (10.3% of the Biome's soy), corresponding to 17.6% of the total deforestation in this period, of which 1.97 million hectares in MATOPIBA (32.9% of this region's soy) and 0.49 million hectares in Other States (2.7% of this region's soy).

Furthermore, considering the deforestation from 2021 to 2023, which corresponds to the EUDR period of interest, 316,900 hectares of native vegetation (1.3% of the Biome's soy), or 10.4% of the total post-2020 deforestation, was converted into soy in crop year 2023/24, of which 257,000 hectares were in MATOPIBA (4.3% of this region's soy) and 59,000 hectares were in Other States (0.3% of this region's soy).

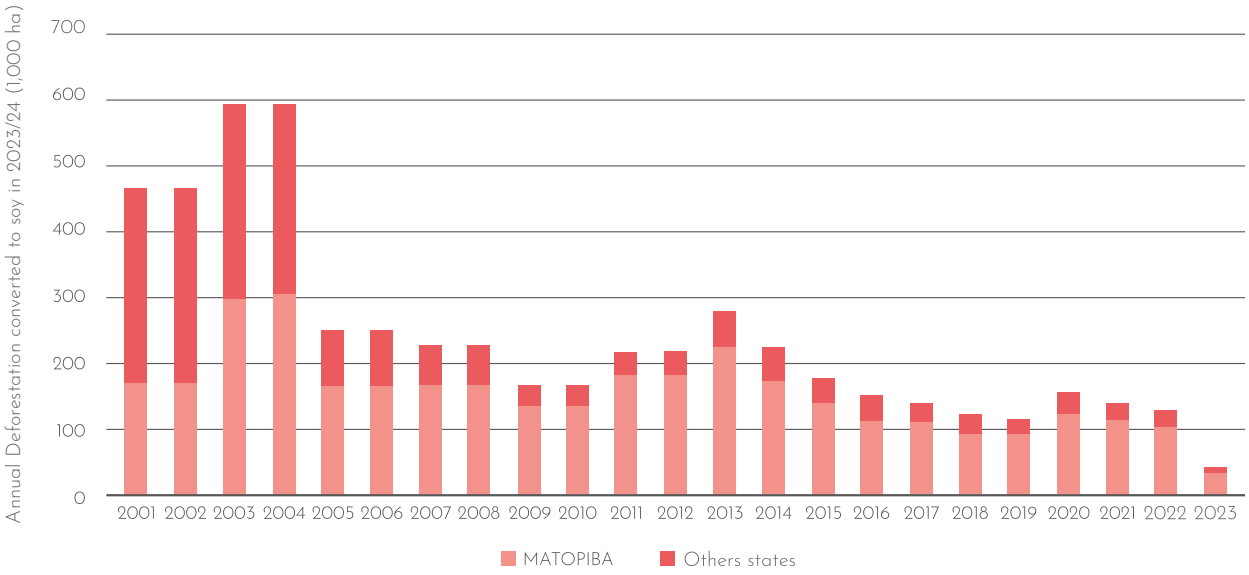


Figure 10. Soy expansion onto land deforested between 2001 and 2023 in the Cerrado Biome, highlighting the MATOPIBA and Other States regions.

The analysis of soy expansion with deforestation was made by crossing these data with the bases of the PRODES-Cerrado deforestation maps.

2.2 Deforestation converted into soy in recent years

In order to verify the occurrence of a possible acceleration in the conversion of recent deforestation into soy over the last few crop years, Figure 11 shows the area of soy grown on land deforested in the five years before each of the last three crop years, i.e., for crop year 2023/24, the soy on PRODES deforestation from 2019 to 2023; for the 2022/23 crop year, the soy on PRODES deforestation from 2018 to 2022; and for the 2021/22 crop year, the soy on PRODES deforestation from 2017 to 2021.

As can be seen, there is a clear trend in the MATOPIBA region for an annual increase of soy on land deforested up to five years before the crop years 2021/22 through 2023/24. This trend is not observed in the Other States region, where a slight downturn occurred in crop year 2023/24 compared with the prior crop year (Figure 11).

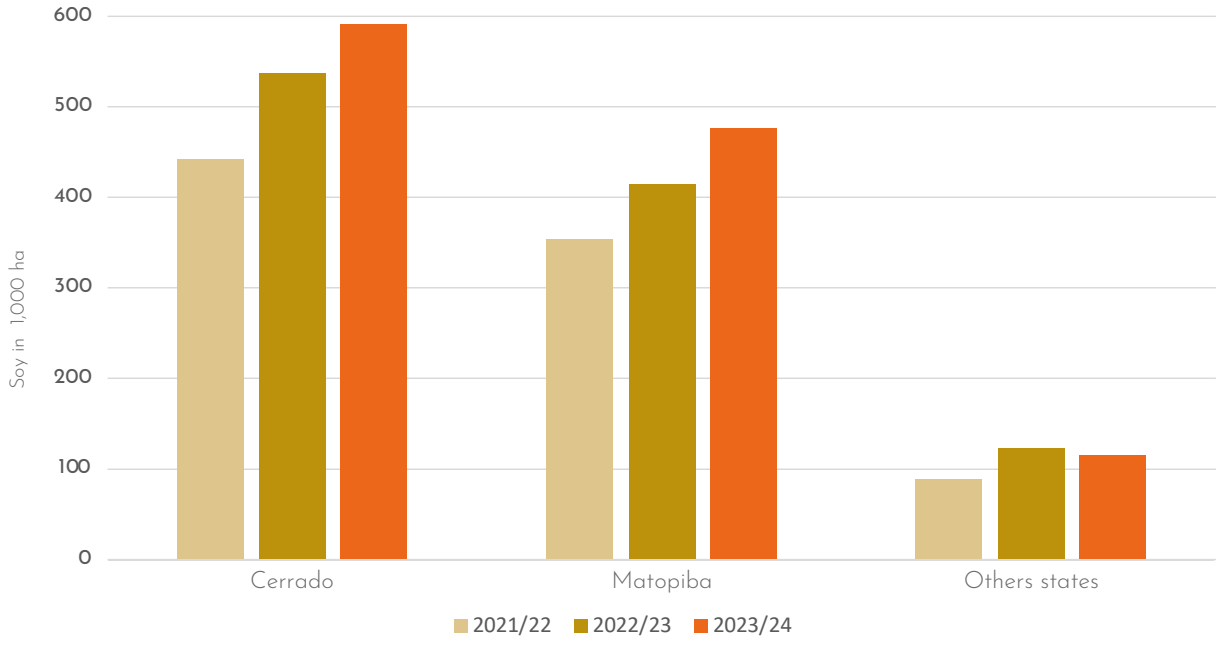


Figure 11. Area of soy grown on deforested land in the Cerrado Biome over the five years preceding each of the last three crop years, showing a growing trend of deforestation converted into soy in the most recent crop years, mainly in the MATOPIBA region.

Figure 12 illustrates the soy area in the last three crop years, by number of years since deforestation. It is clear from this analysis that, with each new crop year, the soy area on land deforested from two to four years before has increased.

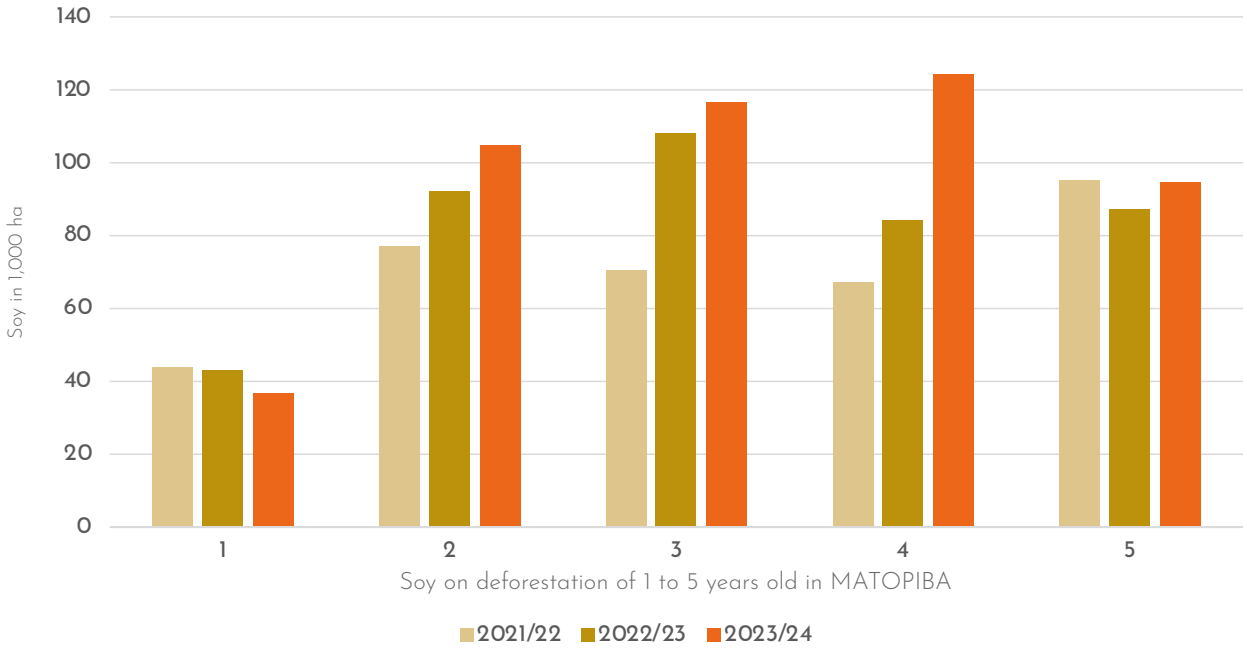


Figure 12. Area of soy grown on land deforested from one to five years before, showing a growing trend for the soy area on land deforested from two to four years previously.

2.3 Deforestation converted into soy in the context of the EUDR

The European Union, through implementation of an anti-deforestation law called EUDR, wants to zero its contribution to greenhouse gas emissions (GHG) caused by conversion of forests for agricultural and livestock uses. The law, which was expected to go into effect at the end of 2024, has been deferred to 2025, but its impact will be retroactive to 31st December 2020, the deadline for deforestation associated with the products covered by the legislation: soy, coffee, cattle, cocoa, palm oil, rubber, wood and certain of their byproducts. In summary, European importers will need to ensure that the agricultural and livestock products they acquire come from areas free of post-2020 deforestation; otherwise, they will be subject to sanctions.

The analysis of soy areas in crop year 2023/24 on land deforested after 2020 revealed that 316,900 hectares of soy were planted on land deforested after 2020, of which 141,900 hectares were in PRODES-2021, 130,100 hectares in PRODES-2022 and 44,900 hectares in PRODES-2023, as shown in Table 4 for the Cerrado Biome and the MATOPIBA and

Other States regions. An important caveat should be made about these estimates since the PRODES mappings are not made to comply with EUDR; therefore, it is recommended that the deforestation mapped from August to December 2020 be eliminated from PRODES-2021, and that in all years only the deforestation of native forest vegetation (as defined in the EUDR) be considered. This will certainly reduce the soy area that does not comply with the EUDR. In any case, based on this analysis, it can be seen that only 1.3% of the soy in crop year 2023/24 was in non-compliance. In other words, 98.7% of all soy is free of deforestation after 2020.

Table 4. Soy area (in thousands of hectares) in crop year 2023/24 on PRODES deforestation to enable an estimate of the soy in non-compliance with the EUDR.

Year of PRODES	2021	2022	2023	Total
Other States	25.5	25.4	8.3	**59.3**
MATOPIBA	116.4	104.7	36.5	**257.6**
Cerrado Biome	**141.9**	**130.1**	**44.9**	**316.9**

Figure 13 shows details of the conversion of native vegetation into soy by state, for the post-2020 period. In the Other States region, most of the deforestation was in the states of Goiás (271,000 hectares), Mato Grosso (216,000 hectares) and Minas Gerais (231,000 hectares), with conversion to soy of 20,600 hectares, 11,100 hectares and 11,700 hectares, respectively. In the MATOPIBA region, the greatest deforestation was in the state of Maranhão (804,000 hectares), followed by the states of Tocantins (607,000 hectares), Bahia (433,000 hectares) and Piauí (290,000 hectares). Maranhão state also had the most land converted to soy (113,300 hectares), followed by the states of Bahia (59,900 hectares), Tocantins (42,500 hectares) and Piauí (41,900 hectares). The MATOPIBA states account for 81.3% of the conversion of native vegetation into soy in the Cerrado Biome during the analysed period. In addition, from 2021 to 2023, the region was responsible for 71% of the Cerrado's deforestation, even though it represents only 36% of the Biome's area.

Figure 13. Area deforested from 2021 to 2023 and converted to soy between crop year 2020/21 and crop year 2023/24 for: (a) portion of the states within the Cerrado Biome; (b) the Cerrado Biome; (c) Other States; and (d) MATOPIBA.

Figure 14 illustrates the municipalities, classified in accordance with the soy area in non-compliance with the EUDR, indicating that most of the municipalities with the largest non-compliant soy areas are located in MATOPIBA. Figure 15 illustrates the information in Figure 14 in terms of percentages, also indicating that the municipalities with the highest percentages of soy on post-2020 deforestation are located in MATOPIBA.

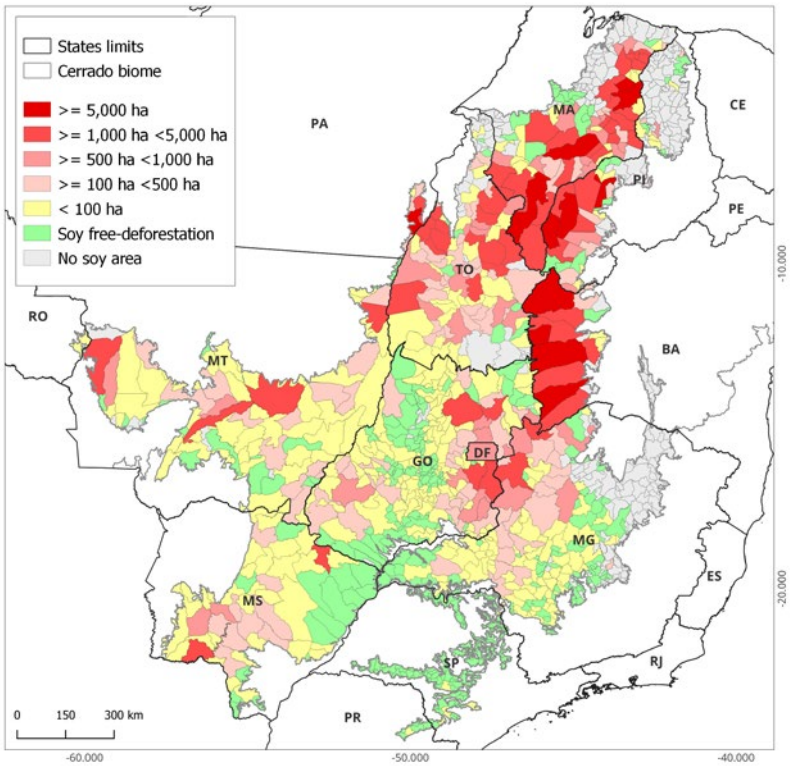


Figure 14. Soy area (in hectares) in crop year 2023/24 on post-2020 deforestation, by category of area in non-compliance with the EUDR.

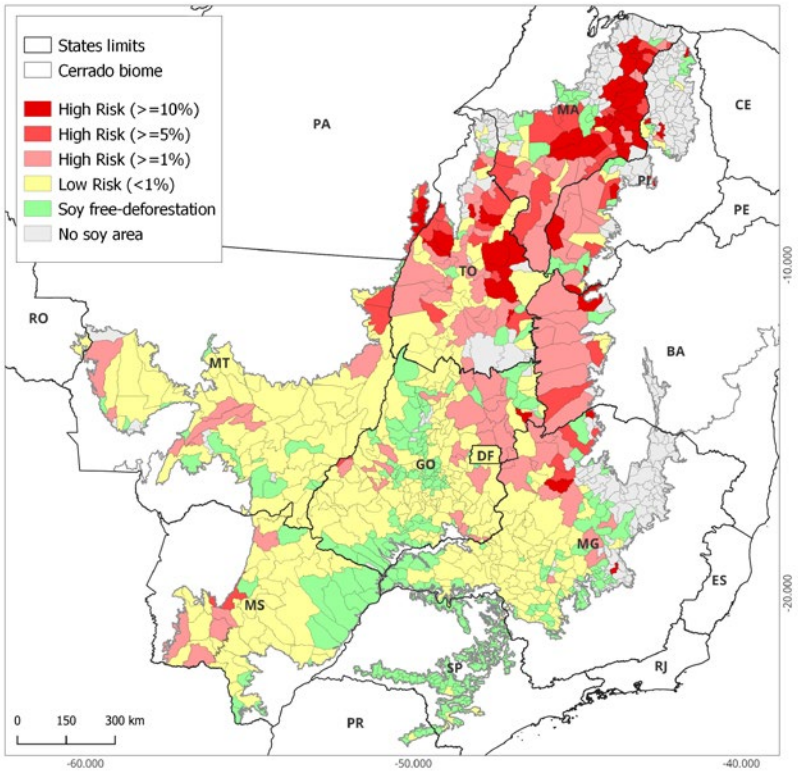


Figure 15. Soy area (%) in crop year 2023/24 on post-2020 deforestation, by category of area in non-compliance with the EUDR.

3. Land use and land cover changes

The land use and land cover changes in the analysed period was classified as follows: (1) land cover change from native vegetation to soy, herein called "expansion with deforestation"[8]; (2) land use change from other land uses to soy, herein called "expansion without deforestation"[9]; and (3) areas of retraction[10], where soy at the beginning of the analysed period (crop year 2020/21) was converted to other land uses, either temporarily (e.g., fallow land or crop rotation) or permanently.

Figures 16 and 17 show two distinct sections in terms of the dynamics of soy expansion in the Cerrado Biome, illustrating the spatial distribution of the soy area and its expansion, with and without deforestation, as well as its retraction in the period from 2020/21 to 2023/24[11]. In these Figures, soy "expansion without deforestation" onto pastures, fallow and other land uses is shown in blue without hatching, and in blue with hatching when the expansion was onto first-crop of corn or of cotton or sugarcane. Soy that underwent retraction is shown in grey without hatching when it was converted to fallow or other land uses, and with hatching when it rotated with first-crop of corn or of cotton or sugarcane.

8. Expansion with deforestation corresponds to land cover change in the Cerrado Biome, caused by deforestation of areas with native vegetation (regardless of the phytophysiognomy) at first period, that were converted to soy at the second period.
9. Expansion without deforestation corresponds to the land use change caused by soy expansion onto areas with other uses at first period, that were converted to soy at the second period. For example, pastures converted to soy consists of land use intensification, which occurs frequently in Other States where there are many pastures with agricultural aptitude for soy. Examples of other uses at the first period include: (a) areas with annual crop rotation (e.g., first-crop of corn or cotton); (b) fallow land; and (c) areas of sugarcane in the process of renewal or conversion to soy.
10. Retraction are the areas that had soy at the first period, that were converted to other uses at the second period. For example, (a) areas in rotation with other annual crops (such as first-crop of corn or cotton); (b) fallow land; (c) areas that reverted to sugarcane due to the sugarcane renewal process; and (d) areas that effectively ceased to have soy due to abandonment or land use change, as occurred in the first decade of this millennium with the large sugarcane expansion in Brazil's Centre-South region (https://www.mdpi.com/2072-4292/2/1/290).
11. To quantify the dynamics of soy expansion-retraction, satellite images were used to assess the soy area in crop year 2023/24 that had expanded without deforestation since 2020/21, separated into: (a) agricultural crops (corn and first-crop cotton and sugarcane); (b) fallow land or other uses; and (c) pastures (Áreas de Pastagens do Brasil, 2023, base LAPIG/MapBiomas). Using the satellite images, an assessment was made of the soy area in the 2020/21 crop year that shrank due to crop rotation, or which was no longer used for soy in crop year 2023/24 (fallow land or other uses).

From 2020/21 to 2023/24, the soy area expanded by 3.87 million hectares, though a much larger area (5.78 million hectares) was impacted in this period due to the soy cultivation dynamic, in which part of the cultivated land rotated with other crops (corn, first-crop cotton, sugarcane renewal) or was left as fallow. In the same way, areas previously cultivated with first-crop of corn or of cotton, or sugarcane, or left as fallow could now be occupied by soy. The soy expansion dynamics therefore consist of incorporating into the production system areas from the conversion of native vegetation, or by intensifying the land use through conversion of pastures and agricultural management practices using crop rotation or fallow land.

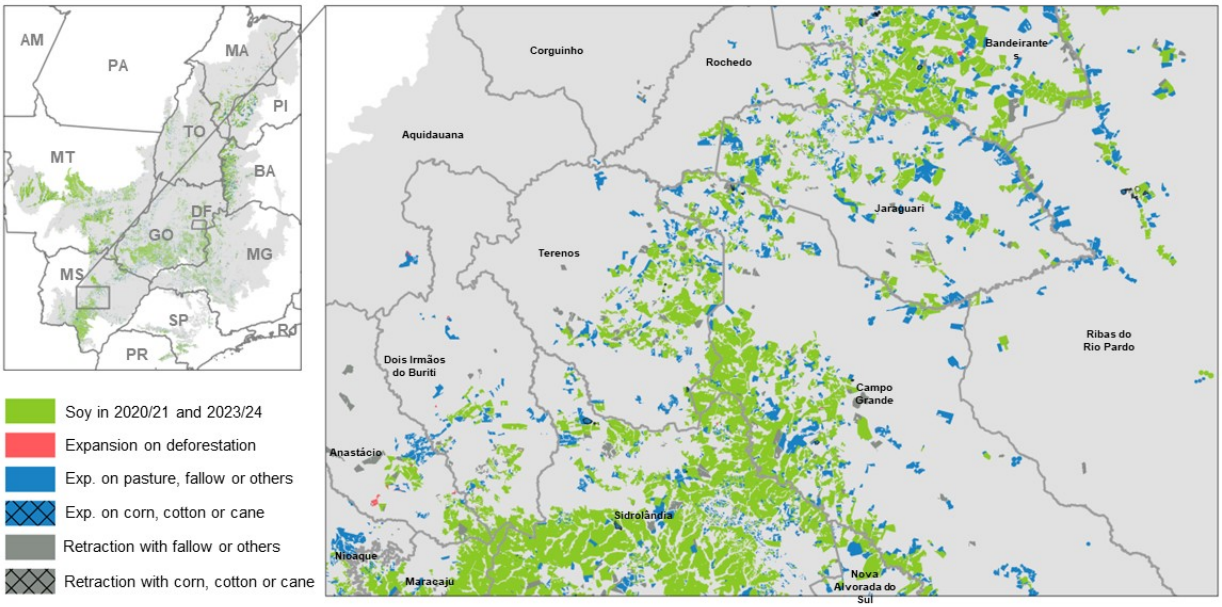


Figure 16. Territorial dynamics of soy from crop years 2020/21 to 2023/24 in the central region of Mato Grosso do Sul state, near its capital Campo Grande, which concentrates large tracts of pastures with high agricultural aptitude for soy and which in recent years has been increasingly converted to soy.

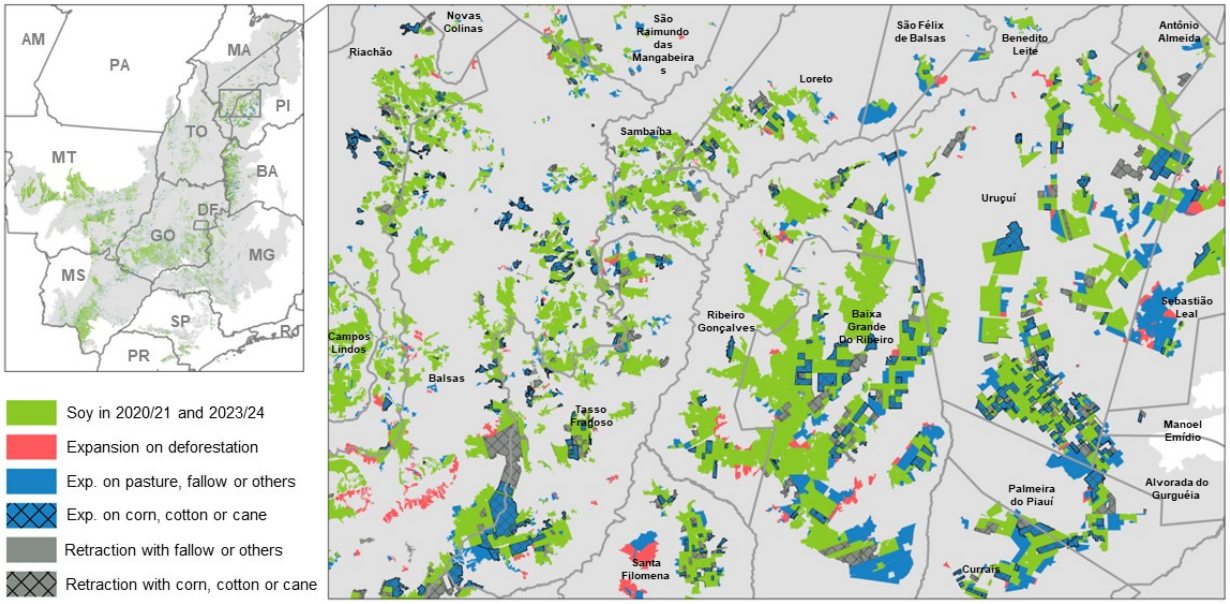


Figure 17. Territorial dynamics of soy from crop years 2020/21 to 2023/24 in the southern region of Maranhão and Piauí states. This region is located in the most recent area of the Brazilian agricultural frontier, where expansion with deforestation in the Cerrado Biome is most evident and where corn and first-crop cotton are also grown in rotation with soy.

The result of this detailed analysis is shown in Figure 18, illustrating the land use and land cover transitions associated with the dynamics of soy in Other States and in MATOPIBA. In Other States, 1.32 million hectares with soy in crop year 2020/21 underwent a retraction, becoming fallow land (0.66 million hectares) or other crops (0.66 million hectares) in crop year 2023/24. On the other hand, soy expanded onto 1.68 million hectares of pastures, 1.38 million hectares of fallow land, 0.82 million hectares of other crops and 0.06 million hectares of native vegetation. Expansion onto land planted with other crops is partly due to the rotation of soy with first-crop corn – a management practice still very common, especially in some regions of the states of Goiás and Minas Gerais – and to the renewal of sugarcane plantations that rotate with soy, or even the replacement of sugarcane plantations with soy, which has been more profitable. Another point in crop rotation is the replacement in recent years of first-crop cotton with soy in much of Mato Grosso state since the practice of second-crop cotton has been increasing in this state.

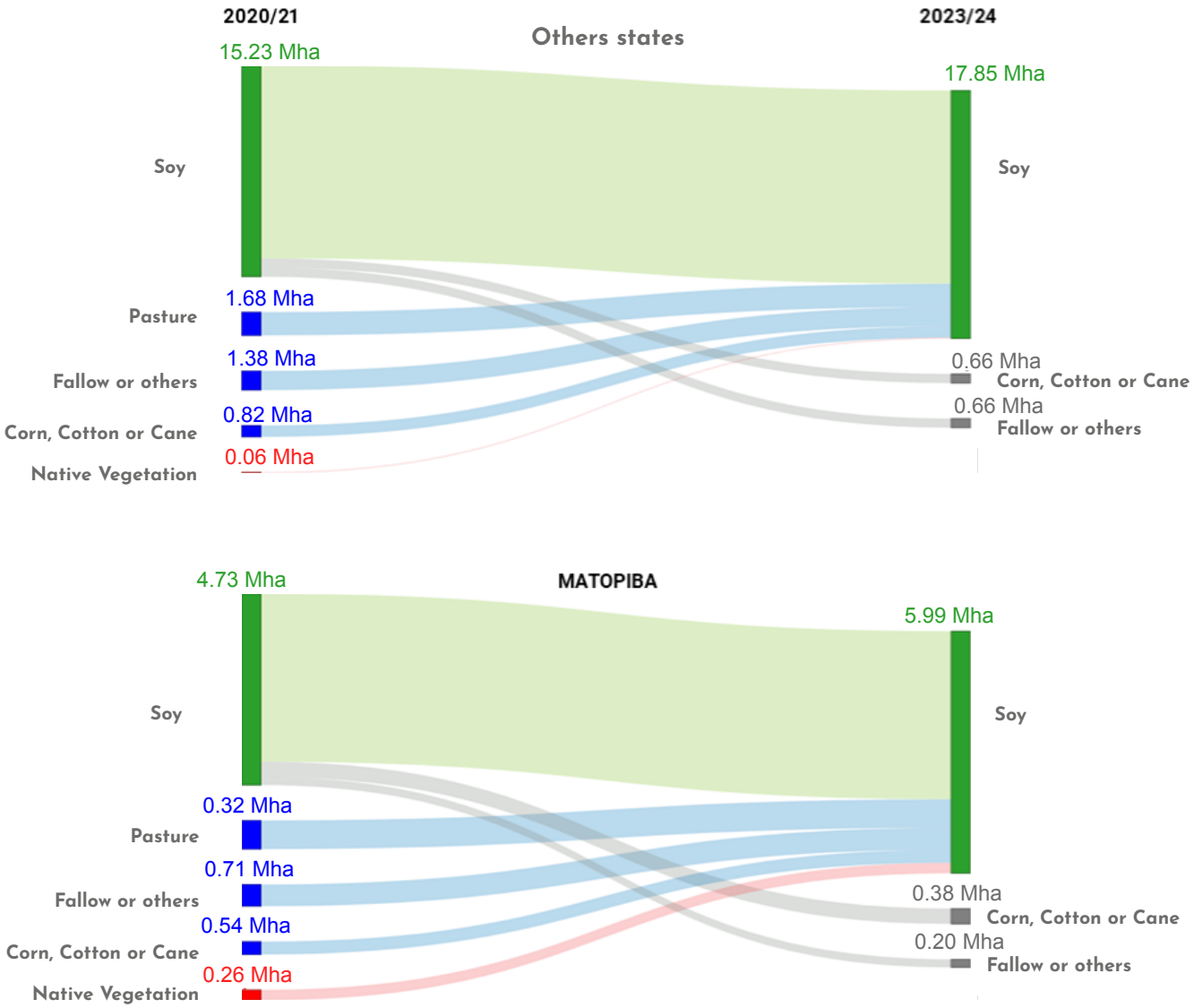


Figure 18. Sankey Diagram, illustrating the dynamics involved in the land use change with the expansion and retraction of soy areas in the period from crop year 2020/21 to crop year 2023/24 in the Other States and MATOPIBA regions.

4. Final considerations

The Cerrado Biome covers an area of 198.45 million hectares, of which 23.84 million hectares were planted with soy in crop year 2023/24, representing 12.0% of the Biome's area and 50.2% (47.44 million hectares) of Brazil's soy area. Over the last three crop years, the Biome's soy area grew 19.4%, an increase of 3.87 million hectares, at an average rate of 1.29 million hectares per year. In crop years 2020/21 and 2022/23, the increase in the Biome's soy area was 1.47 million hectares and 1.72 million hectares, respectively. These are the highest annual growth rates seen in the Cerrado Biome since satellite image monitoring began in crop year 2000/01. In crop year 2023/24, however, the increase in the soy area fell to 683,000 hectares, which is very close to the average annual growth rate for the last 23 crop years (713,000 hectares).

The increase in soy area seen over the last three crop years was mostly onto pastures, fallow land or a result of annual crop rotation. Only 1.3% (316,000 hectares) of the current soy area expanded through conversion of native vegetation. The Other States region has 75% (17.85 million hectares) of the Cerrado Biome's soy area, 99.7% of which is free from post-2020 deforestation. The MATOPIBA region, Brazil's new agricultural frontier, has 25% (5.99 million hectares) of the Biome's soy area, with 95.7% free from post-2020 deforestation.

The land use and land cover changes associated with soy farming differ significantly between the MATOPIBA and Other States regions, especially regarding conversion of native vegetation, as the stocks of land suitable for soy farming cleared before 2020 are limited in the MATOPIBA region, especially in the states of Maranhão, Piauí and Bahia.

Geospatial analysis using remote sensing satellite images allows a wide-ranging assessment of the dynamics of soy expansion in the Cerrado Biome, particularly as regards conversion of new areas, determining the significant recent increase in the growth rates of the soy area, and characterising the transitions in land use that are part of the process of agricultural expansion associated with soy crops.

ISBN: 978-65-982986-1-6

GRANTEE

ABIOVE

EXECUTION

serasa experian