FINAL DEMAND EFFECTS ON DEFORESTATION IN BRAZILIAN BIOMES: AN INPUT–OUTPUT ANALYSIS

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ABSTRACT: This study investigates the effects of final demand—both domestic and foreign—on deforestation across Brazil's major biomes using an interregional input-output approach. Through the decomposition of the input-output matrix, we quantify the deforested area attributable to demand from each of Brazil's 27 federative units as well as from international markets. The results show that livestock farming is the main economic activity associated with deforestation across all biomes, and that the Southeast region, due to its strong productive interconnections, plays a major role in driving environmental degradation. International demand also contributes significantly, particularly in the Amazon and Cerrado biomes. The findings suggest that deforestation mitigation policies should address both domestic productive dynamics and external market pressures, with particular attention to supply chains such as extensive livestock farming.

Keywords: deforestation, input-output matrix, decomposition, Brazilian biomes

JEL Classification: Q56; C67; Q15

INTRODUCTION

Since colonization, Brazil has been the site of extensive deforestation and natural resource exploitation. These practices, initially focused on the extraction of brazilwood and later on agricultural and livestock expansion, have led to the degradation of vast areas of tropical forests. This degradation has not only reduced biodiversity but has also released large amounts of greenhouse gases (GHGs) into the atmosphere, contributing to global warming. Over the centuries, public policies and economic development models have encouraged agricultural expansion and the occupation of new lands, often without considering environmental impacts. This expansion has led to deforestation in biomes such as the Amazon and the Cerrado, increasing GHG emissions into the atmosphere (Huguenin and Meirelles, 2022).

The intensification of climate change, and the damage it causes to society through extreme events such as floods, droughts, and high or low temperatures, is directly related to the continuous process of GHG emissions caused by human activity. Climate change generates impacts that encompass both the social and economic spheres, bringing consequences to economic sectors either directly or indirectly (Artaxo, 2014; Félix et al., 2020).

Climate changes may reduce the productivity of essential crops, negatively affecting agricultural GDP and rural income. In the energy sector, changes in precipitation and temperature patterns may influence hydropower generation, affecting energy supply and, consequently, economic stability (Domingues et al., 2010; Lima, Cavalcante and Perez-Marin, 2011). Félix et al. (2020) highlight that changes in climate influence the adaptation of several crops, resulting in negative impacts, such as an estimated 40% loss in coffee production, and positive impacts, such as in the case of sugarcane.

Land plays a dual role in the GHG cycle, functioning both as a source and as a sink of these gases. Human activities, such as the burning of fossil fuels and inadequate agricultural practices, release GHGs into the atmosphere, contributing to the greenhouse effect and global warming. On the other hand, natural ecosystems, such as forests, soils, and oceans, act as carbon sinks, absorbing and storing CO_2 from the atmosphere, helping to mitigate climate change (IPCC, 2019).

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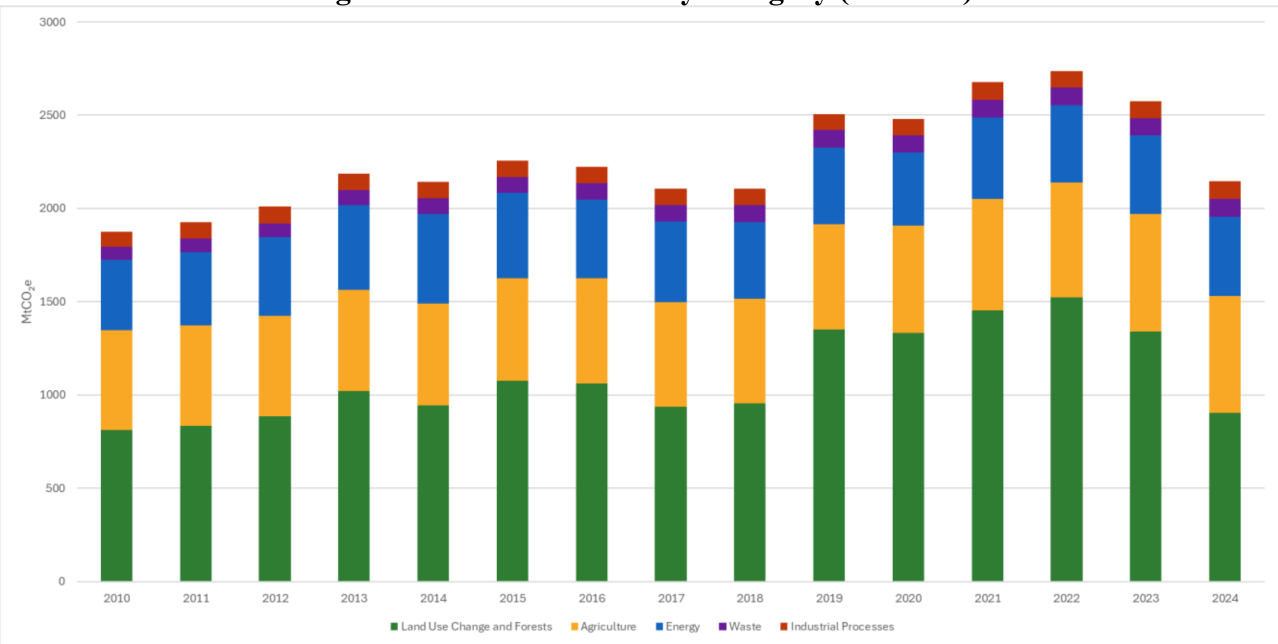
One of the activities that has the potential to release massive amounts of gases such as carbon dioxide, methane, and nitrous oxide, the principal GHGs, is deforestation. Burning and fires in forests and other areas with a high concentration of vegetation release these gases into the atmosphere, contributing substantially to global warming and, consequently, to extreme climate change (Fearnside et al., 2013).

In recent years, deforestation in Brazil has reached alarming levels, intensifying threats to the Cerrado and resulting in the destruction of more than fourteen thousand km² of native forest (Cerrado and Amazon) in 2024 alone (INPE, 2025). Between August 2021 and July 2022, the Amazon lost 10,781 km² of forest cover, mainly due to agricultural and livestock expansion, which has driven the expansion of the extractive agricultural frontier in the country (Sauer, 2024). **Figure 1** presents data from the System for Estimating Greenhouse Gas Emissions and Removals (SEEG), which monitors the trajectory of Brazilian emissions. It shows the evolution of CO_2 emissions by economic activity, making it evident that the activities that contribute most to the increase in atmospheric pollution are Land Use Change and Forests and Agriculture.

Figure 1 – CO_2 Emissions by Category ($MtCO_2e$)



Source: own elaboration based on SEEG data (2026).

One of the largest contributors to deforestation and Brazilian emissions is the livestock sector, specifically beef cattle. According to SEEG data from 2023, since the 1990s the beef cattle herd has increased by about 63%, while GHG emissions related to livestock have increased by 51.8%, and in 2021 the beef cattle herd alone accounted for 96.5% of emissions from meat production. Land use change is also at the top of the list of the largest GHG emitters in Brazil, as these are emissions that occur due to the conversion of forests and other forms of vegetation into pasture and/or agricultural production. Thus, more than half of Brazilian emissions involving agriculture and livestock are due to deforestation (Alencar et al., 2023).

Another element that intensifies environmental degradation involves external relations between countries, especially in the case of a nation with a strongly agro-export-oriented economy such as Brazil. External demand acts as a determining driver for the transformation of domestic production of agricultural and livestock products. Due to the increase in international commodity prices, producers tend to direct investments and efforts toward meeting the demands of global markets, which drives the intensification and modernization of production. This dynamic results in a reallocation of productive resources toward activities with export potential, promoting the adoption of technologies and the expansion of productive capacity in the most competitive areas. However, this dependence on the external market may lead to imbalances, contributing to the concentration of investments in certain regions and deepening disparities in the national productive structure (Sessa et al., 2021).

It is important to consider regional specificities when analyzing vulnerability, recognizing that socioeconomic and political-institutional factors vary significantly across Brazilian regions. This approach makes it possible to identify the most susceptible areas to the impacts of climate change and assists in the formulation of targeted and effective public policies (Eiró, 2010). In the same sense, the effects generated by the COVID-19 pandemic should also be considered, as it weakened trade and food distribution, bringing severe consequences for low-income households and small agricultural producers (Breitenbach, 2021; Sauer, 2024).

Several studies have sought to assess the relationship between external and domestic demand and their impacts on environmental pressure, particularly deforestation. Haddad et al. (2024) used an approach based on the decomposition of land-use demand, distinguishing between domestic markets in Brazil's Center-South, local demand in the Amazon, and external demand, in order to quantify the contribution of each to deforestation in the Legal Amazon. The results reveal that about 83% of forest loss was driven by demand originating outside the Amazon region—approximately 60% from the national Center-South market and 23% from international exports—while internal demand within the Amazon accounted for only 17% of the deforested area, highlighting the predominance of the domestic market in the economic drivers underlying deforestation. In another study, Hoang and Kanemoto (2021) combined deforestation data obtained through remote sensing with a multiregional input-output model in order to quantify and map the deforestation footprint embedded in global consumption. The authors found that several developed economies, as well as China and India, have preserved or expanded their domestic forest areas but have indirectly transferred deforestation to tropical regions, especially in South America, Southeast Asia, and Central Africa.

Arima et al. (2021) employed a computable general equilibrium model (GTAP-BIO) to estimate the impacts of the EU–Mercosur Agreement on land use and agricultural production, followed by a statistical model to spatially allocate the additional deforestation in the Brazilian Amazon. The results indicate that, if ratified, the agreement could generate between 56,000 and 173,000 hectares of additional deforestation, threatening indigenous and conservation areas, unless effective governance measures and multiple-cropping practices are adopted.

Schmitz et al. (2015), in turn, applied an explicitly spatial economic land-use model, coupled with a biological vegetation model, to assess the impacts of agricultural trade liberalization on tropical deforestation. The study concluded that, without intervention, liberalization may result in an additional expansion of 30 to 60 million hectares of tropical forests by 2050, generating between 20 and 40 $GtCO_2$ of associated emissions. Among the policies evaluated, the inclusion of deforestation reduction in a global emissions trading scheme proved to be the most efficient in avoiding deforestation after 2020, and investment in agricultural productivity emerged as an alternative that reduces pressure on forests without requiring direct restrictions.

In this context, the objective of the present study is to identify how domestic and foreign demand affect deforestation levels in different Brazilian biomes. To achieve this goal, we used the Input-Output Matrix decomposition method, since it makes it possible to identify the weight that final demand (Brazilian states and foreign countries) exerts on environmental degradation in each biome. The following section specifies the method used and how the calculation for the analysis was conducted.

METHODOLOGY

The input-output model seeks to capture the interdependencies among the various sectors of the economy, examining how the production of one sector depends on the demand for inputs from other sectors. The central logic of this model is based on the idea that economic activities are interconnected in a network of transactions of intermediate goods and services. Thus, in order to understand how changes in demand or in the production structure affect the economy as a whole, it is necessary to analyze the relationships between sectors and the flow of goods and services among them (Miller and Blair, 2009; Guilhoto, 2011). The basic input-output model is described by equation (1).

$$X = (I - A)^{-1}Y \tag{1}$$

where X represents the vector of total production value by sector, A represents the matrix of technical coefficients (Where $A = Z \times X^{-1}$, with Z being the matrix of interindustry flows), Y is the vector of final demand, and $(I - A)^{-1}$ is the Leontief inverse matrix, which captures the direct and indirect requirements resulting from a change in final demand on production.

One of the most important contributions of the input-output model is the Leontief inverse matrix, which expands the analysis by considering not only the direct effects of intersectoral interactions, but also indirect and induced impacts. The Leontief inverse can be interpreted as a set of multipliers that quantify the total effect of changes in final demand on production in each sector. It is constructed from the economy's technical coefficient structure and can be used for economic policy simulations, environmental impact assessment, and regional studies (Miller and Blair, 2009).

The input-output analysis is based on the assumption that production relationships remain constant over time (Miller and Blair, 2009), which may be a limitation in situations of rapid technological change or significant structural shifts in the economy. However, even with these limitations, the model remains a powerful tool for economic and environmental impact analysis, allowing the formulation of evidence-based policies. At the core of the analysis proposed in this study is the decomposition method applied to the input-output matrix, through which it is possible to calculate the proportion of deforestation in each analyzed region, which is linked to the demand from these same regions and from the external sector.

Considering the separation of final demand by origin (domestic, Y^d, and foreign, Y^m), total production can be expressed as:

$$X = (I - A)^{-1}(Y^d + Y^m) \tag{2}$$

It is worth noting that domestic demand, Y^d, is a final demand matrix by sector that includes the 27 Brazilian federative units.

The vector of deforestation by biome (D^{bio}) will be represented by the ratio of sectoral deforestation by biome in the Agriculture, Livestock, and Mining sectors to total sectoral production, as follows:

$$D^{bio} = \widehat{Defo} \times X^{-1}$$

Substituting X from the fundamental equation (2), we obtain:

$$Defo = D^{bio}(I - A)^{-1}(Y^d + Y^m) \tag{3}$$

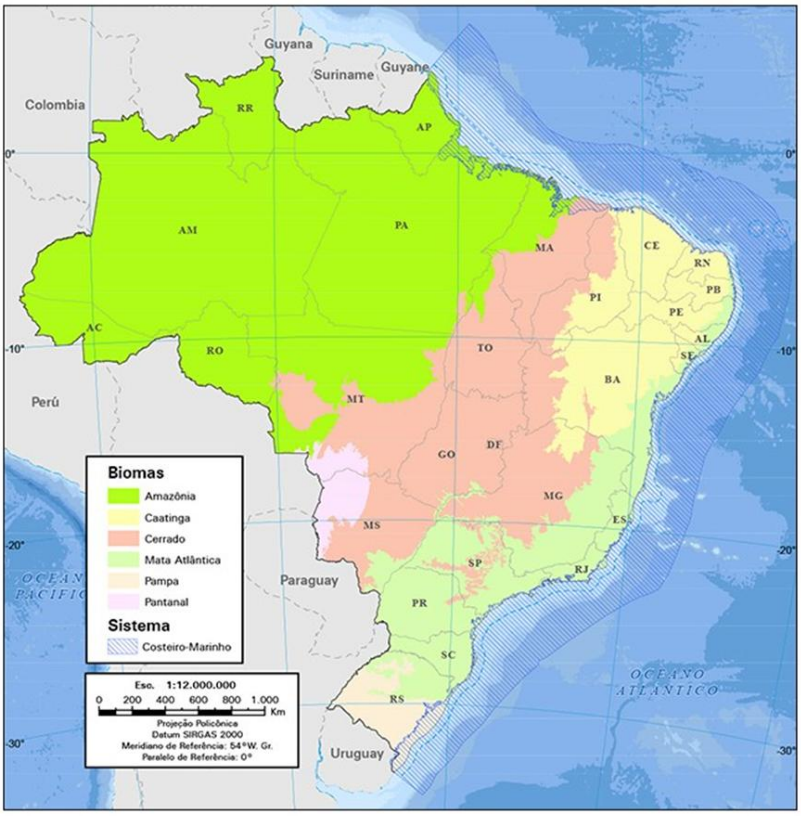
In equation (3), deforestation generated by each sector is the result of final demand (domestic and foreign) multiplied by the Leontief inverse and by the sectoral deforestation coefficient. From this, it is possible to specify how changes in demand, both domestic and foreign, are related to deforestation by biome.

Data

The interregional Input-Output matrix used for the simulation was constructed by Haddad, Gonçalves and Nascimento (2017), through an estimation process for the 27 Brazilian federative units for the year 2011.

For the construction of the deforestation vectors used in the decomposition method, we collected data provided by the MapBiomas platform. From this, it was possible to obtain values of deforested area in hectares according to economic activity, Brazilian state, and biome being affected. The analysis in this study is based on the Agriculture, Livestock, and Mining sectors, which are the main sectors responsible for deforestation in the biomes. Six biomes found in Brazilian territory were considered, illustrated in **Figure 2**: the Amazon, Caatinga, Cerrado, Atlantic Forest, Pantanal, and Pampas.

Figure 2 – Brazilian Biomes Map



Source: IBGE (2025).

RESULTS AND DISCUSSION

The data obtained from the MapBiomas platform (2025) provide an overview of deforestation levels in Brazil, according to economic activity and separated by biome. The economic sectors associated with deforestation are Agriculture, Livestock, and Mining. Among these sectors, in 2015, Livestock ranked first as the activity that generated the most deforestation in all biomes, except for the Pampas in the South, where Agriculture is the main driver of the reduction in native areas.

Deforestation levels in the Cerrado and the Amazon, in terms of livestock expansion, are the most significant, with values of 50.1 and 54.3 million hectares, respectively. The Atlantic Forest ranked third as the biome most affected by the livestock sector, with 31.4 million hectares deforested. Although the agricultural sector presents lower figures compared to Livestock, it is also responsible for a considerable deforested area in the Cerrado, with around 23 million hectares, and in the Atlantic Forest, with 19.6 million hectares deforested. The Mining industry, in turn, shows the lowest levels of deforestation among the sectors, with more prominent deforestation in the Amazon region, totaling 0.2 million hectares. The values for the other biomes, by sector, can be observed in **Table 1**. It is important to note that the year analyzed is 2015 because the most recent input-output matrix available is from that year, which is the one used in the present study; this analysis can be replicated for subsequent years as the matrix is updated.

Table 1 - Deforested Area in Thousand Hectares by Activity in Brazilian Biomes in 2015.

Activity	Amazon	Caatinga	Cerrado	Atlantic Forest	Pantanal	Pampas
Agriculture	5,589.9	1,595.2	23,060.3	19,557.1	8.6	5,855.3
Livestock	50,120.3	23,131.3	54,346.4	31,443.2	1,943.4	0.0
Mining	164.7	7.8	40.4	57.9	1.0	4,161.0

Source: own elaboration based on MapBiomas data (2025).

These data are consistent with those presented by Almeida et al. (2016), who analyzed land use in deforested areas of the Legal Amazon using Landsat-5/TM images and MODIS time series. The authors found that approximately 62% of deforested areas were converted into pasture, while less than 5% were allocated to annual crops, indicating a clear predominance of livestock activity as the post-deforestation land use. Such evidence supports the interpretation that, similarly to what is observed in other Brazilian biomes, livestock constitutes the main driver of native vegetation loss, reinforcing the centrality of this sector in land-use conversion processes. Despite its economic relevance and the possibility of optimizing land use through efficient management and the use of appropriate technologies, Brazilian agriculture and livestock production still face difficulties in aligning sectoral development with environmental preservation and restoration, an issue of great importance in the current debate on climate emergencies (Pellenz, Almeida and Lirio, 2021).

In 2024, the Brazilian government established the Brazilian Emissions Trading System (SBCE), with the objective of gradually regulating the carbon market in the country through sectoral reduction targets and compensation mechanisms. Implementation will be carried out in five phases, culminating in the operation of a cap-and-trade system. However, under the current legislation, sectors that are highly relevant to national emissions, such as agriculture and livestock, remain, so far, outside the system's mandatory coverage, revealing important limitations in the initial regulatory scope (Brasil, 2024a).

In this same context, the ABC+ Plan stands out, as it establishes mitigation targets for the agricultural sector with the aim of reducing 1.1 billion tons of CO_2 equivalent by 2030, through the adoption of sustainable technologies across up to 72 million hectares. However, this is a voluntary policy, with no link to the regulated carbon market, which reinforces the previously mentioned limitation regarding the absence of mandatory emission control mechanisms in this sector (Brasil, 2021). Thus, a dissonance can be observed between the environmental relevance of agriculture and livestock in land-use dynamics and the degree of regulatory stringency applied to the sector. The absence of mandatory instruments compromises the effectiveness of national climate mitigation strategies. Therefore, strengthening integrated and mandatory mechanisms for the sector becomes crucial to align agricultural production with environmental conservation.

From the regional decomposition of deforestation, it is possible to identify the origin of final demand that drives deforestation in Brazilian biomes, for the 27 federative units and the Federal District. These results were aggregated into macro-regions, presented in **Table 2** for values in hectares, and in **Table 3** for percentage shares.

The North region is predominantly characterized by the Amazon biome and, to a lesser extent, by the Cerrado. About 10,718 thousand hectares deforested in the Amazon are intended to meet the demand of the Southeast region, corresponding to approximately 32% of the region's total demand, followed by 7,577 thousand hectares (23%) deforested to meet the demand of the North region itself, and 6,812 thousand hectares (20%) to supply international demand. In the Cerrado, 2,875 thousand hectares (40%) are deforested to also meet the demand of the Southeast region, 1,244 thousand hectares (17%) for international demand, and 971 thousand hectares (13%) for the Northeast region. This shows that most deforestation in the North region, in both the Amazon and the Cerrado biomes, is driven by demand from Brazil's largest economic region, the Southeast. However, the role of international demand in driving changes in these biomes in the North region cannot be ignored.

Table 2 - Results of the Decomposition of Deforested Area by Biome across Macro-regions for the Year 2015.

Deforestation by Biome across Brazilian Macro-regions (1,000 hectares)									
		Origin of Final Demand							
		North	**Northeast**	**Southeast**	**South**	**Central west**	**Foreign**	**Total**
North	**Amazônia**	7,577	3,283	10,718	3,091	1,753	6,812	33,235
	Caatinga	-	-	-	-	-	-	-
	Cerrado	877	971	2,875	764	514	1,244	7,244
	Atlantic Forest	-	-	-	-	-	-	-
	Pantanal	-	-	-	-	-	-	-
	Pampas	-	-	-	-	-	-	-
Northeast	**Amazônia**	358	2,301	2,215	616	310	995	6,794
	Caatinga	528	7,582	7,630	1,830	1,183	2,635	21,387
	Cerrado	358	2,232	2,921	776	459	1,926	8,672
	Atlantic Forest	153	2,434	2,517	589	403	913	7,009
	Pantanal	-	-	-	-	-	-	-
	Pampas	-	-	-	-	-	-	-
Southeast	**Amazônia**	-	-	-	-	-	-	-
	Caatinga	32	116	873	160	105	224	1,510
	Cerrado	305	1,046	8,313	1,656	945	3,296	15,559
	Atlantic Forest	484	1,732	14,970	3,107	1,388	4,636	26,317
	Pantanal	-	-	-	-	-	-	-
	Pampas	-	-	-	-	-	-	-
South	**Amazônia**	-	-	-	-	-	-	-
	Caatinga	-	-	-	-	-	-	-
	Cerrado	2	5	48	21	4	46	125
	Atlantic Forest	223	634	5,727	3,264	519	4,700	15,067
	Pantanal	-	-	-	-	-	-	-
	Pampas	105	271	1,789	1,436	217	2,041	5,860
Central west	**Amazônia**	690	1,492	6,244	1,917	2,000	5,340	17,683
	Caatinga	-	-	-	-	-	-	-
	Cerrado	1,309	3,271	19,479	4,866	5,652	11,230	45,806
	Atlantic Forest	63	165	1,197	317	280	642	2,665
	Pantanal	63	158	917	260	218	337	1,953
	Pampas	-	-	-	-	-	-	-

Source: own elaboration based on the results.

The Northeast has the largest number of biomes within its territory. Considering the Amazon biome, about 2,301 thousand hectares (34%) of deforestation in the Northeast occurs to meet demand from the region itself, 2,215 thousand hectares (33%) to meet demand from the Southeast region, and 995 thousand hectares (15%) in response to international demand. The Caatinga is the almost exclusive and predominant biome of the region, and it is the one that presents the highest values in the decomposition of deforestation in the Northeast. About 7,630 thousand hectares (36%) of deforestation are related to meeting demand from the Southeast, 7,582 thousand hectares (35%) are related to the Northeast's own demand, and 2,635 thousand hectares (12%) are for international demand. The Northeast Cerrado shows a similar pattern to the Caatinga, with predominance of demand from the region itself, the Southeast, and international demand driving deforestation in the biome, with values of 2,921 thousand hectares (34%), 2,232 thousand hectares (26%), and 1,926 thousand hectares (22%), respectively. Finally, the Atlantic Forest found in the region, despite its smaller proportion, also shows a similar structure of demand-driven deforestation as the Caatinga and Cerrado, with 2,517 thousand hectares (36%) for the Southeast, 2,434 thousand hectares (35%) for the Northeast itself, and 913 thousand hectares (13%) for international demand. In summary, in the Northeast, demand from the region itself is the leading driver of deforestation, followed by the Southeast region and external demand in virtually all biomes.

Table 3- Results of the Decomposition of the Share of Deforestation by Biome across Macro-regions for the Year 2015

Deforestation by Biome across Brazilian Macro-regions (%)

		Origin of Final Demand						Total
		North	**Northeast**	**Southeast**	**South**	**Central west**	**Foreign**	
North	**Amazônia**	23%	10%	32%	9%	5%	20%	100%
	Caatinga	-	-	-	-	-	-	-
	Cerrado	12%	13%	40%	11%	7%	17%	100%
	Mata Atlântica	-	-	-	-	-	-	-
	Pantanal	-	-	-	-	-	-	-
	Pampas	-	-	-	-	-	-	-
Northeast	**Amazônia**	5%	34%	33%	9%	5%	15%	100%
	Caatinga	2%	35%	36%	9%	6%	12%	100%
	Cerrado	4%	26%	34%	9%	5%	22%	100%
	Mata Atlântica	2%	35%	36%	8%	6%	13%	100%
	Pantanal	-	-	-	-	-	-	-
	Pampas	-	-	-	-	-	-	-
Sudeste	**Amazônia**	-	-	-	-	-	-	-
	Caatinga	2%	8%	58%	11%	7%	15%	100%
	Cerrado	2%	7%	53%	11%	6%	21%	100%
	Mata Atlântica	2%	7%	57%	12%	5%	18%	100%
	Pantanal	-	-	-	-	-	-	-
	Pampas	-	-	-	-	-	-	-
South	**Amazônia**	-	-	-	-	-	-	-
	Caatinga	-	-	-	-	-	-	-
	Cerrado	1%	4%	38%	17%	3%	36%	100%
	Mata Atlântica	1%	4%	38%	22%	3%	31%	100%
	Pantanal	-	-	-	-	-	-	-
	Pampas	2%	5%	31%	25%	4%	35%	100%
Central west	**Amazônia**	4%	8%	35%	11%	11%	30%	100%
	Caatinga	-	-	-	-	-	-	-
	Cerrado	3%	7%	43%	11%	12%	25%	100%
	Mata Atlântica	2%	6%	45%	12%	11%	24%	100%
	Pantanal	3%	8%	47%	13%	11%	17%	100%
	Pampas	-	-	-	-	-	-	-

Source: own elaboration based on the results.

For the Southeast region, the Atlantic Forest and the Cerrado predominate, with a small proportion of the region occupied by the Caatinga biome. For the latter, 873 thousand hectares (58%) of deforestation occur to meet demand from the Southeast region itself, about 224 thousand hectares (15%) for international demand, and 160 thousand hectares (11%) for the South region. The other two biomes experience deforestation in a similar way, mainly to meet internal demand from the region, external demand, and demand from the South region. In the Cerrado, deforested areas to supply these demands are, respectively, 8,313 thousand hectares (53%), 3,296 thousand hectares (21%), and 1,656 thousand hectares (11%). For the Atlantic Forest, deforestation levels are more significant, reflecting the predominance of the biome in the region, with about 14,970 thousand hectares (57%) to meet internal demand from the region, 4,636 thousand hectares (18%) in response to external demand, and 3,107 thousand hectares (12%) for demand from the South.

In the South region, the biome that occupies the largest area is the Atlantic Forest, followed by the Pampas, which is found only in the state of Rio Grande do Sul, and a small portion of Cerrado present along the border with the Southeast. Although considerably small compared to other biomes in other regions, in the Cerrado about 48 thousand hectares (38%) are deforested to meet demand from the Southeast, and 46 thousand hectares (36%) are for foreign demand. The Atlantic Forest, in turn, has 5,727 thousand hectares (38%) deforested to meet demand from the Southeast, 4,700 thousand hectares (31%) for international demand, and 3,264 thousand hectares (22%) for demand from the region itself. Finally, the Pampas account for about 2,041 thousand hectares (35%) of deforestation driven by external demand, 1,789 thousand hectares (31%) for demand from the Southeast, and around 1,436 thousand hectares (25%) for internal demand.

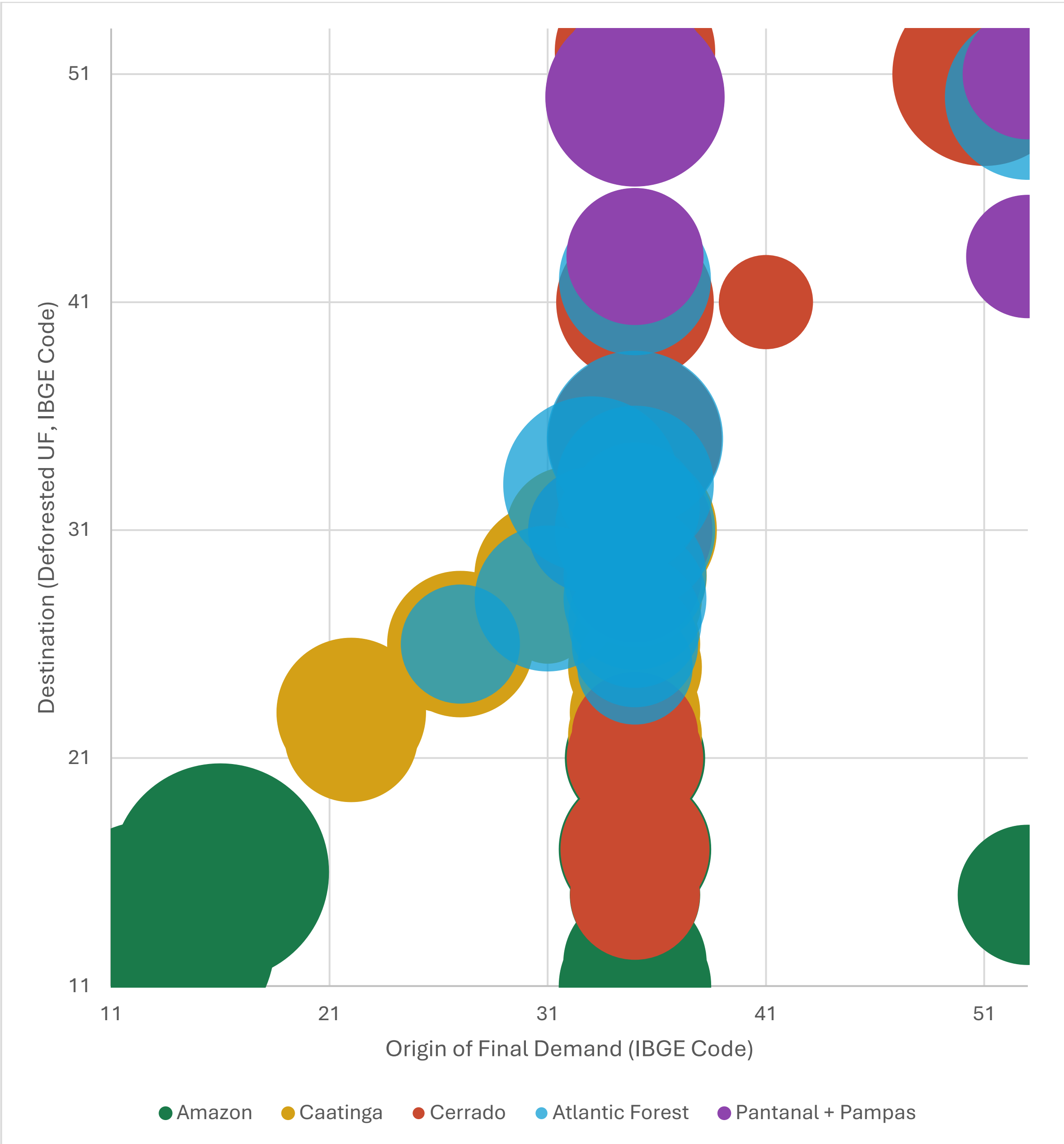
The Brazilian Central-West region is predominantly characterized by the Cerrado biome, but it also contains areas of the Amazon and Atlantic Forest, and it is the only region where the Pantanal is found. The portion of the Amazon forest located in the state of Mato Grosso loses about 6,244 thousand hectares (35%) to meet demand from the Southeast region, while 5,340 thousand hectares (30%) are associated with international demand, these being the most significant values for this biome in the region. The Cerrado, the predominant biome of the region, loses around 19,479 thousand hectares (43%) of vegetation to meet demand from the Southeast, and 11,230 thousand hectares (25%) to foreign demand. The Atlantic Forest follows the same pattern, with losses of 1,197 thousand hectares (43%) and 642 thousand hectares (25%), respectively. Finally, for the Pantanal, the region's exclusive biome, about 917 thousand hectares (47%) and 337 thousand hectares (17%) are lost to meet demand from the Southeast and international demand, respectively. Considering that the region is the largest soybean producer, one of the main products of Brazilian agricultural exports, with production accounting for about 45% of total national output in the 2020/2021 harvest (Seibert et al., 2023), it is possible to associate international demand with strong pressure on deforestation in the region and, consequently, on the total amount of land deforested.

Based on the decomposition results, it is evident that deforestation across Brazilian biomes exhibits a similar pattern in all of them, with livestock being the main associated activity. The Southeast region is at the center of the main domestic demand sources that generate deforestation pressures in most biomes, which can be explained by the fact that it is the most populous region in the country, with about 42% of the total population according to IBGE and has the largest share of national GDP, accounting for about 53.3% in 2022. These characteristics are linked to high consumption of agricultural products produced both within the region and in other Brazilian regions. In addition, inputs produced in other federative units are demanded to supply industries located in the Southeast region, which is also associated with the results found in the decomposition (**Figure 3**).

The second final demand agent that generates the most deforestation is the external sector, represented by international commodity importers. China is the main destination for both soybeans and beef exported by Brazil, which are two of the main agricultural and livestock products in the Brazilian international market. In 2023, the Asian country accounted for more than 70% of external soybean purchases and also led imports of Brazilian beef, followed by the United Arab Emirates and the United States (Brasil, 2024b).

Given that livestock is the main driver of deforestation, it is reasonable to assume that beef importers exert considerable pressure to increase the supply of this type of product for Brazilian exports, which leads to increased deforestation in biomes such as the Amazon and the Cerrado. These results are consistent with those found by Haddad et al. (2024) in their study, in which the authors show that most of the pressure comes from domestic demand, and reinforce that extensive livestock farming remains the main economic driver of deforestation, and that its value chain is highly integrated at the national level.

Figure 3 - Deforestation by Biomes: Origin × Destination of Demand



Source: own elaboration based on the results.

FINAL CONSIDERATIONS

In this study, the impacts of final demand on deforestation in Brazilian biomes were analyzed using a methodological approach based on an interregional input-output matrix. After presenting the historical and theoretical context of deforestation processes and their relationship with economic dynamics and climate change, the conceptual foundations of the Leontief model and the applied decomposition procedure were introduced. Deforestation data by economic activity and biome made it possible to highlight the contribution of each Brazilian region and the external sector to environmental degradation, based on demand for products from the agriculture, livestock, and mining sectors.

The results showed that livestock is the main sector responsible for deforestation in all analyzed biomes, and that the Southeast region of the country, due to its large share of national GDP, population, and level of industrialization, exerts significant indirect pressure on land-use conversion, especially in the Amazon and Cerrado. The external sector also stands out as a relevant source of demand, reinforcing the role of international trade in intensifying agricultural expansion. Regional decomposition made it possible to precisely quantify the contribution of each demand origin to spatial deforestation patterns, providing robustness to the analysis. Overall, there is a need for policies aimed at increasing agricultural productivity, in order to meet both domestic and external demand, as well as discouraging sectoral expansion through deforestation.

Studies such as Strassburg et al. (2014) show that it is technically feasible to meet the growing demand for agricultural products in Brazil through sustainable intensification of production in already converted areas, especially in underutilized pastures. The authors show that productivity improvements could supply almost all projected expansion until 2040 without the need for new deforestation. This conclusion reinforces the strategic role of public policies that encourage the restoration of degraded areas and promote more efficient land use as an alternative to agricultural frontier expansion. Carvalho, Domingues, and Horridge (2017), using a regional computable general equilibrium model linked to a land-use module, indicate that policies aimed at curbing deforestation in the Legal Amazon, when combined with strategies to increase agricultural productivity, can reconcile environmental preservation with the maintenance of economic performance. The authors show that restrictions on agricultural frontier expansion, when implemented in isolation, tend to generate negative effects on regional output and employment; however, such impacts can be mitigated if accompanied by incentives for production intensification in already used areas. The study highlights the importance of integrated policies that combine environmental conservation and productivity gains in rural areas. Moreover, policies such as the recently adopted Brazilian carbon market framework (Brasil, 2024a) could be enhanced with measures aimed at covering additional sectors of the economy. This would further encourage reductions in GHG emissions by activity and through land-use change.

One of the limitations encountered was the lack of a more recent database with input-output matrices compatible with the current structure of the Brazilian economy. This study could be improved using Computable General Equilibrium models to assess the impact of domestic and international demand on land-use change and emissions, as these models consider supply constraints and changes in relative prices. They could also be used to project the impacts of these demands under future scenarios of change.

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