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DECARBONIZATION AND INDUSTRIAL POLICY: CHALLENGES FOR BRAZIL

Working Paper DIP-BR 04/2024

Decarbonization and industrial policy: challenges for Brazil's beef agrifood chain

John Wilkinson

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About the Project DIP-BR

"Decarbonization and Industrial Policy: Challenges for Brazil" (DIP-BR) is a policy-oriented research-action project aimed at influencing public debate on industrial, innovation, and trade policies in Brazil and selected Latin American countries that promote decarbonization and energy transition in the region. The initiative seeks to inform and induce efficacy, efficiency, effectiveness, and innovativeness in policy design and implementation. The methodology encompasses critical benchmarking analyses of past and present policy experiences from an international comparative perspective, regional trade studies, and economic analyses of productive sectors and chains, combining structural analysis of traditional production, employment, and trade statistics and simulation models of sectoral impacts using input-output approach.

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DECARBONIZATION AND INDUSTRIAL POLICY: CHALLENGES FOR BRAZIL'S BEEF AGRIFOOD CHAIN

ABSTRACT

The associated impacts of the Brazilian beef chain are responsible for the major share of the country's emissions, but decarbonization of the Brazilian beef chain poses many challenges. Life cycle analyses, discussed in this text, confirm that emissions are highly concentrated in the primary sector. In addition, the pasture-based production model means that the largest part of these emissions comes from expansion of pasture into woodlands, provoking carbon release through land use change. Degrading of pasture-land through overuse and mismanagement and emissions from enteric fermentation compose the other major sources of emissions. This last source is particularly important because it produces methane emissions which are much more potent than carbon dioxide but remain in the atmosphere for a much smaller period of time and therefore are considered key for short to medium term mitigation efforts. Methane mitigation initiatives include new feed additives, cattle management practices, the development of alternative proteins, and public policies to decrease per capita beef consumption. Brazil made an early commitment to carbon mitigation focusing on an end to deforestation and the recuperation of degraded pasture lands. The Paris COP Agreements in 2016 led to the establishment of Nationally Determined Contributions by all the signatory countries, and in the Brazilian case, they established specific targets for these goals. Europe has traditionally taken the lead in including sustainability criteria in its trade policy, but now the Chinese links in the beef chain will be decisive for achieving the NDC goals. In the second decade of the millennium, Brazil became the world's leading exporter of beef and China the principal consumer. Originally exporting primarily to Europe, 70% of Brazil's beef exports, dominated by three global Brazilian players, JBS, Marfrig and Minerva, now have China as their destiny. Global non-governmental organizations, decisive in the case of the Soy Moratorium which banned soy associated with deforestation, are playing an equally important role in identifying the risks of deforestation in the Brazilian-China beef chain. Traceability is a central issue in the ability to monitor the beef chain, but its implementation has only been partial. Europe has determined that Scope 3 commitments, by which firms become accountable for emissions all along the supplier chain, will become a precondition for entry into the European market. The China Meat Association has included similar provisions in its specification for Meat Industry

Green Trade, but to date, there is no indication that the beef trade has been affected by these specifications. At the end of 2023, China declared that it will be implementing the demand for traceability during the course of 2025. In Brazil, the issue of traceability is the subject of dispute: should it be individual and from birth or by the cattle lots sent from the farm for slaughter? It has become clear that only an identification from birth can pinpoint the connection between deforestation and cattle, and China's recent demand on traceability will increase the pressure for a traceability system which captures this first link in the beef supply chain.

KEYWORDS

Beef Agrifood Chain. Decarbonization. Industrial Policy. Brazil.

DECARBONIZAÇÃO E POLÍTICA INDUSTRIAL: DESAFIOS PARA A CADEIA DE PECUÁRIA

RESUMO

A cadeia de carne bovina brasileira é uma grande contribuinte para as emissões do país, com desafios significativos na descarbonização. As emissões estão concentradas no setor primário, especialmente devido à mudança no uso da terra, à medida que as pastagens se expandem para as florestas, causando liberação de carbono. Pastagens superutilizadas e mal administradas e fermentação entérica também contribuem, com o metano do gado sendo particularmente potente. Os esforços de mitigação se concentram em aditivos para ração, melhor manejo do gado, proteínas alternativas e redução do consumo de carne bovina por meio de políticas. O Brasil se comprometeu a acabar com o desmatamento e reabilitar pastagens degradadas. Os Acordos da COP de Paris em 2016 levaram ao estabelecimento de Contribuições Nacionalmente Determinadas (NDCs) com metas específicas. A Europa, líder tradicional em políticas de comércio sustentável, e o papel da China na cadeia de fornecimento de carne bovina são cruciais para atingir essas metas. Na década de 2010, o Brasil se tornou o maior exportador mundial de carne bovina, com a China como seu principal consumidor. As ONGs desempenham um papel fundamental no enfrentamento dos riscos de desmatamento na cadeia de carne bovina Brasil-China. A rastreabilidade é vital para o monitoramento, mas a implementação é incompleta. A Europa exige compromissos de Escopo 3 para entrada no mercado, e a China exigirá rastreabilidade até 2025, aumentando a pressão sobre o Brasil para implementar rastreabilidade abrangente desde o nascimento.

PALAVRAS-CHAVE

Cadeia Agroalimentar da Carne Bovina. Descarbonização. Política Industrial. Brasil.

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Introduction

Brazil has seen a remarkable transformation of its beef agrifood chain. In the first half of the 1990s it was still a laggard sector with some 40% of its slaughter carried out in the informal sector, exports limited to the "Hilton quota" granted by the European Union (EU), and a net importer. In this period, Sadia, Brazil's leading meat firm, sold off its interests in beef. The second half of the 1990s witnessed a transformation of the sector based on a new generation of national firms – JBS, Minerva, Marfrig – and a rapidly growing export window provided by health and drought crises affecting the world's two leading exporters – the USA and Australia -, and by the expansion of soy at the expense of cattle in the case of the Argentinian pampas region.

In this process, growth in the country's beef herd became concentrated in the Centre--West and the North of the country, two of Brazil's most sensitive biomes. Very rapid industrial concentration and the adjustment of slaughterhouses for export permits led to a sharp reduction in informal slaughter, but the shift to these two biomes was accompanied by an identification of cattle expansion with deforestation and land use change, the two most important factors in Brazil's greenhouse gas emissions.

In the late 1990s and early 2000s Brazil's beef exports were primarily to countries in the global North but as from the second decade when China began to complement animal feed with beef imports Brazil became its principal supplier and the world's leading beef exporter. Given the projections for China's import demand for beef, and the transition to an animal protein diet consequent on rapid urbanization throughout Asia (and with the African continent on the horizon), the perspective of a continued expansion of Brazil's beef sector, increasingly oriented to exports, is driving investment in the sector.

In their latest figures, the Brazilian Association of Meat Exporting Industries (ABIEC, 2024) calculates that some 28% of beef production is currently exported with more than half of this going to China (54%) and second, USA, and third, EU, destinations counting for 8% and 5% respectively. The leading exporter firms also dominate the domestic market and as an increasing number of slaughterhouses are approved for export the sanitary and quality gap between domestic consumption and exports narrows. In addition, the domestic retail beef market is dominated by transnational firms subject to global scrutiny which also leads to a growing convergence in domestic and export standards.

The “Beef Pact” (Pacto Setorial..., 2010), led by these actors, excluding beef identified with recently deforested areas in the Amazon region from supermarket gondolas, was a clear expression of the beef chain’s new patterns of governance.

Brazil was the first country in the global South to present nationally determined contributions (NDCs), to mitigate carbon equivalent emissions within the COP negotiations and, in the light of the above, it is not surprising that these focused essentially on the two issues of deforestation and emissions from cattle raising, the latter being identified with the degradation of pastureland. Deforestation in its turn has been calculated to be almost exclusively motivated by or related to subsequent occupation by cattle raising. Reduction in emissions was, therefore, to be achieved by a radical reduction in deforestation and through the recuperation of some 12 million hectares of degraded pastureland to undercut pressures for the incorporation of new land through productivity increases (Brasil, 2024a).

As the first deadline of 2025 for the NDCs approaches, Brazil is clearly not going to achieve its targets. To understand the challenges posed for achieving the NDC goals and advancing towards decarbonization, the complexities of the Brazilian beef agrifood chain and its global outreach need to be unraveled.

This report provides a detailed analysis of the Brazilian beef chain identifying the incidence and nature of its emissions and its connection with deforestation. It presents the results of monitoring initiatives which have been able to pinpoint the sources of emission risks, but which require a traceability system for effective control by firms and public policies. It further analyses the nature of emissions in the beef production chain, primarily of methane, and the various initiatives being explored to mitigate such emissions. Global commitments on zero deforestation and **Scope 3**[1] targets by individual firms to decarbonize their supply chains show that China and its leading firms, Brazil’s principal market for beef exports, are moving closer to the EU on the demand for zero deforestation. Brazil for its part has developed a complex range of policies to ensure its ability to achieve its NDC targets, but the existence of a Forestry Code (Brasil, 2012) which allows for considerable legal deforestation is a major challenge.

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[1] Scope 3 measures refer to a firm´s assuming responsibility for the decarbonization of its supply systems, Scope 2 for its energy consumption, and Scope 1 for the firm’s own emissions.

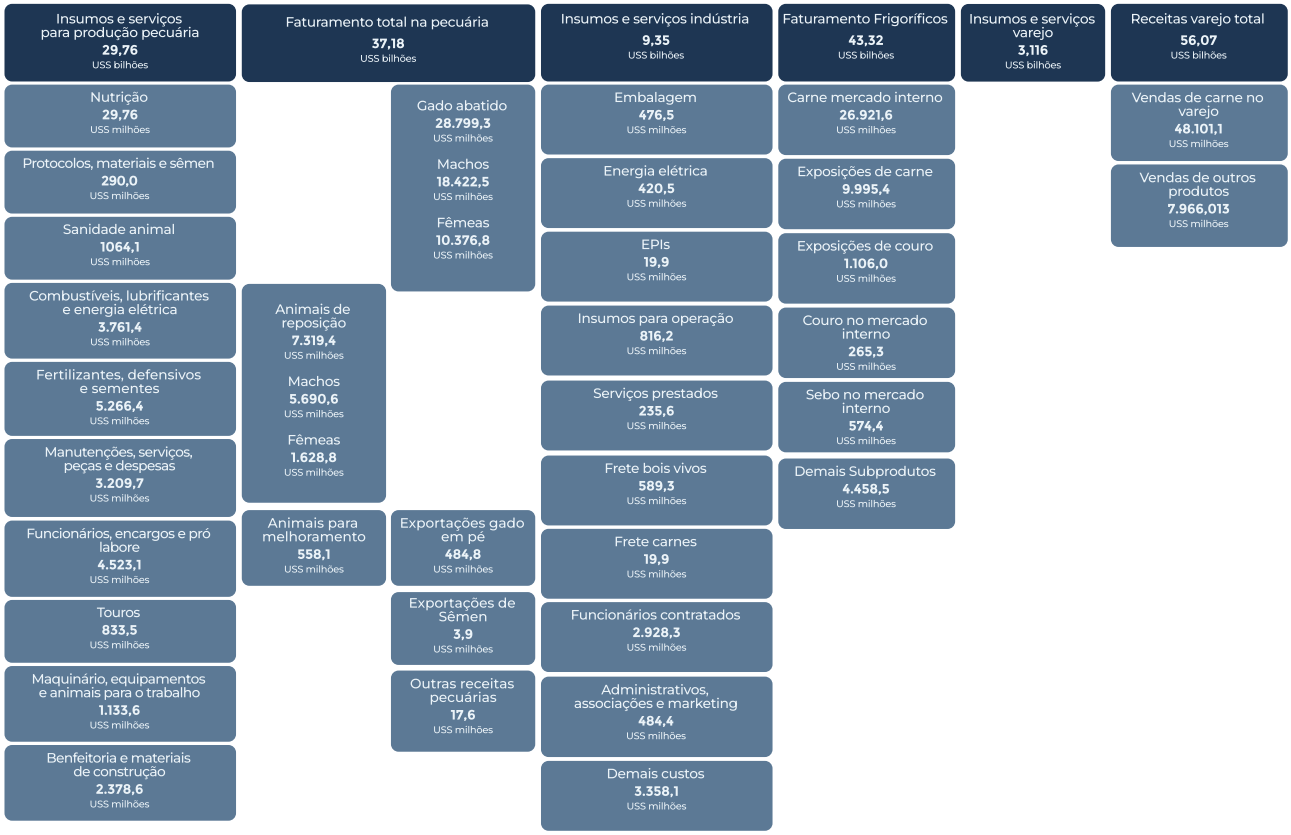
This report is organized into three parts in addition to this introduction. The first is dedicated to a detailed analysis of the beef supply chain, including in its leading importer country, China. In this part we deal with deforestation risks, traceability, life cycle analysis of the emissions internal to the beef supply chain, the various mitigation initiatives being promoted to combat methane emissions and identify Brazil's leading exporters and their Scope 3 commitments. The second part of the report discusses the measures being put into place to ensure that the beef supply chain is exempt from links with deforestation and discusses the extent to which China is aligning itself with the other leading beef importer countries. In the third and final part of the report we discuss Brazil's commitments to climate mitigation and the range of policies adopted to fulfil the NDC commitments arising from the Paris COP Agreements.

1. 1. DESCRIPTION OF THE BRAZILIAN BEEF AGRIFOOD CHAIN AND ITS GLOBAL RAMIFICATIONS

1.1. CHARACTERISTICS OF THE BRAZILIAN BEEF VALUE CHAIN

Figure 1 below makes clear the economic weight of the beef sector, which represents over 30% of agribusiness GDP and 8.2% of total Brazilian GDP. The value of beef exports, excluding carcass for leather and other subproducts, now exceeds that for chicken, which for decades has been Brazil's leading animal protein export. The beef chain, as a whole, generates R$895,32, (US$179,21) billion, but cattle raising represents only some 16% of this value, with the largest shares going first to retail (30%) and then to the meat firms responsible for slaughter and exports, (25%), with the cattle raising input sector also responsible for some 14%.

Figure 1 – The Beef Agroindustrial System, 2023



Source: Adapted from ABIEC (2024, p. 63).

The relatively small share of cattle-raising in the total value of the beef agrifood chain belies its centrality when considering emissions. According to the Greenhouse Gas Emissions and Removals Estimation System ***(Sistema de Estimativas de Emissões e Remoções de Gases de Efeito Estufa – SEEG)***[2], as shown in **Table 1**, the food system was responsible for 73.7% of Brazil's total emissions and cattle raising represented some 80% of these. In these calculations, Land Use Change (LUC) is understood to be a function of the expansion of pastureland after deforestation.

Table 1 - Brazilian carbon emissions by sector

Category	2018	2019	2020	2021	2022
Agropecuária	560.190.322	562.625.609	576.172.699	597.532.212	617.800.840
Energia	408.164.514	411.668.842	309.211.974	437.167.728	415.510.613
Mudança de Uso da Terra e Floresta	879.751.852	1.186.635.265	1.101.771.345	1.367.365.035	1.392.021.906
Processos Industriais	88.704.167	86.923.108	86.923.960	95.882.583	90.390.347
Resíduos	88.228.540	89.552.323	91.397.735	92.106.273	91.302.486
Total	025.039.395	2.336.864.147	2.246.477.713	2.590.053.832	2.607.026.192

Source: Adapted from Observatório do Clima (2024).

The difficulties of control over cattle raising can be better understood when it is recognized that Brazil has some 170 million head of cattle on a similar number of hectares comprising over 2.5 million farms, with 2 million of these farms under 100 hectares and with an average of only 25 cattle **(see Table 2)**. Brazil's largest cattle raiser, on the other hand, has some 2.5 million head of cattle. In sharp contrast to the intensive cattle lots of the US, 80% of Brazil's cattle are raised on pastureland.

Table 2 - Farms with cattle by area and size of herd, 2017

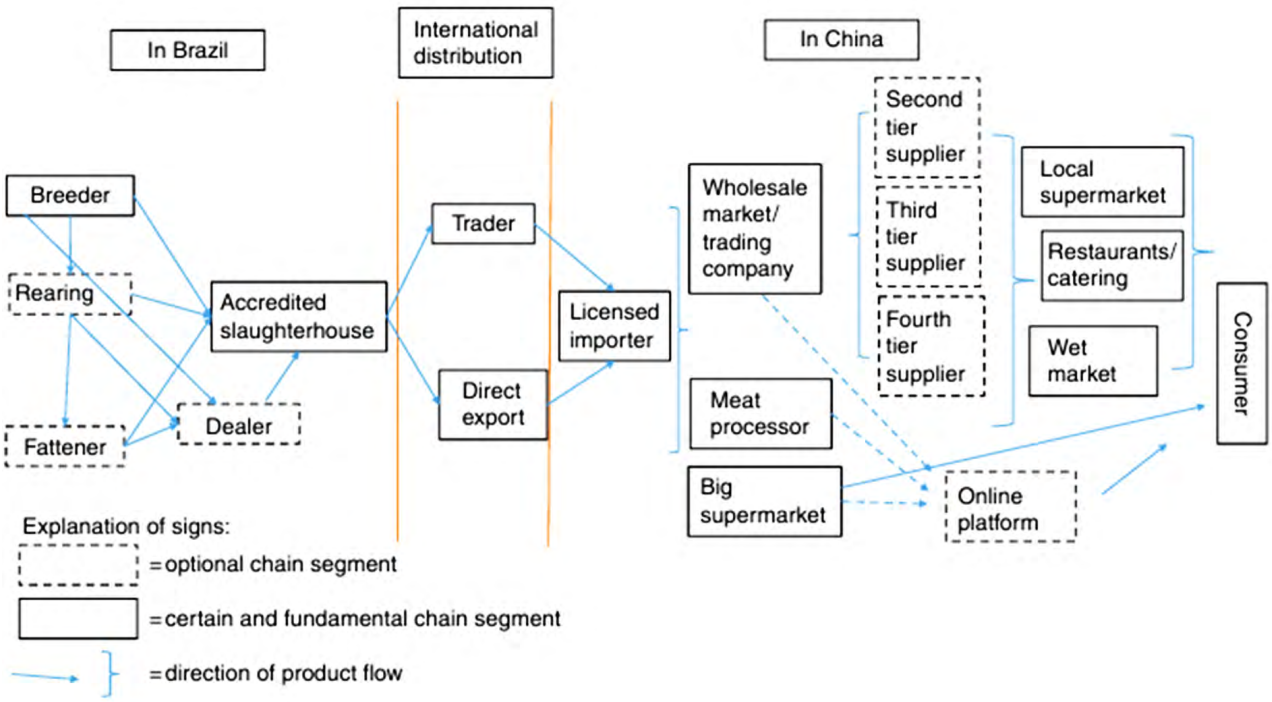
ÁREA	N.º de propriedades	% de propriedades	N.º de cabeças	% de cabeças
De 0 a menos de 100ha	2.158.947	84,75%	50.113.091	29,03%
De 100 a menos de 1000ha	348.101	13,67%	63.624.451	36,86%
Acima de 1000ha	40.291	1,58%	58.891.140	34,11%
TOTAL	**2.547.339**	**100%**	**172.628.682**	**100%**

Source: Adapted from Malafaia and Biscola (2023) based on data from IBGE Agricultural Census (2017).

[2] The SEEG, created by the Climate Observatory, which groups together Brazil´s NGOs working on climate issues, is the Brazilian platform which estimates emissions and eliminations of greenhouse gases.

The primary sector has the further complication of multiple cattle raising systems where the three phases – breeding, rearing, and fattening – can be integrated or divided into separate phases, with the cattle moving from farm to farm, as can be seen in **Figure 2** below.

Figure 2 - The Brazilian China beef chain



Source: Knoll *et al.* (2017, p. 171).

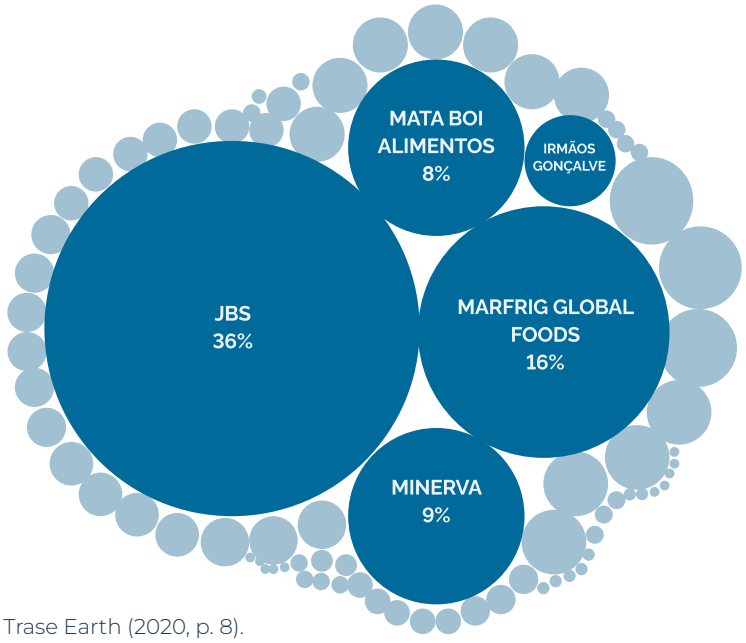
In sharp contrast, the slaughter, processing, and trading industry is highly concentrated, as can be appreciated in **Table 3**, with JBS, Marfrig and Minerva accounting for perhaps 35-40% of national slaughtering capacity and responsible for 70% of beef exports. Retail sales of beef are also increasingly centralized in the supermarket systems of transnational firms in Brazil. The leading firms in both these segments have committed themselves to exclude cattle reared on farms from recently deforested areas and draw on Brazil's official monitoring systems to identify farms which are on the blacklist for deforestation and/or social and environmental infractions. In the case of beef exports to China, **Figure 3**, based on Trase data, shows that only four firms account for 70% of Brazil's exports.

Table 3 - Business profiles of JBS, Marfrig and Minerva, 2019 (in US$)

Business profile	JBS S.A.	Marfrig	Minerva S.A.
Animal protein type	Beef, pork, poultry, lamb	Primarily beef	Primarily beef, incl. livestock
Consolidated net revenue (billion)	50.9	12.4	4.2
Geography of operations	North America, South America, Asia, Europe Africa, Oceania	North America, South America,	South America,
Main revenue source (%)	North America unit -48%	North America unit -71%	Brazil unit -47%
Ownership	Publidy traded	Publidy traded	Publidy traded
Brazilian Beef			
Revenue as part of total revenue (%)	14%	9%	47%
Estimate of market shares (%)	11,5% - 19%	4,5% - 7,5%	4% - 7%
Number of employees	54,000	32,000	17,500
Main source of revenue (% of total revenue)	Exports (51%)	Exports (72%)	Exports (67%)
Prodution units	37	12	10
Slaughtering capacity (heads/day)	33,000	13,000	11,880
Export markets (%)	China, Middle East	China& Hong Kong (34%), Europe (11%) Middle East (7%) United States (5%)	Asia (39%, where 26% to China), Middle East (16%), Africa (14%), Russia (13%), Europe (9%), North America & South America (9%)

Source: Adapted from Slob, Rijk and Piotrowski (2020, p. 4).

Figure 3 - Companies that Dominate Beef from Brazil to China by volume (in %)

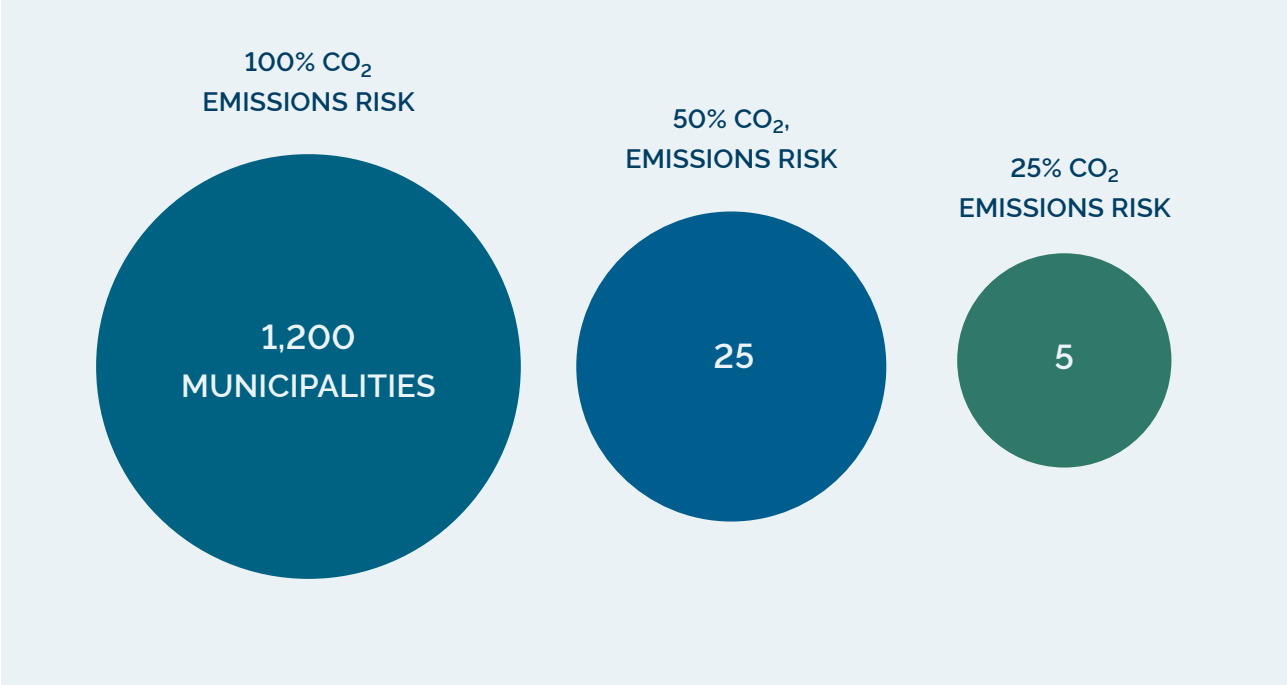


Source: Adapted from Trase Earth (2020, p. 8).

1.2. THE CENTRALITY OF TRACEABILITY

Traceability, however, is very much limited to the farms which directly supply cattle for slaughter. Given the varied production systems indicated above, this procedure does not necessarily capture the farms initially responsible for breeding and rearing which then sell on the cattle for final fattening. NGOs such as Imaflora, Greenpeace, Reporter Brazil, and others have provided detailed analyses which reveal the extent of this lacuna (Brasil, 2021) and in 2009 Greenpeace and the four largest beef packers committed to zero deforestation **(Portal da Moratória da Soja, 2024)**[3]. International traceability initiatives can pinpoint the municipalities and farms where the risk of deforestation is most in evidence. Trase identified some 65-75,000 hectares in the Amazon likely associated with deforestation with some 22,000 hectares attributable to beef exports to China. **Figure 5** below shows how China's deforestation risk is concentrated in only 25 of the 1,200 municipalities which export beef.

Figure 4 – Concentration of China's CO_2 Emissions Risk from Cattle Deforestation



Source: Adapted from Trase Earth (2020, p. 7).

[3] The Mato Grosso State Governor sanctioned a Law approved in the State Assembly in 2024 to restrict benefits to those who continue to commit to the Soy Moratorium (Mato Grosso, 2024).

The implementation of traceability systems in Brazil has, however, been stalled by disagreements over whether cattle should be identified individually from birth or by lots dispatched to the abattoirs (Dias de Sá; Lemos; Jank, 2023). A major advance was the commitment of the Pará State Governor at the Dubai COP to implement an individual traceability system in his State which has the second largest herd in the country, with a 100% target for December 2025 (TNC, 2023). In March of 2023, a joint group of cattle farmers and NGOs presented a national proposal for an Obligatory Individual Traceability System to the Ministry of Agriculture (Brito, 2024). While there will still be conflicting views, it appears to be becoming clear that the only effective traceability system is individual identification from birth which is able to capture the "indirect" suppliers most closely associated with deforestation (Walendorff, 2024).

1.3. LEADING EXPORTERS AND SCOPE 3 RESPONSIBILITIES: EUROPE & CHINA

International pressure is mounting for countries and firms to assume Scope 3 responsibilities for cleaning their supply chains of carbon emissions and the European Union committed to taxing emissions from any form of deforestation, via the EU Deforestation Regulation (EUDR), whether legal or illegal in the country of origin. Initially the date for implementation was fixed at the end of 2024, but this has now been postponed until the end of 2025. Although Europe is now a long way behind China as a destiny for Brazil's meat exports it is still a relevant destiny particularly for industrialized meats. The UK Environment Act (The United Kingdom, 2021) and the USA Forest Act (The United States, 2021) are similarly directed at Scope 3 responsibility for eliminating supply chains of deforestation, but unlike the EU these Acts are limited to deforestation which is illegal in the exporting country.

Nevertheless, it is China which has become the decisive export market, and it is perhaps as or more important to understand China's commitment to the mitigation of carbon emissions in the beef chain. **Figure 2** above, extracted from Knoll *et al* (2017), provides a formal description of the actors in China responsible for the flow of imports and its authors suggest that the links between exporters and importers are quite impersonal. On the other hand, China authorizes abattoirs to export to China on a plant-by-plant basis and these include plants in the Amazon region.

The current criteria are fundamentally sanitary although broader issues of trade diplomacy may come into play. While sanitary criteria do not imply climate change goals, it has been argued that China's requirement that all frozen beef imports, whatever the

country, come from cattle slaughtered at under 30 months has had an enormous impact on reducing emissions in Brazil via the consequent increase in productivity and, therefore, lower emissions per unit of meat. This point was made at the first session of the 4th Dialogue Brazil-China on Green Finances and Cooperation in Agriculture, organized by the Brazil-China Business Council (CEBC, 2024). It should be noted, however, that Brazil began to promote early slaughter as from the 1990s, with significant impact already by the turn of the century (ABIEC, 2024).

In 2019, China introduced a Forest Law whose Article 56 bans the purchase, transportation or processing of illegal timber (The People's Republic of China, 2019). In the light of the Glasow COP, China and the USA issued a Joint Declaration on Enhancing Climate Action in the 2020s which pledged to collaborate on eliminating illegal deforestation (The United States, 2021). In 2023, Brazil and China issued a joint statement on combating climate change whose point 11 explicitly refers to joint efforts to eliminate illegal deforestation **(Brasil, 2023)**[4].

Trase, which we have mentioned above, provides a detailed report on the risks of deforestation involved in Brazil and China's beef trade and identifies the municipalities where this risk is highest. In quantifying this risk, it also makes clear the feasibility of eliminating at least illegal logging from the beef chain of the leading exporters. It should be remembered, however, that some 100 Brazilian firms export beef to China according to ABIEC's latest annual report (ABIEC, 2024). In 2020, JBS signed an agreement with the Chinese W.H. Group which has some 60,000 retail outlets in China which means not only the opportunity of greatly increasing sales and, therefore, further pressure on the vulnerable biomes in question, but personalizes the links between Brazilian exporters and Chinese retail, which in principle should facilitate initiatives to exclude supplies from deforested lands (Best, 2020). On the other hand, according to Chain Reaction Research (2020), the WH Group does not have a zero-deforestation policy and received a note of 1 out of 5 from the not-for-profit Global Canopy (Global Canopy, 2024). At the same time, its investment partners include pension funds with deforestation and **ESG commitments**[5].

[4] Wood and wood products are outside the scope of this Report, but it is important to note that China is second only to the USA in wood and wood products imports, and is the leading exporter of finished wood products, especially to Northern countries. Brazil has become the leading supplier of wood and wood products to China (Wang; Sun; Zhu, 2023). In the first decade of the 2000s, China was seen by international NGOs to be the principal source of deforestation and illegal imports. China's 2019 Forest Law is, therefore, an important development as is the joint statement referred to in the text. Although it is illegal to export untreated logs from the Brazilian Amazon, controls are still very weak (Forest Trends, 2021). Worldwide, traceability techniques have been developed and offer a perspective for control by importing countries, (Kaulen *et al.*, 2023).

[5] A set of standards for monitoring firms referring to environmental, social, governance impacts.

The China Meat Association (CMA) and 64 Chinese companies have signed a Sustainable Meat Declaration (WWF, China..., 2023), but according to the Global Canopy Forest Report 500 referenced in the previous paragraph only 9 of the 30 largest beef companies had public commitments to ensuring that their supply chains were deforestation free. Two Chinese companies have declared deforestation as part of their Carbon Disclosure Project (CDP) commitments and the Fujian Sunner Group, which is also a signatory of the Declaration, claims to be able to trace 80% of its supply chain but argues that existing standards are still not adequate. McDonald's, Walmart and Carrefour which are all present in China have, for their part, committed to deforestation-free beef.

Table 4 - The five companies importing the largest volume of beef to China and related CO_2 emissions risk

Importer	Trade Volume (TONNES)	Trade Value (USD)	CO_2, Emissions Risk from cattle deforestation (TONNES)
Weston Importers	93.007	261.074.746	1.043.418
Parker Higliorini International GMBH	85.929	247.032.923	2.218.346
Total enterprise	23.458	66.385.034	462.032
Shangai New Source International Trading Co	21.478	66.973.058	200.357
Beijing Zhuochen Animal Husbandry Co	20.679	58.097.928	182.616

Source: Adapted from Trase Earth (2020, p. 10).

The balance sheet remains unclear. The perspective of increasing Chinese demand for beef and the greater, more fine-grained, access to its retail distribution networks suggest that pressures to expand production in the Cerrados and Amazon biomes will continue. On the other hand, there are signs that Chinese firms and the Chinese government are aligning themselves with global initiatives to eliminate deforestation, the principal source of carbon emissions in the beef chain. Syngenta's Program Reverte in collaboration with the NGO The Nature Conservancy (TNC), Itaú BBA, and EMBRAPA is working with over 250 farms to restore pastureland involving 165,000 hectares, with a goal of reaching 1 million hectares by 2030 (Recuperação..., 2024). Some R$500 million has already been applied to this initiative.

1.4. BRAZILIAN BEEF CHAIN EMISSIONS. LIFE CYCLE ANALYSES

The most detailed study of Brazilian beef chain emissions was carried out by the Fundação Getúlio Vargas (FGVces, 2019) in partnership with JBS, Minerva, and Marfrig involving 23 farms selected according to four criteria: production for the domestic market; production for export; production for export to the EU as part of the Hilton quota; and farms adopting environmental good practices within **structured programs**[6]. A detailed life-cycle assessment, involving the whole chain, was carried out as indicated in the **Table 5** below.

Table 5 - Brazilian beef emissions: life cycle analysis

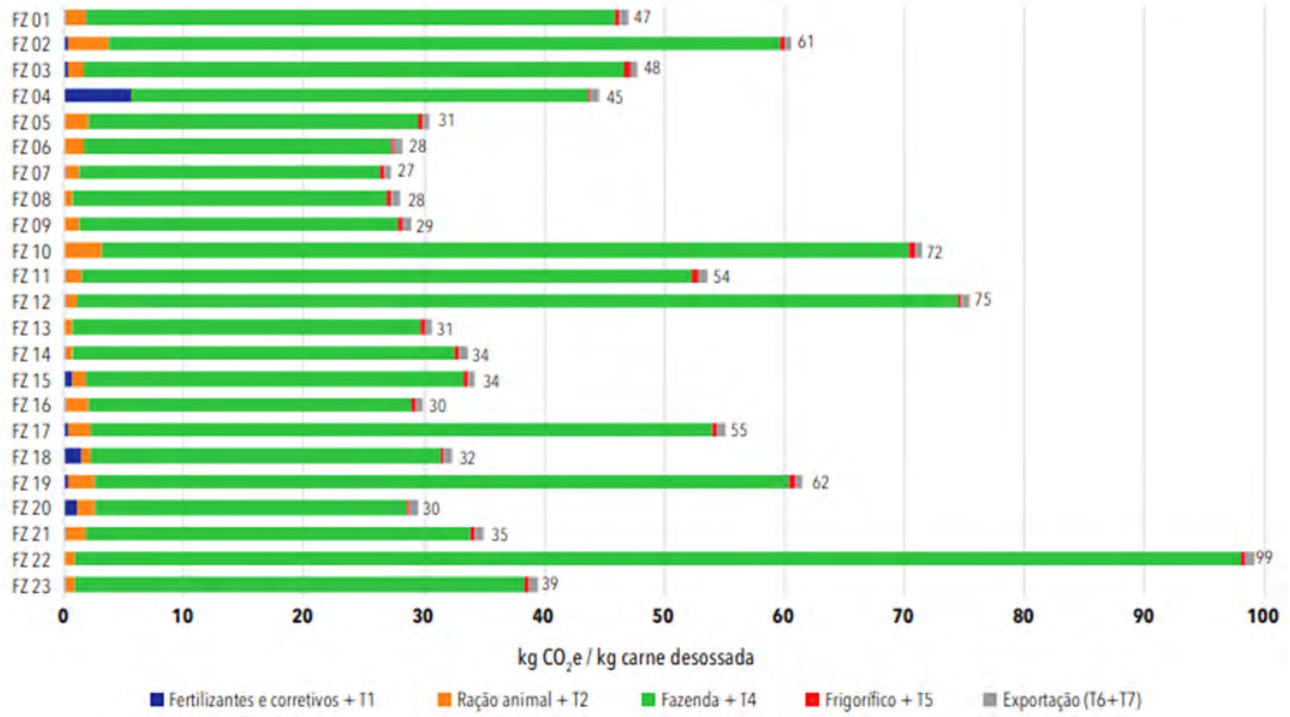
ETAPAS DO CICLO DE VIDA	PROCESSOS CONSIDERADAS EM CADA ETAPA
Produção de fertilizantes e corretivos	Produção de fertilizantes Produção de corretivos
Transporte 1	Transporte dos fertilizantes e corretivos até a fazenda (T1)
Produção de ração animal	Cultivo dos componentes da ração animal Processos agrícolas associados
Transporte 2	Transporte da ração até a fazenda (T2)
Animais comprados de outras fazendas	Atividades de cria e recria Manejo de dejetos Mudança direta do uso da terra (dMUT) Transporte de animais da fazenda de origem para outra (T3)
Fazenda	Aplicação de fertilizantes e corretivos (manejo de pastagem) Atividades de cria, recria e engorda Manejo de dejetos Mudança direta do uso da terra (dMUT)
Transporte 4	Transportes de animais da fazenda para os frigoríficos (T4)
Produção de energia elétrica e combustíveis	Produção de energia elétrica Produção de combustíveis Transporte de energia elétrica e combustíveis até o frigorífico (T5)
Frigorífico	Consumo de energia elétrica e combustíveis Tratamento de efluentes Processos industriais
Exportação	Transporte de produtos até o ponto de saída do Brasil (T6) Transporte de produtos até o ponto de chegadada na UE (T7)

Source: Adapted from FGVces (2020, p. 13).

[6] Other studies on Brazil's cattle emissions include FAO (2006), Opio *et al.* (2013), Bustamente *et al.* (2012) and Silva *et al.* (2018).

The results are presented in the following two figures. In the first, it is clear that on-farm emissions account for the overwhelming majority of emissions in all four cases. Animal feed is the only other significant source of emissions, with fertilizers and correctives making an occasional appearance. Slaughterhouse emissions and transport are notable for their low levels of participation.

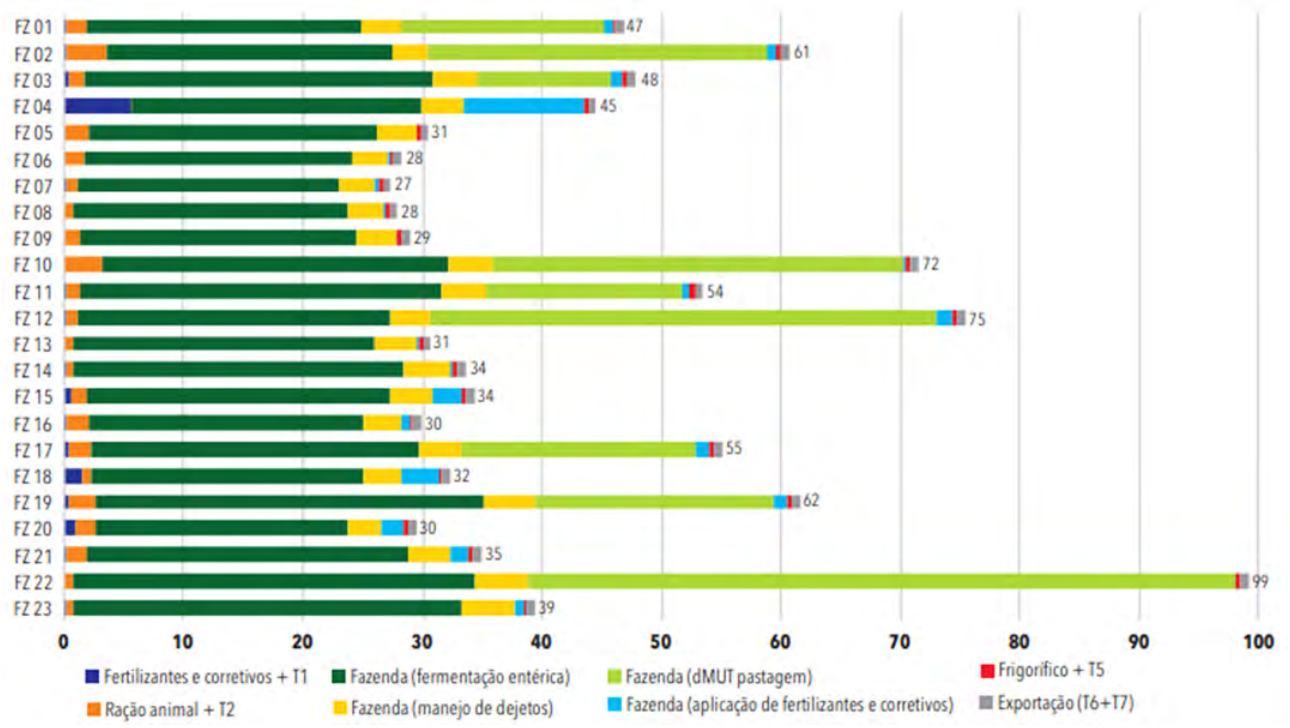
Figure 5 - Carbon Footprint for the 23 Farms Studied: Source and Stage in the Life Cycle



Source: FGVces (2020, p. 18).

Figure 6 distinguishes emissions directly produced in cattle rearing and here the central issue clearly becomes emissions from enteric fermentation on farms with established pastureland and where land-use change does not play an important role. In these cases, animal feed and waste management are also relevant sources of emissions, although to a much lesser extent.

Figure 6 - Emissions Directly Produced in Cattle Production



Source: FGVces (2020, p. 18).

While calculations are normally carried out in terms of CO_2 equivalent emissions, methane, and nitrous oxide are the principal gases when considering enteric fermentation and waste management respectively. The importance of methane emissions has attracted special attention since they are many times more potent than carbon dioxide but have a life span of 10-20 years in the atmosphere, much shorter than that of carbon dioxide. For short term impact, therefore, a reduction in the methane emissions from cattle raising is often presented as the only realistic hope of reaching the Paris commitments.

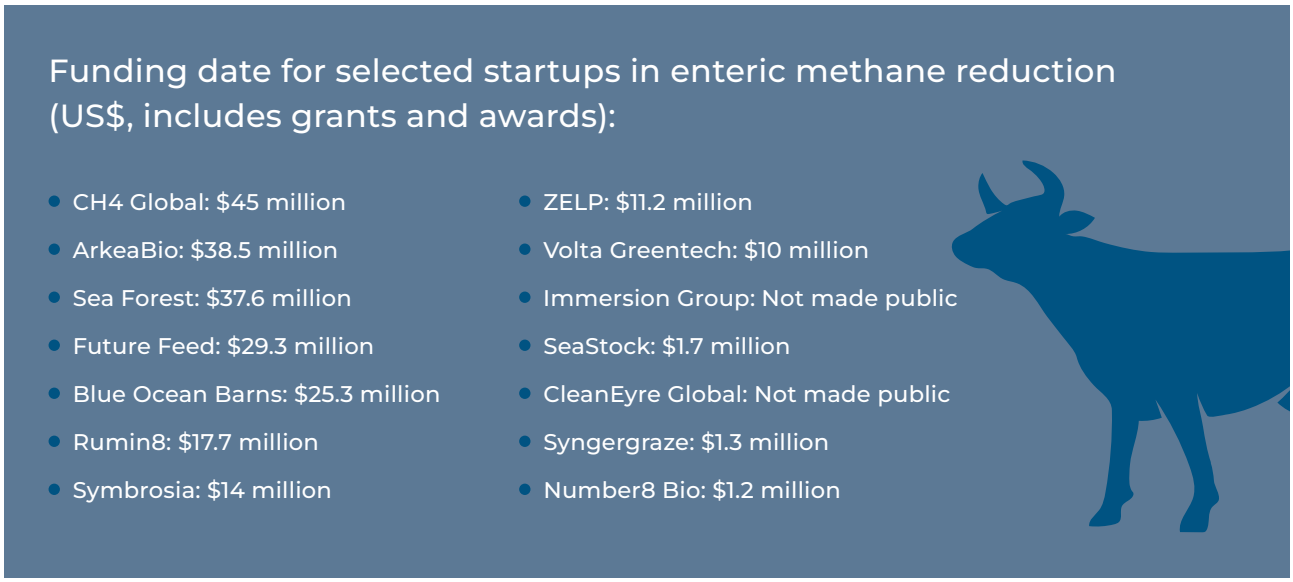
1.5. METHANE MITIGATION INITIATIVES

In 2022, the Institute for Sustainable Leadership at the University of Cambridge, England, published a report (Gidling; Salas; Cracknell, 2022) that presents the case for massive, short term methane emissions reduction through the combined resort to innovations in feed and ruminant digestion, in the management of cattle raising, the promotion of alternative proteins, and shifts in protein consumption. In doing so, the authors reinforce the UNEP Global Methane Report (UNEP, 2021) and the "World Scientists` Warning of a Climate Emergency" (Ripple *et al.,* 2020). This growing consensus led the EU and the US to form the Global Methane Pledge with the aim of cutting these emissions by 30% by 2030 which was signed by more than 100 countries at the COP 26 in 2021, including Brazil (Global Methane Pledge, 2024).

1.5.1. New Feed Additives

Field trials appear to be demonstrating the efficacy of new feed additives with DSM's Bovaer leading to a reduction of 90% for beef cattle and 30% for dairy, and Future Feed's asparogopsis seaweed also showing reductions of between 80-98% (Beef Central, 2024). Syngenta Seeds is promoting a corn variety for dairy cows, Enogen, which it claims reduces methane emissions, and has also carried out LCA analysis which concludes that these benefits can be extended to beef cattle (New research shows..., 2022). Agfunder has compiled a list (see below **Figure 7**) of startups innovating in enteric methane reduction either through new feed additives or through intervention in the digestive system.

Figure 7 - Startups for Enteric Methane Reduction and Funding



Source: Adapted from Watson (2024).

1.5.2. Cattle Management Practices

Regenerative farming practices are also claimed to be effective in reducing methane emissions, (Abramovay *et al.*, 2023), largely through restoring pasture lands, although the FGV study referred to earlier would suggest that these gains may decline once pasturelands have been restored. More efficient breeding and managements practices which reduce the time to slaughter without compromising carcass weight would also lead to lower levels of all three gases. China's demand that age of slaughter be thirty months or under has been an important influence here. At the COP 28 in Dubai in 2023, a Dairy Methane Action Alliance was formed by six of the leading global dairy firms: Danone, Bel Group, General Mills, Lactalis USA, Kraft, and Nestlé (EDF, 2024), in the same spirit as the Global Methane Pledge agreed to between the E.U. and U.S.A. at the COP 26 (GMP, 2024). Danone has pledged a 30% reduction of these emissions by 2030.

1.5.3. Alternative Proteins

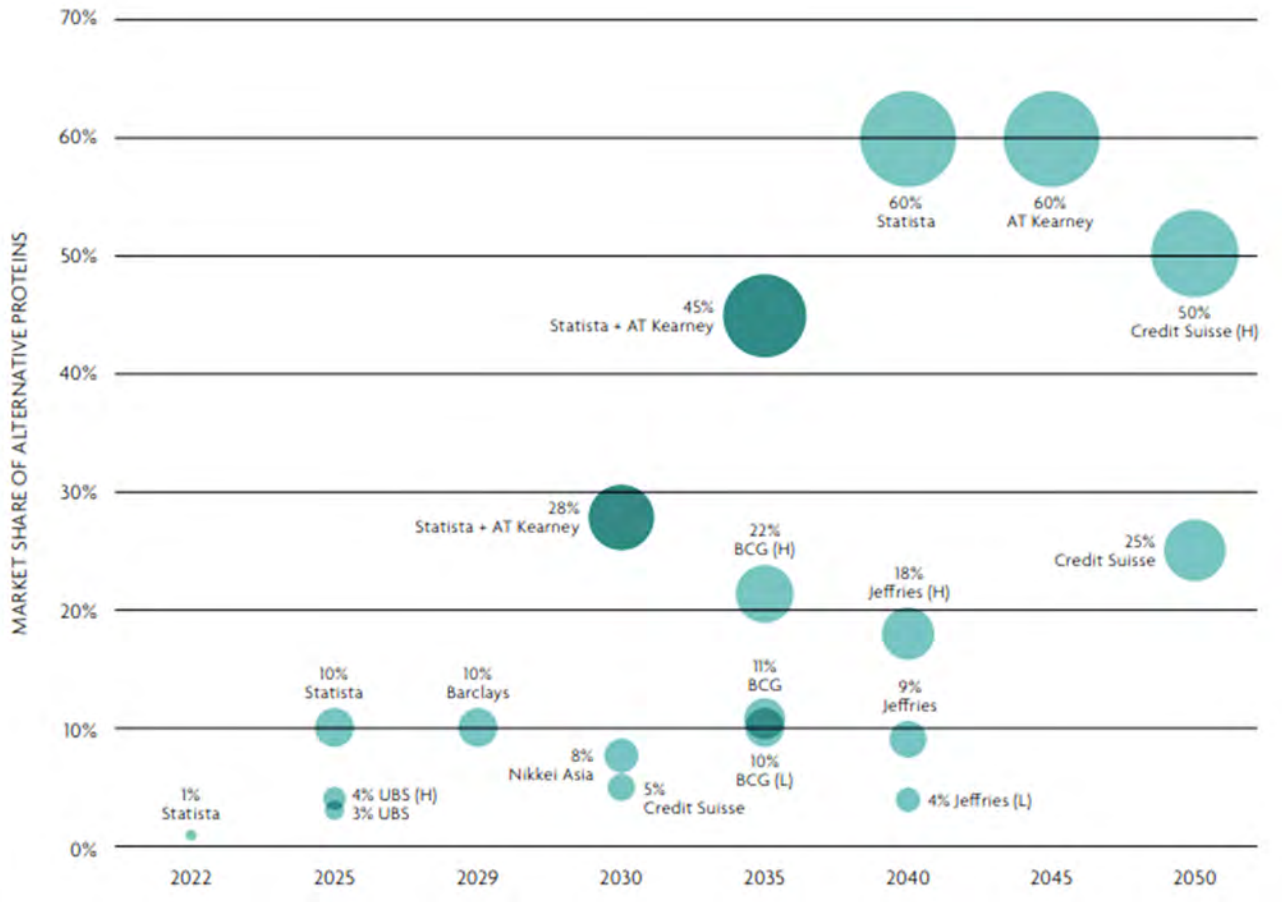
The promotion of alternative proteins forms a third component of these complementary strategies for reducing the carbon and methane emissions of traditional beef production. Although the initial speed with which these alternatives would come on-line, especially cultivated meat, has proved to be unrealistic, investments continue, and most leading incumbent "protein" firms are still engaged in their development. The number of startups engaged in different aspects of this emerging ecosystem and their geographical spread to continents other than the North are further indications that cultivated meat will become a component of the global protein market (Wilkinson, 2024b). **Figure 8** below provides a summary of the market share projections of leading consultancy agencies.

The jury is still out on the carbon footprint of alternative proteins. There is clearly an enormous saving on land, water, and feedstock. Energy use, however, is still largely imponderable, and the consensus points to the importance of integrating alternative proteins into the energy transition (Collet *et al.*, 2021).

Strong opposition to alternative proteins has emerged in some countries reflecting farmer opposition which finds an echo in the NGO world where alternative proteins are, with some important exceptions, identified with junk and/or ultra-processed foods (Howard, 2022). Brazil's leading meat firms – JBS, BRF and Marfrig – on the other hand,

have all invested in alternative proteins, and both JBS and BRF are promoting cultivated meat either directly or through investment in leading global startups. JBS is creating a research center in Florianopolis with a view to eventual industrial upscaling and BRF has investments in the Israeli startup ALEPH, one of the forerunners in cultivated meat (Wilkinson, 2024a).

Figure 8 - Scenarios for the Alternative Protein Market



Source: Fairr (2022).

1.5.4. Consumption Policies and Practices

And finally, consumer trends and public policies have become important factors calling into question the traditional animal proteins markets. Studies on all continents have called attention to the growth of vegetarian and vegan consumption patterns (Tsvakirai ***et al***., 2024). Research has also tended to confirm the strategies of alternative protein companies, identifying a broader flexitarian consumer trend, where there is a disposition to switch to alternative proteins to the extent that the original characteristics of animal protein could be reproduced (Dagevos, 2021). Most countries in their dietary guidelines call for a reduction in per capita meat consumption, identifying in particular high levels of beef consumption with a range of "food-related" illnesses which have become a public health concern (FAO, 2024). Several countries have been debating the introduction of a tax on livestock emissions and one has recently been decided on in Denmark to take effect as from 2030 (Danish liverstock..., 2024). The FAIRR Initiative, a network of global investors committed to the promotion of alternative proteins, encourages firms involved in meat production to work with shadow prices in the expectation of an eventual tax levy (Climate tax on..., 2017).

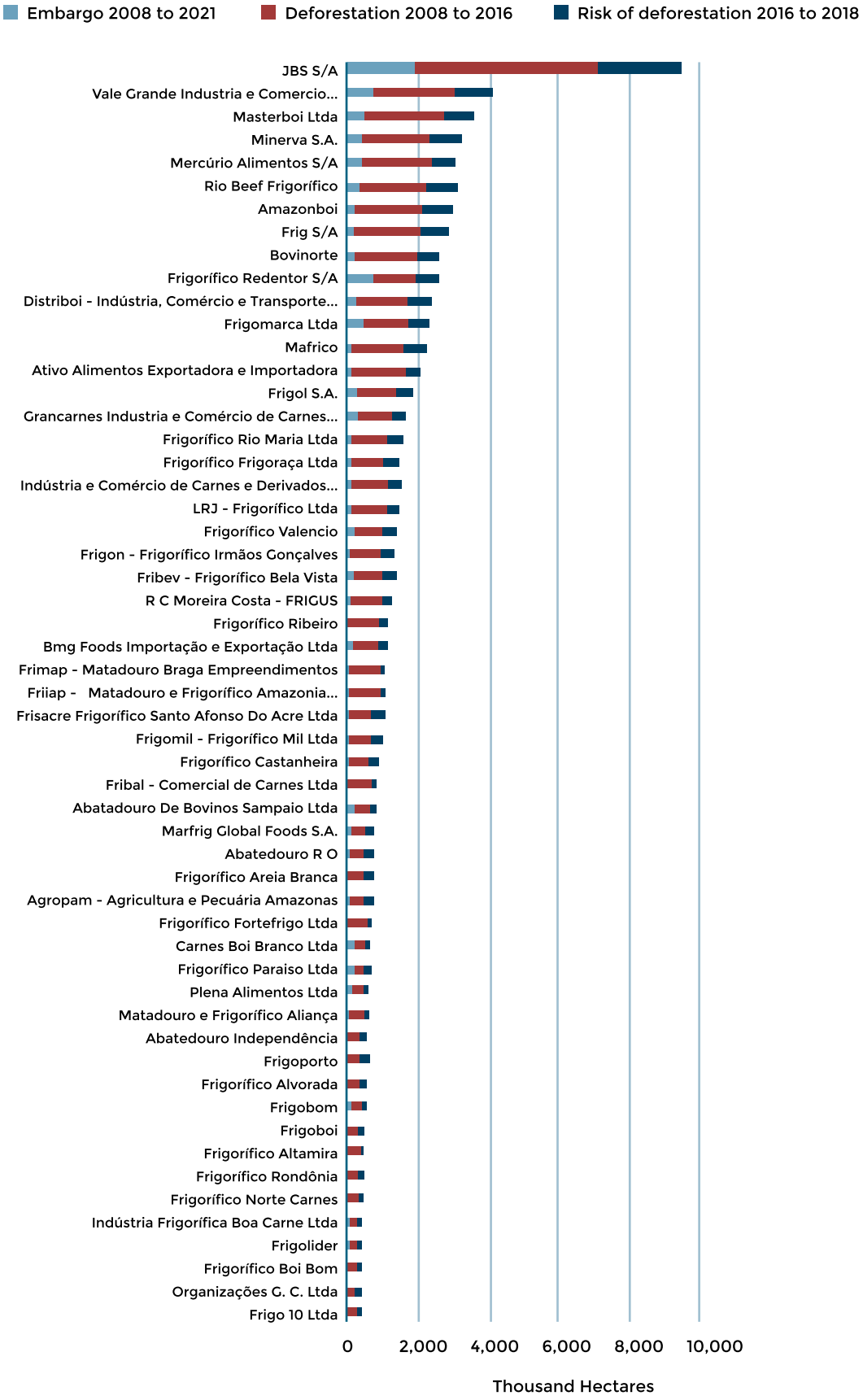
2. POLICIES AND COMMITMENTS OF COUNTRIES AND THEIR LEADING FIRMS DIRECTLY INVOLVED AS IMPORTERS OF BRAZILIAN MEAT

2.1. BEEF EXPORTER FIRMS AND IMPORTER COUNTRIES

As mentioned above, Brazil is currently the world´s leading beef exporter with its principal market being China, a market with a projected 6% year on year growth over the next decade (Malafaia; Biscola, 2023). Currently some 144 abattoirs are authorized to export to China, and the latest authorizations in in the State of Mato Grosso mean that, as from 2024, potential exports have increased from 11% to 57% of the State's beef. Although the big three – JBS, Marfrig and Minerva – are the leading exporters, Brazil, according to ABIEC (2024), exported to 123 countries in 2023, involving many firms and slaughterhouses, with major new markets just opening, such as Mexico and Indonesia. In the Amazon alone there are some 187 slaughterhouses, 87 of which have not signed Terms of Agreements (TAC), committing not to buy cattle from farms involved in deforestation (Are Brazilian beef companies..., 2023).

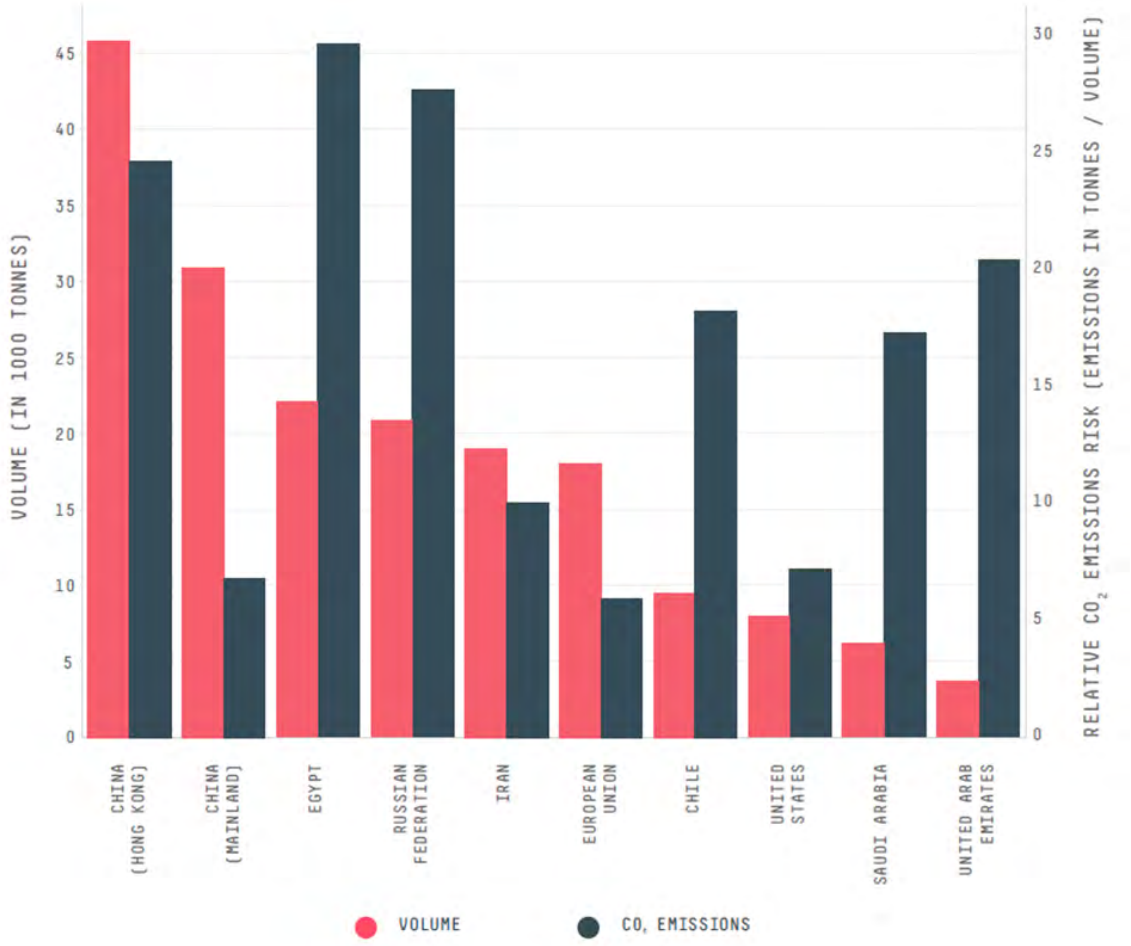
The environmental NGO Imazon has identified these firms and the risk they pose for deforestation. Vasconcelos (2022) and Vasconcelos, Ermgessen and Zhaing (2024) have similarly focused on the most important of these new markets. The risks of deforestation, based on both the number of slaughterhouses and firms currently exporting, and the profile of the importing countries where the identification of exposures to risks of deforestation are considered disproportionately high, point to the need to go beyond monitoring the leading exporters, and a similar need to commit more beef importing countries to the measures being adopted by the EU, the US and China discussed in part 1.

Figure 9 - Ranking of Firms in Relation to Deforestation Risks



Source: Adapted from Barreto *et al.* (2023, p. 33).

Figure 10 - Volume of Beef Imports and Risk of Deforestation



Source: Trase (2020, p. 4).

The EU, as we have seen, is putting in place the most incisive measures to decarbonize its imports. The logic here is impeccable and simply aligns imports with the requirements applied to the EU market. In this sense, it is irrelevant whether deforestation is legal or illegal in the exporting country. In this light, the parallel commitments assumed by the US and by China, which extend only to illegal deforestation in the country of origin, are inconsistent. Global climate commitments cannot be hostage to the inadequacies of exporter country laws and regulations. On the other hand, climate regulation should not be used to camouflage protectionism as would seem to be the case in the negotiations on a free trade agreement between the EU and the Mercosur countries.

Although Brazil's beef exports to Europe would undoubtedly increase significantly if a free trade agreement were to be reached, they currently pale in comparison with those to China, according to the data from ABIEC (2024), accounting for only 3.38% by weight and 5.25% by value of Brazil's total beef exports. Europe is also more important in the case of industrialized beef from the leading firms which is less likely to be subject to, although not immune from, a high risk of deforestation. The US market is somewhat more important, particularly to the extent that it now permits imports of fresh beef from Brazil, but here again its participation is modest: 6.04% by volume and 8.05% by value. In this perspective, it is China that assumes central importance and although, as we have seen, it has formally adopted a similar position to the US on excluding imports from recently deforested areas, not all its leading importers would appear to be on board. In addition, it has not signed the Global Methane Pledge, although it has adopted its own **methane targets**[7].

2.2. FORESTRY INITIATIVES

The New York Declaration on Forests at the Climate Summit of 2014 was signed by 38 National Governments, 20 Sub National Governments, 56 global firms, 15 indigenous people's organizations and 37 non-governmental organizations / civil society organizations (NGOs/CSOs) (Forest Declaration Assessment, 2014). In this Declaration we are presented with a plethora of collective commitments, alliances and funding programs aimed at the elimination of deforestation. The timescale set for the elimination of deforestation was 2020, a goal which was clearly not reached. At the Glasgow COP in 2021 there was a renewed commitment to deforestation with 145 countries signing a Declaration on Forests and Land Use (Forest Declaration Assessment, 2021).

A total of 193 countries signed the COP Paris Agreement which came into force in 2016 and by 2021 all had presented National Determined Contributions (NDCs), for the reduction of carbon emissions (UNCC, 2024). Many countries including Brazil have presented successive revised contributions, generally reflecting targets not, or unlikely to be, reached. Verbal commitments and international bodies proliferate, and global agendas evolve, as with the explicit commitment to an energy transition at the Dubai COP in 2023, but the targets remain elusive (COP28 ends with..., 2023).

[7] It should be noted that for most countries the Global Methane Pledge refers to fossil fuel emissions.

Leading firms and their associations have also committed to similar contributions, applying both to methane reductions, as in the case of the dairy firms mentioned above, and to targets for zero deforestation. The most significant of these is the Chinese Sustainable Meat Declaration signed together with the WWF by the China Meat Association and its 64 Member Companies, (WWF, China Meat..., 2023).This led to the publication of a detailed Specification for Meat Industry Green Trade in 2021 which includes the target of zero deforestation and not simply zero illegal deforestation extending also do indirect suppliers and not only to the final suppliers of beef to the slaughterhouse, the avoidance of sourcing from areas with a high risk of deforestation, the implementation of traceability measures and transparency in the reporting of sourcing transactions (Are Brazilian beef..., 2023). In addition, it should be mentioned that China, and other countries, authorize slaughterhouses on an individual rather than firm basis, which allows in principle for closer monitoring. The Imazon's analysis of the response of Brazilian firms and their slaughterhouses (Are Brazilian beef..., 2023) will be taken up in the next section, but the lack of disclosure identified in the sites of the firms has not had any noticeable effect on the Chinese importers' willingness to trade.

3. BRAZILIAN GOVERNMENT AND PRIVATE SECTOR MEASURES IN RELATION TO THE BEEF CHAIN TO ACHIEVE ITS NDC COMMITMENTS ACCORDING TO THE PARIS COP AGREEMENTS

3.1. BRAZIL'S INITIATIVES ON CLIMATE CHANGE IN THE EARLY 2000s

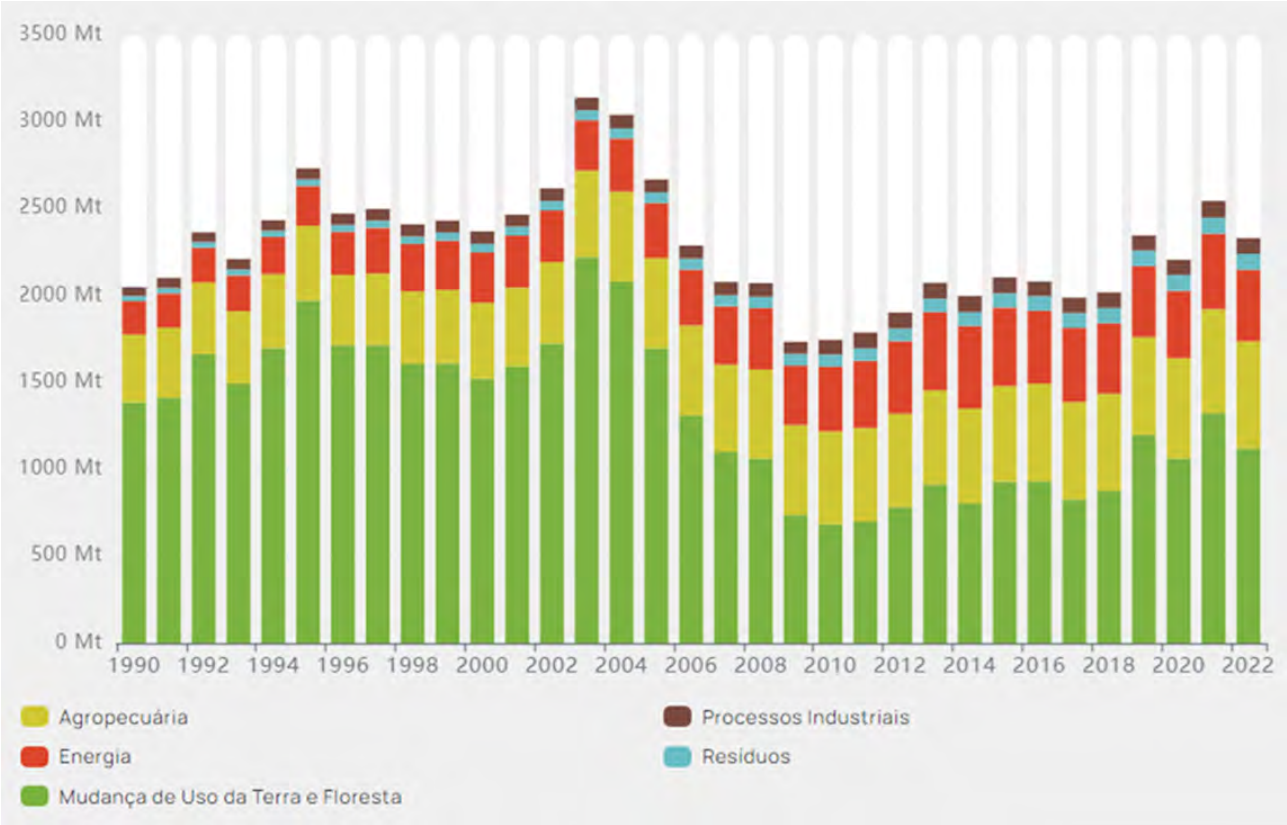
Brazil published a National Policy on Climate Change in 2007 which was then spelled out in the form of a National Plan on Climate (Brasil, 2007) focused on five sectors: i) Reduction of deforestation in the Amazon, (80%); ii) Reduction of deforestation in the Cerrados; iii) Energy; iv) Agriculture and Cattle Raising; and v) Industry. As regards deforestation, agriculture, and cattle raising, many of the elements which compose current policies were already present – the goal of ending illegal deforestation; satellite monitoring of deforestation using several systems, such as the Program for the Monitoring of Deforestation in the Brazilian Amazon Forest by Satellite (PRODES), the System for Detecting Deforestation in Real Time (DETER), and the Detection of Selective Exploration (DETEX); an ambitious program for the recuperation of degraded pasture land; the promotion of integrated crop, grazing and forestry systems (ILPF); and the promotion of the Rural Environmental Register (CAR), to monitor land use at the individual farm level (Brasil, 2007) .

The following year, the Brazilian Ministry of Agriculture launched the National Low Carbon Agriculture Plan (Plano ABC) with favorable lines of credit for the adoption of these proposals. In the following decade some 38 thousand credit contracts were signed to a value of R$32 billion. The Plano ABC+ updated these policies in 2020 with a more specific focus on targeted mitigation of emissions and the National Policy on Climate Change is itself now being updated, based on public feedback, and to be implemented as from 2025 (Brasil, 2024c).

There are some notable differences, however. The National Low Carbon Agriculture Plan (Plano ABC) was elaborated before the 2008 financial crisis, when the agricultural scene was dominated by the promise of biofuels. In the first Lula government, Brazil's sugarcane-based ethanol was projected on a global scale both in terms of potential markets and diplomatically as a strategy of green development for the global South. As a tradeoff, it was argued that these goals could be achieved without impinging on the Amazon and Cerrados biomes and a zoning policy was implemented to ensure this. Secondly, while the policies to curb deforestation are central, there is no explicit connection made between deforestation and the expansion of cattle. In fact, the focus is on

the expansion of soy at the expense of cattle, with the latter's principal export markets still seen to be the US, Japan, Mexico and the South Korea. Soy in expansion could expand through the recovery of degraded pastureland. The major absence in the program document is China which was still to make itself felt and whose future impact seems not to have been considered. These were optimistic times, and the Figure below shows that this was a period of declining emissions.

Figure 11 - Emissions by Sector 1990-2022



Source: MCTI (2023).

3.2. ZERO DEFORESTATION: ADVANCES AND CHALLENGES

In the following decade, the global and national NGOs — Greenpeace, WWF, Friends of the Earth, Reporter Brasil, and Imazon — together with monitoring entities such as Trase and Chain Reaction Research, played a leading role in identifying the intimate relation between deforestation and the advance of soy and cattle raising, and promoted public-private commitments to exclude sourcing from areas identified with deforestation, the most notable being the Soy Moratorium and the Cattle Pact, already mentioned.

Leading firms such as Cargill and JBS integrated their data bases on suppliers into the public data bases on land use, indigenous land rights, and labor conditions, automatically excluding properties in noncompliance. JBS has committed to the elimination of deforestation by 2033, and to net zero emissions (Scope 1), and 100% renewable electricity (Scope 2) by 2040 (JBS, 2023). Cargill's Scope 3 commitment is to reduce carbon emissions by 30% per ton by 2030. Marfrig committed to the elimination of legal and illegal deforestation and to a 68% reduction of Scope 1 and 2 emissions by 2035 based on 2019 levels, and to a 33% reduction of Scope 3 emissions by the same date. However, Marfrig sold off its cattle slaughter and deboning facilities to Minerva in 2023, whose commitments extend only to the elimination of illegal deforestation, and the deal is thought to increase deforestation risk (Mielnik; Richardson, 2023).

Trase, as we presented in the previous section, has shown that it can pin-point locations and levels of deforestation risk. Chinese business is formally committed to exclude deforestation from its supply chain and, given that it authorizes slaughterhouses for export on an individual basis, can in principle control all direct suppliers. The global players operating in Brazil are similarly committed to deforestation, although the legal/illegal distinction is still operative in the case of Minerva.

Zero deforestation, therefore extending to indirect suppliers, is the fundamental challenge and this requires more than the existing commitments of leading players. The Brazilian Forestry Code requires that rural properties are environmentally registered. Although more than 6 million CARs have been submitted, a very small percentage have been analyzed with highs of 20% in the State of Paraná and 12% in Pará but lows 1-2% and under in other States (Apenas 2,7% do..., 2024). Even where levels of analysis are higher, the number of farms which have registered their agreement with the analysis is minimal. The CAR could be a decisive instrument for monitoring deforestation but to date it is clearly not effectively operational.

Specifically relating to the cattle supply chain, all movements of cattle should be accompanied by a document registering transport from one farm to another, the GTA, but these it seems are subject to fraud (Operação Paper OX..., 2024). For effective traceability these two instruments, the CAR and the GTA, must be operational, but this requires robust institutional and human capacity, both of which were severely weakened during the Federal Government, 2019-2022, a period which also saw retreats in the repression of illegal deforestation. Traceability also requires agreements on the methods to be adopted, and as we have seen above, there is still disagreement over the extent and the form in which traceability should be implemented.

According to Trase, in 2022 JBS, Marfrig, and Minerva accounted for 61.3% of Brazil´s beef exports (Vasconcelos; Ermgassen; Zhaing, 2024). This still leaves some 40% being exported by other players. Trase's data indicate that there are some 7.671 slaughterhouses in Brazil, and while the Big 3 clearly have the largest slaughter capacity their combined slaughterhouses amount to 59. In the Amazon alone, as we have seen above, there are 187 slaughterhouses and 87 of these have no TAC agreement on deforestation. According to the IBGE Census of 2017, there are some 500.000 family farms in the Amazon region with 78% of these raising cattle, and some 200.000 depending on cattle for their survival (Abramovay *et al.*, 2023). In addition, therefore, to the efforts to engage and monitor the leading players, efforts must be extended to this broader cattle economy which is the mainstay of so many families in the region and demands supportive policy measures.

CONCLUSIONS AND POLICY PROPOSALS

There is no lack of information, analysis, technology, or policies for advancing decarbonization in the Brazilian beef production sector. Intense pressure from NGOs and reputational concerns have committed the leading players to Scope 1, 2, and 3 goals. Nevertheless, as we have seen, the cattle economy involves an enormous universe – of both slaughterhouses and farmers - which is less covered by all these measures, and which has proved resistant to closing the loopholes on deforestation. It is unlikely that this situation will change substantially during the timeline set for decarbonization.

Measures must clearly be adopted to extend monitoring, inspection and repressions to all the farms and slaughterhouses in the Amazon and other vulnerable biomes. There are indications that IBAMA is now restoring its capacity to punish illegal deforestation as in the fines to the value of R$364 million handed out to JBS and 22 other slaughterhouses, involving 18,000 head of cattle from 69 farms in the States of Pará and Amazonas, in October 2024 (Gabriel, 2024).

Important initiatives have been taken by the China Meat Association and its company members to eliminate contamination of beef chain imports from recent deforestation. These appear now to be supported by the full weight of the Chinese State. After a technical visit at the end of 2023, China made clear that it would require full traceability to be applied to its beef imports. According to the Global Environmental Institute, a Chinese NGO, this measure is expected to be implemented in 2025 (Vilarino, 2024). With this decision, China aligns its demands to those of the European Union and establishes new minimum conditions for Brazil's beef exports.

In addition to repression and the application of new minimum standards for exports, which can only be partially effective given the vast numbers of farmers depending on cattle-raising in these biomes, the majority of whose consumption is directed to the domestic market, the promises of alternative bio-economy initiatives must be vastly expanded as also the financial incentives for climate services rendered.

Pressured by the need for commitments in the light of the COP29 in Baku, Azerbaijan, in November 2024, Brazil released a new version of its NDC commitments and a detailed plan for the climate which includes the following programs: Fuel for the Future, Green Mobility, Eco investments, and Targets for the Recovery of Native Vegetation and for the Reduction of Deforestation (Brasil, 2024b). The NDC establishes a range for these reductions of 59%-67% in relation to 2005 emissions. These NDC commitments and the

accompanying document delineating specific programs are designed to establish a leadership position for Brazil in the run up to the COP30 in Belém, 2025.

According to the Climate Observatory (CO), however, which represents some 119 NGOs and social movement organizations, the targets represent a significant retreat from the commitments made by the Lula Government at COP28, a position endorsed also by the Climate Action Tracker. The CO argues that the reduction target should be 95% in relation to 2005 emissions. Zero deforestation, it notes, has also been replaced by targets which allow for continued deforestation, and are related only to illegal deforestation. Nevertheless, the need for Brazil to assume a protagonist position given its hosting of COP30 favors a continued advance in its climate policies (NDC misaligned with..., 2024).

A second measure, also taken in the light of COP29, was the approval of the law proposal nº. 182/2024, which creates the Brazilian System of Trade in Greenhouse Gas Emissions (Brasil, 2024c). Before this is operative, however, there will be the arduous task of regulation. This "cap and trade" system is in line with similar regulations in the EU, California, and Canada, and it is hoped that it might bring important levels of investments for the goals of "keeping the forest on its feet" and for the recuperation of degraded pastureland.

As we have seen, methane is the main source of emissions in the beef supply chain. Lines of research which might reduce methane emissions, whether through genetics, new pasture varieties, new feedstuffs or innovations regarding ruminant digestion, should be given full priority by funding bodies and through cooperation with global players. Taxes on methane emissions are now widely discussed and are being put into place, as we have seen, in Denmark. In Brazil, perhaps a more appropriate approach would be to vastly expand resources for the adoption of regenerative cattle raising practices with penalties for non-adoption.

Equally important are measures to influence the demand side focusing on consumer practices in the light of public health concerns over the consequences of high levels of beef consumption. Decisive here will be the speed with which alternative proteins can be developed. Despite the expected opposition of entrenched rural interests, Brazil has a favorable regulatory framework, and the leading meat firms seem committed to promoting this addition to their traditional protein products. Although the timeline has been pushed back, alternative proteins continue to advance in many directions simultaneously but will require vastly higher levels of investment if they are to influence the timelines for decarbonization.

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