BRAZILIAN **BEEF CATTLE** PRODUCTION AND ITS GLOBAL CHALLENGES

2025

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SUMMARY

EXECUTIVE SUMMARY

This document analyzes the Brazilian beef system, highlighting its economic and sociocultural importance, the associated socio-environmental challenges, and the adopted strategies. It summarizes the "Brazilian beef cattle production and its global challenges (2025)" Whitepaper that presents the pillars for sustainable development in Brazilian cattle ranching and for decarbonizing the activity, considering pasture stewardship as a driver of this process.

The global context of climate change, highlighted by the IPCC and events such as COP30, calls for urgent decarbonization of the economy and a search for sustainable food systems (SFS). The beef system is recognized as one of the most complex ones, with distinct cultural, economic, and environmental aspects in each country. In Brazil, agribusiness accounts for about 22% of total GDP (CEPEA, 2024) and is the industry that is most exposed to international competition. The livestock industry accounted for 23.2% of agribusiness GDP and 5.1% of total Brazilian GDP in 2024.

According to Stabile et. al (2024), beef cattle production in Brazil has evolved significantly, especially after the Real Plan (1994) and the opening of trade. Advances in nutrition, health, and genetics have driven industry's development and exports. Brazil has become the world's largest exporter of beef, with 3 million metric tons (carcass equivalent), although the domestic market is the destination for about 70% (7.65 million metric tons carcass equivalent) of the total production of 10.6 million metric tons (carcass equivalent[1]) in 2023 (ABIEC, 2024). The importance of exports and their exponential growth, especially to China, and the increasing opening of new markets are directly related to cattle price increases and intensification of part of the production.

Despite market achievements and advances in production, the industry faces social, environmental, and institutional challenges, such as the association of cattle ranching with deforestation, high greenhouse gas (GHG) emissions, pasture degradation, herd traceability, lack of technology across the country, and exclusion of small producers from the production transition process. These challenges highlight to the world the low sustainability of cattle ranching (or Brazil as a major beef supplier), not considering the positive attributes of the chain or the difficulties in coordinating public and private institutions.

[1]The carcass weight equivalent (CWE) is a measure used for standardizing the weighing of beef, which can be compared to the weight of the animal's carcass, which is a percentage of the animal's live weight.

Deforestation, especially in the Legal Amazon[2], is a persistent concern, although Brazilian agricultural productivity has grown significantly with less incorporation of new land in recent decades. Furthermore, the Cerrado has been the focus of much criticism due to changes in land use, even if these are legally based. One of the factors behind this criticism is the fact that land use change is the largest source of greenhouse gas emissions in Brazil, accounting for 39.5% in 2022, which is more than that of the agricultural industry, at 30.5% (Brasil, 2025b).

Another issue related to this activity is emissions from agriculture and livestock, which in Brazil are mainly dominated by methane (CH_4) and nitrous oxide (N_2O), with enteric fermentation from cattle being the main source of these emissions (80%). Pastures undergoing moderate or severe degradation are also a source of emissions. However, it is essential to demonstrate that there is potential for capture through pasture stewardship and integrated systems. Embrapa has shown that beef production can be carbon neutral. This has resulted in the creation of a certification registered with the INPI called *"Carne Carbono Neutro"* (Carbon Neutral Brazilian Beef) for animals produced under intensive grazing conditions and in integrated systems. The forest component is relevant for achieving neutrality. In this sense, restoring and intensifying cattle ranching reduces emissions and boosts productivity gains.

In this debate on land use and emissions, it is worth noting that Brazil has institutions that guide forest conservation and regulate land use. The Forest Code is a fundamental public instrument for conserving native vegetation on rural properties, requiring registration in the Rural Environmental Registry (CAR), and conserving or restoring Permanent Preservation Areas (APPs) and Legal Reserves (ARLs). However, the assessment of the CAR and the effective implementation of the Environmental Regularization Program (PRA) in several states is still ongoing (delayed), compromising the country's public image.

In addition to regulatory institutions, the Brazilian government provides public policies for low-carbon agriculture, such as *Plano ABC* (2010-2020), *Plano ABC+* (2020-2030) and, more recently, Decree N. 11815/2023, the National Program for Converting Degraded Pastures into Sustainable Agricultural and Forestry Systems (PNCPD), which was recently incorporated

[2] The Legal Amazon corresponds to the area covered by the Amazon Development Authority (SUDAM), as defined in Article 2 of Complementary Law No. 124 of January 3, 2007. The Legal Amazon was established for the purpose of defining the geographical boundaries of the political region covered by SUDAM, aiming to foster inclusive and sustainable development of its operating area and the competitive integration of the regional productive base into the national and international economy. The region comprises 733 municipalities in Acre, Amazonas, Roraima, Pará, Amapá, Tocantins, Mato Grosso, and Maranhão States. Its total area is approximately 5 million square km, corresponding to around 58.92% of Brazil's territory, but it is inhabited by only 12.32% of the Brazilian population (IBGE).

into the federal government's *"Caminho Verde Brasil: restauração de terras e segurança alimentar"* ("Brazil Green Way: land restoration and food security") initiative (Brasil, 2025c).

The policies and programs incentive recovering and converting degraded pastures into sustainable production systems, such as no-till farming (NTPS), integrated systems such as crop-livestock-forest integration (iLPF) and other practices and technologies that have the potential to mitigate GHG emissions and increase productivity and climate resilience of livestock, agricultural, and forestry activities (Harfuch et al., 2024). However, public incentives are not entirely capable of financing and achieving full land use change, pasture intensification, and adoption of best practices. Financial resources are finite, and demand and urgency require that other kinds of financing be developed from private and international financial resources and funds to compose blended finance for driving new technologies and small producers.

According to the Agriculture Ministry (Brasil, 2024), there are at least 27.7 million hectares (Mha) of degraded pastures with potential for conversion to sustainable production systems, distributed across 1.02 million private rural properties. For nine Brazilian states selected by the study, the recovery or conversion of 23.1 Mha of degraded pastures in these systems requires initial investments of at least R$ 139 billion, in addition to operating costs that can reach R$ 90.8 billion per year.

Despite the environmental and economic challenges, the social aspect refers to the marginalization and difficulties faced by small producers. Lack of technical assistance, difficulties in accessing credit, or even knowledge of management practices impact the adoption of technologies and good production practices (genetics, adequate nutrition, animal and local health), compromising their activities and profitability in the long term.

Small producers account for a significant share of livestock production and include many families living in the field. However, they are often associated with underdevelopment in the industry, as they lack access to technical assistance, rural credit, and technology. Informality in the cattle supply chain also hinders traceability and social and environmental monitoring.

Unlike agriculture, small cattle farmers are not connected to cooperatives, input suppliers, and other sources that can provide information, technology, technical assistance, and financial support. Small cattle ranchers are providers of calves (in many cases) and conduct other activities on their ranches as a form of diversification and subsistence. Lack of land tenure or land regularization is a bottleneck for development, as it marginalizes small producers who wish to work in line with the country's public and private policies.

Although challenges and bottlenecks persist in the industry, they should be seen as an opportunity for Brazil to contribute to the global agendas for sustainable development, climate change mitigation and adaptation, food security, and poverty reduction. A study coordinated by ABIEC (Lima & Lemos, 2024) addressed the pillars for a sustainable transition of beef cattle ranching, which should be implemented with continuous engagement of rural producers in the actions identified: (i) expanding adoption of technologies and good production practices; (ii) compliance with the Forest Code (analysis and validation of the CAR and its use across the beef chain); (iii) traceability and sanitary and environmental monitoring; (iv) access to diversified financing; (v) productive inclusion of cattle ranching (small producers).

Among the aspects already mentioned, it is worth highlighting the importance of cattle traceability in the country. Although the system proposed by the National Plan for Individual Identification of Cattle and Buffalo (PNIB) is voluntary (during its implementation phases), traceability and individual cattle data production is a matter of health security for Brazil, which recently achieved the status of a country free of foot-and-mouth disease without vaccination, but which shares borders with many South American countries, posing an imminent risk. In this sense, as the herd is traced, diseases and areas can be isolated, without compromising trade.

Herd traceability for environmental reasons is another key issue for the supply chain as a way of ensuring legality of animals and that the origin of production is free from deforestation. In addition to these environmental attributes, producing microdata from cattle establishments contributes to gains in public and private management and in opening markets coordinated by environmental attributes. However, this remains part of future developments as implementation progresses in the states in terms of data infrastructure and traceability models.

As key players in the transformation of cattle ranching, meatpacking plants, especially those that serve the entire national territory and exports with the Federal Inspection System (SIF), have stood out for their role in coordinating this agri-food system, driving improvements in quality standards and processes, and encouraging the adoption of technologies by producers through financial and non-financial incentives. This role is seen as crucial to driving sustainability in the chain due to market pressures, especially international ones. However, dealing with social and environmental issues still represents a dimension that requires collaboration with the public and financial sectors and society.

The case of Marfrig, one of the global leaders in the industry, illustrates this transition. Since 2009, the company has made commitments to decouple its production from deforestation in the Amazon, implementing geo-monitoring systems and strategic partnerships. In 2020, it launched the Marfrig Verde+ Program, with the goal of ensuring that 100% of its production chain is sustainable and free of deforestation by 2030, a commitment that has been brought forward to 2025.

The inclusive approach aimed at supporting supplier regularization in social and environmental non-compliance, rather than excluding them, involves financial mechanisms, technical assistance, and monitoring indirect suppliers. This way, more than 4,000 suppliers have been reintegrated into its supply chain. Marfrig's strategy, with clear targets for eliminating new deforestation in its chain, seeks not only to meet market demands but also to generate positive social and environmental externalities and foster systemic change in the industry.

Finally, the Brazilian beef system is economically vital but faces serious environmental and social challenges. Public policies and private sector initiatives, such as *Plano ABC+*, the *Caminho Verde Brasil* (Brazil Green Way) initiative, and the initiatives of meatpacking companies, point to a path to sustainability based on technology, innovation, social inclusion, and transparency.

However, effective coordination of implementation actions, especially by meatpacking companies, and collaboration between the different organizations involved in the chain and governments, including the challenge of financing, are essential for overcoming these challenges and ensuring that Brazilian beef production continues to contribute to global food security in a sustainable and inclusive manner.

GLOSSARY

Agribusiness:

A concept developed by Davis Goldberg (1957) at Harvard University, representing the total monetary value of all operations involving: producing and distributing inputs and capital goods for agriculture; production operations on agricultural establishments; and storing, processing, and distributing produced agricultural products and items such as food, beverages, fibers, renewable energy, wood, paper, and pulp for consumers.

Agribusiness system model:

Based on the agribusiness concept, Goldberg (1968) built the model based on industry analysis and highlighted the intersectoral, institutional, and organizational connections involving laws, associations, cooperatives, research institutions, and universities.

Beef chain:

This is the beef agribusiness, comprising the entire supply chain.

Beef cattle ranching system:

Group of production agents, including all suppliers that can be organized into diverse types of systems to meet the demand for cattle, organizations that influence this chain, such as universities, technology companies, associations, non-governmental organizations, and domestic and international institutions.

Livestock production systems (beef):

Productive combinations that take place within the farm gate. They range from the choice of type of activity performed in beef cattle ranching, such as breeding, rearing, fattening, complete cycle, feedlot, as well as the technologies used to perform their activities.

Industry:

Beef cattle industry or beef production industry.

Processing companies or processing industry:

Companies that are responsible for slaughtering and processing beef production; meatpacking plants.

1. CONTEXT

The "Summary for Policymakers" report (IPCC, 2022) presents a clear message regarding interdependence between climate, ecosystems, biodiversity, and human society. The clearly noted impacts on ecosystems around the globe should be noted in the structure of the oceans, freshwater, as well as the terrestrial impact on species and weather phenomena. The consequences for human systems are direct in food production, health, well-being, and urban infrastructure, which can be affected by climatic conditions.

The increasing severity of climate change and extreme weather events around the world further emphasizes the importance of the global challenge of reducing emissions by 45% by 2030, based on 2010 levels, as a factor in achieving the Paris Agreement targets. In January 2025, the World Meteorological Organization (WMO) confirmed that global temperatures reached a record high in 2024, exceeding 1.55°C above pre-industrial levels for the first time[3].

The 27th Conference of the Parties (COP27) to the United Nations Framework Convention on Climate Change (UNFCCC) took place in Sharm el-Sheikh from November 6 to 12, 2022, and highlighted this emergency. Public and private action is urgently needed for decarbonizing the economy. Even if all the targets proposed by the Parties to the Paris Agreement are implemented, the temperature could rise by 2.9°C, and a number of impacts will continue to occur or even worsen, especially in countries that are less adapted.

In addition, COP27 was a key moment for driving climate action toward climate neutrality. An important agreement signed between Brazil, Indonesia, and Congo to create a trust fund for preservation and an environmental mechanism underscored Brazil's leadership at the event.

In the Global Stocktake decision adopted at COP28 in 2023, relevant targets for the future of global decarbonization were adopted (UNFCC, 2024):

- Triple the share of renewable energy globally and double the global average annual rate of energy efficiency improvement by 2030.
- Accelerate efforts to eliminate use of coal from projects that do not reduce, capture, or offset emissions.

[3] Available at: https://wmo.int/news/media-centre/wmo-confirms-2024-warmest-year-record-about-155degc-above-pre-industrial-level

- Foster net-zero energy systems using zero- or low-carbon fuels by mid-century at the latest.

- Move away from fossil fuels in energy systems in a fair, orderly, and equitable manner, accelerating action in the next decade, aiming for emissions neutrality by 2050.

- Accelerate zero- and low-emission technologies, including, among others, renewable energy, nuclear energy, reduction and removal technologies such as carbon capture, utilization, and storage, especially in hard-to-reduce industries, as well as low-carbon hydrogen production.

- Accelerate and substantially reduce methane emissions by 2030.

In addition, the Declaration on Sustainable Agriculture, Resilient Food Systems, and Climate Action was signed by more than 160 countries, including Brazil . However, COP28 highlighted the challenges of significantly expanding the sources and volume of financial resources for funding climate action.

COP29, which was held in Baku, Azerbaijan in 2024, approved a new financing target and the required elements for carbon markets' functioning, among other decisions (UNFCCC, 2025). Developed countries should finance USD 300 billion per year to developing countries, an amount that is still far short of what is needed for implementing climate actions, even though USD 1.3 trillion per year has been approved, which will depend on debates to unlock multiple sources of financial resources.

The climate funding theme, which aims to build a roadmap for the USD 1.3 trillion target to be achieved by 2035, will be a central theme at COP30 (called the Baku-Belém Roadmap), and countries must present their updated NDCs, with emission reduction targets for the 2031-2035 period, (Lima, 2025). COP30 in Brazil and the Amazon in 2025 enhances the country's role in its commitments to climate adaptation and mitigation actions. At the same time, companies around the world are taking the lead in improving their businesses toward climate transition.

Considering this context, this document aims to explore the challenges faced by the Brazilian beef cattle system, especially related to the main environmental and social issues that are at the heart of the United Nations 2030 Agenda for Sustainable Development Goals. The second topic presents economic data on the evolution of the beef cattle system in Brazil and its economic importance for the country.

[4] Available at: https://www.cop28.com/en/food-and-agriculture

The third topic presents environmental and social aspects of the beef cattle system and related concerns regarding deforestation, implementing the Forest Code, and greenhouse gas (GHG) emissions. Social issues are presented alongside cultural aspects of consumption in Brazil, as well as the exclusion and difficulties faced by small landowners and family farmers in this system.

From the food system's standpoint — the fourth topic in this document — it brings the beef cattle system to the debate at the Food Systems Summit (FSS). This topic addresses the discussion and indicates Brazil's position and commitments until 2024. In July 2025, the Food Systems Summit will meet to update actions and results.

The fifth topic presents a more conceptual discussion on coordinating this system and its importance. Processing companies are presented as the coordinating agents. Quality programs developed by meatpacking plants are only a first glimpse of the leadership role they play. The historical evolution of environmental issues in the Amazon linking the beef chain to deforestation and their actions are another example of system coordination.

The sixth topic presents the case of Marfrig on how to deal with the challenges posed since 2009 regarding the relationship between its beef cattle system and the environment. As a leading company, Marfrig has been establishing strategies for measuring and monitoring the environment as an asset of its products, and for the company to be coordinated and evaluated by systems and markets. The last topic presents the final considerations.

2. BEEF PRODUCTION IN **BRAZIL**

This topic aims to provide an overview of the Brazilian beef industry and its economic and sociocultural importance, offering a historical perspective on the industry and its evolution through qualitative analysis and data. It also presents an analysis of Brazilian markets – domestic and foreign – and provides a picture of domestic per capita consumption. The last section of this topic highlights opportunities found across the chain, especially in terms of production and international trade.

ECONOMICS OF BEEF CATTLE RANCHING: GENERAL ASPECTS

The beef cattle ranching system is considered one of the most complex ones globally. Cultural aspects, production systems, internal relations between agents, domestic beef consumption, the international market, regional characteristics, technological level and genetics, and the influence of different actors on the beef cattle chain vary from country to country. Despite these differences, it is one of the oldest and most valuable cattle industries in terms of consumer preferences and nutritional values, such as vitamins (especially B12 complex).

Understanding the structure and governance of the main actors involved in the system is a key factor for its development. In Brazil, beef cattle production systems can be considered flexible and diversified. The historical economic perspective of this system has led to developing an activity based on land expansion and asset appreciation due to inflation, the use of traditional systems (land use, capital, and employment), leading to low productivity and a food system with low security until the late 1990s. Technological improvements in nutrition, health, and genetics have replaced this traditional system with more efficient and sustainable ones (Wedekin et al., 2017).

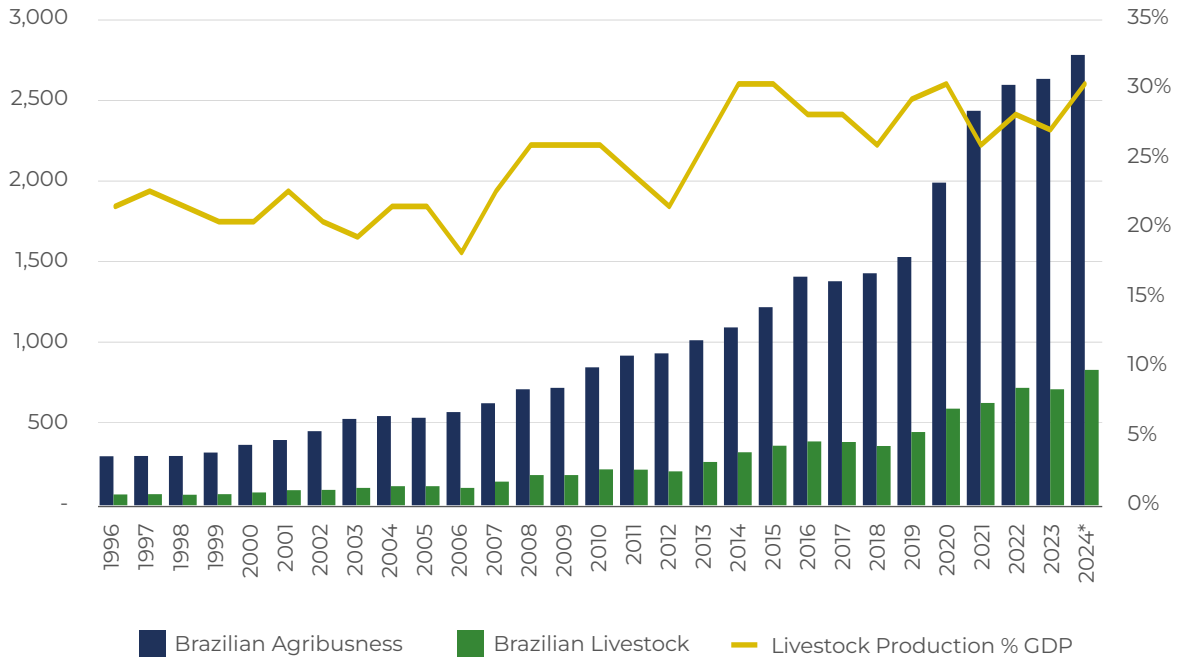
These different technologies in nutrition, genetics, health issues, and monitoring and control processes can also be considered as a set of characteristics that shape different products for markets and consumers and, when coordinated, provide optimized structures for the system (Lemos & Zylbersztajn, 2018).

GROSS DOMESTIC PRODUCT (GDP) OF BRAZILIAN AGRIBUSINESS

The Brazilian agribusiness GDP is calculated using a methodology that considers all activities involved across the chain, before and after primary production. The Brazilian Geography and Statistics Institute (IBGE) only considers and measures what is done within the production system (value added on the farm). However, this methodology underestimates the coordination between agents and their work for improving the entire system.

The agribusiness GDP grew by 815% in 1996-2024 (Figure 2.1). The nominal value went from almost 300 billion in 1996 to 2.7 trillion in national currency, Brazilian reais (R$ or BRL) in 2024 (estimated). The agribusiness GDP has two factors, one from added value in agriculture and the other from livestock. The analyzed period showed a 1,151% increase in the cattle industry's GDP, including all production links, which accounted for 30% of agribusiness GDP and, since 2015, has maintained an average share of 28%. As part of the cattle industry, beef production accounted for 8% of Brazil's total GDP in 2023, according to the Brazilian Beef Exporters Association (ABIEC).

2.1 – Brazilian agribusiness GDP and cattle industry GDP (R$ billion and %)



Source: CEPEA and CNA (2025)

Agribusiness accounts for about 23% of Brazil's total GDP (CEPEA), underscoring its economic importance for the country.

From 2000 to 2024, significant development can be noted, especially in the input and production (on-farm) links (Table 2.1). The former is explained by an increase in technologies on the field. However, production growth can be explained in part by prices, exports of beef and other products (market) and continued growth of the cattle herd.

Table 2.1 - Brazil: the cattle industry GDP (R$ million)

MAIN AGENTS	2000	2010	2020	2024
Inputs	2,837	10,655	26,781	43,316
Production	13,832	51,040	172,788	257,189
Processors	19,353	47,284	106,910	144,950
Services	42,112	109,298	277,575	373,805
Total	**78,134**	**218,277**	**584,054**	**819,260**

Source: CEPEA and CNA (2025)

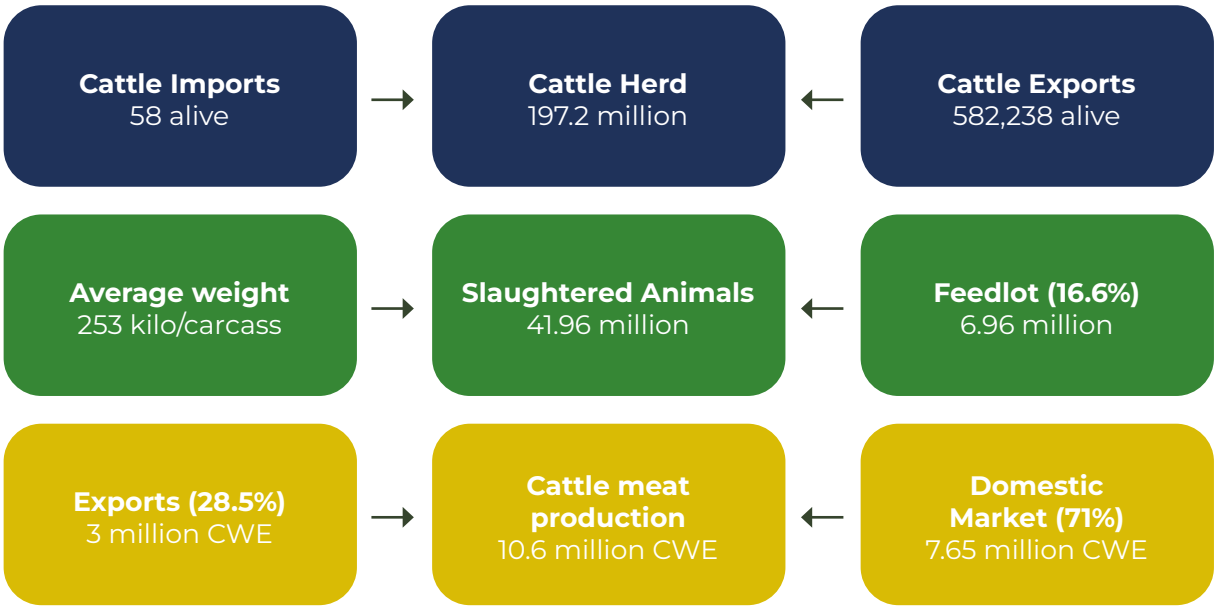
In two decades, from 2000 to 2024, processors multiplied their GDP by almost 6.5 times.

QUANTIFIED BEEF CHAIN

Since the *Plano Real*, the economic plan that changed Brazil's economic structure and stabilized the currency in 1994, the business environment in the beef industry has changed. In the past, cattle were synonymous with assets to be traded and net worth for those who owned them. The economic change brought this activity into the reality of agribusiness and the constant search for efficiency in order to survive.

According to ABIEC, in 2023 there were 161 million hectares dedicated to cattle production with a stocking rate of 1.22 head/hectare, as the total number of animals was estimated at 197.18 million (Figure 2.2).

Figure 2.2 – Quantified production (2023)

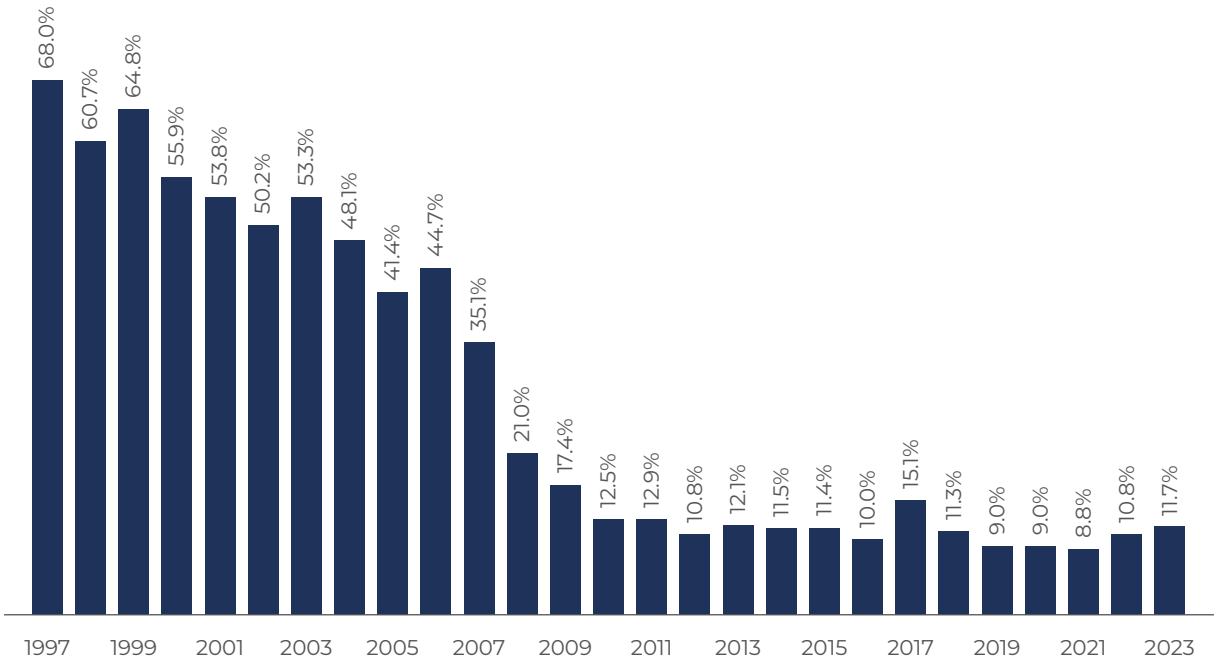


Source: ABIEC (2024)

The 2023 scenario reflects export growth supported by currency devaluation and high international demand due to substitute crises and new markets.

Although the market had an appetite for protein and the devaluation of the Real boosted exports, it is important to highlight these new markets that have emerged over the years, thanks to constant improvements that lead to efficiency and better quality. Technology, innovation, and technical assistance are key factors in this industry's turnaround, even though it has not been completely reformulated. Figure 2.3 shows these improvements historically reflected in the animals' lifecycle before slaughter.

Figure 2.3 - Percentage of animals slaughtered after 36 months of age (only males)



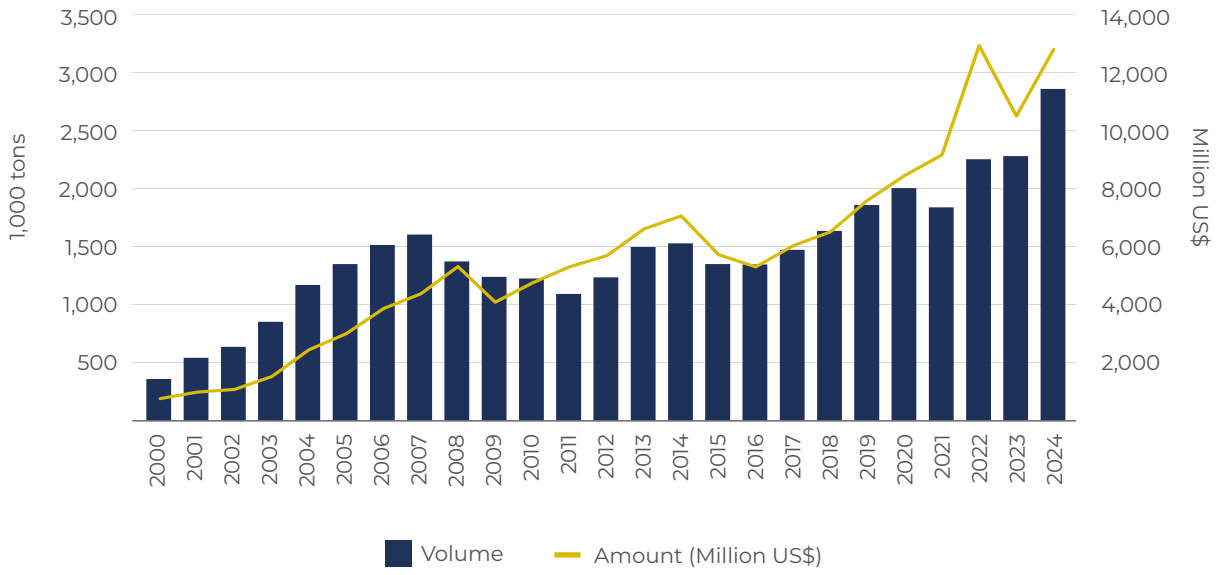
Source: ABIEC (2024)

The beef chain was boosted after the 2000s by technologies and innovations that are bringing greater efficiency to the industry. International trade has also driven development, thanks to export standards, particularly health standards. Since then, Brazil has achieved an internationally reliable health status, particularly for foot-and-mouth disease (Lima, 2005).

2.1 BEEF CATTLE MARKET

Although Figure 2.2 shows that the domestic market accounts for 71.5% of production in the beef industry, it is important to analyze the share of international trade and the evolution of *per capita* consumption over the years. The foreign market influences the price of cattle and drives the intensification of beef cattle production. In 2015, the market structure showed that 81% of production was destined for the domestic market and 19% for the foreign market. In 2024, international trade accounted for 28.5%, with 85.9% of the volume traded *in natura* to 129 countries; China accounted for 59.6% of the total share, followed by Chile (4.9%), the United States (4.8%), and other countries (26.8%) (ABIEC, 2024).

Figure 2.4 – Brazilian exports in 2000-2024 (US$ million x thousand metric tons)



Source: ABIEC (2024)

Industrialized beef accounts for only 7.8% of Brazilian beef exports, especially to developed countries. The United States accounts for 40.9% of the total, followed by the United Kingdom (20.8%), the European Union (10.6%), Canada (2.8%), and others (24.8%). Even so, there has been a significant increase in exports, especially in 2019-2024 (Figure 2.4).

Implementing the World Trade Organization (WTO) Agreement on Applying Sanitary and Phytosanitary Measures (SPS) has helped to strengthen beef exports, given Brazil's high sanitary standards. Brazil now supplies about 20% of global demand (ABIEC, 2021). Data on global beef supply from 2018 to 2024 show that Brazil already accounts for 21% and will represent 28% of global exports in 2033 (USDA, 2024).

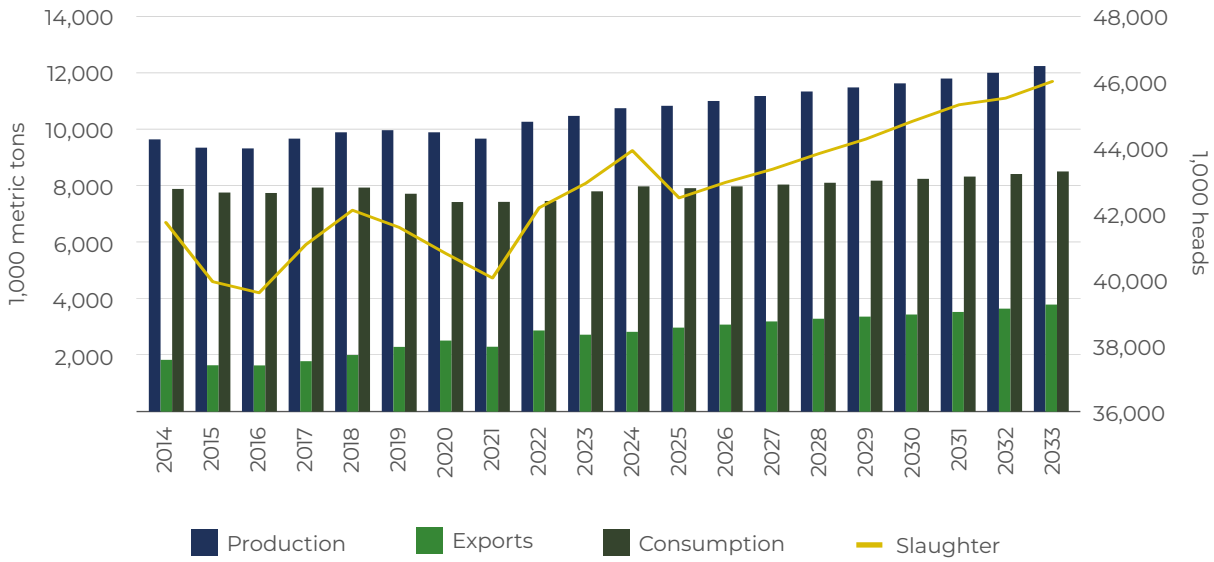
On the other hand, the domestic market has always accounted for the largest share of Brazilian beef production. Beef consumption stems from a cultural aspect. Since colonial times, beef protein has been a staple food in Brazilian households. Even so, it is not the largest total volume consumed, trailing behind the United States, China, and the European Union (USDA, 2024). In kg per capita, Brazil's consumption is similar to that of the United States (about 37 kg/*per capita*/year in 2023), but much lower than that of Argentina (52 kg/*per capita*/year), and Uruguay (48 kg/*per capita*/year).

Technological advances have made superior standards, processes, and products possible. Over the last decade, several brands and programs have been developed by meatpackers for improving quality, with the initial goal of serving the international market, and have seen strong demand in the domestic market. These programs are the result of coordination mechanisms between cattle production and meatpackers and have played a significant role in fostering technological upgrades, technical assistance, and science-based sustainable production systems.

2.2 OPPORTUNITIES

There are many opportunities in the beef cattle system to improve, expand international trade, and feed the domestic market. The key to developing the industry lies in sustainability. USDA projections for 2033 show growth in the domestic market and consumption (7%), as well as an increase in exports (34%) from 2024 to 2033 (Figure 2.5).

Figure 2.5 - Projected Brazilian cattle slaughter (x1,000 head), production, exports, and consumption (x 1,000 metric tons) 2014-2030



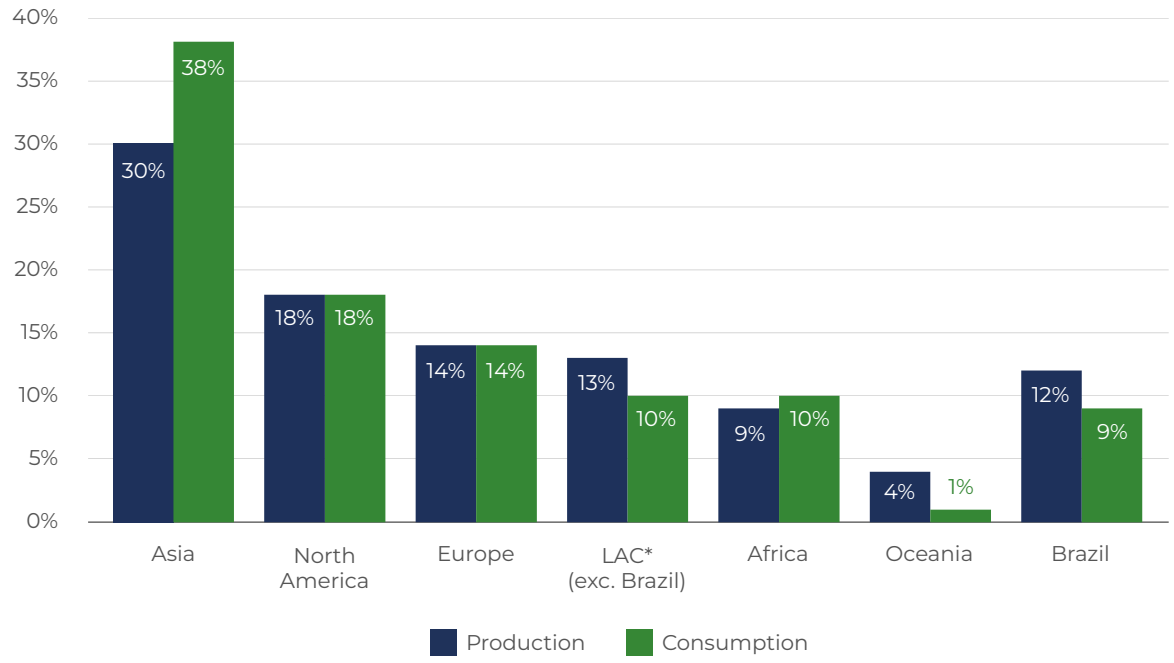
Source: USDA (2024)

The outlook for 2033 shows a 14% increase in production, thanks to a 5% increase in slaughtered heads and a 9% increase in carcass weight, which will account for 15% of total beef production worldwide.

Although the outlook is encouraging at first glance, it requires process improvements and technology adoption by all players. On the production side, constant gains in efficiency will drive the activity and provide better quality to the market, transparency, and repositioning production in consumers' minds. Input companies, research institutes, universities, technical assistance, and agricultural policies geared toward sustainable beef production are fundamental drivers of change.

Improving quality and building a reputation in the international market are constant challenges for this industry's associations and organizations. Efforts to expand and open new markets have shown positive signs. But market diversification should be a goal in order to avoid risks related to dependence. There are opportunities to be seized, especially in Asia and Africa, where most countries are developing or less developed (Figure 2.6).

Figure 2.6 - Beef consumption and production by continent vs. Brazil in 2033



*Latin America and the Caribbean (except Brasil)
Source: OECD-FAO Agricultural Outlook 2024-2033

There are no missed opportunities for Brazilian beef cattle ranching, according to projections and Brazil's capacity to increase production. The main challenge is to expand sustainably, which brings a new specification when it comes to the production process for all agents, such as environmental and social responsibilities, among other indicators. Being sustainable in all dimensions is mandatory for food systems' survival, not only for the beef cattle system, as discussed in the next topic.

Photo: Adobe Stock

3. SOCIAL AND ENVIRONMENTAL

The third topic emphasizes the social, environmental, and economic aspects related to beef cattle ranching in Brazil. Global discussions related to livestock production involve issues such as deforestation and land use, soil degradation, GHG emissions, especially methane, as well as biodiversity loss, animal welfare, and social issues.

Despite technical and technological advances in beef cattle production systems and their dynamics in Brazil, much criticism has been directed at production and consumption due to their relationship with deforestation and climate change. In addition, it is considered an inefficient agribusiness due to the amount of land dedicated to it, pasture degradation, high GHG emissions, water consumption, and the proportion of the population it feeds.

Sustainability has three main axes: economic, environmental, and social (triple axis). The economic pillar of this system can be understood through the evolution of technical aspects and the expansion of the international market, as described in the previous section, and through public and private policies related to financing change for addressing technological intensification, presented in this topic.

Issues such as land use dynamics and policies, exclusion of minorities (such as small producers), deforestation trends, private sector engagement, and actions for achieving sustainability goals, GHG emissions, and low-carbon agricultural practices, as well as a focus on continuous improvement, are other topics addressed.

All these themes reflect a study developed by Lima & Lemos (2024) on priority actions for the transition of cattle ranching, based on its sustainability challenges, which emphasize the need for rural producer engagement, such as: expanding the adoption of technology and good production practices that contribute to reducing GHG emissions; compliance with the Forest Code and validating the CAR and its use across the production chain; cattle traceability and monitoring as a means of health and environmental control; providing diversified financing and productive inclusion.

3.1 SUSTAINABILITY AND ITS **TRIPLE AXIS**

In discussing sustainability, the Sustainable Development Goals (SDGs) should guide our understanding of the current situation and the improvements that need to be made. The beef cattle ranching system in Brazil, like other food systems, plays a key role in providing nutritious food and ensuring food security, health, and well-being (SDGs 2 and 3). Beef is a rich source of vitamins that are important for the human body and its development, especially B vitamins. Some of these are not necessarily found in other types of animal or vegetable protein, such as B12 (Comerford et al., 2021).

However, when it comes to the environment and social aspects, there is no shortage of criticism of this system. The basis for a sensible debate on the main environmental and social challenges facing the cattle industry in Brazil must be based on reliable data that considers current livestock production patterns, a brief comparison with the past, and projections for the future, always considering the relationship with SDG 8, decent work and economic growth, which are addressed in the last topic on the importance for the Brazilian economy, and SDG 12, responsible consumption and production, one of the foundations for addressing this topic.

Figure 3.1 – Sustainable Development Goals (SDGs)

Source: FAO (2015)

3.2 **SOCIAL AND CULTURAL ASPECTS** OF THE BEEF SUPPLY CHAIN AND ITS CHALLENGES

The beef consumption culture in Brazil dates back to colonial times. It is part of the basic diet in the domestic market (Wedekin et al., 2017). However, prices and income are the main determinants of consumption, especially in developing and less developed countries. As noted in the previous topic, devaluation of the national currency has opened up opportunities for exports associated with lack of supply increases in several countries around the world.

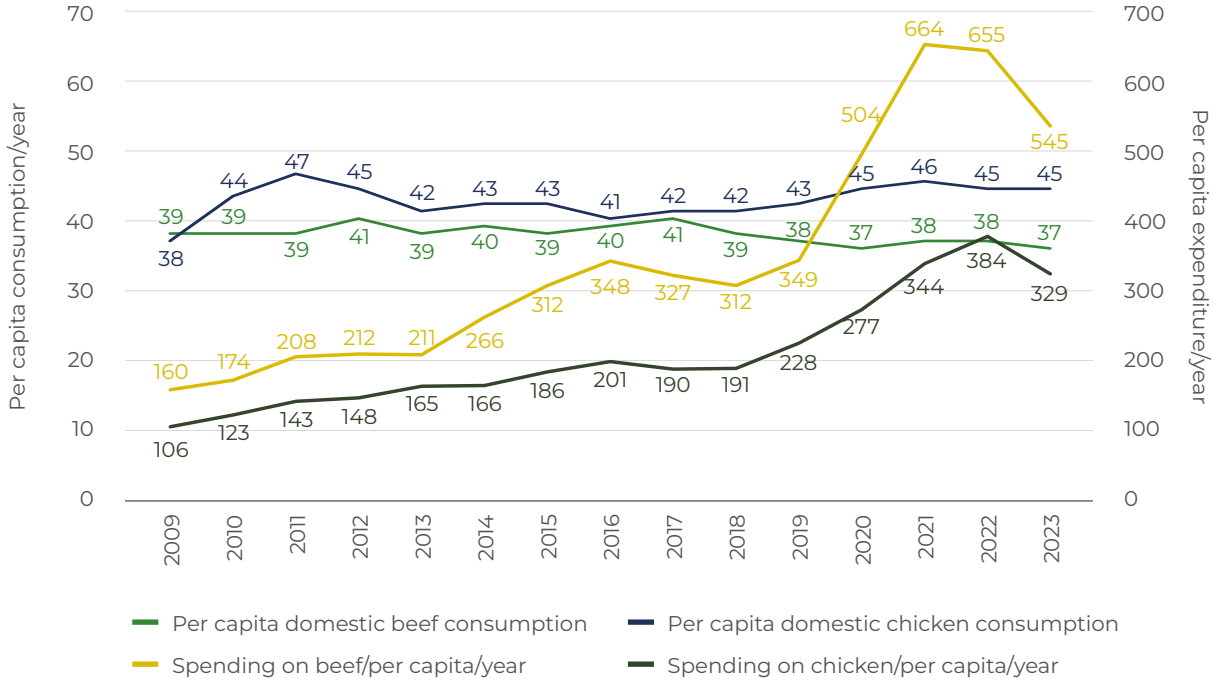
Innovation and technology have a direct impact on prices, as they lead to efficient production methods and increased supply. Brazilian animal protein agribusinesses are examples of changes in consumption patterns due to prices and technological advances. In 1970, beef accounted for the majority of meat consumption, at 67%; pork accounted for 24%; and chicken accounted for 9%. Brazilians could buy 7.9 kg of beef for every kg of chicken. In 2016, beef consumption accounted for 38%; pork, 14%; and chicken, 48%. And each kg of beef could buy 1.3 kg of chicken (Wedekin et al., 2017).

The chicken production system incorporated technological advances and drastically reduced input costs. Availability has increased and consumption has risen over time, but this does not mean that Brazilians' preferences have changed. A closer look at household preferences for protein consumption reveals that the population is willing to spend approximately one-third more on beef than on chicken (Figure 3.2).

This analysis reveals the relationship between consumer behavior and income, their preferences shaped by culture, which can be directly linked to SDG 3 on well-being, but should address the discussion on SDG 12 on responsible consumption, which concerns having balanced meals that include the most diverse types of food available. Knowledge about nutrition, availability, and access are essential for providing good solutions for balanced consumption without neglecting cultural differences.

Beef consumption behavior in Asia, especially in China, has ultimately boosted exports, as shown in the previous topic (Figure 2.6). There are imbalances between production and consumption on the continent, and the increase in income over the last decade – coupled with African swine fever (in 2018), which reduced the pig herd – ended up driving demand for beef from Brazil. It is important to emphasize that increased income also leads to behavioral changes.

Figure 3.2 – Brazil: comparison between beef and chicken consumption (kg/per capita/year) and expenditure (R$/per capita/year)



Source: ABIEC (2024); ABPA (2014); SEAB-PR (2025). Prepared by: Agroicone

REGIONAL GROWTH, JOB CREATION, AND INCOME

Expansion of agribusiness, especially in rural Brazil, has led to an increase in the workforce in the Midwest and local development. However, this was based on combating hunger (SDG 1) through access to safe food at affordable prices (SDG 2), as stated by Wedekin (2021) on the tropical agriculture revolution.

Two analyses were conducted for explaining the benefits of agribusiness expansion in the Brazilian Cerrado. The first was the Human Development Index by Municipality (IDHM) of 1,102 municipalities in the Cerrado biome, which rose from 0.386 in 1991 to 0.671 in 2010. This was a 73.8% increase in locations where agribusiness is the main economic activity.

In other words, agribusiness and its development bring well-being, health, and generate work and development for a region where it began developing, in accordance with SDGs 2, 3, and 8. The second analysis was based on the share of food costs in household consumption, ranked by minimum wage in 1974-1975 and 2017-2018 (Table 3.1).

Table 3.1 - Brasil: share of food costs in household consumption expenditure, by minimum wage (SM) per month, from 1974-1975 to 2017-2018 (% of total expenditure)

PERIOD	TOTAL	UP TO 2 SM	>2 TO <3 SM	>3 TO <10 SM	>10 TO <15 SM	>15 SM
1974-1975	33.9					
1987-1988	25.3	44.1	41.3	34.6	28.7	21.3
1995-1996	23.4	35.2	37.1	30.2	24.2	20.4
2002-2003	20.8	34.5	31.9	24.8	19.4	15.1
2008-2009	19.8	29.6	27.0	21.7	17.3	13.8
2017-2018	17.5	23.8	21.3	18.2	15.6	122.6
Duration (ponts)	**-16.4**	**-20.3**	**-20.0**	**-16.4**	**-13.2**	**-8.7**

Source: POF-IBGE/ Prepared by: Wedekin (2021)

The data show a reduction in food spending in household budgets over time in Brazil, emphasizing that innovation efforts have provided well-being (SDG 3) and sustainable consumption and production (SDG 12) to a country that, in the 1960s, depended on food imports. The share of food in the family budget was reduced from 44.1% to 23.8% in low-income social strata (up to two minimum wages), highlighting the importance of advances in agriculture.

Bonelli (2001) presents similar results using a different methodology to verify the economic and social impacts of agribusiness. The author analyzed data from 1975 to 1996 to assess the dynamics of agribusiness and its impact on state GDP and on the Human Development Index (HDI) and its evolution. The results clearly showed that innovation and improvements in agribusiness in Brazil led to social inclusion and economic growth.

The study analyzed the demographic dynamics associated with urbanization, which yielded interesting results. In new cultivation and pasture areas, population growth was higher, even when the national rural population was not growing. This leads to the conclusion that agribusiness growth led to developing urbanization through services and establishing local businesses for meeting regional demand. In terms of impact, the author states that a 1% increase in agribusiness income led to a 1.07% increase in income in other activities unrelated to agribusiness.

The overall analysis of the expansion and growth of agribusiness in Brazil shows its relationship with urbanization and in developing support services that lead to employment of the workforce not directly in agribusiness, but generating income and well-being characterized by the Human Development Index.

In terms of the direct and indirect impacts of agribusiness industries, when using the 2006 nationwide input-output matrix (updated to 2010 values), Costa, Guilhoto, and Imori (2013) showed that an increase in final demand for processed agricultural products (such as cattle slaughter) has impacts on the Brazilian economy, separated by direct and indirect impacts and effects on income (Table 3.2). Each additional R$ 1 million in final demand for cattle slaughter generates 111 jobs in the economy, increases the Gross Product Value by R$ 5.4 million, and the national GDP by R$ 2.4 million.

Table 3.2 - Brasil: Direct and indirect impacts and income effect resulting from a R$ 1 million* "shock" in total demand for cattle slaughter

VARIABLE	DIRECT & INDIRECT IMPACTS	EFFECT ON INCOME	TOTAL IMPACT
Employment (numbers)	62	49	111
Gross Product Value (thousand R$)	3,084	2,359	5,443
Gross Domestic Product – GDP (thousand R$)	1,167	1,267	2,434

Source: adapted from Costa, Guilhoto, Imori (2013)

According to the authors, most of the impacts of this shock occur in the agricultural industry (primary production), followed by the industry that is directly affected by the shock (cattle slaughter), but it also affects other areas of the economy, mainly GDP and wages in the service and agricultural input import industries.

When it comes to the beef cattle system, ABIEC (2020) estimates that 4.5 million jobs supply the entire chain in Brazil. Considering only ranches and meatpacking plants, operations had 3.3 million jobs in 2019 and generated R$ 65 billion in wages (11% of the beef cattle GDP).

Even though innovative employment on farms raises the idea of a shortage of human capital or population settlement in rural areas, this thesis does not apply entirely. Innovation and development in rural areas drive the need

for new skills and human development for managing businesses in ways that lead to efficiency, boosting education systems (SDG 4) for supporting development. In addition, they raise employment levels in services, workforce training, technical assistance, and supply industries, which creates an environment for evolution.

THE IMPORTANCE OF **SMALL PRODUCERS** IN BEEF CATTLE PRODUCTION IN BRAZIL

According to Garcia et al. (2021), the 2017 Agricultural Census presented its results based on Law N. 11,326/2006 (National Policy on Family Farming and Rural Family Enterprises), relating to family and non-family producers. The results revealed that has approximately 5.07 million rural producers, covering a total area of 351 million hectares. Of these, family farming accounts for 3.9 million (76.8%) rural establishments, covering 80.9 million hectares (23%), while 74% of establishments have cattle production, and pasture is the main land use, with 39 million hectares (48% of the total area of all rural establishments).

Considering the total sales of cattle presented by the 2017 IBGE Agricultural Census, family farmers accounted for 17% of the total (considering ranchers with more than 50 heads), while sales to other cattle ranchers for fattening and breeding purposes represented 23.4% of the total animals sold. This reveals the importance of family farmers in the beef cattle ranching system in Brazil, with less direct relationship with meatpacking plants.

The same authors state that, in addition to its productive importance, family farming is also responsible for the employment of more than 10 million people, representing 67% of those employed on ranches (15.1 million); of these, 8.8 million are related to the producers, i.e., family members, and family farming still accounts for 32% of the total number of people employed without family ties to producers, which is directly related to SDG 8 on decent work and SDG 10 on reducing inequalities.

In Brazil, there are 2.5 million establishments that produce cattle, with varied sizes, production techniques, and stewardship (IBGE, 2017). It is worth highlighting that 1.2 million establishments have less than 20 hectares, while 1 million are 20 to 200 hectares, as shown in Figure 3.3. This underscores the challenge of incorporating technology into cattle ranching and providing access to technical assistance.

The data in Figures 3.3 and 3.4 show that 91.8% of establishments whose main activity is beef cattle ranching have up to 200 hectares and account for 39.73% of the herd, equivalent to 80 million animals. This reveals that there is much room for strengthening technology and using good practices in family ranching and small-scale cattle production.

Figure 4 – Distribution of establishments by area (hectares)

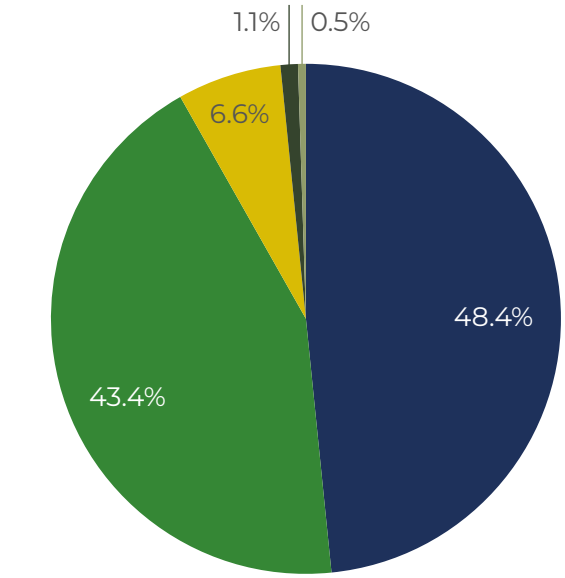
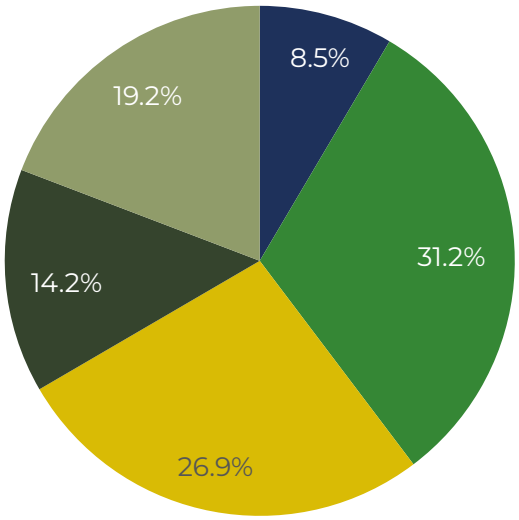
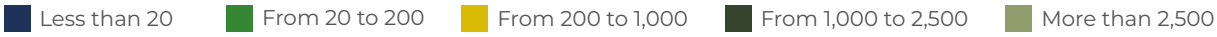


Figure 5 – Distribution of herd (%) by establishment (hectares)





Source: IBGE (2017)

Other important indicators that result in low productivity and income and, consequently, environmental degradation, are the fact that, in 2017, 87% of family farmers did not use limestone for correcting the soil, which is an essential input for at least maintaining the carrying capacity of pasture to meet the animals' nutritional requirements; 82% of producers did not receive technical assistance and only 14% had access to rural credit (IBGE, 2017).

This points out the need to foster innovation, technological inclusion, access to credit, and technical assistance for supporting the steady growth of efficiency on small rural properties, reversing the cycle of environmental degradation and low income on the farm.

Another sensitive social issue that can be discussed is the inclusion of informal cattle producers. These are cattle ranchers who have some pending issues with formalizing land use related to property rights and informal relationships with other producers. This situation can create barriers to traceability and formal slaughter, or slaughter that may not be related to any type of health inspection system.

Sustainable production does not only raise environmental issues, but it also includes governance over land use and property rights. These rights are important for controlling and monitoring by governments and the private sector, and are essential for accessing bank credit and adopting technologies.

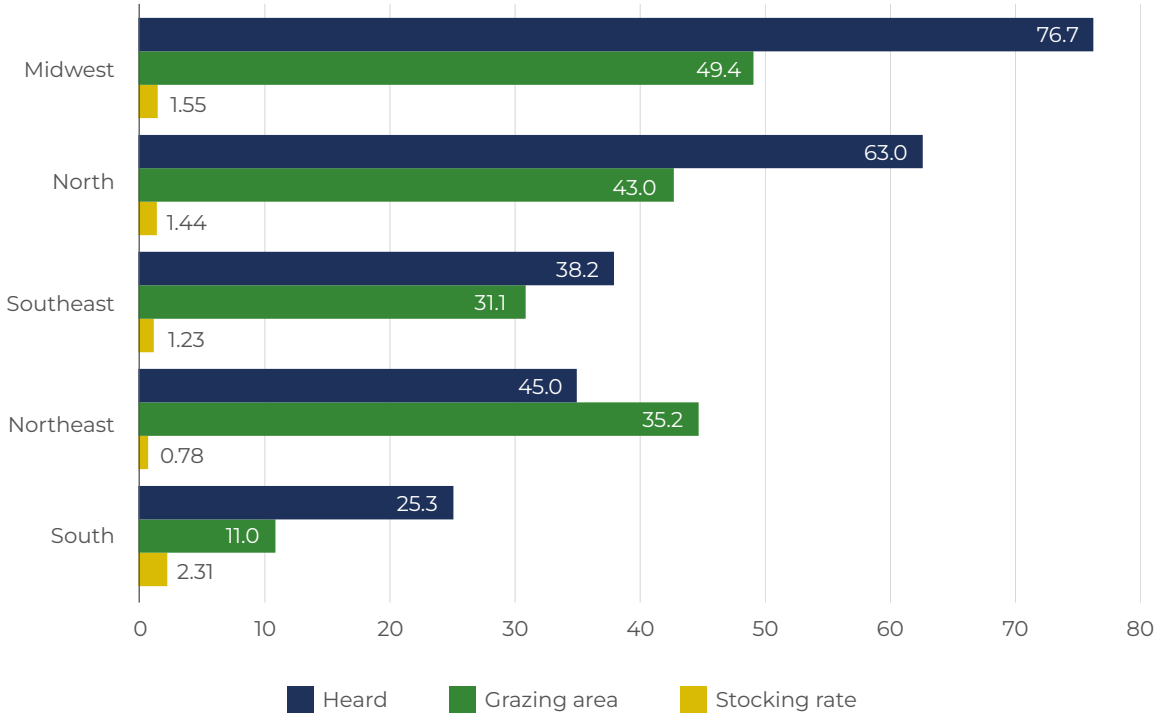
Informality in the meat chain has been addressed through monitoring and plans for including these agents. If Brazil has informal relationships in the beef cattle system, full traceability will not be possible, and this opens the door to opportunistic behavior with complex consequences — where deforestation is just one of them. Above all, this reflects the health vulnerability in beef production.

TECHNOLOGICAL ADOPTION AND EXPANDING GOOD PRODUCTION PRACTICES

In addition to characterizing the activity's social and cultural relevance, the way it is conducted still reflects the aspect of animal husbandry as a means of securing land and a low-risk substitute for investment. This culture dates back to the high inflation and agricultural expansion period (Wedekin et al., 2017). However, the consequences show in poor performance of the production system relatively to the covered area.

Priority actions for driving the transition of beef cattle ranching and mitigating its production and sustainability challenges include fostering the adoption of technologies and good agricultural practices. Gains related to this action include increased productivity and income, improved animal stewardship, increased profitability, animal welfare, and reduced GHG emissions. Although beef cattle ranching has recorded productivity gains in recent decades, there is a lack of homogeneity between Brazilian regions, as can be seen in Figure 3.5.

Figure 3.5 – Distribution of the cattle herd (million head), grazing area (million hectares), and stocking rate (head/hectare) by region in 2023

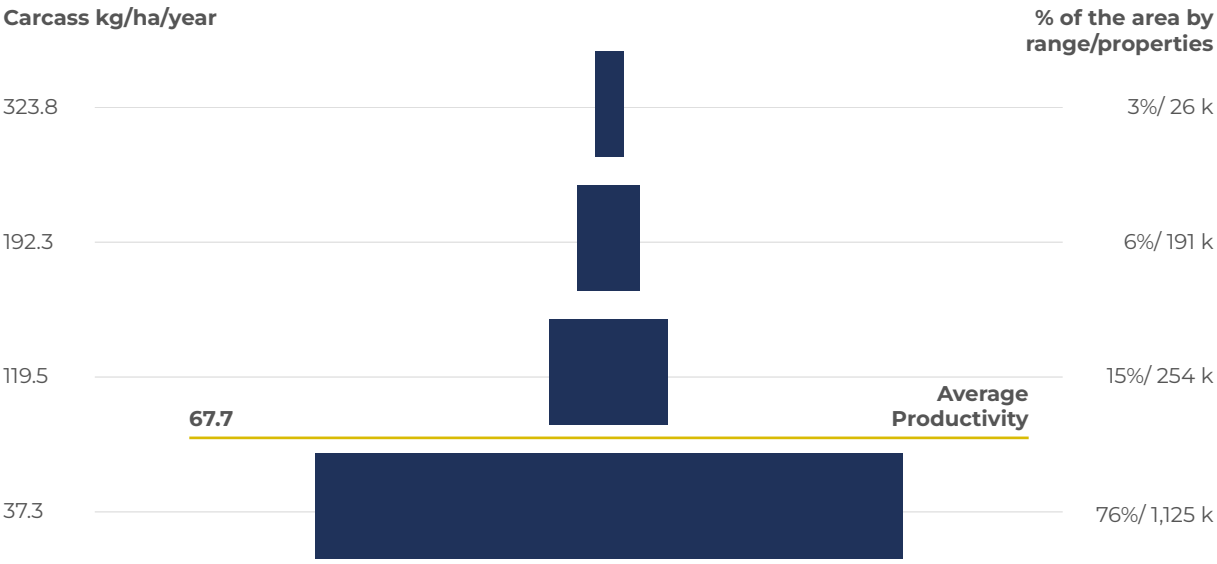


Source: IBGE, Lapig. Prepared by: Agroicone

Distribution of the herd (million head) and grazing area (million hectares) by region (IBGE, Lapig, 2023) highlights the challenges of the third indicator, which reflects the low stocking rate distributed by region. Although microdata indicate the relevance of the Midwest and North regions for the industry, there is no segregation by type of activity (breeding, rearing, fattening, and complete cycle), which makes it difficult to analyze stocking rates and productivity (reflected in other indicators, such as animal weight gain per hectare per year, slaughter rate compared to total herd, etc.). It is noteworthy that these two regions have the highest deforestation rates, which in many cases are attributed to the expansion of beef cattle ranching.

However, Figure 3.6 shows the distribution of establishments by productivity level. According to ABIEC (2024), the average productivity of Brazilian cattle ranching is 67.7 kg of carcass per hectare/year. However, only 24% of establishments are above the nationwide average.

Figure 3.6 – Number of establishments by productivity level



Source: ABIEC (2024)

As previously emphasized, intensifying production and reducing slaughter age lead to concentration of production per area unit and possible release for other uses, such as integrated systems, crops, and forest restoration.

TRACEABILITY AND MONITORING

Another aspect that reflects Brazilian social and cultural paradigms, which is nothing new, is cattle traceability. Since the Sisbov System was created in 2002 for tracking health information on cattle and buffalo, producers have been able to voluntarily adhere to individual animal traceability in order to serve the export market. However, it is essential to point out that individual health traceability does not cover the entire Brazilian herd and is restricted to identification of animals up to 100 days before slaughter. In this sense, it does not cover the animals' journey from birth to slaughter.

Currently, two factors are driving the search for a national traceability solution for the Brazilian herd. The first reason is to ensure the health of Brazilian products. The second one relates to social and environmental requirements and demand for products that are guaranteed as not originating from illegally

deforested areas. Both processes have led meatpacking plants to adhere to voluntary commitments such as the Public Commitment on Livestock (CPP) and Conduct Adjustment Agreements (TAC).

The challenges of decoupling the beef cattle chain from deforestation remain, given the fragmentation of the cattle production cycle, which makes it difficult to monitor indirect suppliers (those cattle producers who do not supply directly to meatpackers and are in the breeding and/or rearing stages) and the flow of production and compliance information to consumers. Having a comprehensive system is imperative for building credibility and legitimacy. The federal and state governments are working on developing basic platforms for this governance to take place, and for traceability systems, Animal Transit Guide (GTA) and Rural Environmental Registry (CAR) to be able to communicate with private or public-private systems.

In December 2024, the National Plan for Individual Identification of Cattle and Buffalo (PNIB) was launched for tracking and recording each identified animal's history, current location, and trajectory. This plan is expected to strengthen animal health programs and provide transparency to the production system. The plan is expected to be fully implemented by 2032, with the following phases:

Phase 1 – 2024 to 2026: building the national database and integrating agricultural defense agencies.

- Creating a national database, gathering information on herds and production systems
- Integrating Agricultural Health Enforcement Agencies into the PNIB computerized system
- Defining ordinances and resolutions by the Agriculture Ministry (MAPA).
- Preparing states for setting up their own systems, based on the national model

Phase 2 – 2027 to 2029: beginning individual animal identification, with priority for those undergoing health stewardship.

- Beginning of mandatory individual identification of the animals, with priority given to those undergoing health stewardship, such as brucellosis vaccination, and those included in private protocols

- Using technologies such as electronic ear tags and tracking chips
- Identifying animals before their first transfers

Phase 3 – 2030 to 2032: aims at large-scale implementation, identifying all animals before their first transfers.

- Identifying all animals that transit through national territory before their first transfer
- Completing identification of 100% of the national cattle herd

While a nationwide solution is not yet a reality, several traceability models have been proposed by industry associations, non-governmental organizations, and public agencies, as well as batch and individual tracking systems based on using official documents and/or voluntary adhesion by cattle ranchers, covering indirect suppliers (Armelin et al. 2023): Conecta (organized by Safe Trace), Visipec (organized by the National Wildlife Federation - NWF); SMGeo (organized by Niceplanet Geomonitoramento) and Selo Verde (organized by the Pará State Government).

Figure 3.7 – Monitoring and traceability tools for the meat chain in 2018-2023

INSTRUMENT	INSTITUTIONS	SPECIFIC GOALS AND PREMISES
Drone Monitoring	Embrapa Southern Livestock	Research on using drones in herd monitoring. Not yet consolidated, but there is potential for disease control andanimal health anomalies and herd monitoring.
Bovine Electronic Platform (BEP)	Embrapa Beef Cattle; Indext; UFMS.	Construction of a device that measures respiratory and heart rates, skin surface temperature, ambient temperature, relative humidity, and solar radiation with no need for implantation.
SMGeo Prospec	Niceplanet Tecnologia	An application that enables rural producers to conduct detailed geospatial research, with access to historical and socio-environmental analyses of farms, using only Sicar or data from those

INSTRUMENT	INSTITUTIONS	SPECIFIC GOALS AND PREMISES
Marfrig Verde +	Marfrig	Marfrig Verde+ is a program for ensuring that 100% of the meatpacking plant's production chain is sustainable, traceable, and free from deforestation by 2030 (brought forward to 2025).
Arezzo Traceability	Arezzo	The Arezzo&Co group, one of the largest shoe manufacturers in the country, wants to track and monitor the origin of its main raw material, leather. The technology chosen by Arezzo is the same as the one used by companies such as JBS and Marfrig: blockchain, for validating and providing transparency to the different stages that leather goes through along the chain until it becomes shoes in the company's factories, most of which are in Vale dos Sinos, in Rio Grande do Sul.
Green Passport	IMAC	Eliminate illegal deforestation from cattle ranchers and ensure complete socio-environmental monitoring of production and meat quality in Mato Grosso state.
Net Zero Commitment – Minerva	Minerva	Monitoring deforestation in the supply chain and eradicating illegal deforestation; traceability of all cattle for slaughter; providing support to measure emissions on farms and restore native vegetation; paying suppliers for adopting sustainable production practices.
Visipec	Minerva; National Wildlife Federation; Universidadede Wisconsin-Madison; Amigos da Terra	A new monitoring tool that works in tandem with the monitoring systems used by meatpacking plants in Brazil. The tool aims to help reduce risk of exposure to deforestation in the early stages of the supply chain. To do so, it cross-references information from public databases (such as GTA and CAR), providing regularly updated data in an integrated tool.
Safe Beef	iRancho; BR Angels; AgroVen	Blockchain platform with the potential for tracing cattle from birth.

INSTRUMENT	INSTITUTIONS	SPECIFIC GOALS AND PREMISES
Retail Meat Supplier Monitoring Protocol	Imaflora; Abras	Standardized protocol for the retail industry, on a voluntary basis, for verifying that meat purchased from meatpackers in the Amazon is not linked to irregularities such as deforestation and slave labor. Lack of standardization of processes between companies made it difficult to compare performance. The protocol proposes three levels of requirements for meat suppliers, from essential to most demanding.
Virtual Fence	MSD Animal Health	Cattle management using integrated systems with no need for physical fences. A collar produces electrical stimuli that guide cattle through virtual paddocks. Producers can monitor each animal's position. This is expected to facilitate pasture rotation and integrated ILPF systems.
Transparent Cattle Ranching Platform	JBS	Integration of all direct and indirect cattle suppliers for monitoring socio-environmental risk in the agri-livestock production chain using blockchain technology.
PREM MT	IMAC; MPF; Acrimat; Sindifrigo; SEMA; Agrotools	Virtual geo-monitoring platform developed by Agrotools for Imac that aims to monitor the environmental regeneration of deforested areas on blocked rural properties. PREM enables cattle ranchers to re-enter the formal market, provided they commit to isolating the deforested area without authorization from the relevant authorities.
Linha Sabor & Qualidade	Carrefour; IDH	A line of products from 450 farms of up to 300 ha. Approximately 6,000 cattle were slaughtered with guaranteed traceability and origin of the meat. Products with a QR code that provides information on the origin and path to slaughter.

INSTRUMENT	INSTITUTIONS	SPECIFIC GOALS AND PREMISES
MSD Animal Health Intelligence	MSD Animal Health	A tool that enables identifying physiological, pathological, sanitary, nutritional, and reproductive aspects, enabling assertive interventions. Management software that captures all this information 24 hours a day and produces reports.
Net Zero Commitment – JBS	JBS	JBS issued a joint statement with other large companies committing to develop a sectoral roadmap to limit global warming to 1.5°C above pre-industrial levels. In addition, the company has committed to becoming a net-zero greenhouse gas emissions company by 2040.
Databoi	Databoi	This method identifies each animal individually by its snout, recording every event involving the animal and enabling complete and effective management for both purchase and sale, as well as better control and identification of each head of cattle.
Amazônia Connect	Solidaridad; JBS Fund for the Amazon; Elanco Foundation	Provides technical assistance and a digital platform for herd traceability for small producers. The JBS Fund for the Amazon and the Elanco Foundation have committed to investing R$ 25 million by 2026 to serve 1,500 families, with the intention of preserving more than 20,000 hectares of forest.
Aplicativo SMgeo Indireto	Niceplanet Geotecnologia	The app enables producers to check the social and environmental status of the farms they do business with, assessing whether the cattle were produced in deforestation-free areas using good practices.
Selo Verde - Pará	SEMAS; CIT; NICFI; Climate and Land Use Alliance; Amazon	A platform for integrating socio-environmental data that supports the monitoring and evaluation of sustainable agricultural development policies and combats illegal deforestation in Pará State.

INSTRUMENT	INSTITUTIONS	SPECIFIC GOALS AND PREMISES
Conecta	Safe Trace; Amigos da Terra; P4F	Monitoring platform with Blockchain technology that enables tracking of socio-environmental and health aspects of cattle farming. It places producers at the center of the issue by capturing data and information on production and property. It enables assessing livestock production cycles, covering all links in the beef chain.

Source: Harfuch et al. (2023)

Multiplicity of models emphasizes efforts for delivering traceability to environmental monitoring of Brazilian beef cattle ranching, as well as "inefficiency" in terms of costs related to their formatting and operationalization. However, lack of clarity regarding implementation costs for each model is a factor that hinders comparability between systems and their effectiveness in ensuring a deforestation-free chain.

3.3 **ENVIRONMENTAL ASPECT:** LAND USE AND ITS CHALLENGES

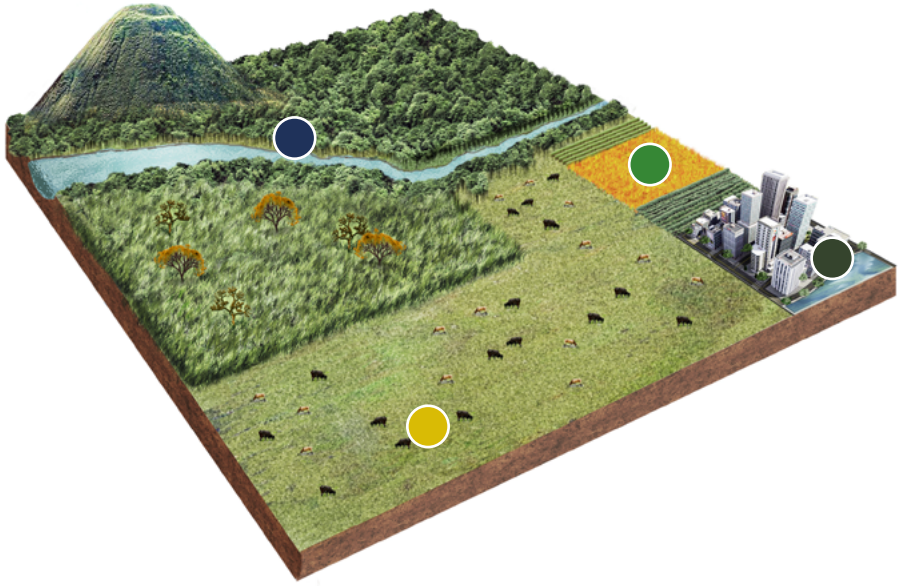
Interaction between conservation and production policies is at the forefront of agricultural and livestock sustainability. On the one hand, conservation units based on the National Conservation Units System (SNUC) account for 163 million hectares (Environment Ministry). In addition, indigenous lands account for 118 million hectares.

Furthermore, it is estimated that there are 187 million hectares of protected native vegetation on rural properties (overlapping with other land categories), thanks to the Forest Code's conservation requirements (Permanent Preservation Areas – APPs – and Legal Reserve Areas) and 81 million hectares of remaining vegetation on private land not covered by specific conservation policies.

Figure 3.8 shows land use in Brazil for 2023, based on estimates using available data. Cropland and planted forests comprise 70 million hectares (for the first harvest only) and around 165 million hectares of pasture, representing 8% and

19% of Brazil's total area, respectively. In addition, there are areas that have agriculture and/or cattle ranching in a mosaic of uses, including integrated systems, totaling 29 million hectares. Based on these calculations, the area used for agriculture and cattle ranching totals 263 million hectares (31% of the national territory).

Figure 3.8 – Land use in Brasil (2023)



569 Mha of natural vegetation

- 113 Mha of Protected Areas
- 118 Mha of Indigenous Land
- 185 Mha of natural vegetation on farms
- (Permanent Preservation Areas and Legal Reserves)
- 103 Mha of remaining vegetation on farms*
- 45 Mha of other types of remaining vegetation**

78 Mha of agriculture (1st harvest) and planted forests

165 Mha of pastures

49 Mha of urbanization and other uses

* Estimated areas of rural properties and settlements (overlapping with other land use categories).
**Includes public forests not designated for specific uses, rural settlements, quilombola settlements, and others (estimated).
Note: Calculation for all land tenure and land use categories based on available data compiled for 2023. No official data from the Brazilian government is available.
Sources: MapBiomas (2024) Collection 9 for native vegetation, pastures, and agriculture; PAM and PEVS (IBGE, 2024) and LAPIG (2023) for total agricultural area; CNUC for Conservation Units (Brasil, 2025); Funai (2024) for Indigenous Lands; OCF (2024) – Forest Code Thermometer for remaining vegetation on rural properties. Prepared by: Agroicone

NATIVE VEGETATION PROTECTION LAW

The Native Vegetation Protection Law (Law N. 12,651/2012, also known as the "Forest Code") is a fundamental legal instrument that aims to foster conserving and restoring natural vegetation, curbing illegal deforestation, and monitoring permitted conversion or legal deforestation.

The 2012 Forest Code has several amendments and regulations related to obligations for maintaining and restoring Permanent Preservation Areas (known as APPs) and Legal Reserve Areas (ARLs). The Code created a compliance process considering producers who deforested prior to and after July 22, 2008, with specific rules for each of them. Non-compliant producers must recover APP and ARL areas by planting native species, fostering natural revegetation, and, in the case of ARLs, if permitted, offsetting in remaining natural vegetation areas that would be legally eligible for legal deforestation in the same biome and state (offsetting in different states would have to occur in priority areas and follow strict criteria).

In this sense, compensation can become a kind of payment for environmental services, through which landowners with surplus native vegetation will be paid for conserving it. Although regulations related to Environmental Reserve Quotas (CRAs) have not yet been approved, there are different schemes aimed at building compensation markets in the states, and they promise to become an essential tool for environmental compensation and market incentives in the future, preventing legal deforestation. The first step required by law is the registration of rural properties in the Rural Environmental Registry (CAR), an online registration platform (SiCAR) that includes information on Permanent Preservation Areas (APP), Legal Reserve Areas (ARL), and, if applicable, native vegetation *deficits*.

Thus, for the first time in history, the country has a reliable and clear source of information describing the actual state of natural vegetation protected by producers and the liabilities of APPs and ARLs that need to be recovered through restoration or compensation in other natural areas (the latter only in the case of ARLs deforested before July 22, 2008). However, rural properties must be registered in the CAR and analyzed by the relevant environmental agency to certify their environmental compliance or the need for regularization

The CAR can also be used as a tool for landscape and agricultural planning and transparency regarding environmental compliance of Brazilian farms. In the future, the CAR, with its ability to provide clear and reliable information on land use, may become an important tool for producers, industry, retailers,

and consumers. In addition, as of 2019, producers without the CAR **are not eligible for rural credit from financial institutions.**

As a second step, the **law creates the Environmental Regularization Program (PRA)**, defining specific rules to be followed by producers to ensure that rural properties are in compliance with APPs and/or ARLs. Thus, recovery of native vegetation in APPs and ARLs, where possible, ARL areas could also be compensated, and 50% of the ARL liability area could be regularized by planting of exotic species for economic exploitation if certain requirements are met.

THE FOREST CODE AND ITS CHALLENGES

Still on the subject of the Forest Code, two major challenges are currently being faced: controlling deforestation, and land and environmental regularization. Both cases have critical implications for Brazilian agriculture due to legal issues related to production, implications for greenhouse gas emissions, and access to public policies (such as rural credit).

Deforestation in the Legal Amazon has been declining again in the last four years. The increase in 2014-2021, as shown in Figure 3.9, has been associated with the beef cattle system due to the growing number of cattle head (as well as soybean production), especially in the Legal Amazon. However, systematic growth and the developing cattle ranching system can also be seen at times when deforestation was "under control" in an attempt to meet international commitments.

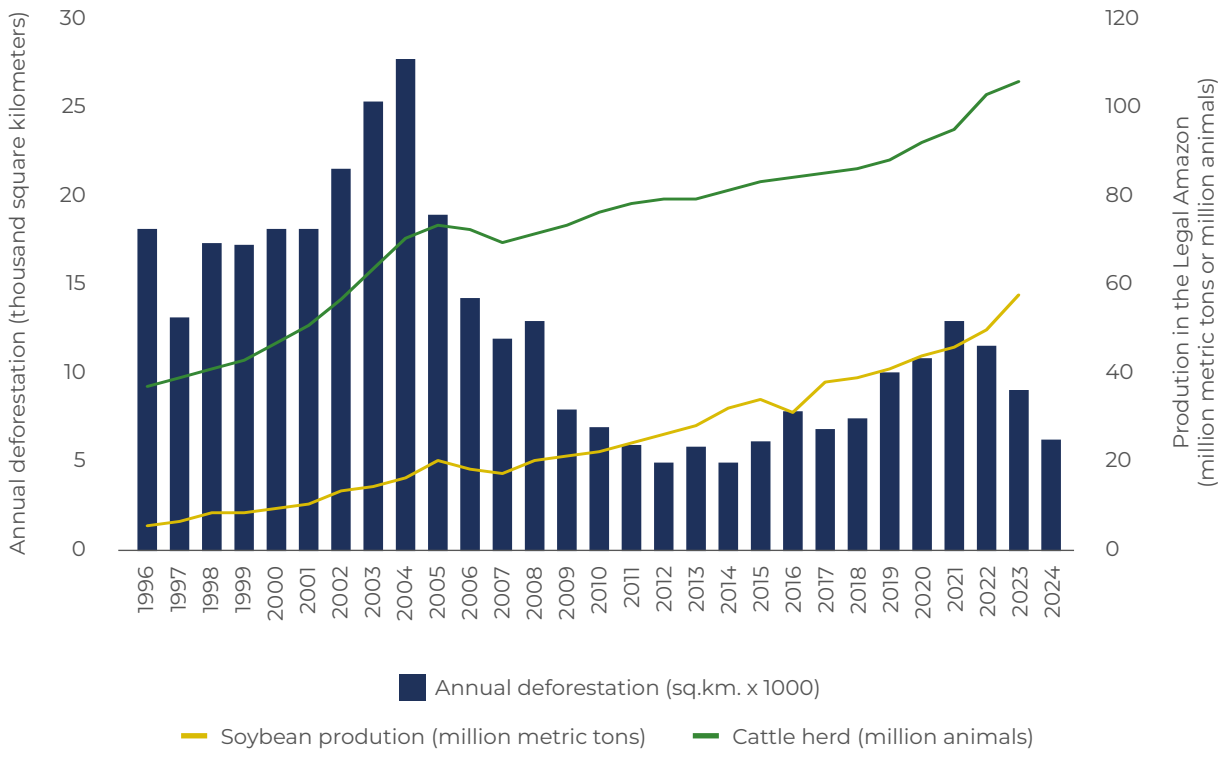
It is noteworthy that Brazil's voluntary target for reducing deforestation in the Amazon (from 3,900 sq.km) was not achieved, and in 2019-2024 it increased again compared to 2012 (4,600 sq.km), ending the period at over 10,000 sq.km per year.

On the other hand, according to Arias et al. (2017), Brazil increased its agricultural productivity above that of other countries, doubling cattle productivity and quadrupling crop productivity. The same authors state that:

> "Despite environmental complaints about the Brazilian agricultural industry, which mainly involve deforestation and land degradation, the industry has contributed to reducing pressure on natural resources in recent decades. Over the past 25 years, production has grown by 90%, but thanks

to technological innovations — and increasingly taking environmental constraints into account — incorporation of new land has been only 32%. This trend is likely to be amplified by the spread of climate-smart agriculture (CSA) technologies and practices." (Arias et al., 2017, p. 20)

Figure 3.9 - Brazil: Deforestation and cattle herds in the Legal Amazon



Source: IBGE (PAM), IBGE (PPM), PRODES/INPE

The main obstacles to implementing the Forest Code and the compliance process lie in analyzing and evaluating the Rural Environmental Registry (CAR). The relevance of this process is to provide transparency and manage land use in private areas, including agrarian reform settlements. The CAR is the basis that will enable providing information on land use, such as:

a. Ex-ante compliance with APP and ARL obligations.

b. Conformity process via state Environmental Regularization Programs (PRAs).

c. Identification of the existence of surplus native vegetation that is eligible for compensation, Payment for Environmental Services (PSA) programs, and potential carbon credit projects.

d. The request and authorization for removing legal native vegetation.

e. Rural credit access under public policies and private financing.

f. Environmental licensing, among other legal rights and obligations related to the property that is subject to registration.

According to the Brazilian Forestry Service, by July 2025, a total of **7.8 million CARs had been registered, covering a 705-million-hectare area**, which is much larger than the number of private areas and their total area. According to data from the 2017 Agricultural Census, there are 5 million rural properties and holdings, which proves that there are overlaps between different CARs, indigenous areas, Conservation Units, and undesignated public forests, which help explain part of these overestimated figures. It is noteworthy that the CAR is independent of land regularization of rural property or tenure, and a rural property may have more than one CAR linked to it.

Figure 3.10 – Rural Environmental Regularization in the Amazon and Cerrado Biomes

	AMAZON	CERRADO	TOTAL
Number of Rural Properties	955,584	1,342,110	2,297,694
Area of Rural Properties (ha)	313,284,643	194,811,508	508,096,151
Area of Remaining native vegetation (ha)	148,799,489	77,519,303	226,318,792
Area of APPs (ha)	9,701,400	9,356,814	19,058,214
Area of RLs (ha)	135,873,570	44,834,188	180,707,758

Source: Serviço Florestal Brasileiro/SICAR (July, 2025).

Construction of the AgroBrasil+ Sustentável Platform by the Agriculture Ministry aims to integrate public data, including the CAR, which will enable other initiatives to use the information provided by the CAR for business development and public policy implementation. It is worth pointing out that the platform will not disclose private data of producers.

Another relevant challenge is the PRA's operationality in many states. It has been effectively implemented in 19 states and the Federal District, with a fully operational system, commitment agreements signed, and compliance plans being executed and monitored in APPs and Legal Forest Reserves. Seven states, Paraíba, Piauí, Rio Grande do Norte, Roraima, Santa Catarina, and Sergipe are still pending the construction of a minimum regulatory framework for rural property environmental regularization.

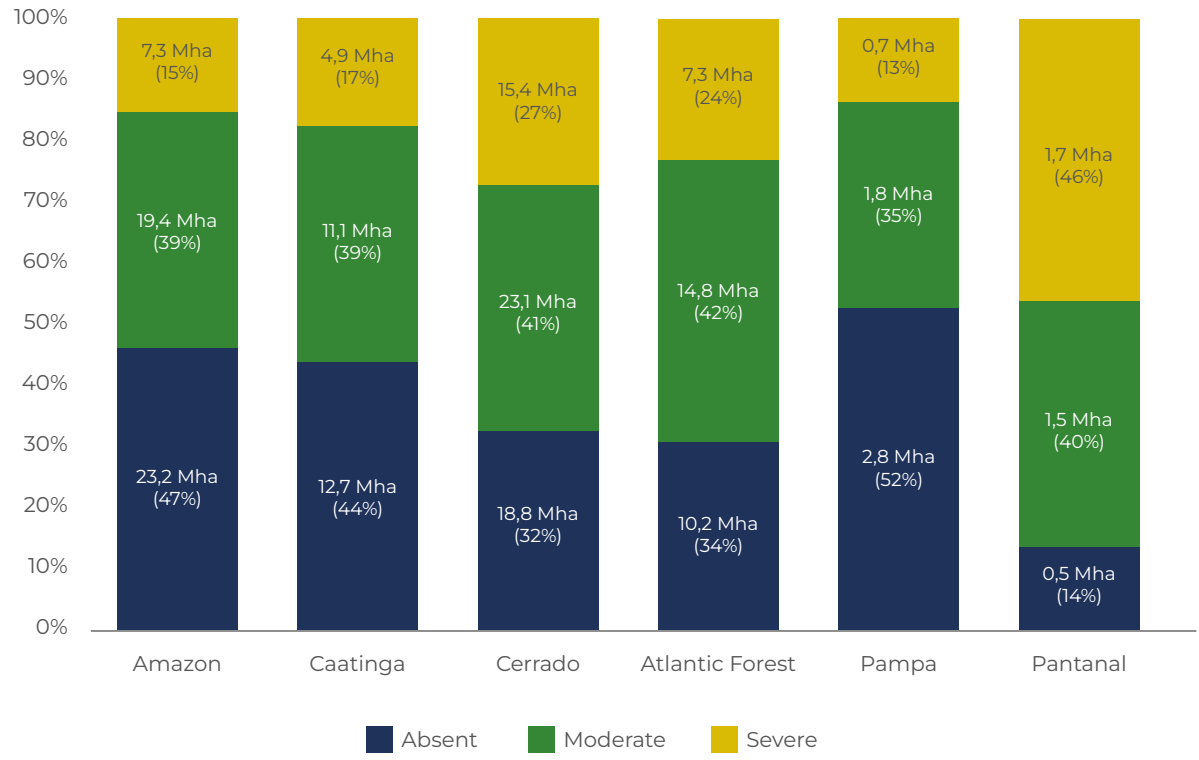
Progress in implementing the PRA was notable in several states, due to the increase in the number of signed commitment agreements (TACs) in Acre, Alagoas, Mato Grosso, Minas Gerais, Pará, and São Paulo states. Another alternative that accelerated the progress of environmental regularization was in adopting self-declaratory PRAs, prior to CAR analysis. This model enabled regularizing rural properties in Minas Gerais to reach the end of 2024 with almost 200 TACs signed (CPI, 2024, p. 25-26).

It is noteworthy that the environmental compliance agenda is a long-term policy that is expected to last up to 20 years after each producer has joined the regularization process. Considering the CAR analysis process in the states, approval of PRAs to base the compliance process, and the beginning of area recovery, this will lead to a new dynamic in land use, mainly by reducing pasture areas (Harfuch et al., 2016a).

PASTURE AREA CHALLENGES

Given the amount of available pasture and the possibility of improving productivity through the implementation of technology, there is a major challenge regarding private land use. Figure 3.11 shows the availability of degraded areas that can be recovered or allocated to other uses such as native vegetation restoration, agriculture, or even recovering and intensifying areas with some degree of degradation.

Figure 3.11 – Pasture degradation levels by biome



Source: Lapig (2022), Prepared by: Agroicone.

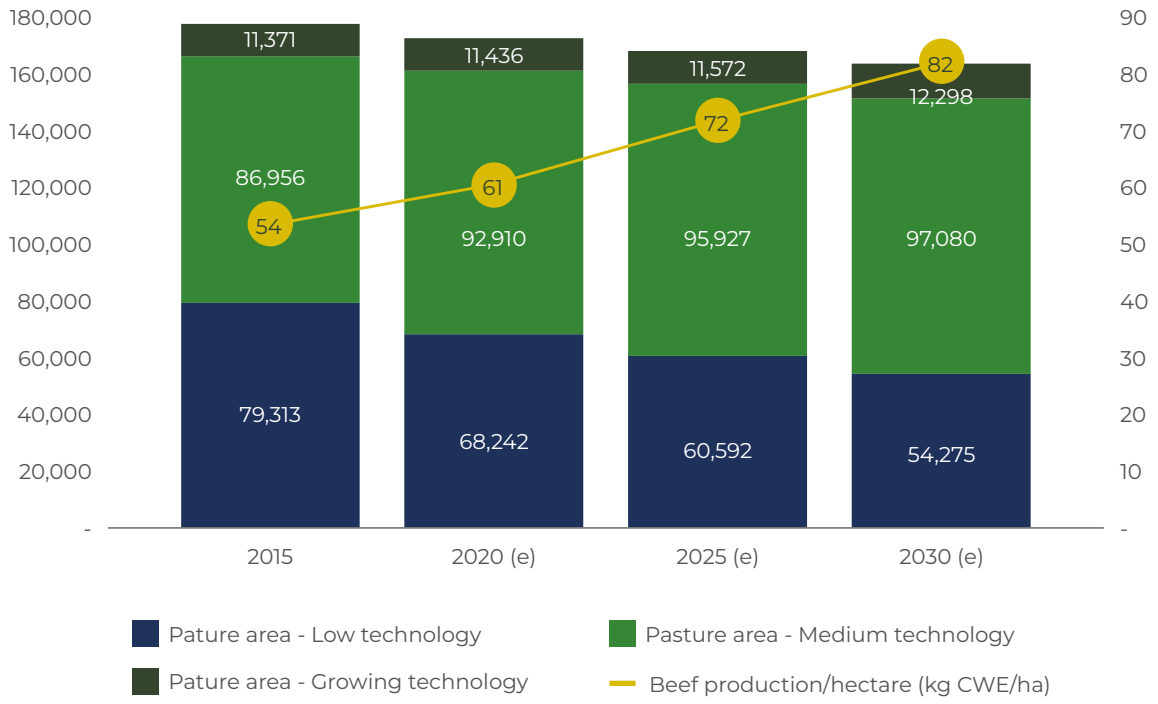
"Poor" allocation of land use has severe implications for agricultural production (below efficient levels), financial consequences for rural producers, as low productivity leads to low profitability of their businesses, and direct environmental implications such as deforestation (previous topic) and greenhouse gas emissions (next topic). However, given the diagnosis and public efforts, changes in land use for agriculture and cattle ranching in the coming years are likely to occur and will come from the following sources:

- The area of pasture that will be recovered / intensified (pasture stewardship and integrated crop-livestock - iLP and crop-livestock-forestry - iLPF systems).
- The area that will be freed up by pasture for other agricultural activities.
- Effective implementation of the Forest Code, requiring restoration of native vegetation.

Regarding land use changes occurring on pasture, more efficient land use and increased productivity are essential. Starting from 178 million hectares in

2015 (Figure 3.12), it is estimated that by 2030 the pasture area would be 161 million hectares (including integrated systems).

Figure 3.12 - Pasture area (1.000 ha) and beef production per ha



Source: Agroicone using the Brazilian Land Use Model (BLUM), adapted from scenarios presented by Centro Clima (2020).

Intensifying cattle ranching and recovering pastures will also increase cattle productivity, which is expected to reach an average of 90 Kg/hectare/year in 2030 (up from 63 kg/ha/year in 2020). However, this process would depend on issues including:

1. Disseminating knowledge about cattle herd intensification and its benefits for producers, and adopting good practices:

- Deploying rotational grazing and pasture stewardship
- Incentivizing producers to invest in training their staff in the technological process and in implementing sustainable practices
- Improving the use of inputs and animal genetics

2. Increasing access to rural credit, enabling producers to invest in accelerating the pasture recovery process:

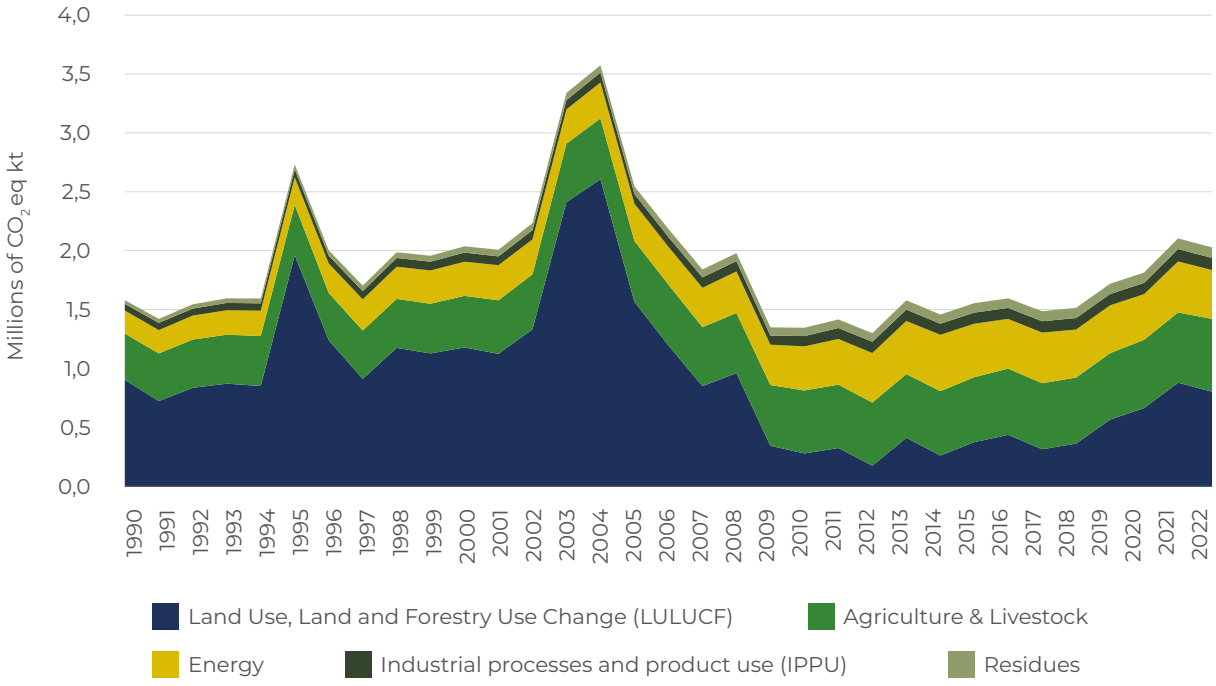
- Contracting technical assistance for implementing intensification
- Encouraging producers to manage (costs and revenues) their properties, as well as productive efficiency indicators

3. Supporting producers in complying with the Native Vegetation Protection Law (Forest Code)

GHG EMISSIONS AND SUSTAINABLE PRODUCTION IN BRAZIL

The Brazilian GHG emissions pattern has changed in recent years. In 2005, emissions from land use, land use change, and forestry (LULUCF) accounted for 61.4% of total CO_2 equivalent emissions (BRASIL, 2025b), as shown in Figure 3.13.

Figure 3.13 – Evolution of GHG emissions by industry

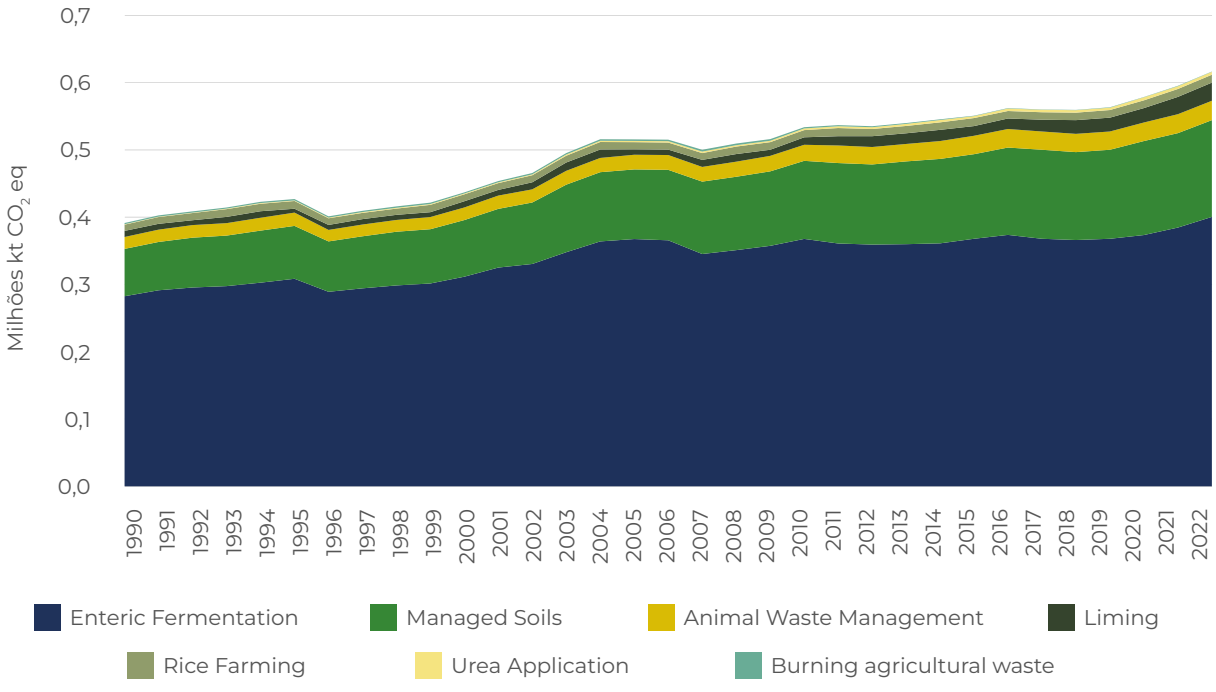


Source: Brasil (2025b)

In 2012, this figure dropped to 13.2% due to reduced deforestation, and the energy and agriculture industries became the most important ones in terms of emissions, accounting for 32.5% and 41.3%, respectively. Data from 2022 show that LULUCF once again became the most representative industry, accounting for 39.5% of total CO2 equivalent emissions, surpassing the agricultural industry, which accounted for 30.5% (BRASIL, 2025b).

Methane (CH_4) accounted for 70.9% and nitrous oxide (N_2O) for 24% of total agricultural emissions. A total of 622 million tons of CO_2 equivalent was recorded in 2022 – a 3.6% increase compared to 2021, and 15.2% compared to 2012 (540 million tons of CO_2 equivalent) (BRASIL, 2022).

Figure 3.14 – Evolution of GHG emissions by agricultural subsector



Source: Sirene, BRASIL (2025b)

Solid waste disposal, soil emissions, and enteric fermentation were the main drivers of methane emissions (84%), with enteric fermentation from beef cattle accounting for 87%, followed by 10% from dairy cattle and 3% from

enteric fermentation from other animals, manure, and burning sugarcane and rice residues. The main N_2O emissions come from agricultural soils due to animal manure, using synthetic fertilizers, and grazing animals (BRASIL, 2025b).

In Brazil, improvements can already be seen in methodological aspects related to GHGs in cattle ranching: (i) organizing data and information for integrated analysis at regional level; (ii) developing new assessment methods, methodological standardization, and creating emission factor databases for assessing the carbon footprint life cycle in cattle production systems; and (iii) developing applications for production systems that enable assessment of greenhouse gas balances and strategies for mitigating greenhouse gas emissions on farms (Imaflora, 2020; Imaflora, 2021).

Recognizing that recovering degraded pastures and intensifying cattle ranching are the main drivers of productivity gains, it is important to consider carbon sequestration from improved pasture stewardship, pasture recovery, and practices such as integrated systems as parameters for measuring the beef production life cycle in Brazil.

Agricultural soils can act as a source of GHG emissions or removals, depending on the stewardship system to which they are subjected (IPCC, 2001). Stewardship systems that increase addition of plant residues and carbon retention in the soil are relevant alternatives for increasing CO2 capture capacity. Soils that are uncovered or subjected to intense tillage practices, in different stages of degradation, are a source of GHG emissions. However, even estimates of soil carbon stocks are a challenge in terms of monitoring and mapping the complexities of different soils (Imaflora, 2020).

This shows that increased emissions can be avoided if carbon stocks from deforestation are curbed and the recovering degraded pastures leads to higher stocking rates in these areas and greater production per area unit, combined with conservation and restoration under the Forest Code. These factors will enable reduced and more accurate GHG balances from agricultural production.

In addition to diagnosing emission sources and their balance, it was understood that intensifying animal feed results in a reduction in GHG emissions on Brazilian ranches. Congio (2023), for example, outlines genetic and nutritional strategies in terms of emission reductions (%) and productivity gains (%), as shown in Figure 3.15.

Figure 3.15 – Cattle stewardship strategies and impacts on emissions and productivity gains

METHANE MITIGATION STRATEGY	EMISSION REDUCTION (%)	PRODUCTIVITY GAIN (%)
Animal genetics	-38	+99
Continuous grazing Stewardship	-22	+22
Rotational grazing Stewardship	-35	+71
Adequate protein in the diet	-10	+12
Increased feed intake	-37	+171

Source: Congio (2023)

In general, practices that increase productivity influence the reduction of emissions resulting from land-use change, as they (i) avoid the clearing of new areas; (ii) promote the maintenance of native vegetation areas or even their restoration; (iii) contribute to the reduction of other adverse impacts by promoting environmental services, such as soil and water conservation, and the maintenance of fauna, flora, and scenic beauty (Imaflora, 2015).

Carbon Neutral Brazilian Beef

The quest to neutralize CO2 emissions from livestock farming led Embrapa to research a research-based solution for the production system. Carbon Neutral Beef is a production seal that aims to certify that beef has neutralized emissions volumes during its production process (at the farm gate) through the adoption of audited integrated systems on the farm (livestock-forest or crop-livestock-forest). The methodology considers the volume of emissions according to the number of animals, weight, age (number of teeth), and for "sequestration," the volume captured by tree trunks in addition to the amount already captured by pastures, thus creating a single baseline.

The Carbon Neutral Meat brand is registered with the National Institute of Industrial Property (INPI) and can be used for any type of meat—fresh, frozen, or processed. However, the Embrapa seal (a private

sustainability standard) is not yet an additional payment factor for producers, which would favor its adoption.

The advancement of best practices was demonstrated in the 4th National Emissions Inventory of 2022, which demonstrated that the sector was able to increase production (and productivity) given the 30% reduction in emissions estimated for the year (631.2 MtCO2e) in the agricultural sector. In this sense, even though livestock farming has a positive emissions balance, good practices for intensifying pasture use or other land uses can mitigate part or all of the emissions generated (e.g., carbon-neutral beef), while maintaining or increasing productivity. The challenges of this process are land allocation, financing for reversing the degradation process to more efficient uses, and securing rural producers' buy-in.

3.4 **ECONOMIC AND FINANCIAL ASPECTS:** PUBLIC AND PRIVATE POLICIES

Along with improving GHG methodologies and accounting, adopting low-carbon practices has positive impacts on cattle production and other agricultural practices, in line with **SDGs 7, 12, and 15 for fostering clean energy, sustainable production, and soil conservation**. Brazil adopted the path to low-carbon agriculture in 2010 as part of the National Climate Change Policy (Federal Law No. 12,187/2009), which was enacted after Brazil committed to Nationally Appropriate Mitigation Actions (NAMA) during COP15 in Copenhagen.

Plano ABC (Low Carbon Agriculture Plan) is a sectoral plan for climate change mitigation and adaptation created by the federal government and administrated by the Agriculture Ministry. Its different objectives include specific financial incentives for the following six most relevant actions to be carried out by 2020[7].

To achieve these objectives, a special incentive/credit line was created and approved by the federal government (National Monetary Council - CMN) to finance sustainable technologies/projects, which offered R$ 4.5 billion in 2014 alone, with annual interest rates of 5%. *Plano ABC* projected a total of R$ 197 billion for financing low-carbon agricultural projects during the 2011-2020 period, achieving up to **163 million tons of CO_2eq reductions by 2020**. The results for the 2010-2020 decade are presented in Figure 3.16.

Figure 3.16 – *Plano ABC* – Goals and Results 2010-2020

TECHNOLOGIES	IN AREA MILLION ha			MITIGATION MILLION Mg CO_2eq		
	GOAL	RESULT	REACH	GOAL	RESULT	REACH
Degraded Pasture Recovery	15	26.8	179%	104	36.01	35%
Crop-Livestock-Forest Integration	4	10.76	269%	18 to 22	40.78	185%
No-Till System	8	14.59	182%	16 to 20	26.7	133%
Biological Nitrogen Fixation	5,5	11.78	214%	10	21.56	216%
Planted Forests	3	1.88	63%	-	8.82	-
Animal Waste Treatment	4.4 million cu.m.	38.34 million cu.m.	871%	6,9	59.81	867%
TOTAL *PLANO* ABC	**35,5 million ha**	**54.03 million ha**	**152%**	**133 to 163**	**193.67 million Mg CO_2eq**	**119%**

Source: Agriculture Ministry (MAPA)

The *ABC* Program was launched as a financial instrument for financing *Plano ABC* technologies since 2010, as well as for incorporating compliance with the Forest Code. However, despite the importance of the *ABC* (or *ABC+*) Program, which was renamed RenovAgro in the 2023/2024 harvest, as a GHG mitigation financing program for the rural industry, it has faced challenges since its inception with regard to regional credit disbursement/assessment vs the schedule. A strong disproportion in disbursements and contracts signed between regions can be clearly identified.

In the 2013/2014 to 2023/2024 crop years, the Midwest and Southeast regions contracted R$ 10 billion and R$ 7.6 billion in the *ABC+* Program, respectively, while the North and Northeast regions, which are in dire need of more support for developing their economies and reduce poverty, especially in the rural population, contracted R$ 3.8 billion and R$ 3.9 billion, respectively, in the same period (SICOR, 2025). These latter regions recently increased their demand for financial resources from the Program.

The new targets for 2030 were included in the Sectoral Plan for Adapting to Climate Change and Low Carbon Emissions in Agriculture and Livestock, with a view to Sustainable Development (2020-2030) - ABC+ (MAPA, 2021):

- Recovery of degraded pastures **(30 million hectares)**
- No-till farming **(12.58 million hectares)**
- Biological nitrogen fixation **(5.5 million hectares)**
- Crop-livestock-forest integration - iLPF **(10 million hectares)**
- Planted forests **(4 million hectares)**
- Agroforestry systems **(0.1 million hectares)**
- Biological inputs **(13 million hectares)**
- Irrigated systems **(3 million hectares)**
- End of slaughter feed **(5 million animals)**
- Animal waste treatment **(208.4 million cu.m.)**

Plano ABC+ is also based on the Paris Agreement and the need to create an environment that is conducive to fostering degraded pasture recovery and good agricultural practices. The ability to measure GHG reductions based on the Plan is also a cross-cutting challenge that deserves attention.

In addition to the financial resources from the *ABC/ABC+/*RenovAgro Program, other financing lines have been redesigned for family farming, creating distinct financing lines in the Family Farming Strengthening Program (Pronaf), which is summarized in Figure 3.17.

Figure 3. 17 – Pronaf Credit Lines, their purposes, financial resource volumes, and main products financed in 2018-2024

PRONAF INVESTMENT CREDIT LINES	PURPOSES	FINANCIAL RESOURCES VOLUME (2018-2024)	MAIN FINANCED PRODUCTS (2018-2024)
Pronaf Floresta	Agroforestry systems; sustainable extractive exploitation; restoration of APP and ARL; Recovery of degraded areas; enriching forest areas.	R$ 435 Million	Açai (R$ 242 Million); Cocoa (R$ 98 Million)

PRONAF INVESTMENT CREDIT LINES	PURPOSES	FINANCIAL RESOURCES VOLUME (2018-2024)	MAIN FINANCED PRODUCTS (2018-2024)
Pronaf Agroecologia	Agroecological or transition production systems; organic systems.	R$ 42 Million	Cattle (R$ 5 Million)
Pronaf Bioeconomia	Renewable energy; sustainable extractive systems; environmental technologies; recovery of ARL and APP; forest seedling nurseries; silviculture; agroforestry systems; rural tourism; bio-inputs.	R$ 4.3 Billion	Renewable energy (R$ 1.4 Billion); Rural electrification (R$ 846 Million)
Pronaf Semiárido	Projects for coexistence with the semi-arid region (resilience) focused on agroecosystem sustainability.	R$ 1 Billion	Lake, tank, ponds, canals, reservoirs (R$ 236 Million); Irrigation (R$ 139 Million)

Source: Banco Central do Brasil; Sicor. Accessed on June 29, 2025. Prepared by: Agroicone

Although credit lines are geared toward implementing sustainable production systems and environmental technologies, there is low uptake among family farmers specifically for the purpose of recovering degraded pastures.

Brazil Green Way

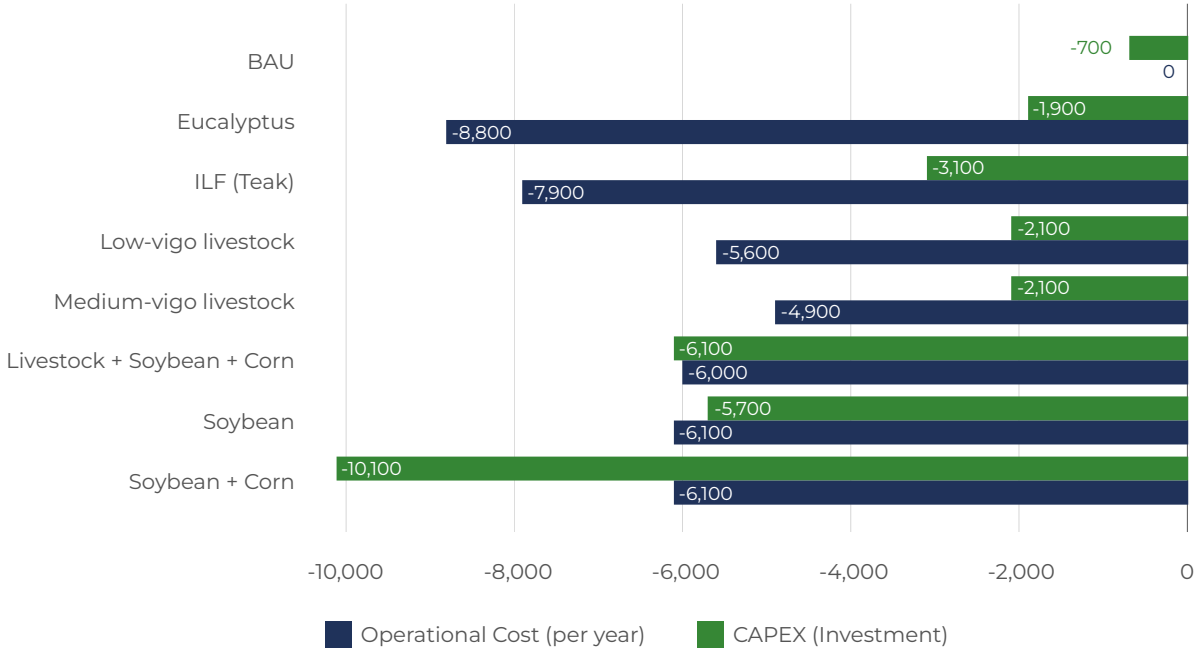
Caminho Verde Brasil (Brazil Green Way) was launched by the federal government, and aims to boost environmental recovery and productivity in the agricultural industry by restoring degraded areas and providing support for sustainable systems. The government aims to raise private and foreign funds, as well as climate funds, for area

restoration projects. The Eco Invest Program is jointly coordinated by the Finance Ministry and the Environment and Climate Change Ministry, which is part of Novo Brasil, a strategy aimed at transitioning the Brazilian economy through bioeconomy, green industry, and sustainable finance. The Agriculture Ministry (MAPA) and the Inter-American Development Bank (IDB) are partners in the Green Way Brazil initiative.

Brazil Green Way aims to recover 40 million hectares of degraded pastureland over ten years and convert it into sustainable agricultural and forestry systems. Eco Invest Brasil will fund the first stage, which involves recovering 1 million hectares through a call for projects.

Estimates of initial investments and annual operating costs for recovering or converting degraded pastures into sustainable systems were presented for nine Brazilian states in Brasil (2024). Each production system, pasture conditions, and property infrastructure affect these estimates, in addition to differences in costs and economic viability in each of the country's states and regions. Figure 3.18 presents these estimates for Mato Grosso state as an example for the selected systems.

Figure 3.18 – Cost estimates for degraded pasture conversion (per hectare, for Mato Grosso state, in 2023)



Source: Agroicone – Data Panel on Degraded Pastures and Potential for Conversion to Sustainable Systems, results from Brasil (2024)

According to Brasil (2024), considering the nine Brazilian states selected for the study, the recovery or conversion of 23.1 Mha of degraded pastures into sustainable systems requires initial investments of at least R$ 139 billion (USD 29 billion[5]), in addition to operating costs that could reach R$ 90.8 billion (USD 18.8 billion) per year.

DIVERSIFIED FINANCING

All challenges involved in transitioning cattle ranching require financial resources, some of which are non-repayable. In some cases, such as environmental adaptation, infrastructure, technology implementation, and recovering degraded pastures in line with public policies (Plano ABC+, Green Way Brazil initiative), they require easy financing conditions, in addition to strict social, environmental, and climate criteria, which require monitoring.

Public financial resources are limited. In 2013/2014 and 2023/2024, R$ 9.5 billion were contracted for cattle ranching in investment credit lines aimed at sustainable systems (Agroicone, 2025). This means that private financing plans for cattle ranching must take into account the scale of actions required for supporting the cattle ranching transition (as defined by the assessment conducted by Brasil, 2024).

The amount of degraded pastureland that must be recovered, used for other agricultural purposes or for recovering native vegetation, requires specific projects to boost CO_2 emission mitigation and foster the development of agribusiness production chains, considering the three pillars of sustainability.

The importance of the previously presented social aspect should also be emphasized and reflected in the financing conditions. Return on investment in beef cattle ranching is different when compared to agriculture, and cattle ranchers are more averse to risk. In this sense, and given the costs of implementing the National Program for Converting Degraded Pastures (Decree N. 11,815/2023, incorporated into the Brazil Green Way initiative), private and international capital financing should be part of the solution.

In addition to financial tools for enabling the shift to more productive and sustainable cattle ranching, other instruments that take into account preserved vegetation areas and value the surplus of native vegetation must be considered, such as Payment for Environmental Services (PES), Environmental Reserve Quotas (CRAs), or other carbon market instruments. Discouraging

[5] Commercial exchange rate on 31/DEC/2023: BRL/USD 4.84

legal conversion of native vegetation areas is a challenge that has not yet been addressed due to the inability to connect financial resources in a concrete way on a large scale.

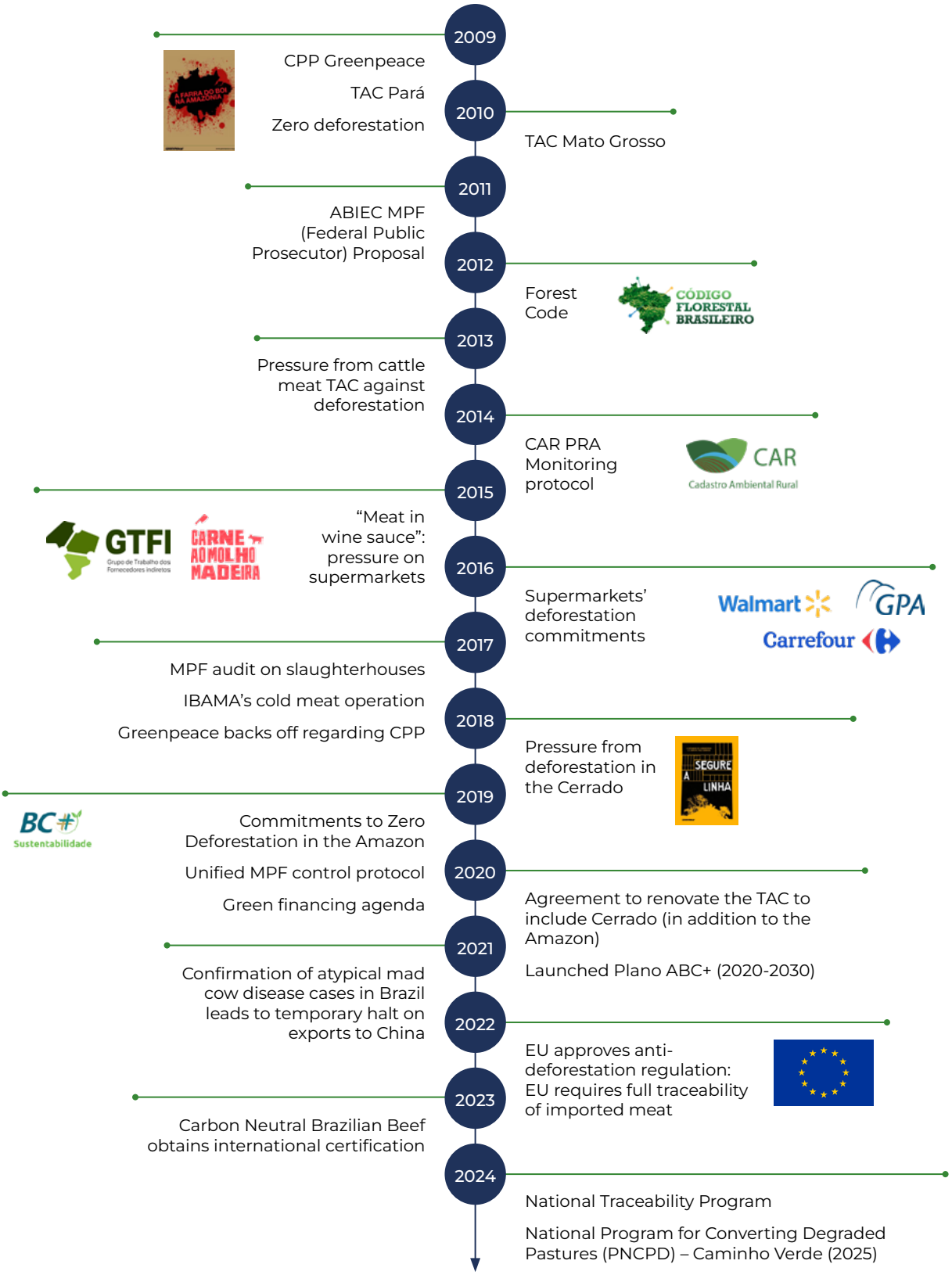
3.5 CONTINUOUS IMPROVEMENT OF THE BEEF CHAIN

The beef cattle system poses several challenges in terms of the triple axis of sustainability. This has led to the development of a series of global initiatives aimed at improving processes and practices in the chain in the social, environmental and economic areas, with a view to ensuring that the industry remains at the forefront of production.

The milestones highlighted in Figure 3.19 represent the evolution of domestic institutions and the reorganization of the main actors in the system, who play an important role and draw attention to a system that responds and advocates interests supported by the private sector and science. All actors, whether private, public, or non-governmental organizations, are increasingly seeking cooperation for this industry's evolution to understand, address, and propose solutions to the challenges of the triple axis of sustainability.

Photo: Adobe Stock

Figure 3.19 - Historical perspective of the beef cattle system, deforestation, and traceability



Source: prepared by Agroicone

4. THE FUTURE OF FOOD SYSTEMS

According to FAO (2024), 638 to 720 million people went hungry and almost 2.3 billion people did not have access to adequate food in 2023, a 20-million people increase in only one year. The challenges of food and nutrition security and poverty eradication (SDGs 2 and 1) were severely impacted by the COVID-19 pandemic, which put greater pressure on the goal of achieving food security for a growing population.

The Food Systems Summit (FSS) convened by the United Nations in 2021 generated an important debate on how to improve and transform the different segments of food systems, from farm to table. The global challenge for food security and nutrition needs to consider four dimensions: availability, access, utilization, and stability (HLPE, 2020).

Availability of nutritious, healthy, and diverse foods depends on several factors, according to each country's realities and characteristics. These include water supply, availability of productive land, access to technology and innovation, good agricultural practices, access to technical assistance and financing, and other factors.

Access to food depends on different aspects, such as availability, socioeconomic conditions, development levels, social policies aimed at providing safe food to vulnerable populations, school feeding programs, urban agriculture programs, food trade, and others.

Food utilization, for example, is related to how people are using their resources to ensure their livelihoods, including food security. Stability means having all three dimensions stable.

The connection between each line of action and the realities and challenges faced by countries, as well as the debates held at the Pre-Summit in July 2021, generated global convergence on the need to foster resilient and improved agricultural systems as a basis for addressing the impacts of climate change on food security. Coalitions for change emerged at the Pre-Summit, five specific and two general ones related to the five lines of action: school feeding, zero hunger and nutrition, agro-ecological and sustainable systems, aquatic food, and climate resilience. The general or cross-cutting ones were income and decent work and "food is not waste".

In 2021, the Food Systems Summit (FSS) process proposeda global debate on how to improve and transform food systems, considering five lines of action:

Sources: United Nations/Food Systems Summit 2021. Prepared by: Agroicone.

The Food Systems Summit held in September 2021 saw the commitment of 155 Member States. More than 100 countries submitted strategies for their local priorities to be implemented over the following 10 years. Around 2,500 ideas for solutions for change were proposed to be developed over the same period. The five lines of action were grouped into four (nourish all people, scale up nature-positive production, foster equitable livelihoods and strengthen communities, and build resilience to vulnerabilities, shocks, and stress), and the coalitions became 28 linked to these four lines (by July 2023).

At the 2021 FSS, Antonio Guterres drew attention to the negative relationship between food systems and the emission of one-third of greenhouse gases and 80% of biodiversity loss worldwide. There is a need for solutions that completely change this outlook, while at the same time, they are capable of feeding people. He also points out that agriculture must be part of the solution for mitigating climate change and biodiversity loss, and not the problem.

The coalitions submit ways for achieving this goal. The main contributions discussed during the FSS can be summarized in the following points:

- Smart agriculture can address the industry as part of the solution, not as a problem. Technology and innovation adapted to local food systems can enable GHG emission reductions and increase resilience.

- Science and technology as a basis for transforming and adapting food systems, together with technical assistance and capacity building for producers.

[6] Additional information can be accessed at: https://www.unfoodsystemshub.org/en

- Reducing food waste and loss across food systems by improving infrastructure, access to the cold chain, and monitoring.

- School feeding and breastfeeding coalitions for ensuring healthy nutrition from early childhood.

- Protecting smallholders, indigenous people, farming practices, and land rights; involvement in minority inclusion, including women, and their empowerment in financial matters - access to credit, knowledge of techniques and technologies, and increased income.

- Financial assistance for implementing technologies and foster change. Most least developed and developing countries do not have sufficient budgets to include all producers in sustainable food systems, provide technical assistance, and boost income.

- Access to water – scarcity, high temperatures, and soil degradation leave entire countries in a state of constant vulnerability and dependence on imports.

- Fair international trade and equal production conditions in all countries, reducing subsidies and barriers.

These key topics discussed during the FSS and debated in national dialogues provide a sense of the principles that will guide developing and transforming food systems by 2030. The United Nations Secretary-General stated in his speech that food is not a mere commodity, but a right. He emphasized the need for government leadership and governance in this direction, as well as financial resources and platform support from the United Nations.

BRAZIL IS PART OF SIX GLOBAL COALITIONS ON FOOD SYSTEMS

Updated through July 2023, Brazil is a member of six coalitions: Coalition for Action on Healthy Diets in Sustainable Food Systems for Children and All; Food is Not Waste; International Coalition for Territorial Governance of Food Systems; Coalition on Sustainable Productivity Growth for Food Security and Resource Conservation; Coalition for Food and Forest Systems; and Coalition for School Feeding . All of these debates are connected to the beef cattle system due to its relation to nature and natural resources, and because meat is a rich source of nutrients and vitamins that are essential for human health and child growth.

Livestock production, especially beef cattle, is part of many forums that include climate change and deforestation, soil degradation, water efficiency, and healthy nutrition. Beef production and its importance were highlighted by several countries. Latin American countries stood out — Argentina, Paraguay, Uruguay, and Brazil — in addition to those suffering from lack of animal protein and vitamins.

Image: Capão Redondo Farm, by Rodolpho Botelho

It is important to highlight that:

> 1) The debate reached decarbonizing this system through sustainable technologies and integration with agriculture and forestry. The Brazilian National Pathways presented at the Food Systems Summit feature balanced objectives to agribusiness, in accordance with the work carried out by public policies, the private sector, research institutes, and NGOs. Continuous and inclusive scientific research and innovation to foster and improve food systems. In the beef cattle system, R&D and continuous innovation are key to efficient and sustainable production, which are as important as the evolution of methodological measurements of GHG emissions for these globally recognized systems.
>
> 2) Developing food systems adapted to local circumstances that incentive reducing greenhouse gas emissions and foster a resilient agriculture. Linking livestock production to other systems by biome can be a challenge, but it is a solution for the adaptation process in creating sustainable food systems. Biomes and their characteristics need to be considered before coordination plans for resilient agriculture and livestock production are developed.
>
> 3) Agriculture as a solution to climate change. Cattle farming as part of an integrated system can also be a solution to climate change. Developing low-carbon agriculture is the best solution for the entire system.

[7] Translation by the authors into Portuguese from Brazil's selection at: https://www.unfoodsystemshub.org/about-us/advisors-and-partners/compendium-of-food-systems-coalitions/en

4) Favor using renewable energy generation in food systems. The beef cattle system is linked to generating biofuels through tallow and feed produced as co-products (such as corn ethanol), but it can also incentive and coordinate the adoption of renewable energy across the chain.

5) Support smallholders and family farming for driving sustainable livelihoods and food diversification. Cattle is not an exclusive activity for large ranchers. Smallholders and family farming are part of this chain, and they can offer more information about their supply. In addition, coordination mechanisms can diversify the link between assistance for land use problems and social inclusion, as well as technical assistance for boosting integrated systems.

6) Ensure safe, healthy, and nutritious food for all. Beef is one of the richest sources of B vitamins, especially vitamin B12. Ensuring availability of and access to a safe and healthy amount of beef is desirable so that the population can secure nutrients and well-being.

7) Combat food waste and loss. Beef is one of the most expensive products for consumers. Preventing waste and loss means providing safer products for them. Coordination between producers and processors can prevent losses during slaughter. Proper training of supermarkets and specialized establishments in proper cutting can also prevent losses. However, one of the main issues that needs to be improved to prevent meat waste is cold chain logistics. Proper transportation and storage are important to ensure a safe and healthy product.

8) Fair trade. The beef cattle system is one of the most protected ones in international trade. Sanitary barriers or tariffs are part of the repertoire. Fostering fair trade when the system follows international standards should be considered.

With regard to the beef cattle ranching system, *Plano ABC+* (2020-2030) is the main public policy for incentivizing pasture recovery, integrated production systems, and efficient cattle production that enable emission reductions, as well as the *Caminho Verde Brasil* (Brazil Green Way) that was launched in 2025, which is expected to boost the implementation of sustainable systems.

Another matter related to the beef cattle system is deforestation, biodiversity loss, land tenure rights, and climate change. This agenda has many institutional aspects, such as the enforcement of the Forest Code in Brazil and the unfolding of beef production, as highlighted in topic 2. Brazilian cattle ranching is growing independently of deforestation (Figure 2.9), but this does not mean that this industry cannot contribute positively to all

these issues, driving efforts and joining forces with other systems to make agriculture a solution, not a problem.

In pursuit of this scenario and the Brazilian National Pathways for developing Sustainable Food Systems within the FSS, the trends are:

- Public-private partnerships for research and development of positive technologies for beef cattle production in decarbonized systems.

- Provide training for producers, processors, and technicians to work with these technologies and disseminate them to ranches of all types and sizes.

- Improve communication and information regarding system processes, from ranch to table, and foster transparency.

- Value environmental and social assets and communicate with the market, not only about production efficiency and financial assets.

- Include small producers and communities in sustainable beef production systems, technologies, and technical assistance, as well as help with land tenure rights and environmental knowledge that leads to preserving and conserving biodiversity in Brazilian biomes.

- Coordinated actions across the entire system to prevent food loss and waste, as well as resource (land, water, and its reuse) usage.

- Boost international trade and open new markets in a fair manner, also based on nutritional needs.

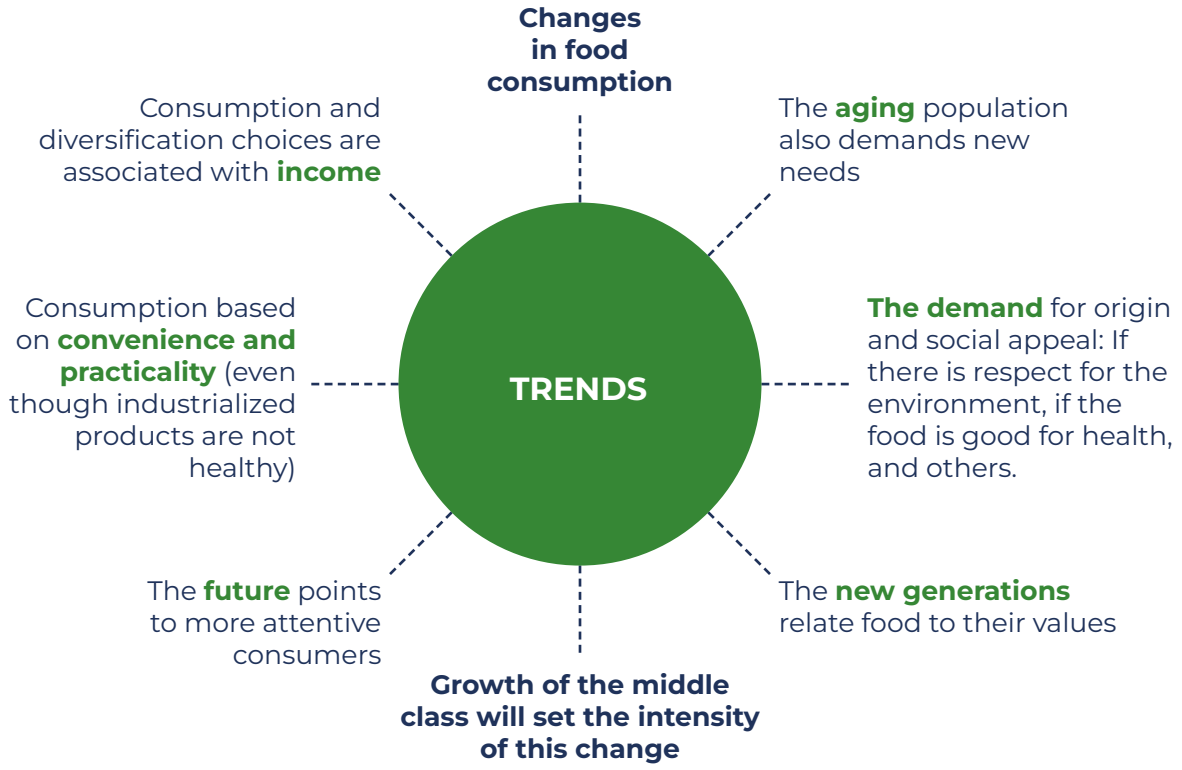
Trends discussed at the Food Systems Summit and presented in the Brazilian National Pathways confirm previous research conducted by the São Paulo State Federation of Industries (FIESP) in 2017 on the behavior of Brazilian food consumers. One of these is prioritizing cheaper products when the domestic economy is in crisis and incomes are falling. This leads to more frequent home cooking and a preference for preparing food rather than buying semi-prepared foods.

Another aspect is regarding the information and sources of information that people seek. The Internet prevails as the main channel, rather than TV, as was pointed out in the first survey in 2010. The most searched topics in 2010-2017 were: organic food (26 p.p.), sustainability (21 p.p.), and carbon emissions (14 p.p.). Food was the third most searched topic on Google between 2011-2016. In 2017, it lost one position to finance.

Some contradictions were pointed out, as 81% of those interviewed confirmed that they are looking for better ways to improve their diet, and 71% are not concerned about paying more for healthy products. However, 61% confirm that the taste of food drives their food choices rather than their health, and 52% say that healthy foods do not taste very good. The survey also revealed that there is a difference between eating (healthy food during the week) and eating (tasty food on the weekend for pleasure). Beef ranks third as Brazilians' favorite food, followed by rice and beans (a staple food in Brazil), and pasta.

Figure 4.1 goes beyond the initial analysis and shows food consumption trends in Brazil. This can be seen as a step forward or what is to come in the future of the food system in terms of demand. The needs of the aging population, the values of new generations, originality and social appeal, convenience, and practicality are the drivers of changing consumption and eating habits. However, income and growth of the middle class will fuel the speed of these changes.

Figure 4.1 - Food consumption: determining factors and changes in habits



Source: Prepared by Agroicone

When it comes to both aspects (supply and demand) for beef cattle systems, as stated by Malafaia et al. (2021), global advances in the beef supply chain by 2040 will come from highly technical, professional, and competitive production based on technology and quality. For Brazil, the authors concluded the following megatrends:

> "(i) biological advances and waste management; (ii) biotechnological transformation of cattle ranching; (iii) less grass and more beef; (iv) profits based on animal welfare; (v) consolidated cattle ranching with major players; (vi) more natural and high-quality meatpacking plants; (vii) beef with origin identification; (viii) digital technology that transforms the entire supply chain; (ix) availability of quality labor; (x) Brazil as a major exporter of beef and genetics." (Malafaia et al., 2021).

Finally, in July 2025, the Food Systems Summit will be held to update actions and results.

Photo: Adobe Stock

5. THE INDUSTRY'S POSITION ON ADDRESSING SOCIAL AND ENVIRONMENTAL CHALLENGES

This topic emphasizes the important role of beef processors in coordinating the beef cattle system and its limitations. It introduces some concepts of the system's dynamics and coordination and how processors respond to challenges related to social and environmental issues and pressures. This topic is intended to serve as a bridge to the next one, introducing some concepts.

5.1 AGRIBUSINESS SYSTEMS AND DYNAMICS

The origin of "Agribusiness System Analysis" comes from a concept developed at Harvard University in the early 1960s as:

The sum of all operations involved in manufacturing and distributing agricultural supplies and production operations on the farm, and storing, processing, and distributing agricultural commodities. (Davis & Goldberg, 1957)

The analysis is based on two main elements (Zylbersztajn, 2017):

- Agriculture, treated as an isolated industry, has become part of a specialized interdependent system of agents operating in interconnected industries.s.

- Value added at farm level tends to decline over time as a share of total production value, with serious strategic consequences.

Goldberg was the first academic expert to point out that margins are higher as the product approaches its final market destination. The developed model highlights intersectoral connections. Implicit in his studies is the assumption of cost-free markets and frictionless interactions between industries, with no institutions.

The conceptual model opened a new door for looking at possibilities in agriculture regarding strategic issues. Several case studies have been conducted around the world, looking at systemic analysis. The analysis and strategy of the beef cattle system were conducted by Lemos & Zylbersztajn (2017).

Its importance for the systems development was the main theoretical discovery (Lemos & Zylbersztajn, 2017) of an industry in which agents had been pitted against each other for decades (Wedekin et. al, 2017). It also clarified the different strategies pursued by Brazil's largest meatpacking companies for meeting different market demands (Lemos & Zylbersztajn, 2017).

However, the importance of this type of analysis is not only to respond to market demands or institutional shocks, but also to shape strategies for the entire supply chain to evolve with coordination efforts.

Looking at all the interactions between agents across the system and how they are influenced by institutions and non-private organizations is a challenge for any agribusiness. Those less developed in terms of technology and support for innovation, human capabilities, and strong and established institutions may be more challenging.

The beef cattle system in Brazil faces these challenges due to the production's origins and its complexity. There are many variables to be analyzed that influence the final product delivered to meatpacking plants: genetics, internal health system (within the ranch), adopted feeding system, production stages developed by producers and their suppliers, level of information about producers and their suppliers. Some of these characteristics were listed by Lemos & Zylbersztajn (2017) in a study on quality standards perceived in international and domestic markets.

Known as specific assets or beef cattle attributes, these are what shape the product's strategy and governance structures (Lemos & Zylbersztajn, 2017). Through coordination, these attributes are measured, controlled, and evaluated across the system, creating a financial information flow.

5.2 BEEF PROCESSING PLANTS

The beef cattle ranching system is coordinated by beef processing plants (Lemos & Zylbersztajn, 2017). They are the agents that demand specific consents in their transactions with producers, translated into animal attributes. The coordination "movement" is made and shaped through

establishment requirements, transparent monitoring and controlling results and incentives (economic, development status and other rewards). Coordination has several positive results and generates positive externalities for the entire system. Research conducted by Lemos (2017) with three major meatpacking plants revealed the following:

- Coordination was achieved through quality programs created by meatpacking plants, and producers responded positively to attribute requirements and economic incentives.

- Technologies were progressively adopted by producers to "be part of the programs and standards". Technologies related to genetics, nutrition, and health, as well as animal welfare were adopted, and product standardization became a reality.

- Supply standards have enabled meatpackers to publicize brands in the domestic market, linking organizational strategies to product differentiation.

- Specially coordinated quality standards and systems (an example is organic beef) can be seen in the domestic market, not just to meet international market requirements.

- A better relationship between producers and processors and an understanding of their interrelationships can also be noted.

Positive externalities can be linked to good results from private sector coordination:

- This has driven technologies and low-carbon beef production through integrated systems or pasture recovery programs (such as the *Plano ABC* and *Plano ABC+*).

- Improvements in quality standards lead to opening new markets and exploring different strategies in the domestic market. Organizations were able to focus their efforts on their objectives, rather than just meeting the demands of the "mass."

- Differentiation was made possible through information exchange and transparency among all actors.

However, trading tangible attributes and fostering a positive relationship with producers that would lead to an information and financial flow was part of a 15-year development "plan" and did not consider bureaucratic attributes as mandatory (only production that would meet European Union standards,

mainly regarding health standards). The required controls were also valued differently, but never represented an important part of the dynamics of the beef cattle system, and were considered strictly coordinated for serving a specific market.

5.3 MAIN CHALLENGES FACED BY MEATPACKERS

When it comes to social and environmental issues and requirements, system coordination takes on a whole new dimension. The challenges outlined above have a significant impact on the public domain, such as land use enforcement, planning, and regulation.

On the other hand, taking responsibility for monitoring suppliers and enforcing transparency on both sides is a win-win partnership for providing information to consumers, markets, government, stakeholder inclusion, and enable sustainable standards coordination.

The conceptual debate about the role that meatpackers play in sustainable production standards brings ethical, sociological, and governance issues to the forefront. They can drive efficient and sustainable production methods that have positive results on productivity, reducing GHG emissions and deforestation.

But this coordination mainly brings ethics to the debate on beef consumption and its environmental efficiency. The challenge is not whether to do it or not, cooperate or not, but the survival of a system if transparency, information, and decarbonization are not established as mandatory for the well-being of humanity.

Meatpackers are particularly important for their coordinating role, but meeting social and environmental goals is not their sole responsibility within the industry. Considering the broader picture, partnerships between the public and private sectors to enforce sustainable requirements should be established to involve all stakeholders and protect the Brazilian beef industry.

This way, organizations, especially meatpackers, can develop strategies in their market and control mechanisms for meeting specific demands. Transparency and communication should be public rights in this case. The next and final topic is the case of Marfrig, one of the world's largest meatpackers. This case is remarkably interesting from a coordination standpoint because this organization has transformed the concepts of sustainability and environmental protection into tangible assets to be controlled, measured, monitored, and coordinated through incentives across the system.

6. MARFRIG'S STRATEGY

This last topic covers Marfrig's strategy and positioning on environmental challenges and its role as chain coordinator. From a historical perspective, a narrative will be constructed on the "problem" and the "strategic moves" that the company has designed over the years, leading up to the *Programa Marfrig Verde+* (Marfrig Green Program). An entire section will be dedicated to Marfrig Verde+ for exploring transparency, rationale, and data on producers linked to the company and those that are not yet monitored. The last section of this topic addresses how to include the excluded actors, describing existing problems and anticipating new ones.

6.1 MARFRIG'S STRATEGY AND POSITIONING

Marfrig is the world's largest hamburger producer and one of the leading beef companies. It has units in South America (Argentina, Brazil, and Uruguay), with a slaughter capacity of approximately 7,600 animals per day, and North America, with a slaughter capacity of 13,300 animals per day, and a total production capacity of 247,000 tons of hamburgers per year. The company employs more than 10,000 nationwide, distributed across 10 slaughterhouses and 16 production units that process beef products and by-products, such as leather, for the domestic and international markets.

In 2024, the company's net revenue was 144.2 billion Brazilian reais. Marfrig is recognized for the quality of its products and its sustainable operations, has pioneering projects for preserving the environment and natural resources.

MARFRIG'S POSITIONING AGAINST DEFORESTATION

Beef cattle production has historically been perceived as the industry with the greatest impact on Brazilian forests and biodiversity loss.

In response to growing international and domestic environmental concerns, Marfrig's aspiration over the last 15 years has been to increasingly disassociate its products from deforestation. Since 2009, following agreements with Greenpeace and later with the Brazilian government, Brazil's leading meatpacking companies (including Marfrig) have been working to step up

their cattle procurement procedures for reducing their production chains' environmental and social risks. Over more than 15 years, several partnerships and projects have been developed. The main objective is to build a sustainable beef cattle system through private coordination.

The governments' and the private sector's efforts have contributed to an impressive decline in deforestation trends in the Brazilian Amazon over many years, but cattle ranching is still perceived as the core of deforestation, not as a consequence or one of the plausible causes.

Deforestation rates in the Brazilian Amazon have indeed increased since 2012, and even more significantly since 2018 (Figure 3.5), but the beef cattle system has never stopped growing, even when deforestation was under control. Efficiency plays a significant role, and coordination programs are standing out, such as the Marfrig Club.

From a historical perspective, since 2009, Marfrig has developed several strategic plans for improving sustainability in its coordinated system. From the outset, it has made commitments and declared strategic actions based on data monitoring and investments in science for developing deforestation-free beef, low-carbon beef, or carbon-neutral beef. Figure 6.1 shows the evolution of plans and actions that reflect the companies' vision of sustainability as a strategic and specific high-value asset.

Photo: Adobe Stock

Figure 6.1 - Marfrig's strategic investments in sustainability

2009

· Committed to a **deforestation-free** supply chain in the Amazon

2010

· **Launched** a satellite geo-monitoring platform

2014

· 100% of farm areas in the Amazon are **included in the geo-monitoring platform**

2018

· Marfrig established a partnership with EMBRAPA, the Brazilian Agricultural Research Corporation, for **launching Carbon Neutral Beef and Low Carbon Beef**

2019

· Marfrig **began monitoring** fire outbreaks in the Amazon via satellite

2020

· Marfrig launched the **Marfrig Verde+ Program**

· Viva - a **Carbon Neutral Beef** product line

· Marfrig launched the Social and Environmental Risk Map

· Marfrig joined the Sustainable Calves Program

2021

· **Indirect monitoring tools**

· **Marfrig Club:** monitoring protocol and support center for producer compliance

· **Recovery programs** for reintegrating cattle ranchers

· **Cerrado monitoring:** adapted the satellite geo-monitoring system

2022

· The company implemented the **"Direct and Indirect Supplier Network Map"** tool, which enables **monitoring connections between links in the chain**

· Jointly created **BIOMAS**, the largest company in Brazil that is fully dedicated to forest **restoration, conservation, and preservation activities in the country**

· After establishing a partnership with MAPBIOMAS, Marfrig began the map base incorporation phase for **expanding the company's geo-monitoring layers**

· The company completed the Social and Environmental Risk Mitigation Map for the Atlantic Forest Biome, which enabled **expanding Marfrig's social and environmental practices** to this biome as well, in line with the Marfrig Verde+ Program

· Marfrig reduced its scopes **1, 2 and 3 emission targets, which were approved** by the SBTi (Science Based Targets initiative). It is the only company in the beef protein industry in the Americas to **commit to limiting global temperature increase to 1.5°C**

· The company launched its **sustainability content hub (www.pratodoamanha.com.br)**. This platform provides information on innovation and technology for developing more sustainable, low-carbon cattle ranching. It already ranks 9th in terms of audience, with **more than 40,000 hits in the month since its launch**

2023

- New cycle of the *Programa Verde+* (Green+ Program), with an **investment of around R$ 100 million** in areas such as **pasture recovery and transformation, ecological restoration, regenerative agriculture, and genetic improvement.**
- Five-year advance in the goal of **100% traceability of direct and indirect suppliers** in purchasing animals for slaughter. New goal: 100% of the supply chain traced by the end of 2025, in all biomes in Brazil.
- First audit cycle of the Amazon Cattle Supplier Monitoring Protocol **(Boi na Linha)**, conducted by the Federal Public Prosecutor's Office (MPF), with 100% compliance.

2024

- Maintained leadership in the beef protein industry in the FAIRR Initiative ranking and achieved an unprecedented triple A rating from the CDP, joining a select group of only eight companies out of more than 22,000 evaluated.
- Adopted an **integrated reporting model based on double materiality**, following the guidelines of the IIRC, GRI, and IFRS Foundation.
- **100% renewable energy use in Brazil by 2024**; global target of 100% by 2030.
- Marfrig was granted the **gold seal** of the Brazilian **GHG Protocol** program, the highest level of certification issued to companies that meet all transparency criteria in publishing greenhouse gas emission inventories.
- For the fifth consecutive year, Marfrig is part of B3's Carbon Efficient Index (ICO2) portfolio
- Implemented sustainable solutions for **treating and reusing of effluents** in production units; the highlight was for the Liberal unit (Kansas/USA), which treats and reuses around 7 billion liters per year as natural fertilizer.
- Maintained 100% compliance in all units audited according to the North American Meat Institute (NAMI) protocol, underscoring its **commitment to animal welfare**. Marfrig continues to stand out as one of the best-ranked beef protein companies in the **Business Benchmark on Farm Animal Welfare** (BBFAW).

Source: Marfrig (2025)

Until 2019, the timeline clearly shows actions for controlling the cattle's origination in the Amazon biome. Until 2020, strategic governance and transparency played a key role. The results of investments made in science and coordination with producers is noteworthy, and a new product, "Carbon Neutral Brazilian Beef", is launched on the market, as well as green credit, USDA organic beef certification, and others.

The Marfrig Club Program in producers to adopt good cattle ranching practices, which contributes to the ranches' sustainable development and ensures safer production with fewer environmental resources. The program was launched in 2010, and has three dimensions: respect for animals (traceability, animal welfare, nutrition, and health), respect for the environment (preserving native vegetation, soil, and water, waste treatment), and social respect (labor laws, housing conditions, health, and incentives)

6.2 THE MARFRIG VERDE+ PROGRAM

The *Programa Verde+* (Green+ Program) was launched in July 2020, in partnership with IDH - The Sustainable Trade Initiative. Its goal is to ensure that 100% of the company's production chain is sustainable and free from deforestation by 2025. In other words, a system that is positive for nature and smart for the climate.

Eliminating deforestation across the supply chain is a novelty in this industry, not only because other private companies have been unable to achieve this, but mainly because it depends largely on law enforcement (Forest Code) and other illegalities in private areas. This raises questions about the limits of private coordination for preventing deforestation.

What distinguishes Marfrig's commitments is the conviction that, in order to achieve zero deforestation across the entire chain as the company desires, this change must become systemic. In other words, the company should not limit itself to excluding farmers involved in deforestation from its supply chain (partly due to the leaking issue mentioned earlier).

The company seeks to refer non-compliant suppliers to technical assistance for regularization and more sustainable production models. Finally, Marfrig has committed to achieving a deforestation-free supply chain in the Amazon biome by 2025 and in the other biomes by 2030, although this target has been brought forward to 2025.

By deepening its traceability (monitoring) systems and strengthening its "purchasing and compliance" (control) mechanisms, the company believes

that for change to happen, it needs to be channeled through a process of inclusion and continued improvement, ultimately leading to those suppliers to become compliant. Through different tools and innovations, coordination will once again be conducted by the company for achieving a "sustainable asset."

In other words, Marfrig is contributing to improving the availability and access to nutritious food (SDG 2) through sustainable production methods (SDG 12) and driving the beef cattle system to adapt to a zero-emission system for preventing climate change (SDG 13).

Indirectly, it can also be related to better land use and conservation (SDG 15) and decent work, in addition to economic growth (SDG 8), since the system is very important for the Brazilian economy. Other relationships can be explored between the SDGs and improvements in the beef cattle system, but the most important ones for the plan to stand out are based on the three main solutions:

Financial mechanisms: attracting investment so that producers implement the Forest Code, calf intensification systems using integrated cropping and forestry systems, payment for environmental services and maintenance.

Technical assistance: supporting change on ranches through nutrition, genetics, health, and environmental compliance. It also supports the implementation of a "carbon neutral protocol" and "low carbon protocol" on ranches.

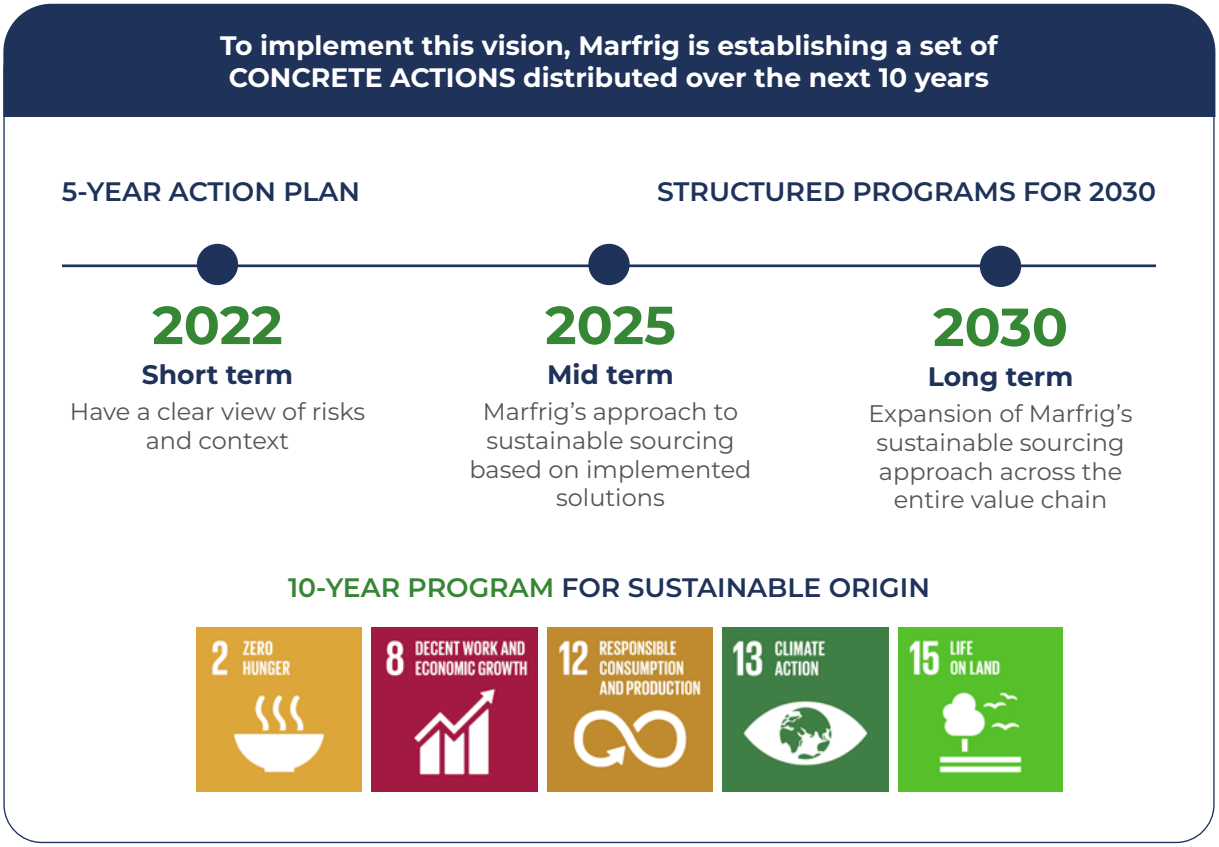
Monitoring indirect suppliers: by creating a close connection with suppliers, Marfrig intends to mitigate the risks of deforestation. The long-term vision for implementing the plan is to take 10 years to address the entire industry, following these steps and objectives:

- Direct suppliers: Expand the purchasing policy and monitor other biomes, fostering integrated cattle ranching systems for all sizes and production stages.

- Indirect suppliers: Develop control mechanisms for indirect suppliers under an inclusive approach, supported by a technical assistance network and financial mechanisms, providing better conditions for small and medium-sized producers to be included.

- Industry approach: Coordinated efforts with producers, meatpackers, retailers, banks, investors, and society for reaching market equality and avoiding opportunistic and illegal behavior risks.

Figure 6.2 - The links between these main objectives for achieving a sustainable beef system, the SDGs, and their implementation steps



Source: Marfrig Verde+

6.3 THE CHALLENGE: INCLUDING THOSE WHO WERE EXCLUDED

Since 2009, Marfrig has been monitoring direct suppliers in the Amazon biome for the following social and environmental indicators, as required by the Federal Public Prosecutor's Office (Imaflora, 2020):

- Rural Environmental Registry (CAR)
- Ranch perimeters with no overlapping with Conservation Units and Indigenous Lands
- Zero deforestation (legal or illegal) on the ranch since July 22, 2008
- No slavery-like labor

- Areas under environmental embargo by federal agencies (and some state agencies)

- Environmental licensing registration in some states

- Producers must present the GTA (Animal Transit Guide) to meatpacking plants.

When producers fail to comply with at least one of these requirements, Marfrig cannot purchase cattle from their ranches. Therefore, producers are excluded as suppliers of the meatpacking plant.

Excluding producers involved in deforestation from its supplier base would only eliminate the problem from the company's supply system, as these producers would have more incentives to continue deforesting or engaging in illegal activities. A systemic and effective change requires mechanisms for including these producers.

The Marfrig Club, a procurement program launched in 2010, fosters relationships between cattle producers and the company. The Club is used as a platform for supporting knowledge sharing and promoting incentive-based schemes to improve environmental and social practices. Currently, 100% of Marfrig's direct suppliers in the Amazon biome are registered with the Marfrig Club.

The inclusion-based approach is extending the company's zero deforestation procedures to indirect suppliers by establishing a network that targets small and medium-sized producers to provide them with technical assistance and financial mechanisms for implementing changes at farm level, as previously explained.

Including small and medium-sized producers is linked to improvements in several SDGs, bringing balance to the social, economic, and environmental pillars of sustainability. They also enable Marfrig to improve suppliers' ability to comply with its policies. Inclusion does not refer only to direct suppliers **(1), but mainly to indirect suppliers (2), with whom the company has no relationship.**

Marfrig acquired its cattle for slaughter from approximately 8,000 direct suppliers in 2024. For these direct suppliers, the company's vision was to establish new relating ways that support a more organized chain by developing a commercial integration model. This group does not appear to be Marfrig's biggest concern, especially since it has already secured a solid base of stakeholders in advance through the proposals of the Programa Marfrig Verde+ (Marfrig Green+ Program).

> Based on its RFI tool, which requires information from indirect suppliers of producers who sell cattle to Marfrig (direct suppliers), the company has been collecting information about its indirect supply chain. Marfrig's intention is to trace the origin of cattle at ranch level and across the different production stages (from breeding to slaughterhouse) in the different biomes in which it operates ("source control").

According to Marfrig, in Brazil, in 2024, 32,000 ranches were monitored (a 36-million-hectare area). By 2024, with solutions and actions such as technical support for documentation, multitemporal geospatial technical analyses, and a forest restoration program, more than 4,000 ranches were reintegrated into Marfrig's supply chain.

Reincluding these producers not only brings more suppliers to the company, but mainly steps up compliance with socio-environmental criteria, reduces informality in selling these cattle on the market, and takes these producers out of illegality.

Using evidence of social and environmental variables associated with cattle production and land use, the company is using risk maps to strengthen its monitoring system, guide and adapt solutions by region to the commercial conditions set for suppliers. The intention is to achieve "origination control" in all biomes where it operates by 2025, in line with technical assistance and financial instruments for enabling small and medium-sized producers to transform their production systems.

The biggest challenge of including the excluded ones is what will provide a shift in the company's strategy and its position in the market. At industry level, similar action plans are expected to be implemented for addressing the same issues.

On the other hand, this battle should not be a unilateral approach. It needs the support from multiple stakeholders, for it to be a win-win process. Many of them are already aligned and are allies to Marfrig's cause, as partners in the following initiatives: Cattle Supplier Monitoring Protocol, Reintegration and Monitoring Program in Matto Grosso State, Instituto PCI - Produce, Conserve, and Include in Mato Grosso, Sustainable Calf Production Program, Conecta monitoring tool (blockchain pilot application), beef production protocols (such as low-carbon beef, carbon-neutral beef).

In order to improve its purchasing protocols, social and environmental monitoring, and action strategies, Marfrig uses social and environmental risk mitigation maps developed by partners, whose exposure to risks requires localized and differentiated actions in the territories.

The established governance is an example of how coordination and incentives can bring positive social and environmental externalities to all stakeholders and transformational changes to the industry.

Photo: Adobe Stock

7. FINAL CONSIDERATIONS

1. The beef cattle ranching system is relevant to Brazil and to other nations involved. In terms of net contribution to GDP and the workforce, it contributes to SDGs 2, 8, and 12.

2. In terms of demand, it is at the cultural root of Brazilian agribusiness and consumer behavior. Beef is a protein rich in vitamins for human development, especially B12, which is important for growth, improved health, and well-being.

3. Historically, cattle production was the main activity on the field, with a role to play in land occupation. Over time, Brazilian beef improved its health system, which was essential for it to become a major exporter.

4. Urgency of action against climate change has brought challenges for food systems around the world. Beef production is seen as a source of environmental degradation linked to GHG emissions and deforestation.

5. Public policies provide pathways for low-carbon agricultural production. The ABC (2010 to 2020) and ABC+ (2020 to 2030) plans enhance mitigation and adaptation technologies and practices. The same is true of the *Caminho Verde Brasil* (Brazil Green Way) program for recovering degraded pastures or changing the use of these areas. However, full implementation is far from the current scenario.

6. The pillars for enforcing the transition of beef cattle ranching, which must be implemented with a continuous commitment from rural producers in the identified actions, are: (i) expanding adoption of technologies and good production practices; (ii) compliance with the Forest Code (validating the CAR and its use across the beef chain); (iii) traceability and monitoring (sanitary and environmental); (iv) diversified financing; (v) productive inclusion of cattle ranching (small producers).

7 Integrated production technologies such as integrated Crop-Livestock-Forestry (iLPF) and Crop-Livestock (iLP) are considered positive regarding mitigating GHG emissions from the activity, according to studies conducted by Embrapa and the launch of the "Carbon Neutral Brazilian Beef" certification.

8 Other technologies such as investments in genetics, animal nutrition and using intensified pastures, adequate health resources, adopting traceability, animal welfare practices, and others, contribute to developing a cattle ranching that is less intensive in terms of natural resource degradation and enables accelerated production.

9 Environmental issues are still an institutional challenge regarding validation of the CAR and its use in the beef chain as an environmental and financial management mechanism (credit mechanism).

10 Since 2009, the Brazilian beef cattle industry has implemented zero deforestation commitments in the Amazon biome, using geospatial monitoring tools. Prior to 2019, the industry's main action was to exclude ranches and producers that did not comply with social and environmental attributes.

11 Individual cattle traceability (beef and dairy) is a tool with three uses: health, environmental, and management. It enables herd control regarding diseases and identification of animal origin and where it has been, while environmentally, it enables control and proof that an animal was not produced in restricted or deforested areas. Individual animal management matters also enable producers to have greater control over their herd, their productivity, and the quality of the final product.

12 However, ensuring that all these changes are implemented and maintaining databases and controls both at institutional level and across the production chain requires diverse funding sources.

13 All these actions apply to producers and ranchers in general. However, small producers, as in agriculture, require special attention. Lack of common infrastructure and cooperative systems geared toward this activity highlights the need for an integrated system of supplies, credit, technical assistance, and business management.

14 Meatpacking plants are the main coordinators or leading companies in orchestrating changes in this system, from quality standards to sustainability compliance. The Marfrig case illustrates this change through creation of control and compliance mechanisms, as well as incentives for sustainable beef cattle production.

15 The company launched Marfrig Verde+ program in 2020 with a commitment to zero deforestation, including producers excluded from the supply chain, and plans to achieve these goals by 2030. This is a positive example of how to transform a food system into a sustainable path with positive impacts across the industry.

16 First, because it will support small and medium-sized producers who do not comply with sustainability attributes, bringing them into the formal supply chain and eliminating illegalities. Second, it will provide knowledge, technical assistance, and combat deforestation. Third, it will bring legitimacy and transparency to all stakeholders, including consumers.

17 Finally, with incentives and positive coordination, it is possible to have a sustainable beef cattle ranching system to supply a growing population worldwide, ensuring that it is built on social and technological inclusion and environmental compliance. As a result, the industry does not need to face exclusion from food systems, as has been advocated by many actors.

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This document analyzes the Brazilian beef system, highlighting its economic, social and cultural importance, the associated social and environmental challenges, and the adopted strategies. It provides an in-depth look at the pillars for productive transition and the importance of coordination among beef chain agents in implementation actions in order to contribute to global sustainable development agendas.

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