



Transforming Brazilian Cattle Ranching: Enhancing Productivity and Mitigating Methane Emissions

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About Climate Policy Initiative

Climate Policy Initiative (CPI) is an organization with international expertise in finance and policy analysis. CPI has seven offices around the world. In Brazil, CPI has a partnership with the Pontifical Catholic University of Rio de Janeiro (PUC-Rio). In 2026, CPI/PUC-Rio will celebrate 15 years of operation in the country. Our work in Brazil focuses on developing evidence-based analyses and establishing strategic partnerships with members of the government, civil society, the private sector, and financial institutions.



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List of Acronyms and Abbreviations

ABC Plan Agricultural Sector Plan for Climate Change Mitigation and Adaptation for the Consolidation of a Low-Carbon Economy (*Plano Setorial de Mitigação e de Adaptação às Mudanças Climáticas para a Consolidação de uma Economia de Baixa Emissão de Carbono na Agricultura*)

CAR Rural Environmental Registry (*Cadastro Ambiental Rural*)

CH₄ Methane

CO₂e Carbon Dioxide Equivalent

CPI/PUC-Rio Climate Policy Initiative/Pontifical Catholic University of Rio de Janeiro

EMBRAPA Brazilian Agricultural Research Corporation (*Empresa Brasileira de Pesquisa Agropecuária*)

GHG Greenhouse Gases

GDP Gross Domestic Product

ICLF Crop-Livestock-Forestry Integration

PRA Environmental Compliance Program (*Programa de Regularização Ambiental*)

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Introduction

Brazil occupies a unique position in global food production, particularly in cattle ranching. Over the past few decades, the country has consolidated its role as one of the world's largest producers and exporters of beef, supported by large-scale production systems, significant land availability, and the ability to supply diverse international markets. This leadership, however, is being redefined. Growing global demands for sustainable production, climate mitigation, and supply chain traceability have become structural elements of agricultural trade, fundamentally reshaping the criteria for sectoral competitiveness.

In this context, **productivity and sustainability are no longer parallel agendas; they have become inseparable components of the future of Brazilian cattle ranching.** The climate challenge is not merely an external obstacle, but a central element shaping the sector's growth strategy. Consequently, how Brazil responds to this challenge will directly influence its ability to maintain and strengthen its leadership in the global meat market.

Methane occupies a pivotal position in this debate. As a highly potent greenhouse gas, it is a major contributor to Brazil's emissions profile. More than 60% of the methane emitted in Brazil comes from the livestock sector, primarily from enteric fermentation in beef and dairy cattle (Figure 1) (SEEG 2025). Addressing methane emissions represents a critical opportunity for Brazil to increase productivity while simultaneously reducing its climate footprint. The country already benefits from established production technologies, robust frameworks for public policy and financial instruments, technical assistance, and advanced monitoring capabilities—all of which can drive large-scale transformations. Combined, these elements create a strategic opportunity to accelerate the sector's transition toward carbon neutrality.

Figure 1. Methane and Enteric Fermentation Emissions in Brazil



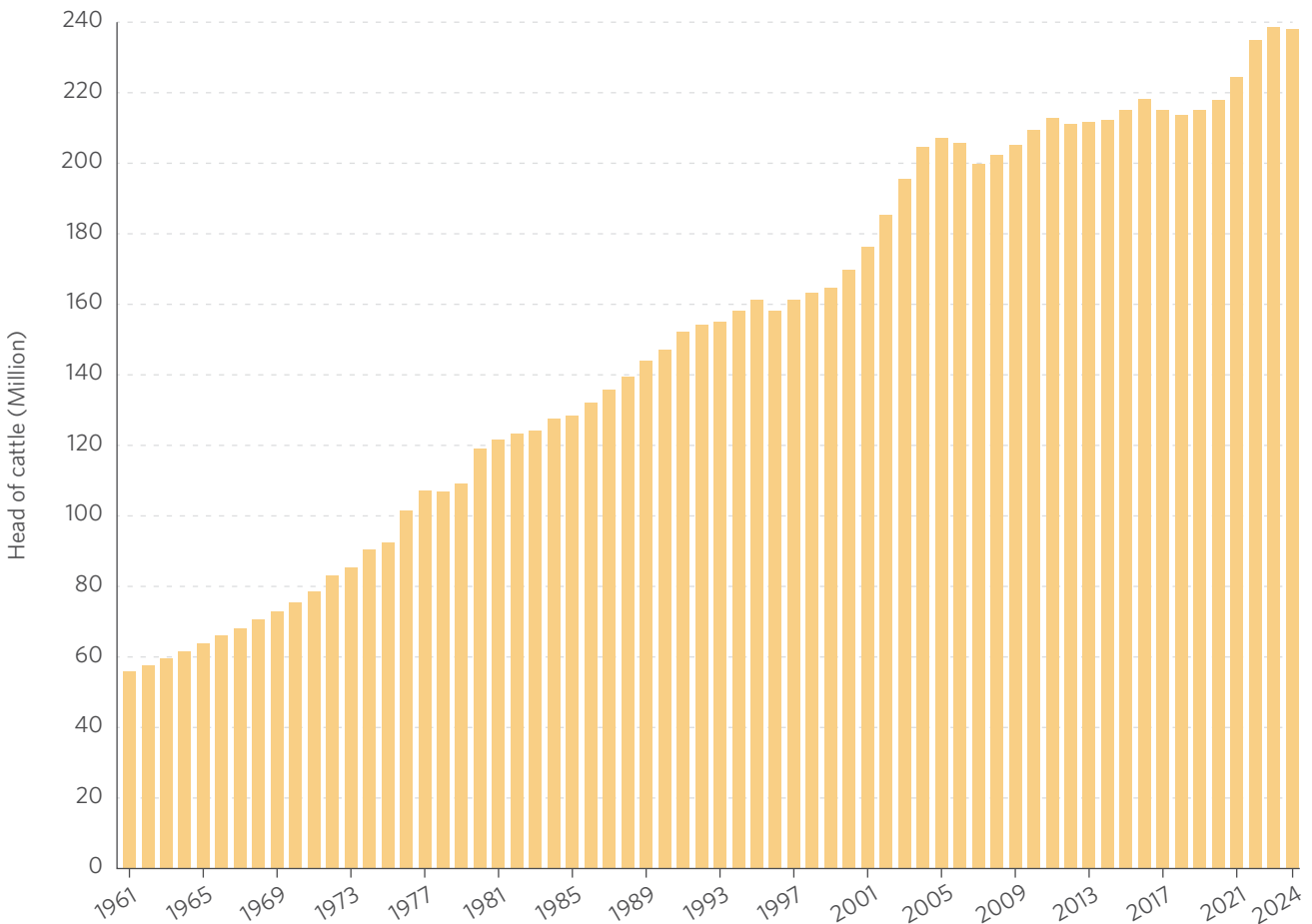
Source: CPI/PUC-Rio with data from SEEG (2025), 2026

In this report, researchers from Climate Policy Initiative/Pontifical Catholic University of Rio de Janeiro (CPI/PUC-Rio) examine the strategic role of Brazilian cattle ranching in the context of climate change. The analysis identifies the main sources of methane emissions in the sector and presents a set of solutions that can enhance cattle productivity and emissions reductions. It further explores how these solutions apply to different production systems and assesses how existing public policies and instruments can facilitate their large-scale adoption, thereby strengthening Brazil's position as a global leader in sustainable cattle production.

The Brazilian Cattle Sector

Brazil occupies a central position in global food production and supply, playing a strategic role in international agricultural markets. Within this context, the cattle sector stands out for its scale, expansion, and increasing economic significance over recent decades, consolidating itself as one of the main pillars of Brazilian agribusiness. Over the last 60 years, Brazil has tripled the size of its cattle herd, becoming home to the largest commercial herd in the world (FAO 2025), as illustrated in Figure 2.

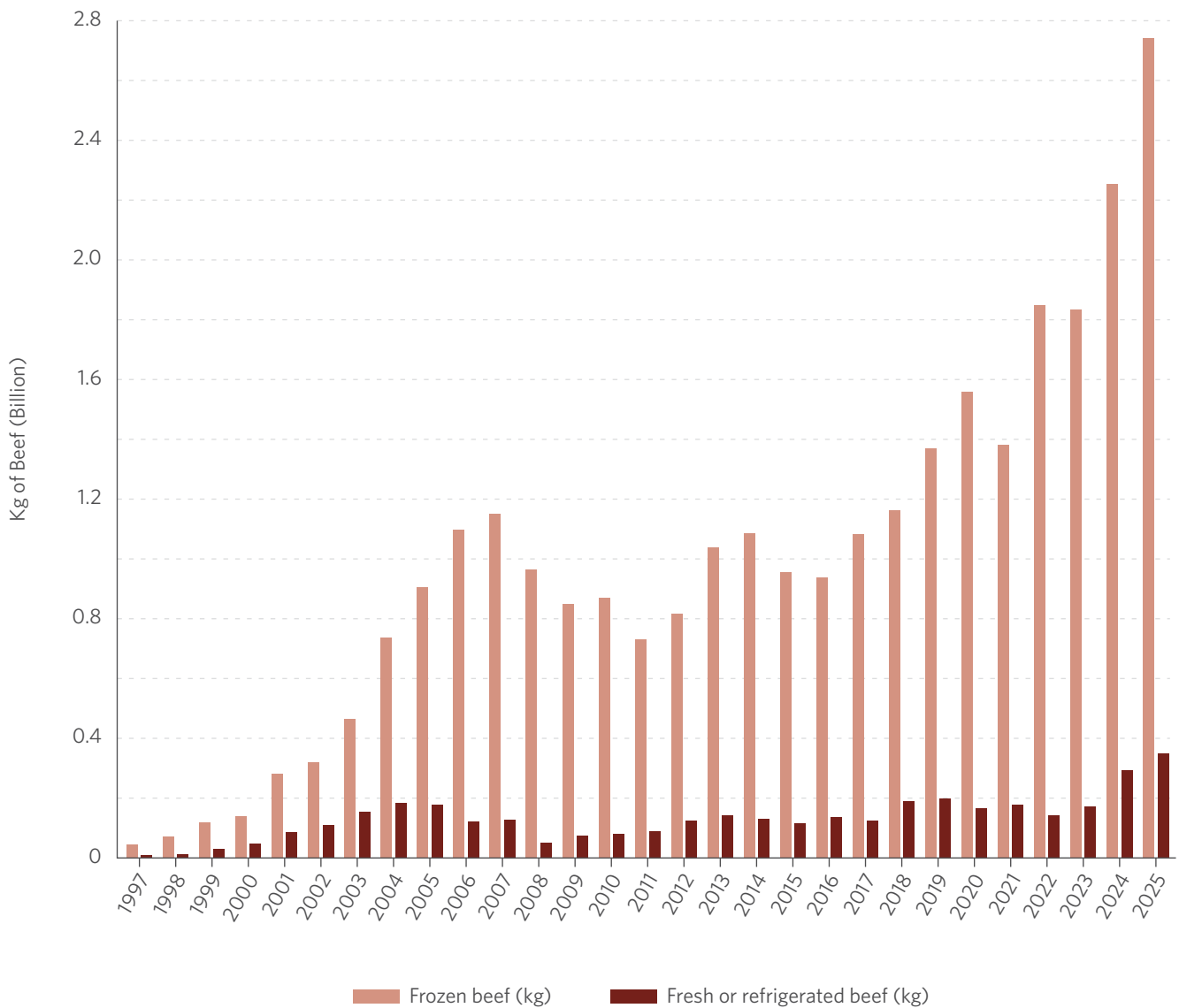
Figure 2. Brazilian Cattle Herd, 1961-2024



Source: CPI/PUC-Rio with data from FAO (2025), 2026

This expansion has been accompanied by a significant increase in the sector’s economic importance. In 2023, cattle production accounted for at least 7% of Brazil’s Gross Domestic Product (GDP) (CEIC Data nd). By 2025, Brazil solidified its position as the world’s largest beef exporter (ABIEC 2025), reinforcing its leadership in global markets. This trend is further illustrated in the evolution of Brazilian beef exports shown in Figure 3. Projections indicate that this trend will continue, with an anticipated additional growth of approximately 5% in the cattle herd in the coming years (ABIEC 2025).

Figure 3. Brazilian Beef Exports, 1997-2025



Source: CPI/PUC-Rio with data from MDIC (2026), 2026

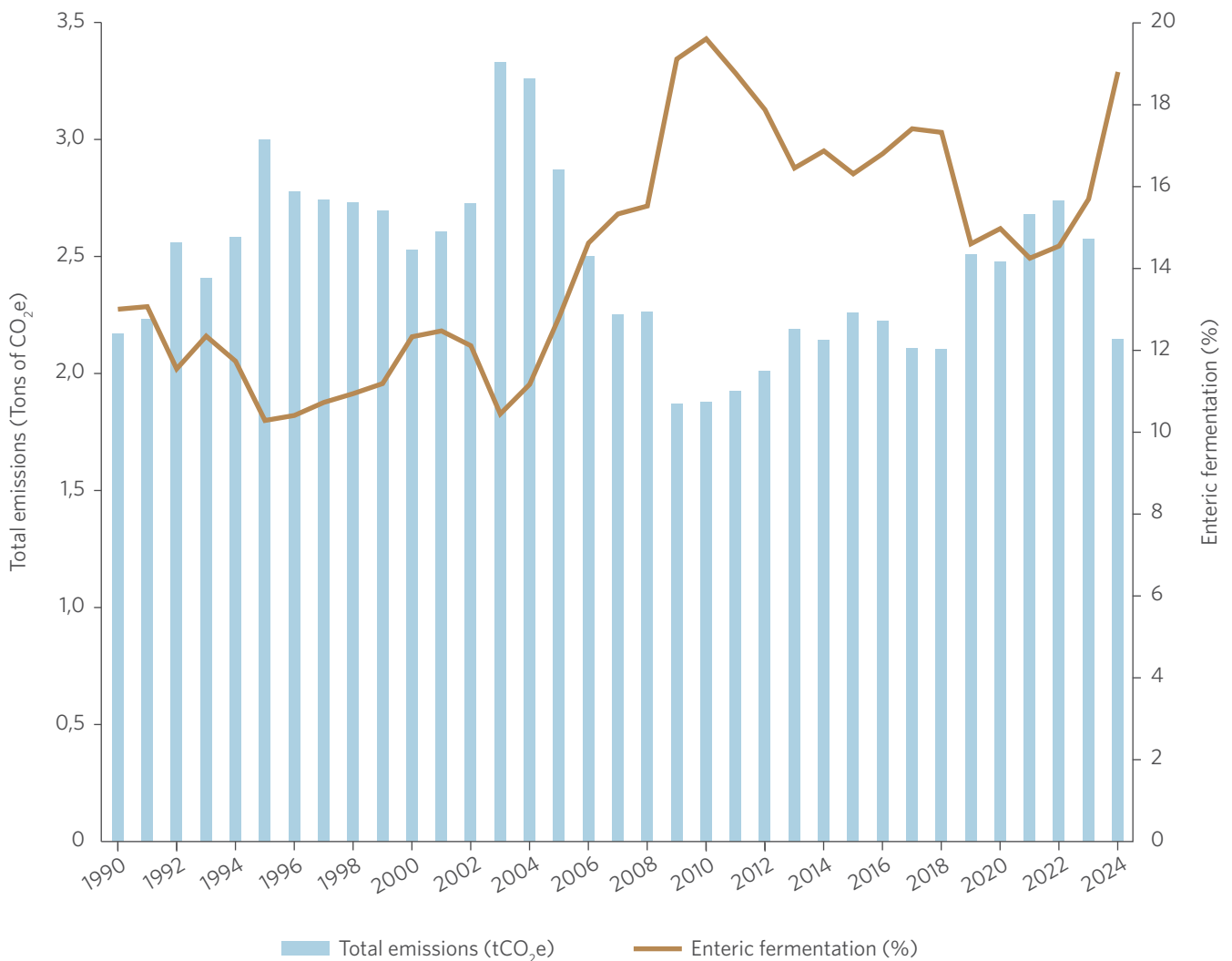
The relevance of cattle ranching in Brazil extends beyond its economic contributions. Meat production and consumption hold a central position in Brazilian culture and are integral to the identity of various regions of the country. In rural areas and regions historically shaped by agriculture and livestock, social practices, culinary traditions, and lifestyles are deeply intertwined with cattle ranching. Social gatherings, celebrations, and regional cultural expressions often feature meat as a unifying element, underscoring the sector’s significance in Brazilian social and cultural life.

These factors uniquely position Brazil on the global stage. The country combines large-scale production, economic relevance, and cultural legitimacy to claim sustainable global leadership in the livestock sector. **The consolidation of this leadership depends on the sector’s ability to simultaneously advance productivity and sustainability, thereby enhancing competitiveness and ensuring long-term economic, social, and climate contributions.**

The Cattle Sector and Brazilian Emissions

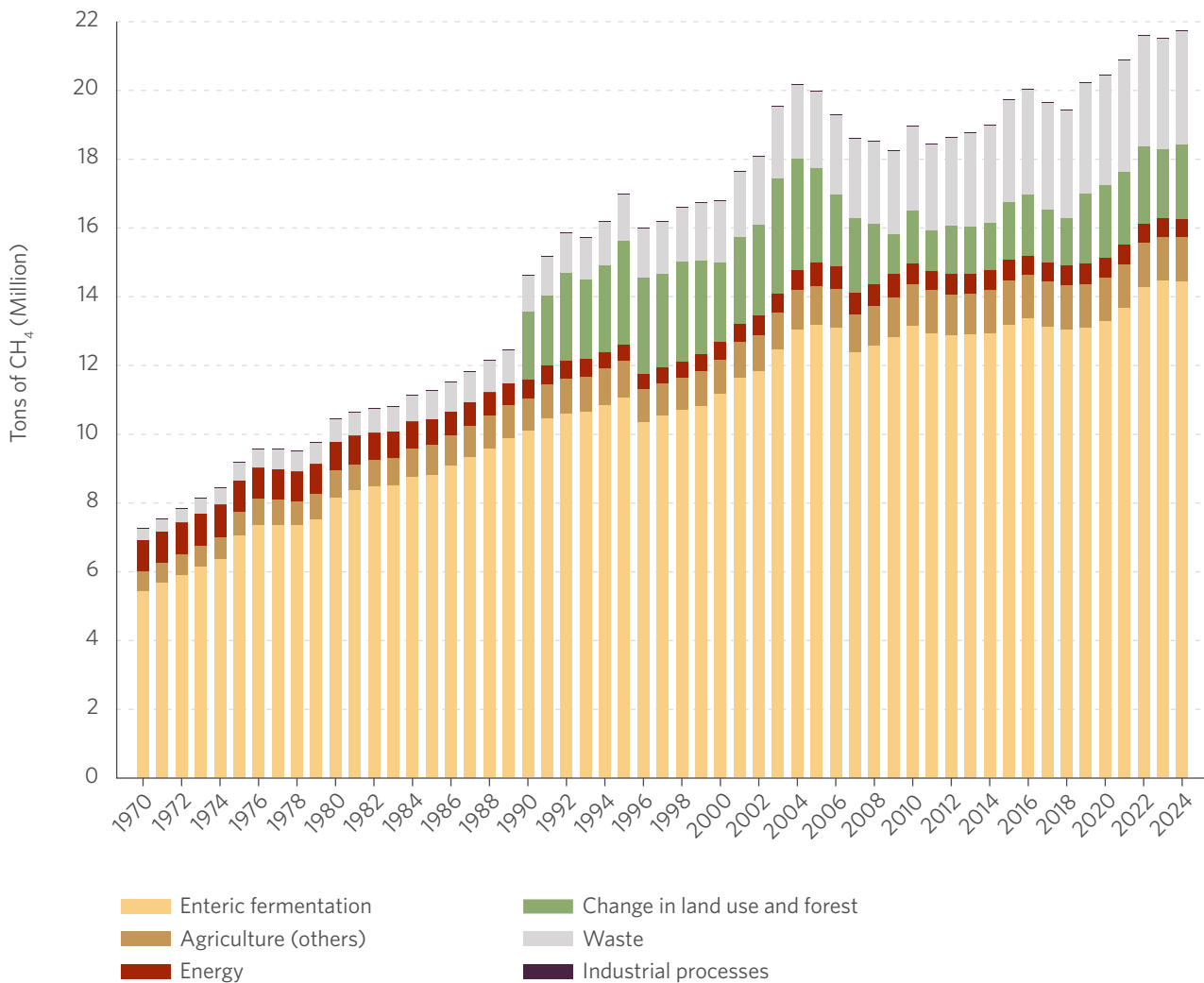
Despite its economic relevance, agriculture is currently the second largest emitter of Greenhouse Gases (GHG) in Brazil. A significant portion of these emissions is linked to cattle ranching, in particular enteric fermentation associated with beef and dairy cattle, which accounts for about 17% of the country's total emissions and approximately 60% of national methane emissions (SEEG 2025). The evolution of Brazilian emissions by sector shows the continuous growth of emissions from enteric fermentation, both in the case of carbon dioxide and methane, as illustrated in Figures 4 and 5, respectively.

Figure 4. Brazilian Total Emissions and Share of Emissions from Enteric Fermentation, 1990-2022



Source: CPI/PUC-Rio with data from SEEG (2025), 2026

Figure 5. Brazilian Methane Emissions by Sector, 1970-2022



Source: CPI/PUC-Rio with data from SEEG (2025), 2026

Enteric fermentation is a natural biological process that occurs in the digestive system of ruminants, such as cattle, and is the primary link between livestock farming and methane emissions. During digestion, microorganisms in the rumen break down the organic matter consumed by the animals, generating methane as a byproduct, which is primarily released through respiration and belching (Smith et al. 2022; Miranda 2011; CLEAR 2020). This mechanism underscores why cattle ranching occupies a central position in the emissions profile of the Brazilian agriculture sector.

In this context, Brazilian cattle ranching should not be viewed solely as part of the climate problem. Given the significant magnitude of its contribution to emissions, the sector is necessarily a crucial component of the solution. This challenge comes at a time when countries importing Brazilian meat have increased environmental requirements, reinforcing the need for consistent advances in sustainability throughout the production chains. At the same time, this scenario provides an opportunity to elevate global leadership, based not only on production scale but also on environmental performance.

Biogenic methane plays a particularly relevant role in the climate debate as a highly potent greenhouse gas with a short atmospheric lifetime. Over a 100-year horizon, one ton of methane is equivalent to about 27 tons of carbon dioxide in terms of global warming potential (IPCC 2023). Due to its high potency and significant share of emissions from the agriculture sector, methane is a strategic focus for transforming Brazilian cattle ranching, as evidenced by the predominance of enteric fermentation in national methane emissions (Figure 5).

The short atmospheric lifespan of methane implies that increases in herd size rapidly contribute to global warming, reinforcing the limits of strategies based on extensive production expansion. On the other hand, there is significant potential for enhancing productivity through improved management, increased production efficiency, and better pasture quality, all of which can reduce emissions per unit of product.

Full adoption of the most effective technologies to reduce methane in cattle by 2030 could result in a reduction of up to 2.8 gigatons of CO₂ equivalent annually on a global scale (Arndt et al. 2022). **Thus, the transformation of Brazilian cattle ranching is crucial for converting the climate challenge into an opportunity for sustainable global leadership. By aligning productivity gains with emissions reductions, the sector can strengthen its international competitiveness and establish Brazil as a model for low-carbon cattle ranching.**

A Portfolio of Solutions for Brazilian Cattle Ranching

A wide and diverse set of solutions can simultaneously promote productivity gains and advance sustainability in the Brazilian livestock sector. Many of these solutions have relatively low costs and the potential to generate results in the short term, enhancing their economic feasibility and capacity for large-scale adoption.

These strategies are neither uniform nor mutually exclusive. Different solutions can be applied according to the different production systems across the country, respecting differences by region, technology, and scale. This diversity allows meaningful advances in both intensive and extensive systems, provided that the interventions are appropriate to the specific production contexts.

The main solutions are presented based on four complementary axes. **The first axis refers to land use and condition, particularly in managing pastures. The second addresses increasing the biological productivity of animals. The third deals with feed quality and management strategies. Finally, the fourth axis focuses on production system management, including planning, monitoring, and decision-making practices.** Together, these axes comprise a coherent framework for achieving more productive, efficient, and sustainable cattle ranching.

Land Use and Condition

Solutions related to land use and condition are particularly crucial for extensive pasture systems, which account for the majority of the area used for cattle ranching in Brazil.

Within these systems, productivity is significantly influenced by pasture quality, soil fertility, and land management practices over time. Interventions in this area can lead to increased production per hectare, reduce the necessity for expanding agricultural land, and consequently decrease emissions per unit of product. For instance improvements in forage type and quality alone can achieve reductions of up to 25% in enteric methane emissions (Langley and Tirado 2026).

One of the most important strategies in this context is the recovery of degraded pastures.

Better pasture better conditions yield higher quality forage and greater biomass availability, translating into better animal performance and reduced time to slaughter. Additionally, pasture recover interventions, when combined with tailored technical assistance, have shown to generate measurable productivity gains. Evaluations of the Agricultural Sector Plan for Climate Change Mitigation and Adaptation for the Consolidation of a Low-Carbon Economy in Agriculture (*Plano Setorial de Mitigação e de Adaptação às Mudanças Climáticas para a Consolidação de uma Economia de Baixa Emissão de Carbono na Agricultura - ABC Plan*) indicate that producers receiving technical assistance restored significantly larger portions of their pasture areas and experienced a 7% increase in total productivity, along with a notable rise in agricultural income (Bragança et al. 2022). Furthermore, pasture recovery contributes to better soil structure, increased water infiltration, and reduced erosion processes, with positive effects in the medium term (Maia et al. 2009; Segnini et al. 2019; Oliveira et al. 2022). In contrast, degraded pastures reduce soil carbon stocks by approximately 10% compared to their original conditions (Oliveira et al. 2022).

Soil correction is critical in facilitating pasture recovery and maintenance. Adjusting soil acidity and ensuring adequate nutrient replacement create conditions for greater forage productivity and enhance input efficiency. Amended soils support more intensive and stable farming systems, thereby reducing production variability and increasing the return on other interventions (Dick et al. 2015; Mazzetto et al. 2015; Oliveira et al. 2020).

The use of digestate, a by-product of anaerobic biodigesters, further integrates waste management with land use. As an organic fertilizer, digestate can partially replace mineral fertilizers, improving soil fertility, and promoting productivity gains in pastures and other crops. This practice helps close nutrient cycles within the production system and enhances the environmental benefits associated with effective management of cattle waste (Meng et al. 2023; Kowalczyk-Juśko et al. 2023; Alam et al. 2025; He et al. 2023).

Sustainable cattle production encompasses these practices to increase productivity per area without expanding the agricultural frontier, combining economic gains with significant climate benefits. By enhancing pasture productivity and animal performance, it is possible to produce more meat in existing areas, thereby alleviating pressures to convert new land and contributing to mitigation of GHG emissions associated with land use change.

Crop-Livestock (ICL) and Crop-Livestock-Forestry Integration (ICLF) systems further this approach by promoting multiple and dynamic land uses over time. In these systems, areas designated for cattle can also be used for growing grains or other agricultural or forestry products during specific periods, allowing pastures to rest and recover. This arrangement facilitates more efficient land use, diversifies production, and generates additional sources of income, reducing reliance on cattle ranching alone (Figueiredo et al. 2017; Monteiro et al. 2024; Thompson et al. 2025; Macedo 2001; Mavisoy et al. 2024; Cerri et al. 2021). Forest-integrated systems also serve as a means to achieving carbon neutrality or even net carbon sequestration, as demonstrated by the Brazilian experiences documented by EMBRAPA (2015).

In addition to productivity gains, integrated systems offer important environmental benefits. The rotation of crops and pastures improves soil structure and fertility, increases organic matter content, and promotes carbon sequestration. The inclusion of trees in integrated systems improves the microclimate, provides shade for animals, reduces heat stress, and can contribute to improved animal welfare and productivity. Furthermore, integrated systems support biodiversity and allow for greater utilization of ecosystem services (Figueiredo et al. 2017; Monteiro et al. 2024; Thompson et al. 2025; Macedo 2001; Mavisoy et al. 2024; Cerri et al. 2021).

Finally, these systems broaden the range of commercially valuable products generated on the same land, including grains, fibers, wood, and other forest products, in addition to meat. By allowing various land uses throughout the year, integrated systems increase economic efficiency, mitigate production risks, and strengthen the resilience of the system to climate and market shocks.

Increased Biological Productivity

Increased biological productivity refers to the ability to produce more meat per animal throughout its productive life by optimizing genetic, health, and physiological aspects. This focus is directly linked to reducing emissions per unit of product, as more efficient animals convert feed into animal protein more quickly and generate lower cumulative methane emissions throughout the production cycle. These solutions can yield significant benefits even in extensive production systems, although their application tends to be more direct in confined systems, where there is greater control over genetics, environment, and individual animal management.

Genetic improvement is a central strategy within this axis. Selecting animals for feed efficiency reduces the amount of feed required for the same weight gain, which translates into lower methane emissions per kilogram of meat produced. Targeted crossbreeding can combine desirable traits, such as higher average daily gain, precocity, and improved adaptation to specific production conditions (de Haas et al. 2011; Manzanilla-Pech et al. 2022; Congio et al. 2021; Lassen and Difford 2020; Smith et al. 2022).

While the effects of genetic improvement tend to materialize in the medium and long term, their impacts are persistent and cumulative, reinforcing structural productivity gains. **In Brazil, these results are already evident: between 2000 and 2020, the national dairy breed, Girolando, achieved a 39% reduction in enteric methane emissions per kilogram of milk produced, alongside a 60% increase in average productivity per animal (EMBRAPA 2020).**

Animal health and welfare are also critical components of biological productivity. Providing adequate shade, regular access to drinking water, and effective sanitary management can reduce physiological stress and improve animal performance. Healthy animals have better feed conversion and reach slaughter weight more quickly, which reduces total methane emissions over their lifetimes. These improvements can be observed in relatively short periods and complement other strategies, such as nutritional and genetic improvements (Lluch et al. 2017; Shields and Orme-Evans 2015).

Although animal welfare is still rarely featured in discussions of climate mitigation in the cattle sector, it presents an opportunity for environmental gains without compromising animal well-being. This perspective is particularly relevant in Brazil, where the livestock matrix encompasses diverse production systems, from extensive pasture to highly intensive feedlots with higher stocking densities and prolonged confinement. Such conditions can lead to negative impacts on animals, including chronic stress, limited natural behaviors, overcrowding, and health issues like metabolic disorders and lameness (Shields and Orme-Evans 2015).

Additionally, anti-methane vaccines represent an experimental yet promising solution. These vaccines aim to stimulate immune responses that reduce the population of methanogenic microorganisms in the rumen, thereby decreasing methane production during digestion. Although not yet commercially available, their development illustrates a promising technological frontier, particularly in intensive systems where application and monitoring are more feasible (Baca-González et al. 2020; Khanum et al. 2022; Muntari et al. 2023).

Feed and Manure Quality and Management

Feed quality and management play a central role in both cattle productivity and emissions, as diet directly influences the enteric fermentation process. Improvements in this area can increase the productive efficiency and reduce the intensity of methane emissions. These solutions are particularly effective in feedlot systems, where greater control over diet formulation, feeding frequency, and waste management is possible.

Feed additives are one of the most direct strategies for reducing enteric methane emissions. Specific substances can alter the microbial dynamics in the rumen, leading to reduced methane production during digestion. Depending on the type of additive, the effects can be observed in the short term, with significant emission reductions in the short term, complementing genetic and nutritional improvements for greater effects (Hristov et al. 2015; Kinley et al. 2020; Wanapat et al. 2024; Congio et al. 2021; Fouts et al. 2022; Hegarty et al. 2021; Smith et al. 2022).

Among the most promising additives, 3-NOP (3-nitroxypropanol) has garnered considerable attention. Its inclusion in the diet can lead to approximately 30% less methane emitted per unit of feed consumed, with no adverse effects on consumption, digestion, or milk production (Hristov et al. 2015). The seaweed *Asparagopsis taxiformis* also has the potential to reduce emissions by more than 40% without detrimental effects on ruminal function or meat quality (Kinley et al. 2020). The inclusion of nitrates or vegetable oils in animal diets can yield emission reductions of approximately 10% to 25% (Ku-Vera et al. 2020).

Nutritional improvements focus incorporating more balanced and higher quality diets, including legumes, silage, and agro-industrial by-products. More digestible diets increase weight gain and reduce the time required for slaughter, thus decreasing cumulative methane emissions. In addition, utilizing by-products benefits the entire production system by integrating agro-industrial chains, minimizing waste, and increasing profitability (Kaewpila et al. 2021; Bica et al. 2022; Fernandes et al. 2024; Fouts et al. 2022; Parnian-khajehdizaj and Moharramnejad 2025; Yu et al. 2021).

Waste management also plays an important role in emissions mitigation strategies, even though it accounts for a smaller share of total emissions. In 2024, waste management accounted for about 1.36% of Brazil's GHG emissions and approximately 4.14% of national methane emissions (SEEG 2025). In the cattle ranching sector, technologies such as composting and anaerobic biodigesters can reduce emissions while generating useful and commercially valuable by-products such as biogas and biofertilizers. The outcomes can be observed in both the short and medium term and work synergistically with land use solutions, such as fertilization with digestate (Pattey et al. 2005; Setoguchi et al. 2022; Symeon et al. 2025).

Management of the Production System

The management of the production system encompasses practices that cut across the other axes and enhance their results. These solutions are generally cross-cutting, relying more on planning, monitoring, and management decisions based on production indicators rather than specific technologies. Effective management allows for the alignment of productivity, profitability, and emissions reduction by coherently coordinating genetics, feed, land use, and animal management. Given that around 95% of beef production in Brazil is derived from pasture-based systems (Medeiros, Gomes, and Bungestab 2015), and recognizing that most enteric fermentation emissions are associated with beef cattle, this section focuses on management practices related to pasture use. In this context, pasture management is a particularly important lever for improving environmental performance in Brazilian cattle production.

Control of stocking rates is a central element of strategies under this axis. **Adjusting the number of animals to the productive capacity of pastures prevents soil degradation, improves individual animal performance, and reduces production inefficiencies associated with overcrowded or underutilized systems** (Dick et al. 2015; Mazzetto et al. 2015; Oliveira et al. 2020). This practice is essential for enabling sustainable intensification strategies and maximizing gains obtained from pasture recovery and rotational management.

Rotational grazing complements this set of practices by promoting better use of available forage and greater production stability over time. By alternating grazing and resting areas, rotational management contributes to maintaining soil productivity, improves animal performance, and creates favorable conditions for control of stocking and the recovery of degraded areas. This practice reinforces the integration between management decisions and both productive and environmental outcomes (Dick et al. 2015; Mazzetto et al. 2015; Oliveira et al. 2020; Zubieta et al. 2021). Moreover, each hectare of well-managed pasture incorporates about 2.5 tons of carbon into the soil per year (Fronza et al. 2024).

Monitoring and traceability throughout the production chain are also central components of effective management. These practices make it possible to follow animals and production processes across different stages of the beef supply chain, ensuring compliance with environmental, sanitary, and production standards. For producers closer to the final stages of the chain, stronger monitoring and traceability mechanisms can assure that cattle sourced from suppliers adhere to good practices and sustainability standards. In this way, traceability strengthens coordination across the chain and helps align farm-level management decisions with broader market and sustainability requirements.

The prevalence of extensive and relatively low-technology systems in Brazilian cattle ranching indicates that productivity-enhancing measures can significantly boost the profitability of the sector. While part of this adjustment may occur within existing properties through more effective use of existing land, it can also create broader economic incentives that attract new producers into the industry. In contexts where land speculation is driven by expectations of future productive use, higher anticipated returns to cattle ranching can contribute to both legal and illegal deforestation (Decamps nd; Assunção, Gandour, and Rocha 2017). Therefore, strengthening traceability systems is essential, not just as a means of monitoring production practices but also as a mechanism to help prevent the incorporation of newly deforested areas into supply chains. These efforts should be complemented by robust command-and-control policies to ensure that gains in productivity and methane mitigation translate into net positive environmental outcomes.

Together, effective management practices in production systems demonstrate that significant productivity gains and emissions reductions can be achieved by adjusting operational methods. **By responding to market signals, adopting performance metrics, strengthening monitoring and traceability, and integrating decisions throughout the production chain, Brazilian cattle ranching can accelerate its transition to more efficient, competitive, and environmentally sustainable production systems.**

Extensive Cattle Ranching in Brazil

Extensive cattle ranching is the predominant production system in Brazil, playing a central role in land occupation and the organization of cattle agriculture, particularly in the Northern and Midwestern regions. In this system, animals are primarily raised on pasture, with minimal use of external inputs, relying heavily on natural soil conditions, climate, and vegetation. In contrast, less than 20% of cattle in Brazil are raised in feedlot systems. The historical availability of land and the expansion of the agricultural frontier have solidified this model, which now accounts for the majority of the national cattle herd, particularly in the Legal Amazon.

Despite its economic and territorial significance, extensive cattle ranching in Brazil is characterized by low productivity levels. The country has an average stocking rate of approximately 1.2 animals per hectare (ABIEC 2025), with this figure dropping to around 0.9 head per hectare in Northern Brazil (Figure 6). These rates are low by international standards and largely reflect the prevalence of degraded pastures, inadequate soil management, and inefficient land use.

Figure 6. Pasture Area and Stocking Rate in Brazilian Regions in Agricultural Census Years, 1985-2017



Source: CPI/PUC-Rio with data from MAPBIOMAS (2025) and IBGE (1985, 1995/1996, 2006, 2017), 2026

This production pattern has direct implications for the sector's emissions and land use dynamics. In several regions, particularly in the Amazon, low-intensity cattle raising has historically been employed as a strategy for land occupation and valuation. Maintaining small herds with low productivity and minimal investment characterizes the land as productive, meeting formal land use requirements and serving as a mechanism for land speculation. In these situations, cattle ranching plays a less productive role and often serves primarily to consolidate land ownership (Margulis 2003; Reydon, Fernandes, and Telles 2020).

This dynamic establishes a direct connection between low-productivity, extensive cattle ranching and deforestation. Herd expansion frequently occurs through the opening of new areas, even when large tracts of already cleared pastureland possess low economic value. This model increases pressure on forest areas while keeping the sector's productivity below its potential (Margulis 2003; Reydon, Fernandes, and Telles 2020).

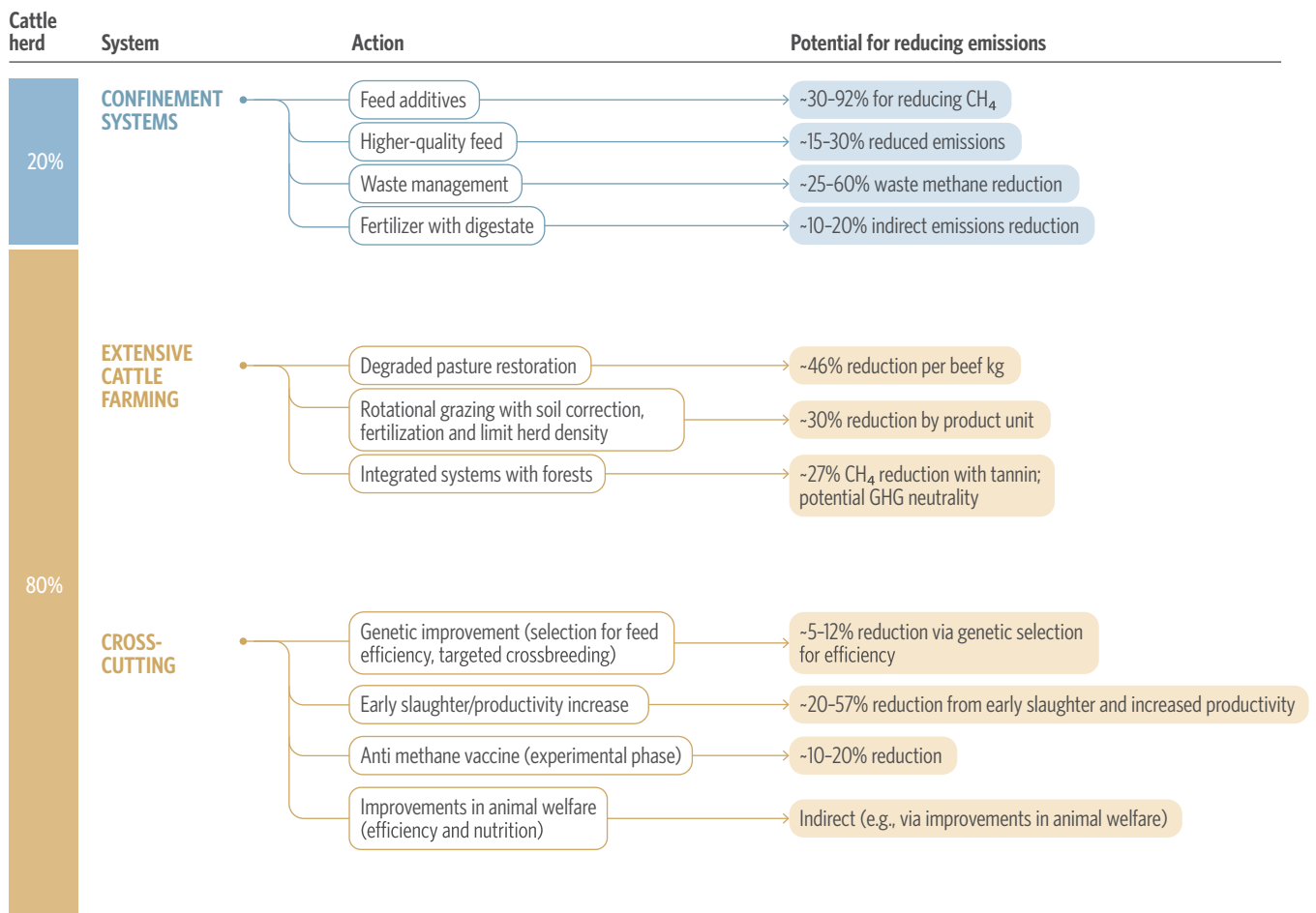
However, this characteristic also reveals a critical opportunity for transforming Brazilian cattle ranching. The areas currently cleared for pasture could sustainably support the expansion of cattle production and even herd growth without the need to clear additional land (Assunção et al. 2025). Degraded pastures can be rehabilitated and converted into more productive areas, whether for cattle intensification, cultivation of agricultural crops, or restoration to forest vegetation. This approach creates opportunities for carbon storage and sequestration, frees up land for other uses, and reduces the pressure for new land openings.

Significantly increasing stocking rates and productivity per hectare is possible even within extensive systems, through pasture recovery, soil correction, proper fertilization, and the adoption of more efficient management practices. These adjustments minimize the time animals remain in the system, reduce relative methane emissions, and enable higher production within the same area, achieving both economic and environmental gains (Assunção et al. 2025).

In this context, extensive cattle ranching should not be viewed merely as an environmental challenge but recognized as a key driver of transformation in the sector. Elevating cattle productivity in already cleared areas is vital to decoupling cattle growth from deforestation, transforming land use, and aligning Brazilian cattle farming with a sustainable and competitive long-term trajectory.

Figure 7 summarizes the identified actions that can help reduce methane emissions while enhancing productivity in cattle ranching. For each action, it outlines the associated mitigation potential based on the scientific literature and specifies the cattle production system where implementation is most appropriate, showing that mitigation opportunities exist across different production contexts.

Figure 7. Solutions to Reduce Brazilian Methane Emissions from Enteric Fermentation



Source: CPI/PUC-Rio, 2026

Policies and Implementation

The effective implementation of solutions to enhance cattle productivity and reduce emissions from Brazilian cattle ranching relies on a robust framework of public policies that coordinate incentives, mitigate uncertainties, and expand the adoption of available practices. **Brazil already possesses a solid institutional foundation and considerable experience in methane mitigation policies, along with consolidated instruments that can be mobilized in a coordinated manner, leveraging synergies with existing agricultural, environmental, and rural development policies.**

In recent years, methane has increasingly featured in Brazil's national climate agenda. The **Zero Methane Program** (*Programa Metano Zero*) marks a significant advance in recognizing methane as a strategic gas for climate policy due to its high potency and short atmospheric lifetime. This program plays a crucial role in creating political space for methane mitigation as a legitimate component of the national climate agenda. It establishes guidelines for emissions reduction in key sectors, including agriculture and livestock, and creates an institutional framework for coordinating actions, aligning sectoral policies, and signaling priorities to the private sector (MMA 2023). However, the program has a strong focus on waste management, even though enteric fermentation remains the most significant source of methane emissions in the country. While practical implementation relies on complementary instruments, the Zero Methane Program provides a conceptual and political basis for integrating methane issues into existing agricultural and environmental policies.

This integration is particularly feasible within the **Agricultural Plan** (*Plano Safra*), Brazil's primary agricultural policy instrument. With its extensive reach, territorial coverage, and history of adaptation to public priorities, the Agricultural Plan incorporates credit lines aimed at sustainability, recovery of degraded areas, and production intensification, such as RenovAgro. In the context of cattle ranching, this instrument can finance practices with direct impacts on productivity and emissions, including pasture recovery, integrated systems, nutritional improvements, genetics, and management practices. By reducing capital costs and spreading risks, rural credit plays a crucial role in making these solutions economically viable, especially for rural producers facing liquidity constraints or uncertainties regarding return on investment.

Programs like **Brazilian Green Way** (*Caminho Verde Brasil*) enhance this potential by linking credit availability, environmental regularization, and incentives for sustainable production. The Brazilian Green Way has an initial financing envelope of approximately R\$ 30 billion, with additional funding still being mobilized. A complementary initiative is the second auction of the Eco Invest Brasil program, which uses blended finance to support the recovery of degraded land, attracting private capital, reducing investment risks, and increasing credit availability for sustainable agricultural practices.

By combining financial instruments with explicit environmental objectives, these initiatives help align economic incentives with climate and land use goals. This alignment is particularly relevant for cattle ranching, as it facilitates productivity gains while mitigating the pressure for land expansion and addressing historical environmental liabilities. Brazil's experience with such policy frameworks illustrates its capability to coordinate different agendas through established instruments.

In addition to formal public policies, private certification initiatives and voluntary standards are increasingly significant in driving change within the Brazilian cattle sector. These mechanisms operate throughout the production chain by establishing environmental, health, and traceability criteria that govern access to markets with higher value. In the context of growing international demand, these initiatives serve as complementary instruments to public policy by creating direct economic incentives for the adoption of efficient and sustainable practices.

Two prominent examples of this movement are the Carbon Neutral Beef and Low-Carbon Beef protocols, developed within the scope of national agricultural research. These protocols establish technical parameters for measuring, reducing, and offsetting emissions associated with beef production, with a focus on methane emissions. By defining clear eligibility, monitoring, and verification criteria, these systems enable product differentiation in the market based on environmental performance (EMBRAPA 2015; EMBRAPA 2020).

The **Carbon Neutral Beef** protocol neutralizes emissions by integrating cattle ranching with forest components. The presence of trees in integrated systems allows for sufficient carbon sequestration to offset emissions throughout the production cycle, resulting in a carbon-neutral product. In addition to climate benefits, this model provides significant collateral gains, such as improved microclimate, reduced heat stress on animals, and diversification of production (EMBRAPA 2015).

The **Low-Carbon Beef** protocol, on the other hand, focuses on reducing emissions per unit of product without requiring complete neutralization. This system encourages practices that enhance production efficiency, including pasture recovery, proper feed management, genetic improvement, and reduced slaughter age. By decreasing emissions intensity, the protocol promotes gradual and scalable transformations, especially suited for extensive systems seeking to boost productivity (EMBRAPA 2020).

Both protocols directly address previously discussed emission reduction strategies and serve as economic signaling mechanisms. By linking environmental performance to access to differentiated markets, these voluntary standards reinforce incentives for adopting more efficient production practices, even when initial motivations are tied to commercial or health requirements. In this context, private certifications and public policies can work together, broadening the scope and effectiveness of methane mitigation strategies in Brazilian cattle ranching.

Among the available public policy instruments, rural credit remains a key leverage point for transforming the sector. Its design allows for the progressive incorporation of environmental criteria, either through specific credit lines or by attaching conditions to access resources. In the context of methane mitigation, credit can fund investments in high-quality feed, feed additives, waste management, pasture recovery, and integrated systems, thereby creating clear incentives for adopting these practices. Additionally, utilizing credit as a policy instrument enables synergies with pre-existing objectives, such as increased productivity, productive inclusion, and regional development.

The connection between rural credit and technical assistance is crucial to ensuring that mobilized resources translate into effective changes in production systems. In cattle ranching, the primary challenge often lies not in the absence of technologies but in the effective dissemination and adaptation of known solutions to local contexts (Groeger and Zylberberg 2025). Technical assistance focused on disseminating best production and management practices can mitigate information asymmetries, enhance the efficiency of investments financed by rural credit, and expedite the adoption of solutions that impact productivity and emissions directly.

Measurement completes this set of instruments by providing the foundation for monitoring, evaluating, and improving policies. The capacity to measure emissions, production performance, and environmental outcomes is essential for guiding public

decisions, lending credibility to initiatives, and creating performance-based incentive mechanisms. In cattle ranching, robust measurement systems are also necessary to meet international market requirements, facilitate certification, and structure financial mechanisms associated with environmental outcomes.

Besides national initiatives, Brazil has accumulated significant experience with subnational public policies aimed at reducing emissions in cattle ranching. States such as Mato Grosso, Pará, and Mato Grosso do Sul have implemented their sustainable agriculture development programs, often in coordination with state departments of agriculture and the environment, public banks, and rural extension agencies. These initiatives include programs for pasture recovery, incentives for ICLF, actions related to the Rural Environmental Registry (*Cadastro Ambiental Rural* - CAR) and the Environmental Compliance Program (*Programa de Regularização Ambiental* - PRA), as well as regional strategies aligned with subnational climate commitments. Many of these efforts involve institutions like the Brazilian Agricultural Research Corporation (*Empresa Brasileira de Pesquisa Agropecuária* - EMBRAPA), state agricultural research agencies, and partnerships with the private sector, creating institutional arrangements conducive to adopting lower-emission, higher-productivity practices, though with varying scope and impact across states.

Despite the broad range of policies, programs, and initiatives currently underway, significant structural gaps remain in transforming Brazilian cattle ranching. A considerable proportion of pastures remain degraded, indicating that instruments like the Agricultural Plan, RenovAgro, and initiatives aimed at recovering productive areas still face limitations concerning scale, focus, or execution. Similarly, integrated production systems such as ICL and ICLF have yet to achieve widespread adoption, despite their recognized productive and environmental potential. These challenges highlight difficulties in translating widely accepted technical guidelines into effective large-scale practices.

Some gaps are linked to specific dimensions of the production system that receive insufficient attention in public policies. There is a lack of explicit emphasis on strategies targeting herd feed efficiency and genetic improvement, areas where research institutions and private initiatives often lead alongside public efforts. Challenges persist in enhancing the participation of more intensive systems, such as feedlots. In the environmental domain, although financing for waste management and treatment technologies has advanced, their use remains limited. Furthermore, there is a relative lack of more structured and coordinated policies aimed at animal welfare, despite its importance for productive performance, indirect emission reduction, and access to demanding markets. Finally, traceability in cattle production remains limited, with progress driven by both public initiatives and private certification schemes that are still insufficient for facilitating systemic change.

Together, these experiences and instruments demonstrate that Brazil possesses a solid institutional foundation to confront the challenge of methane emissions in cattle ranching. However, there are gaps in policies encouraging animal improvements, early slaughter, and attention to animal welfare. The country has prior experience in creating and implementing policies aimed at addressing these gaps and has consolidated instruments capable of inducing large-scale productive changes. The challenge lies in deepening, articulating, and directing existing instruments while leveraging synergies with agricultural, environmental, and rural development policies. By doing so, Brazil can turn its accumulated experience into a cohesive strategy for sustainable global leadership in the cattle sector.

Public Policy Recommendations

- **Treat methane as a strategic priority in climate policy for the cattle sector.** Methane accounts for about a quarter of Brazil's emissions, with enteric fermentation being the main source. Its high potency as a greenhouse gas underscores its relevance in the country's climate agenda. There is a significant opportunity for the cattle sector, as several mitigation measures can simultaneously reduce emissions and increase productivity.
- **Improve coordination and strategic use of existing policy instruments.** This should include the explicit incorporation of methane reduction targets into established instruments, such as the Agricultural Plan. Brazil already has a comprehensive array of agricultural, environmental, and financial policies to support methane mitigation. Better coordination and clearer prioritization of high-impact practices can enhance effectiveness without the need for new policy frameworks.
- **Strengthen the link between rural credit, technical assistance, and measurable performance.** The primary barrier to transformation is often not the lack of available technologies but the challenge of implementing them effectively across diverse production contexts. Combining financial support with technical assistance and linking both to clear performance indicators can increase adoption rates and enhance the effectiveness of public resources.
- **Direct rural credit and related policies toward production systems that combine productivity gains and emissions reductions.** This includes scaling up the recovery of degraded pastures, strengthening dissemination of integrated systems, and expanding support for nutritional improvements, animal health, and welfare. Combining credit with technical assistance, measurement, and clear eligibility criteria can enhance the effectiveness of these instruments, increase stocking rates in already cleared areas, provide diversified income sources, improve market access, and reduce pressure on the agricultural frontier.
- **Strengthen traceability and monitoring across the cattle supply chain.** More robust traceability systems can ensure that sustainability standards are met not just by final producers but throughout the entire production chain. This is essential for meeting market demands, improving transparency, and aligning incentives across various production stages.

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