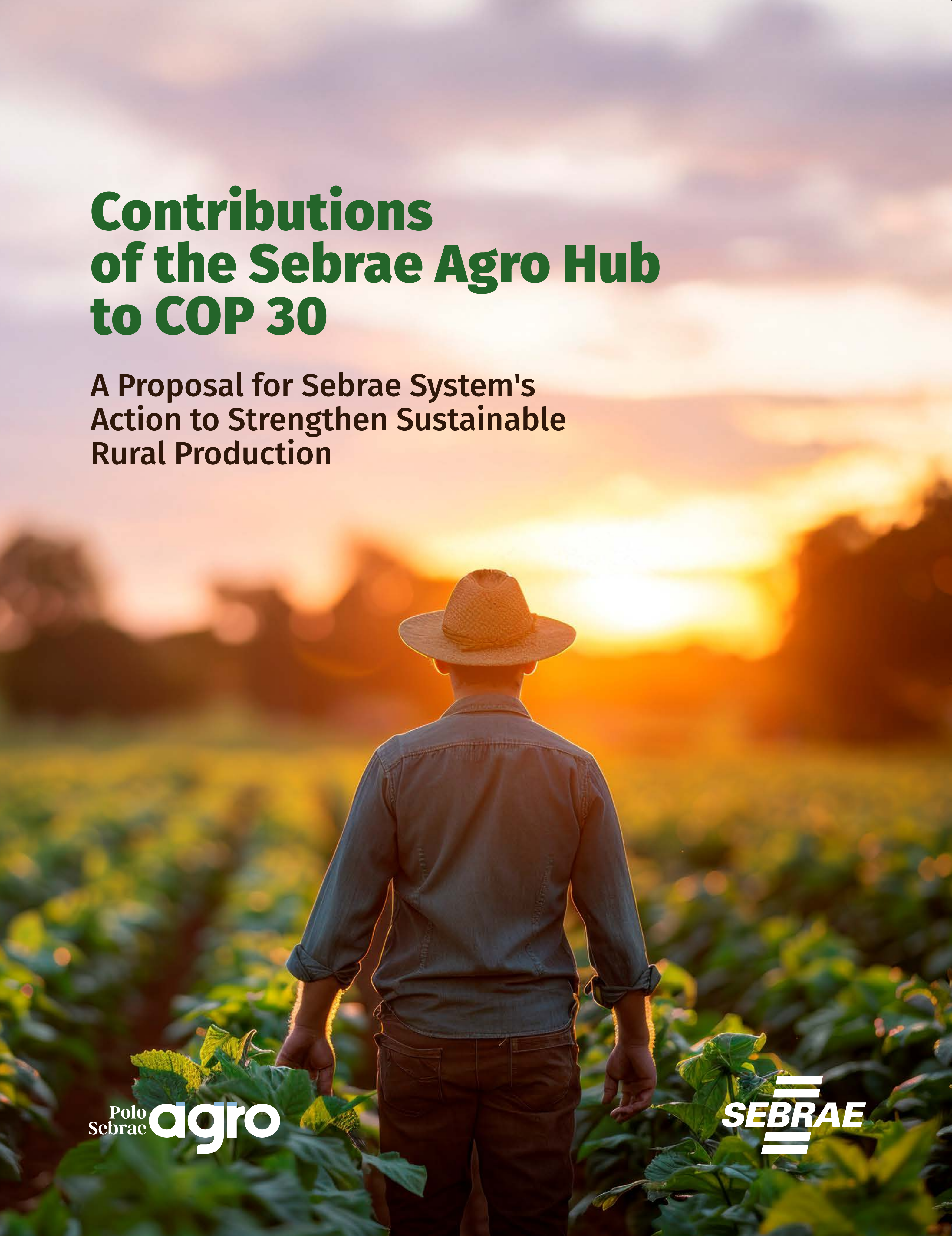

Contributions of the Sebrae Agro Hub to COP 30

A Proposal for Sebrae System's Action to Strengthen Sustainable Rural Production

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A Proposal for Sebrae System’s Action to Strengthen Sustainable Rural Production

Produced by

Sebrae Goiás

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Message from the State Deliberative Board of Sebrae Goiás

The Deliberative Council of Sebrae Goiás strongly endorses this strategic initiative aimed at advancing knowledge, management, and reduction of Greenhouse Gas (GHG) emissions in the rural sector.

We recognize the proposed solution as a key instrument to increase the competitiveness of small producers, preparing them for sustainable management and new opportunities in the global market.

The council views the project as a practical convergence of production and preservation. We believe that the breadth and accuracy of the data will be crucial to turning challenges into real business opportunities.

As COP 30 approaches, we reaffirm our commitment to advancing tangible initiatives that empower Brazilian agribusiness. This publication marks an important step in that direction, the result of the joint efforts that define Sebrae's approach.

Message from the Executive Board of Sebrae Goiás

Antônio Carlos de Souza Lima Neto

Chief Executive Officer

Marcelo Lessa Medeiros Bezerra

Technical Director

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Director of Administration and Finance

Sebrae Goiás is honored to present this document as a strategic contribution from the Sebrae System toward strengthening truly sustainable rural production. This proposal was built collaboratively and grounded in technical expertise, aiming not only to support small producers but also to position Brazilian agribusiness at a new level of leadership in the face of global climate challenges.

At this historic moment, as Brazil prepares to host the 30th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 30), we believe it is essential to demonstrate—through data and concrete actions—the commitment of Brazilian institutions to a responsible, innovative, and environmentally conscious agriculture.

Leading the Agribusiness Reference Hub within the Sebrae System, Sebrae Goiás is proud to coordinate a national network of professionals who, across seven states and all six Brazilian biomes, joined efforts to develop, test, and validate an accessible tool—adapted to rural realities and capable of accurately measuring Greenhouse Gas (GHG) emissions and removals.

The Executive Board of Sebrae Goiás presents this publication as a sincere and substantial contribution to COP 30, confident that it represents not only a technical proposal but also an invitation to dialogue and collective action in favor of a more sustainable future for Brazil and for the planet.

CONTENTS

1. INTRODUCTION

The world today faces a critical intersection between climate change, food security, and environmental sustainability. Greenhouse Gas (GHG) emissions continue to drive global warming, with consequences that span across all continents (Yang, 2023). The agricultural sector, while deeply embedded in this challenge, also holds significant potential to become a key part of the solution.

Brazilian agribusiness holds a central position in the national economy, representing one of the main drivers of employment, income, food production, and export earnings for the country. Renowned worldwide for its productivity, the sector now faces a pivotal moment in its transition toward more sustainable systems. In a context marked by climate change, sustainability pressures, and increasing demands from international markets, it is essential that the sector's development occurs in a balanced way—focused on productive efficiency and environmental responsibility.

1.1 Climate Change and Its Global Impact

Climate change refers to long-term alterations in the Earth's climate caused by both natural processes and human activities. Currently, the main driver of these changes is the anthropogenic increase in the concentration of Greenhouse Gases (GHGs) in the atmosphere—particularly carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (Jones et al., 2023). Since the pre-industrial era, CO_2 concentrations have risen by more than 40%, methane by over 150%, and N_2O by approximately 20%, resulting in a global temperature increase of about 1.1°C by 2023 (IPCC, 2021).

IMAGE: Wenderson Araújo - CNA/SENAR System

Emissions stem primarily from the burning of fossil fuels, land use, deforestation, and industrial and agricultural activities. Between 1990 and 2023, the warming impact associated with GHGs increased by 51%, with CO_2 alone contributing a 42% rise (IPCC, 2021). Agriculture and land-use change accounted for between 13% and 21% of global emissions over the past decade, while agri-food systems as a whole reached approximately 37% of global emissions in 2022 (Yang, 2024).

Climate change and global warming trigger a range of environmental effects, including increased frequency and intensity of extreme events such as heatwaves, wildfires, storms, and droughts; the melting of glaciers and the rise in sea levels—which could increase by 32 to 101 cm by 2100 under high-emission scenarios; ocean acidification, which hampers the activity of various marine organisms; and shifts in rainfall and evaporation patterns, leading to greater erosion, soil degradation, and reduced fertility (Kompas, 2024).

Human health is highly vulnerable to climate change, as intensified heatwaves increase mortality rates, while vector-borne diseases may expand into new regions (WHO, 2023). Climate change also poses a threat to food production, given that these systems are heavily dependent on water resources and ecosystems across multiple scales. Some regions are already experiencing disruptions in the water cycle, including the intensification of extreme weather events (e.g., droughts, floods) and the depletion of groundwater reserves. Future risks include heat stress and water stress in global food production, with direct implications for food security (Kompas, 2024).

Climate change has wide-ranging and interconnected effects on agriculture, health, food security, the economy, and social stability. Leading scientific journals such as Nature, Scientific Reports, and Climate and Atmospheric Science have published articles consolidating evidence of these impacts, reinforcing the urgency of coordinated global action.

Science, however, also points to clear pathways: the transition to clean energy, the preservation and restoration of ecosystems. Climate-smart agriculture and the strengthening of mitigation and adaptation policies are essential strategies to limit the effects already underway. These efforts are crucial to protect the most vulnerable, ensure food security, and maintain livable conditions for future generations.

1.2 Institutions Developing Climate Change Mitigation Initiatives

Climate change stands as one of the greatest challenges of the 21st century, demanding coordinated responses grounded in scientific evidence and globally articulated mitigation strategies. The intensification of the greenhouse effect, driven by the emission of gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), is directly linked to human activities—primarily the burning of fossil fuels, land-use changes, and intensive agricultural practices (IPCC, 2022). In light of this reality, scientific, intergovernmental, and civil society institutions play a central role in shaping policies, methodologies, and actions aimed at reducing Greenhouse Gas (GHG) emissions, contributing to the commitments established under the Paris Agreement and to the goal of keeping global temperature rise below 1.5°C (UNEP, 2024).

The Intergovernmental Panel on Climate Change (IPCC), established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), is widely recognized as the global scientific authority on climate change. The IPCC does not conduct original research but compiles and reviews thousands of peer-reviewed studies, producing the Assessment Reports (ARs), the sixth edition (AR6) of which is considered the most comprehensive to date. These reports provide the scientific foundation that guides the formulation of climate policies at the global level and serve as technical input for negotiations at the Conferences of the Parties (COPs) under the United Nations Framework Convention on Climate Change (IPCC, 2022).

Another prominent organization is the World Resources Institute (WRI), founded in 1982 and headquartered in Washington, D.C., with a global presence. WRI leads initiatives focused on the sustainable use of natural resources, environmental governance, and climate change. In partnership with the World Business Council for Sustainable Development (WBCSD), WRI developed the Greenhouse Gas Protocol (GHG Protocol), the most widely used global standard for quantifying and managing corporate and institutional emissions. The GHG Protocol provides guidelines for Scopes 1, 2, and 3 emissions, and is adopted by companies, governments, and financial institutions for carbon measurement and reporting (WRI/WBCSD, 2004).

The United Nations Environment Programme (UNEP) also plays a crucial role, particularly through the publication of its annual Emissions Gap Report, which analyzes the discrepancy between projected emissions and the levels required to meet the targets of the Paris Agreement. The 2024 report indicates that global GHG emissions reached 57.1 $GtCO_2e$ in 2023, marking a 1.3% increase compared to 2022, and underscores the urgent need for emissions cuts of up to 42% by 2030 to limit global warming to 1.5°C (UNEP, 2024).

The International Energy Agency (IEA), in turn, provides technical analyses and projections for the energy sector—one of the main contributors to global emissions. Its reports are widely used to inform policies on energy transition, efficiency, and decarbonization (IEA, 2023).

In addition to these, research centers such as the Potsdam Institute for Climate Impact Research (PIK) stand out for their contributions to climate modeling and interdisciplinary analyses of climate impacts and solutions. The Grantham Research Institute on Climate Change and the Environment, based at the London School of Economics, also plays a key role by developing studies on the economic risks of climate change and public policy responses. (Schneider et al., 2024).

In Brazil, institutions such as the National Institute for Space Research (INPE), the Brazilian Agricultural Research Corporation (Embrapa), and the Climate Observatory play key roles in data production, deforestation monitoring, and the development of proposals aimed at reducing national emissions, with a focus on the unique characteristics of Brazilian biomes.

These institutions, with distinct mandates and scopes of action, form a global network of scientific, technical, and political cooperation. They enable progress toward building a low-carbon economy by providing methodologies, technical training, and scientific grounding to guide decision-making at all levels—from rural producers to international policymakers.

The consolidation of these initiatives is essential to ensure the effectiveness of climate action, making sure that targets are translated into public policies, investments, and technological innovations. The future of climate mitigation largely depends on the continuity and strengthening of these institutions, as well as on collaboration among science, governments, and civil society.

1.3 Agriculture and Livestock in the Context of Climate Change

In this context, agriculture stands out for its interaction with three major Greenhouse Gases: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Although present in lower concentrations, CH_4 and N_2O have significantly higher global warming potential—approximately 28 to 265 times greater than CO_2 (Li et al., 2024). The rising concentration of these gases in the atmosphere has altered the planet's solar radiation balance, contributing to an increase in average global temperatures and triggering extreme and catastrophic climate events, with economic, social, and environmental consequences. According to IPCC data, between 1990 and 2005, global agricultural emissions of CH_4 and N_2O increased by 17%, representing approximately 60 $MtCO_2e$ per year (IPCC, 2022) (Figure 1).

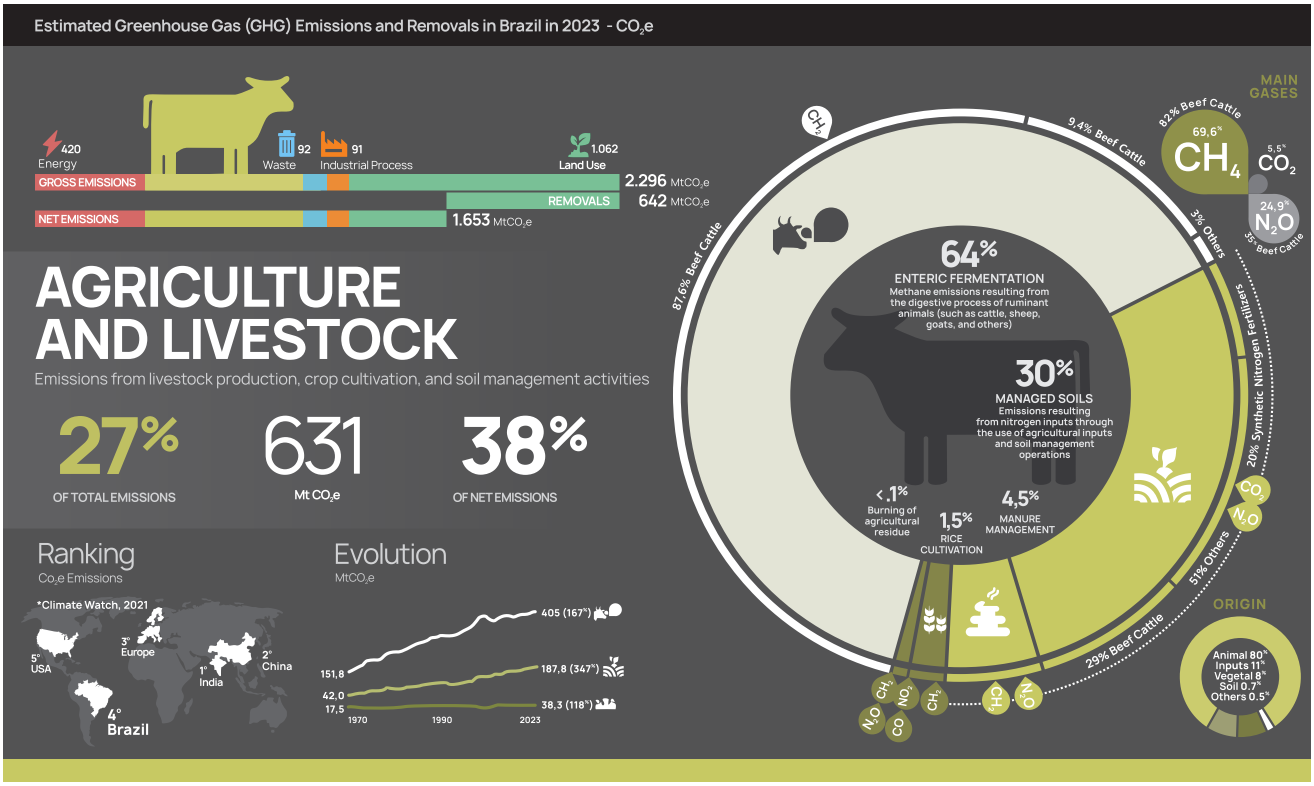

Figure 1. Estimate of Greenhouse Gas (GHG) Emissions and Removals in Brazil in 2023. (SEEG, 2023)

Livestock accounts for approximately 90% of CH_4 emissions in Brazil's agricultural sector, while manure management contributes around 33% of N_2O emissions (Torres et al., 2017). These emissions have a significant impact on the country's carbon footprint and demand targeted mitigation strategies. Studies project that climate variability may reduce the productivity of crops such as soybean, corn, and beans by up to 18% per hectare, with regional effects ranging from −40% to +15% (Assunção; Chein, 2016). Forecasts for 2050 indicate that agricultural production in regions such as the North and Northeast may decline, negatively affecting regional economies and the well-being of rural families (Tanure et al., 2024; Taylor et al., 2024).

Between 2007 and 2016, the AFOLU sector (Agriculture, Forestry and Other Land Use) accounted for 23% of human-induced emissions (IPCC, 2020). However, Chapter 7 of IPCC's AR6 emphasizes that this sector holds one of the greatest mitigation potentials within the global system, both through emission reductions and the enhancement of carbon sinks. Land-based measures, such as forest restoration and sustainable management, could represent 20% to 60% of cumulative mitigation by 2030 in global transformation scenarios.

The Low-Carbon Agriculture Plan (Plano ABC), established in 2009 and expanded as ABC+ through 2030, outlines structured mitigation actions in the agricultural sector, including the recovery of degraded pastures, crop–livestock–forestry integration (ILPF), no-till farming, biological nitrogen fixation, and manure management. The ABC Plan had the potential to mitigate up to 162.9 million tCO_2e by 2020 and was renewed with updated targets under ABC+ (World Bank, 2024).

Another relevant policy is the Agricultural Zoning for Climate Risk (ZARC), developed by Embrapa, which guides planting calendars based on regional climate risks, contributing to adaptation and the reduction of productivity losses.

The adoption of practices such as regenerative agriculture, agroforestry systems, and integrated management has proven effective in reducing Greenhouse Gas (GHG) emissions and promoting soil sustainability. Recently, Brazilian researchers have encouraged techniques like early drainage in irrigated rice cultivation, which can reduce methane emissions by 85% to 90% without compromising yield (Islam et al., 2020). In the Cerrado Mineiro and other coffee-producing regions, farmers have combined regenerative management with ecological integration, reducing chemical inputs and enhancing climate resilience (Reuters, 2024).

Brazil's 2023 update of its Nationally Determined Contributions (NDCs) reaffirmed the goal of reducing emissions by 48% by 2025 and 53% by 2030, compared to 2005 levels, with a focus on climate measures in the agricultural sector and the strengthening of the ABC+ Plan (World Bank, 2024).

Brazilian agriculture faces the dual challenge of reducing its own emissions and adapting to the impacts of climate change. However, the country also holds significant potential to become a global mitigation asset through the synergy of public policies, technological innovation, and regenerative practices. The consolidation of programs such as the ABC+ Plan, the adoption of sustainable systems like crop–livestock–forestry integration (ILPF), and the inclusion of climate finance can position agriculture as a key driver in the transition toward a low-carbon, resilient, and competitive rural model.

1.4 The Role of the COPs

Environmental issues began to be debated at the Stockholm Conference. The conference, held in 1972 in Stockholm, Sweden, reflected a growing global interest in environmental conservation and laid the foundations for global environmental Governance (Vieira et al., 2021).

The Conferences of the Parties were established for the development of strategies and actions aimed at combating climate change, and they began as the United Nations Framework Convention on Climate Change (UNFCCC) and was established in 1992 at Rio-92. From that point on, the Conferences of the Parties (COPs) became the main global forum for guiding climate action (United Nations, [n.d.]). The first COP took place in Berlin in 1995, bringing together 117 countries with the goal of establishing rules to guide future commitments. These meetings sought to translate general goals into concrete plans. In this sense, COP 3 in Kyoto (1997) approved the Kyoto Protocol, establishing mandatory emission reduction targets for developed countries, while subsequent initiatives paved the way for its successor, culminating in the Lima Call for Action (COP 20, 2014), a key step in articulating the efforts that would later be formalized in Paris

At COP 21 (Paris, 2015), the Paris Agreement was established—a milestone demanding the commitment from all countries in the form of NDCs (Nationally Determined Contributions), aiming to keep the temperature increase well below 2 °C, while striving to limit it to 1.5 °C. This treaty, in force since November 2016, introduced five-year 'ratchet' cycles to encourage progressively stronger commitments. Following Paris, successive COPs have worked to structure the agreement's implementation. In 2025, with a focus on the Amazon and the inclusion of local actors, COP 30 is expected to be a historic opportunity to strengthen mitigation through real action, robust financing, and Brazil's leadership.

Since 1995, the Conferences of the Parties (COPs) have increasingly focused on the agricultural sector. According to the UNFCCC, effective climate policies require recognizing agriculture not only as a victim of climate change but also as an active contributor to solutions. At COP 28, the urgency to revise targets and expand the scope of initiatives in the sector became evident, with an official goal of reducing global emissions by 43% by 2030. Figure 2 presents a timeline of the main COPs and their central themes.

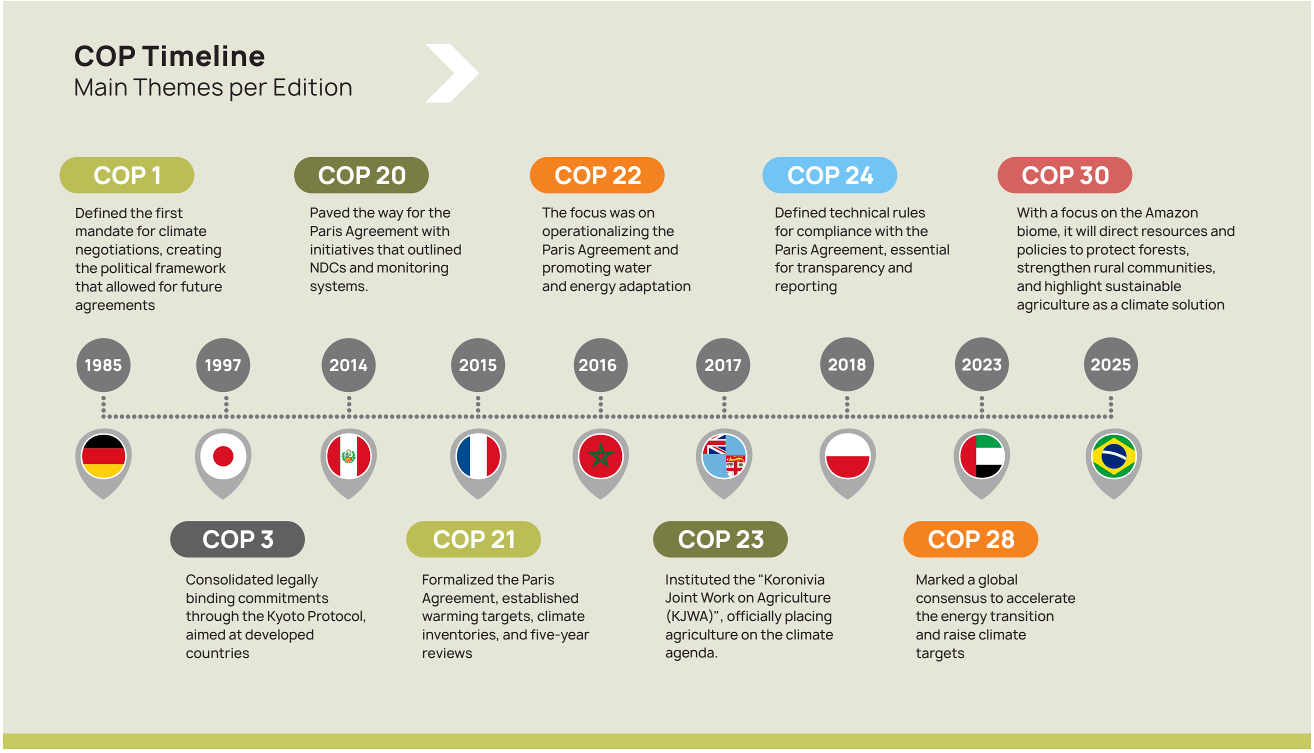

Figure 2. Timeline of the main Conferences of the Parties, highlighting the COPs that introduced significant agreements for climate change mitigation.

1.5 The Importance of CO_2 Measurements

Climate-Smart Agriculture (CSA), promoted by the FAO, integrates three key objectives for climate change mitigation: improving productivity and income without expanding cultivated land, strengthening resilience, and reducing or removing GHG emissions (Chiriacò, 2025).

Understanding and quantifying emissions is imperative for effective policies. To develop strategies and actions aimed at combating climate change, it is essential to first quantify Greenhouse Gas emissions and identify their main sources. This quantification is carried out through the Greenhouse Gas Emissions Inventory, using specific methodologies for measurement (Flizikowski, 2012). Figure 3 presents GHG emission data obtained from the SEEG platform.

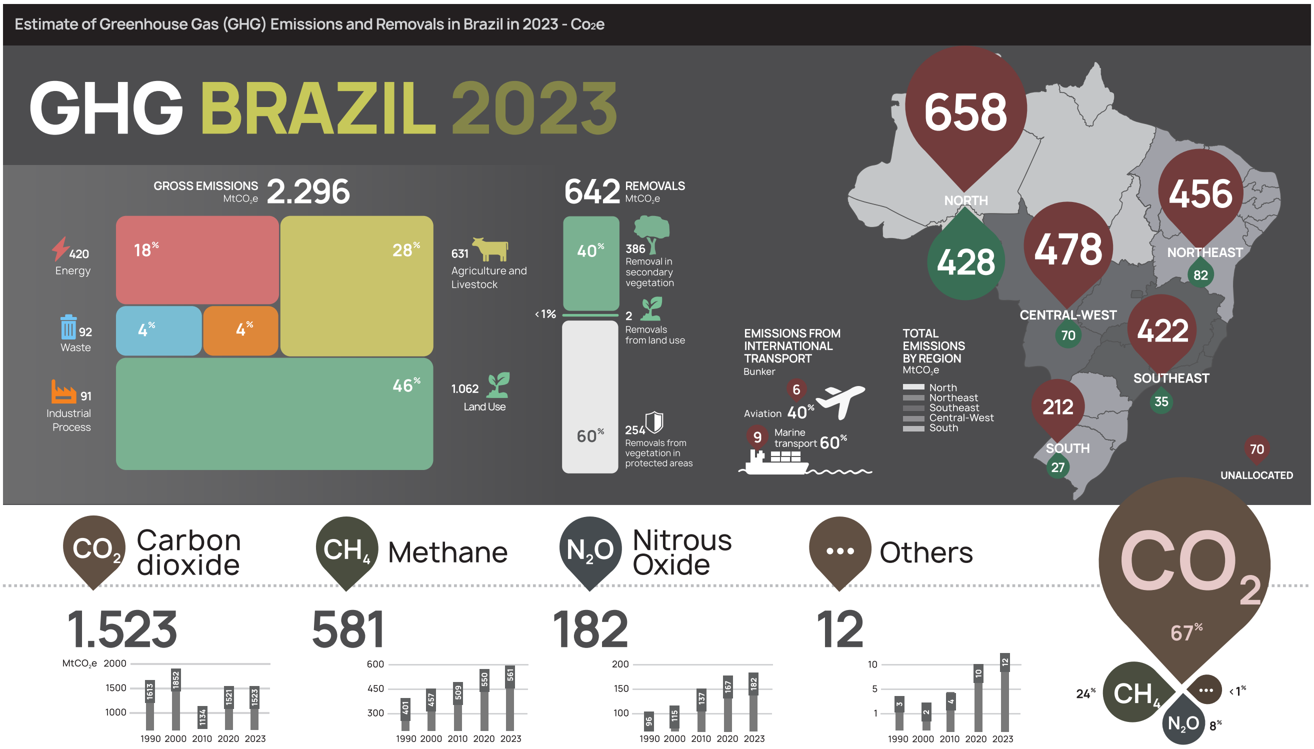

Figure 3. Estimates of Greenhouse Gas Emissions and Removals in Brazil in 2023 (SEEG, 2023).

The IPCC climate panel confirms that the global average temperature has already exceeded 1°C above pre-industrial levels and continues to rise, driven primarily by emissions of CO_2, CH_4, and N_2O. (IPCC, 2023). In 2019, the Energy and Heating sector accounted for 34% of global emissions, followed by Industry with 24%, and the Land Use, Agriculture, and Forestry sector (AFOLU) with approximately 22%. When considering the entire food system—including production, logistics, processing, and consumption—emissions can account for up to 26% of the global total (FAO, 2023).

Carbon dioxide equivalent (CO_2 eq.) is a metric used to standardize the emissions of various Greenhouse Gases based on their relative impact compared to CO_2. To calculate CO_2 eq., conversion factors are applied that consider the Global Warming Potential (GWP) of each gas, as proposed by the IPCC. Table 1 presents the GWP values used for these calculations.

Table 1. Global Warming Potential (GWP) of Greenhouse Gases. Gas – Chemical Formula – GWP.

GAS	CHEMICAL FORMULA	GWP
Carbon dioxide	CO_2	1.0
Nitrous oxide	N_2O	273.0
Methane – Fossil	CH_4	29.8
Methane – Non-fossil	CH_4	27.0

Source: IPCC (2023).

1.6 Greenhouse Gas Emissions Calculators and What Still Doesn't Exist for Small Businesses

Greenhouse Gas (GHG) emissions calculators are essential tools for quickly and consistently estimating emissions resulting from human activities, such as those related to the agricultural and forestry sectors. Although they do not replace complex scientific models, they support decision-making, environmental communication, and the design of action plans (Denef et al., 2013 apud FAO, 2013). These calculators vary in complexity, but all aim to make it easier to determine emissions by Scope (1, 2, and 3) based on data related to production, input usage, energy consumption, and management practices (FAO, 2013). They serve as an interface between the IPCC's technical knowledge and the practical needs of field application. Among the most widely used tools are: IPCC-Calc, BR-Calc, WFLDB, Nemecek-Calc, WRI, and Agri-footprint—especially for products such as cashew nuts, wheat, and other crops (MDPI, 2023). These calculators are used to estimate carbon footprints across different scenarios and to align methodologies with ISO standards for life cycle assessment (MDPI, 2023).

Comparisons between methodologies reveal significant differences in results. For example, in calculating emissions per ton of cashew nuts, there was a variation of up to

24.5% between the values obtained using IPCC-Calc (129.5 kg CO_2e) and Nemecek-Calc (104 kg CO_2e) (MDPI, 2023). Methane and nitrous oxide were identified as the main contributors to the emissions balance, with N_2O accounting for up to 75.9% of total emissions (MDPI, 2023).

Another notable example is the study that compared three tools for agricultural inventories in Europe, showing that some tools tend to overestimate N_2O and CH_4 emissions in tropical systems by up to two times compared to direct measurements (Richards, 2016). This highlights the need to calibrate and adapt the tools to the regional context (Richards, 2016).

Calculators are valuable tools for technical training, awareness-raising, and planning, enabling producers, technicians, and consultants to visualize scenarios and make data-driven decisions (FAO, 2013; Capi, 2024). They offer a low entrance barrier, allow quick simulations, and are useful for identifying trends and opportunities for emission reduction.

According to data from the latest Agricultural Census (2017), Brazil has approximately 3.9 million rural establishments classified as family farming, out of a total of around 5 million agricultural establishments. These family farmers occupy an area of over 80 million hectares, which represents about 23% of the agricultural land in the country, and they are also responsible for more than 65% of the rural labor force employed in these establishments (IBGE, 2017). If we also consider small rural businesses with an annual revenue of up to R$ 4.8 million, the total area and number of workers engaged in this productive segment becomes even more significant.

In this context, the Sebrae System—composed of Sebrae Nacional and its state-level

IMAGE: Wenderson Araújo - CNA/SENAR System

units—is a strategic player in disseminating and implementing these methodologies among small rural producers. With a presence throughout Brazil and a solid track record in supporting entrepreneurship and the competitiveness of small businesses, Sebrae operates in rural areas by promoting sustainable practices, innovation, and efficient management—essential pillars for enabling the practical and accessible quantification and reduction of emissions.

In recent years, the Sebrae System has been consolidating its strategy to promote sustainable practices and adapt to the emerging green economy in Brazilian agriculture, especially regarding the inclusion of small producers in a new low-carbon economy. One of the key initiatives in this effort is the development of the Greenhouse Gas (GHG) Emissions Inventory tool for rural activities—a pioneering solution that enables the measurement and qualification of the carbon footprint of rural properties in an accessible, educational, and scientifically grounded way. This document is presented as a proposal for Sebrae's role in supporting sustainability management in small rural businesses, a mission that gains even greater relevance considering the upcoming 30th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 30), which will take place in Brazil in 2025.

The proposal is a milestone in integrating innovation, democratizing the sustainability agenda, and fostering productive inclusion. It offers solutions tailored to the realities of small producers and aligned with Brazil's global climate commitments. It is thus understood as Sebrae's contribution to strengthening the country's image as a leader in sustainable agriculture.

The context behind the creation of a tool that fulfills this purpose, the history of its development, the results achieved, pathways for its implementation, and proposals for national and international partnerships to expand its reach are presented below.

2. RATIONALE

The rationale for developing Sebrae's Greenhouse Gas (GHG) Emissions Calculator is anchored in four strategic pillars: the global climate emergency, the growing demands of markets, the technical gap faced by small producers, and Sebrae's historical role as a transformative agent in the small business ecosystem. As an agro-environmental powerhouse, Brazil must measure, plan, and mitigate its emissions in a transparent, accessible manner aligned with international guidelines, such as the Paris Agreement. However, conventional inventories are generally complex, costly, and inaccessible to small producers. It is within this context that the need for Sebrae's calculator emerges. Unlike academic or corporate tools, this solution was designed with a robust technical foundation, yet features a user-friendly interface tailored to the realities of different production chains and Brazilian biomes. The tool enables the quantification of net emissions from rural properties.

Moreover, the solution is also strategic for consultants, managers, and their financial institutions and economic and climate incentive programs, as it enables the generation of aggregated and reliable data—useful for public policy planning, green rural credit pricing, and environmental certifications.

Finally, the justification also rests on Sebrae's institutional role: to develop innovative solutions that strengthen small businesses. With this tool, Sebrae reaffirms its leadership in supporting the sustainable transition of Brazilian agriculture, offering an accessible, reliable, and transformative instrument to address one of the greatest challenges of the 21st century.

3. DESCRIPTION OF THE METHODOLOGY

The methodology behind Sebrae's Greenhouse Gas (GHG) Emissions Inventory tool was designed to accurately and technically reflect the realities of Brazilian rural properties. Based on the geolocation of each property, the tool considers the specific characteristics of biomes, phytogeographical regions, and edaphoclimatic conditions, enabling estimates of GHG emissions and removals that are consistent with each productive context.

Based on parameters differentiated by agricultural activity and regional emission factors, the tool integrates the main carbon sources and sinks in a practical and accessible manner, providing a reliable and customized analysis to support mitigation strategies in the field.

3.1 Development

The calculator was developed based on the international methodology of the Greenhouse Gas Protocol (GHG Protocol), adapted to the specific characteristics of the Brazilian rural context in accordance with the guidelines of ABNT NBR ISO 14064-1:2007 and the emission factors established by the IPCC (Intergovernmental Panel on Climate Change). The three emission Scopes were considered:

a. **Scope 1:** direct emissions from the property (such as enteric fermentation, manure management, and fuel combustion in tractors and generators);

b. **Scope 2:** indirect emissions from the purchase of electricity;

c. **Scope 3:** indirect emissions not controlled by the property, such as outsourced transportation, use of pesticides, and contracted mechanized services.

Based on this rationale, an Excel spreadsheet was developed and adapted to incorporate all factors outlined in international methodologies for measuring emissions and carbon sinks. The tool reflects the diversity of agricultural production chains across Brazil's five regions and the specific characteristics of its six biomes.

With 24 distinct data entry tabs, the spreadsheet allows for over 1,000 possible records, comprehensively covering rural activities. Available fields include: general property information, fuel consumption, use of fertilizers and soil amendments, generation of agricultural waste, types of crops and livestock, land use change, timber forest products, soil carbon variation, management of organic soils, agricultural and organic solid waste, sanitary effluents, fugitive emissions, electricity consumption, outsourced activities, use of agricultural pesticides, reforestation areas, integrated systems, perennial agriculture, and carbon sinks.

Each tab allows for different data entry formats, reflecting the variability of productive practices across the national territory. The spreadsheet also includes a dedicated tab with the bibliographic references used, as well as the formulas and equations that support the calculations of emissions and removals, based on parameters defined by internationally recognized publications. Completing this tool enables the execution of a Greenhouse Gas (GHG) inventory for rural properties located in different Brazilian regions. The application model is based on the use of the spreadsheet by a specialized and properly trained professional, who conducts on-site visits to collect the necessary information from the producer for analysis.

Once completed, the tool automatically calculates the GHG emissions and removals associated with the property's agricultural activities. The inventory always considers a continuous 12-month period, which can be individually adjusted for each property to more accurately reflect production cycles and the specific characteristics of the local production system.

However, the tool represents only part of the solution. The effectiveness of measurement depends directly on the availability and quality of the data provided. Therefore, it is essential that prior alignment be conducted with producers, aiming to raise awareness about the importance of systematically recording property information—especially the data that will feed into the tool. Additionally, successful implementation also requires proper training of the professionals responsible for data collection. These professionals must master 'Good Measurement Practices,' including technical knowledge of regional variables, data entry criteria, and the ability to formulate precise questions for producers, as well as verify information when necessary.

Another key component of the solution is the stage following the generation of results: the development of a Mitigation Plan. This plan outlines consistent strategies for reducing emissions, prioritizing sustainable practices that preserve—or even enhance—the profitability of rural properties, both in the short and long term.

In summary, the development of the solution encompasses:

1. Technical Training: proper training of the team of professionals responsible for implementing the solution, with a focus on best practices for GHG measurement;
2. Producer Engagement: identification and awareness-raising among rural producers on properties with available and well-organized data relevant to the GHG balance;
3. Implementation of the Tool: conducting on-site technical visits by trained professionals to collect information and calculate the GHG emissions and removals balance on the property;
4. Mitigation Plan: development of technically and economically viable strategies to reduce emissions, with a focus on sustainability and maintaining profitability.

The following are the structural components of the tool, considered to be the operational core of the solution and an essential element for the technical measurement of GHG emissions and removals in rural areas.

3.1.1 SCOPES

Scope 1 includes all direct Greenhouse Gas emissions from sources that are owned or controlled by the organization. In the agricultural context, this includes, for example, the use of diesel-powered tractors and harvesters, the burning of agricultural residues, and enteric emissions from ruminant animals. Scope 1 also covers industrial processes that generate GHGs and the use of nitrogen-based fertilizers that lead to the release of nitrous oxide (N_2O). Since these emissions fall under the direct control of the property or company, monitoring Scope 1 is essential for implementing more immediate and effective mitigation actions. Table 2 presents the emission sources considered under Scope 1 for conducting the GHG inventory on rural properties.

Table 2. Sources of Scope 1 Emissions.

ID	EMISSION SOURCE
SCOPE 1	
1	Stationary combustion
2	Mobile combustion
3	Application of organic fertilizers
4	Application of nitrogen fertilizers
5	Application of urea
6	Application of soil amendments
7	Crop residues
8	Green manure
9	Pasture renewal
10	Irrigated rice cultivation
11	Animal waste management
12	Enteric fermentation
13	Land-use change
14	Harvested Wood Products
15	Indirect emissions from volatilization and atmospheric deposition
16	Indirect emissions from leaching and surface runoff
17	Soil carbon change
18	Emissions from nitrogen mineralization
19	Management of organic soils
20	Agricultural solid waste
21	Solid waste and sanitary effluents
23	Fugitive emissions

Scope 2 refers to indirect emissions associated with the generation of purchased electricity, steam, heat, or cooling consumed by the organization. In agriculture, this mainly applies to electricity used in irrigation systems, cooling, grain processing, mechanical milking, among other activities. Although these emissions do not physically occur within the property, they are accounted for because they result directly from the operation's energy consumption. Reducing emissions in this Scope may involve adopting renewable sources, such as solar energy or biomass, and improving the energy efficiency of the equipment used.

Table 3. Scope 2 Emission Sources.

ID	EMISSION SOURCE
	SCOPE 2
23	Scope 2 Emission Sources

Scope 3 emissions are a consequence of the property's activities but occur from sources that are not owned or controlled by the property. Scope 3 covers all other indirect emissions not included in Scope 2, occurring throughout the organization's value chain, both upstream (suppliers) and downstream (clients and consumers). Examples include emissions related to the production and transportation of agricultural inputs (such as fertilizers and feed), the transportation of products to the final consumer, off-site industrial processing, and waste disposal. In agribusiness, this Scope can represent a significant share of total emissions, requiring collaborative strategies with value chain partners for measurement and mitigation. Understanding Scope 3 is essential for a systemic and more comprehensive approach to environmental sustainability. Table 4 presents the emission sources considered under Scope 3 of the GHG inventory for rural properties.

Table 4. Scope 3 Emission Sources

ID	EMISSION SOURCE
SCOPE 3	
24	Outsourced transportation
25	Outsourced mechanized activities
26	Application of agricultural pesticides
27	Agricultural solid waste
28	Sanitary solid waste and effluents

3.1.2 BIOGENIC CARBON

CO_2 emissions from biomass combustion are considered climate-neutral, as this CO_2 is generated through a biological cycle. The IPCC, as well as the GHG Protocol, recommends that CO_2 emissions from biomass combustion be considered climate neutral. Biogenic carbon emissions are divided into two categories:

a. Land use: soil emissions, decomposition of dead organic matter, and burning of agricultural residues;

b. Biofuel use: emissions from the use of biofuels (such as ethanol).

3.1.3 CARBON REMOVAL ESTIMATE

Carbon sinks are reservoirs that absorb more CO_2 than they release it, playing a central role in maintaining the planet's climate balance. Oceans, soils, and forests are among the main carbon sinks (FAO, 2023; UNFCCC, 2008).

Oceans absorb approximately 25% of human CO_2 emissions annually, operating through both physical mechanisms (such as solubility) and biological processes (including marine vegetation), like mangroves and seagrass meadows (Monteiro, 2021). Soils store around 1,500 billion tonnes of carbon, more than the atmosphere and terrestrial vegetation combined. Its carbon sequestration capacity surpasses that of the oceans in terms of exchange speed with the atmosphere (FAO, 2023). For agribusiness, this represents one of the greatest opportunities for mitigation. Tropical forests are natural reservoirs that sequester carbon in both biomass and soils, actively mitigating up to ~6 t C/ha/year (Raveroaritiana & Wanger, 2023).

ID	CARBON SINK
1	Primary forest
2	Secondary forest (former forest land)
3	Secondary forest (former pastureland)
4	Secondary forest (former cropland)
5	Secondary forest (other land-use history)
6	Primary grassland
7	Secondary grassland
8	No-till farming
9	No-till system

10	Perennial agriculture
11	Improved pasture with inputs
12	Conserved pasture
13	Perennial agriculture
14	Reforestation – Forestry
15	Crop-Livestock-Forest Integration systems

Removals are calculated based on the principles and methodological guidelines of the Intergovernmental Panel on Climate Change (IPCC, 2006) and applies to production systems that maintain or increase carbon stocks under current land use. To that end, the types of land cover and land use reported by producers and observed during field visits were considered, as well as the historical use of these areas in the years before the inventory.

The recorded removals refer primarily to:

a. Preserved native vegetation, such as primary forests, natural grasslands, and secondary formations in advanced stages of regeneration;
b. Conservation-oriented agricultural systems, such as no-till farming and crop-livestock-forest integration (CLFI);
c. Pastures under proper management or in restoration, which help increase soil carbon stocks;
d. Reforestation efforts, whether with native or non-native species (silviculture), that capture carbon throughout their growth cycle.

Each type of carbon sink was assessed based on the area it occupies, its previous land-use history, the species or type of vegetation present, and its conservation status. For removal estimates, carbon sequestration factors specific to each land-use category and biome were used, considering both aboveground biomass and soil carbon, where applicable.

These removals play a key role in the net emissions balance of rural properties, with the potential to partially or fully offset the gross emissions from agricultural activities. The following are the consolidated estimates of the main types of carbon sinks recorded on the inventoried properties.

3.1.4 NET EMISSIONS

The estimation of Greenhouse Gas (GHG) emissions on rural properties was based on field-collected data and the application of emission factors in accordance with the guidelines of the IPCC (2006) and the GHG Protocol.

Net emissions correspond to the difference between the total $CO_{2\text{-eq}}$ emissions and CO_2 removals, as expressed in the following equation:

$$\text{NET EMISSION} = \sum \text{EMISSIONS} - \text{REMOVALS} \quad (1)$$

Where:

NET EMISSIONS refer to the net CO_2 equivalent emissions from the inventoried rural property (tons of CO_2 eq);

EMISSIONS refer to the total sum of emissions from all sources within the inventoried rural property (tons of CO_2 eq.);

REMOVALS is the total amount of CO_2 eq removed from the atmosphere by the carbon sinks present on the inventoried rural property (tons of CO_2 eq.).

3.1.5 POTENTIAL FOR ADAPTATION TO THE BRAZILIAN TERRITORY

The methodology adopted by the developed Greenhouse Gas (GHG) inventory tool was designed to ensure representativeness, technical robustness, and alignment with the realities of Brazilian rural properties. To that end, the tool was field-tested across all six Brazilian biomes—Amazon, Caatinga, Cerrado, Atlantic Forest, Pantanal, and Pampa—encompassing the diversity of production systems, agricultural practices, and the environmental and social characteristics of each region.

This approach enabled the calibration of the methodology according to the specific characteristics of each biome, adjusting emission factors, management practices, land-use types, and carbon sequestration potential. The territorial division ensured that the tool was not a generic solution, but rather a science-based technology tailored for each region, enhancing its accuracy and legitimacy for use in public policies, incentive programs, and mitigation strategies aligned with local contexts.

Therefore, the geographic location of the property is used as the starting point for estimating GHG emissions and removals, applying parameters specific to each state, biome, and phyto-physiognomic region. This approach allows the calculations to accurately reflect the environmental and productive variability across the national territory, while respecting the specific characteristics of each agricultural system.

With regard to emissions, the tool incorporates differentiated emission factors for activities such as enteric fermentation in ruminants and animal waste management, based on the state in which the property is located. For example, a cattle herd in the state of Mato Grosso will have its emissions estimated differently from a similar herd in Santa Catarina, due to differences in climate, feed, management practices, and infrastructure. This differentiation is essential to ensure data accuracy and to guide tailored mitigation strategies.

In addition, the tool also calculates carbon removals based on the specific characteristics of each biome and phyto-physiognomic region. Factors such as the type of native vegetation, the presence of forested areas, and soil conditions directly influence carbon sequestration rates. Soil carbon estimates, for instance, consider both the original carbon stock of the area and the changes resulting from land-use and management shifts, such as the conversion of degraded pastures into more intensive or integrated systems. These calculations are based on the exact geolocation of the property, ensuring that the results are consistent with the local productive and environmental reality.

Therefore, the tool adopts a methodology that prioritizes accuracy and applicability, using regional data and consistent technical criteria. This ensures that the calculation of emissions and removals is not only more reliable, but also to serve as a foundation for the development of individualized action plans, contributing to the transition toward a more sustainable, low-carbon agriculture aligned with global environmental commitments.

3.2 Field Pilot for Tool Testing

Considering the development of the Greenhouse Gas inventory tool and the structuring elements of the proposed solution, a practical field validation phase was carried out. This initiative aimed to test the operational applicability of the tool in real rural properties, evaluating its efficiency, alignment, and measurement capacity across different productive and environmental contexts. This strategy was essential to ensure that the proposal, although conceptually sound and technically grounded, could be evaluated from the perspective of its practical effectiveness.

A total of 216 rural properties were inventoried across seven states, covering all six Brazilian biomes. The results provide a detailed overview of emissions and removals across the analyzed properties, considering their productive, geographic, and environmental characteristics. These data make it possible to identify patterns, compare performance across different biomes and production systems, and, above all, highlight concrete mitigation opportunities.

Below is a brief overview and the key findings of the national pilot, highlighting the perception of a viable commercial framework, national-level coordination efforts, and the unique regional characteristics that directly influence the carbon balance of agricultural activities.

3.2.1 ORIGIN OF THE SOLUTION WITHIN SEBRAE

The initiative to develop a Greenhouse Gas (GHG) inventory tool for agribusiness began at Sebrae Santa Catarina, in a context of growing concern for sustainability and increasing international market demands for environmental traceability and proof of good agricultural practices. The first concrete discussion about the possibility of a national tool took place in 2023, sparked by the realization that agribusiness leaders were interested in joining forces with partner institutions, such as Sebrae, to implement GHG inventories in integrated rural properties.

In February 2023, Sebrae Santa Catarina invited Sebrae's Agribusiness Reference Hub to learn about the initiative in the western region of Santa Catarina. At the time, Sebrae SC presented a proposal developed in partnership with local agribusinesses, aimed at providing producers with a tool to inventory GHG emissions. Initially, the idea raised doubts, as the topic of climate change still seemed distant from the reality of most small producers. However, the enthusiasm shown by agribusinesses and their interest in using the tool as part of their sustainability strategies revealed a potential path toward a viable commercial model, as well as the broader promise of the proposal.

With support from Sebrae Goiás, which leads Sebrae's Agribusiness Reference Hub, a deeper and more systematic understanding of the initiative was initiated. Despite initial skepticism regarding the engagement of small producers, it became clear that the participation of agribusinesses—as both funders and beneficiaries of the results—could make the model viable. Based on this realization, the Hub took the lead in crafting a strategy for the development of a national solution.

The initial nationalization effort involved forming a small technical cooperation group composed of Sebrae state units—such as Mato Grosso, Minas Gerais, and Santa Catarina—alongside Sebrae Nacional, with the goal of developing a nationwide implementation strategy. These stakeholders were engaged due to their experience in leading relevant local initiatives and to enable coordination with nationally recognized institutions, with the aim of gathering insights and validating the proposed pathways.

The outcome of the discussions revealed that the initiative went beyond simply adding a new solution to Sebrae's national portfolio. In fact, it was a concrete opportunity to contribute to the image and development of Brazilian Tropical Agriculture, especially in light of the growing demand for sustainability in the country's agribusiness sector.

From this perspective, it was concluded that developing the tool was not only feasible, but essential—requiring, therefore, a robust model aligned with the complexity of the challenges at hand. Thus, the following principles were established to guide its refinement and expansion:

- The tool should cover a broader range of production chains, going beyond the initial scope focused on the Southern region;
- The six Brazilian biomes must be considered, reflecting the country's territorial and productive diversity;
- The tool must be field-tested across all six biomes, considering different value chains and the diverse realities of rural producers;
- Viable business models must be proposed to enable the solution's implementation by small producers;
- The tool must ensure a high standard of quality in measurement and analysis, supported by a robust methodology that delivers reliable results at every stage;
- Finally, applications should be designed to create value for strategic partners, rural producers, and market-driven companies, thereby strengthening their adoption and impact.

In this context, the Sebrae Agro Hub developed a strategy to ensure that the tool became more than just a technical instrument—it was about building a scientifically grounded solution, institutionally recognized and tested at the national level.

The strategy initially relied on hiring a specialized company to lead the expansion of the tool, ensuring it would encompass multiple production chains and all six Brazilian biomes. Simultaneously, six additional Sebrae state units—alongside Sebrae Santa Catarina—were invited to test this expanded version of the tool, with each representing one of Brazil's six biomes.

As outlined in the strategy, each Sebrae state unit was instructed to establish local partnerships with agribusinesses, associations, cooperatives, municipal or state governments, or other institutions with an interest in the topic. These organizations were referred to as "anchor companies". The Hub took part in meetings with the anchor companies nominated by each Sebrae state unit, aiming to present the project, assess their level of interest in the initiative, and gather insights on its potential application.

The anchor companies, in turn, were responsible for selecting rural producers within their own networks to participate in the national pilot of the tool, known as the "Biomes Pilot." The Hub was responsible for hiring and guiding local consultants in each of the seven participating states, with the goal of applying the tool in 30 rural properties per state and sending the data to a specialized company to generate the results.

The distribution of tests across the biomes took place as follows:

- Sebrae RS: application in the Pampa Biome;
- Sebrae PR e Sebrae SC: application in the Atlantic Forest Biome;
- Sebrae GO: application in the Cerrado Biome;
- Sebrae MS: application in the Pantanal Biome;
- Sebrae RN: application in the Caatinga Biome;
- Sebrae PA: application in the Amazon Biome.

State-level agro managers, members of the Sebrae Agro Hub network, were responsible for coordinating and monitoring partnerships with anchor companies, overseeing the implementation of inventories on rural properties carried out by contracted consultants, scheduling feedback meetings with producers and anchor companies, and collaborating with the Hub by sharing insights and suggestions on potential uses and delivery formats for the tool.

The participation of Sebrae Nacional was especially strategic in promoting the Hub's engagement with leading national institutions, such as Embrapa, Getúlio Vargas Foundation (FGV Agro), the Ministry of Agriculture, Livestock and Supply (MAPA), and the Brazilian Confederation of Agriculture and Livestock (CNA), among others. This coordination enabled the institutional presentation of the project, the mapping of similar ongoing initiatives, and the identification of potential synergies and complementarities.

In addition, the Hub consulted these institutions to assess their interest in joining a national network of highly credible organizations, with the purpose of validating and endorsing the proposed methodology. Every institution, without exception, expressed interest in contributing to the development of this network and showed support for its creation, recognizing its strategic importance for strengthening the initiative both technically and institutionally. The endorsement from these partners gave the tool greater technical robustness, institutional legitimacy, and alignment with strategic sustainability agendas in Brazilian agriculture.

Given this trajectory—marked by a robust and strategically coordinated national effort involving key institutional stakeholders, the development of a scientifically validated tool, field tests conducted across seven states representing Brazil's six biomes, and the direct engagement of agribusiness managers from the Sebrae System—we can safely affirm that a major national institutional movement, led by Sebrae, has been successfully consolidated. This movement offers a concrete response to global demands in the face of climate change, while also reaffirming the commitment of reputable national institutions to the sustainability of the agricultural sector.

More than a technical solution, this is a strategic position that strengthens the image of Brazilian agribusiness on the international stage, show that the Brazilian society supports one of the country's most important economic sectors. With this vision, the Greenhouse Gas (GHG) inventory tool developed by Sebrae has the potential to become a milestone in the institution's sustainability efforts: an accessible technology, tailored to the realities of rural areas, and with strong potential to open doors to markets that value sustainable production practices.

Below are the key results of the Biomes Pilot.

3.3 Results of the "Biomes Pilot"

The Greenhouse Gas (GHG) inventories covered a total of 216 rural properties, with a combined area of approximately 55,100 hectares. These properties are distributed across all Brazilian biomes and represent a diverse and comprehensive sample of the country's agricultural production, both geographically and in terms of production systems. The activities carried out encompass the main sectors of primary production, with emphasis on agriculture and livestock, organized under different production systems and technological levels.

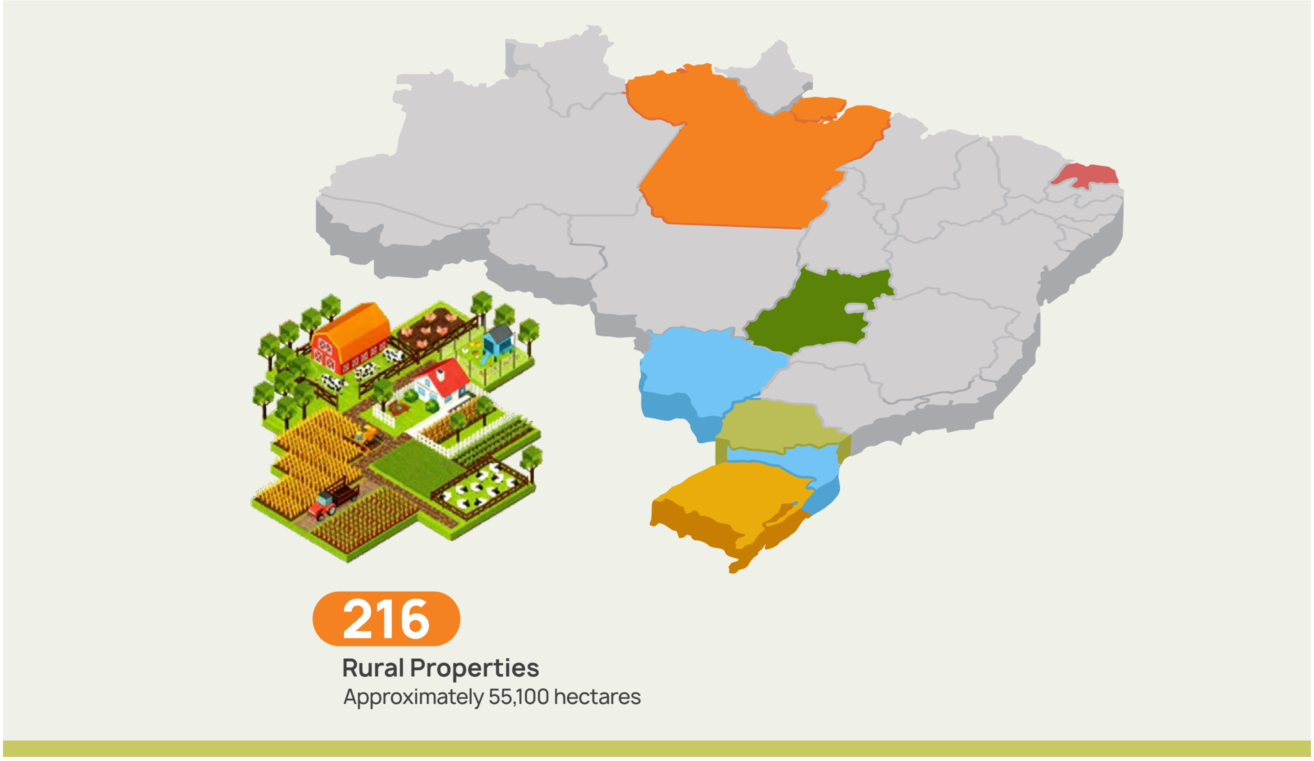

Figure 4. States Where the Biomes Pilot Project Was Implemented.

In the agricultural sector, a wide variety of crops was identified, encompassing both annual and perennial farming systems. Annual crops are predominantly composed of grains and cereals, with emphasis on the production of soybean, corn, rice, and beans, as well as other regional crops intended for human and animal consumption. Areas with vegetables and short-cycle crops in intensive systems were also recorded. Perennial agriculture was strongly represented by fruit farming, including species such as açaí, banana, yerba mate, and citrus fruits, among other long-cycle crops.

In livestock farming, the observed diversity reflects the plurality of production systems found across the different regions of the country. Properties dedicated to beef and dairy cattle farming were identified, with varying degrees of intensification and waste management practices. In addition, there was a significant presence of sheep farming, pig farming, broiler poultry farming, and layer poultry farming, each with its own structural and operational characteristics.

One notable aspect was the detailed characterization of animal waste management systems, which vary significantly depending on the species raised, the size of the property, and the type of confinement. Practices such as the direct deposition of waste onto the soil by animals in extensive grazing systems were recorded, as well as more structured collection and storage systems, including manure pits, confinement flooring, anaerobic lagoon systems, and biodigesters. Accurate identification of these systems is crucial, as they directly influence the potential for methane (CH_4) and nitrous oxide (N_2O) emissions on the properties.

Total consolidated emissions amounted to approximately 348,424.2 tons of carbon dioxide equivalent (tCO_2e). The main emission sources identified under Scope 1, which accounts for approximately 91% of total emissions, were:

a. Enteric fermentation from ruminants (67,424.4 tCO_2e), primarily associated with beef and dairy cattle farming. This is one of the largest methane (CH_4) sources in the agricultural sector;

b. Land-use changes (89,972.2 tCO_2e), reflecting the conversion of native vegetation into agricultural or pasture areas, with the release of stored carbon from biomass and soil;

c. Stationary combustion (54,531.4 tCO_2e) resulting from the use of firewood, diesel, and other fuels in boilers, dryers, heating systems, and fixed engines;

d. Animal waste management (24,984.6 tCO_2e), with emphasis on CH_4 and N_2O emissions depending on the management system adopted;

e. Application of organic fertilizers and urea, which contributed over 20,000 tCO_2e through N_2O emissions.

Scope 2 emissions, associated with electricity consumption from the grid, were relatively modest (459 tCO_2e), partly due to the use of photovoltaic systems on several properties, which fully or partially met their electricity demand.

Scope 3 encompassed indirect emissions linked to service provision and the acquisition of input, such as:

a. Outsourced transportation of inputs or products (31,630.2 tCO_2e);
b. Application of agricultural pesticides (1,407.2 tCO_2e);
c. Contracted mechanized activities (378.6 tCO_2e).

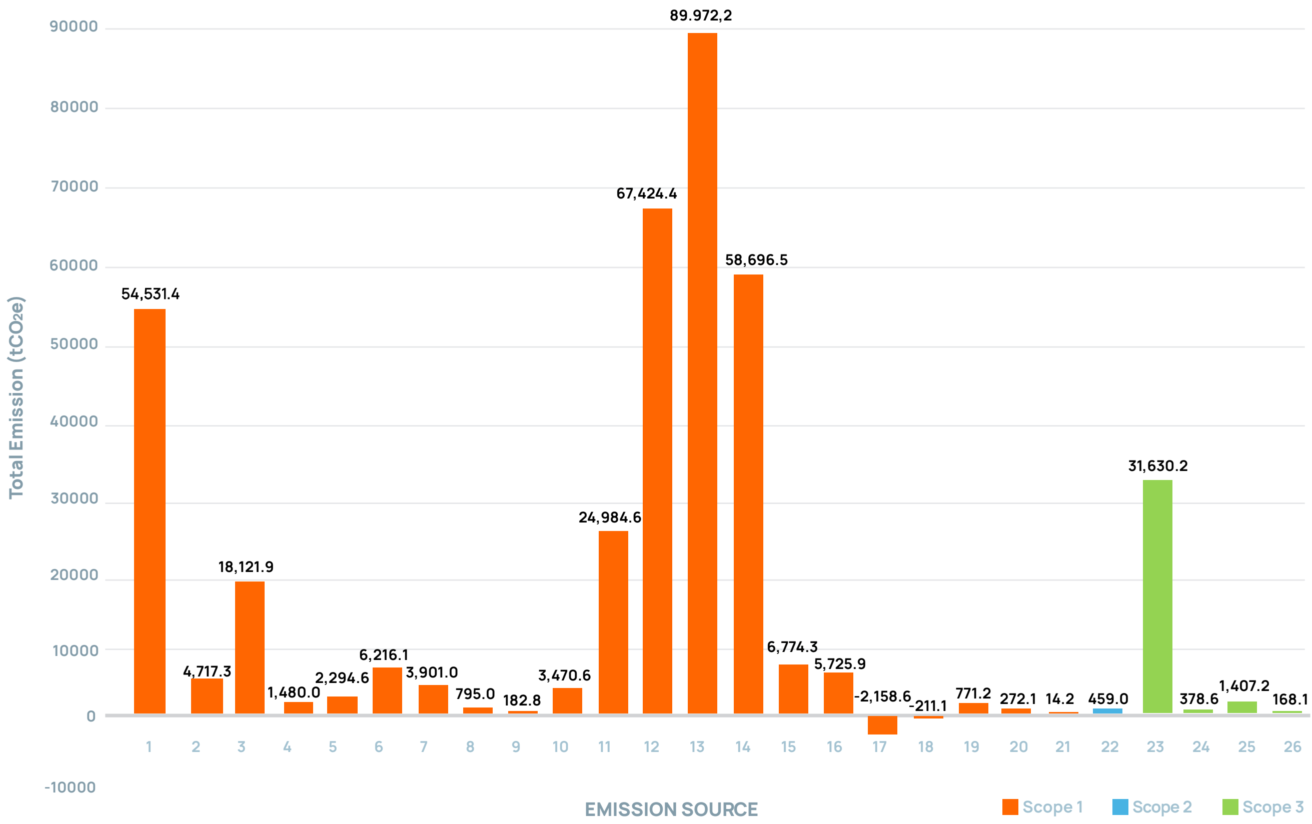

Figure 5. Emissions by source.

In addition to emissions associated with agricultural activities, the inventories conducted on the 216 rural properties also accounted for natural and managed processes of carbon dioxide (CO_2) removal from the atmosphere. These removals occur through the biological fixation of carbon in different ecosystem compartments, especially in plant biomass and soil organic carbon, and are referred to as GHG sinks.

The quantification of Greenhouse Gas removals was based on the reported areas of native vegetation, conservation-oriented agricultural systems, and land-use practices that promote carbon sequestration, as identified by field consultants on each property.

The areas were categorized based on their previous land-use history and current type of cover and management. This allowed for the application of differentiated removal factors, respecting the dynamics of each system and its actual carbon sequestration potential.

Primary and secondary forests accounted for the largest area with removal potential, totaling over 14,900 hectares, reflecting the role of native vegetation in carbon retention. The relevance of native and secondary grassland areas, common in regions such as the Pampa and Pantanal, also stands out, as they serve as important carbon sinks.

The existence of approximately 9,100 hectares under no-till and no-till systems demonstrates the effort of some property owners to adopt management practices that promote carbon accumulation in the soil, contributing to the mitigation of agricultural emissions.

Planted forest systems (silviculture) and integrated production systems (ILPF) were recorded on a smaller scale, but with high removal capacity per hectare, especially when combined with sustainable practices and soil cover maintenance. These areas, along with well-managed pastures and perennial agriculture, are the foundation of agricultural carbon sequestration on the inventoried properties.

The total estimated Greenhouse Gas (GHG) removals across the 216 inventoried rural properties reached –583,316.5 tons of carbon dioxide equivalent (tCO_2e), a significant result that highlights the central role of carbon sinks in the emission dynamics of the agricultural sector. Removals occurred through natural and managed processes of carbon sequestration in vegetation and soil, associated with various types of land use and conservation-oriented agricultural practices.

The largest contributor to carbon sequestration was reforestation (forest plantations), which accounted for –377,080.4 tCO_2e, representing approximately 65% of all recorded removals. This figure shows the high potential of areas undergoing reforestation to capture atmospheric carbon, even when combined with exotic species, as in the case of silviculture.

IMAGE: Wenderson Araújo - CNA/SENAR System

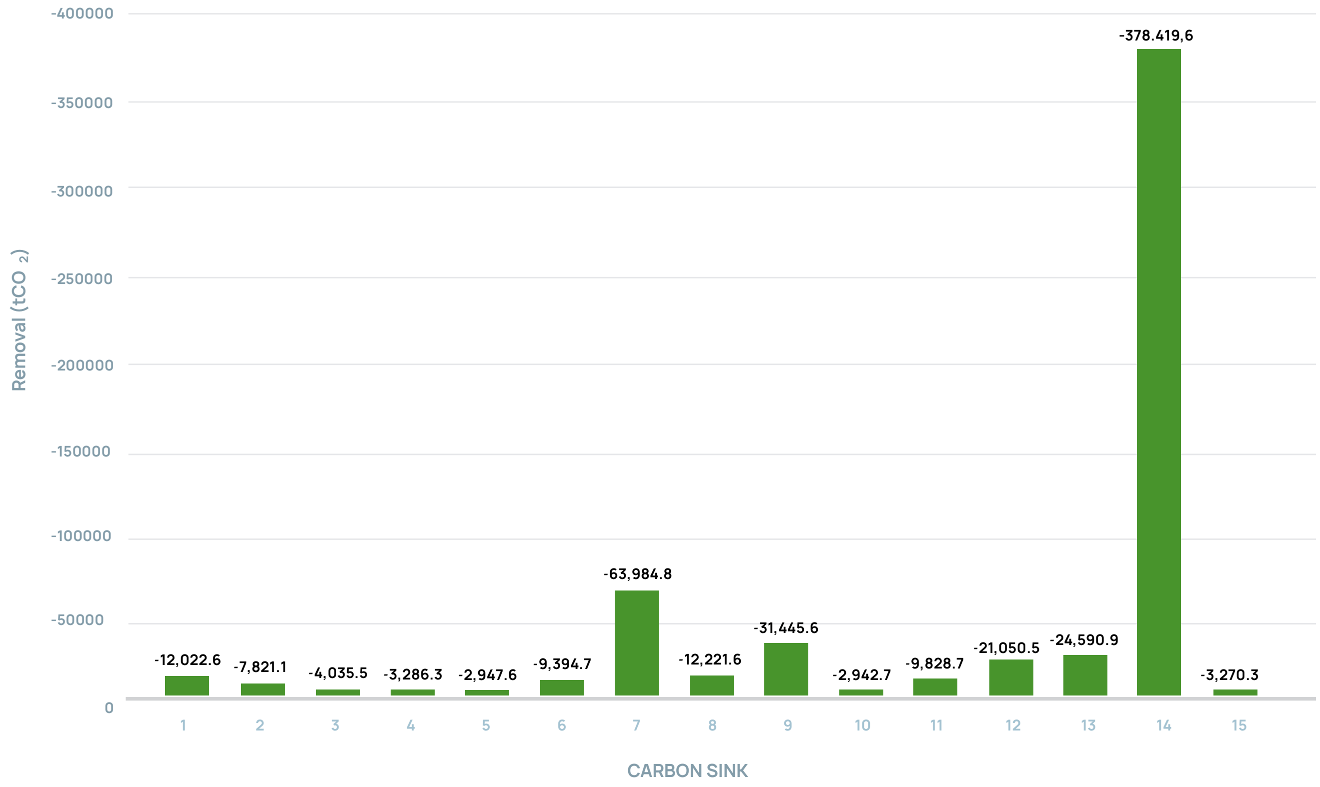

Figure 6. Average CO_2 eq. removals by source across all inventoried properties.

The consolidation of data from the 216 inventoried properties revealed a significantly positive net climate balance, highlighting the role of the agricultural sector in mitigating climate change. Total emissions in Scopes 1 and 2, according to the GHG Protocol, amounted to approximately 348,625.6 tons of carbon dioxide equivalent (tCO_2e), covering activities such as enteric fermentation, use of fuel and fertilizers, manure management, and electricity consumption.

On the other hand, GHG removals reached –583,316.5 tCO_2e, mainly through sinks such as native vegetation, reforestation, no-till farming, well-managed pastures, and perennial crops, which promote carbon sequestration in biomass and soil. The balance between emissions and removals resulted in a net total of –234,690.9 tCO_2e, confirming that, over the 12-month period analyzed, the properties acted as net carbon sinks.

This performance highlights how sustainable practices—such as the restoration of degraded areas, forest conservation, and the use of integrated production systems—are effective in reconciling agricultural production with environmental conservation. In addition, the positive outcome creates opportunities for properties to access offset mechanisms, carbon markets, and payment for environmental services programs.

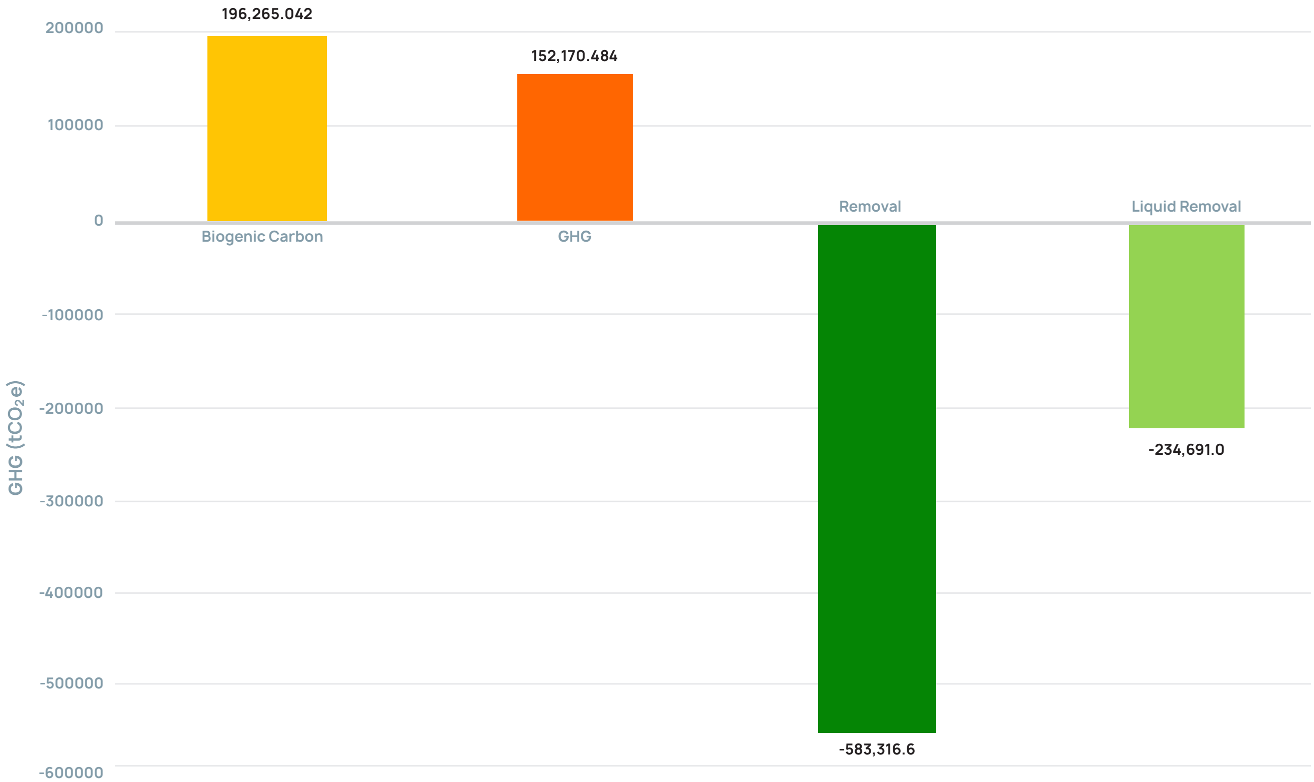

Figure 7. Average net emissions from all inventoried properties in Brazil.

It is important to emphasize that, although the consolidated result indicates net removals across the inventoried properties, this figure represents an aggregated average and should not be interpreted as a uniform standard among all production units.

In practice, it was observed that emissions in some properties exceeded their removals, while others demonstrated a significantly greater capacity for carbon sequestration than their emissions. This variability reflects differences in production systems, degree of intensification, presence of native vegetation, adopted management practices, and land ownership structure.

Therefore, the average results presented in this report should be understood as a collective portrait, which does not replace the individualized analysis required for planning specific actions on each property.

Below are the results found for each Brazilian biome in relation to the seven states. We will describe the inventoried property area by state, the project's partner companies in each state, the main activities carried out on these properties, and the emissions, removals, and net balance.

3.3.1 AMAZON

In the Amazon biome, the Greenhouse Gas (GHG) emissions inventory was conducted on 30 rural properties, covering a total area of 3,344.17 hectares. The inventory was carried out through the engagement of Sebrae Pará, which mobilized the companies Bellamazon and Amazônia Cacau to select rural producers. Total combined emissions, considering Scopes 1, 2, and 3, amounted to 101,398.11 tons of carbon dioxide equivalent (tCO_2e). This corresponds to an average of 30.3 tCO_2e per hectare, one of the highest among the biomes evaluated.

This result partly reflects the specific characteristics of the region, such as the conversion of forest areas to agricultural use—a practice that leads to emissions associated with land-use change. Also contributing to this emissions profile are the presence of more intensive activities on some properties and the role of Scope 3, which expands emissions accounting by including indirect stages of production, such as inputs and transportation. More than a challenge, these data reinforce the importance of strengthening and expanding sustainable production practices that reconcile environmental conservation with income generation.

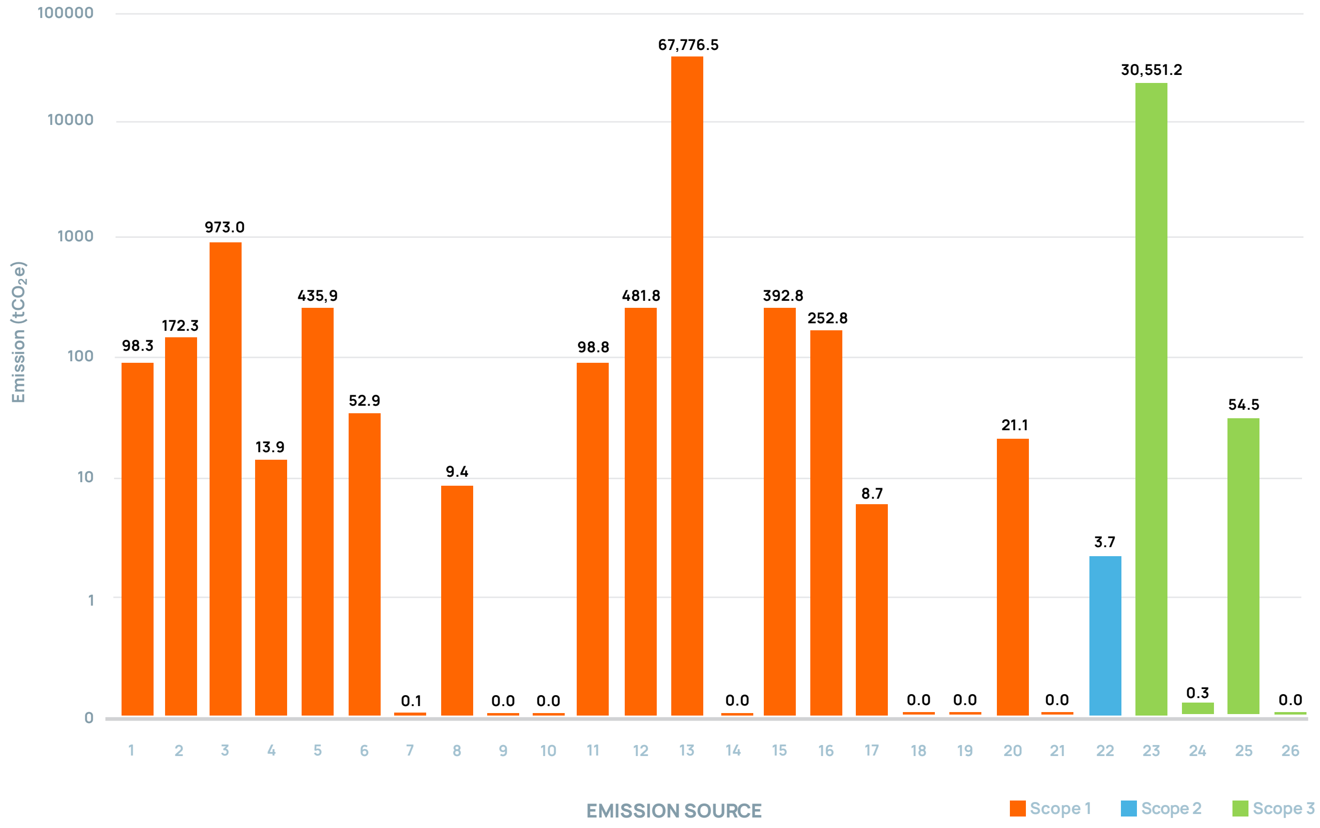

Figure 8. Emission by source in the Amazon biome.

ID Emission Source			GHG (t)				Total emissions (tCO_2e)
		Biogenic carbon (tCO_2)	CO_2	CH_4	N_2O	CO_2e	
Scope 1							
1	Stationary combustion	1.591	96.596	0.002	0.001	96.682	98.272
2	Mobile combustion	20.121	148.865	0.020	0.010	152.219	172.340
3	Application of organic fertilizers	-	-	-	3.564	973.014	973.014
4	Application of synthetic nitrogen fertilizers	-	-	-	0.051	13.859	13.859
5	Application of urea	-	175.949	-	0.952	435.927	435.927
6	Application of soil amendments	-	52.917	-	-	52.917	52.917
7	Crop residues	-	-	-	0.000	0.093	0.093
8	Green manure	-	-	-	0.034	9.395	9.395
9	Pasture renewal	-	-	-	0.000	0.000	0.000
10	Irrigated rice cultivation	-	-	0.000	-	0.000	0.000
11	Management of animal waste	-	-	0.446	0.318	98.822	98.822
12	Enteric fermentation	-	-	17.844	-	481.800	481.800
13	Land-use change	67,776.500	0.000	-	-	0.000	67,776.500
14	Timber forest products	0.000	-	-	-	-	0.000
15	Indirect emissions from volatilization and atmospheric deposition of N	-	-	-	1.439	392.831	392.831
16	Indirect emissions from leaching/surface runoff of N	-	-	-	0.926	252.807	252.807
17	Soil carbon change	8.738	-	-	-	-	8.738
18	Emissions from N mineralization	-	-	-	0.000	0.000	0.000
19	Management of organic soils	-	-	-	0.000	0.000	0.000
20	Solid waste and sanitary effluents	-	-	0.573	0.021	21.127	21.127
21	Fugitive emissions	-	-	-	-	0.000	0.000
Subtotal Scope 1		67,806.949	474.327	18.886	7.316	2,981.492	70,788.442
Scope 2							
22	Electricity consumption	-	3.712	-	-	3.712	3.712
Subtotal Scope 2		-	3.712	-	-	3.712	3.712
Scope 3							
23	Outsourced transportation	0.796	243.121	336.001	240.000	30550.41	30551.208
24	Outsourced mechanized activities	0.024	0.229	0.000	0.000	0.233	0.257
25	Application of agricultural pesticides	-	54.487	-	-	54.487	54.487
26	Solid waste and sanitary effluents	-		0.000	0.000	0.000	0.000
Subtotal Scope 3		**0.820**	**297.837**	**336.00**	**240.00**	**30,605.13**	**30,605.952**
Total		**67,807.769**	**775.876**	**354.89**	**247.32**	**33,590.34**	**101,398.106**

Figure 9. Summary presentation of GHG emissions in the Amazon biome.

Regarding removals, 30 inventoried properties, spread across a total area of approximately 3,344.17 hectares, were responsible for an estimated total removal of –40,194.84 tCO_2e. This volume represents an average of –12.02 tCO_2e per hectare, a significant amount, especially considering the region's productive and environmental complexity.

Removals in this biome were strongly influenced by the presence of areas with preserved native vegetation—such as primary and secondary forests—and by managed systems like reforestation and perennial agriculture. The high removal rate per hectare reflects the strong carbon sequestration potential of Amazonian ecosystems, which contain large aboveground and belowground biomass.

This performance reinforces the strategic importance of the Amazon in global climate regulation, even on properties engaged in productive activities. The conservation and proper management of these areas can ensure not only that removals are maintained, but also their expansion, provided they are aligned with sustainable land and vegetation use practices, as illustrated in the figure below.

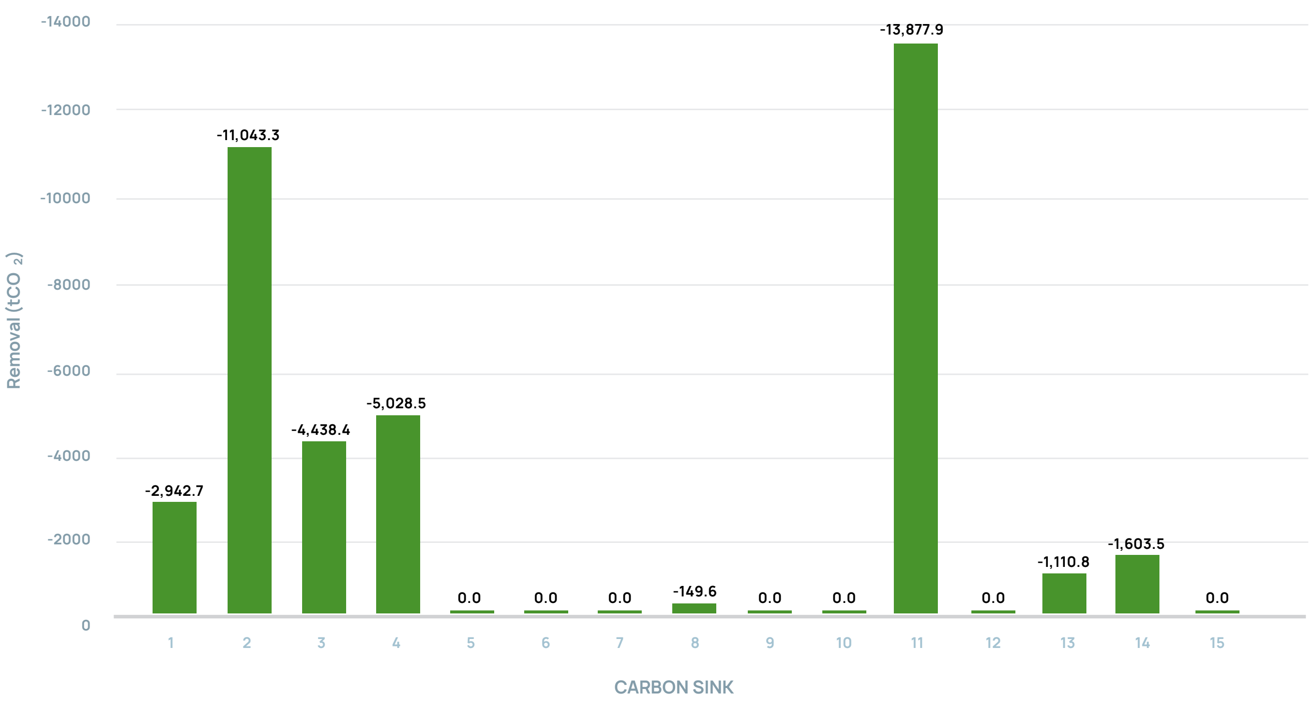

Figure 10. CO_2 eq. removals by sources on inventoried properties in the Amazon biome.

In the Amazon biome, the 30 inventoried properties showed a net positive balance of 30,597.32 tCO_2e, indicating that, overall, emissions exceeded removals during the assessed period. This result represents an average of 9.15 tCO_2e per hectare, one of the highest positive balances among the biomes analyzed.

The result shows that, even in a biome with high carbon sequestration potential, the type of intervention and the intensity of land use are key factors in determining the final balance. This underscores the importance of region-specific policies that integrate sustainable production, native vegetation conservation, and forest conversion control, in order to reverse the trend of positive net emissions and transform Amazonian properties into net carbon sinks.

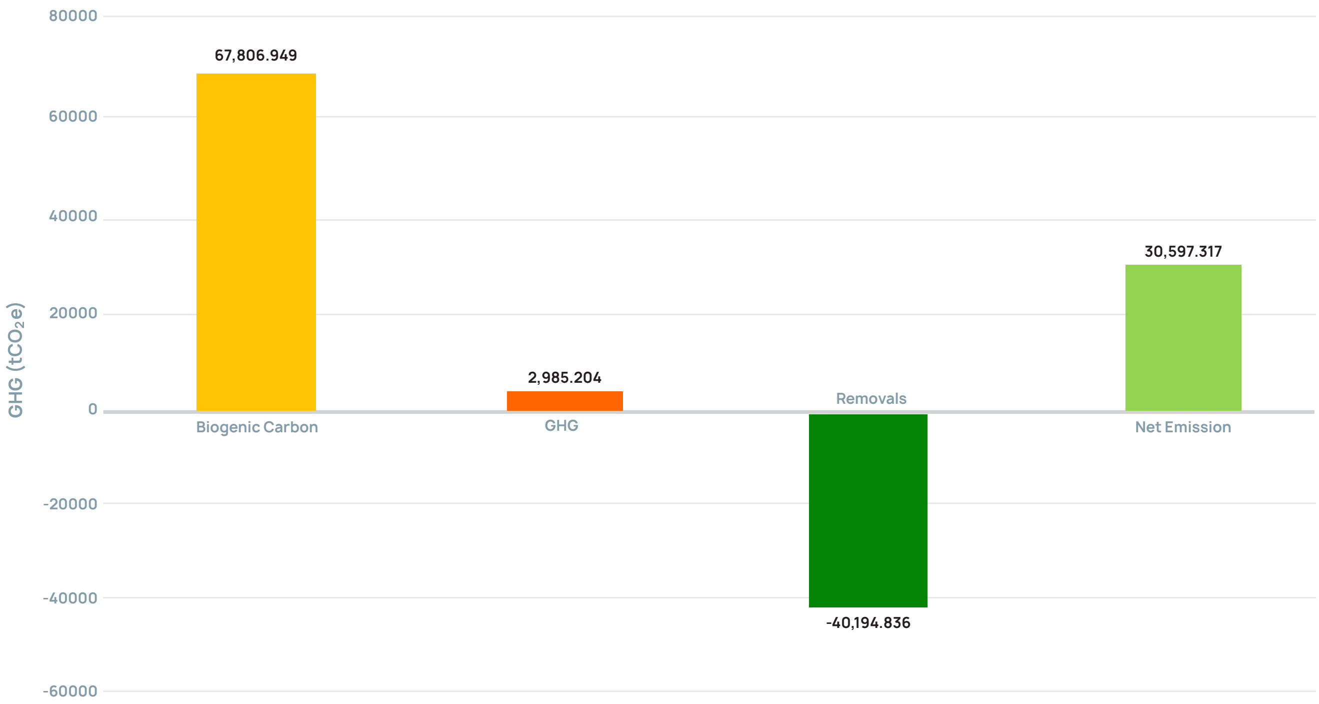

Figure 11. Net emissions from inventoried properties in the Amazon biome.

3.3.2 CAATINGA

In the Caatinga biome, 50 rural properties were inventoried, covering a total area of approximately 5,279.46 hectares. Sebrae RN facilitated the engagement for the conduction of these inventories, which mobilized the companies Cooplacana, Queijeira do Galero, and the Association of Producers from the Baixo Açu Irrigated District. The total GHG emissions accounted for on these properties amounted to 9,018.52 tCO_2e, considering Scopes 1, 2, and 3.

This value corresponds to an average emission of approximately 1.71 tCO_2e/ha, one of the lowest among the biomes assessed. This low emissions intensity may be associated with several region-specific factors, such as:

- The predominance of extensive production systems, especially in livestock farming, with lower input use and mechanization;
- Lower use of nitrogen fertilizers and fossil fuels;
- The presence of preserved native vegetation areas, commonly found on properties with lower levels of productive intervention.

Despite the low average emissions per hectare, the Caatinga faces significant challenges regarding soil fertility management, water resilience, and the preservation of native vegetation cover—factors that must be considered when formulating mitigation and climate change adaptation strategies specific to this biome.

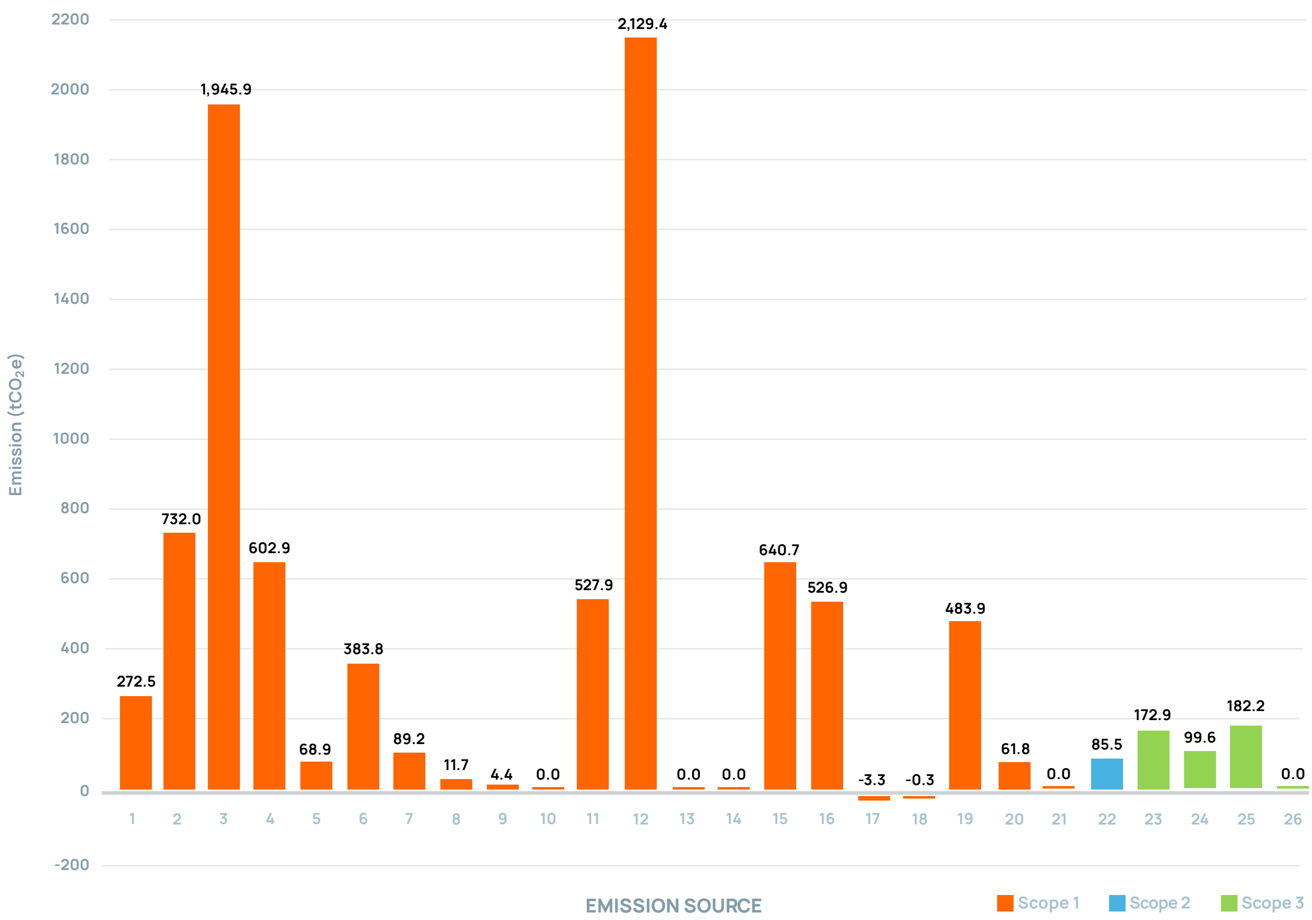

Figure 12. Greenhouse Gas Emissions from Rural Properties, by Source, in the Caatinga Biome.

ID Emission Source			GHG (t)				Total emissions (tCO_2e)
		Biogenic carbon (tCO_2)	CO_2	CH_4	N_2O	CO_2e	
Scope 1							
1	Stationary combustion	234.198	17.291	0.629	0.008	38.336	272.534
2	Mobile combustion	81.343	637.049	0.079	0.041	650.638	731.981
3	Application of organic fertilizers	-	-	-	7.128	1945.890	1945.890
4	Application of synthetic nitrogen fertilizers	-	-	-	2.209	602.945	602.945
5	Application of urea	-	27.838	-	0.150	68.895	68.895
6	Application of soil amendments	-	383.825	-	-	383.825	383.825
7	Crop residues	-	-	-	0.327	89.180	89.180
8	Green manure	-	-	-	0.043	11.692	116.692
9	Pasture renewal	-	-	-	0.016	4.370	4.370
10	Irrigated rice cultivation	-	-	0.000	-	0.000	0.000
11	Management of animal waste	-	-	2.131	1.723	527.872	527.872
12	Enteric fermentation	-	-	78.867	-	2,129.416	2,129.416
13	Land-use change	0.000	0.000	-	-	0.000	0.000
14	Timber forest products	0.000	-	-	-	-	0.000
15	Indirect emissions from volatilization and atmospheric deposition of N	-	-	-	2.347	640.700	640.700
16	Indirect emissions from leaching/surface runoff of N	-	-	-	1.930	526.910	526.910
17	Soil carbon change	-3.282	-	-	-	-	-3.282
18	Emissions from N mineralization	-	-	-	-0.001	-0.320	-0.320
19	Management of organic soils	-	-	-	1.773	483.912	483.912
20	Solid waste and sanitary effluents	-	-	2.091	0.019	61.772	61.772
21	Fugitive emissions	-	-	-	-	0.000	0.000
Subtotal Scope 1		312.260	1,066.002	83.797	17.713	8,166.033	8,478.293
Scope 2							
22	Electricity consumption	-	85.501	-	-	85.501	85.501
Subtotal Scope 2		-	85.501	-	-	85.501	85.501
Scope 3							
23	Outsourced transportation	22.154	148.057	0.013	0.008	150.752	172.906
24	Outsourced mechanized activities	9.228	88.930	0.006	0.005	90.422	99.650
25	Application of agricultural pesticides	-	182.174	-	-	182,174	182.174
26	Solid waste and sanitary effluents	-	-	0.000	0.000	0.000	0,000
Subtotal Scope 3		**31.382**	**419.162**	**0.019**	**0.013**	**423.348**	**454.730**
Total		**343.642**	**1,570.665**	**83.816**	**17.726**	**8,674.882**	**9,018.524**

Figure 13. Summary of emissions in the Caatinga Biome.

Regarding carbon equivalent removals, the 50 inventoried properties, totaling approximately 5,279.46 hectares, showed an estimated total removal of −4,432.21 tCO_2e, which corresponds to an average of −0.84 tCO_2e per hectare.

This relatively low removal value per hectare is directly related to the natural characteristics of the Caatinga, which consists of seasonal vegetation with lower aboveground biomass density compared to other biomes such as the Amazon or the Cerrado. Moreover, the predominant production systems in the region are generally extensive and low-intervention, with limited adoption of practices such as reforestation or no-till farming, which could enhance carbon sequestration.

Nevertheless, the observed performance highlights the carbon sequestration potential of semi-arid ecosystems, even under restrictive soil conditions. Investments in conservation management practices—such as the restoration of degraded areas, agroecology adapted to semi-arid conditions, and productive integration with native species—can enhance the role of the Caatinga in mitigating GHG emissions and adapting to climate change.

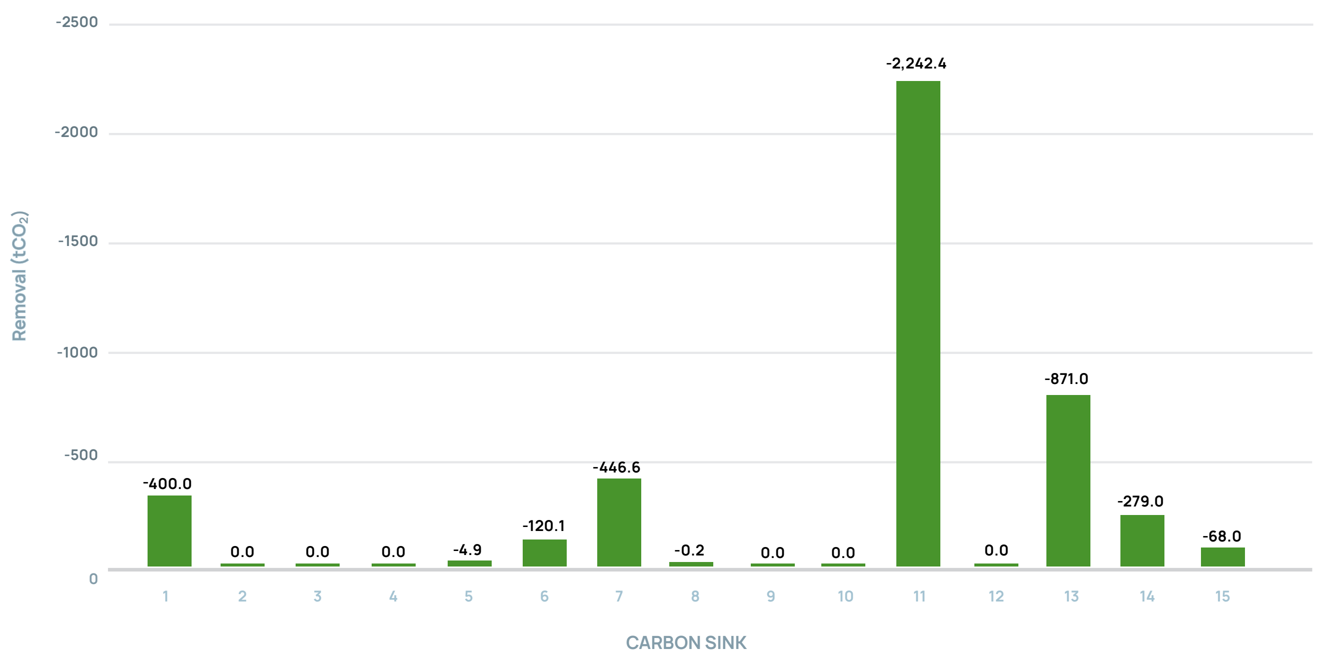

Figure 14. Carbon removals by source from inventoried rural properties in the Caatinga Biome.

In the Caatinga biome, the 50 inventoried properties showed a net positive balance of 4,131.58 tCO_2e, indicating that, overall, emissions exceeded removals during the assessed period. This value represents a net average emission of 0.78 tCO_2e per hectare—the lowest among the biomes that showed a positive balance.

The result reflects the extensive and low-intensity production profile predominant in the region, characterized by reduced input use and lower pressure for mechanization, which helps limit the total volume of emissions. However, the carbon removal capacity is also limited due to the natural characteristics of the semi-arid biome, which features lower aboveground biomass accumulation and less fertile soils.

Although the balance was positive, the relatively low value indicates that the region is close to carbon neutrality. Targeted actions—such as expanding areas with native vegetation, restoring degraded lands, and promoting agroecological practices adapted to semi-arid conditions—can significantly contribute to reversing the balance and placing the Caatinga as a biome with a neutral or negative climate footprint.

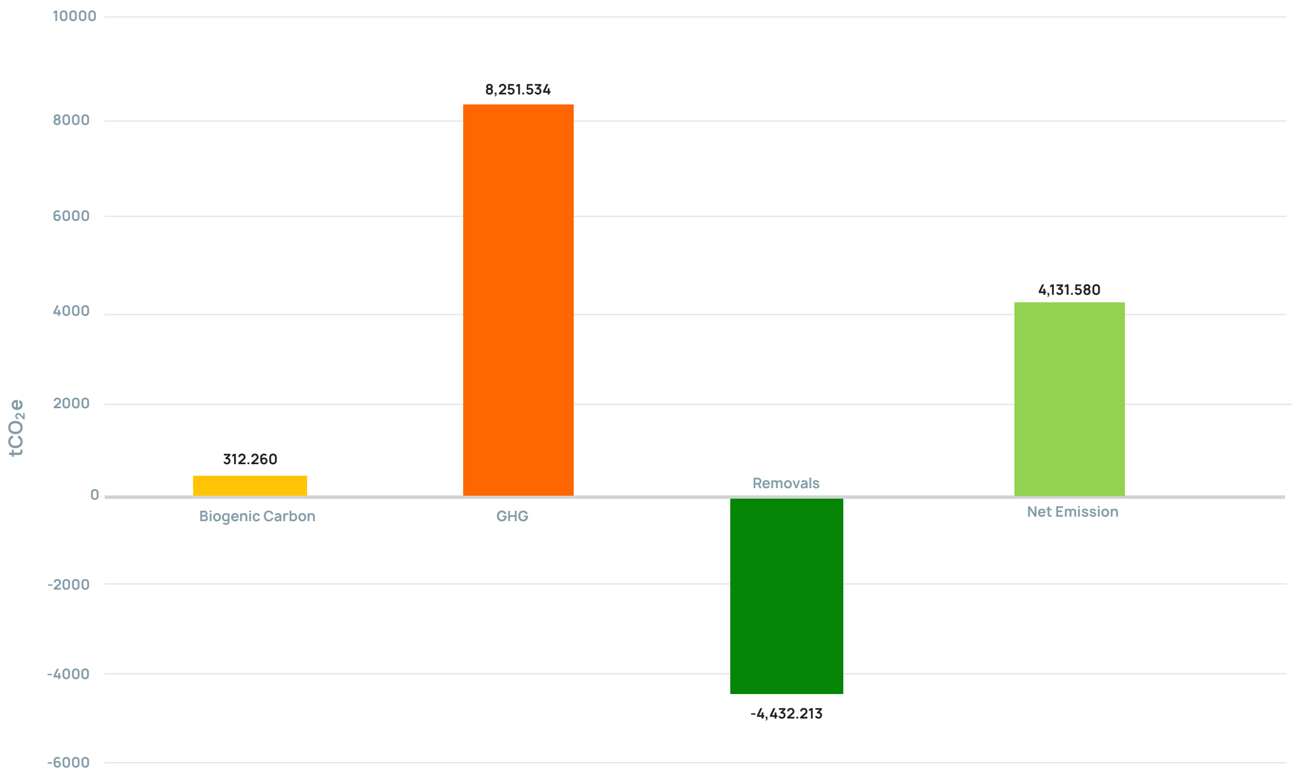

Figure 15. Net Emission in the Caatinga Biome.

3.3.3 CERRADO

SEBRAE Goiás was responsible for the mobilization in the Cerrado Biome; 28 rural properties belonging to the companies Piracanjuba and São Salvador Alimentos were inventoried, totaling an area of approximately 9,783.94 hectares. The total GHG emissions accounted for on these properties amounted to 4,6912.78 tCO_2e, considering Scopes 1, 2, and 3.

The average emission per hectare in the Cerrado was approximately 4.80 tCO_2e/ha, an intermediate value among the biomes analyzed. This emission intensity reflects the region's production profile, characterized by:

- Significant presence of livestock activities, such as cattle and poultry farming;
- Use of fuels in stationary sources, especially biofuels.

Emissions may also be related to the conversion of native Cerrado areas into agricultural uses, which results in direct emissions from land-use change and the loss of carbon stocks.

At any rate, many properties in the region have adopted conservation practices such as no-till farming, crop-livestock integration, and the maintenance of legal reserve areas, which help balance emissions with removals and support a transition toward more sustainable models.

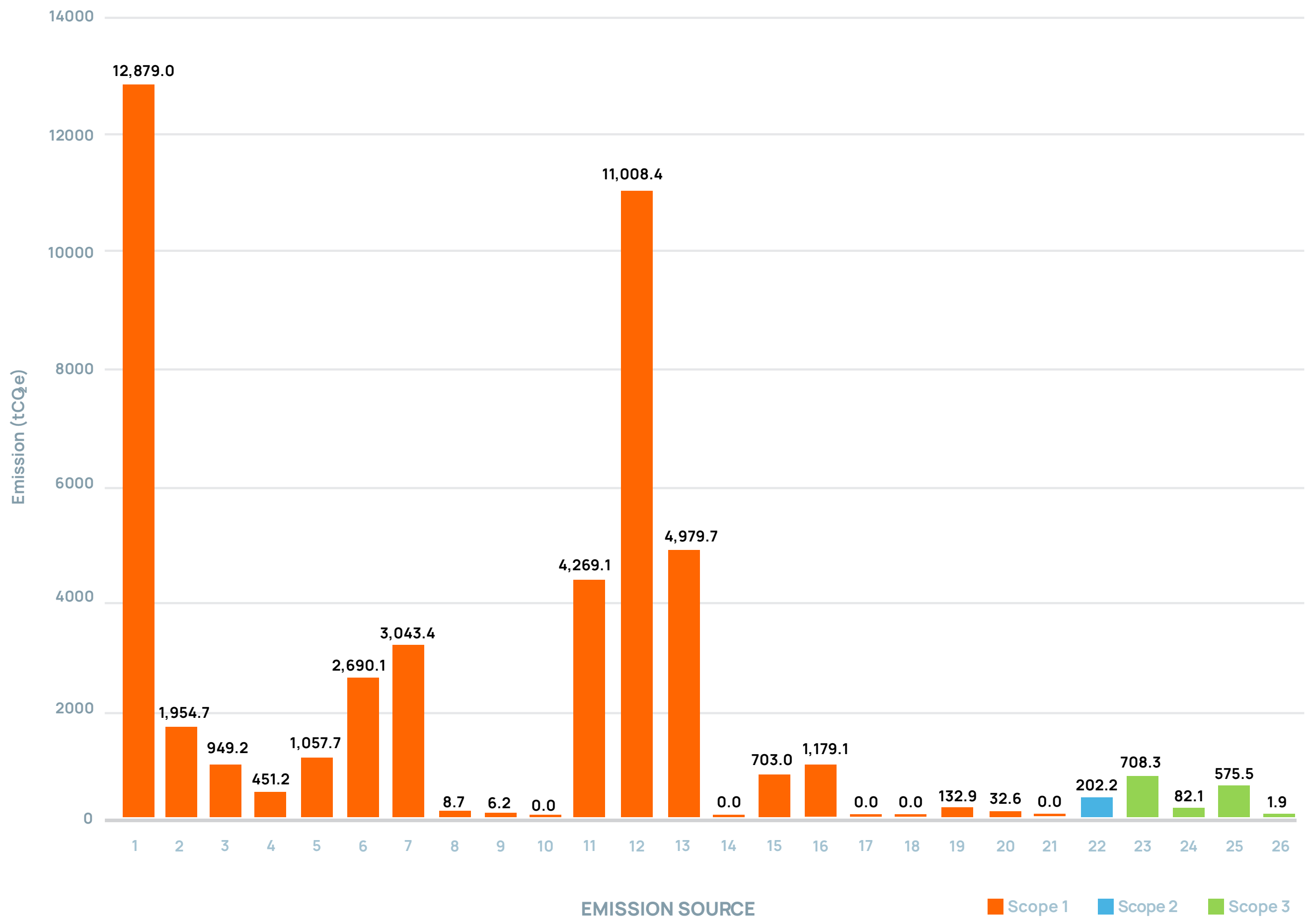

Figure 16. Greenhouse Gas Emissions in the Cerrado Biome, by source.

ID Emission Source			GHG (t)				Total emissions (tCO_2e)
		Biogenic carbon (tCO_2)	CO_2	CH_4	N_2O	CO_2e	
Scope 1							
1	Stationary combustion	11,229.269	643.339	30.070	0.404	1,649.718	12,878.986
2	Mobile combustion	191.045	1733.711	0.128	0.096	1763.617	1,954.663
3	Application of organic fertilizers	-	-	-	3.477	949.229	949.229
4	Application of synthetic nitrogen fertilizers	-	-	-	1.653	451.182	451.182
5	Application of urea	-	427.360	-	2.309	1,057.659	1,057.659
6	Application of soil amendments	-	2,690.054	-	-	2,690.054	2,690.054
7	Crop residues	-	-	-	11.148	3,043.413	3,043.413
8	Green manure	-	-	-	0.032	8.658	8.658
9	Pasture renewal	-	-	-	0.023	6.205	6.205
10	Irrigated rice cultivation	-	-	0.000	-	0.000	0.000
11	Management of animal waste	-	-	69.240	8.790	4,269.133	4,269.133
12	Enteric fermentation	-	-	407.718	-	11,008.375	11,008.375
13	Land-use change	4,979.718	0.000	-	-	0.000	4,979.718
14	Timber forest products	0.000	-	-	-	-	0.000
15	Indirect emissions from volatilization and atmospheric deposition of N	-	-	-	2.575	702.961	702.961
16	Indirect emissions from leaching/surface runoff of N	-	-	-	4.319	1,179.057	1,179.057
17	Soil carbon change	0.000	-	-	-	-	0.000
18	Emissions from N mineralization	-	-	-	0.000	0.000	0.000
19	Management of organic soils	-	-	-	0.487	132.887	132.887
20	Solid waste and sanitary effluents	-	-	1.052	0.015	32.608	32.608
21	Fugitive emissions	-	-	-	-	0.000	0.000
Subtotal Scope 1		16,400.032	5,494.464	508.208	35.326	28,944.755	45,344.787
Scope 2							
22	Electricity consumption	-	202.186	-	-	202.186	202.186
Subtotal Scope 2		-	202.186	-	-	202.186	202.186
Scope 3							
23	Outsourced transportation	66.153	631.396	0.044	0.034	642.100	708.252
24	Outsourced mechanized activities	7.599	73.233	0.005	0.004	74.461	82.060
25	Application of agricultural pesticides	-	575.489	-	-	575.489	575.489
26	Solid waste and sanitary effluents	-	-	0.018	0.005	1.917	1.917
Subtotal Scope 3		**73.752**	**1,280.118**	**0.049**	**0.038**	**1,292.050**	**1,365.802**
Total		**16,473.784**	**6,976.768**	**508.257**	**35.365**	**30,438.991**	**46,912.775**

Figure 17. Summary presentation of GHG emissions in the Cerrado Biome.

Regarding CO_2 equivalent removals, the 28 inventoried properties covered an area of approximately 9,783.94 hectares and showed an estimated total removal of –189,526.75 tCO_2e. This value corresponds to an average of –19.37 tCO_2e per hectare, one of the highest among all biomes evaluated.

The Cerrado's strong performance in terms of removals is related to the significant presence of areas with preserved or regenerating native vegetation, as well as the adoption—by some properties—of conservation practices such as no-till farming systems and the existence of substantial reforested areas.

Despite the Cerrado's well-known vulnerability to agricultural conversion, data show that when managed sustainably, the biome has a strong capacity to act as a carbon sink—both in biomass and in the soil. This underscores the importance of preservation and strategies for sustainable use in this biome, which is recognized for its rich biodiversity and as one of the most critical areas for mitigating GHG emissions in Brazil's agricultural sector.

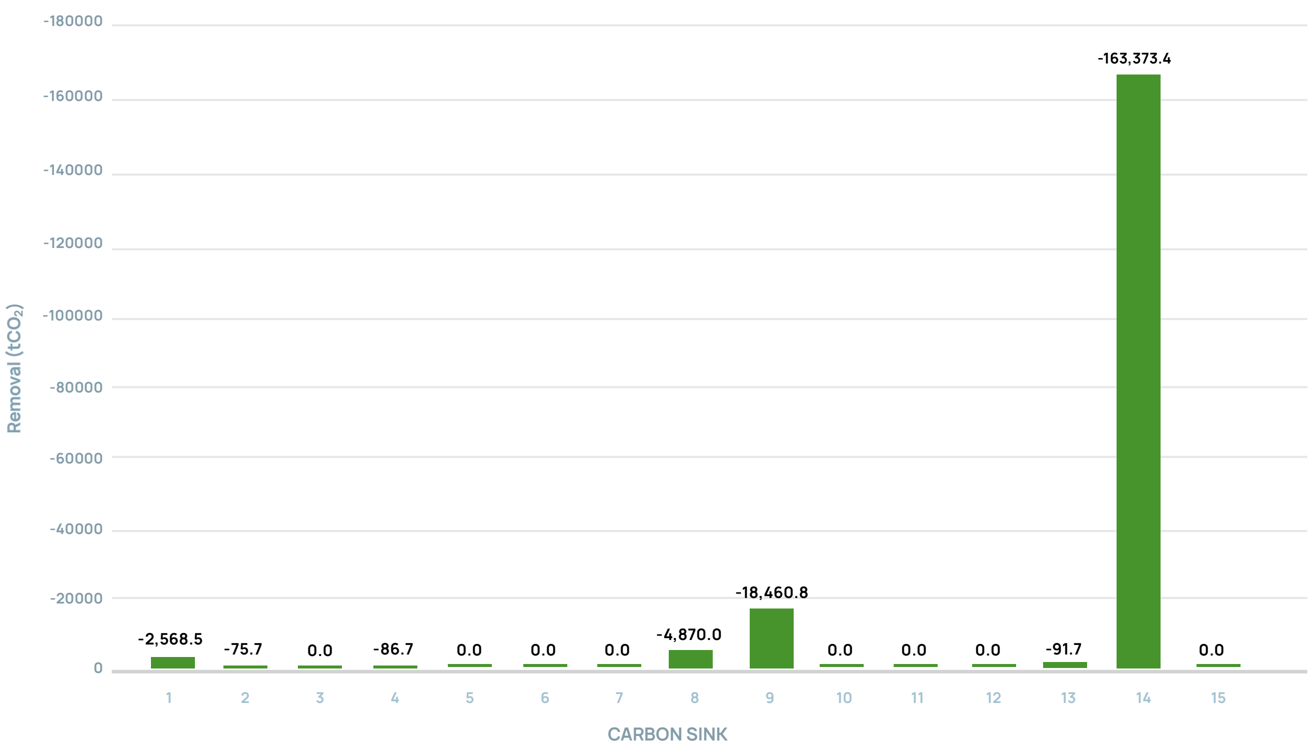

Figura 18. CO_2 eq Removals by Source.

In the Cerrado Biome, the 28 inventoried properties showed a net negative balance of –143,979.77 tCO_2e, indicating that, overall, carbon removals significantly exceeded emissions during the period analyzed. This result represents an average net removal of –14.72 tCO_2e

per hectare, highlighting the Cerrado as one of the main net carbon sinks among the biomes evaluated. This positive performance is strongly associated with the significant presence of reforested areas.

Even with the presence of intensive agricultural activities that contribute to emissions, the overall balance was largely favorable due to the extent of areas with carbon sink characteristics and the adoption of conservation management practices on some properties.

The results reinforce the strategic potential of the Cerrado for climate change mitigation, especially if actions are implemented that reconcile agricultural production with the preservation of native vegetation and the efficient use of natural resources.

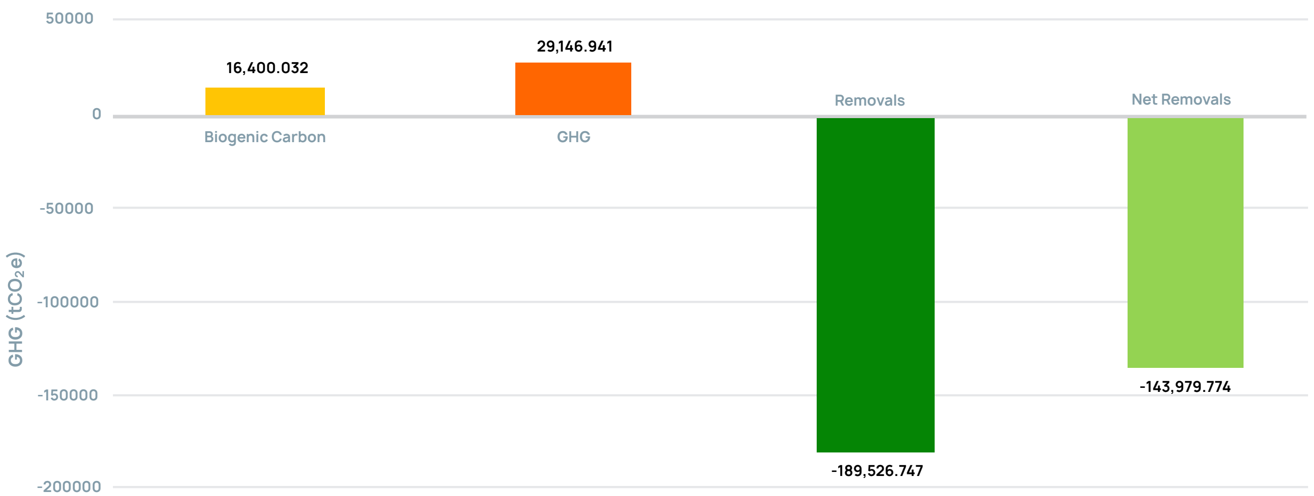

Figure 19. Net emissions in the Cerrado Biome.

3.3.4 ATLANTIC FOREST

In the Atlantic Forest biome, mobilization was carried out through Sebraes SC and PR to conduct GHG inventories on rural properties linked to the companies Master Agroindustrial, Aurora Coop, Ervateira Gheno, and Cooperja in Santa Catarina, and Risotolândia in Paraná. A total of 62 rural properties were inventoried—32 located in Santa Catarina and 30 in Paraná—covering a total area of approximately 954.28 hectares, with 403.68 ha in Santa Catarina and 550.60 ha in Paraná. The total GHG emissions accounted for on these properties amounted to 38,220.91 tCO_2e, considering Scopes 1, 2, and 3.

The average emission per hectare was approximately 40.05 tCO_2e/ha, the highest value among the biomes analyzed. This high emission intensity is associated with a range of factors characteristic of land use and the region's production structure:

- Strong presence of intensive livestock farming (dairy cattle, swine, poultry), which concentrates significant sources of enteric fermentation and animal waste management;
- Properties with smaller areas and more technified agriculture systems, involving higher use of inputs and energy;
- More intensive use of fertilizers, fuels, and energy-demanding structures (such as coolers and sheds).

Despite the high emissions per hectare, many properties in the region maintain management and conservation practices—such as the use of improved pastures, proper handling of organic waste, and areas of native vegetation and reforestation—that help partially offset emissions and should be recognized in future mitigation efforts.

The results highlight the need for tailored solutions for intensive systems operating in limited areas, prioritizing low-emission production efficiency practices and strategies that enhance the value of environmental services.

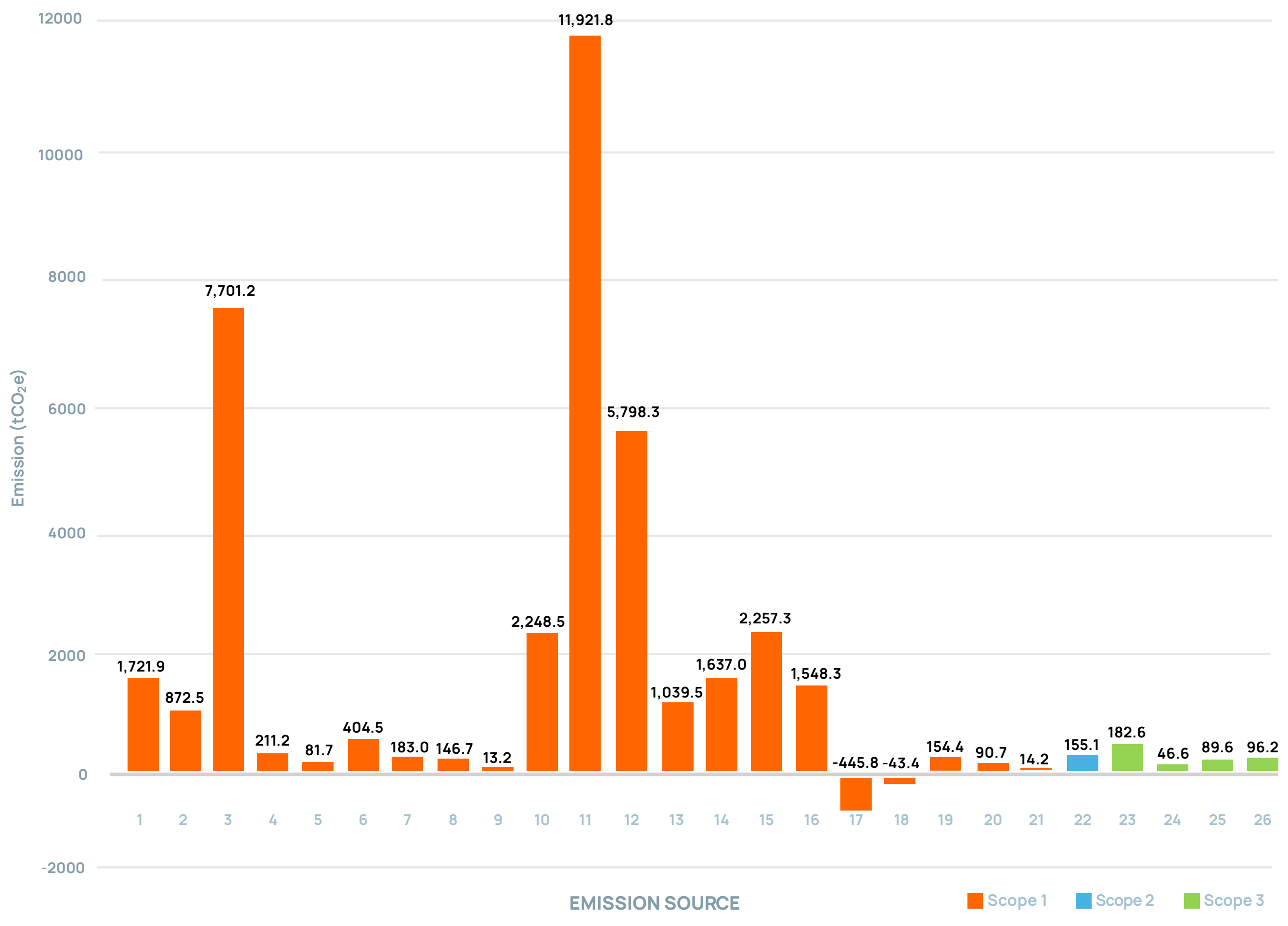

Figure 20. CO_2 eq. emissions by source in the Atlantic Forest biome.

ID	Emission Source	Biogenic carbon (tCO_2)	GHG (t) CO_2	CH_4	N_2O	CO_2e	Total emissions (tCO_2e)
Scope 1							
1	Stationary combustion	1,526.820	75.376	3.576	0.048	195.079	1,721.899
2	Mobile combustion	85.225	772.716	0.074	0.045	787.287	872.512
3	Application of organic fertilizers	-	-	-	28.210	7,701.226	7,701.226
4	Application of synthetic nitrogen fertilizers	-	-	-	0.774	211.179	211.179
5	Application of urea	-	32.995	-	0.178	81.658	81.658
6	Application of soil amendments	-	404.506	-	-	404,506	404.506
7	Crop residues	-	-	-	0.670	183.025	183.025
8	Green manure	-	-	-	0.537	146.729	146.729
9	Pasture renewal	-	-	-	0.048	13.194	13.194
10	Irrigated rice cultivation	-	-	83.279	-	2,248.546	2,248.546
11	Management of animal waste	-	-	411.438	2.978	11,921.837	11,921.837
12	Enteric fermentation	-	-	214.750	-	5,798.260	5,798.260
13	Land-use change	1,039.481	0.000	-	-	0.000	1,039.481
14	Timber forest products	1,637.045	-	-	-	-	1,637.045
15	Indirect emissions from volatilization and atmospheric deposition of N	-	-	-	8.268	2,257.262	2,257.262
16	Indirect emissions from leaching/surface runoff of N	-	-	-	5.672	1,548.338	1,548.338
17	Soil carbon change	-445.758	-	-	-	-	-445.758
18	Emissions from N mineralization	-	-	-	-0.159	-43.422	-43.422
19	Management of organic soils	-	-	-	0.566	154.440	154.440
20	Solid waste and sanitary effluents	-	-	2.947	0.041	90.747	90.747
21	Fugitive emissions	-	-	-	-	14.174	14.174
Subtotal Scope 1		3,842.814	1,285.593	716.066	47.877	33,714.066	37,556.880
Scope 2							
22	Electricity consumption	-	155.106	-	-	155.106	155.106
Subtotal Scope 2		-	155.106	-	-	155.106	155.106
Scope 3							
23	Outsourced transportation	17.330	162.438	0.012	0.009	165.249	182.578
24	Outsourced mechanized activities	4.319	41.617	0.003	0.002	42.315	46.633
25	Application of agricultural pesticides	-	89.631	-	-	89.631	89.631
26	Solid waste and sanitary effluents	-	-	3.529	0.003	96.187	96.187
Subtotal Scope 3		**21.648**	**293.686**	**0.029**	**0.011**	**297.612**	**319,260**
Total		**3,864.462**	**1,734.386**	**716.095**	**47.888**	**34,166.784**	**38,031.246**

Figure 21. Summary presentation of GHG emissions in the Atlantic Forest Biome.

The total estimated GHG removal on these properties was −89,249.63 tCO_2e, which corresponds to an average of −93.54 tCO_2e per hectare—the highest removal rate per hectare among all biomes evaluated.

This result reflects the strong presence of highly efficient carbon sinks, such as reforested areas, along with a significant proportion of conserved pastures and production systems managed with a conservation-oriented approach, including no-till farming and perennial agriculture. Despite the relatively small area, the intensive use of carbon sequestration practices explains the high volume of removals per unit of area.

Despite being highly fragmented and historically pressured, the Atlantic Forest demonstrates that small properties with proper management can achieve extremely high climate efficiency. This performance highlights the strategic role of more anthropized regions in ecological restoration, emissions offsetting, and the generation of environmental services—especially in contexts where agricultural production is integrated with environmental conservation.

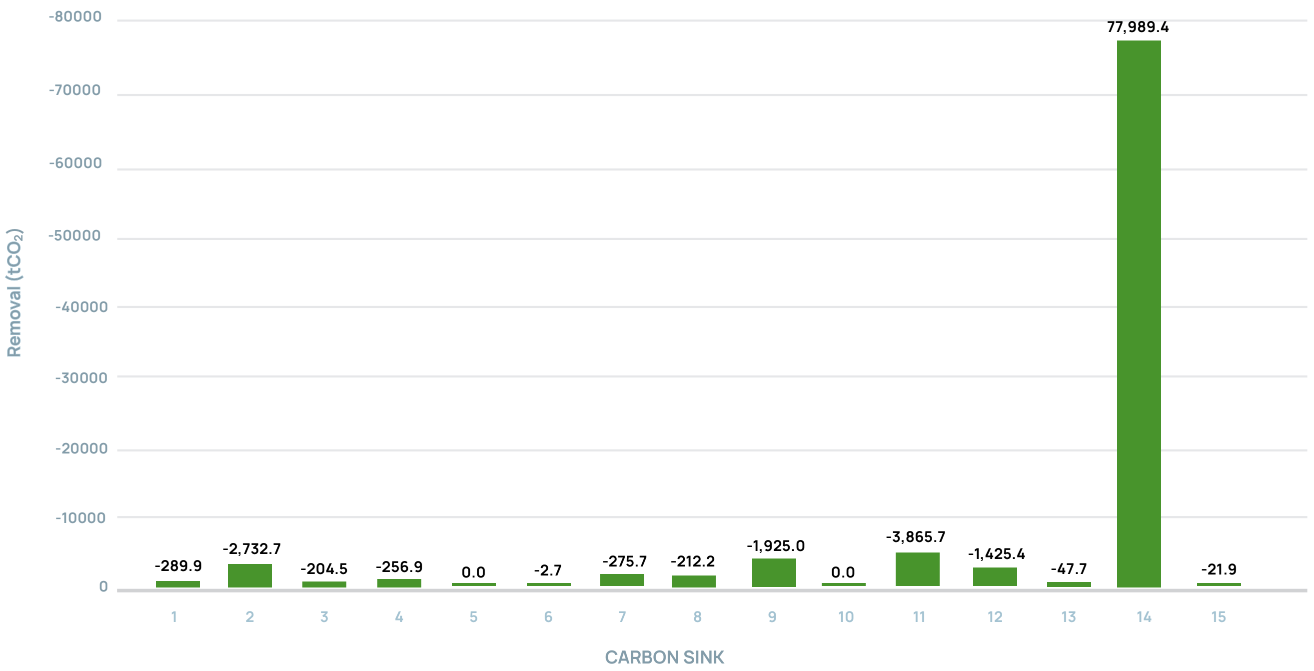

Figure 22. CO_2 eq. removal by source in the Atlantic Forest biome.

In the Atlantic Forest biome, which included 62 inventoried properties, the net balance was −51,361.74 tCO_2e, indicating that, overall, removals exceeded emissions during the evaluated period. This result represents an average net removal of −53.82 tCO_2e per hectare—the highest among all biomes analyzed—even though the Atlantic Forest is the biome with the smallest total inventoried area.

This high per-hectare performance is directly related to the adoption of conservation-oriented production practices on small, well-managed properties, such as:

- Presence of regenerating secondary forests;
- Use of no-till farming systems and perennial agriculture;
- Maintenance of reforested areas and conserved and improved pastures.

Although the Atlantic Forest is historically the most deforested and fragmented biome in the country, the results show that it can play an important role in emissions offsetting—especially when linked to low-emission production models, integrated management, and the preservation of forest remnants.

The negative net balance reinforces the potential of Atlantic Forest properties to function as carbon sequestration units, even in contexts of high population density, intensive livestock farming, and intensive land use. This highlights the feasibility of reconciling agricultural production with environmental conservation in anthropized areas, provided that management is guided by sustainability principles.

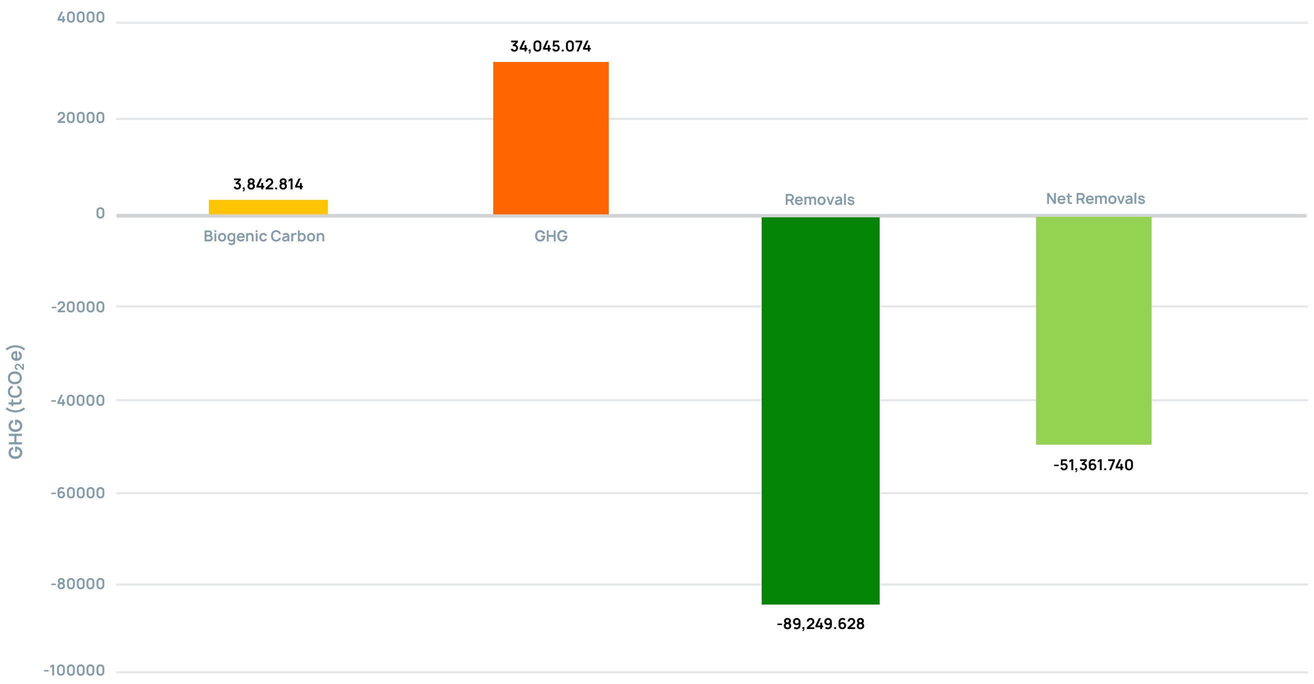

Figure 23. Net emissions in the Atlantic Forest biome.

3.3.5 PAMPA

In the Pampa Biome, 30 rural properties were inventoried through Sebrae RS, which mobilized the companies Coopesul, Apropampa, Alianza del Pastizal, IDEPEC, IBRAOLIVA, and the Association of Wines of Campanha Gaúcha, totaling a significant area of approximately 21,490.25 hectares. The total GHG emissions accounted for on these properties amounted to 170,112.45 tCO_2e, considering Scopes 1, 2, and 3.

The average emission per hectare in this biome was approximately 7.91 tCO_2e/ha, an intermediate value among the biomes analyzed. This result reflects a balance between areas of lower production and significant sources of emissions, such as:

- The presence of extensive beef cattle ranching, a long-standing tradition in the region, with emphasis on native grassland-based systems, which tend to generate lower emissions per animal;
- Significant emissions associated with enteric fermentation, due to the size of the herds.

Despite the lower input intensity, the Pampa biome showed a high total emission due to the large territorial extent of the inventoried properties. This highlights that, even in extensive systems, land area can be a determining factor in the absolute volume of emissions.

At the same time, the biome shows high potential for carbon removal, especially through the conservation and proper management of native grasslands, which stood out in the sink estimates of this inventory.

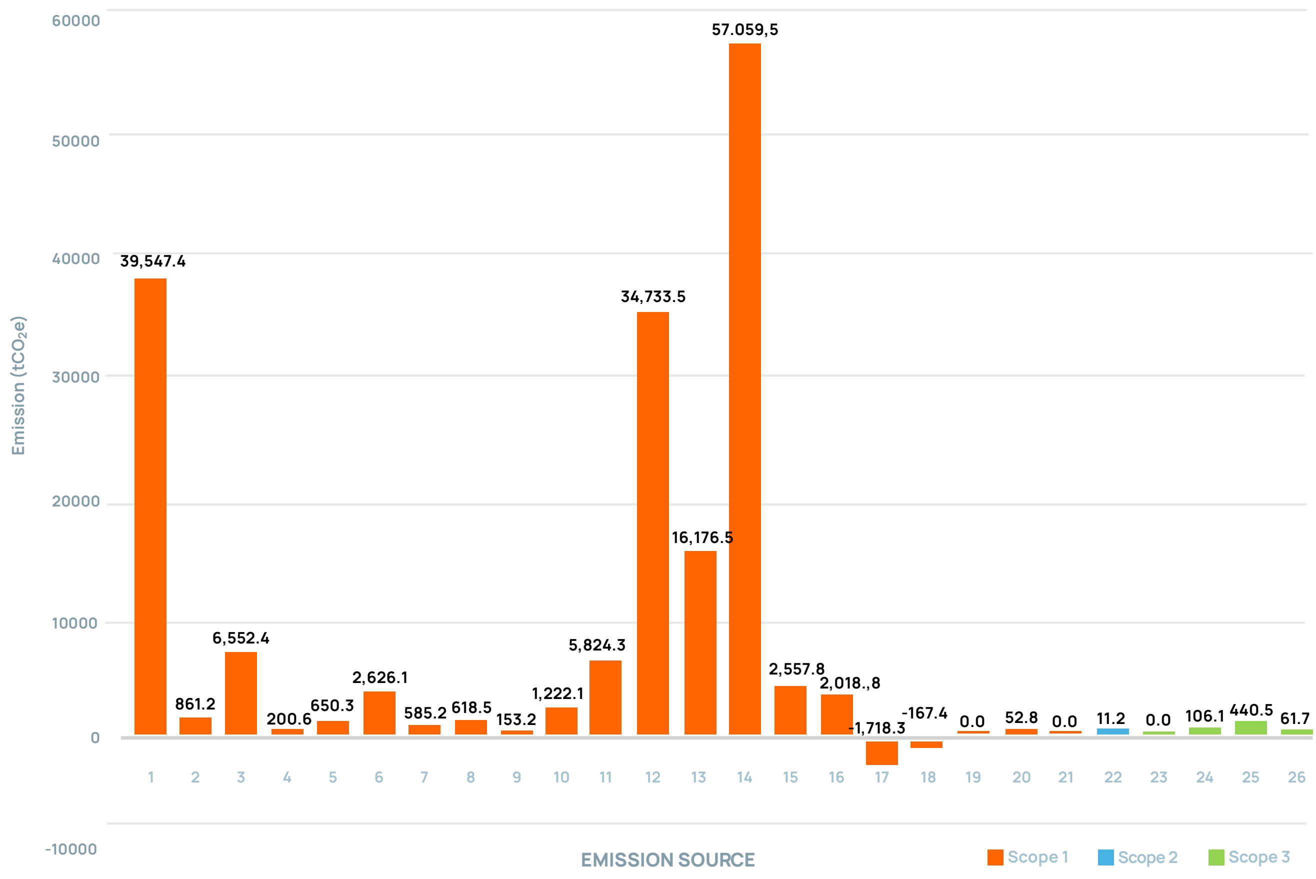

Figure 24. CO_2 eq. emissions in the Pampa Biome.

ID Emission Source			GHG (t)				Total emissions (tCO_2e)
		Biogenic carbon (tCO_2)	CO_2	CH_4	N_2O	CO_2e	
Scope 1							
1	Stationary combustion	36,288.037	4.192	97.344	1.298	3,259.376	39,547.413
2	Mobile combustion	83.310	764.292	0.061	0.043	777.870	861.180
3	Application of organic fertilizers	-	-	-	24.001	6,552.374	6,552.374
4	Application of synthetic nitrogen fertilizers	-	-	-	0.735	200.611	200.611
5	Application of urea	-	262.781	-	1.420	650.348	650.348
6	Application of soil amendments	-	2,626.122	-	-	2,626.122	2,626.122
7	Crop residues	-	-	-	2.144	585.250	585.250
8	Green manure	-	-	-	2.266	618.542	618.542
9	Pasture renewal	-	-	-	0.561	153.219	153.219
10	Irrigated rice cultivation	-	-	45.262	-	1,222.074	1,222.074
11	Management of animal waste	-	-	27.414	18.623	5,824.282	5,824.282
12	Enteric fermentation	-	-	1,286.424	-	34,733.454	34,733.454
13	Land-use change	16,176.536	0.000	-	-	0.000	16,176.536
14	Timber forest products	57,059.500	-	-	-	-	57,059.500
15	Indirect emissions from volatilization and atmospheric deposition of N	-	-	-	9.369	2,557.799	2,557.799
16	Indirect emissions from leaching/surface runoff of N	-	-	-	7.395	2,018.791	2,018.791
17	Soil carbon change	-1,718.288	-	-	-	-	-1,718.288
18	Emissions from N mineralization	-	-	-	-0.613	-167.381	-167.381
19	Management of organic soils	-	-	-	0.000	0.000	0.000
20	Solid waste and sanitary effluents	-	-	1.579	0.037	52.802	52.802
21	Fugitive emissions	-	-	-	-	0.000	0.000
Subtotal Scope 1		107,889.096	3,657.386	1,458.084	67.279	61,665.533	169,554.629
Scope 2							
22	Electricity consumption	-	11.234	-	-	11.234	11.234
Subtotal Scope 2		-	11.234	-	-	11.234	11.234
Scope 3							
23	Outsourced transportation	0.000	0.000	0.000	0.000	0.000	0.000
24	Outsourced mechanized activities	9.821	94.645	0.006	0.005	96.232	106.053
25	Application of agricultural pesticides	-	440.534	-	-	440.534	440.534
26	Solid waste and sanitary effluents	-	-	2.263	0.002	61.702	61.702
Subtotal Scope 3		**9.821**	**535.179**	**0.006**	**0.005**	**536.766**	**546.587**
Total		**107,898.917**	**4,203.799**	**1,458.091**	**67.284**	**62,2134533**	**170,112.450**

Figure 25. Summary presentation of GHG emissions in the Pampa Biome.

The total estimated GHG removal for this group was –226,835.24 tCO_2e, representing an average of –10.56 tCO_2e per hectare.

The removals observed in the Pampa are strongly associated with the widespread presence of well-preserved native grasslands and secondary fields undergoing regeneration, which characterize much of the region's productive landscape. In addition, the adoption of extensive livestock systems, with reduced soil disturbance and the maintenance of perennial vegetation cover, contributes to carbon accumulation in herbaceous biomass and in the soil.

Although the Pampa Biome is often underestimated in terms of carbon sequestration, the results obtained demonstrate that its traditional production systems—when properly managed—have high potential for GHG removal. This underscores the importance of policies that promote the conservation of southern grasslands, preventing their replacement by intensive agricultural systems that could compromise the region's ecological and climatic integrity.

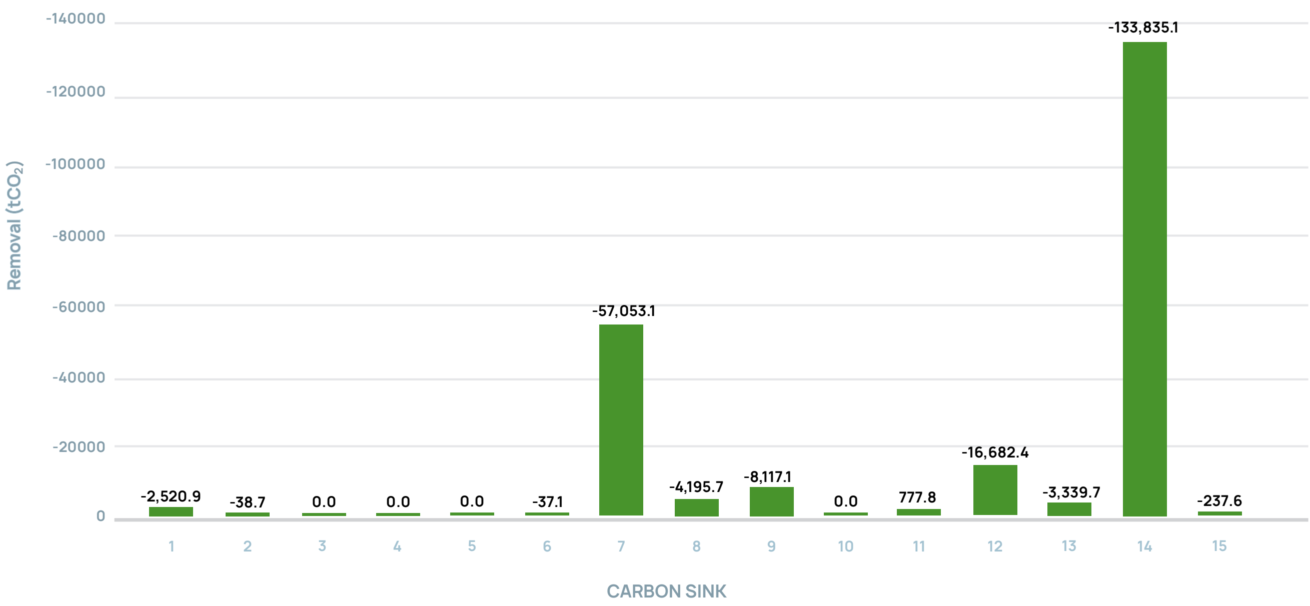

Figure 26. Removals by source in the do Pampa Biome.

In the Pampa Biome, the 30 inventoried properties showed a net negative balance of –57,269.38 tCO_2e, indicating that, overall, removals exceeded emissions. This result corresponds to an average net removal of –2.66 tCO_2e per hectare, demonstrating a favorable climate balance, albeit with lower intensity when compared to other biomes that adopt more intensive conservation practices.

The widespread presence of preserved and managed natural grasslands, which serve as important carbon sinks, especially in the soil and herbaceous vegetation, was the main contributor to this performance. In addition, the predominant practices in the region, such as extensive livestock farming on native pastures, tend to generate lower emissions compared to intensive animal production systems.

Although the emission per hectare is moderate, the extent of the inventoried areas in the Pampa favored a significant total volume of removal. This shows that the preservation and proper management of southern grasslands play a significant role in regional climate balance and should be recognized as part of mitigation strategies.

The result also reinforces the need to value the traditional production systems of the Pampa, which—when combined with good management practices—are compatible with agricultural decarbonization goals.

Figure 27. Net emissions in the Pampa Biome.

3.3.6 PANTANAL

In the Pantanal Biome, through Sebrae MS and the mobilization of the state's rural unions, 16 rural properties were inventoried, totaling an area of approximately 14,247.1 hectares. The total GHG emissions accounted for on these properties amounted to 16,378.77 tCO_2e, considering Scopes 1, 2, and 3.

The average emission per hectare was approximately 1.15 tCO_2e/ha, the lowest value among the biomes analyzed. This result reflects typical land use characteristics in the region, such as:

- The predominance of extensive livestock systems, with low animal density and minimal use of external inputs;
- The preservation of large areas of native vegetation, especially natural grasslands and wetlands, which not only reduce emission sources but also serve as important carbon sinks;
- The limited presence of mechanized agriculture, which significantly reduces emissions from fossil fuel combustion and fertilizer application.

Despite the low average emissions per hectare, the Pantanal faces specific challenges in terms of environmental vulnerability, as it is a biome sensitive to changes in the hydrological regime, climate change, and anthropogenic pressures. Therefore, the low level of emissions should be interpreted as a strategic opportunity for conservation and recognition of the environmental services already provided by the region's properties.

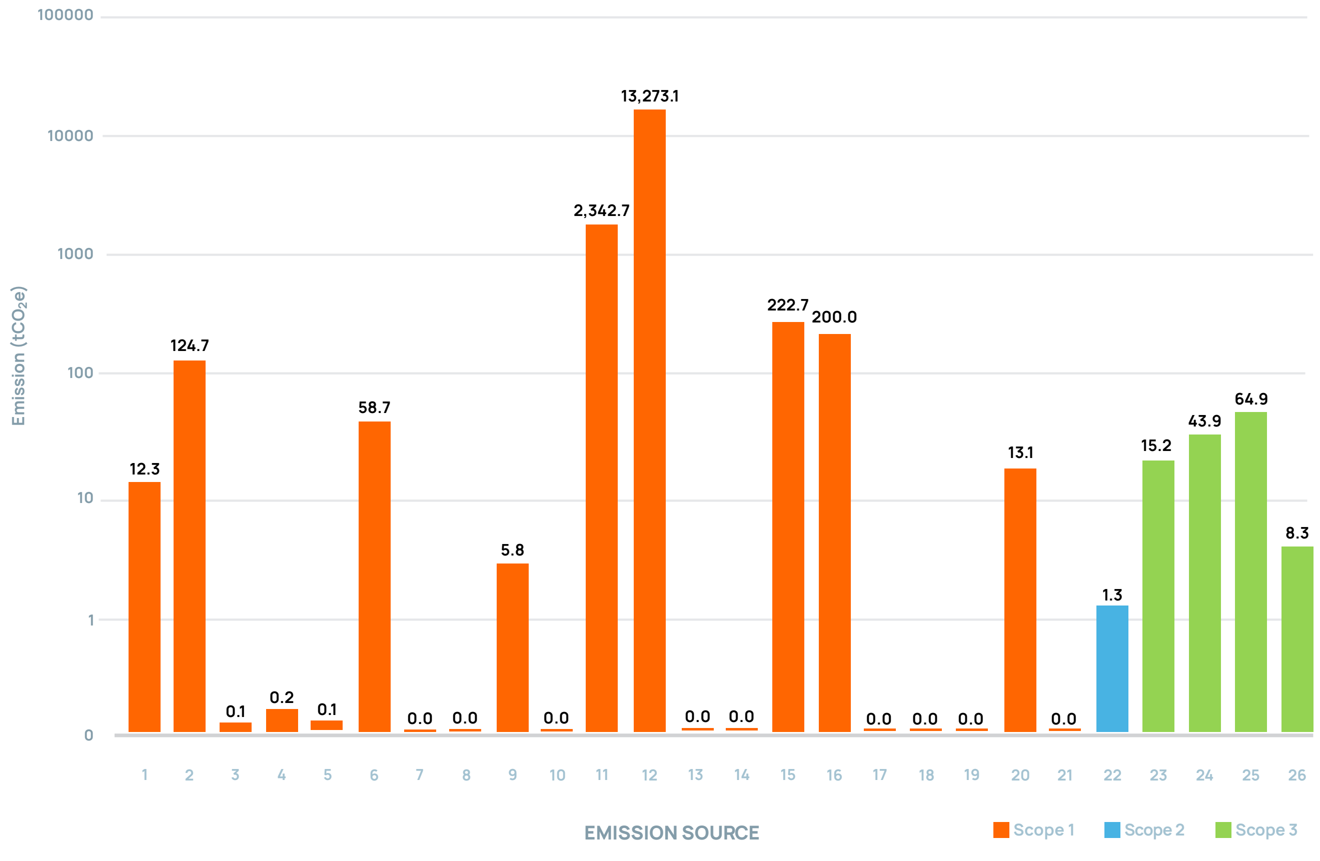

Figure 28. CO_2 emissions by source in the Pantanal Biome.

ID	Emission Source	Biogenic carbon (tCO_2)	GHG (t) CO_2	CH_4	N_2O	CO_2e	Total emissions (tCO_2e)
Scope 1							
1	Stationary combustion	1.362	10.824	0.003	0.000	10.942	12.304
2	Mobile combustion	12.529	110.037	0.012	0.006	112.143	124.672
3	Application of organic fertilizers	-	-	-	0.000	0.118	0.118
4	Application of synthetic nitrogen fertilizers	-	-	-	0.001	0.231	0.231
5	Application of urea	-	0.030	-	0.000	0.074	0.074
6	Application of soil amendments	-	58.667	-	-	58.667	58.667
7	Crop residues	-	-	-	0.000	0.000	0.000
8	Green manure	-	-	-	0.000	0.000	0.000
9	Pasture renewal	-	-	-	0.021	5.785	5.785
10	Irrigated rice cultivation	-	-	0.000	-	0.000	0.000
11	Management of animal waste	-	-	8.484	7.742	2,342.703	2,342.703
12	Enteric fermentation	-	-	491.596	-	13,273.105	13,273.105
13	Land-use change	0.000	0.000	-	-	0.000	0.000
14	Timber forest products	0.000	-	-	-	-	0.000
15	Indirect emissions from volatilization and atmospheric deposition of N	-	-	-	0.816	222.718	222.718
16	Indirect emissions from leaching/surface runoff of N	-	-	-	0.733	200.018	200.018
17	Soil carbon change	0.000	-	-	-	-	0.000
18	Emissions from N mineralization	-	-	-	0.000	0.000	0.000
19	Management of organic soils	-	-	-	0.000	0.000	0.000
20	Solid waste and sanitary effluents	-	-	0.414	0.007	13.081	13.081
21	Fugitive emissions	-	-	-	-	0.000	0.000
Subtotal Scope 1		13.892	179.558	500.510	9.327	16,239.585	16,253.476
Scope 2							
22	Electricity consumption	-	1.280	-	-	1.280	1.280
Subtotal Scope 2		-	1.280	-	-	1.280	1.280
Scope 3							
23	Outsourced transportation	1.436	13.554	0.001	0.001	13.786	15.222
24	Outsourced mechanized activities	4.065	39.177	0.003	0.002	39.834	43.899
25	Application of agricultural pesticides	-	64.888	-	-	64.888	64.888
26	Solid waste and sanitary effluents	-	-	0.301	0.001	8.340	8.340
Subtotal Scope 3		**5.501**	**117.619**	**0.004**	**0.003**	**118.508**	**124.009**
Total		**19.393**	**298.457**	**500.513**	**9.330**	**16,359.373**	**16,378.766**

Figure 29. Summary presentation of GHG emissions in the Pantanal Biome.

In the Pantanal Biome, 16 rural properties were inventoried, covering a total area of approximately 14,247.10 hectares. The total estimated GHG removal for this group was -33,077.89 tCO_2e, corresponding to an average of –2.32 tCO_2e per hectare.

The relatively low removal per hectare, when compared to other biomes such as the Cerrado and the Atlantic Forest, can be explained by a combination of factors: land use patterns and the predominant vegetation type, which has lower aboveground biomass density, as well as the seasonal and flood-prone nature of the soil, which affects the accumulation and decomposition of organic matter. Moreover, production systems in the Pantanal are generally extensive and with low intervention, which reduces both emissions and the potential for substantial increases in carbon sinks through active management.

Nevertheless, the observed result reinforces the role of the Pantanal as a climate-regulating biome, whose balance relies heavily on the preservation of its natural hydrology and the conservation of grasslands and native vegetation. The protection and valorization of these environments are essential not only for carbon sequestration, but also for preserving biodiversity and the region's ecological resilience in the face of climate change.

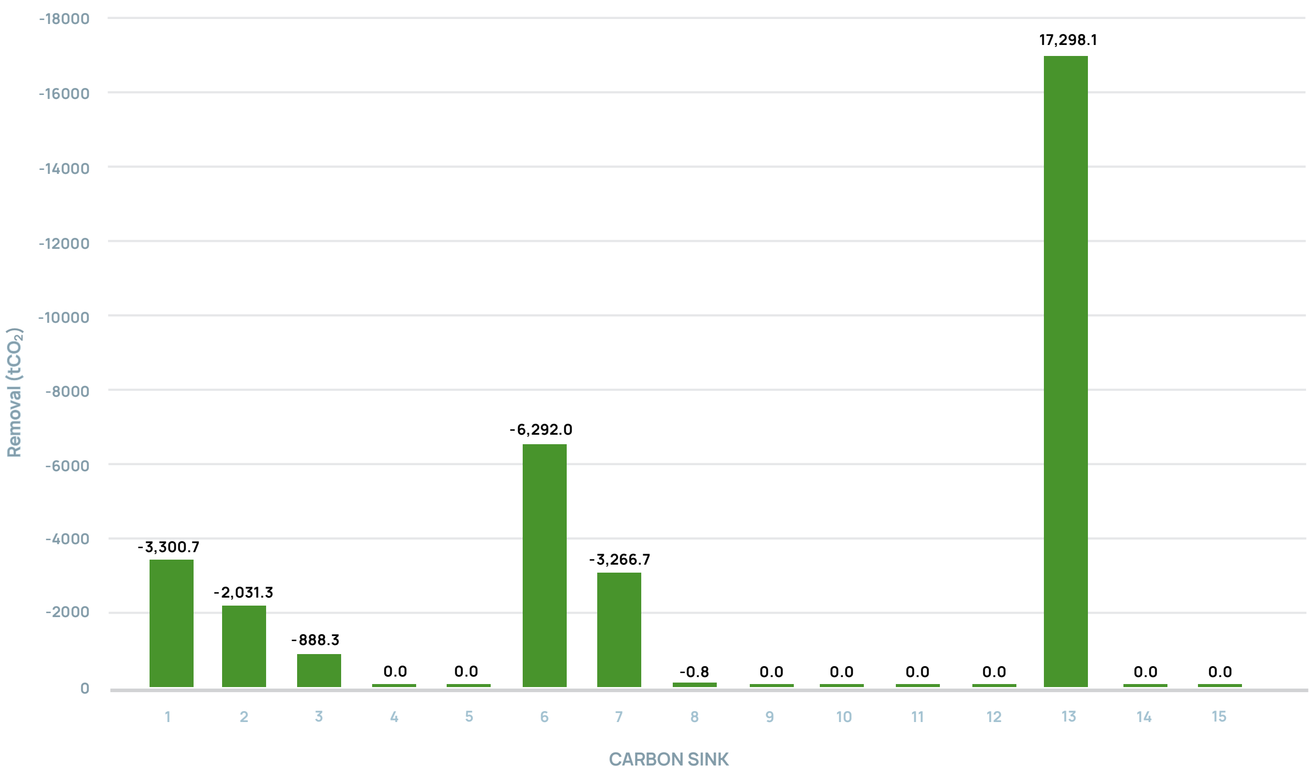

Figure 30. Removals by source in the Pantanal Biome.

In the Pantanal Biome, the 16 inventoried properties presented a net negative balance of –16,823.13 tCO_2e, indicating that, overall, carbon removals exceeded emissions. This value corresponds to an average net removal of –1.18 tCO_2e per hectare, representing a positive climate outcome, albeit moderate in terms of intensity per area.

This performance is linked to the extensive, low-emission production profile that characterizes the Pantanal, marked by the predominance of traditional livestock systems and broad coverage of native vegetation, including wetlands and riparian forests. These areas function as natural carbon sinks, even without active management, contributing to carbon sequestration—especially in the soil. Although the removal rate per hectare is lower than that observed in biomes with more intensive conservation practices, the negative balance demonstrates that preserving the Pantanal landscape is effective in maintaining a positive climate balance, even under pressure from changes in the hydrological regime and the expansion of the agricultural frontier.

The results highlight the importance of preserving the ecological functioning of the Pantanal, protecting its natural dynamics and promoting the continuation of production systems compatible with climate sustainability.

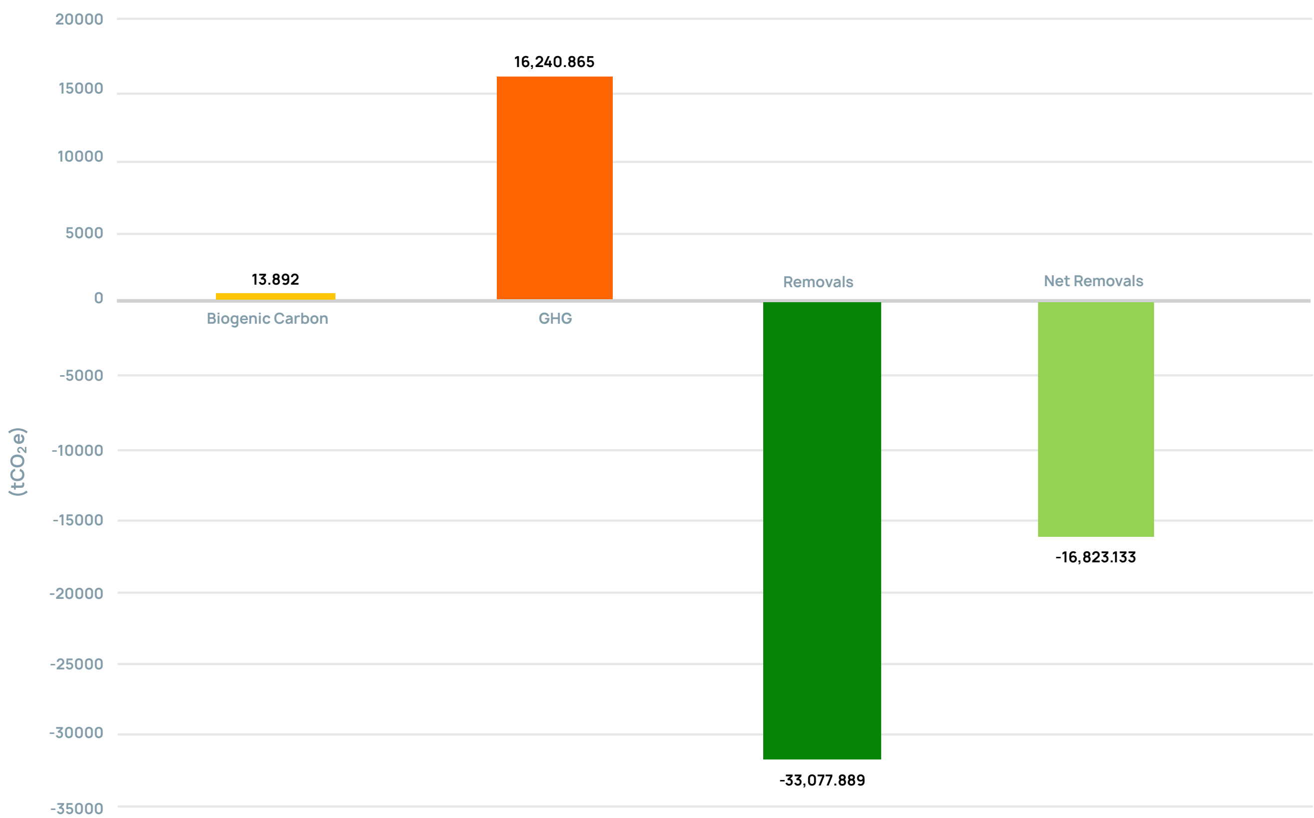

Figure 31. Net emissions in the Pantanal Biome.

3.4 Mitigation Plan

The plan for mitigating Greenhouse Gas (GHG) emissions on Brazilian rural properties, developed based on inventories conducted across several biomes, is structured around three main pillars: the reduction of direct emissions (Scope 1), focusing on zootechnical efficiency, soil management, rational use of fertilizers, and best practices in animal production; the energy transition and reduction of indirect emissions (Scopes 2 and 3), prioritizing the use of renewable sources and greater control over the supply chain; and the enhancement of carbon sinks through the preservation, restoration, and management of native vegetation, pastures, and the integration of production systems.

The implementation of these strategies requires attention to regional specificities, with adaptations according to the characteristics of each biome. In the Amazon, for instance—where one of the highest average emissions per hectare was recorded (30.3 tCO_2e/ha)—the focus is on practices that reconcile conservation with income generation, such as agroforestry systems (SAFs), crop–livestock–forestry integration (ILPF), and the restoration of degraded areas. The promotion of low-emission socio-biodiversity value chains also stands out as a promising pathway.

In the Caatinga biome, characterized by water scarcity and fragile soils, the average emission was 5.1 tCO_2e/ha. Mitigation efforts prioritize the rational use of water through technologies such as cisterns and reuse systems, along with the strengthening of family farming through sustainable practices. Preserving native vegetation and controlling desertification are essential to maintain and enhance the biome's carbon sequestration capacity.

In the Cerrado biome, with an average of 8.9 tCO_2e/ha, the focus is on improving pasture productivity and restoring degraded areas. The adoption of integrated systems—such as crop–livestock (ILP) and crop–livestock–forestry (ILPF) integration—along with rotational grazing and investments in animal genetics and nutrition, significantly contribute to reducing emission intensity per unit of product.

In the Atlantic Forest biome, with an average emission of 10.9 tCO_2e/ha, small-scale farms and value chains such as horticulture and dairy production are predominant. The mitigation plan proposes reforestation of marginal areas with native species, regenerative agriculture practices, and incentives for organic production. Due to strong urban pressure, integration with local public policies—including Payment for Environmental Services (PES) programs—is considered essential.

In the Pantanal biome, where extensive cattle ranching and the use of native grasslands prevail, one of the lowest average emissions was recorded (4.7 tCO_2e/ha). The natural balance of the system is maintained through traditional practices and sustainable pasture management. Strategies such as monitoring the biome's carrying capacity and promoting differentiated products—such as organic beef—reinforce the sustainable nature of local production.

In the Pampa biome, with an average emission of 7.3 tCO_2e/ha, value chains such as beef cattle, viticulture, and olive growing were analyzed. Actions prioritize the sustainable management of native pastures and productive diversification, with emphasis on integrated systems and environmental traceability. Technological innovation and the restoration of degraded areas are also key to maintaining low emission levels and adding value to local products.

Based on the analysis of the collected data, the mitigation plan reinforces the importance of integrated and context-specific strategies that respect the ecological and socioeconomic diversity of Brazil's territory. The success of these initiatives depends on producer engagement, coordination between public and private institutions, and the use of tools such as GHG inventories. By consolidating these actions, Brazil can position itself as a global leader in the transition toward a low-carbon, resilient, and competitive agriculture—aligned with international climate commitments and the valorization of its environmental assets.

All of these mitigation examples must be framed within the context of a just transition—a central concept in global climate discussions and one that will play a prominent role at COP 30, especially for developing countries. It refers to the need to ensure that the shift toward a low-carbon economy occurs in an inclusive, equitable, and socially responsible manner, protecting workers, communities, and sectors most vulnerable to the impacts of this transformation. This means promoting public policies and investments that guarantee decent jobs, professional training, access to clean technologies, and social inclusion—particularly in regions heavily dependent on emission-intensive activities such as conventional agriculture, mining, and basic industries.

In Brazil's case, a just transition is a strategic pathway to reconcile climate commitments with economic development and the reduction of inequalities—especially in the Legal Amazon and territories inhabited by traditional communities, Indigenous peoples, and smallholder farmers.

3.5 Best Measurement Practices

The qualification of the workforce responsible for implementing the Greenhouse Gas (GHG) Emissions Inventory in the agricultural sector is a key element for the successful transition to low-carbon agriculture in Brazil. In a context of growing environmental demands from consumer markets, the technical capacity of those who measure, analyze, and interpret emission data becomes a strategic advantage. Within this scenario, the Sebrae System plays an essential role—not only as the developer of the tool, but also as a promoter of training and knowledge dissemination among the field agents who will carry out this work.

The GHG Inventory is a technical and rigorous methodology that requires mastery of agronomic, zootechnical, and environmental concepts, as well as familiarity with diverse production systems and their respective emission sources. Conducting this type of assessment on rural properties demands a deep understanding of input and energy flows, soil and vegetation management systems, animal feeding and confinement practices, fertilizer use, among other factors. Each detail can significantly influence emission calculations and, consequently, the mitigation strategies adopted.

Given the level of complexity involved, it is not enough to simply provide an innovative tool. It is essential to ensure that it is operated with technical competence, methodological rigor, and sensitivity to the local context. A poorly conducted inventory can undermine data credibility, lead to misinterpretations, and—worse—discourage rural producers from engaging in sustainability initiatives due to a lack of trust in the results. Therefore, the training of highly qualified technicians and consultants is a critical condition for the success of this agenda.

This is where Sebrae's role becomes especially relevant. With nationwide reach, strong territorial presence, a well-established track record of supporting small businesses, and a National Agribusiness Dissemination Hub, the institution is fully equipped to lead a structured process for training and certifying professionals qualified to apply the GHG Inventory on rural properties.

The proposal is for these professionals to become qualified multipliers, capable of translating a technically robust tool into practical, accessible, and understandable actions for rural producers.

This training should include, in addition to the technical aspects of the inventory, skills in communication, awareness-building, and trust-building with rural producers. After all, data collection depends on the producer's openness and engagement with the process. It is essential that the technician can clearly explain the purpose of the tool, the benefits of its application, and how the data can be translated into concrete, advantageous action plans for the property.

Therefore, investing in workforce training for the implementation of the GHG Inventory is not a mere operational detail—it is a key strategy for consolidating low-carbon agriculture in Brazil. It means laying the groundwork for sustainability to become part of the daily routine of small farms. Above all, it ensures that Brazil moves forward with quality, credibility, and leadership in building a greener and more competitive future.

3.6 Perceptions of Stakeholders Involved in the Biomes Pilot

The participation of state-level Sebrae units in the development of the GHG (Greenhouse Gas) Inventory tool was marked by enthusiasm and recognition of the relevance of the environmental agenda. The proposal sparked great interest, as it addresses an emerging and strategic topic aligned with sustainability requirements and the evolving demands of international markets. The tool proved to be a concrete opportunity to position Brazilian agribusiness in a distinctive way, while also opening space for innovation and competitiveness among small-scale producers. Some Sebrae units highlighted that the project enabled a deeper understanding of the environmental realities of businesses across biomes, while others expressed pride in being part of a nationally impactful initiative. The connection between sustainability, environmental traceability, and access to new markets was a shared source of motivation among the states.

From the perspective of the Hub, this project fostered integration among units, strengthened collective identity, and advanced the improvement of collaborative network practices. It was a highly complex initiative, involving institutional coordination, strategic alignment, and a strong capacity for joint execution.

3.6.1 INSTITUTIONAL SUPPORT AND INTERNAL COORDINATION

In the states, the decision to participate in the project was supported and encouraged directly by the Executive Board. All Sebrae state units demonstrated alignment with the Sebrae Agro Hub and strong commitment to locally coordinating the pilot's implementation. The process involved institutional coordination, partner mobilization, and a careful selection of participating properties—highlighting the strength of their representatives and Sebrae's strategic role as a facilitator of policies and programs focused on sustainability in rural areas.

3.6.2 MOBILIZATION STRATEGIES AND SELECTION OF PROPERTIES

In most cases, the mobilization of producers was carried out through local partners such as cooperatives, associations, companies, and research institutions. This strategy was essential to ensure diversity across production chains and territorial representation. In Goiás, for example, coordination was led by anchor companies that directly engaged producers. In Rio Grande do Sul, there was a strategic selection of representatives from key production systems in the Pampa Biome—such as beef cattle, viticulture, and olive growing—with support from local institutes, associations, and companies. In Santa Catarina and Paraná, integrated agribusinesses and cooperatives played a strong role as intermediaries between Sebrae and the producers.

3.6.3 KEY MILESTONES AND PROJECT RECOGNITION

Several participants highlighted symbolic moments that marked their involvement in the project. Recognition through awards at sustainability-focused events stood out, signaling the value society places on the networked efforts carried out by the Sebrae System. Expressions of gratitude and acknowledgments made during feedback sessions with partners were also memorable aspects of the experience. These moments symbolize not only the technical validation of the tool, but also the institutional strengthening of Sebrae as a reference in sustainability across the participating states.

3.6.4 PRODUCERS' REACTIONS AND PERCEIVED VALUE

Producers' perception of the tool was generally positive. Many saw opportunities beyond emission mitigation, such as the potential to add value to their products through labels and campaigns based on sustainable practices.

The viticulture and olive-growing chains, for example, expressed interest in exploring the low-carbon label as a competitive differentiator. In some regions, exposure to the tool sparked producers' curiosity and a search for technologies that could help them meet lower-emission standards—highlighting the importance of feedback as a tool for awareness and engagement.

IMAGE: Tony Oliveira - CNA/SENAR System

3.6.5 PRODUCERS' REACTIONS AND PERCEIVED VALUE

Among those involved in the Biomes Pilot, visions for the future of the tool converge toward its systemic and widespread use. The expectation is that it will be integrated into programs such as ALI Rural, productive linkage projects, producer consulting services, and even municipal and state public policies.

There were perceptions regarding the potential of an online Sebrae platform to be used in rural sustainability programs, with a focus on training technicians and local agents, as well as serving as an environmental management tool for producers. There is also an understanding that the tool could become a foundation for environmental certifications and distinctions, in addition to supporting environmental traceability across agribusiness supply chains.

3.6.6 SEBRAE'S ROLE IN DISSEMINATION AND TECHNICAL CAPACITY BUILDING

All stakeholders involved agree that Sebrae should take on a structuring role in training a qualified workforce to operate the tool. Technical training for consultants, specialists, and local agents will be essential to ensure efficient implementation and scalability of the solution. The expectation is that Sebrae Nacional will provide infrastructure, training programs, courses, and digital tools, while state-level Sebrae units will act as operators of the solution within their territories. The future strategy points to a networked approach, supported by partner institutions such as SENAR, CNA, MAPA, and Embrapa.

4. SUGGESTED FORMATS FOR DELIVERING THE SOLUTION PELO SEBRAE

Sebrae has consistently played a key role in strengthening Brazilian agribusiness, especially by supporting small enterprises and developing solutions that directly address the challenges of sustainability, innovation, and competitiveness. In this context, an integrated proposal for applying the tool is presented, which can be explored across various strategic fronts. Potential applications range from partnerships with anchor companies to structured programs such as ALI Rural, national consulting services, courses and training, as well as institutional coordination through strategic partnerships. Each of these fronts represents a concrete opportunity to expand reach, consolidate learnings, and generate positive impacts for small agribusinesses.

4.1 Solution Offered in Partnership with Anchor Companies

Building solutions in partnership with anchor companies stands out as one of the most promising strategies for disseminating and consolidating the tool for measuring Greenhouse Gas emissions and removals in agribusiness. Large agribusinesses, cooperatives, producer associations, and leading companies within their production chains are increasingly interested in integrating sustainable practices and environmental indicators into their management processes and communication with consumers and international markets.

In this context, the tool developed by Sebrae can be offered as a value-added service within the sustainability strategies of anchor companies, enabling them to engage their networks of integrated or partner producers. This approach creates an environment of scale and reach that facilitates the implementation of the solution across hundreds of properties, generating consolidated, comparable data of high value for the sector.

Moreover, the invol0076ement of anchor companies enables the financial sustainability of the tool's implementation, as they can co-finance or subsidize access—ensuring the participation of small producers who would otherwise struggle to afford the inventory costs. The existing relationship of trust between producers and anchor companies enhances mobilization, while also strengthening the companies' corporate image in the market by aligning them with global ESG and decarbonization commitments.

Therefore, this strategic front enables Sebrae to significantly expand the reach of the solution, generate a critical mass of environmental data within Brazilian agribusiness, and simultaneously contribute to the competitiveness of anchor companies and the inclusion of small businesses in a new model of sustainable production.

4.2 Solution Offered through ALI Rural

The ALI Rural Program, recognized as one of Sebrae's most impactful initiatives for transforming small rural businesses, represents a strategic field for applying the Greenhouse Gas emissions and removals inventory tool. The proposal is to integrate the solution into ALI's methodological portfolio, enhancing the program's ability to deliver practical innovation tailored to the realities of rural properties.

In this model, the Local Innovation Agent (ALI, from Agente Local de Inovação) can act as a facilitator of measurement, supporting the producer in gathering the necessary information, using the tool, and interpreting the results. More than just an environmental assessment, the solution becomes part of ALI's ongoing guidance process, adding value to existing efforts in management, productivity, and sustainability.

Integrating this solution into the ALI Rural Program creates an opportunity for participating producers to receive a comprehensive assessment of their properties—considering not only economic efficiency but also socio-environmental dimensions. This strengthens their ability to access more demanding markets, differentiated credit lines, and certification programs linked to sustainability and low-carbon practices.

Finally, integrating the tool into ALI Rural creates a multiplier effect: each agent can reach dozens of properties in their region, consolidating a robust and representative database of Brazilian agribusiness. In doing so, Sebrae strengthens its role as a driver of innovation and sustainability in the field, while helping small businesses prepare for the challenges and opportunities of the green economy.

4.3 National Consultancy

Offering the solution in the National Consulting format enables Sebrae to serve different segments of agribusiness in a structured and strategic way, at a broader scale. In this model, the tool is applied by specialized consultants from Sebrae Nacional's accredited network, trained to carry out Greenhouse Gas emissions and removals inventories on rural properties across any Brazilian biome—ensuring methodological standardization, technical quality, and consistency in results.

This approach allows small businesses to access a high-value service that was previously limited to large corporations or costly private consultancies. With Sebrae's support, producers receive not only the inventory results but also a personalized mitigation plan, including practical recommendations to reduce emissions, improve production efficiency, and enhance competitiveness in markets that value sustainability.

In addition to individualized support, Sebrae Nacional's program can generate consolidated reports by region, production chain, or biome—providing valuable inputs for public policies, green financing programs, certifications, and corporate strategies aligned with the low-carbon economy.

Some of the data collected during the Pilot phase revealed the tool's potential as a foundation for developing municipal and state public policies aimed at decarbonizing rural territories. The inventory can serve as the first step in this process, providing a robust, traceable diagnosis tailored to the reality of small producers—while exploring opportunities such as carbon-neutral, organic, and regenerative agriculture.

Through this model, Sebrae Nacional positions its regional units as key players in democratizing climate measurement and mitigation solutions—enabling small businesses to access tools that strengthen their market position and expand their integration into global value chains.

4.4 Courses and Training Programs

The tool can also be disseminated through courses and training programs aimed at producers, technicians, consultants, and partner institutions. This strategic front seeks to broaden understanding of the importance of measuring Greenhouse Gas emissions and to equip local stakeholders to use the solution in a practical and effective way.

Courses can be offered in different formats—in-person, online, or hybrid—and tailored to the needs of each target audience. For rural producers, training may focus on best practices for recording property data, understanding results, and implementing mitigation plans. For consultants and field technicians, the emphasis may be on mastering the tool's methodology, interpreting inventories, and developing emission reduction strategies that preserve profitability.

This approach creates a multiplier effect: the more professionals are trained, the greater the solution's reach—allowing it to be implemented across thousands of properties in all regions of Brazil. Moreover, by incorporating sustainability and carbon topics into training programs, Sebrae helps shape a new generation of technicians and entrepreneurs who are aware of the importance of transitioning to low-carbon agriculture.

Finally, training programs can also be developed in partnership with educational institutions, cooperatives, associations, and anchor companies—strengthening the innovation ecosystem and ensuring that the tool is permanently integrated into rural management practices.

4.5 Partnerships

The consolidation of the solution relies directly on the articulation of strategic partnerships. Sebrae's experience shows that when different stakeholders come together around a common purpose, the outcomes gain greater scale, legitimacy, and impact. In this context, the tool can be enhanced through partnerships with public and private institutions, universities, research centers, international organizations, cooperatives, sectoral associations, and companies committed to the sustainability agenda.

These partnerships can take many forms. In the institutional sphere, universities and research centers can contribute to the methodological refinement and scientific advancement of the tool. In the business sector, cooperatives, agribusinesses, and anchor companies can support financing and mobilize producers for large-scale implementation. Partnerships with international organizations and financial institutions further expand access to resources for mitigation and adaptation programs, while aligning Brazil with global decarbonization commitments.

In this arrangement, Sebrae acts as the central coordinator, ensuring that small businesses remain at the heart of the strategy and have democratic access to the benefits generated. At the same time, partnerships reinforce the solution's legitimacy, securing technical and institutional recognition at both national and international levels.

Ideas and suggestions gathered during the pilot phase revealed potential uses of the tool in municipal government programs aimed at promoting the ecological transition of local agriculture. Integrating the solution into Technical Assistance and Rural Extension (ATER, from Assistência Técnica e Extensão Rural) initiatives—with trained technicians applying it during property monitoring—would reinforce their role as agents of transformation and promoters of environmental management.

Thus, building a strong collaborative network not only expands the tool's reach but also fosters trust, financial sustainability, and lasting impact for the agricultural sector—and for Brazil's image as a global leader in low-carbon agriculture.

5. EXPECTED IMPACTS

The adoption of the tool developed by Sebrae for measuring Greenhouse Gas emissions and removals in agribusiness is designed to generate impacts that go beyond the scale of individual rural properties and resonate throughout Brazilian society. It is a solution that connects science, innovation, and strategic management in favor of sustainability—with the potential to transform production practices, create new markets, and position Brazil competitively and prominently on the global stage.

5.1 Impacts at the Level of Rural Properties

The application of the tool will allow each producer to understand, in a practical and accessible way, how their activity interacts with climate dynamics. This means that thousands of small businesses will be able to identify key emission sources, recognize existing carbon removal practices, and plan mitigation strategies. More than just reports, the inventories will become management instruments—guiding producers toward a future where sustainability and profitability go hand in hand. This shift in mindset marks a qualitative leap in property management, driven by concrete and verifiable metrics.

5.2 Economic and Market Impacts

By making their carbon emissions visible, small businesses will be able to access new market niches that increasingly demand traceability and sustainability. Products from properties that measure and mitigate GHGs tend to gain a competitive edge in global value chains—especially in sectors such as meat, grains, coffee, fruit, and dairy. Moreover, the availability of reliable environmental data will enable the creation of more accessible green credit lines, encouraging investments in low-carbon technologies and regenerative practices. The solution, therefore, opens doors for producers not only to reduce costs and improve efficiency, but also to capture added value in premium markets and payment for environmental services (PES) programs.

5.3 Environmental and Climate Impacts

At scale, the implementation of the solution will generate an unprecedented national database on the emission balance of Brazilian agribusiness. This will enable the identification of trends, the most effective mitigation practices, and opportunities for replication across different biomes and production chains. The expected environmental impact is twofold: on one hand, the effective reduction of gross emissions; on the other, the strengthening of carbon sinks such as native vegetation areas, integrated production systems, well-managed pastures, and reforestation efforts. At the same time, producers will begin adopting practices that enhance the resilience of their systems to extreme climate events—such as droughts and floods—reducing risks and ensuring greater food security.

5.4 Social and Territorial Impacts

Democratizing access to this technology places small businesses at the center of the climate agenda, helping to reduce historical inequalities that have limited their participation in sustainability programs. The inclusion of family farmers, land reform settlers, cooperative members, and small-scale livestock producers creates opportunities for income generation, boosts productive self-esteem, and enables integration into value chains previously restricted to large players. At the territorial level, network-based adoption of the solution strengthens local development arrangements, generates jobs in consulting and technical assistance, and supports families in remaining in the countryside through economically viable and environmentally responsible activities.

5.5 Institutional and Strategic Impacts

By leading this initiative, Sebrae reaffirms its pioneering role in developing innovative solutions for small businesses. The tool will become a symbol of how the institution transforms technical knowledge into accessible practice—capable of reshaping the global perception of Brazilian agribusiness. On the international stage, especially in the context of COP 30, Brazil will be able to present concrete and consistent data showcasing the leadership of small producers in climate mitigation, strengthening its position as an agro-environmental powerhouse. Nationally, Sebrae is solidified as the central coordinator of a network that connects science, markets, and society around a collective sustainability project.

5.6 Long-Term Impacts and Legacy

The expected impacts go beyond immediate results. This is about cultivating a culture of sustainable management in rural areas—where measuring, planning, and mitigating become common and deeply rooted practices. The legacy of this initiative is the establishment of a new standard for Brazilian agribusiness: competitive, innovative, and sustainable, where every property, regardless of its size, can contribute to global climate commitments. This movement strengthens public and market confidence in Brazilian agriculture and lays a solid foundation for future generations to inherit a more resilient, productive, and environmentally balanced countryside.

In summary, the expected impacts combine economic, environmental, social, and institutional gains in an integrated approach. While empowering rural producers with qualified information, the solution also creates the conditions to reposition Brazil within the global climate debate. More than a technical tool, it represents a strategic institutional effort to transition agribusiness toward a low-carbon, inclusive, and forward-looking economy.

6. CONCLUSION

The pilot confirmed the tool's feasibility and generated valuable data for adjustments and improvements. It also demonstrated that it is possible to raise awareness and engage small producers in a strategic agenda such as climate change—provided the messaging is clear, the tools are applicable, and the benefits are tangible.

In this context, the Greenhouse Gas (GHG) Emissions Inventory for rural properties is an essential tool for understanding the climate impact of agricultural activities. Through it, producers can identify major emission sources, quantitatively estimate emitted and removed gases, plan mitigation strategies collaboratively, and—above all—support technical, environmental, and economic decision-making aimed at the sector's sustainability.

With the model now consolidated, Sebrae has more strategically integrated the climate agenda into its service approach for small producers; today, it stands as a national reference in sustainability for small rural businesses.

7. ACKNOWLEDGMENTS

The Executive Board of Sebrae Goiás extends its sincere appreciation to all who contributed to the design, development, and consolidation of this tool—which represents not only a technical advancement, but also a milestone in the collective commitment to the sustainability of Brazilian agribusiness.

First and foremost, we extend our gratitude to Sebrae Nacional and the Sebrae network, gathered under the Sebrae Agro Hub, for their engagement, dedication, and willingness to tackle such a challenging issue as the transition to low-carbon agriculture. The joint effort of technicians, managers, and partners was instrumental in turning this proposal into a concrete, accessible, and high-impact solution.

We also acknowledge the invaluable contributions of our partner institutions—universities, research centers, international organizations, cooperatives, agribusinesses, and anchor companies—which, throughout the process, provided scientific legitimacy, strategic support, and institutional trust. This collaborative network strengthens Sebrae and ensures that rural small businesses are part of a global movement aligned with the demands of a society that values responsible production.

A special thank-you goes to the productive sector, especially the small rural businesses that—with courage, openness, and resilience—accepted the challenge of participating in the pilot tests, sharing information, and incorporating sustainability measurement and management practices into their daily routines. These producers embody the essence of Brazilian agribusiness: entrepreneurs who balance tradition and innovation, face climate and market adversities, and, even amid uncertainty, remain key players in building a more sustainable future.

It is thanks to this willingness to learn, experiment, and evolve that Brazil can now present to the world a robust, inclusive, and transformative initiative. For this reason, our gratitude extends to every farmer, livestock producer, field technician, public manager, private partner, and institution that believed in the importance of this journey.

To all of you, our heartfelt thanks. May this work developed by the Sebrae Agro Hub be just the beginning of a collective journey to strengthen Brazilian agribusiness—reaffirming Sebrae's commitment to innovation, sustainability, and the empowerment of small businesses as drivers of economic, social, and environmental development for the country.

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