Overview of the carbon balance in coffee production

Solidaridad

MASTHEAD

Solidaridad is an international civil society organization that has been active in the development of socially inclusive, environmentally responsible and economically profitable agricultural chains. It proposes to accelerate the transition to inclusive, low-carbon production, contributing to food and climate security. Across the globe, **Solidaridad** has over half a century of activity in more than 40 countries. In Brazil, it has developed sustainability initiatives with its partners for 15 years in the following chains: cocoa, coffee, sugarcane, yerba mate, orange, livestock, and soy.

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OVERVIEW OF THE CARBON BALANCE IN COFFEE PRODUCTION

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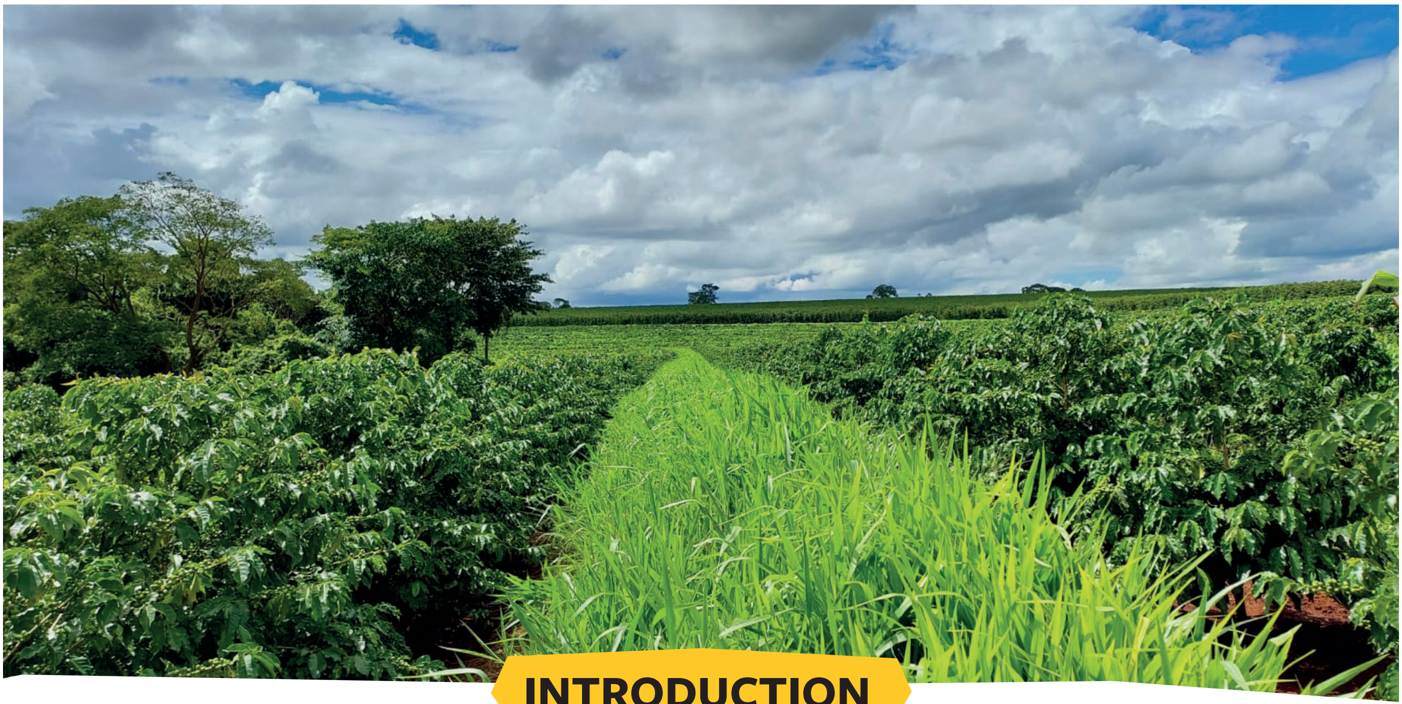


INTRODUCTION

The information in this study pertains to the characteristics of coffee plantations in the Alta Mogiana region, spanning the states of São Paulo and Minas Gerais. The purpose is to contribute to the discussion on strategies and perspectives for effective carbon management and the mitigation of emissions related to coffee production. Below is the profile of the properties analyzed and the main results regarding carbon emissions.

Data on properties and their production in
Alta Mogiana

19 Groups representing **76** farms

1,866 hectares of coffee

134,000 bags of coffee produced in the 2022/2023

CO_2

Average CO_2e emissions from coffee production

2.4 tCO_2e/ha

1.3 Kg of CO_2e/kg of coffee produced

Biggest emissions factor: **use of nitrogen fertilizers**

INTRODUCTION

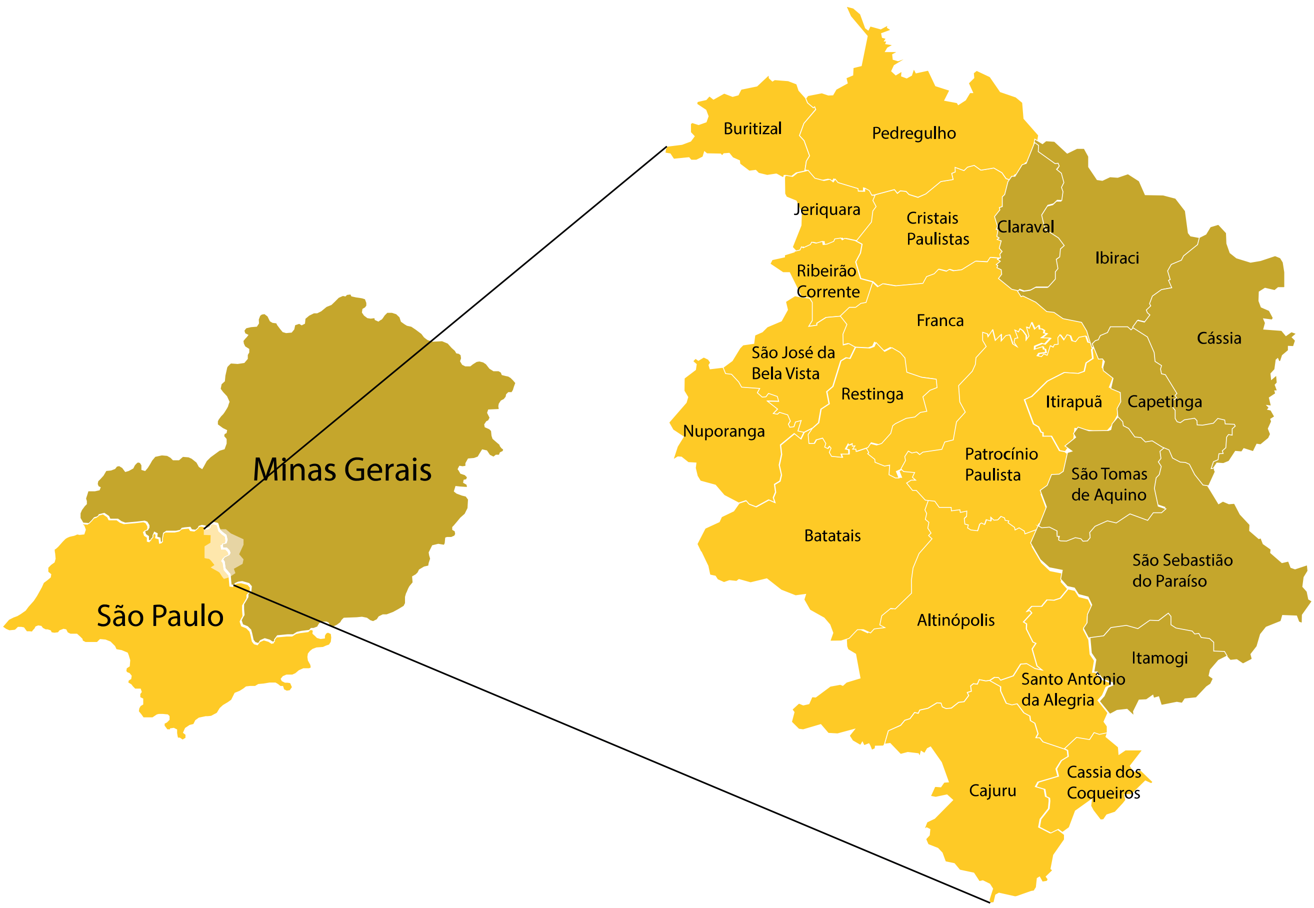
As a global leader in coffee production, Brazil faces the challenge of balancing growing demand with the need to reduce greenhouse gas (GHG) emissions and promote the conservation of natural resources. Strategies such as regenerative agriculture, which aims to restore ecosystems and promote soil health, are gaining prominence as they offer a path to more sustainable coffee production. By adopting better agricultural practices and investing in innovative technologies, the Brazilian coffee sector can play a vital role in combating climate change, promoting the quality and excellence of its specialty coffees on the international market.

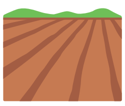
In Latin America, **Solidaridad** plays a crucial role in analyzing emissions and carbon sequestration in coffee farming, utilizing the Cool Farm Tool method to evaluate and compare results. By exchanging experiences between countries and conducting efficient fieldwork, the environmental impact of agricultural practices in the region can be estimated, providing valuable data for sustainable decision-making in the coffee sector. Using this internationally recognized tool to assess the carbon footprint of agriculture enables the quantification of emissions and the identification of opportunities to reduce emissions and increase carbon sequestration. This approach helps develop more resilient production systems in the face of climate change.

Based on this context and aiming to understand the carbon emissions scenario in coffee production, the **Solidaridad** conducted a study in the Alta Mogiana region with 19 groups of farms, focusing on the 2022/2023 harvest performance. The study's conclusions offer crucial insights into evaluating emissions management practices, identifying mitigation opportunities and promoting more sustainable agricultural practices.

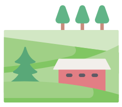
ABOUT THE REGION

The Alta Mogiana region is internationally recognized as a geographical indication for producing excellent coffee. Situated between the states of São Paulo and Minas Gerais, this region boasts ideal soil and climate conditions for coffee cultivation, including altitudes between 900 and 1,200 meters, fertile soils and a favorable climate. Coffee growing is integral to the local identity and culture, influencing the economy as well as the socio-cultural and historical aspects of the region.





120,000
Hectares cultivated



5,000
Coffee farms

Over **200 years**
of tradition

To outline the scope of the work, a territorial cut-off was established, covering ten of the 23 municipalities in the region. Seventy-six coffee farms volunteered to participate in the survey. The average number of hectares of coffee-growing land among the properties in the study was 50.86 hectares.

METHOD

DATA COLLECTION

To ensure the viability and reliability of the data in this study, properties with a management, operations, and control system in place for the 2022/2023 harvest were selected.

Once the producers signed up, the **Solidaridad's** technical team used the Cool Farm Tool (CFT) to dynamically work through all historical data and information for each farm in collaboration with the farm management. To obtain the necessary data and information, the following triangulation method was used:

- Semi-structured interviews to apply the CFT questionnaire.
- Inspections and collection of technical information directly in the fields.
- Verification of technical records pertaining to production system management practices.

COOL FARM TOOL (CFT)

CFA
COOL FARM ALLIANCE

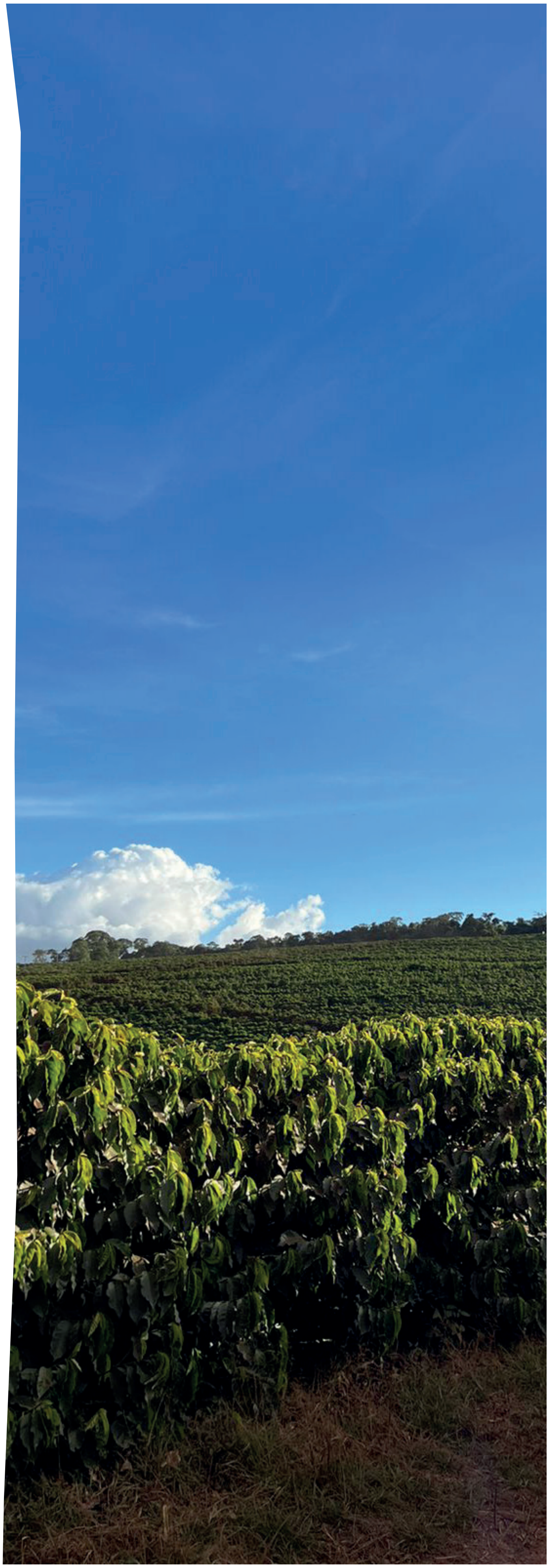
The CFT is an online platform from the global pre-competitive initiative Cool Farm Alliance, designed to help farmers and agricultural companies assess and manage the environmental impact of their activities. The tool enables users to calculate GHG emissions and evaluate the sustainability of their practices. It considers various factors such as energy consumption, soil management, and fertilizer and pesticide application, providing a comprehensive analysis of the climate performance associated with each management practice on a farm or agricultural production system. This includes quantifying carbon dynamics (emission and removal) in the production system, with indicators for crop yield, cultivation area, management and post-harvest practices, as well as details on fertilizer application (type, dose and frequency) and energy consumption (in kWh and fuel).

RESULT ANALYSIS

Many producers in the project owned multiple properties. It was assumed that these properties shared the same management practices based on a group management system. Consequently, the areas and inputs were consolidated, reflecting a single production location for analysis. This approach resulted in 19 groups, encompassing 76 farms. This method simplified the analysis, enabling easier comparison of emissions and agricultural practices on a broader scale, thus contributing to a more comprehensive and accurate assessment of the environmental impact of agricultural production on these farms.

The results for each of the 19 groups were evaluated, focusing solely on the "inside the gate" indicators related to coffee-growing areas. This means that production and logistics involved in acquiring inputs for the property, as well as the logistics for storing and selling coffee, were not considered for storing and selling coffee. The study's analysis was exclusively centered on coffee-growing areas, excluding other cultivation and vegetation areas belonging to the farms.

The data was organized and analyzed, with some cases requiring additional collection to confirm information. Once processed, the data was assigned to the group of farms using the CFT indicators, which calculated the carbon balance. A report was then generated and delivered to the producers for discussion and validation. This document detailed the emissions and removals for each group of properties, included a comparison with the study's average results[1], and provided a technical analysis with observations on management practices to encourage more sustainable methods.



[1] The average study results used for comparison were presented in the individual reports in an aggregated and anonymous form.

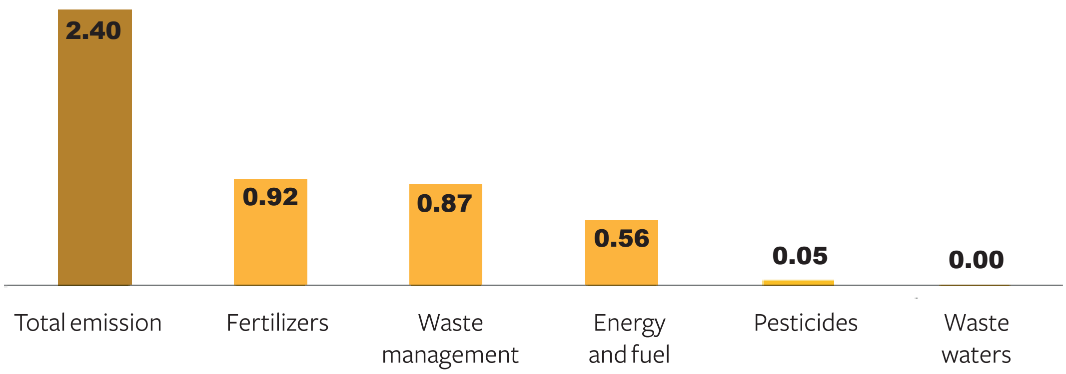
RESULTS

It is important to note that although this study is based in Alta Mogiana, its findings cannot be generalized to the entire region or other coffee-producing areas. The data presented reflects only a specific group within the region.

The data collection for calculating the carbon balance was structured around indicators established by emission factors. These factors were carefully analyzed to understand the carbon emissions panorama in the coffee production systems of the farms studied.

Based on the CFT analysis, the average emission from the group of farms was 2.4 tCO2e/ha[2]. The main emission sources in the coffee-growing properties analyzed were the use of nitrogen fertilizers, waste management, and fuels and energy.

Fertilizers
In addition to emissions generated by fertilizer use, the CFT method also accounts for emissions from their production. While fertilizer production is the responsibility of the entire supply chain, this specific result was not highlighted in the "inside the gate" analysis. If emissions from fertilizer production were included, the share of emissions from fertilizers would increase from 0.92 tCO2/ha to 2.13 tCO2/ha, raising the farm's average emissions from 2.4 tCO2/ha to 3.61 tCO2/ha.



Emissions (tCO2e/hectare)

The average CO2e removal from the properties was -0.43 tCO2e/ha

[2] Carbon equivalent per hectare measures the total greenhouse gas (GHG) emissions associated with a given area of land, usually expressed in hectares. This metric combines emissions of various GHGs, such as carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), into a single unit based on their global warming potential over a specific period, typically 100 years. It is often used in environmental impact assessments, carbon management, and sustainable agriculture to quantify total GHG emissions per unit area of land. This measure allows for the comparison of the climate impact of different agricultural practices, cropping systems, or geographical areas.

When calculating carbon sequestration, the CFT considers the presence or absence of shade tree biomass in the coffee-growing area. Including shade trees increases the total biomass capable of capturing and storing carbon, leading to a higher estimate of carbon sequestration compared to systems without this practice, such as coffee monocultures. Therefore, shade trees significantly contribute to higher sequestration rates per hectare, helping mitigate climate change by capturing and storing atmospheric carbon and enhancing the production system's resilience. However, this production model is not widely adopted in Brazil, and none of the areas fall within the conventional definition of agroforestry. This results in a relatively low average removal compared to the potential sequestration achievable with coffee and shade tree intercropping systems.

Regarding the carbon balance scenario, the study's average was 1.97 tCO2e/ha.

In a scenario focused on emissions, agricultural operations emerge as the primary sources of GHG from the coffee plantations studied. These emissions stem from the entire production chain, including the use of synthetic fertilizers, energy consumption, fossil fuels, and the management of organic waste and soil. This study aimed to identify the main sources of emissions from coffee plantations to develop strategies for reducing them, considering Brazil's context of monocultural systems and key indicators such as productivity and profitability for rural producers. It is important to note that although GHG removal is also relevant, it can vary significantly between different methods.

OPERATIONAL EFFICIENCY

Considering the emissions of the analyzed properties relative to the volume of coffee produced, the average operational efficiency[3] was 1.3 kg CO2e per kilogram of coffee.

The higher productivity of full-sun coffee production systems in Brazil, compared to shaded systems, is due to a combination of historical factors, favorable climate conditions, research and technology, adapted coffee varieties, intensive agronomic practices, economies of scale and economic models focused on high production.

In the group of farms analyzed, the average yield was 35 bags per hectare. The Brazilian Agricultural Research Corporation (Embrapa) estimated the national average for arabica coffee at 29 bags per hectare during the first survey of the 2023 coffee crop by the National Supply Company (Conab).

For shade-grown coffee, concrete data to estimate the national average is still insufficient. However, experts indicate a much lower production value in bags per hectare when comparing the averages.

[3] Operational efficiency refers to a coffee production operation's ability to minimize carbon emissions while maximizing coffee yield. This involves finding ways to reduce the carbon footprint across all stages of the production process, from cultivation to processing.

SCENARIO FOCUS

MAJOR EMISSION CASE

Emission:
14.98 tCO_2e
Main emission source:
Fertilizers
Operational efficiency:
1.66 kg CO_2e
per kg of coffee produced

According to the analysis, as fertilizer use for coffee production intensifies, there is a consequent increase in GHG emission factors, primarily nitrogen oxides (NOx), during their application and decomposition in the soil. Moreover, excessive use of nitrogen fertilizers can lead to soil acidification and nitrate leaching, resulting in indirect emissions of nitrous oxide (N_2O), a potent GHG. Therefore, while nitrogen fertilizers boost coffee production, it is essential to consider their environmental impacts and adopt more sustainable agricultural practices, such as using controlled-release fertilizers and soil management techniques that minimize GHG emissions while maintaining coffee productivity and quality.

LOWEST EMISSION CASE

Emission:
0.76 tCO_2e
Main emission source:
Waste management
Operational efficiency:
0.29 kg CO_2e
per kg of coffee produced

This scenario resulted from a combination of four factors analyzed on the farm:

1. **Implementation of composting systems:** These systems decompose organic waste, producing compost used as a soil conditioner for crops and gradually reducing the need for synthetic chemical fertilizers.

2. **Use of cover crops:** Planting a mix of seeds between the coffee trees increases diversity, biomass production capacity per hectare and water retention. The need for herbicides is also reduced, and nutrient cycling and availability in the production system are improved, leading to better soil health.

3. **Adoption of biological products:** These are used to control pests and diseases, preventing unwanted contamination of the environment and protecting human health.

4. **Adoption of clean and renewable energy sources:** Utilizing solar panels[4] reduces dependence on polluting and non-renewable energy sources.

[4] The adoption of solar panels offers numerous environmental benefits for farms. Firstly, by generating electricity without direct GHG emissions, they significantly reduce total carbon emissions. Additionally, solar energy production replaces the need for fossil fuel-based sources such as coal, oil, and natural gas, thereby decreasing the demand for these high carbon-emitting sources. Finally, by making the property self-sufficient in electricity, solar panels reduce or eliminate the need to purchase electricity from the grid, thus lowering the emissions associated with conventional power plants. These benefits not only reduce the carbon footprint but also promote the transition to sustainable and ecologically responsible agriculture.

CONSIDERATIONS

This study underscores the importance of understanding and addressing carbon emissions on coffee farms in the Alta Mogiana region. Implementing more sustainable agricultural practices and adopting mitigation strategies can significantly reduce GHG emissions and promote sustainability in the coffee industry.

When more sustainable management is adopted on the farm—through best management practices—agricultural production becomes more process-oriented, reducing the need for consumption-based agriculture. This approach promotes competitive coffee growing with profitability, lowers CO2e emissions, and makes the production system more climate-efficient.

The data collected from the properties, which align with best coffee management practices, reveal several factors that impact emission reductions:

- ✔ Seek alternatives to reduce the use of nitrogen fertilizers, which are major contributors to carbon emissions, such as composting systems for organic fertilizers.
- ✔ Use organic products.
- ✔ Implement soil conservation practices to prevent erosion.
- ✔ Invest in renewable energy and efficient water management practices.
- ✔ Optimize and promote the efficiency of agricultural machinery, particularly in fuel use.
- ✔ Continuously assess carbon emissions to identify potential areas for improvement.
- ✔ Involve the family—in the case of family-run farms—along with farm workers, neighboring producers, and the community in promoting practices that reduce carbon emissions.

FINAL NOTE

After reviewing the individual feedback results, the farmers involved in this work committed to revising and improving their "inside the gate" agricultural practices. Their goal is to reduce GHG emissions and make farming on their properties more responsible and sustainable.

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