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Going Climate Smart with Costa Coffee

Establishing Carbon Footprint Baselines in Brazil, Colombia, and Honduras

The Rainforest Alliance is creating a more sustainable world by using social and market forces to protect nature and improve the lives of farmers and forest communities.

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EXECUTIVE SUMMARY

Drying beans on the San Diego coffee farm in Colombia.

Introduction

Leading coffee companies are investing in climate mitigation projects within their agricultural supply chains. In 2022, Costa Coffee and the Rainforest Alliance designed a pilot study to measure the carbon footprint of Rainforest Alliance Certified farmers in Brazil, Colombia, and Honduras. This study sought to quantify carbon emissions from coffee production and processing, identify emission hotspots, and propose reduction pathways through the adoption of regenerative agriculture practices within Costa Coffee's supply chain.

Methodology

A sample of 266 Rainforest Alliance Certified farms was randomly selected from cooperatives within Costa Coffee's supply chain in key sourcing regions across Brazil, Colombia, and Honduras. The study utilized the Cool Farm Tool (an online emissions calculator) to estimate on-farm greenhouse gas (GHG) emissions and carbon sequestration in the coffee farms. This was supplemented with the use of the i-Tree Eco V6 tool to explore the carbon sequestration potential of shade trees on farms. Additionally, in-depth surveys and focus group interviews were conducted with a smaller subset of farmers to explore the feasibility of adopting agricultural practices that would reduce carbon emissions and increase carbon removals.

Main Findings

- Fertilizer production and use were the main source of carbon emissions on coffee farms in all three countries, followed by energy use.
- Carbon footprints were similar in Brazil and Colombia, but lower in Honduras.
- Carbon footprints were highly variable across farms and agricultural landscapes due to differences in land management practices.
- Shaded agroforestry systems were key sources of on-farm carbon sequestration.
- Farmers face barriers to adopting more sustainable practices, highlighting the need for more technical and financial support.

Key on-farm intervention pathways include:
- Transitioning to organic fertilizers to minimize the use of synthetic agrochemicals.
- Investing in soil health practices, such as cover cropping and composting.
- Introducing or enhancing agroforestry systems, or implementing tree planting along farm borders.
- Implementing improved organic residue management, such as mulching and composting.
- Replacing emissions-intensive energy sources with coffee husks and biofuels, or other forms of renewable energy.

Next Steps

Together, Costa Coffee and the Rainforest Alliance will build on the learnings from this project and explore intervention pathways that work with farmers to reduce their emissions.

TABLE 1

Carbon footprints for farms sampled in Brazil, Colombia, and Honduras.

	Brazil		Colombia		Honduras	
Sample size	n=89		n=88		n=89	
	Mean	Median	Mean	Median	Mean	Median
Carbon footprint per kg (kg CO_2e/kg GBE*)	5.7	2.8	5.4	3.7	2.8	1.3
Carbon footprint per ha (kg CO_2e/ha)	5,285.4	3,804.6	5,102.1	4,273.1	2,320.1	1,874.8

**GBE = Green bean equivalent*

Growing coffee under shade cover on a farm in Colombia.

INTRODUCTION

Climate change poses daunting challenges to the coffee sector, particularly for the farmers and rural communities who depend on productive and sustainable growing systems for their livelihoods. As the effects of climate change continue to threaten coffee production, the need for action grows ever more urgent. At the same time, the coffee sector continues to contribute its own share of GHG emissions, through deforestation, land conversion, and harmful practices such as the use synthetic fertilizers. Estimates even suggest that by 2050, the coffee sector will be responsible for 1.65–3.3 gigatons of carbon emissions.[1] As the demand for coffee continues to grow globally, this presents us with a huge opportunity to improve the sustainability of coffee production worldwide. Leading coffee companies are scaling up climate mitigation and adaptation projects within their agricultural supply chains. Costa Coffee is at the forefront of these efforts.

The Rainforest Alliance has a long-established relationship with Costa Coffee, celebrating its 15-year anniversary in September 2023. As part of Costa Coffee's roadmap to achieve

What is a Carbon Footprint?

The carbon footprint of a production system is a measure of its contribution to global warming. Total GHG emissions include emissions of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). It is customary to convert all GHG emissions into a common unit called the carbon dioxide equivalent (CO_2e). The combined emissions are known as a carbon footprint. Carbon footprints can be measured by the emissions per unit of product (i.e., emissions per kg of coffee) at a specific point in the value chain, or by the emissions generated per unit of land dedicated to the crop (i.e., emissions per hectare of coffee plantation), or by both metrics.

Carbon footprints can vary in the types of emissions-generating activities they include: some footprints may only include emissions from on-farm coffee production, others also include emissions from the transportation and processing of coffee, and others include emissions from land use change, like the conversion of land from forest to agriculture.

its 2030 science-based carbon reduction target, the business is committed to driving carbon reductions across its supply chain, especially in key hotspots such as green coffee.

As a first step, in 2022, Costa Coffee and the Rainforest Alliance designed a pilot study to measure the carbon footprint of some of their coffee farmers in Brazil, Colombia, and Honduras. This study sought to quantify carbon emissions from coffee production and processing, identify emission hotspots, and design reduction pathways through the adoption of regenerative agriculture practices within Costa Coffee's supply chain.

Reforestation efforts on a coffee farm in Honduras.

Costa Coffee's Carbon Reduction Goals

Costa Coffee is on a mission to ensure that their coffee not only tastes great, but also has a positive impact on the environment and the communities they partner with.

Costa Coffee set a science-based target (SBT) to halve its greenhouse gas emissions per coffee serving by 2030, from a 2019 baseline before becoming Net Zero by 2040. To achieve this target, the business must reduce its absolute scope 1 and 2 emissions by 50 percent, whilst simultaneously reducing the intensity of its scope 3 emissions. Green coffee beans in coffee supply chains are an increasingly important part of scope 3 emissions, so it is essential to understand exactly how these emissions can be reduced over the coming years. This will require even greater progress on its carbon reduction journey, and collaborative action across the industry to achieve impact at scale will be essential.

Supporting Companies to Reduce GHG Emissions

The Rainforest Alliance partners with allies across the global supply chains where we work to help companies achieve their climate mitigation goals by providing integrated opportunities to reduce GHG emissions and increase carbon sequestration in agricultural and forestry supply chains. One of the ways we support companies is by conducting carbon footprinting and developing insetting projects to help companies measure Scope 3 GHG emissions, set robust, science-based emissions reductions targets, and finance nature-based solutions to avoid, reduce, and remove GHG emissions in agricultural and forestry supply chains.

This report is a summary of these pilot studies from Brazil, Colombia, and Honduras. These pilot studies had three primary objectives:

1. Measure farm-level carbon emissions by conducting baseline carbon footprint assessments in each country.
2. Conduct a Farmer Adoption Analysis survey to highlight facilitators and barriers to adoption of carbon emission reduction practices.
3. Illustrate reduction strategies and intervention scenarios for each country, highlighting the country-specific activities needed to reduce carbon emissions.

METHODOLOGY

The project focused on three countries within Costa Coffee's supply chain: Brazil, Colombia, and Honduras. All farms sampled were Rainforest Alliance Certified. The methodology for the study was divided into two parts: the baseline carbon footprint assessment, and the farmer practice adoption survey.

Baseline Carbon Footprint Assessment

Sampling Approach
A sample of 266 (89 farms in Brazil and Honduras, 88 farms in Colombia) Rainforest Alliance certified farms was randomly selected from cooperatives within Costa Coffee's supply chain in key sourcing sheds in each of the three origins (Table 2, Figures 1-3). The study included a representative sample of small, medium, and large farms from each region,[2] and included a diversity of coffee production systems. In Brazil, the farms sampled were primarily large monoculture plantations that were mechanized and sun-grown, with cover crops planted in between rows. Coffee beans were processed on-farm. In Colombia, the sample included a mix of sun and shade-grown coffee systems, with beans processed on-farm. In Honduras, farms were mostly smallholder shade-grown systems at higher altitudes, with beans processed off-farm at centralized mills.

TABLE 2

Summary of farm characteristics of sampled coffee farms.

	Brazil	Colombia	Honduras
Sample size	n=89	n=88	n=89
Mean farm size (ha)	186.3	28	4.8
Mean yield (kg/ha)	1,434.8	1,270.3	1,394.5
Mean NPK* application rate (kg/ha)	478.7	566	128

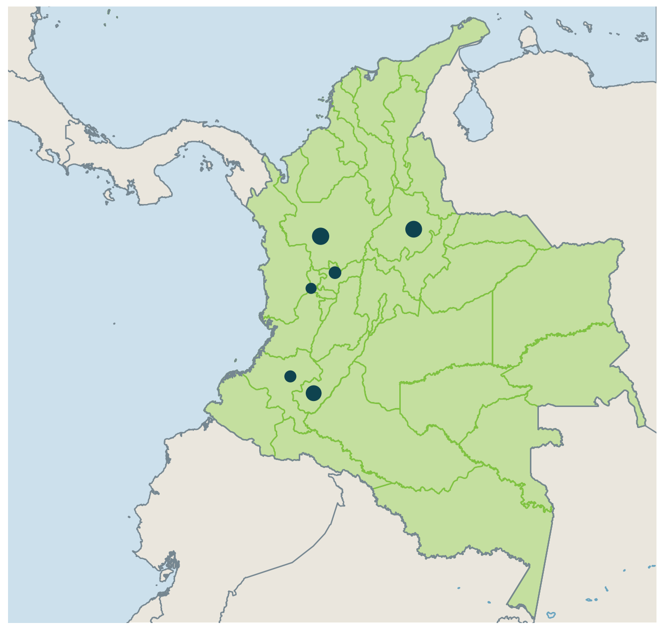
** NPK stands for nitrogen, phosphorus, and potassium*

FIGURE 1

Study areas in Brazil. Sample size per region: 81 farms in Minas Gerais, 8 farms in São Paulo.

FIGURE 2

Study areas in Colombia. Sample size per region: 28 farms in Huila, 17 in Santander, 17 in Antioquia, 11 in Cauca, 9 in Caldas, 6 in Risaralda.



Data Collection

Data were collected by enumerators through on-farm interviews using an offline questionnaire. The Rainforest Alliance designed a standardized offline questionnaire which collected the inputs required by the Cool Farm Tool, which was the primary framework for carbon footprint estimations and included indicators on farm and crop characteristics, fertilizer and pesticides, irrigation, direct energy, land management, transport, tree biomass, co-products, and wastewater. Data collected was based on a one-year baseline for the October 2021 to October 2022 harvest season.

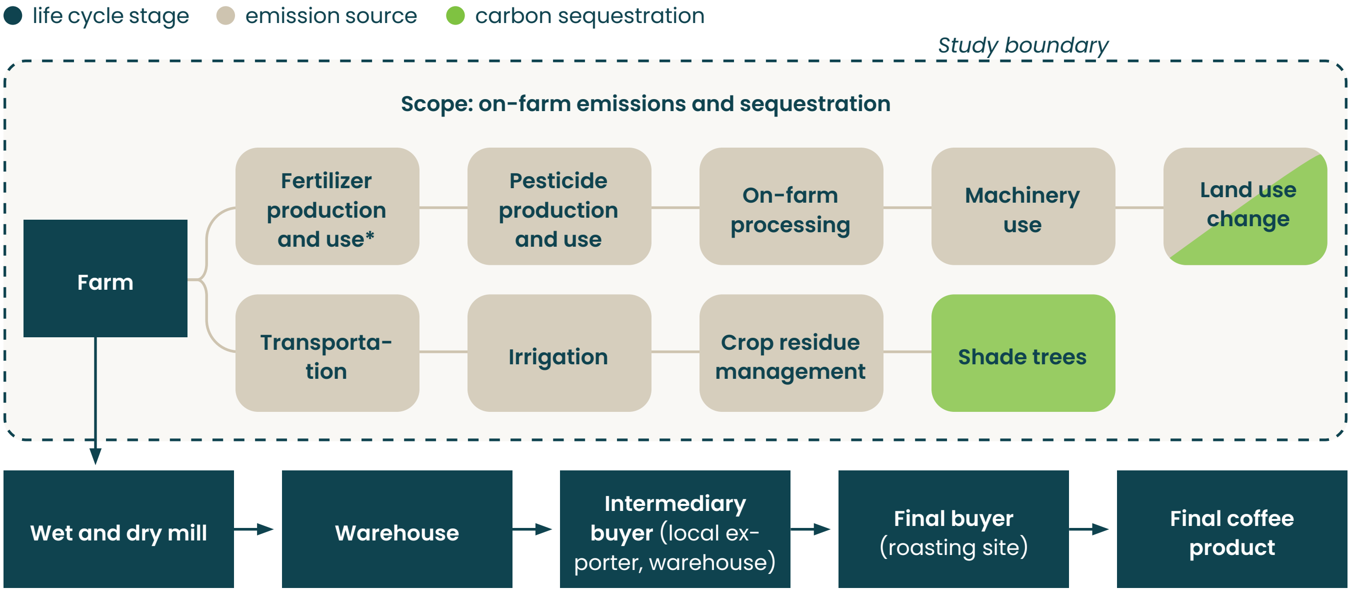
The system boundary of this carbon footprint assessment is "field-to-farmgate" emissions, which includes emissions from deforestation and other land use change, agronomic practices, and processing practices (if processing occurred on

FIGURE 3

Study areas in Honduras. Sample size per region: 29 farms in Centro-Nor-Occidente, 60 in Occidente.

FIGURE 4

Study scope.



Note: This is a high-level diagram. Stages of the coffee supply chain may vary depending on the country. On-farm processing was included as an emission source for Brazil and Colombia, but not Honduras.
** Emissions from fertilizer production include emissions from all relevant activities from raw material supply up to the final product at the factory gate. Emissions from fertilizer use include emissions from soil that stem from the application of nitrogen fertilisers and limestone."*

the farm) (Figure 4). The system boundary also includes removals from land use change, changes in soil management, and changes in out-of-crop biomass. Data was collated, cleaned, and analyzed by the Rainforest Alliance and technical partners to generate carbon footprint estimates.

Methodology
The study utilized the Cool Farm Tool[3] (an online GHG emissions calculator), to measure on-farm GHG emissions and carbon sequestration. The Cool Farm Tool offers quantified and standardized metrics based on empirical research, a broad range of published data sets, and IPCC methodologies through an easy-to-use online platform. Additional analyses were performed using the i-Tree Eco V6 tool to explore the carbon sequestration potential of shade trees on farms.

Indicators collected in the Cool Farm Tool include:

- Farm characteristics
- Crop characteristic
- Pesticides and herbicides
- Irrigation
- Fertilizers
- Direct energy
- Land management
- Transport
- Co-products

This carbon footprint assessment was performed for a one-year baseline: the 2021-2022 growing season. External factors such as climate variability, increasing fertilizer prices, and lingering effects of the COVID-19 pandemic may have distorted farming practices and yields during this period and influenced footprinting results. This should be considered when reflecting on the representativeness of the presented emissions estimates.

Survey of Feasibility of Adopting Climate Mitigation Practices

In-depth surveys were conducted with a smaller subset of farmers (40) to explore the feasibility of adopting agricultural practices that would reduce carbon emissions and increase carbon removals. Surveys were conducted with 13 farmers in Brazil, 15 in Honduras and 12 in Colombia. Additionally, two focus groups were held in each country, which included a combination of coffee growers and cooperative technicians (four to eight per focus group).

Survey questionnaires and focus group guiding questions were co-designed with technical and field advisory partners. These included a mix of structured, semi-structured and open-ended questions. Participants were asked about types of practices they used, their interest in adopting specific practices, and potential barriers to adoption.

Both in-depth surveys and focus group interviews took place after the quantitative baseline carbon assessment, with the goal of gathering more insights from producers and technicians on the key opportunities for, and barriers to, adoption of climate mitigation practices.

MAIN FINDINGS

Fertilizer production and use were the main source of carbon emissions on coffee farms in all three countries, followed by energy use (Figure 7).

- Across all three countries, fertilizer production and use were the primary source of GHG emissions. Fertilizer production and use represented 89 percent in Brazil, 82 percent in Colombia, and 92 percent in Honduras. This key finding indicates that there are clear opportunities to reduce emissions through changes in the types and application rates of fertilizers.

- Energy use was the second largest source of emissions—particularly in Brazil—due to the mechanized nature of farming and the use of irrigation equipment on larger farms. Energy was also used to power mechanical coffee driers. In Brazil, 82 percent of energy use emissions stemmed from the use of diesel.

- In Colombia, emissions from land management were higher, accounting for eight percent of emissions. These emissions stem from land use change to establish new coffee plantations (which occurred in one of the newer coffee growing regions).

- Emissions related to residue management were also important, though in this study only residues from pulp and mucilage were considered. Residue from plant litter and pruning were not taken into account since these are not yet considered in the underlying Cool Farm Tool model.

- Other emissions sources such as transportation and crop protection were reported as minimal across all countries.

Carbon footprints were similar in Brazil and Colombia, but lower in Honduras (Figures 5–6).

- Overall, Colombia had the highest fertilizer application rates (566 kg/ha), and lowest yields (1,270.3 kg/ha) across the three countries, which helps explain that this sample had the highest median footprint of 3.7 kg CO_2e/kg GBE (green bean equivalent). Honduras, on the other hand, had the lowest carbon footprint (median of 1.3 kg CO_2e/kg GBE), which can be explained by their low fertilizer application rates (75 percent lower than in Brazil or Colombia) and by the fact that fertilizer use and application were a major emissions hotspot.

FIGURE 5

Means, medians, and ranges of carbon footprints per kilogram of green beans across farms sampled in Brazil, Colombia, and Honduras (kg CO_2e/kg GBE).

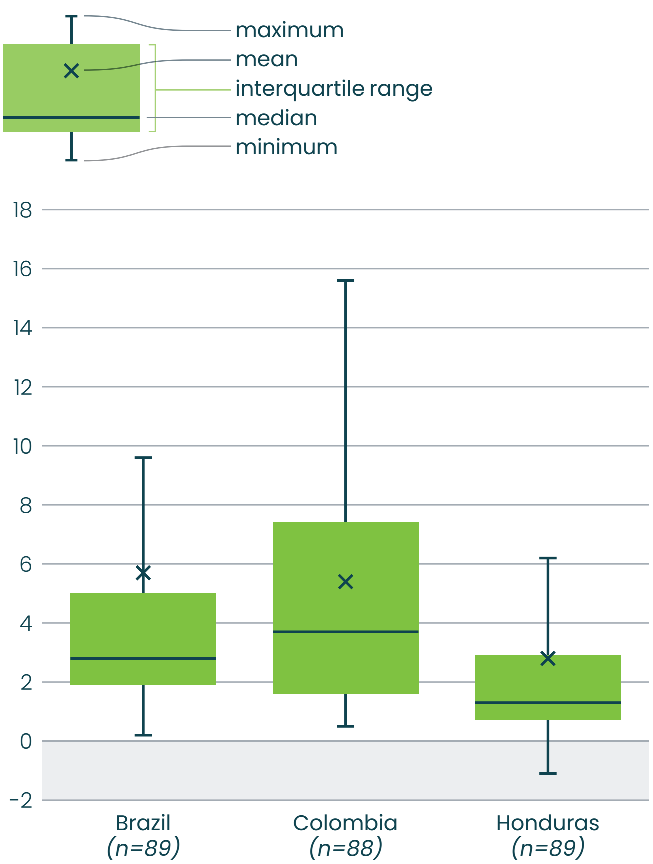


FIGURE 6

Means, medians, and ranges of carbon footprints per hectare across farms sampled in Brazil, Colombia, and Honduras (kg CO_2e/ha).

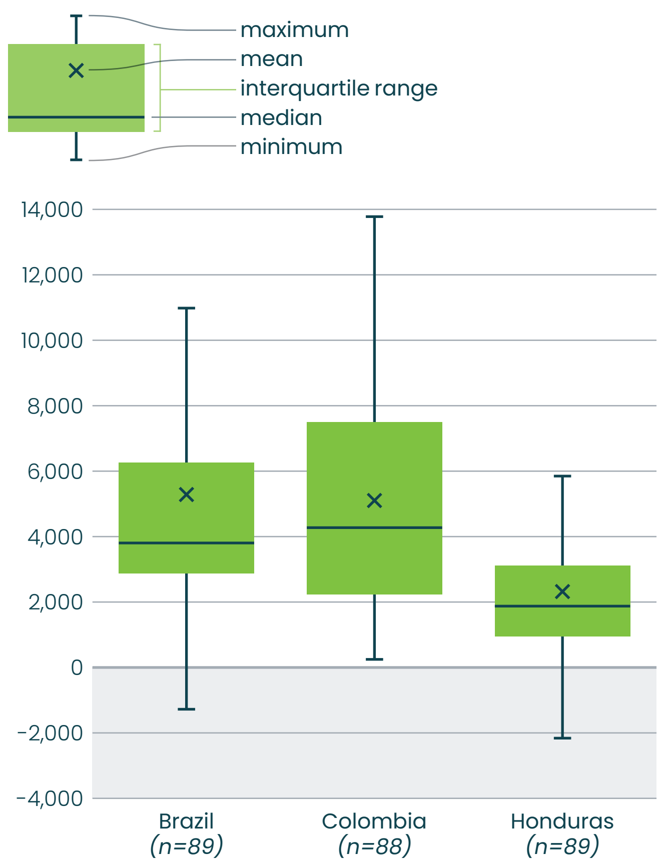
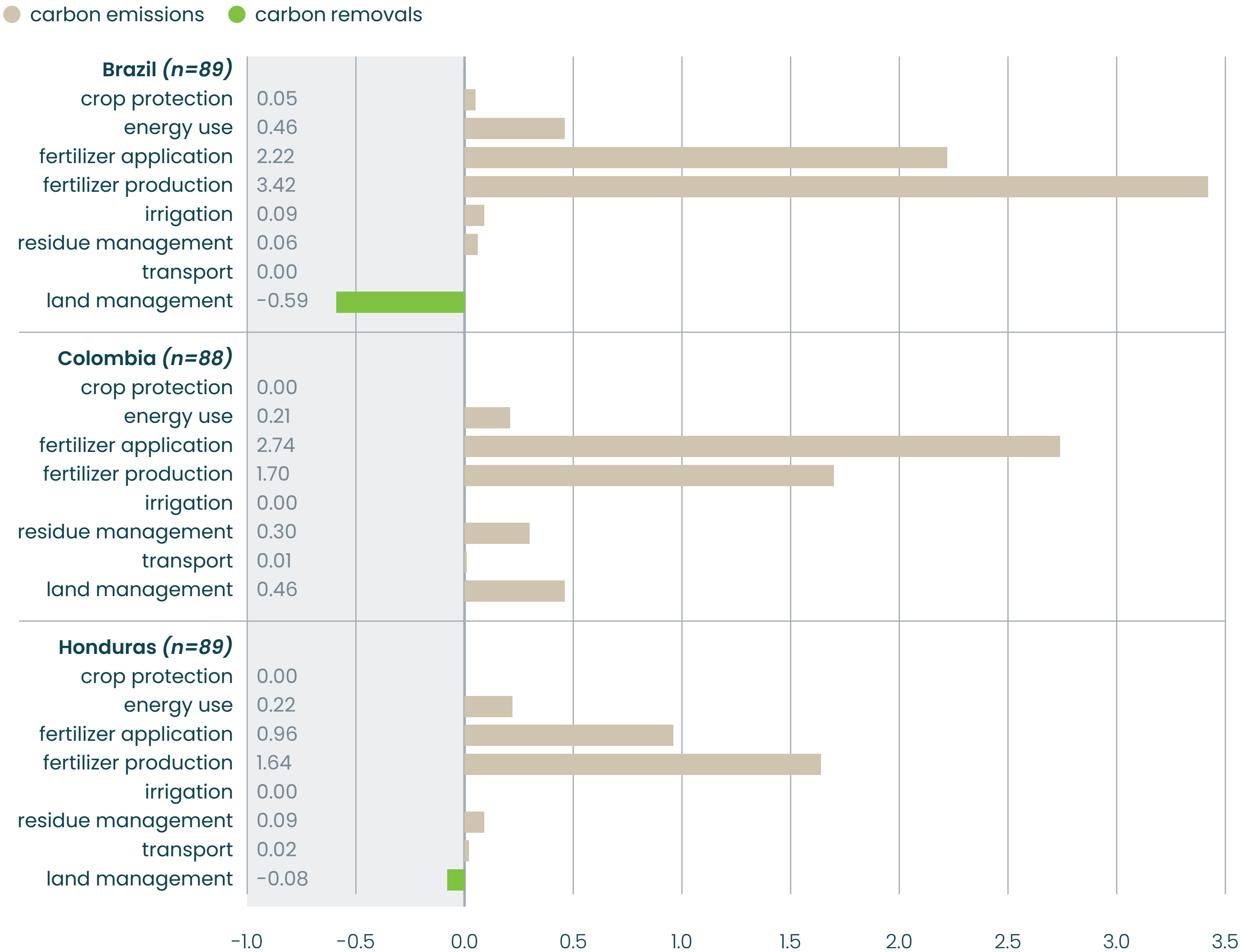


FIGURE 7

Carbon footprint per country, split by emission and sequestration source (kg CO_2e/kg GBE).



Note: The land management category includes activities that contribute to emissions—such as deforestation—as well as removals due to the use of cover crops and reduced tillage.

- The coffee farms in Honduras were characterized by being primarily shade-grown coffee systems on smallholder farms, compared to the more mechanized and sun-grown systems of Brazil. Colombia falls somewhere in the between, with a mix of sun- and shade-grown coffee systems of varying sizes.

Carbon footprints were highly variable across farms and landscapes due to differences in management practices (Figures 5–6).

- Carbon footprints varied greatly across farms within each country. The range was widest in Brazil, where footprints spanned anywhere from -10.5 kg CO_2e/kg GBE to 68.6 kg CO_2e/kg GBE. These differences were largely due to variations in management practices. Some farms had a fertilizer application rate that was much higher than others; some farms had high rates of emissions from land use change; other farms had different ways of managing residues. When measured per kg of green beans, the high variability in carbon footprints could also be explained by high variations in yields.

- Overall, the high variability in results provides a unique opportunity to understand what exactly is driving low footprints on certain farms. These results also helps us consider how such systems could be replicated elsewhere.

Shaded agroforestry systems were key sources of on-farm carbon sequestration.

- Agroforestry systems were most prevalent in Honduras, with 94 percent of the farms planting shade-trees at an average density of 175 trees per hectare. These shade-grown systems sequestered an average of 474 kg CO_2e per hectare. In Colombia, shade-grown production was still implemented by a large majority of farms (78 percent). The average shade tree density was lower, at 83.8 trees per hectare—though the average sequestration rate was the highest, at 830 kg CO_2e per hectare. Agroforestry was the least common in Brazil due to the mechanized nature of coffee production. Around 12 percent of the farms surveyed did plant shade trees, at an average density of 99 trees per hectare, and average sequestration rate of 263 kg CO_2e per hectare.

- Some farms sampled are already implementing agroforestry and sequestering carbon, indicating the potential to improve species selection and shade tree coverage on farms to further enhance carbon removals while ensuring productivity.

Farmers face barriers to adopting more sustainable practices and need technical and financial support.

- For any climate-smart coffee project to be successful, farmers must have the necessary resources to invest in these practices—and be appropriately incentivized. Farmers in this study expressed the need for technical and financial support to motivate action and encourage practice adoption. Farmers also often lack access to supplies (both external inputs and equipment) and infrastructure support, and cited this as a barrier to practice adoption. Demonstrating to farmers that practice adoption can lead to improved productivity and financial sustainability is essential.

REDUCTION INTERVENTIONS

Understanding some of the key emission hotspots was essential to inform which emissions sources could be targeted at the farm level for feasible and effective interventions. In partnership with technical and field advisory partners and Costa Coffee the Rainforest Alliance has identified the following potential carbon reduction intervention strategies[4]:

Fertilizer use

- Conduct annual soil analyses to develop soil and fertilizer management plans to support a more targeted use of synthetic fertilizers and minimize their use.
- Switch from synthetic to organic fertilizers, which have a significantly lower carbon footprint.
- Invest in soil health practices, such as cover cropping and composting, to reduce the need for chemical inputs and enhance soil carbon retention.

Energy use

- Replace emissions-intensive energy sources such as coal, gasoline, and diesel with coffee husks and biofuels to power coffee drying machines.
- Adopt solar driers and install photovoltaic panels, where applicable, to increase the use of renewable energy.

Residue management

- Implement improved organic residue management, such as mulching and composting, to minimize emissions generated from leaving residues piled in fields.
- Invest in waste management technologies, such as biodigesters, on larger farms that have livestock.

Wastewater

- Implement improved water treatment plans to minimize emissions from organic matter decomposition.
- Invest in water equipment technologies, such as Ecomill[5], to reduce the amount of water used in wet processing.

Land management

- Introduce or improve agroforestry systems to enhance carbon sequestration.
- Where agroforestry systems are not feasible (such as with mechanized production), implement tree planting along borders to increase carbon removal while also serving as windbreaks and supporting biological pest control.

Water use

- Adopt innovative and efficient irrigation systems, where applicable, to minimize water use and the energy needed to power irrigation systems.

Colombian coffee farmer Ivan Vega and his son with coffee seedlings growing in the nursery on their farm. Photo by David Dudenhoefer

Country-Specific Highlights

Honduras
A transition to renewable energy sources presents a strong opportunity for emissions reduction. Almost 19 percent of emissions on coffee farms in Honduras came from energy use, which represented the largest share of emissions from energy use of the three countries studied. A switch from gasoline to biofuels on farms would require new equipment, and both financial and technical support, but would help reduce on-farm emissions; less than half of producers currently use biofuels. It is estimated that a biofuels energy transition could reduce these emissions by up to 82 percent. Additionally, using solar energy on large farms and centralized wet mills where coffee is processed could reduce emissions by 75 percent.

Colombia
Here, farmers typically use on-farm wet mills to process their coffee harvests (this is in contrast to Honduras, where coffee is primarily processed at centralized facilities). Around 91 percent of farmers surveyed in Colombia process wastewater on farm, though over half report not having processing equipment. 87 percent were interested in acquiring an Ecomill[5] for wastewater management. Since farmers need support to improve their current wastewater management systems (to comply with national regulations) there is an appetite and incentive to use on-farm Ecomills, provided technical assistance can be obtained for the necessary machinery.

Brazil
Results demonstrate that there is an important opportunity to switch to more organic fertilizer use—in combination with synthetic fertilizers—to reduce GHG emissions on coffee farms in Brazil. In contrast to the farmers surveyed in Colombia, all farmers surveyed in Brazil reported conducting soil analyses—which are required for the transition to organic fertilizers. Since farms are, on average, larger in Brazil, there is more space to make organic fertilizer on farm (a common issue raised with considering adoption of this practice). Farmers reported using coffee husks for composting, so the need for inputs for organic fertilizer production may be lower in Brazil that other locations. Composting could also reduce emissions linked to residues by around 98 percent. One of the most significant needs would be to supply technical and economic support to Brazilian coffee farmers in this transition.

NEXT STEPS

Through this project, we have obtained data to calculate baseline carbon footprints, assessed intervention pathways, and generated actionable insights. This study has demonstrated that it is feasible to collect detailed carbon footprint data, quantify the main sources of GHG emissions within coffee farms, identify barriers that prevent farmers from adopting practices that reduce on-farm emissions, and determine emission reduction pathways.

The outputs of this study will enable Costa Coffee and the Rainforest Alliance to build and share learnings, and explore opportunities which help drive long term positive change. The Rainforest Alliance and its partners will continue to invest in improving coffee supply chains to help farmers in their transition to climate-smart, regenerative coffee production, with the objectives of enhancing farm resilience while improving farmer livelihoods and biodiversity.

Ultimately, this partnership upholds the vision that companies and supply chain actors should share the responsibility of developing a regenerative coffee sector which centers producers while accelerating climate action.

ENDNOTES

1. Specialty Coffee Association, "Carbon and Coffee: GHG Emission Reductions Progress and Strategies Across the Value Chain", 2022.

2. Farms were stratified using the criteria of the Brazilian Institute of Geography and Statistics (IBGE), Instituto Hondureno del Café, and FNC. In Brazil, 30 percent were small farms (<300 ha), 47 percent were medium farms (between 100 and 300 ha), and 23 percent were large farms. In Colombia, 38 percent were small farms, 34 percent were medium farms, 28 percent were large farms. In Honduras, 52 percent were small farms (<3.5 ha), 32 percent were medium farms (between 3.5 ha and 10 ha) and 16 percent were large farms.

3. This study used the CFT 1.0 annual version, which has limited ability to provide robust farm-level estimates of carbon stock changes and does not include removals from coffee trees. The upcoming CFT perennial module, expected in late 2023, will more accurately quantify the carbon emissions and potential sequestration in perennial crops.

4. These recommendations are generalized for all three countries and are meant to guide the development of the next phase of the project. All future interventions will be tailored to the specific country and agricultural context of the producers.

5. Ecomill is a processing technology which considerably reduces water and energy consumption and completely eliminates wastewater contamination during the coffee de-pulping or processing stages.

ACKNOWLEDGMENTS

First and foremost, the Rainforest Alliance would like to thank the farmers that shared their data and participated in this study. We would also like to thank the technical advisory team, Promising Crops, for their work in the field, and Costa Coffee for supporting this pilot study.

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