EXECUTIVE SUMMARY

Low carbon agriculture in the Amazon

The economic viability of GHG emissions scenarios in smallholder agricultural production

Solidaridad

Atypical property of the Tuerê Settlement, Novo Repartimento (PA). Photo: Diego Rinaldi/Solidaridad

Less GHG, more profit

This executive summary highlights results from the study "Low carbon agriculture in the Amazon: The economic viability of GHG emissions scenarios in smallholder agricultural production." The paper evaluated scenarios of greenhouse gas (GHG) emissions - the gases that are emitted in the atmosphere and that cause global warming - combined with the economic viability analysis of the productive activities of family farmers in the Tuerê settlement, in the municipality of Novo Repartimento, in Pará.

Given the relevance of the study "Low carbon agriculture in the Amazon: Scenarios and opportunities in the balance of GHG emissions in smallholder agricultural production," published in 2018 and reissued in 2020, **Solidaridad** incorporated an economic feasibility analysis for the transition to low-carbon farming. In the present study, data were collected from the Tuerê settlement producers in the municipality of Novo Repartimento to analyze different scenarios' economic viability.

The results show that good practices with low GHG emissions are economically viable and that cocoa cultivation is more profitable than livestock farming. There is also an opportunity for livestock production to expand the adoption of low carbon practices, significantly reducing GHG emissions and increasing profitability and efficiency.

Conducted by **Solidaridad**, this study is part of the Inclusive and Sustainable Territories in the Amazon initiative. It aims to contribute to the discussion on the role of smallholder farming in reducing GHG emissions, potentially acting as an emissions sink in the region and protecting forest areas, and assisting in the creation of public and sector policies.

Good reading!

Tuerê, agriculture, and forestry

Brazil is one of the ten largest GHG emitters in the world. GHG emissions' primary sources are agriculture (degradation of the soil and use of nitrogen fertilizers) and land-use change (deforestation for agriculture expansion), contributing to more than 72% of Brazil's total emissions in 2019. In Brazil, deforestation is largely responsible for increasing GHG emissions, followed by the agriculture and energy sectors (SEEG, 2020). Amongst the GHG emissions emitted by livestock, methane (CH4) has the highest global warming potential at 86 times greater than that of CO2.

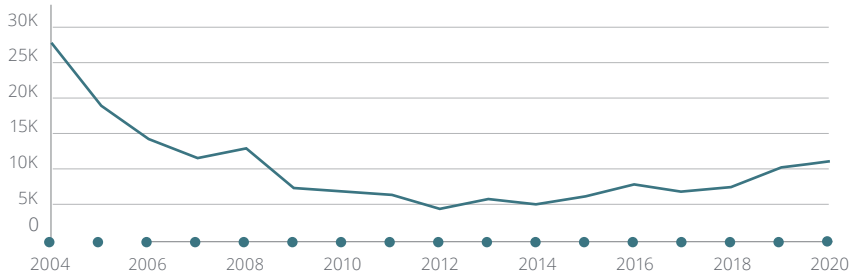
In Brazil, there is a lack of data on GHG emissions in small-scale agriculture. This data gap leads to fewer public and sector policies aimed at smallholder farmers to enable their access to low-carbon agricultural practices. These, when well implemented, can increase the economic viability of smallholder farming.

Solidaridad has implemented a low carbon agricultural model in the Tuerê settlement since 2016 to support the transition from smallholder farming to a low carbon economy, enabling families to grow cocoa, raise cattle and conserve the forest. However, for these agricultural practices to be truly sustainable, they also need to be profitable.

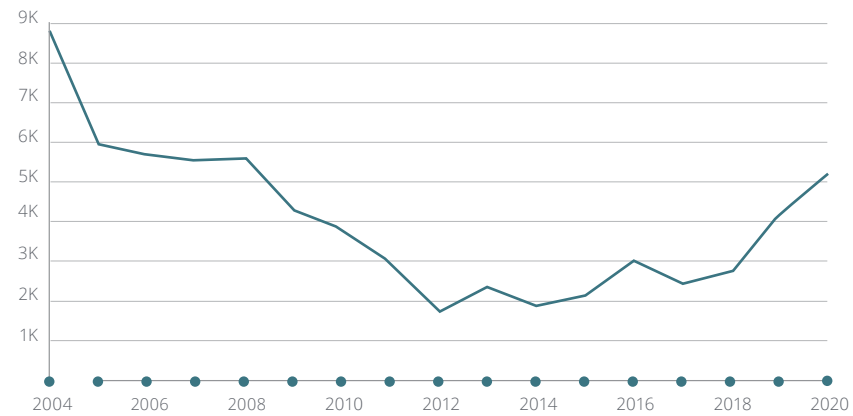
Solidaridad contributes to the reduction of GHG emissions through the socioeconomic inclusion of rural producers. Photo: Diego Rinaldi/Solidaridad

Location of Novo Repartimento and Tuerê Settlement

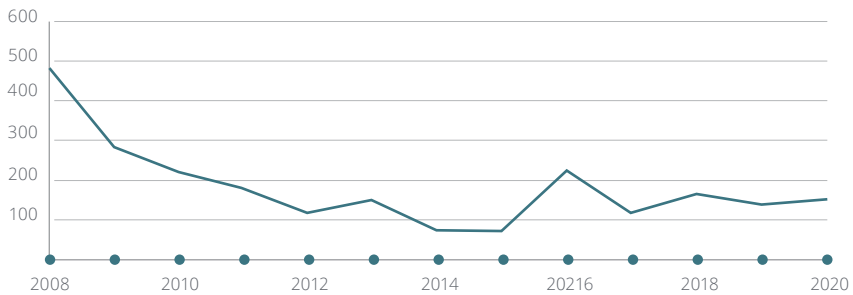
Annual Deforestation Rate - Legal Amazon (Km²)



Annual Deforestation Rate - Pará (Km²)



Annual Deforestation Rate - New Distribution (Km²)



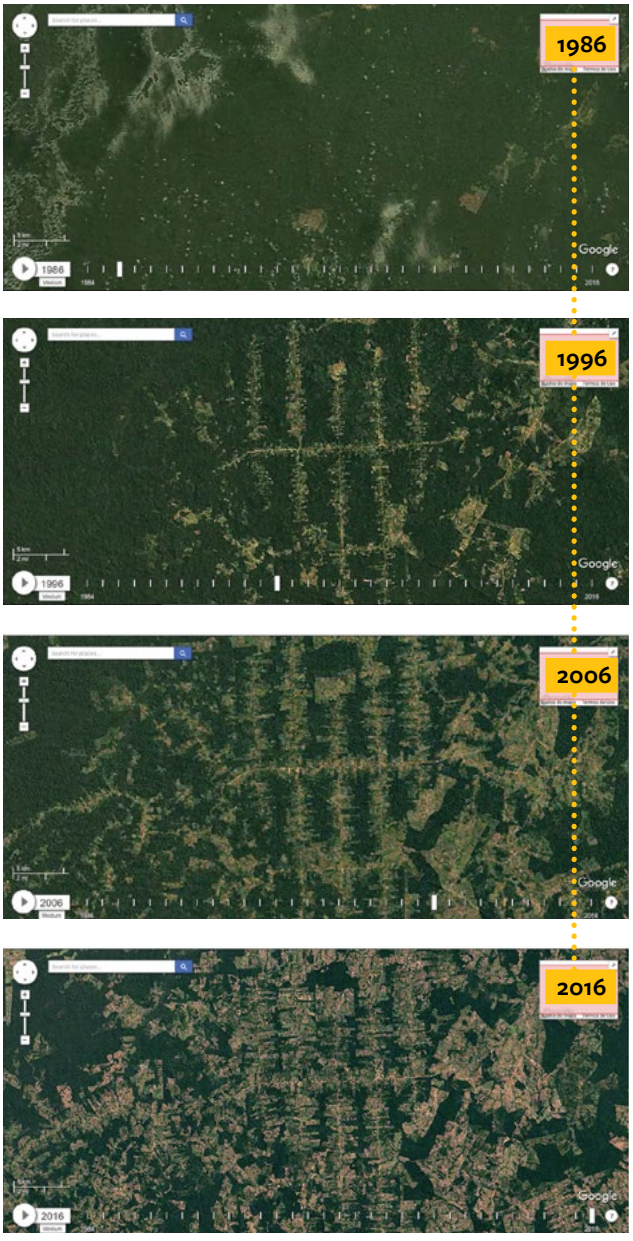
Where we are: Novo Repartimento Municipality

Location: Southeastern region of the state of Pará, on the banks of the Transamazon Highway (BR-230)
Area: 15,464.19 km2
Population: About 73 thousand inhabitants - 90% living in rural areas and linked to agricultural production.

Novo Repartimento is home to 39 rural settlements created by the National Institute of Colonization and Agrarian Reform (INCRA), totaling an area of 517,246 hectares. Until 1990, the main economic activities were the collection of Brazil nuts and forestry. Currently, cattle breeding predominates with a municipal herd of 970,837 heads (IBGE/PPM, 2018). Cocoa production is also a relevant economic activity for the municipality. The first cocoa plantations started in the 2000s, with the support of the Executive Committee of Cocoa Agriculture Plan (CEPLAC). In 2019 it had a total crop harvest area of 4,167 hectares (IBGE/PAM, 2019).

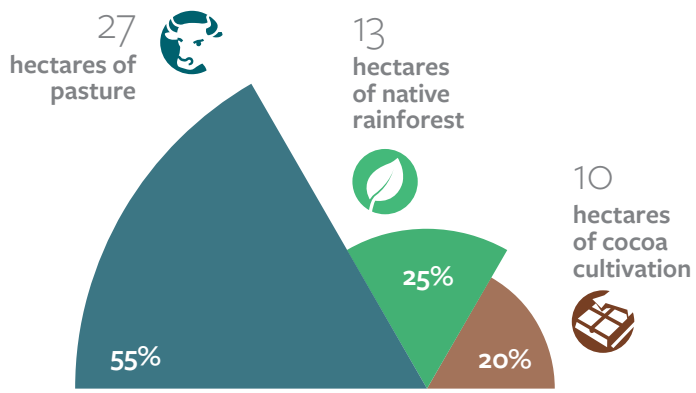
Tuerê, from 1986 to 2016

With 240,800 hectares of an area originally covered by the Amazon Forest, Tuerê is one of the largest Latin American settlements - home to circa 3,000 agricultural plots. In 2000, Tuerê had the highest rate of deforestation among Brazilian rural settlements.



Main types of land use

50 hectares



Source: Solidaridad

Cocoa

Cacao production in the Amazon rainforest can increase forest cover, reduce soil degradation and generate income for family farmers. This is especially the case for agroforestry systems (SAFs, in which cacao is grown with other forest species and crops.

Most cocoa plantations in the settlement are between six and ten years old, and the oldest crops are around 18 years old. Some farmers continue to plant new areas each year, and the majority use few inputs. Others work in an extractive manner, planting and carrying out few management activities. Tree pruning and soil fertility management practices are not widely practiced, directly impacting plant productivity and carbon sequestration.

The average productivity of the cocoa areas in the settlement is 700 kg/ha. However, in areas with technical support from **Solidaridad** and adopting good production practices, the average productivity exceeds 1,000 kg/ha. The gradual and methodical adoption of technologies is one of the pillars of success of the technical assistance implemented with Tuerê's local actors.

The forest

The forest size on rural properties varies according to the farmers' decision to convert forests to pasture and crops. In the Amazon biome, the Brazilian Forest Code requires the management of native vegetation - the so-called Legal Reserve - on 80% of a property's area. However, in Novo Repartimento, due to the Ecological-Economic Zoning (ZEE), the mandatory Legal Reserve is 50% of the area.

The difficulty of ensuring producers' compliance with the Rural Environmental Registry (CAR) and the Environmental Regularization Program (PRA) generates some impacts, such as the delay in complying with the obligation of 50% of the Legal Reserve area and the recovery of Permanent Preservation Areas (APP).

Livestock

Concerning livestock, cattle breeding in the Tuerê settlement is focused on calf production. Herds have 25 to 35 heads per property, 25 to 30 of which are female. The average occupancy rate is 0.86 Animal Unit (AU) per hectare. Herds have an average weaning rate of 75%, generating an average sale of 18 calves/property/year. Pasture areas are simple to rotate, usually divided into three pasture sites. Burning old pastures is a common practice to renew species of forage grasses, which has proved unsustainable over the years.

The practice of slash and burn is used for converting forests to pastures. The use of limestone and fertilizers in pastures is almost non-existent, generating insignificant contributions to the balance of GHG emissions. Most of the emissions from livestock systems in Tuerê are linked to the herd, followed by soil degradation and pastures' burning.

Project beneficiaries receive technical guidelines for sustainable and more profitable practices.
Photo: Diego Rinaldi/Solidaridad

Inclusive and Sustainable Territories

Since 2015 **Solidaridad** has been operating in the Tuerê settlement with smallholder farmers to promote sustainable, low-carbon agriculture. About 200 families have benefited from individual technical visits and collective training on good practices in livestock activity and cocoa production. The training sessions focus on management practices such as pruning, which is essential for carbon sequestration as it enhances the immobilization of CO2 by cocoa plants. The adoption of good practices increased through Solidaridad's interventions. Today, 42% of families fertilize their crops, and 90% participate in training and production pruning. Improving productivity has a positive impact on the carbon balance, emitting less per kilo of cocoa produced.

Interventions focused on livestock to increase profitability are also carried out by **Solidaridad**. Soil fertility management, rotational grazing, conservation practices, and recovery of degraded pastures are among the actions taken. The project also encourages the conversion of degraded pastures into agroforestry systems (SAF, with cocoa as the flagship fruit.

Productive innovations in cocoa management, livestock, and forest restoration are carried out together with families directly in their plots where the Demonstrative Units (UD) are installed. These areas also help promote knowledge transfer between producers. Part of the initiative also includes engaging demand and buyers to enable access to new markets for the cocoa supply chain.

Also, Solidaridad promotes producer engagement with public agencies and private companies to accelerate adherence to the CAR and the Environmental Regularization Program (PRA).

Through Solidaridad Brasil's interventions, the adoption of good practices increased:

42%
of producers fertilize their crops

90%
participate in training and production pruning on cocoa

Deforestation, the villain

Changes in land use represent 23% of GHG emissions in the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC), mitigating actions are necessary to achieve safe levels of GHG emissions and to limit global warming below 2°C, a target established in 2015 by the signatory countries of the Paris Agreement, as is the case of Brazil. However, future climate predictions indicate considerable risk for the Amazon, the world's largest rainforest.

New regulations that assess local biodiversity and traditional knowledge are needed, especially in developing countries, to curb deforestation, in addition to actions that promote the protection of forests.

The understanding of GHG emissions in smallholder farms is minimal, especially in the Amazon biome. This can hinder the adoption of low-carbon agriculture by small producers. Further, it also limits their negotiation power in supply chains in regards to environmental commitments and support programs that promote a transition to more sustainable and efficient models.

The increasing forest fires in the Amazon threaten the planet's climatic stability. Photo: Diego Rinaldi/Solidaridad

Emissions in Tuerê

In 2018, **Solidaridad** published a study with the objectives of understanding the GHG emissions profile of agricultural activity and measuring producer families' potential to mitigate emissions.

A specific calculation methodology was created to estimate the carbon balance of a typical family production unit in the Tuerê settlement under different conditions. The tool was designed for and featured in the study **'Low-carbon agriculture in the Amazon: Scenarios and opportunities in the balance of GHG emissions in smallholder agricultural production**. Considering the agricultural practices carried out on the properties (see Table The Key Scenario Variables; the calculations identified estimates for baseline balance sheets and four scenarios:

- **Baseline** - includes the ongoing agricultural practices carried out on the smallholder farms in Tuerê in 2016.
- ***"Business as usual"*** - divided into BAU 1, BAU 2, and BAU 3 - scenarios that represent the low adoption of good agricultural practices and land use.
- **Improved scenario** - represents the adoption of good agricultural practices without deforestation.

The Key Scenario Variables

- Deforestation
- Land use dynamics
- Herd stocking rate
- Herd fertility
- Pasture degradation
- Cocoa productivity
- Cocoa shading

The baseline and the four scenarios

SCENARIOS	BASELINE
DEFORESTATION RATE	Zero
LAND USE CHANGE	
CHANGE IN LIVESTOCK	• Herd size: 0.86 heads/ha • Fertility rate: 75%
STATE OF GRAZING PASTURES	Degraded
COCOA SYSTEMS	• Stable productivity at 720kg/ha • 60% of the systems are shaded

GHG emissions per scenario

SCENARIO	TOTAL GHG/YEAR BALANCE SHEET (tCO_2e)	GHG BALANCE PER HA/YEAR (tCO_2e)
BASELINE	1.76	0.04
BAU 1	438.7	8.77
BAU 2	-27.9	-0.56
BAU 3	414.3	8.29
IMPROVED	-94.7	-1.89

BAU 1	BAU 2	BAU 3	IMPROVED
5% of the forested area	Zero	5% of the forested area	Zero
90% of the newly deforested area converted to pasture and 10% to cocoa		90% of the newly deforested area converted to pasture and 10% to cocoa	
• Herd size: 0.43 heads/ha • Fertility rate: 75% to 70%	• Herd size: 0.43 heads/ha • Fertility rate: 75% to 70%	• Herd size: 1.38 head/ha • Fertility rate: 75% to 80%	• Herd size: 1.72 head/ha • Fertility rate: 75% to 80%
Degraded	Degraded	Improved	Improved
• Stable productivity at 720kg/ha • 60% of the cocoa systems shaded	• Stable productivity at 720kg/ha • 60% of the cocoa systems shaded	• Enhanced productivity to 1,200kg/ha • 60% of the cocoa systems are combined with native trees • Use of fertilizers	• Enhanced productivity to 1,200kg/ha • 100% of the cocoa systems are combined with native trees • Use of fertilizers

The choice of agroforestry systems, with cocoa as the flagship product, is due to the combination of forest restoration and income generation. Photo: Diego Rinaldi/Solidaridad

Results of the economic viability study and carbon balance scenarios

Methodology

The economic viability study for smallholder farming was carried out based on data collected in 2018/2019 with cocoa and livestock family producers in Tuerê. A ten-year period was used for economic projections. To analyze the relationship between agricultural activities, GHG mitigation and economic viability, economic indicators were applied and compared to the GHG emissions scenarios.

EMISSIONS AND PROFITABILITY PER SCENARIO

BASELINE
CO_2 emissions scenario and not economically viable.

BAU 1
High CO_2 emissions scenario and medium profitability.

BAU 2
CO_2 sequestration scenario and low profitability.

BAU 3
CO_2 emissions scenario and not economically viable.

IMPROVED SCENARIO
CO_2 sequestration scenario and high economic profitability.

Understanding the tables

Average revenue: the annual revenue corresponds to the sum of the producer cash inflows, while the average revenue, in turn, is the average of the annual revenues.

Average Effective Operating Cost: is the average of the annual direct production expenses; in other words, it represents producer spending or the average of the cash outflows.

Net Present Value (NPV): The sum of all future cash flows adjusted to the present value at a discount rate, which is generally equivalent to the minimum attractiveness rate of return (MARR). How to interpret the formula: if the NPV is positive, it can be determined that the project is viable. Therefore, the more positive (or greater)the result, the better the financial evaluation will be.

Simple payback: time required for the initial investment to be recovered.

Discounted payback: the method of discounted payback is similar to that of simple payback. The difference is that the discounted payback takes into account the value of money over time, so the discount rate (DR) is used to adjust future cash flows to the present value.

Internal Rate of Return (IRR): the IRR is the discount rate applied to cash flows that makes the outflow values (adjusted to the present value) equal to the values of the investment returns. The evaluation of the IRR is made based on the comparison with the minimum attractive rate of return (MARR). Thus: i) If, IRR> MARR, the investment is attractive; ii) If, IRR = MARR, the investment yields the same as a minimum risk-free rate; iii) If, IRR <MARR, the investment is not attractive.

Break-Even Point: The break-even point corresponds to the point of financial equilibrium, where revenue equals costs: the producer has no losses and no profits. When the break-even point is reached, the project starts to be profitable.

Gross profit: inflows minus cash outflows (revenue minus cost).

Profitability Index (PI): measures the average profitability of sales. The PI separates net profit and sales revenue (total revenue) for a given period of time, with values between 0 and 1. Thus, the PI expresses the operational profitability in relation to the sales made. If the project, for example, presents PI = 0.10 it means that 10% of the revenue is profit.

Weighted average: is the average of the profitability indexes (profit from revenue), weighted by the productivity of each farmer. This measure is useful for the integrated analysis. It allows for comparison between the baseline averages and the scenarios - BAU 1, BAU2, BAU 3, and Improved.

Economic results by carbon balance scenario

Baseline: CO_2 emissions and economically not viable

BASELINE ECONOMIC INDICATORS* (IN BRL)	
Average revenue	49,934
Average Effective Operating Cost:	-62,786
NPV	-83,948
IRR	-
Simple payback	-
Discounted payback	-
Break-Even Point	-
Gross profit	-12,852

* Annual average (two farms analyzed)

A typical family farm in the Tuerê settlement, observed at the beginning of **Solidaridad**' s intervention in the territory (represented by the Baseline), has an emissions balance of 1.76 tCO2e GHG/year over an area of 50 hectares - or a balance of 0.04tCO2e/year per hectare. Land use and land-use change was not analyzed for the baseline, only agricultural practices were. Considering the average effective operating cost of BRL 62,786.00, the expected loss is BRL 12,852.00. Despite presenting a low value for CO2 emissions, this scenario is not economically viable due to the failure to adopt good agricultural production practices.

BAU 1: High CO_2 emissions scenario and medium profitability

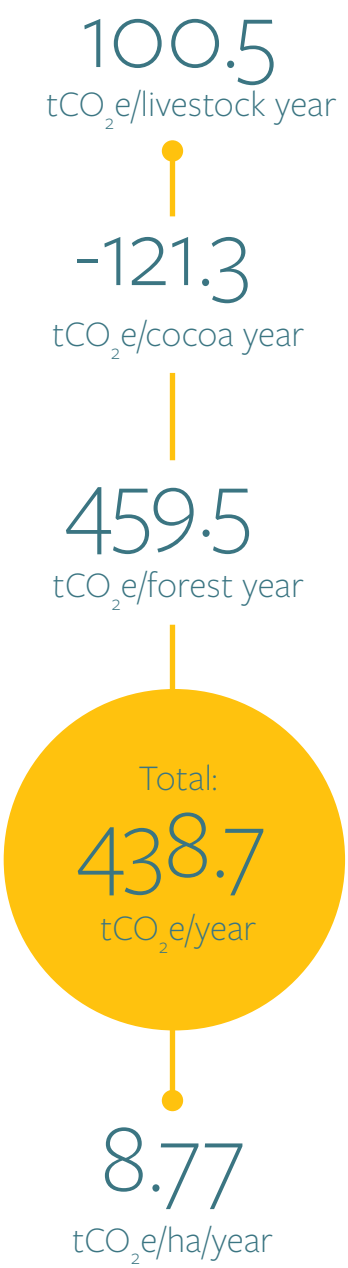
BAU 1* ECONOMIC INDICATORS (IN BRL)	
Average revenue	95,262
Average Effective Operating Cost:	-37,544
NPV	199,461
IRR	41,5%
Simple payback	3 years
Discounted payback	4 years
Break-Even Point	Year 1
Gross profit	57,718

* Annual average (eight properties analyzed)

The leading cause of this significant increase in emissions (220 times) concerning the baseline is deforestation caused by slash and burn practices. By allocating 90% of the deforested area to pasture and 10% to the cocoa cultivation, the intensity of emissions per product increased 8.5 times compared to the baseline, 746% per kilo of weaned calf and 62% per ton of cocoa beans.

The average revenue considered for the analyzed period is BRL 95,262.00 per year. In the assessed period, only positive returns were seen from year 5 onwards. Considering the average effective operating cost of BRL 37,544.00, the expected gross profit for this scenario is BRL 57,885.00/year.

Emissions in the BAU 1 scenario



BAU 2: CO_2 sequestration scenario and low profitability

BAU 2 ECONOMIC INDICATORS* (IN BRL)	
Average revenue	76,905
Average Effective Operating Cost:	-43,978
NPV	222,067
IRR	-
Simple payback	-
Discounted payback	-
Break-Even Point	-
Gross profit	32,927

* Annual average (five farms analyzed)

The Reduced Productivity scenario (BAU 2) is equivalent to BAU 1 concerning livestock and cocoa management practices, except for deforestation, which corresponds to zero. In this scenario, cash flows show regular average revenue over the period in the amount of BRL 76,905.00. The accumulated cash flow and NPV demonstrate positive results from year 1 onwards, as in this scenario, there was no implementation of new cocoa or livestock areas that require more significant initial investments. However, considering the average effective operating cost of BRL 43,978.00 and the expected gross profit of BRL 32,927.00, this scenario presents low profitability.

Emissions in the BAU 2 scenario

BAU 3: CO_2 emissions scenario and not economically viable

BAU 3 ECONOMIC INDICATORS* (IN BRL)	
Average revenue	128,136
Average Effective Operating Cost:	-102.742
NPV	-33,899
IRR	3,8%
Simple payback	7 years
Discounted payback	10 years
Break-Even Point	Year 1
Gross profit	25,394

* Annual average (five farms analyzed)

Emissions in the BAU 3 scenario

75.4
tCO_2e/livestock year

-120.6
tCO_2e/cocoa year

459.5
tCO_2e/deforestation year

Total:
414.3
tCO_2e/year

8.29
tCO_2e/ha/year

The BAU 3 production systems analyzed in the 10-year period presented regular cash flows of average revenue of BRL 128,136.00. Considering the average effective operating cost of BRL 102,742.00, the expected gross profit for this scenario is BRL 25,394.00. The systems in this scenario are not financially viable, with negative NPV, in addition to demonstrating emissions from deforestation. The observed result in this scenario shows that even if the producer adopts good agricultural production practices to expand activity through deforestation (at an annual rate of 5% to increase pastures), the cost of clearing and implementing new pasture areas does not render production economically viable in the evaluated period due to the low economic return of livestock.

Improved Scenario: CO_2 sequestration and high economic profitability scenario

IMPROVED SCENARIO ECONOMIC INDICATORS* (IN BRL)	
Average revenue	235,394
Average Effective Operating Cost:	-161,725
NPV	495,025
IRR	-
Simple payback	-
Discounted payback	-
Break-Even Point	-
Gross profit	73,669

* Annual average (two farms analyzed)

The average revenue projected for the Improved Scenario over the ten-year period of the analysis is BRL 235,394.00. Considering the average effective operating cost of BRL 102,742.00, the expected gross profit for this scenario is BRL 25,394.00. In this scenario, the farm's productivity increases with zero deforestation. Pasture restoration and improvements to the cocoa cultivation system reduce emissions compared to the Baseline by 55 times (from 1.76 tCO2e/year to -94.7 tCO2e/year). Amongst the five scenarios, the Improved Scenario has the best economic performance.

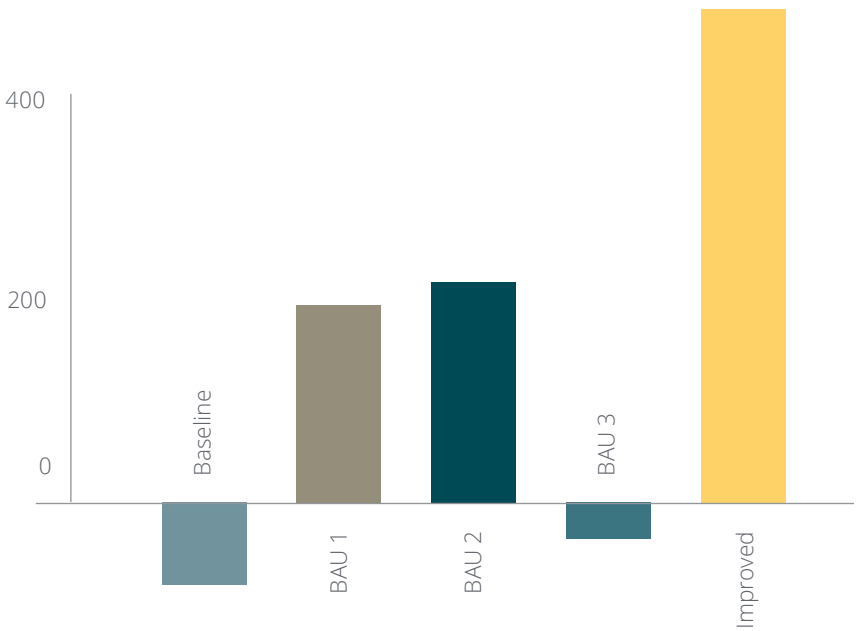
Emissions in the Improved scenario

Results comparison

What differentiates the scenarios are changes in land use, management of livestock, and cocoa production systems, with an impact on productivity and the pasture's soil conditions. BAU 1 and BAU 2 do not adopt good practices, contrary to BAU3. The Improved Scenario relies on technical assistance provided by **Solidaridad**, focused on: improved livestock management and cocoa production, practices increased diversity of agroforestry systems, zero deforestation production, and carbon mitigation.

The comparison of the NPV between the scenarios (see graph on the side) shows that the Improved Scenario presents positive results above average. BAU 1 and BAU 2 also had positive NPV, indicating that they are financially viable. The BAU 3 scenario and the Baseline, with negative values, are financially not viable.

Average NPV per scenario (BRL)



Profitability

When comparing the gross profit between the emission scenarios, the Improved Scenario presents the production systems' best performance. In this scenario, good production practices and zero deforestation are adopted. In the emissions balance, the cocoa production systems play a key role in removing GHG emissions, an effect that is amplified when pruning is adopted. The increase in tree species that provide shade for the cocoa production systems also contributes

Gross profit per scenario (BRL)

SCENARIOS	GROSS PROFIT
BASELINE	12,852
BAU 1	57,718
BAU 2	32,927
BAU 3	25,394
IMPROVED	73,669

significantly to the immobilization of GHGs and for the health of cocoa cultivation, positively influencing productivity.

The results of the profitability index obtained for livestock were lower compared to the cultivation of cocoa. BAU 2 was the scenario that presented the best result, 0.05%, followed by the BAU 1 (see chart on the side). The BAU 3, Baseline and Improved Scenarios presented negative profitability index results for livestock production.In these scenarios the activity generates losses, indicating the need to build productive livestock models adapted to the producers' context and that are more economically viable.

Profitability Index (%)

SCENARIOS	COCOA INDEX	LIVESTOCK INDEX
BASELINE	0.04	-0.14
BAU 1	0.08	0.01
BAU 2	0.12	0.05
BAU 3	0.09	-0.22
IMPROVED	0.23	-0.19

*The comparisons between the scenarios based on the profitability indexes must be complemented by each producer's analysis, given their different production systems. Nonetheless, cocoa cultivation is more profitable than livestock breeding, and the Improved Scenario presents better economic and environmental performance.

Technical knowledge helps producers to increase productivity with zero deforestation. Photo: Diego Rinaldi/Solidaridad

Low-carbon agriculture must be socioeconomically inclusive

Using an economic viability analysis, this study sought to discuss smallholder farming's role within the context of GHG emissions balance in agriculture and land use activities in the Amazon.

This study's results contribute to the dissemination of a new perspective that seeks to reposition smallholder farmers as part of the solution, and offer them opportunities that may arise in the transition to low carbon agriculture and efficient land use in the Amazon.

Promoting zero-deforestation agriculture is the most significant action to reduce GHG emissions and preserve the biome. The improved management of cocoa agroforestry systems and livestock is the most profitable pathway for the economic development of the families that live in the region.

The study showed that access to technology, knowledge, and inputs is essential for the transition from current agricultural management and land-use practices to a low carbon rural economy that promotes the socioeconomic inclusion of smallholder and family farming in the Amazon.

Thus, **Solidaridad** aims to facilitate the expansion of this program so that structured public and private actions can improve the lives of smallholder families in Amazonian territories.

Credits

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LOW CARBON AGRICULTURE IN THE AMAZON: THE ECONOMIC VIABILITY OF GHG EMISSIONS SCENARIOS IN SMALLHOLDER AGRICULTURAL PRODUCTION

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February 2021

Solidaridad

Solidaridad

Solidaridad is an international civil society organization that has been active for more than a decade in Brazil developing socially inclusive, environmentally responsible, and economically profitable agricultural supply chains. The organization seeks to accelerate the transition to inclusive, low-carbon production, contributing to national and global food and climate security. Solidaridad currently develops sustainability initiatives with its partners in the following supply chains: cotton, cocoa, coffee, sugar cane, yerba mate, orange, livestock, and soy.

Globally, Solidaridad has been active for more than half a century in over 40 countries. Solidaridad promotes partnerships and innovative solutions with governments, organizations, cooperatives, and companies to support producers and rural workers to farm better and reduce food production's climate impacts. Its mission is to ensure the transition to an inclusive and sustainable economy, which maximizes the benefit for people and the planet.

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